

# **NI 43-101 TECHNICAL REPORT FOR THE PRESTEA WEST REEF FEASIBILITY STUDY, GHANA EFFECTIVE DATE 1ST MAY 2013**

**Prepared For  
Golden Star Resources Ltd**

**Report Prepared by**



SRK Consulting (UK) Limited

Effective Date 1<sup>st</sup> May 2013

UK4935

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<b>Report Title</b>	NI 43-101 TECHNICAL REPORT FOR THE PRESTEA WEST REEF FEASIBILITY STUDY, GHANA EFFECTIVE DATE 1ST MAY 2013	
<b>Effective Date:</b>	01 May 2013	
<b>Signature Date</b>	01 May 2013	
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## EXECUTIVE SUMMARY

### NI 43-101 TECHNICAL REPORT FOR THE PRESTEA WEST REEF FEASIBILITY STUDY, GHANA EFFECTIVE DATE 1ST MAY 2013

## 1 EXECUTIVE SUMMARY

### 1.1 INTRODUCTION

SRK Consulting (UK) Ltd (“SRK”) was engaged by Golden Star Resources Ltd. (“GSR”, the “Company” or the “Client”) during September 2012 to complete a Feasibility Study (“FS”) for their West Reef Project (“WRP”) at the Prestea Underground Mine (“PUG”) in Ghana. It is noted that the operating entity in Ghana is known as Golden Star Bogoso Prestea Ltd. (“GSBPL”) in which GSR holds a 90% interest. This exercise was based on a Mineral Resource estimate prepared by SRK as part of a previous mandate in accordance with the CIM Code followed by the generation of a FS to assess the economic potential to mine the West Reef. The PUG is currently on Care and Maintenance (“C&M”) having ceased operation in 2002. The Qualified Person (“QP”) with overall responsibility for reporting of Mineral Resources is Dr John Arthur, a Principal Consultant (Resource Geologist) with SRK. The QP with overall responsibility for preparing this report and for reporting of Mineral Reserves is Mr Michael Beare, a Corporate Consultant (Mining Engineer) with SRK. Each QP is independent of the Company.

This technical report documents Mineral Resource and Mineral Reserve statements for the WRP prepared by SRK following the guidelines of the Canadian Securities Administrators’ National Instrument 43-101 (“NI 43-101”) and Form 43-101F1. The Mineral Resource and Mineral Reserve statements reported herein were prepared in conformity with generally accepted CIM “Estimation of Mineral Resources and Mineral Reserves Best Practice Guidelines.”

The Bogoso/Prestea mining complex consists of several open pit operations along thirty kilometres of the Ashanti Trend. The PUG is located 16 km south of the Bogoso mine and adjacent to the town of Prestea. The property consists of two currently operational access shafts and extensive underground workings and support facilities. Access to the mine site is via a paved road from Tarkwa.

The current Life of Mine (“LoM”) plan for the West Reef Project has commencement of ore production in Q4 2016 and full production in Q3 2017. The LoM plan considers the mining of ore from the underground mine using a Mechanised Cut and Fill (“MCF”) method at an average ore production rate of 250 ktpa. GSBPL is planning to process the Prestea WRP ore in the Bogoso Processing plant situated at the Bogoso operation some 16 km away from Prestea, close to the Chujah open pit operation. The WRP underground ore will be trucked from a storage facility at the new hoisting shaft.

The Bogoso processing facility currently treats ore from the open pit operations and consists of two circuits: an Oxide Circuit (“OC”) with a 1.5 Mtpa design capacity, used for non-refractory ores; and a Bio-Oxidation (“BIOX®”) Circuit with a 3.5 Mtpa design capacity, used for refractory ores. Prestea WRP ore will be processed through the OC as a blend with

other Bogoso Mine open pit ore feeds.

The main requirement for project infrastructure is the construction of the new mine accesses comprising raisebored hoisting and ventilation shafts. The planned approach in the FS is to use an international contractor to develop/construct the shafts which would allow the GSBPL two years to develop a mining team with the assistance of expatriate mining specialists.

Bogoso is located on the main road from Tarkwa to Kumasi and has paved road access to Accra (6 hours), Tarkwa (1 hour) and the major port at Takoradi (3 hours). There are airports at Kumasi (3.5 hours) and Takoradi, which provide daily services to the International Airport at Accra.

## 1.2 GEOLOGICAL SETTING

The Prestea-Bogoso mineralization occurs at the southern end of the Ashanti Belt, where eleven gold deposits, mined or under exploration, are localised principally along up to three steep to sub vertical major crustal structures. Rock assemblages from the southern area of the Ashanti belt were formed between a period spanning from 2 080 to 2 240 million years (“Ma”) with the Sefwi Group being the oldest rock package and the Tarkwa sediments being the youngest. The Ashanti belt is host to numerous gold occurrences, which are believed to be related to various stages of the Eoeburnean and Eburnean deformational events.

The geology of the Prestea Mine site is divided into four main litho-structural assemblages, which are fault bounded and steeply dipping to the west. This suggests that the contacts are structurally controlled and that the litho-structural assemblages are unconformable. These packages are from the eastern footwall to the western hanging wall, the Tarkwaian litho-structural assemblage, the tectonic breccia assemblage, the graphitic Birimian sedimentary assemblage and the undeformed Birimian sedimentary assemblage.

At Prestea, the principal structure is the mineralised quartz vein, known as the Main Reef which is relatively continuous and has been modelled and worked over a strike length of some 6 km and to a depth of approximately 1 450 m below surface (35 L). The subordinate West Reef and East Reef, in the immediate hangingwall and footwall respectively of the former structure, are discontinuous. West Reef occurs some 200 m into the hangingwall of the Main Reef structure and, at present is known to occur over a strike length of 800 m and has currently been defined by underground drilling between 550 to 1 150 m below topography as far as the 24 L.

## 1.3 MINERAL RESOURCE

A detailed geological report was prepared by SRK as part of the November 2008 Mineral Resource estimate. The Mineral Resource Statement presented herein has been updated and prepared in accordance with the terms and definitions given in the CIM Code.

Deposit modelling has been completed on the basis of modelling the lithological units, of which there is a good understanding. SRK is satisfied that the geological modelling supports the current geological information and knowledge. The location, quality and quantity of the drillhole data are sufficiently reliable to support the subsequent Mineral Resource estimate. The Mineral Resource statement has been prepared using a block cut off grade of 3.08 g/t based on a US\$ 1,750 /oz gold price and appropriate costing data to produce a Mineral Resource which matches the requirements that the deposit should have “reasonable prospects for economic extraction” as defined by the CIM. The statement was prepared by Dr. John Arthur who is a Qualified Person pursuant to National Instrument 43-101 and independent from GSBPL. The effective date of the Mineral Resource Statement is 1 May 2013. The updated Mineral Resource Statement for Prestea Underground is given below in

Table ES 1.

**Table ES 1      Prestea Underground Mineral Resource Statement 1 May 2013**

Orebody	MEASURED			INDICATED			INFERRED		
	Tonnes (kt)	Grade g/t Au	Content (koz Au)	Tonnes (kt)	Grade g/tAu	Content (koz Au)	Tonnes (kt)	Grade (g/t Au)	Content (koz Au)
Main Reef	-	-	-	325	6.02	63	2,955	6.08	580
West Reef*	-	-	-	863	18.27	507	510	11.62	190
Footwall	-	-	-	375	7.60	92	240	8.28	65
Hangingwall	-	-	-	-	-	-	60	3.2	5
Shaft Pillar	-	-	-	-	-	-	375	9.04	110
JCI Blocks	-	-	-	-	-	-	1,045	8.68	290
<b>Total</b>	-	-	-	<b>1,563</b>	<b>13.17</b>	<b>661</b>	<b>5,185</b>	<b>7.44</b>	<b>1,240</b>

\* The mineral reserves reported in this feasibility study relate to the mining of the West Reef resources only.

## 1.4 GEOTECHNICAL STUDIES

SRK has carried out a feasibility level geotechnical program involving mapping, sampling, testing and analysis. The characterisation of the deposit rock mass has been completed by visual inspection of conditions in the mine and the examination of borehole core.

SRK has verified excavation sizes and sill pillar dimensions which have been incorporated into the feasibility designs using the MCF method. According to the results from the analysis, development in the mine will not require systematic support to ensure stability of excavations although this has been budgeted for in the form of rock bolts and mesh. It has been determined that the cemented rock fill adjacent to the sill pillars will not require steel reinforcement.

## 1.5 MINING

### 1.5.1 ACCESS

Rehabilitation and repairs to the Central Shaft are required to maintain access for preparatory works for proposed new access infrastructure for the WRP. The FS has indicated that a 660 m vertical shaft of 4.8 m diameter should be developed for combined ore hoisting and transport of men and materials and to provide primary fresh air intake for the ventilation circuit. A 3.8 m diameter vertical ventilation shaft of 653 m depth will be required as the primary ventilation exhaust and a primary axial flow fan will be installed underground at the base. Before pilot hole drilling can commence, both the shaft collars will require pre-sink excavations down to bedrock at a depth of 50 m.

### 1.5.2 MINING METHOD

The MCF method has been selected as the primary mining method for the WRP where ore drives are developed on either side of a central access ramp to the end of a designated mining panel. Mining commences at the bottom of a panel and progresses upwards. As each set of drifts are completed, they are filled with waste rock fill to facilitate mining of the next cut. The first cut is filled with cemented rock fill so that it can be undercut from the panel below. Following placement and setting of the cemented rock fill in the first cut, the cross cut access ramp is slashed upwards to access the next cut. Subsequent cuts are taken by working off the placed fill from the cut below. The major benefits of using this method are a high level of selectivity and orebody recovery and good dilution control.

The WRP is scheduled for an average ore production of 250 ktpa over the LoM.

### 1.5.3 MINING OPERATION

The West Reef will be mined with single boom jumbos and 1.5 m<sup>3</sup> LHD's. Ground support in the ore drives will be undertaken employing hand held drilling methods. The staff and labour requirements for the planned 250 ktpa WRP underground operation at Prestea have been developed based on the typical management and professional staffing levels for this size of operation, operating 2 x 10 hour shifts a day and 7 production days per week, 350 days per year. The maximum manpower required (excluding the Surface G&A staff) is 258, including 38 expatriates for the first two years for training of the local workforce.

The equipment required to undertake mining activities at Prestea WRP was selected based on practical experience of working in similar mining environments and accepted industry standards. Generally the equipment selection has been based on the orebody dimensions and required mining rate and the quantity of equipment has been based on estimated operating hours.

### 1.5.4 MINERAL RESERVES

The following table summarises the Mineral Reserves available for the life of mine plan as of 1 May 2013, prepared in accordance with the CIM Code.

The Mineral Reserves have been estimated based on: cut-off grades determined at a gold price of \$1,500/oz; suitable mining recovery factors and operating costs; and detailed mine designs which account for varying waste dilution as a result of changes in mineralization dip and width.

The Mineral Reserves stated in Table ES 2 are contained within the Mineral Resources stated in Table ES 1.

**Table ES 2 Prestea WRP Mineral Reserve Statement 1 May 2013**

Category	Quantity (kt)	Grade (g/t Au)	Metal Content (koz Au)
Proven	-	-	-
Probable	1,434	9.61	443
<b>Total Mineral Reserves</b>	<b>1,434</b>	<b>9.61</b>	<b>443</b>

#### Notes

1. The QP with overall responsibility for reporting of Mineral Reserves is Mr Michael Beare, B.Eng, MIMMM, C.Eng. a Corporate Consultant (Mining Engineering) with SRK. Mr Beare has 20 years' experience in the mining industry and has been involved in the reporting of Mineral Reserves on various properties in Europe and Africa during the past ten years.
2. Based on the anticipated costs, recoveries and a gold price of USD\$ 1,500/oz an operating CoG of 4.7 g/t Au is estimated.

### 1.6 PROCESSING

The metallurgical testwork program undertaken for the purposes of the FS was to determine the potential to process the Prestea WRP ore through the OC at Bogoso with a focus on understanding:

- The presence of any refractory component(s) in the WRP ore;
- The presence of any significant preg-robbing component(s) in the WRP ore;
- Expected recoveries under typical OC processing operating conditions; and
- The operating cost to process the Prestea WRP ore through the Bogoso OC.

In the absence of any historical core the FS testwork was conducted on samples of diamond drill core from the underground geotechnical drilling program that was undertaken in late 2012 and early 2013. The testwork was conducted at SGS Lakefield laboratory in Canada.

Samples from eight drillholes were available, with six from 17 L and two from 24 L. The samples included expected dilution from the hangingwall and footwall as defined by geotechnical studies.

For comparison purposes, a sample of Pampe Fresh ore was also provided for testwork. Pampe Fresh ore is one of the current Oxide circuit feedstocks, and so the aim in parallel testing Pampe Fresh ore was to allow the opportunity to assess the results of the testwork on the Prestea WRP ore in the context of testwork on an ore source with which the Bogoso operation is familiar. The Pampe Fresh sample was taken from a surface stockpile of the material.

The following testwork was conducted on the composite samples:

- Bond Work Index (“BWi”), at a closing screen size of 100 mesh (150 µm);
- 25 element head assay;
- Preg-robbing test;
- Gravity separation at a grind size of 80% -150 µm;
- Bottle roll cyanidation tests on the gravity tailings; and
- Tailings characterisation tests.

The metallurgical testwork results indicate that the Prestea WRP ore is non-refractory and not significantly preg-robbing, with high Au recoveries reported under both Carbon-in-Pulp (“CIP”) and Carbon-in-Leach (“CIL”) operating conditions, following the removal of the gravity recoverable component. It is therefore suited to processing through the current Bogoso Oxide circuit.

The proportion of gravity recoverable gold in the Prestea ore is relatively high at approximately 80%. The cyanidation leach kinetics are relatively rapid and the reagent consumptions in leaching (cyanide and lime) are reasonable and relatively low respectively.

Compared to the sample of Pampe Fresh ore tested, the Prestea WRP ore exhibits a higher gravity recovery and a higher overall recovery, significantly less preg-robbing, similar leach kinetics, slightly higher cyanide consumption and lower lime consumption. The Prestea WRP ore is somewhat harder than the Pampe Fresh ore, and there is evidence that the ore becomes harder with depth and preg-robbing may also increase.

Several key assumptions were initially made for the FS analysis, which were later confirmed by the testwork as follows:

- The Prestea WRP ore can be processed through the Bogoso OC;
- The overall gold process recovery is 90%; and
- The operating cost to process the Prestea WRP ore through the Bogoso OC will be based on the recent historical processing costs adjusted for plant operation at full capacity.

SRK notes that the metallurgical testwork results reported to date support the assumptions used for the purposes of this FS.

## **1.7 PROJECT INFRASTRUCTURE**

The WRP does not require substantial infrastructure in terms of roads and other facilities. The WRP is situated in a long established mining town that is generally well served with roads and power infrastructure.

### **1.7.1 ELECTRICAL**

The WRP has been designed to be independent from the existing electrical infrastructure of

the Prestea Underground Mine historic workings. This is possible due to the geographical location of the West Reef resource and surface infrastructure.

The system has been designed in this FS according to Ghanaian mining regulations and to most efficient mining standards. The primary high voltage for reticulation is 11 kV and for low voltage 1 000 V. The key electrical loads installed will be for the two new winders at the RHS, ventilation fans, air compressors, dewatering pumps and the electric-hydraulic drills.

The existing electrical infrastructure both on surface and underground has been in existence for between 20 and 60 years and in the last 20 years has received very limited maintenance. GRIDCO, the national electrical distributor, has a main transformer yard (“Job 600”) just 1 km from the Central Shaft. There are a number of issues with the current electrical system that have been addressed as part of the FS.

SRK notes that electrical system reliability is not expected to be a material issue due to the fact that there is adequate provision for labour and materials to effect repairs. It is further noted that should the pumps stop due to electrical problems there is ample capacity in the lower levels of the mine to store water until such time as the electrical issue is resolved.

The proposed solution is to have the incoming supply bypass the Job 600 yard and continue at 33 kV in the existing Bondaye line to service the hoisting shaft and all new underground installations. The main 33 kV to 11 kV transformers will be located at the hoisting shaft site. Central Shaft load requirements that remain to support the West Reef shall be connected through the Job 600 substation. Since power will continue at 33 kV to Bondaye Shaft, a new 33/3.3 kV transformer will be required at Bondaye. This new system removes remnants of the old 55 kV high voltage, retains both Prestea and Bondaye on 3.3 kV and introduces 11 kV at the RHS. The key upgrades required are:

- Install a by-pass feed for the 33 kV at the Job 600 yard (and remove the step-up transformer from the system);
- Install a spur line off the existing overhead to the hoisting shaft; and
- Replace the 55/3.3 kV with 33/3.3 kV at Bondaye.

The main cost components are to replace the 3.3 kV circuit breakers and motor starters which have been provided for in the FS estimates of capital costs.

### **1.7.2 WASTE STORAGE FACILITIES**

In general, waste rock produced from the WRP will be kept underground and used for backfill. The exception to this is during the early years of the WRP when there are insufficient voids available to allow backfilling to commence. In this case, the waste rock will be transported to surface.

In the first year of project development, 100 kt will be hoisted up the Central Shaft. Due to a lack of suitable sites on surface, it has been determined that all the waste rock will be transported to the waste rock dump site location at the RHS where an engineered storage facility will be constructed. Even though a geochemical examination of the rock types by SRK suggests negligible acid generating potential, this facility will be constructed to contain any problematic material so that run off can be, if required, treated appropriately. During the ramp up of production in the early years there is also an excess of waste rock. This will necessitate a further 300 kt of material to be hoisted up the RHS and stored on surface.

### **1.7.3 TAILINGS STORAGE FACILITIES**

GSBPL currently operates a number of open pit mines at Bogoso and is planning to commence underground mining of the WRP. The tailings from the both open pit and

underground operations will be processed in the same facilities at Bogoso and the tailings will be delivered to the the present TSF, termed TSF2.

TSF2 is a paddock type facility consisting of four cells. A total of 17 embankments separate the four Cells. The WRP will generate approximately 1.4 Mt of tailings waste which will be deposited in Cells 1 and 2 of TSF2 over a 7 year period. Although the testing on the new Prestea tailings is fully not completed, indications suggest that the tailings will be coarser than presently deposited in the TSF2.

SRK considers that the commingling of the tailings in the TSF2, from Bogoso and Prestea mines will not create any new constructability issues providing that the facility continues to be managed and constructed in line with design and supernatant pond levels are maintained at operational levels through water management and treatment.

## 1.8 ENVIRONMENTAL AND SOCIAL

The corporate responsibility undertaken by GSPBL on the environmental and social aspects of planning for the Prestea WRP has been extensive. The corporate responsibility team was an integral part of the design engineering team, which has allowed for a comprehensive assessment of available options for the project development and enables an understanding of the impact on the environment and socioeconomic factors in the project area.

Following on from the FS, environmental permitting will continue with the incorporation of the designs of the project and assessment of the environmental effects and the residual environmental effects following the implementation of the mitigation measures and strategies. To allow the impact assessment to be completed, baseline studies within the project area have been developed. The Project area has been extensively disturbed as a result of urbanization, small scale farming and extensive unauthorized mining (small and medium scale) have essentially removed most of the natural cover in the vicinity of the project. The baseline socioeconomic studies showed an impoverished neighbourhood with relatively low levels of education and poor economic stability.

The main potentially adverse socioeconomic effect of the project is the need to resettle the Prestea Goldfields International School. This is currently located immediately over the location for the RHS. However, negotiations with key stakeholders and the school board of trustees have provided an opportunity to consider the resettlement of the school to another location selected by the community. This would allow the mutual benefit of access to the land and a new school for the community to be realized.

GSPBL management have been adaptive from a corporate responsibility perspective to allow the incorporation of the resettlement requirements into a Prestea Projects Re-settlement Action Plan (“RAP”), which combines the resettlement / relocation requirements for the Prestea South Project (surface mining) and the Prestea WRP operations. As such, the Prestea Huni Valley District Assembly is able to review the requirements for all the current projects in the area, allowing an optimized approach for both RAP review and approval, and then implementation. The Project Affected People (“PAP”) would also have a single window approach for concerns associated with the RAP, so allow for improved response times and an overall elevated level of understanding with the PAP.

Some additional studies for the EIS are required including the following:

- Additional air quality modelling to reflect the changes to the project parameters;
- Risk assessment for development and safety management, more specifically with the interaction with the un-surveyed unauthorized small mining workings;
- Detailed studies related to the location of the waste rock dump; and

- Evaluation of the acid generation potential for the waste rock that will be moved to surface.

## 1.9 CAPITAL COSTS

Capital costs for the WRP have been derived principally from planned equipment requirements and estimates for major infrastructure such as the shafts, relocation of the International School and mine closure, Table ES 3. The estimated Capital costs total US\$ 150.1 million over the LoM which includes a 5 % contingency on all capital items except the following:

- School Relocation. This estimate was built up by GSBPL and contains at least 10 % contingency;
- Shaft complex construction. SRK considered that the estimate prepared by Murray and Roberts Cementation (“MRC”) contained adequate levels of contingency added by the designers for tender purposes;
- Closure Costs; and
- Preproduction Development.

The cost and time to construct the RHS, RVS and related ancillary work has been estimated for the FS in detail by underground contractors, MRC at US\$ 53.8 million which is the largest capital expenditure comprising 35.8 % of the total over the LoM. The mining fleet capital (15.6 %) is primarily expended early in the life of the operation, though it also includes replacement of major mining equipment after four years of operation.

Pre-Production development has been capitalised and comprises the first 9 months of development activities scheduled for Q2 2016 to Q4 2016, totalling US\$ 35.8 million or 23.9 % of the total estimated capital costs.

**Table ES 3 LoM Capital Expenditure**

<b>Capital Breakdown</b>	<b>Capital Expenditure (US\$ million)</b>	<b>% Capital</b>
Mining Fleet	23.5	15.6%
Ventilation Fans	2.7	1.8%
Dewatering Pumps	0.8	0.5%
Raisebored Shafts	53.8	35.8%
Preparatory Works	5.7	3.8%
Underground Infrastructure	0.9	0.6%
Other Infrastructure	10.0	6.7%
General	3.8	2.6%
Contingency (5%)	4.9	3.3%
School Relocation	4.5	3.0%
Closure Cost	3.7	2.5%
<b>SubTotal – Capex (US\$ million)</b>	<b>114.3</b>	<b>76.1%</b>
Preproduction Development	35.8	23.9%
<b>Total Project Capital (US\$ million)</b>	<b>150.1</b>	<b>100.0%</b>

## 1.10 OPERATING COSTS

SRK has derived the operating costs for the WRP from first principles and the LoM breakdown per tonne milled is provided in Table ES 4 which totals US\$ 179.3 /t milled (excluding preproduction capital development). The underground mine operating costs comprise 61.4 % of the total operating costs and includes development costs (excluding preproduction capital development), equipment, power, labour and Maintenance and Repair Contract (“MARC”) costs. Power costs are significant (26 %) and are based on requirements to dewater the historic workings and operate the existing primary fan and a power cost of US\$ 0.178 /kWhr from the national grid, supplied by GRIDCO.

An operating cost of US\$ 5.5 /t is required for transporting the ore 16 km to the Bogoso plant and US\$ 15 /t processing costs is based on a review of metallurgical testwork of WR samples and current operating costs at the process facilities adjusted to account for maximum plant throughput.

A 10 % contingency has been included for operating costs to allow for minor items and omissions. The royalty payable to the government equates to US\$ 20.9 /t milled.

**Table ES 4 LoM Unit Operating Cost Breakdown (US\$/t milled)**

Operating Cost Breakdown	LoM Operating Cost (US\$/t milled)	% Operating Cost
<b>Total Mining</b>	<b>125.4</b>	<b>61.4%</b>
Direct Costs	26.2	
Mining Fleet	24.7	
Power	32.6	
Labour	36.5	
MARC	5.3	
<b>Total Processing</b>	<b>20.5</b>	<b>10.0%</b>
Trucking to plant	5.5	
Processing Cost	15.0	
<b>Total G&amp;A</b>	<b>19.3</b>	<b>9.4%</b>
G&A Labour	5.6	
Current G & A	5.7	
Water treatment chemical cost	4.5	
Rental for head gear	3.1	
<b>Total Refining</b>	<b>1.5</b>	<b>0.7%</b>
<b>Contingency (10%)</b>	<b>16.7</b>	<b>8.2%</b>
<b>Total Royalty</b>	<b>20.9</b>	<b>10.2%</b>
<b>Total Operating Cost (US\$/t milled)</b>	<b>204.3</b>	<b>100.0%</b>
<b>Total Operating Cost, excluding Preproduction (US\$/t milled)</b>	<b>179.3</b>	

Table ES 5 provides a summary breakdown of the operating costs per troy ounce of gold produced.

**Table ES 5 Summary of LoM Unit Operating Costs (US\$/oz Au)**

<b>Operating Cost Summary</b>	<b>LoM Operating Cost (US\$/oz Au)</b>
Total Mining	450.8
Total Processing	73.8
Total G&A	69.4
Total Refining	5.6
Contingency	59.9
Total Royalty	75.0
<b>Total Operating Cost (US\$/oz Au)</b>	<b>734.4</b>
<b>Total Operating Cost, excluding Preproduction (US\$/oz Au)</b>	<b>644.7</b>

## 1.11 ECONOMIC ASSESSMENT

SRK has assessed the WRP economics by constructing an independent Technical Economic Model (TEM) and using the mining schedule and cost estimation to determine the viability of the project. The TEM reflects capital and operating expenditures commencing 1 April 2013 going forward in real terms US\$ where there is no allowance for inflation or escalation on capital and operating costs, inputs or revenues. A discount rate of 5 % and gold price of US\$ 1 500 /oz has been specified by GSBPL for the base case to determine the Net Present Value (NPV). The following summary points have also been considered in the TEM:

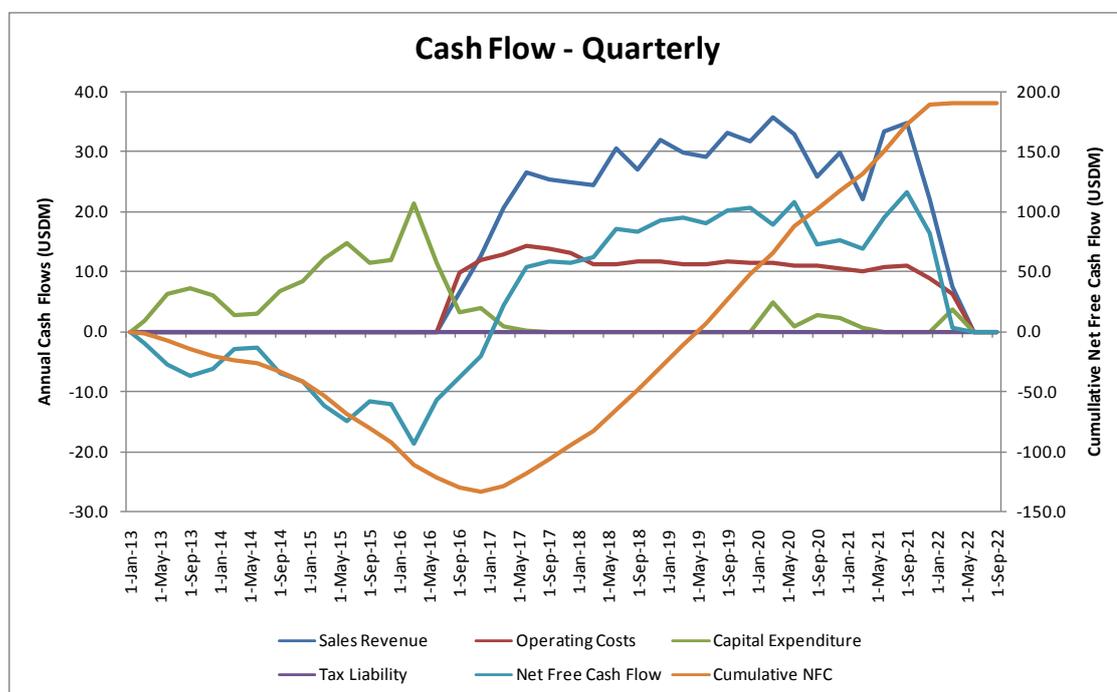
- expressed in post-tax and pre-financing terms which assumes 100 % equity;
- Corporate tax rate of 35 %;
- Windfall Profits Tax (“WPT”) based on an interpretation of the calculation provided by the Client;
- An opening assessed tax loss of US\$ 400 million has been included in the TEM as advised by the Client. This figure represents tax pools available at both Prestea and Bogoso operations. This results in no corporation tax being payable for the WRP;
- VAT is not included;
- Does not include any acquisition costs or previous expenses from the owner;
- Capital investment is depreciated on an annual fixed percentage basis as per the fiscal regime of Ghana. It has been assumed that all capital items have been fully depreciated and at the end of the mine life there is no terminal value to consider; and
- Reflects funding to be available for construction by 1 September 2013.

Table ES 6 provides a summary breakdown of the key financial parameters for the TEM over the LoM plan.

**Table ES 6 Summary of LoM Financial Parameters**

Revenue	(US\$ million)	598
Operating Costs	(US\$ million)	-257
<b>Operating Profit</b>	<b>(US\$ million)</b>	<b>341</b>
Tax Liability	(US\$ million)	
Capital Expenditure	(US\$ million)	-150
<b>Cash Flow</b>	<b>(US\$ million)</b>	<b>191</b>
Ore Produced	(kt)	1,434
Waste Mined	(kt)	930
Contained Au	(koz Au)	443
Recovered Au	(koz Au)	399
Mining Cost	(US\$/t ore)	-125.4
Processing Cost	(US\$/t ore)	-20.5
G&A Cost	(US\$/t ore)	-19.3
Refining Cost	(US\$/t ore)	-1.6
Contingency	(US\$/t ore)	-16.7
Royalty	(US\$/t ore)	-20.9
<b>Total</b>	<b>(US\$/t ore)</b>	<b>-204.3</b>
Revenue	(US\$/oz Au)	1,500
Operating Costs	(US\$/oz Au)	-734.4
<b>Operating Profit</b>	<b>(US\$/oz Au)</b>	<b>765.6</b>

Figure ES 1 provides a cashflow analysis over the LoM which shows the the majority of capital expenditure in the first 4 years and sales revenue commencing after 3.5 years based on a starting date of 1 April 2013.



**Figure ES 1 Quarterly Cash Flow over the LoM**

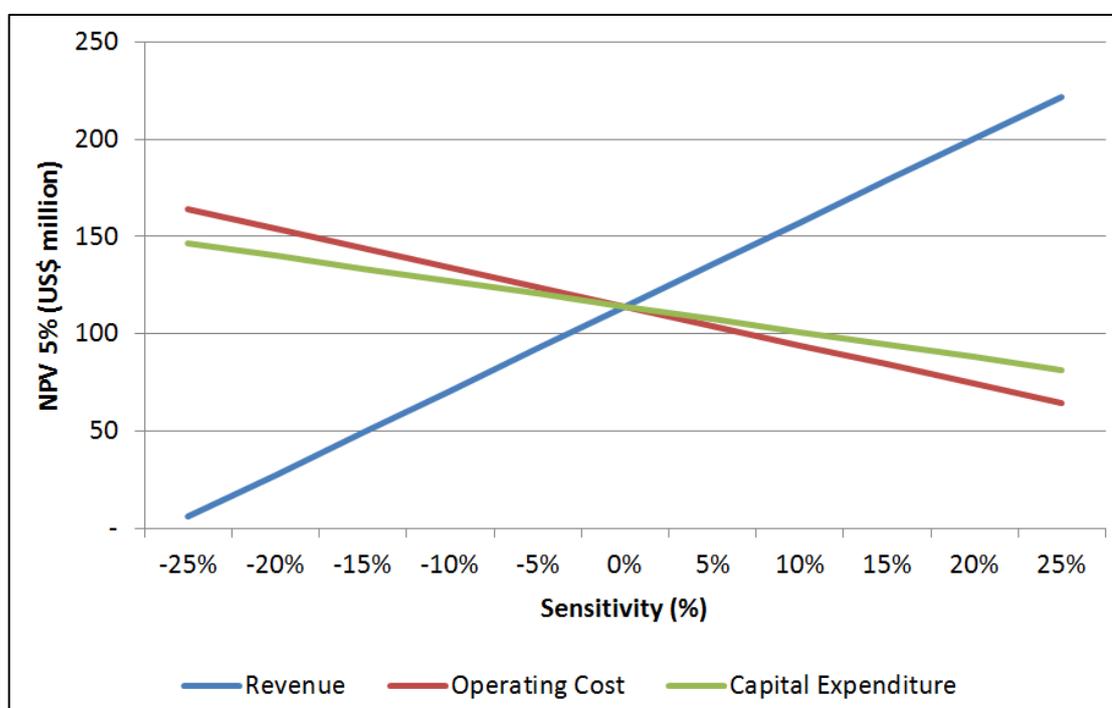
Table ES 7 provides an NPV sensitivity analysis for gold prices ranging from US\$ 1 100 to 1 700 per troy ounce and a discount rate, ranging from 0 to 15 %. SRK notes that at 5 %

discount rate the post-tax NPV is US\$ 114 million and the IRR is 22.7% with a Base Case gold price scenario assumed of US\$ 1 500/oz. At US\$1 300 /oz Au the NPV<sub>5%</sub> drops to US\$ 59 million and at US\$ 1 700/oz Au it increases to US\$ 169 million.

**Table ES 7: NPV sensitivity for Discount Rate**

Discount Rate	0%	5%	8%	10%	12%	15%
NPV (US\$ million) @ US\$1 100/oz Au Price	40	5	-10	-17	-23	-30
NPV (US\$ million) @ US\$1 300/oz Au Price	115	59	36	23	13	0
NPV (US\$ million) @ US\$1 500/oz Au Price	191	114	81	64	49	31
NPV (US\$ million) @ US\$1 700/oz Au Price	267	169	127	104	85	61

Figure ES 2 provides an NPV sensitivity chart for mine operating costs; capital expenditure and commodity sales price for the Base Case. The Prestea NPV is most sensitive to revenue (grade or gold price) and has a moderate sensitivity to capital and operating costs. The breakeven gold price assuming a 5 % discount rate is US\$1 084/oz. This is the gold price when the NPV is zero using a 5 % discount rate.



**Figure ES 2 Base Case Sensitivity Analysis**

The TEM is shown to report a positive economic outcome and support the Mineral Reserve estimate for the WRP for GSBPL. The project payback period is 6 years from start of project development (3 years from start of ore production) with a maximum drawdown of US\$ 134 million incurred at the end of the fourth year if the commencement date is considered for 1 April 2013.

## 1.12 CONCLUSIONS

Based upon the work completed for the FS, SRK concludes the following:

- The Prestea WRP has favourable economics and based on the assumed metal prices is considered robust in terms of the estimated operating margins and return on investment. The feasibility study work by SRK indicates an NPV of US\$ 114 million using the average base case gold price of US\$ 1 500/oz and a discount rate of 5 %. The payback period is estimated to be 6 years from start of project development;
- The WRP does not require substantial infrastructure in terms of roads, rail and port facilities. The Project is situated in a long established mining town that is generally well served with roads and power infrastructure;
- The FS technical work has determined that an average production rate of 250 ktpa (including ramp up and tail) containing 70 koz Au can be attained from the Prestea orebody using modern trackless mining methods. The sink rate required to maintain this is only 4.7 m vertical per month which equates to 31 m of ramp development. SRK considers this production rate to be low risk and notes that there is potential to increase production volumes;
- An option study showed that a new decline from surface is not warranted for the WRP. The study has concluded that the needs of the mine are best served by repairing the Central Shaft for the short and medium term in order to prepare for a RHS that will serve the WRP for both ore hoisting and man riding. The ventilation requirements for the WRP will be served by establishing a raisebored ventilation raise to surface that will remove contaminated air. Fresh air will be provided by the RHS and from other parts of the mine;
- The rock mass is generally of reasonable strength and rock mass quality. However, cut and fill stoping has been recommended for all of the orebody due to the low risk of unplanned dilution with this method;
- The FS LoM plan reports a Probable Mineral Reserve tonnage of 1.434 Mt from the Prestea operation at a run of mine grade of 9.61 g/t Au prepared in accordance with the CIM Code. This has been planned over a 7 year project life (23 quarters of ore production excluding the waste development period at project start-up) and is based on the 2013 Mineral Resource estimate with losses for mining recovery and dilution applied;
- A process recovery of 90 % in the Bogoso processing plant is considered achievable;
- SRK does not consider there to be significant issues associated with accommodating the WRP ore in the existing and planned tailings storage facilities at the Bogoso operation;
- The WRP area has been extensively disturbed as a result of urbanization, farming and extensive unauthorized mining (small and medium scale). This has essentially removed most of the natural vegetation cover in the vicinity of the WRP. The baseline socioeconomic studies showed an impoverished neighbourhood with relatively low levels of education and poor economic stability. The main potentially adverse socioeconomic effect of the WRP is the need to resettle the Prestea Goldfields International School. This is currently located immediately over the location for the RHS. However, negotiations with key stakeholders and the school board of trustees have indicated that the relocation can be undertaken without adverse impact on the WRP;
- The economics of the Prestea WRP generally show little sensitivity to operating or capital costs. This can be attributed to the grade of the deposit giving high contained values and a strong operating margin per tonne;
- When benchmarked against other similar operations the estimated costs for the Prestea WRP are in the lower third in terms of production costs per ounce. In other words, if the

gold price falls then two thirds of other gold producers will trade at a loss before the WRP;

- Average operating costs for Prestea WRP have been estimated to be US\$ 179 /t ore and US\$ 645/oz Au (excluding capitalised operating costs and including contingency and royalty). Average operating costs including capitalized operating costs, contingency and royalty are US\$ 204 /t and US\$ 734 /oz; and
- Total Capital has been estimated at US\$ 150 million. Capital costs for fixed equipment and surface installations have been estimated to be US\$ 114 million over the mine life, with US\$ 91 million expended in the first three years of the WRP as initial capital from Q2 2013 to Q3 2016 inclusive and the remaining US\$ 23 million as sustaining capital from Q4 2016 onwards. Operating costs incurred from Q3 2013 to Q3 2016 inclusive are capitalised and are estimated at US\$ 36 million.

### 1.13 RECOMMENDATIONS

Based on the results of the FS, SRK recommends the following:

- Prestea continues with its planned programme of preparatory works at the mine with a view to progress development of the WRP by September 2013. SRK notes that contractor and equipment lead times need to be further investigated because this could be potentially be a constraint to a rapid start up;
- The parts of the WRP orebody that have not been considered for the Mineral Reserve estimate due to an Inferred Mineral Resource classification are delineated further by infill drilling with the aim of upgrading their classification;
- A detailed development plan is progressed for the first two years of the underground operation based on the results of continuing infill drilling and site investigation holes around the proposed shafts;
- Additional geotechnical work is undertaken in the future to verify the design parameters used in the FS and understand the stress constraints on the sill pillars and the changes through the mine life;
- Improve the understanding of the hydrogeology of the deposit through measurement of the pumped volumes and investigate the potential to reduce water inflow to the mine from surface features;
- Continue with implementation of programme relating to environmental and social management for the PUG WRP;
- Implement a safety plan to comply with Ghanaian regulations and international best practice;
- Development of a comprehensive performance management plan to include tracking of all relevant project data including but not limited to development and production statistics; and
- Further development of capital costs with detailed quotes and competitive tenders to verify the FS estimates, assumptions and confirm lead times for major plant and equipment.

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## NI 43-101 TECHNICAL REPORT FOR THE PRESTEA WEST REEF FEASIBILITY STUDY, GHANA EFFECTIVE DATE 1ST MAY 2013

### 1 INTRODUCTION (ITEM 2)

#### 1.1 General

SRK Consulting (UK) Limited (“SRK”) is an associate company of the international group holding company, SRK Consulting (Global) Limited (the “SRK Group”). SRK was engaged by Golden Star Resources Ltd (“GSR”, the “Company” or the “Client”) during September 2012 to complete a Feasibility Study (“FS”) for their West Reef Project (“WRP” or the “Project”) at the Prestea Underground Mine (“PUG”) in Ghana, West Africa. PUG is currently on care and maintenance (“C&M”) having ceased operation in 2002. GSR hold a 90 % interest in the subsidiary company / operating entity in Ghana, known as Golden Star Bogoso Prestea Ltd (“GSBPL”).

The Bogoso/Prestea mining complex consists of several open pit and underground operations along thirty kilometres of the Ashanti Trend. PUG is located 16 km south of the Bogoso mine and adjacent to the town of Prestea. The property consists of two currently operational access shafts and extensive underground workings and support facilities. Access to the mine site is via a gravel road from Tarkwa.

GSBPL is planning to process the Prestea WRP ore in the Bogoso Processing plant situated at the Bogoso operation some 16 km away from Prestea, close to the Chujah open pit operation. The WRP underground ore will be trucked from the planned Raisebored Hoisting Shaft (“RHS”).

The Bogoso processing facility currently treats ore from the open pit operations and consists of two circuits: an Oxide Circuit (“OC”) with a 1.5 Mtpa design capacity, used for non-refractory ores; and a Bio-Oxidation (“BIOX®”) Circuit with a 3.5 Mtpa design capacity, used for refractory ores. Prestea WRP ore will be processed through the OC as a blend with other Bogoso Mine open pit ore feeds.

Bogoso is located on the main road from Tarkwa to Kumasi and there is a gravel road between Bogoso and Prestea. The property has paved road access to Accra (6 hours), Tarkwa (1 hour) and the major port at Takoradi (3 hours). There are airports at Kumasi (3.5 hours) and Takoradi, which provide daily services to the International Airport at Accra.

#### 1.2 Terms of Reference and Purpose of the Report

The Mineral Resource estimate for PUG has been revised by SRK for the FS on the WRP. The revision is based on an estimate made in 2008 where the economic parameters have been reassessed according to the current assessment for future potential economic extraction.

The FS is intended for the use of GSBPL to further the evaluation of the WRP by estimating Mineral Reserves in accordance with the CIM Code which is the Canadian Institute of Mining, Metallurgy and Petroleum (“CIM”) resource and reserve classification system. The FS assesses the economic potential to mine the West Reef by determining the optimal approach to mining method, access and infrastructure and estimating the associated capital and

operating costs to a sufficient level of accuracy required to support a Mineral Reserve estimate. Metallurgical testwork has been undertaken on representative samples for the WRP to determine the likely recovery of gold and process costs in the operating Bogoso process facilities.

The FS Life of Mine (“LoM”) plan excludes the mining of Mineral Resources classified as Inferred that are considered too speculative, geologically, to have economic considerations applied to them. This technical report documents Mineral Resource and Mineral Reserve statements for the WRP prepared by SRK following the guidelines of the Canadian Securities Administrators’ National Instrument 43-101 (“NI 43-101”) and Form 43-101F1. The Mineral Resource and Reserve statements reported herein were prepared in conformity with generally accepted CIM ‘Estimation of Mineral Resources and Mineral Reserves Best Practice Guidelines’.

The metric (SI System) units of measure are used in this report unless otherwise noted to describe quantities in this report.

### 1.3 Background

GSR is a 25 year old, mid-tier gold mining company with total historical gold production of over two million troy ounces (“oz”) and was established under the Canada Business Corporations Act on 15 May 1992 as a result of the amalgamation of South American Goldfields Inc., a corporation incorporated under the federal laws of Canada, and Golden Star Resources Ltd., a corporation originally incorporated under the provisions of the Alberta Business Corporations Act on March 7 1984 as Southern Star Resources Ltd.

The Company has two mining operations situated along the Ashanti Gold Belt in Ghana, West Africa. The growth strategy of GSR is the result of exploration and expansion activities at both Bogoso/Prestea and Wassa Hwini-Butre and Benso (“HBB”).

Golden Star has a stated long-term commitment to sustainability of their mining operations in Ghana with particular emphasis on health, education and the environment. While the majority of the exploration activities are proximal to the operations in Ghana, GSR has a property portfolio that includes projects in other parts of Ghana, West Africa and Brazil.

PUG is an inactive underground gold mine which consists of two currently operational access shafts with extensive underground workings and support facilities. PUG was mined from the 1870’s until 2002 when mining ceased following an extended period of low gold prices in the late 1990’s and early 2000’s. PUG has produced approximately 9 Moz of gold, the second highest production of any mine in Ghana. The underground workings are extensive, reaching depths of approximately 1 450 m below surface and extending along a strike length of 9 km. Underground workings can currently be accessed via two operating surface shafts, one near the town of Prestea (Central Shaft) and a second approximately 4 km to the southwest at Bondaye.

GSBPL holds a 90 % ownership in the Prestea Underground Mine with the Government of Ghana holding a 10 % ownership interest in the Prestea Underground Mine as well as its 10 % holding in GSBPL, resulting in an 81% beneficial ownership by GSR. The Government of Ghana receives a Gross Revenue Royalty of 5 % on all GSBPL gold production.

GSBPL continues to dewater the PUG and is currently refurbishing the Central Shaft and completing maintenance works on the 12, 17 and 24 Levels.

The current LoM plan for the WRP has plans for commencement of ore production in Q4 2016 and full production in Q3 2017. The LoM plan considers the mining of ore from the underground mine using a Mechanised Cut and Fill (“MCF”) method at an average ore

production rate of 250 ktpa.

## 1.4 Sources of Information

In compiling this report, SRK has utilized data from the following key sources:

- Digital Mineral Resource Estimation Block Models containing grade, density, geological and quality information completed by SRK and GSR;
- Historical production and recovery statistics, current operating statistics and costs for the processing plant, provided by GSR;
- Preliminary Feasibility Study prepared by Turgis (Pty) Ltd, 2008;
- NI 43-101 Technical Report (Mineral Resource Estimate) prepared by SRK (UK) Ltd, 2008;
- NI 43-101 Technical Report (Preliminary Economic Assessment) prepared by GSR Inc., 2012;
- Geotechnical assessment report prepared by SRK (UK) Ltd in 2013;
- Hydrogeological assessment report prepared by SRK (UK) Ltd in 2013;
- Metallurgical assessment report prepared by JMA Ltd in 2012;
- Various other in-house and external reports and papers;
- Tailings and waste management information;
- Data relating to the social and environmental effects of the existing and planned mining operations, provided by GSR.; and
- Data archives at the Prestea Underground Mine site offices.

Further detail is provided in Section 26 to this report which provides a complete list of references.

## 1.5 Site Inspections

### 1.5.1 SRK Staff

The following SRK staff have visited PUG for the FS and for previous Mineral Resource preparation work with Qualified Persons (“QP”) responsibilities as stated:

- John Arthur (QP for Mineral Resources and Geology) 23 to 27 January 2012;
- Neil Marshall (QP for Geotechnical) 6 to 15 September 2012;
- Tony Rex (QP for Hydrogeology) 1 to 5 October 2012;
- Jurgen Fuykschot 19 to 25 November 2012;
- Rod Redden 1 to 5 October 2012 and 1 to 5 April 2013;
- Michael Beare (QP for Mineral Reserves and Mining) 1 to 5 April 2013;
- Kris Czajewski (QP for Tailings Storage) 15 to 19 October 2012; and
- John Willis (QP for Metallurgy) 15 to 19 October 2012.

## 1.6 Qualifications of Consultants

The SRK Group comprises 1,600 staff in 49 offices. The SRK Group’s independence is ensured by the fact that it holds no equity in any project. This permits the SRK Group to provide its clients with conflict-free and objective recommendations on crucial judgment issues. The SRK Group has a demonstrated track record in undertaking independent assessments of resources and reserves, project evaluations and audits, CPRs and independent feasibility evaluations on behalf of exploration and mining companies and financial institutions worldwide. The SRK Group has also worked with a large number of major international mining companies and their projects, providing technical consultancy services. The SRK work at Prestea has been prepared based on a technical work by a team of five

consultants sourced from the SRK Group's offices in the United Kingdom over a 12-month period. These consultants are all experienced specialists in their respective fields. The individuals from SRK who have provided input to the May 2013 FS are listed in Table 1-1. All the specialists involved have extensive experience in the mining industry and are members of good standing of appropriate professional institutions.

**Table 1-1 Project Team**

Role	Person
Project Director	Iestyn Humphreys, C.Eng. BSc, PhD, FIMMM
Geotechnical	Neil Marshall, C.Eng., B.Eng. (Hons) MIMMM
Geotechnical	Ben Westgate, BSc, PhD, MSc, CGeol
Hydrogeology	Tony Rex, BSc(Hons) PhD, FGS, CGeol
Hydrogeology	Maria Bennett, BSc, MSc, FGS
Geology and Mineral Resources	John Arthur, C.Eng., PhD, BSc, MIMMM
Mining, Project Management	Michael Beare, C.Eng., B.Eng. (Hons) MIMMM, ACSM
Mine Scheduling	Jurgen Fuykschot, B.Eng, MAusIMM (CP)
Mine Design and Ventilation	Rod Redden, B.Eng, MAusIMM (CP), MBA
Mine Planning	Katja Sestakova, BSc
Tailings	Krzysztof Czajewski, BSc, APEGBC
Cost Estimation	Kousik Bose B.Eng, MAusIMM (CP)
Economics	Keith Joslin, B.Eng. (Hons) MSAIMM, ACSM
Mineral Processing	John Willis, B.Eng, MAusIMM (CP)
Environmental	Fiona Cessford, BSc, MSc, PRN, MIAIA
Environmental	Rowena Smuts, BSc, MSc

The Qualified Person (“QP”) with overall responsibility for reporting of Mineral Resources is Dr John Arthur, a Principal Consultant (Resource Geologist specialising in all aspects of mineral resource estimation and classification and has eighteen years’ experience in the resource sector.

The QP with overall responsibility for reporting of Mineral Reserves is Mr Michael Beare, a Corporate Consultant (Mining Engineer) with SRK. Mr Beare has 20 years’ experience in the mining industry and has been involved in the reporting of Mineral Reserves on various properties in Europe and Africa during the past ten years.

## 1.7 Project Approach / Methodology

Site visits were undertaken by key members of the team during the course of the project programme. During the site visits, and subsequently in the Cardiff office the following steps were undertaken:

- Existing underground workings and C&M activities in the mine were observed;
- Discussions were held with the GSBPL mine staff regarding detailed issues relating to the mine operation;
- The available survey pickups from existing underground workings were received and reviewed by SRK along with the latest Mineral Resource block model. This data was imported into Geovia Surpac software for subsequent review, manipulation and mine planning (including underground design and scheduling);
- All available relevant historical data was reviewed;
- Price data for consumables was provided by GSBPL staff and their suppliers;
- Various cost items from the GSBPL mine budget were reviewed to incorporated into the SRK Technical Economic Model (“TEM”);

- Follow up visits were made to the mine site to obtain input from mine employees and to validate assumptions and designs; and
- SRK finalised the life of mine plan, production schedule and economic model, before completing the technical report.

The level of accuracy of this life of mine plan and cost estimate is considered to be +/- 15% which is suitable for FS level.

## **1.8 Limitations, Reliance on SRK, Declaration, Consent, Copyright and Cautionary Statements**

SRK's opinion contained herein and effective **1 May 2013**, is based on information collected by SRK throughout the course of SRK's investigations, which in turn reflect various technical and economic conditions at the time of writing.

SRK has received data and documentation from GSR staff and its advisors in good faith and has checked this for adequacy and appropriateness. SRK has verified the treatment and interpretation of this data but has not evaluated the source data itself in detail. No warranties regarding the source data provided by third parties can therefore be given.

In preparing this report, SRK reviewed mining plans, geological reports and maps, miscellaneous technical papers, company letters and memoranda, and other public and private information. SRK has assumed that all of the information and technical documents reviewed are accurate and complete in all material aspects. While SRK carefully reviewed all of this information, SRK has not conducted an independent investigation to verify its accuracy and completeness. SRK has not independently verified the legal status or ownership of the property or the underlying agreements.

SRK personnel made several site visits to Ghana in 2012 and 2013 as part of this mandate. SRK carried out discussions with GSR management and technical personnel and was provided full and open access to all available information relating to the WRP. GSR staff have stated that a full disclosure of all material information in its possession or control has been made to SRK. GSR has agreed that neither it nor its associates will make any claim against SRK to recover any loss or damage suffered as a result of SRK's reliance upon information provided by staff at the Prestea Mine. GSBPL staff have reviewed draft copies of the report for factual errors. Any changes made as a result of these reviews did not involve any alteration to the conclusions made. Hence, the statements and opinions expressed in this document are given in good faith and in the belief that such statements and opinions are not false or misleading at the date of this report.

SRK is not an insider, associate or an affiliate of GSR, and neither SRK nor any affiliate has acted as advisor to GSR, its subsidiaries or its affiliates in connection with this project. The results of the FS by SRK are not dependent on any prior agreements concerning the conclusions to be reached, nor are there any undisclosed understandings concerning any future business dealings.

## 2 RELIANCE ON OTHER EXPERTS (ITEM 3)

The preparation of the FS has mainly been completed by SRK staff however there are disciplines where SRK was not the sole author or relied on specialists in a particular field. In these cases, SRK reviewed the work of other consulting firms or that of GSBPL as follows:

- SRK sub contracted Alan Auld Engineering (UK) Ltd (“AAE”) to inspect the Central Shaft and prepare a report on the refurbishment works necessary to re-commission the facility. AAE is a UK based consultancy specialising in shaft design and construction;
- Murray and Roberts Cementation Ltd (“MRC”) were contracted directly by the GSR to provide input to the FS. MRC’s mandate was to prepare a schedule and cost estimate to construct a raisebored hoisting shaft and a raisebored ventilation shaft. MRC are a South African based engineering, contracting and construction services company with extensive expertise in raiseboring and shaft engineering;
- SRK notes that the plan for tailings storage is to use the existing processing and storage facilities at the nearby Bogoso operation. The design of these facilities was undertaken by consultants from Knight Piésold Ltd who have also carried out periodic reviews; and
- GSBPL has a strong on-site environmental and social team who have authored this section for the FS with review input from SRK. The key contributors were Philipa Varris and Dr Mark Thorpe of GSR.

### 3 PROPERTY DESCRIPTION AND LOCATION (ITEM 4)

#### 3.1 Location and land Tenure

The Prestea concession is located in the Western Region of Ghana approximately 200 km from the capital Accra and 50 km from the coast of the Gulf of Guinea. Bogoso and Prestea comprise a collection of adjoining mining concessions that together cover a 40 km section of the Ashanti gold district in the central eastern section of the Western Region of Ghana (Figure 3-1), with the processing facilities situated approximately 10 km south of the town of Bogoso. GSBPL currently holds five mining leases as well as several prospecting licenses to the southwest, northeast and west of Bogoso.

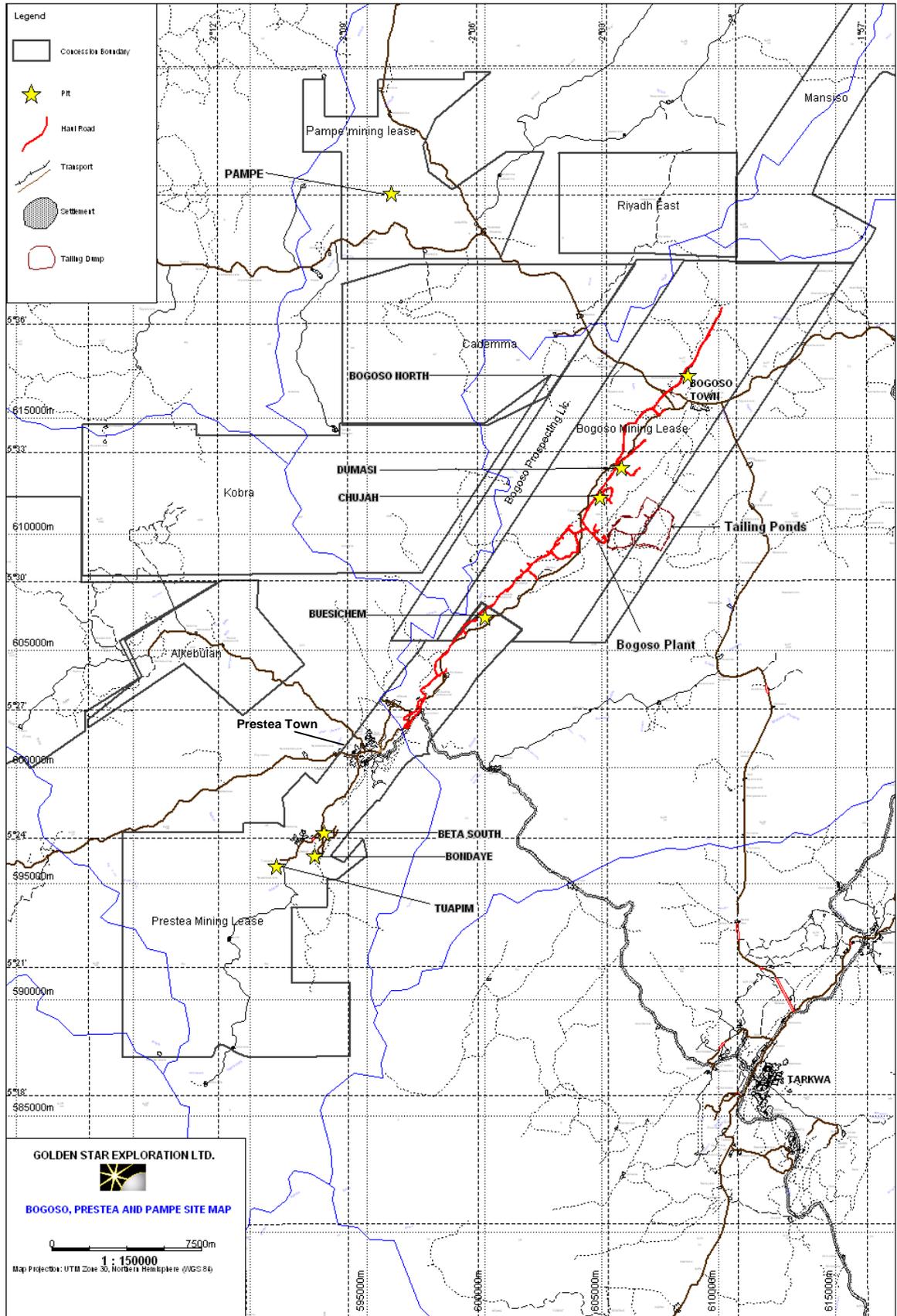


**Figure 3-1 Location of Bogoso/Prestea in the Regional Context of Ghana and West Africa (Source: United Nations 2008)**

Figure 3-2 shows the location of the mining licence boundaries in relation to the location of the main GSBPL mine workings at Bogoso, Prestea and Pampe including:

- Bogoso mining lease. Chujah Main and Bogoso North are the current major producing open pit mines for the GSBPL deposits located within the Bogoso mining lease. The other main deposit includes Dumasi (immediately north of the Chujah Main pit). The processing facilities are located just south of the Chujah Main open pit; and
- Prestea mining lease. The Buesichem deposit and PUG lie to the north of the Prestea lease with the Beta Boundary South, Bondaye and Tuapim deposits (collectively, Prestea South) located south east, in the central part of the lease.

The map in Figure 3-3 illustrates the outline of the Prestea mining lease along with geographic latitude and longitude of each points of the mining lease.



**Figure 3-2 Location of Principal Operations in Relation to Mining Licence Boundaries at Bogoso/Prestea (Source: GSR 2011)**

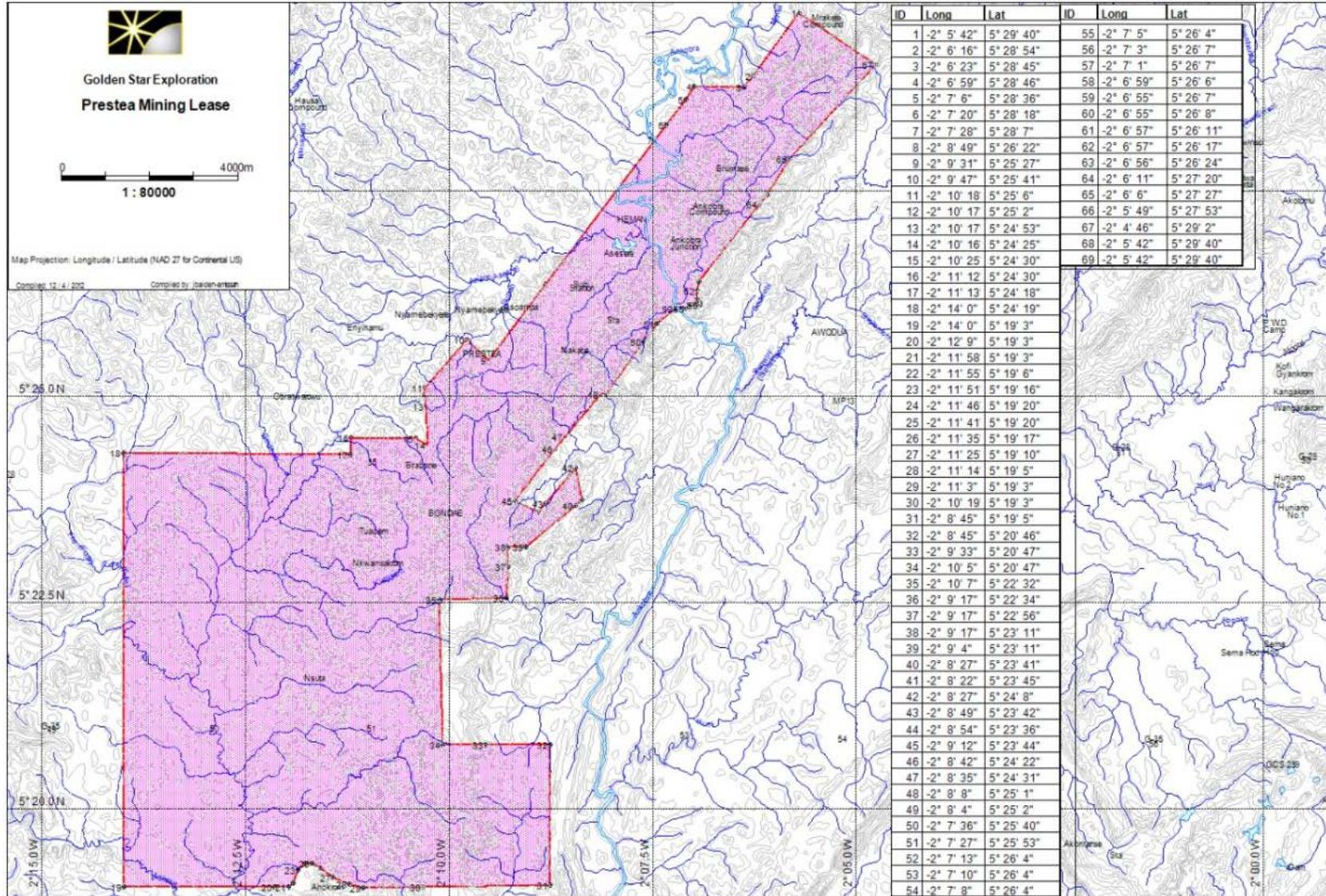


Figure 3-3: Prestea Mining Lease (Source: Golden Star Exploration)

### 3.2 Mineral Titles and Agreements

A detailed investigation into the legal tenure of the Prestea Mine concession was beyond the scope of the FS and this technical report. However, SRK has reviewed the concession boundaries provided by GSBPL and concludes that the Mineral Resources determined by SRK lie inside of the current licence area.

The Prestea concession is a mining lease that was issued to Prestea Gold Resources Limited (“PGR”) on 29 June 2001 by the Government of Ghana with land registry number 2799/2001. The agreement granted PGR the exclusive right to operate underground mining within the Prestea Concession lower than a depth of 150 m below sea level for a period of 30 years effective from the date of Mining Lease. The strike of the underground lease extends from the Ankobra shaft in the north to the Tuapim shaft to the south and covers an approximate area of 11.27 km<sup>2</sup>, which represents only a portion of the entire 129 km<sup>2</sup> Prestea Mining Lease. A joint operating agreement was signed in January 2002 between Bogoso Gold Limited (“BGL”), a subsidiary of GSR incorporated under the laws of Ghana, and PGR. An amount of US\$ 2.1 million was paid to PGR as a first option payment. This agreement granted Bogoso Gold Limited the right to develop and operate the PUG while also setting out the protocols and procedures to be observed by BGL and PGR in the day-to-day operations of the surface and underground mining operations.

A second agreement entitled Memorandum of Agreement (“MoA”) was signed on 14 March, 2002 between PGR, BGL, Prestea Goldfields Limited, the State Gold Mining Company Limited (“SGMC”), the Ghana Mineworkers Union of Ghana and the Republic of Ghana. This agreement was formed to create a joint venture agreement between all parties who had an interest in the PUG at the time and to consolidate the management of the underground mine. The agreement also defined the conditions for the PUG to be put under C&M, which includes mine dewatering and shaft maintenance along with the number of employees required. The PUG has remained under C&M since the signature of the agreement.

### 3.3 Royalties and Encumbrances

Royalties associated with the Prestea Mining lease are defined under Section 21 of the mining lease that was issued to PGR on 29 June 2001. The agreement stipulates that the company shall pay royalty on a quarterly basis to the government as prescribed by the legislation. Royalties are based on production and are to be paid through the Commissioner of Internal Revenue within thirty days from the end of the quarter.

During 2010, SRK understands that the Internal Revenue Service of Ghana stipulated that Royalties were to be raised from 3 to 5 % with retroactive effect from 19 March, 2010. This 5 % royalty is the only royalty associated with the Prestea mining lease.

The Prestea mining lease is subject to a rent for land usage, which is defined under Section 20 of the mining lease that was issued to PGR on 29 June 2001. The rent is paid bi-annually before the first day of January and on or before the first day of July; the amount is fixed at US\$ 0.50 /km<sup>2</sup>.

Another financial obligation related to the Prestea mining lease is rent payable to the government of Ghana for the Central Shaft headframe and other mine infrastructure. The rent is US\$0.5 million per year.

### 3.4 Environmental Liabilities

The existing environmental liabilities associated with the Prestea underground operation were included in an indemnity granted to Prestea Gold Resources (now part of GSBPL) by the Republic of Ghana. The indemnity document is dated 21 December 2001 and titled ‘Prestea

Gold Resources Indemnity Against Pre-Existing Environmental Liabilities’. SRK has assumed that this indemnity will be honoured by the authorities and the WRP will be allowed to function independently of the rest of the PUG and not be obliged to treat the water emanating from the wider Prestea Mine.

### **3.5 Operating Permits Required**

To re-start the PUG, an environmental approval for the WRP is required. An outline of the permitting process is as follows:

- Submission of form EA2 to the Environmental Protection Agency (“EPA”) to register the project (completed);
- Submission of a draft Environmental Scoping Report and Terms of Reference for EPA comment (completed);
- Completion of an EIA with the submission of a draft EIS for EPA comment;
- Revision and submission of the EIS; and
- Issuance of the Environmental Permit.

## **4 ACCESSIBILITY, CLIMATE, LOCAL RESOURCES, INFRASTRUCTURE AND PHYSIOGRAPHY (ITEM 5)**

### **4.1 Infrastructure and Physiography**

Local population centres are located at Bogoso town in the northern half of the Bogoso Concession, and Prestea town, which is about in the centre of the Prestea Concession. Bogoso is located on the main road from Tarkwa to Kumasi and there is a paved road between Bogoso and Prestea. The town of Prestea is located adjacent to the backfilled workings of the Plant North open pit. The Central Shaft complex and offices for PUG are also located within the town limits.

### **4.2 Topography, Elevation and Vegetation**

The topography of the area within which the GSBPL assets are located is characterized by a series of northeast-southwest trending sub-parallel ridges. The mineralization tends to occur on the western slopes of the ridges with the intervening valleys occupied by farming communities and seasonal streams. Vegetation in the area has been largely disturbed by the various activities and consists of a patchwork of small farms, urban development with some secondary growth on the steep slopes and hill tops that are not suitable for farming.

### **4.3 Climate and Length of Operating Season**

As the WRP is an underground mine, the climate has no significant impact on the operations. In the tropical environment, work on the surface can continue year round with short breaks during the mostly short-lived storm events.

### **4.4 Access to the Property**

Access to the property by road is a 6 hr drive from Accra via the port city of Takoradi. The road is paved from Accra to Tarkwa with the last 1 hrs to Prestea being paved road in appalling condition. There are airports at Kumasi and Takoradi, which provide daily services to the international airport at Accra. Kumasi is situated approximately 3.5 hrs drive from the Project. Road surfaces in the area vary from poor (on the section between Bogoso and Tarkwa) to good (Accra to Takoradi). There have been government plans to re-surface the road between Bogoso and Tarkwa for several years and remains in poor condition but is passable throughout the year.

### **4.5 Local Resources and Infrastructure**

PUG is in an area where mining has occurred more or less continuously since the late 1800's. Therefore, a significant portion of the required services, infrastructure and community support are already in place. The following services and infrastructure are relevant to the assessment the Project:

- Surface access to PUG is via the public road network that extends to the Project;
- Electricity and water are available – electricity from the Ghanaian national grid is currently used to power the existing underground dewatering pumps;
- Surface infrastructure in the area consists of a variety of government, municipal, and other roads with good overall access;
- Processing of the ore will be carried out at the existing GSBPL Bogoso processing facility, 16 km by road from PUG;
- Tailings storage will be in the existing GSBPL Tailings Storage Facility (“TSF”) at Bogoso;
- Any waste rock generated at the site will be disposed in an engineered storage facility

close to the WRP site; and

- The extensive history of mining in the local area and also in Ghana provides opportunities to obtain skilled underground workers. Any additional training requirements can be sourced within Ghana.

## 5 HISTORY (ITEM 6)

### 5.1 Prior Ownership

Recorded production for the Prestea mine began in 1912 under the British company Ariston Mining, which operated the mine until the 1950's and was responsible for the majority of the underground development including shaft sinking, ventilation and level development. The mine was nationalized in the late 1950's, following the independence of Ghana, when all mining operations in the Prestea region were consolidated under the management of Prestea Gold Limited, a subsidiary of the SGMC.

In the early 1990's, the government of Ghana reopened the mining industry to foreign companies and a joint venture agreement was formed between Barnex JCI Ltd., Prestea Gold Ltd., the SGMC and the government of Ghana. Barnex JCI Ltd. withdrew from the joint venture in 1998 due to low gold price and aging infrastructure. A consortium supported by the Ghana Mine Workers Union was then founded to operate the mine under the name PGR. The mine operated for 3 years until closure in early 2002 due to depressed gold prices and financial difficulties, the mine has remained under C&M since the 2002 closure.

### 5.2 Past Exploration and Development

Ariston Mining established most of the current infrastructure and underground development prior to nationalization in the late 1950's. The PUG workings extend over a distance of 6 km along strike and down to a maximum depth of about 1 450 m below surface. The two primary shafts of the Prestea Mine are the Central Shaft and Bondaye Shaft.

Central Shaft is the primary access to underground mining levels, extending to a depth of 1 238 m below surface to 30 L. Numerous levels were developed off the shaft to provide access to the Main Reef stoping areas. Traditional narrow vein mining methods were employed; primarily shrinkage stoping and captive cut and fill. Ore and waste were trammed to the Central Shaft to loading pockets located below 20 L, 25 L, and 30 L, which served to load the ore into skips for conveyance to the surface bins. The total capacity of the system at its peak may have been around 1 300 to 1 600 t/day.

Bondaye Shaft extends to a depth of 1 103 m but unlike Central Shaft, there is no dedicated rock handling system at Bondaye, ore cars were loaded into the cages and raised to surface.

In addition to Central and Bondaye shafts, there are several internal shafts. The No. 4 and No. 6 shafts are located to the south of Central Shaft. No. 4 shaft extends from 23 L to 35 L and was used as the primary access to 35 L, the lowest developed level in the mine. No 6 Shaft which extends from 24 L to 31 L. A longitudinal view of the Prestea Mine is shown in Figure 15-1.

During the Ariston Mining period, exploration consisted mainly in driving crosscuts from the main footwall drive across the orebody fault structure and collecting channel samples across the fault-filled veins. The first drilling campaign was conducted in 1938, a total of 17 holes were drilled that year and consisted of short holes at Alpha Shaft which were targeting a subsidiary footwall structure. Exploration drilling ramped up in the 1960's after the nationalization of the mine; over 350 holes were drilled during that decade mostly targeting subsidiary structures of the Main Reef.

The focus of this FS is the West Reef orebody, which is parallel to and located in the hanging wall to the west of the Main Reef structure. Exploration drilling targeting the West Reef structure essentially started in the 1970's and continued until the closure of the mine in 2002.

### 5.3 Historic Mineral Resource and Reserve Estimates

Previous operators of Prestea, Barnex JCI Ltd., have historically classified a certain quantity of mineralised material as a Mineral Resource. This historical resource was reviewed by SRK, who reported this data in a NI 43-101 technical report to GSBPL in 2003. The historical resource consists of simple volumetric estimates based on vertical longitudinal projection block grades and thickness and this material had been included in the latest Mineral Resource statement. The historical resource is classified as Inferred material under the category 'JCI Blocks', but is not included as a mining target in the FS or this technical report. SRK notes that NI 43-101 compliant Mineral Reserves have not been reported historically for PUG.

### 5.4 Historic Mine Production

Mining in the Prestea area dates back several centuries. The first direct involvement by Europeans in the area occurred in the 1880's with the establishment of the Gio Apanto Gold Mining Company and the Essaman Gold Mining Company.

These companies changed to the Apanto Mines and Prestea Mines Limited in 1900. Both companies merged to become Ariston Gold Mines in 1927. Companies associated with Ariston carried out exploration and some mining to the north east of Prestea at Quaw Badoo and Brumasi. The company also prospected concessions immediately to the south west of Prestea at Anfargah.

Prospecting and some mining had been carried out independently on the adjacent Ekotokroo, Bondaye and Tuapim concessions located to the south of Anfargah. These concessions were acquired by Ghana Main Reef Limited in 1933 and operated continuously until 1961.

Ghana State Mining Corporation was set up with effect from March 1961 under an Instrument of Incorporation signed by the President. From April 1963 the various Ghanaian gold operations, were regrouped and renamed Tarkwa Goldfields, the Ariston and Ghana Main Reef concessions which were combined to form PGL, Dunkwa Goldfields and Bibiani Goldfields. The SGMC was established under the SGMC Instrument 1965.

Both the Ariston Mines and Ghana Main Reef companies were purchased by the Government of Ghana and merged to form PGL. The Buesichem concession to the north east and along strike from Brumasi was subsequently added to the Prestea concessions. The Buesichem concession contained a small historical open pit, one of several operated by Marlu Gold Mining Areas until 1955.

Figure 5-1 summarises the total historical production from the various orebodies at PUG. SRK notes that some production figures for the area are not available, particularly for the early years. Total production from the Ariston Mines and PGL was in the order of 16.8 Mt of ore for the recovery of 5.95 Moz Au. The average ore grade is estimated to have been 11 g/t Au. In addition the Brumasi Mine is reported to have produced 0.3 Mt yielding 0.23 Moz Au for an average grade of 23.3 g/t Au. Prior to the amalgamation with Prestea, Ghana Main Reef produced about 2.0 Mt of ore for approximately 1 Moz Au at an estimated ore grade of 15 g/t Au. Total underground production from the area, excluding the Buesichem open pit is estimated to be in excess of 19 Mt of ore and 7.18 Moz Au. The Ghana Chamber of Mines has recorded approximately 9 Moz of gold produced from the Prestea area since 1877 which also includes production from open pit mines.

Production from Prestea peaked at 446,372 t in 1964 when 166,973 oz of gold were obtained at an average grade of 11.6 g/t.

Recovered grade peaked much earlier in the life of mine with a grade of 20.4 g/t Au in 1927.

Production endured a serious decline throughout the mid to late 1970's due to a reduced number of stopes being developed and lack of underground development to access new ground. The mine closed down in 2002 and has remained under C&M since.

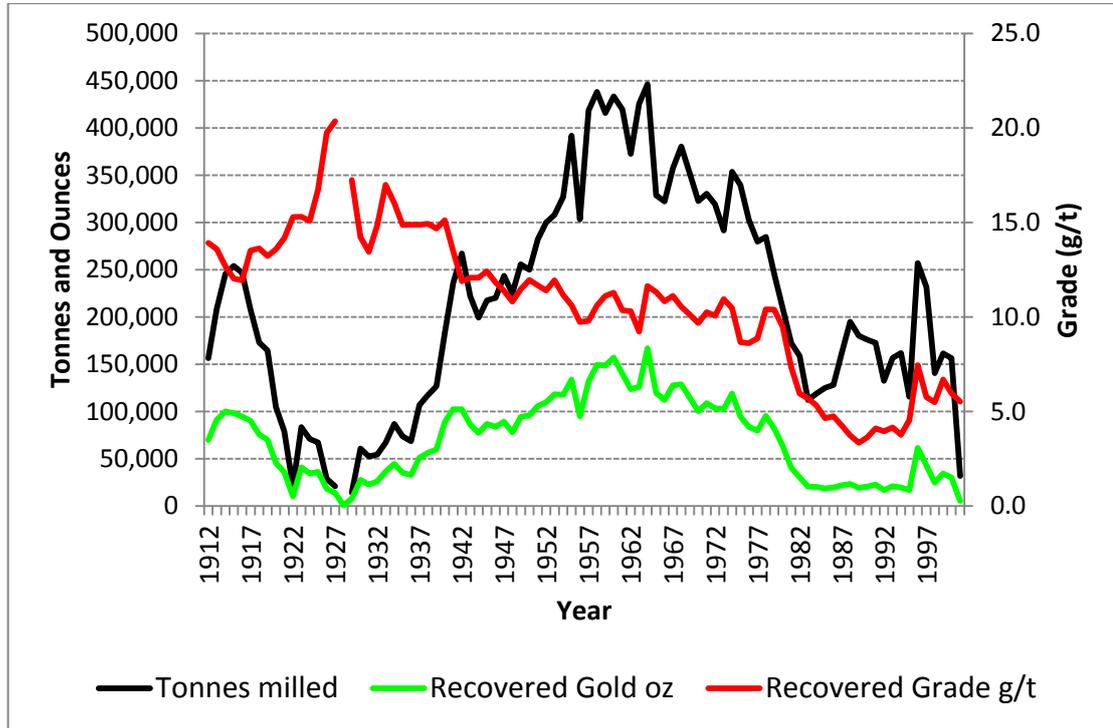


Figure 5-1 Historic PUG Production (Source: GSR)

## 6 GEOLOGICAL SETTING AND MINERALIZATION (ITEM 7)

### 6.1 Regional Geology

The regional geological setting of the Ashanti belt has been described by several authors previously. The most recent publication describing the geological setting of the sub-region was from Perrouty et al., in Precambrian Research in 2012.

The Ashanti greenstone belt in the Western Region of Ghana is composed primarily of paleoproterozoic metavolcanic and metasedimentary rocks that are divided into the Birimian Supergroup (Sefwi and Kumasi Groups) and the Tarkwa Group. Both units are intruded by abundant granitoids (Figure 6-1) and host numerous hydrothermal gold deposits such as the Obuasi and Prestea mines and paleoplacer deposits such as the Tarkwa and Teberebie Mines.

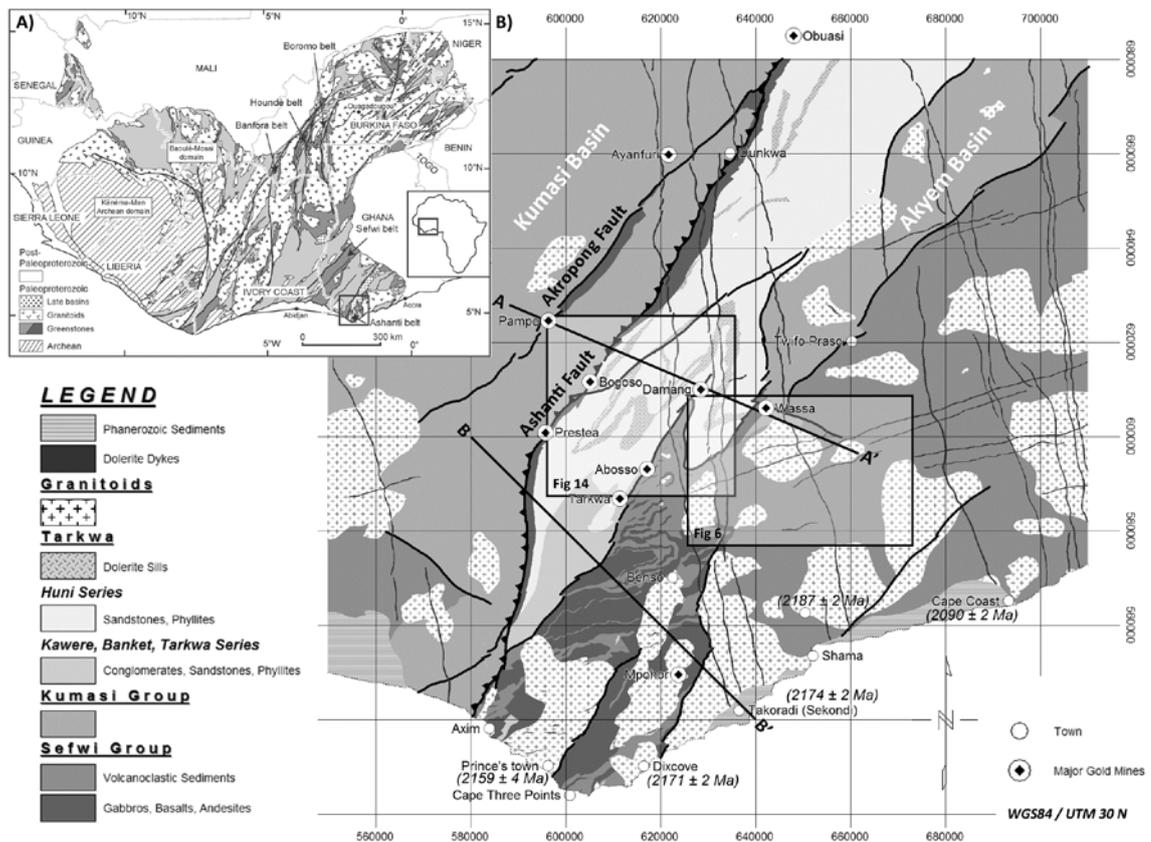


Figure 6-1 The West African Craton (Source: Perrouty et al, 2012)

The Birimian series was first described by Kitson (1918) based on outcrops located in the Birim River (around 80 km east of the Ashanti Belt). Since this early interpretation, the Birimian stratigraphic column has been revised significantly. Before the application of geochronology, the Birimian super group was divided in an Upper Birimian group composed mainly of metavolcanics and a Lower Birimian group corresponding to metasedimentary basins. Subsequent authors have proposed synchronous deposition of Birimian metavolcanics. Most recently, Sm/Nd and U/Pb analyses have reversed the earlier stratigraphic interpretation with the younger metasediments overlying the older metavolcanics. Proposed ages for the metavolcanics vary between  $2162 \pm 6$  Million years (“Ma”) and  $2266 \pm 2$  Ma. Detrital zircons in the metasediments indicate the initiation of their deposition between  $2142 \pm 24$  Ma  $2154 \pm 2$  Ma. The Kumasi Group was intruded by the late sedimentary Suhuma

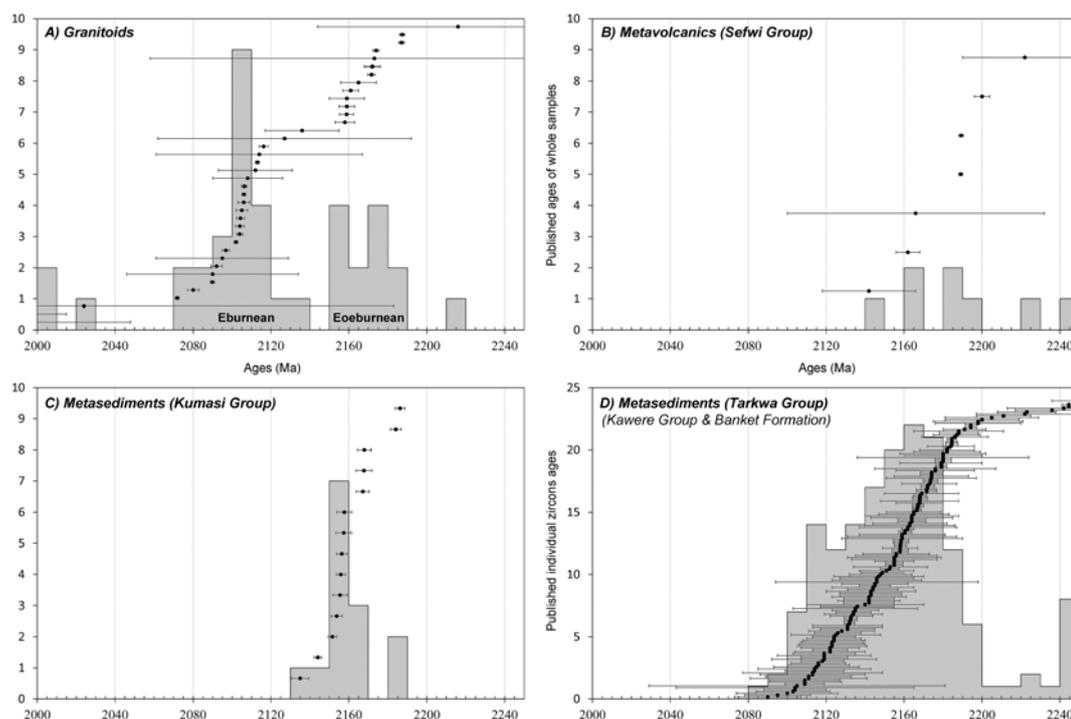
granodiorite at  $2136 \pm 19$  Ma (U/Pb on zircon, Adadey et al., 2009).

The Tarkwa super group was first recognized by Kitson (1928) and consists of a succession of clastic sedimentary units, which have been divided in four groups by Whitelaw (1929) and Junner (1940) (Table 6-1). The Kawere Group located at the base of the Tarkwaian super group is composed of conglomerates and sandstones with a thickness varying between 250 and 700 m. The unit is stratigraphically overlain by the Banket Formation, which is characterized by sequences of conglomerates interbedded with cross-bedded sandstones layers with the maximum thickness of this group is 400 m. The conglomerates are principally composed of Birimian quartz pebbles (>90 %) and volcanic clasts (Hirdes and Nunoo, 1994) that host the Tarkwa Placer deposits. The Banket formation is overlain by approximately 400 m of Tarkwa Phyllites. The uppermost unit of the Tarkwa super group is the Huni Sandstone, comprised of alternating beds of quartzite and phyllite intruded by minor dolerite sills that form a package up to 1,300 m thick (Pigois et al., 2003). U/Pb and Pb/Pb geochronology dating of detrital zircons provide a maximum depositional age of  $2132 \pm 2.8$  Ma for the Kawere formation and  $2132.6 \pm 3.4$  Ma for the Banket formation (Davis et al., 1994; Hirdes and Nunoo, 1994). These ages agree with the study by Pigois et al. (2003) that yielded maximum depositional age of  $2133 \pm 4$  Ma from 71 concordant zircons of the Banket formation. According to all concordant zircons histogram (161 grains) and their uncertainties (Figure 6-2), a reasonable estimation for the start of the Tarkwaian sedimentation could be as young as 2107 Ma.

Allibone et al. (2002a) separated the Paleoproterozoic Eburnean orogeny into two distinct phases known as Eburnean I and II. The Eburnean I event predates the deposition of Tarkwaian sediments and is associated with a major period of magmatism and metamorphism in the Sefwi Group basement. The Eburnean II event is associated with significant post-Tarkwaian deformation that affected both the Birimian Supergroup and overlying Tarkwaian sediments. The Eburnean II event is associated with major NW-SE shortening that developed major thrust faults, including the Ashanti Fault, along with isoclinal folds in Birimian metasediments and regional scale open folds in the Tarkwaian sediments. These features are overprinted by phases of sinistral and dextral deformational events that reactivated the existing thrust faults and resulted in shear zones with strong shear fabrics.

**Table 6-1 Tarkwaian sedimentary sequences & estimated thickness (Source: Perrouty et al, 2012)**

	Tarkwaian Unit	Thickness			Pigois et al., 2003
		Whitelaw, 1929	Junner, 1940	Kesse, 1985	
<b>Huni Sandstones</b>	Dompin quartzites	300 m			
	Dompin phyllites	150 m	1,370 m	1,370 m	>1300 m
	Humi Sandstones	450 m			
<b>Dolerite sills</b>			180 m		< 200 m
<b>Tarkwa phyllites</b>		240 to 300m	180 m	120 to 400 m	120 to 400 m
<b>Banket Group</b>	Sandstones		150 to 180 m	100 to 180 m	
	Mineralised conglomerates	640 m	30 to 90 m	20 to 90 m	150 to 600 m
	sandstones		300 m	150 to 350 m	
<b>Kawere Group</b>	Conglomerate levels interbedded with sandstones and phyllites			250 to 700 m	250 to 700 m



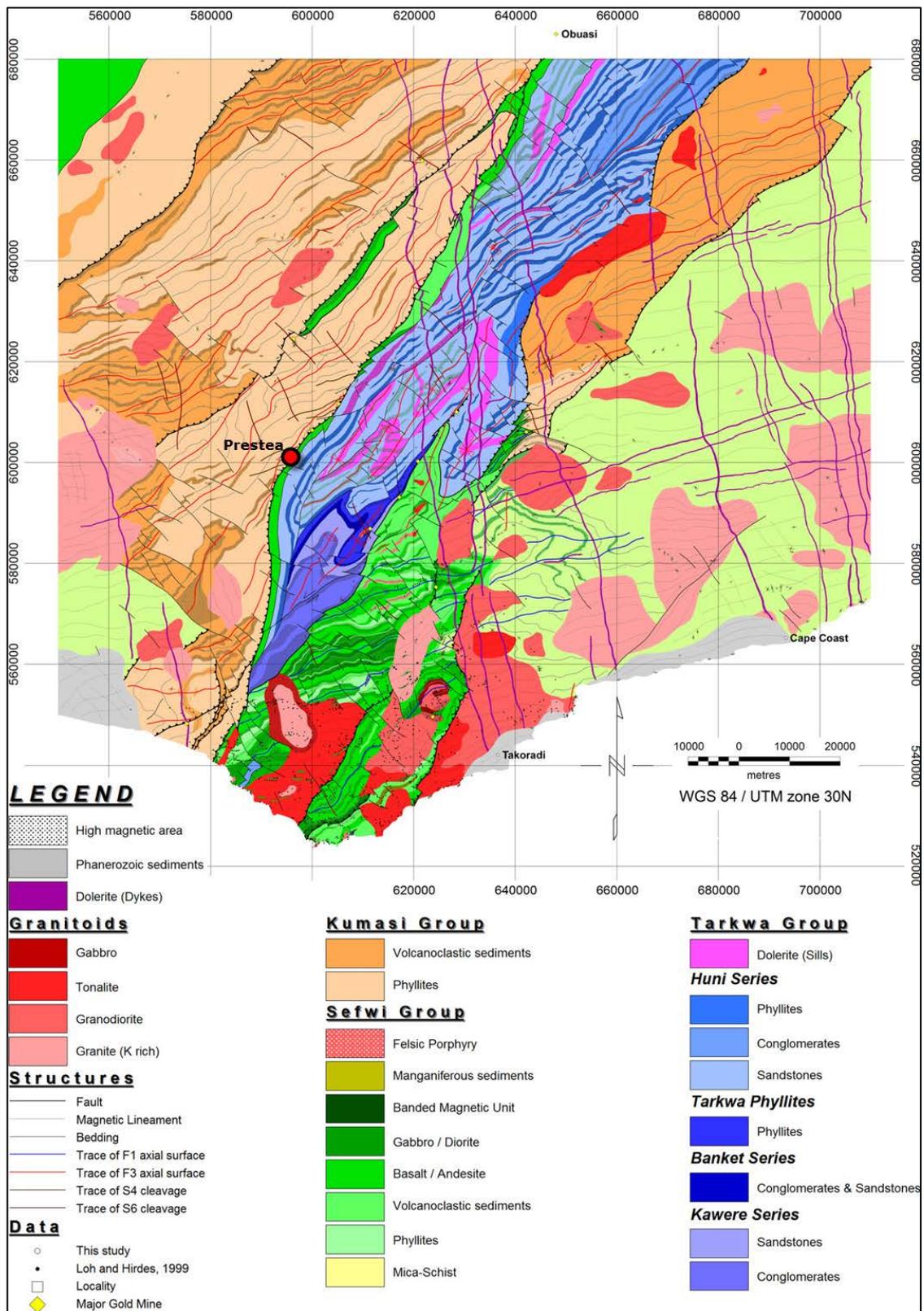
**Figure 6-2: Radiometric age data histograms (Source: Perrouty et al, 2012)**

Abundant granites and granitoids intruded the Birimian and Tarkwaian units during the Paleoproterozoic. Eburnean plutonism in southwest Ghana can be divided into two phases between 2180 to 2150 Ma (Eoeburnean) and 2130 to 2070 Ma (Eburnean) that is supported by the current database of U/Pb and Pb/Pb zircon ages. Most of the granitoids intruded during both phases correspond to typical Tonalite–Trondhjemite–Granodiorite (“TTG”) suites. However, in the southern part of the Ashanti Belt, intrusions within the Mphor complex have granodioritic, dioritic and gabbroic compositions.

Dolerite dykes oriented N-S and ENE-WSW that are generally less than 100 m in thickness are abundant across the West African craton where they cross-cut Achaean and Paleoproterozoic basement. In south-western Ghana these dykes are well defined in magnetic data where they are characterised by strong magnetic susceptibility. Dolerite dykes are observed to cross-cut undeformed K-feldspar rich granites that formed during the late Eburnean, and are overlain by Volta basin sediments with a maximum depositional age of 950 Ma (Kalsbeek et al., 2008). These relationships constrain dyke emplacement to between 2000 Ma and 950 Ma. In contrast some older dolerite/gabbro dykes and sills were deformed during the Eburnean orogeny and are dated at  $2102 \pm 13$  Ma (U/Pb on zircon, Adadey et al., 2009).

With the exception of some late Eburnean granitoids, dolerite dykes and Phanerozoic sediments, all other lithologies have undergone metamorphism that generally does not exceed upper greenschist facies. Studies on amphibole/plagioclase assemblages suggest the peak temperature and pressure was 500 to 650°C and 5 to 6 kbar (John et al., 1999), dated at  $2092 \pm 3$  Ma (Oberthür et al., 1998).

Figure 6-3 provides a simplified geological plan of the Bogoso and Prestea licence areas highlighting the main geological and structural features.



**Figure 6-3 Detailed geology of southern Ghana showing location of the Prestea operation (Source: Perrouy et al, 2012)**

## 6.2 Property Geology

The Prestea-Bogoso area occurs at the southern termination of the Ashanti Belt, where eleven gold deposits, mined or under exploration, are localised principally along up to three steep to sub vertical major crustal structures at any one deposit.

At Prestea, the principal structure is the mineralised quartz vein, known as the Main Reef which is relatively continuous and has been modelled and worked over a strike length of some 6 km and to a depth of approximately 1,450 m below surface (35 L). The subordinate West Reef and East Reef, in the immediate hangingwall and footwall respectively of the former structure, are discontinuous. West Reef occurs some 200 m into the hangingwall of the Main Reef structure and, at present is known to occur over a strike length of 800 m and has currently been defined by underground drilling between 550 to 1 150 m below topography as far as the 24 L.

The geology of the Prestea Mine site is divided into four main litho-structural assemblages, which are fault bounded and steeply dipping to the west. This suggests that the contacts are structurally controlled and that the litho-structural assemblages are unconformable. These packages are from the eastern footwall to the western hanging wall, the Tarkwaian litho-structural assemblage, the tectonic breccia assemblage, the graphitic Birimian sedimentary assemblage and the undeformed Birimian sedimentary assemblage.

Several studies of the relationship between deformation and mineralisation events in the Ashanti Belt, which have included the Prestea area, have been reviewed by SRK: Bourassa (2005), Davis and Allibone (2004) and Bardoux (2003). In addition, SRK has examined a regional synthesis paper by Perrouty et al. (2012). The deformation framework set-out by these studies differ in detail, with the various works documenting up to four or five deformations in the Prestea area. However, the studies concur that two principal events occurred in the Prestea area:

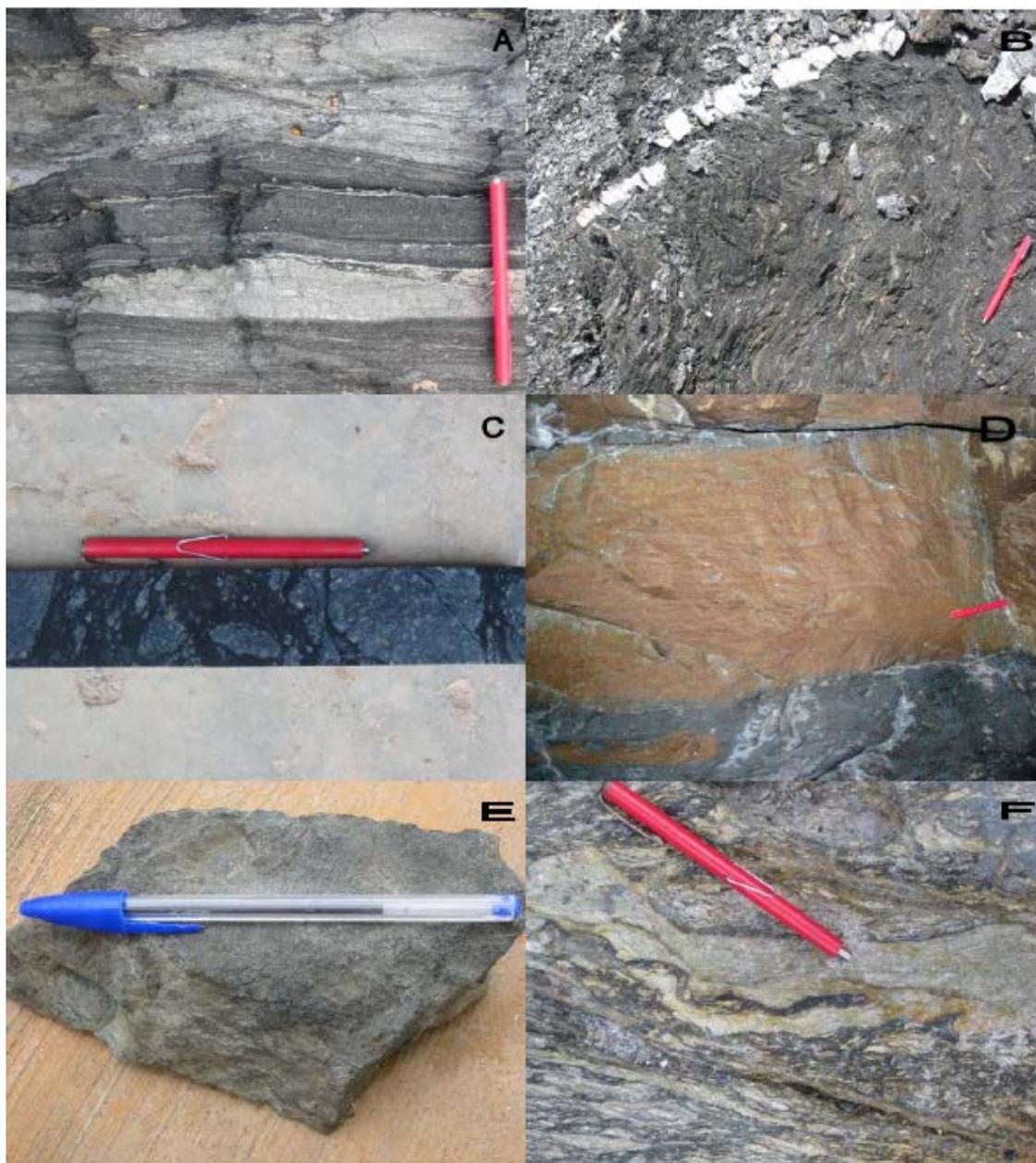
- D1 - an early contractional deformation (thrusting) that gave rise to a penetrative planar foliation; and
- D2 - a widespread folding event resulting in the folding of the earlier formed planar foliation into mesoscale folds related to ductile sinistral transpressional deformation.

The Tarkwaian litho-structural assemblage to the west is mostly composed of sandstone, and locally pebbly sandstone. Bedding and sedimentary textures have been observed but very sporadically, in most cases they have been obliterated by hydrothermal alteration and deformation.

The litho-structural assemblage overlying the Tarkwaian sediments is a tectonic breccia bounded to the west by the Main Reef fault. The tectonic breccia is a polygenic assemblage, composed of various rock types such as volcanic rocks, volcanoclastics, Birimian sediments and sparse Tarkwaian sediment clasts. Volcanic lenses illustrated on Figure 6-4 have been divided into two units based on their alteration pattern, weakly altered mafic volcanic rocks are characterized by a distal chlorite/calcite alteration pattern while strongly altered mafic volcanic rocks are characterized by a proximal silica/sericite/Fe-Mg carbonates alteration pattern. These strongly altered mafic volcanic lenses are generally located at proximity to the Main Reef Fault or bounded by second order footwall faults. The tectonic breccia assemblage is believed to have been the focal point of the post thrusting deformational event (Syn-D2 to syn-D4), therefore, no primary textures, whether syn-volcanic nor syn-sedimentary, have been observed. Pictures D to F of Figure 6-4 illustrates well the diversity of protoliths found within the Main Reef Fault footwall, in picture F, pale green volcanic and volcanoclastic clasts have structurally been stretched and thinned along foliation within a graphitic matrix.

The graphitic Birimian sediment litho-structural assemblage is bounded to the east by the Main Reef fault and to the west by the West Reef Faults. This sedimentary package is a strained and brecciated sequence of siltstones, mudstones and wacke units. As shown in pictures B and C from Figure 6-4, the unit is strongly deformed and affected by a pervasive graphite alteration. Primary textures are generally overprinted and obliterated by deformation, but bedding has locally been preserved. Although this package is strongly strained, deformational reactivation has only taken place within a discrete corridor of deformation, the reason being that movement during the second to fourth deformational event mainly affected the footwall of the Main Reef fault where reactivation developed some strong penetrative shear fabric.

The most western litho-structural assemblage within the Prestea Mine site is bound to the east by the West Reef fault and consists of relatively undeformed to weakly strained Birimian sediments. The assemblage is composed of a series of flyschoid sequences where the most common units found are argillites, mudstones, siltstones and wackes, which are all commonly referred to as phyllite in Ghana. Several syn-sedimentary textures have been observed such as beddings, graded beddings and cross-beddings. Chert horizons are locally intercalated within the flysch sequence, but appear to lack lateral continuity. Picture A from Figure 6-4 illustrates typical beddings of siltstones intercalated with wacke sub-units.



**Figure 6-4 Lithologies hosting the Prestea deposit**

**Key to Figure 6-4**

A: Undeformed Birimian sediments from Plant North pit.

B: Graphitic Birimian sediments from Plant North pit.

C: Brecciated graphitic Birimian sediments from hole UC1044 at a depth of 68.4 m.

D: Contact between altered mafic volcanic and the footwall tectonic Breccia from 30 L at crosscut 204N.

E: Hand sample from 24 L of mafic volcanic rocks.

F: Footwall tectonic breccia from Plant North Pit.

**6.2.1 Timing of Mineralisation**

The various authors interpret the Main and West Reef structures to represent D1 reverse faults. However, there is some debate about when quartz veining, i.e. emplacement of the

lode deposits, took place. Undoubtedly there are several generations of quartz veining. Davis and Allibone (2004) interpret a syn-D1 quartz veining event, but others believe a syn-D2 age is more likely. Significantly, gold within the West and Main Reefs is associated with smoky grey quartz veinlets which re-fracture the milky quartz material that comprises the majority of the reef. These are said to be undeformed (Stefan, 1997; cited in Davis and Allibone, 2003), therefore the emplacement of gold bearing quartz within the lodes may have taken place at a later time than D1. To SRK's knowledge, the timing and nature of the actual gold mineralisation event is not well constrained.

The PUG site litho-structural assemblages are affected by five distinct syn-Eburnean ductile events and at least one post-Eburnean brittle event, resulting in late reactivation of the major thrust fault systems. The Eburnean deformational events have been described and observed by several authors throughout the West African shield including Milesi, Alibone and Perrouty. The D1 deformational event at Prestea affects the older volcano-sedimentary Birimian and was generated during an extensional phase. The D2 deformational event is believed to be a thrusting event, resulting in the thrusting of the older Birimian volcano-sedimentary sequences over the younger Tarkwaian sedimentary group. At Prestea, the development of the penetrative S2 foliation as well as major thrust faults, such as the Main Reef fault and the West Reef faults are the main syn-D2 structural features. The third and fourth Eburnean phases (the D3 and D4 events) are transcurrent event, resulting in strike-slip movement along the major D2 faults, the development of regional scale fold (Figure 6-5) and of a second (D3) and third penetrative foliations (D4). On the Prestea Mine site, the tectonic breccia located in the footwall of the Main Reef fault is the assemblage that was the focus of reactivation during the second and third deformational event resulting in a strong shear fabric while the Birimian hanging wall developed orthogonal steep penetrative fabrics at an angle to the main S2 foliation. The fifth and last Eburnean phase, the D5 event, is defined as a minor transcurrent event, the effects of the D5 event are noticeable in Prestea by the presence of a flat lying crenulation (S5), observable locally on the S2 foliation plane. Relationships between all the different structural features are exposed in pictures E and F of Figure 6-5.

Over five hundred structural measurements were taken during the course of an underground geological compilation which was undertaken between 2003 and 2007. All measurements have been compiled per levels, distributions of S0 beddings and S2 foliations are very similar, suggesting a transposition of beddings along S1 foliation during the D1 event. Both distributions for S0 and S2 are consistent with increasing depths, showing identical patterns regardless of levels. A total of 241 measurements were taken for S2 foliations and 90 for S0 beddings. The average orientation for S0 beddings is 172/76 and 175/80 for S2 foliations, all measurements were taken at mine grid (40 degree eastern rotation to magnetic North). The average orientation for S3 foliations is 229/55, suggesting approximately a 55 degrees rotation in azimuth and 25 degrees in dip of the main stress fields from the D2 deformational event to the D3 event. No measurements of the S4 foliations were taken during the underground compilation as this feature is more discrete than the S3 foliation. A total of 8 measurements were taken for L52 lineations, very little attention was paid to syn-D5 structural features during the geological compilation as mineralization controls are believed to be syn-D2 to syn-D4. Nonetheless, the lineations' average indicates a shallowly north plunging feature (356/22). Syn-D5 structural features are not very common on the PUG site, minor reactivation of the main fault system probably accommodated most of the stress during that event.

The structural complexity of the Prestea Mine site is mainly due to reactivation of the fault system during the later events of Eburnean deformation. A more detailed look at S3 foliations

recorded on 17 L from crosscut 307 to 308S shows that the tectonic breccia located in the footwall of the Main Reef fault has undergone intense shearing during the D3 and D4 deformational events. A comparison between the orientation of S2 foliations taken from the footwall and the hanging wall of the Main Reef fault was conducted and the average orientation for S3 foliations in the footwall of the Main Reef fault is 211/53, while the average for the hanging wall of the Main Reef fault is 252/49, suggesting syn-D3 reactivation in the footwall domain and transposition along the S2 foliation.

Several studies along the Ashanti trend are suggesting a syn-D4 timing for gold emplacement. Earlier studies at Prestea also suggested a syn-D3 to syn-D4 gold mineralized event, but it is still unclear whether syn-D2 gold events could have taken place and have been remobilized during later hydrothermal syn-D3 to D4 pulses. Field evidence and structural relationships are suggesting that certain quartz veins along the Prestea major fault systems were in place during the earlier deformational event and deformed by subsequent events.

### 6.2.2 Mineralisation Style

Davis and Allibone (2004) show the Main Reef to be deformed in a variety of styles, including being affected by folding and boudinage associated with the sinistral deformation and a third sub-ordinate folding event. SRK observed evidence for at least some of the lesser quartz veins in the walls to the West Reef to be strongly affected by a sinistral strike-slip deformation, but has not observed the mesoscopic folding documented by these authors.

The margins of the West Reef mineralised quartz vein are strongly sheared and comprise a brittle-ductile zone of deformation in the graphitic schists a few centimetres to up to 2 m in width on both sides of the vein at any locality. The deformation along the margins of the vein is interpreted to be due to post-mineralisation deformation nucleating on the margins of the vein, which represents a strong competency contrast with the graphitic wall rocks. The kinematics of this deformation appears to be dextral. Over the length of the vein exposed on the 17 L, several subsidiary shears were observed to cut through the vein which either caused the vein to be duplicated, causing local thickening of the mineralised vein over approximately 0 to 10m, or caused extensional offsets of the vein. One 10 m gap in the continuity of the resource on 17 L could be attributed to one of these shears. Overall however, these are relatively minor disturbances which just cause local irregularities in the vein and there should be no overall material loss.

Critically for the vertical continuity of the mineralisation, the Ashanti Trend has not been affected by a major deformation event with a sub-horizontal fold axis which may have acted to truncate the mineralisation at depth. Moreover, the planarity of the mineralised trend is testament to the fact that, on the scale of the deposits, they have relatively simple sheet-like geometries, unaffected by major disruption.

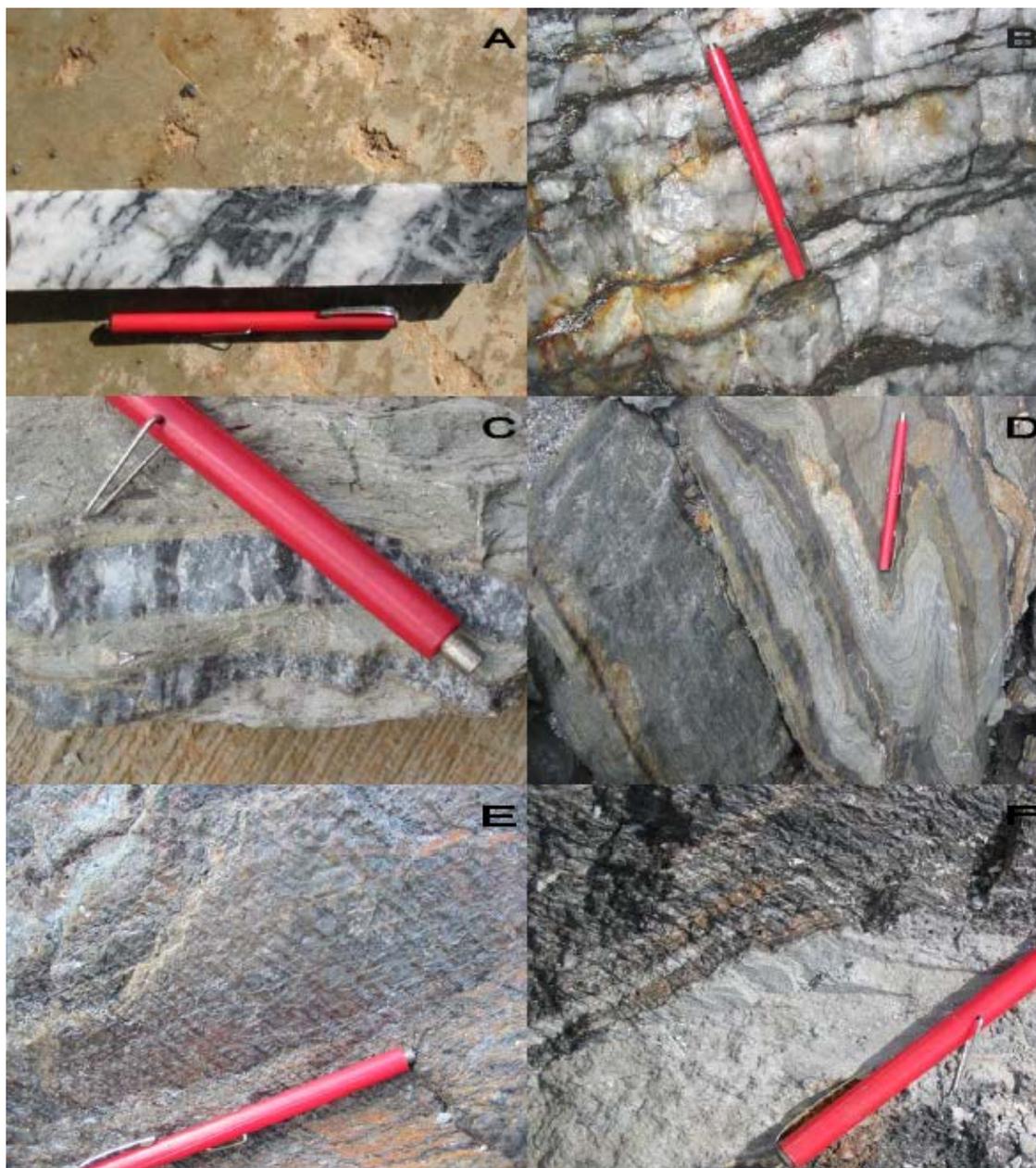
Two distinct styles of mineralization are found on the Prestea Mine site. The more extensive of the two mineralization styles are laminated fault fill quartz veins (Reef style mineralization), bound to the Main Reef fault or to the second order faults found in the Birimian sediments hanging wall. The second mineralization style, which has never been mined in past, consists of arsenopyrite rich, brecciated and altered volcanic lenses.

Fault fill quartz veins have been generated over an extensive period of time through multiple fluid pulses. They are bound to major and second order faults and characterized by laminated and stylolitic smoky to translucent quartz veins. Pictures A and B from Figure 6-5 are examples of two fault filled quartz veins coming from two different faults, the Spur Reef fault from Bondaye shaft and the West Reef fault from Main shaft. Late gauge is commonly

associated to the mineralized quartz veins and is also generally mineralized, although in most cases at lower grades than the associated quartz veins. Quartz veins are typically one to two metres wide, but widths up to 5 m have been observed. Thicker fault fill quartz veins occur in dilation zones along the fault systems, it is still unclear what controls the emplacement of those dilation zones, but several mineralized quartz veins seem to have a spatial association with volcanic lenses found in the immediate footwall of the Main Reef fault.

An alteration assemblage of silica/sericite/Mg-Fe carbonates characterizes the arsenopyrite rich volcanic lenses. They are typically composed with 2 to 10 % acicular arsenopyrite crystals and 1 to 5 % euhedral to sub-euhedral pyrite grains. They are also characterized by presence of brecciated and stockwork-like smoky to translucent quartz veins that can account for up to 30 % of the volcanic lenses' volume. Picture C from Figure 6-5 illustrates typical mineralized volcanic lenses with narrow, buckled smoky quartz veins. Those mineralized volcanic lenses are generally located in the immediate footwall of the Main Reef fault or faulted within the Main Reef fault system. Mineralized volcanic lenses are generally narrow (10 to 25 metres) and stretched along a North-South trend, sub-parallel to the main foliation. On average the lenses will be 50 to 100 m long and locally up to 300 m. This style of mineralization has never been in the past the object of economic mining activity.

Several subsidiary faults are developed within the Birimian sedimentary hanging wall, these faults are generally narrower in comparison to the Main Reef fault which is located at the contact between the tectonic breccia and the Birimian sedimentary package. The West Reef fault is characterized as a hanging wall subsidiary fault, the fault is typically 1.5 to 2.0 m with fault filled quartz vein developed along a graphitic gauge rich fault. The quartz veins within the West Reef fault have laminated textures with smoky to translucent quartz.



**Figure 6-5 Mineralization styles and structural features characterizing the Prestea deposit**

**Key to Figure 6-5**

- A: Reef style mineralization (Fault fill quartz veins) from hole UC 1044 at a depth of 130 m.
- B: Reef style mineralization (Fault fill quartz veins) from the Spur Reef Fault, 7 L of the Bondaye shaft.
- C: Altered and brecciated mafic volcanic with hydrothermal breccia and arsenopyrite mineralization.
- D: Birimian sediments affected by F3 folding, both bedding (S0) and S1-S2 foliation are tightly folded.
- E: Structural relationship between S0, S2, S3 and S5.
- F: Refraction of S3 foliations across Birimian mudstone and a more competent wacke sub unit.

## 7 DEPOSIT TYPES (ITEM 8)

The Prestea deposit can be classified as a lode gold deposit or an orogenic mesothermal gold deposit, which are the most common gold systems found within Achaean and Paleoproterozoic terrains. In the West African shield, orogenic gold deposits are typically underlain by geology considered to be of Birimian age and are generally hosted by volcano-sedimentary sequences. The Ashanti belt, which hosts the Prestea deposit, is considered prospective for orogenic mesothermal gold deposits and hosts numerous other lode gold deposits such as at the Obuasi mine.

B. Dubé and P. Gosselin of the Geological Survey of Canada described these deposits as greenstone-hosted quartz-carbonate vein deposits in the 2007 special publication no.5 entitled Mineral Deposits of Canada. The authors described these deposits as typically occurring in deformed greenstone belts and distributed along major compressional crustal scale fault zones commonly marking the convergent margins between major lithological boundaries. The greenstone-hosted quartz-carbonate vein deposits correspond to structurally controlled complex deposits characterized by networks of gold-bearing, laminated quartz-carbonate fault-fill veins. These veins are hosted by moderately to steeply dipping, compressional brittle-ductile shear zones and faults with locally associated shallow-dipping extensional veins and hydrothermal breccias. In these deposits, gold is mainly confined to the quartz-carbonate veins, but can also occur within iron-rich sulphidized wall rocks or within silicified and arsenopyrite-rich replacement zones.

At Prestea, gold mineralization exhibits a strong relationship with major shear zones, fault zones and second order structures. Two types of mineralization have been identified at Prestea, which are both characterised as mesothermal gold mineralization:

1. Fault-fill quartz veins along fault zones and second order structures, which typically contains non-refractory, free milling gold; and
2. Disseminated mineralization associated with brecciated zones of iron-rich footwall volcanic lenses, which are characterized by finely disseminated arsenopyrite rich and silicified replacement zone. This type of mineralization is generally lower grade, refractory and locally termed 'sulphide ore'.

The weathering profile at Prestea is deep and typically results in extensive surface oxidation of bedrock, to a depth of up to 100 m. Generally, the weathering profile typically consists of a lateritic surface, a saprolitic horizon, a transitional zone and a deeper primary sulphide zone.

## 8 EXPLORATION (ITEM 9)

Data validation and selected evaluation drilling from underground have helped to increase the confidence in the morphology and orientation of the mineralization at Prestea. Cross cut samples and JCI era drilling data (surface drilling) accounts for some 92 % of the available data. The remainder is a mixture of surface (“RC”) and Diamond Drill (“DD”) holes drilled by GSR and underground channels and diamond drillholes acquired by GSR as part of their purchase of the Prestea Mining rights.

The cross cut and JCI data extends over a strike length of some 8 km with the majority lying between y=6000 to y=12000 in the GSR mine grid system. Sampling covers a depth extent of 1400m from surface. The GSR data is largely concentrated in the area underlying the Plant North open pit, Central Shaft and the northern extent of Beta Boundary.

The previous Mineral Resource estimate for the Prestea underground orebodies was based on a combination of GSR underground sampling from some 157 drillholes, 117 rock saw samples and channel sampling from 2 cross cuts. During late 2005 and throughout 2006 GSR drilled an additional 106 underground holes into the Main Reef (“MR”) and West Reef (“WR”) orebodies. This drilling has been carried out using fan drilling from cubbies on the most accessible levels but predominantly from the 12, 17 and 24 Levels.

The Prestea underground West Reef target was the last area to be mined by PGR in 2002. The subsequent exploration of the West Reef underground target has been planned and managed by Golden Star Resources Ltd and was initiated in 2004. The 17 L West Reef drive exposes the vein structure from 7618 N in the south to 8065 N in the north a distance of approximately 450 m. Along the West Reef drive the backs have been sampled approximately every 5 m with a 2 x 2 inch channel sample cut using an air driven diamond blade rock saw. The channel samples were cut orthogonal to the main structure. The channel samples and the reef drive have been surveyed and tied into the mine grid at surface. A total of 81 channel samples were collected on the 17 L reef drive averaging 2.4 m width with composite grades ranging from 0.1 to 127 g/t Au. The results are summarized in Table 8-1.

**Table 8-1 Channel Sample results 17 L West Reef Drive**

Channel #	X (m)	Y (m)	Z (m)	Level	From (m)	To (m)	Interval (m)	Grade g/t Au
17WR_01A	11949.0	8041.3	4464.9	17	0.0	2.6	2.6	0.6
17WR_02	11946.0	8034.2	4466.3	17	0.0	1.9	1.9	6.2
17WR_02A	11946.3	8034.5	4467.1	17	0.0	1.9	1.9	6.5
17WR_03	11945.0	8029.1	4466.6	17	0.0	1.3	1.3	127.1
17WR_03A	11944.9	8028.8	4466.8	17	0.0	1.3	1.3	1.7
17WR_03B	11945.0	8029.7	4466.5	17	0.0	1.5	1.5	1.1
17WR_04	11943.9	8022.1	4466.2	17	0.0	2.0	2.0	20.2
17WR_04A	11944.2	8022.8	4467.0	17	0.0	2.1	2.1	3.9
17WR_05	11943.3	8018.0	4466.3	17	0.0	2.3	2.3	5.3
17WR_05A	11943.4	8018.2	4467.0	17	0.0	2.3	2.3	9.0
17WR_06	11943.0	8015.0	4466.6	17	0.0	2.4	2.4	64.9
17WR_06A	11943.2	8015.2	4466.6	17	0.0	2.0	2.0	1.7
17WR_06B	11943.1	8014.0	4466.3	17	0.0	2.8	2.8	22.2
17WR_07	11937.5	7992.6	4466.2	17	0.0	3.0	3.0	37.4
17WR_07A	11937.5	7993.1	4466.5	17	0.0	2.8	2.8	63.4
17WR_07B	11937.3	7992.3	4466.1	17	0.0	3.1	3.1	13.9
17WR_08	11936.1	7987.9	4466.0	17	0.0	3.1	3.1	74.9
17WR_08A	11936.3	7988.2	4466.0	17	0.0	3.2	3.2	69.5
17WR_08B	11936.3	7988.3	4466.0	17	0.0	3.0	3.0	28.7

Channel #	X (m)	Y (m)	Z (m)	Level	From (m)	To (m)	Interval (m)	Grade g/t Au
17WR_09	11934.7	7977.8	4466.0	17	0.0	2.5	2.5	31.4
17WR_09A	11934.7	7978.2	4466.0	17	0.0	2.3	2.3	53.2
17WR_10	11933.1	7967.1	4465.6	17	0.0	3.0	3.0	42.1
17WR_10A	11933.1	7967.4	4465.5	17	0.0	2.9	2.9	1.8
17WR_10B	11933.1	7967.6	4465.6	17	0.0	2.8	2.8	18.4
17WR_11	11928.6	7941.2	4464.9	17	0.0	2.2	2.2	116.9
17WR_11A	11928.4	7940.7	4465.0	17	0.0	1.6	1.6	6.2
17WR_11B	11929.1	7942.0	4464.8	17	0.0	2.8	2.8	57.8
17WR_12	11926.1	7923.3	4464.9	17	0.0	2.1	2.1	108.0
17WR_12A	11925.9	7922.8	4464.7	17	0.0	2.1	2.1	6.4
17WR_12B	11925.8	7922.2	4464.6	17	0.0	2.5	2.5	34.9
17WR_13	11925.2	7913.9	4464.7	17	0.0	2.4	2.4	51.3
17WR_13A	11925.2	7913.5	4464.7	17	0.0	2.3	2.3	4.0
17WR_13B	11925.0	7914.4	4464.9	17	0.0	2.2	2.2	18.8
17WR_14	11924.3	7906.1	4464.9	17	0.0	2.1	2.1	5.7
17WR_14A	11924.3	7906.4	4464.9	17	0.0	2.4	2.4	36.9
17WR_15	11923.2	7898.7	4464.7	17	0.0	2.1	2.1	42.8
17WR_15A	11923.1	7898.1	4464.8	17	0.0	1.8	1.8	22.3
17WR_15B	11923.2	7898.9	4464.7	17	0.0	2.3	2.3	17.5
17WR_16	11923.6	7887.5	4465.2	17	0.0	2.7	2.7	12.4
17WR_16A	11923.6	7887.9	4465.2	17	0.0	2.8	2.8	4.7
17WR_17	11923.4	7875.9	4465.6	17	0.0	2.9	2.9	14.8
17WR_18	11921.8	7869.7	4465.1	17	0.0	1.4	1.4	8.9
17WR_19	11921.4	7865.1	4464.9	17	0.0	2.7	2.7	3.2
17WR_20	11923.4	7861.5	4464.6	17	0.0	3.0	3.0	20.3
17WR_21	11922.0	7853.3	4464.3	17	0.0	3.3	3.3	1.4
17WR_22	11922.0	7848.3	4464.0	17	0.0	2.9	2.9	1.5
17WR_23	11922.2	7843.4	4464.2	17	0.0	3.1	3.1	1.8
17WR_24	11922.7	7838.8	4464.3	17	0.0	2.7	2.7	0.6
17WR_25	11924.4	7830.9	4464.7	17	0.0	3.2	3.2	0.9
17WR_26	11923.9	7826.3	4464.8	17	0.0	2.5	2.5	2.4
17WR_27	11923.7	7821.5	4464.6	17	0.0	2.3	2.3	0.3
17WR_28	11922.6	7817.3	4464.9	17	0.4	3.2	2.8	0.3
17WR_29	11919.9	7811.9	4464.5	17	0.0	2.5	2.5	0.2
17WR_30	11916.9	7807.9	4465.0	17	0.0	1.8	1.8	1.2
17WR_31	11916.1	7804.1	4464.9	17	0.0	3.0	3.0	5.9
17WR_32	11915.9	7782.9	4464.6	17	0.0	2.6	2.6	6.0
17WR_33	11916.1	7776.9	4464.9	17	0.0	2.3	2.3	12.9
17WR_34	11917.3	7767.0	4465.3	17	0.0	2.3	2.3	12.2
17WR_35	11917.6	7762.5	4465.7	17	0.0	1.9	1.9	14.4
17WR_36	11918.7	7757.2	4465.9	17	0.0	1.8	1.8	34.2
17WR_37	11919.1	7752.2	4465.2	17	0.0	2.3	2.3	20.2
17WR_38	11918.7	7745.9	4465.5	17	0.0	2.1	2.1	7.9
17WR_39	11917.0	7741.3	4465.7	17	0.0	2.3	2.3	4.4
17WR_40	11916.5	7736.4	4465.7	17	0.0	3.0	3.0	7.1
17WR_41	11915.2	7732.2	4465.7	17	0.0	2.6	2.6	1.9
17WR_42	11915.6	7726.8	4465.6	17	0.0	2.4	2.4	5.4
17WR_43	11914.2	7721.9	4466.3	17	0.0	2.5	2.5	2.2
17WR_44	11914.2	7716.7	4465.4	17	0.0	2.5	2.5	1.3
17WR_45	11912.2	7712.2	4465.9	17	0.0	2.9	2.9	1.0
17WR_46	11912.0	7706.6	4466.1	17	0.0	2.4	2.4	5.1

Channel #	X (m)	Y (m)	Z (m)	Level	From (m)	To (m)	Interval (m)	Grade g/t Au
17WR_47	11911.3	7701.8	4466.8	17	0.0	1.7	1.7	0.4
17WR_48	11910.6	7697.1	4466.2	17	0.0	2.1	2.1	1.4
17WR_49	11909.9	7692.1	4466.5	17	0.0	2.6	2.6	2.4
17WR_50	11909.7	7687.1	4466.4	17	0.0	2.4	2.4	0.3
17WR_51	11907.2	7679.5	4466.4	17	0.0	2.9	2.9	0.6
17WR_52	11906.3	7674.6	4466.8	17	0.0	2.9	2.9	0.1
17WR_53	11902.5	7654.1	4465.9	17	0.0	2.2	2.2	2.7
17WR_54	11901.0	7644.7	4466.9	17	0.0	2.2	2.2	2.0
17WR_55	11898.4	7633.9	4466.4	17	0.0	2.4	2.4	3.0
17WR_56	11897.7	7628.1	4467.9	17	0.0	1.9	1.9	1.2
17WR_57	11896.1	7618.5	4466.6	17	0.0	2.3	2.3	2.5

\*(hole\_id)A: Samples assayed at Bogoso Laboratory except for 17WR\_14A, 15A and 16A

\*(hole\_id): Samples assayed at SGS Tarkwa

\*(hole\_id)B: Resamples of high grade channels incorrectly sampled. Assayed at SGS Tarkwa.

\*Not true widths

The results from the 17 L channel sampling show that the mineralization along the reef is hosted in several higher grade pods. These high grade pods were drill tested at depth from cubbies on the 17 L and 24 L, drilled from the footwall to the hanging wall obliquely to the moderately west dipping foliation and reef. The details of this drilling will be discussed in Section 8.

In addition to the exposures on 17 L the West Reef has been encountered on a small reef drive on 24 L, approximately 300 m below 17 L. On the 24 L West Reef drive the structure was encountered but the vein here has pinched. Drilling from 24 L has delineated wider vein widths to the north of this reef drive alluding to a steep northern plunge of the higher grade mineralized zone hosted in the West Reef structure. Prior to 30 L being flooded, two hangingwall crosscuts were excavated for drill access to test the Main Reef between 30 L and 35 L. In the 270S 30 L cross-cut the West Reef was sampled intersecting a horizontal width of 5.8 m grading 3.1 g/t Au and 5 m at a grade of 3.3 g/t Au on the north and south sides of the excavation respectively. Neither of these samples has been included in the current West Reef resource estimates and show that the structure continues at depth below 24 L.

## 9 DRILLING (ITEM 10)

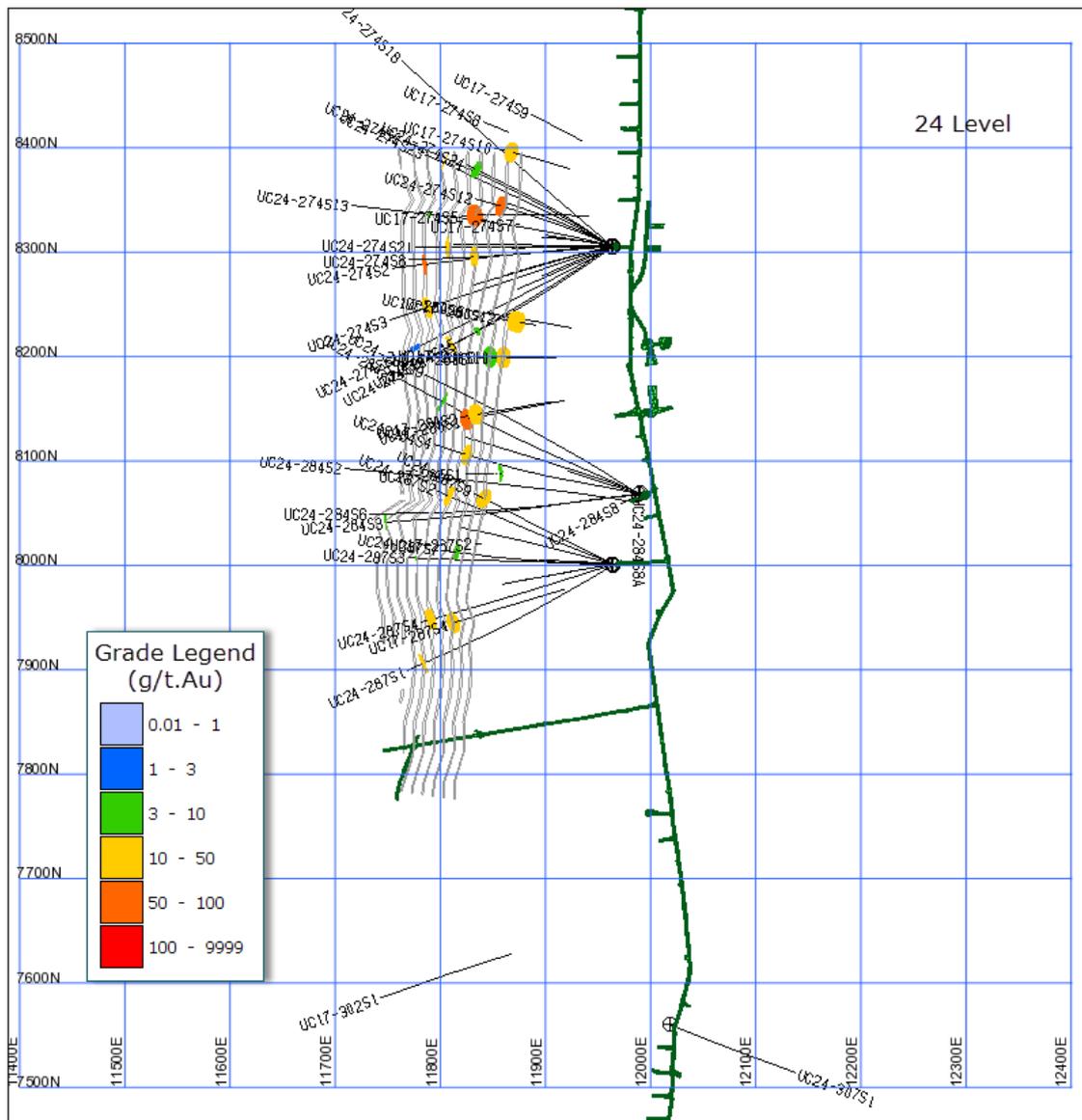
The samples used for the current Mineral Resource estimates at Prestea are based on a combination of surface DD drilling and underground core drilling. Fan drilling is carried out from drill cubbies in order to reduce the movement of the drill rigs. In addition to the drilling, rock saw channels have been cut on a number of levels to provide channel samples across the orebody and to investigate the grade distribution in the immediate contact zones adjacent to the orebody in order to better define the potential dilution. Drilling for the Main Reef orebody has been carried out at roughly 80-100 m spacing along strike from surface. The underground drilling has been largely concentrated on the West Reef orebody and has consisted of fan drilling from individual cubbies with up to 21 holes drilled from a single collar location. Underground collar locations are spaced approximately 80 m apart along strike on the 17, 24 and 30 Levels.

Data is currently available from some 675 surface and underground drillholes in the Prestea area broken down as follows:

- DD surface = 274 drillholes; 29 700 m
- RC surface = 137 drillholes; 14 000 m
- DD underground = 264 drillholes; 41 500 m

Drilling for the West Reef resource was conducted from underground drill stations, predominantly from 17 and 24 Levels. The drilling was conducted by Golden Star Resources and no historical data was used in the resource estimates. On 17 L, 10 drill stations were established along the MR footwall access where fan drilling was conducted dominantly horizontally and down dip (Figure 9-1). The up dip portion of the WR remains to be tested between 12 and 17 Levels and remains one of the priority drill targets. The 17 L drill stations are located on the following cross cuts, 274S, 277S, 280S, 285S, 287S, 290S, 293S, 297S, 302S and 308S testing the strike over approximately 775 metres.



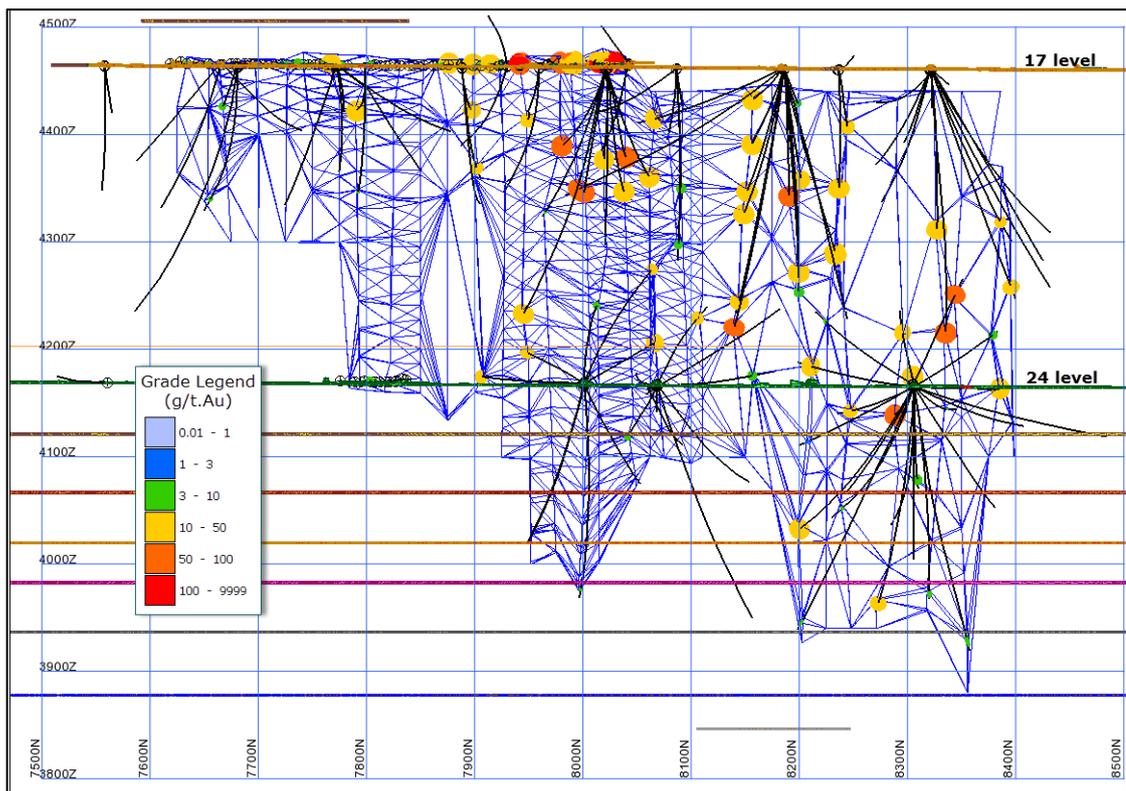


**Figure 9-2 24 Level drill plan and West Reef contours showing reef intersections**

The underground drilling of the West Reef target was conducted in several campaigns from 2004 to 2006 with a total of 128 holes and 28 790 metres being completed during this time. All drilling was conducted with underground diamond drill core rigs using NQ2 (~ 50 mm) sized core. All drill hole collars were surveyed using the underground survey control brought down from surface using the mine grid. The holes were also surveyed nominally every 25 to 30 metres down hole using a Reflex single shot survey instrument.

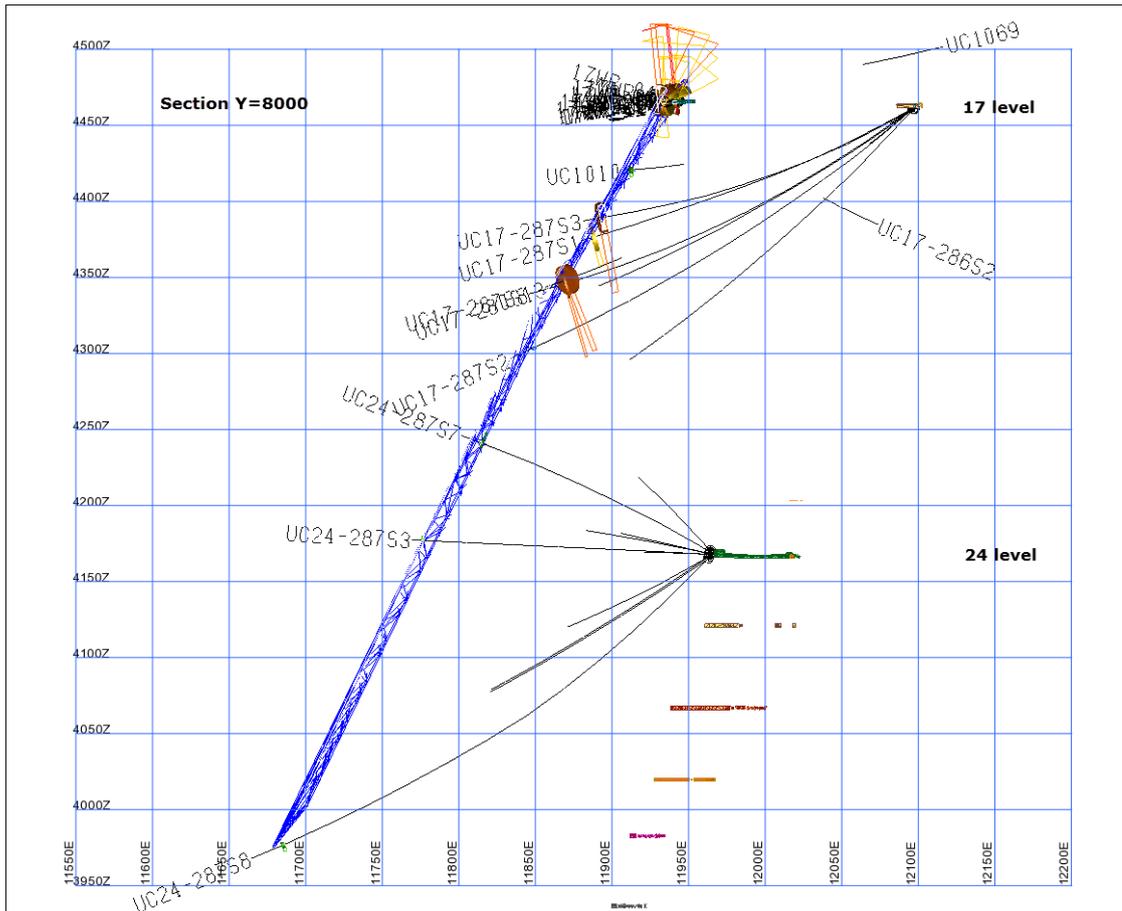
Core recovery through the mineralized zone was optimized by using chrome core barrels, viscous muds and short drilling runs but in some holes some of the "graphitic fissures" (graphic rich fault gouge) were washed away. Areas of lost core were not sampled and in the database are identified as insufficient sample or "IS" and were given a zero grade. Generally core recovery was good through the zone.

West Reef intersections in the areas where the resources have been classified as indicated are on a nominal 25 x 25 metre grid whereas inferred resources exceed the 25 metre drill hole spacing (Figure 9-3).



**Figure 9-3 West Reef Long section looking west from footwall with drill hole pierce points and current drives**

Several representative drill sections have been included below (Figure 9-4 and Figure 9-5) showing the attitude of the West Reef and the relatively consistent dip and gold tenures.



**Figure 9-4 West Reef drill X Section 8000N showing reef and drill hole intersections**

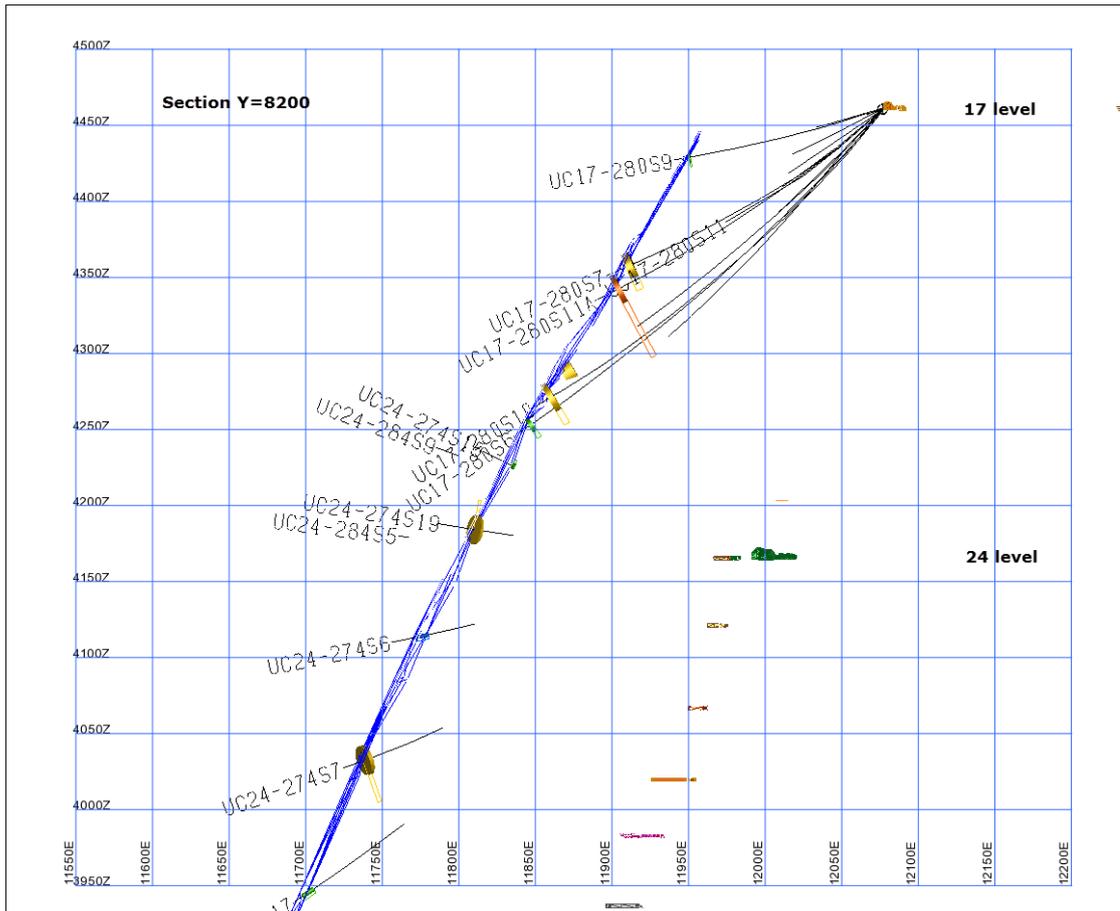


Figure 9-5 West Reef drill X Section 8200 N showing reef and drill hole intersections

## 10 SAMPLE PREPARATION, ANALYSES AND SECURITY (ITEM 11)

Sampling from Reverse Circulation (RC) drilling is carried out using a standard single cyclone with samples collected at 1 m intervals through the expected orezone. In zones of waste rock the sample interval is occasionally increased to a 3 m composite. However all samples are assayed and if a 3 m sample returns a significant grade value the original 1 m samples will be assayed individually. All samples are riffled and bagged at the drill site and returned to the Bogoso Mine for reduction and sample preparation.

Diamond drilling (“DD”) core from surface drilling is collected using HQ size core barrels (63.5 mm). The core is logged and sawn in half at the Bogoso mine site and 1 m samples are prepared through the prospective orezone. However, geological contacts are taken into account and samples will therefore vary slightly in length. In waste zones samples are collected at 1 m nominal intervals where alteration, sulfidation or quartz veins are observed. Underground drilling is carried out using NQ or HQ size core and the core is sawn in half and prepared for assay. The orebodies dip steeply to the west and depending if the drilling is from surface or undergrounds is angled to try and intersect the mineralized zone orthogonally, however from underground drilling cubbies this is often not possible. Recoveries and SCR values are recorded in the database and 80 % of the diamond samples have a recovery greater than 95 % with 92 % showing a recovery greater than 80 %.

Samples used for the West Reef resource estimations were of two types, rock sawn channel samples on 17 L and 24 L reef drives and NQ sized diamond drill core.

Channel samples were collected using a double diamond blade Cheetah air driven rock saw. This saw produced a channel sample roughly 50 mm deep by 50 mm wide. Sample collection and dispatch to the laboratory was supervised by a geologist who ensured the samples were taken correctly, labelled and transported to the surface.

Core samples generated from the underground drilling were processed at either the core logging facilities at Prestea Central Shaft or at the main core storage facility near the Bogoso processing plant. Core boxes with lids were delivered to the logging facilities at the end of every shift by the drillers. The core logging process involved initial cleaning of the core and checking of the metre blocks and mark ups on the individual boxes, if there are any discrepancies they are addressed with the driller who was responsible for the core. All core was photographed prior to being logged and sampled. Two teams logged the core at surface one being responsible for recording geotechnical information and over all core recovery between drilling runs. Following the geotechnical drilling the core is logged by the geologist who pays particular attention to structure, lithology, alteration and mineralization. All of the core has been orientated with a spear orientation device and this has been used to take structural measurements while the core is being logged.

Sampling intervals are laid out by the geologist logging the core and are based on geological contacts with samples in mineralized zones generally not exceeding one metre. The physical sampling of the core was done with a diamond blade core cutting saw. The core was sawn in half along the line marked by the geologist to ensure a representative sample is taken. The half sawn core samples were deposited into individual plastic bags where the sample number was both written on the bag as well as on a piece of flagging which was inserted into the bag. The remaining half core sample was returned to the core boxes and kept for future reference. During the sampling, standards and blanks are inserted in the sample numbering sequence and these are recorded on the lab dispatch sheets. Every 20 samples that are submitted to the laboratory are accompanied by a sample standard and a blank to check the precision of

the analysis. Additional checks are done on samples once the results have been returned.

Samples are dispatched to either SGS laboratories or Transworld Laboratories (now Intertek Mineral Lab) in Tarkwa. Samples were organized in the core logging facilities where they were checked and put into numeric order. The transportation to the laboratory in Tarkwa is provided by the lab. Sample turnaround and dispatch are recorded either in a spreadsheet (earlier samples) or with the database software acQuire.

Sample rejects and pulps were returned to the Bogoso core logging facility where they are stored for up to a year and then disposed of. Approximately 10% of the coarse reject samples, above detection limit that are returned to site are renumbered and resubmitted to the laboratory for duplicate analysis and used for QA/QC evaluations. The processing, handling, analysis and storage of the samples for the Prestea Mine are considered to be within or exceed industry standards.

## **11 DATA VERIFICATION (ITEM 12)**

### **11.1 Introduction**

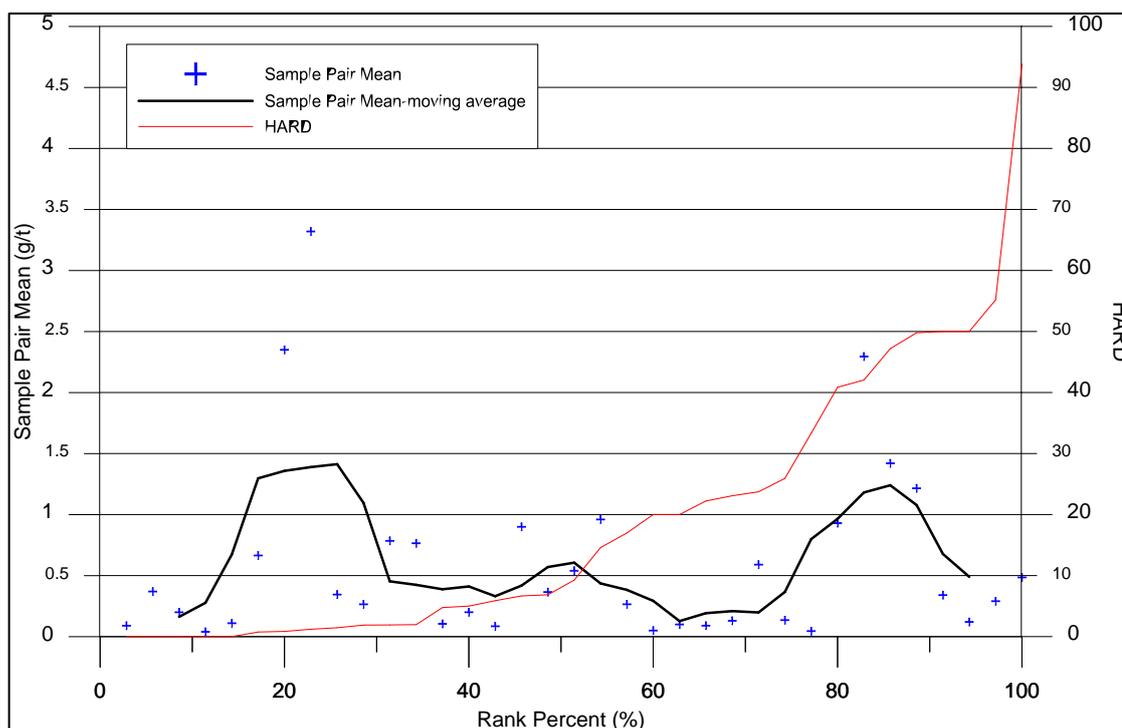
Samples are obtained from various stages of the drilling and sampling procedure. Analysis is carried out using scatterplots to indicate bias between sets of sample pairs using correlation analysis. The other plot used is a HARD analysis (ranked Half Absolute Relative Deviation) which examines the relative precision of assay pairs representing the same sample interval within the drillholes. The relative error is obtained by dividing the absolute error in the quantity by the quantity itself. The relative error is usually more significant than the absolute error. When reporting relative errors it is usual to multiply the fractional error by 100 and report it as a percentage.

The following section discusses the results of the QAQC work carried out on the Prestea West Reef underground exploration and Prestea Main Reef (Plant North) samples obtained during 2004-2008.

### **11.2 Replicates**

Two separate samples are collected at the drill site and bagged separately from which two individual samples will be produced. The results of these checks can be useful in highlighting natural variability of the grade distribution.

Replicates were produced from the surface diamond drilling at Plant North for those holes targeting the underground Main Reef and West Reef deposits. The results are summarised in the following HARD plot and indicate a relatively poor correlation between the two sets of results. Some 40 % of the sample pairs have a HARD of >20 %. However, the reason for this may be partly due to the use of a relatively low number of low grade intersections generally less than 1 g/t which are not representative of the underground orebody. Lower grade samples tend to be more likely to have larger relative differences in grade due to the nuggety nature of the orebody. Therefore SRK consider the replicate sampling to be inappropriate and recommend that the core be resampled with high grade intersections which more appropriately represent the orebody.



**Figure 11-1 Prestea Main Reef exploration replicates HARD plot**

### 11.3 Duplicates

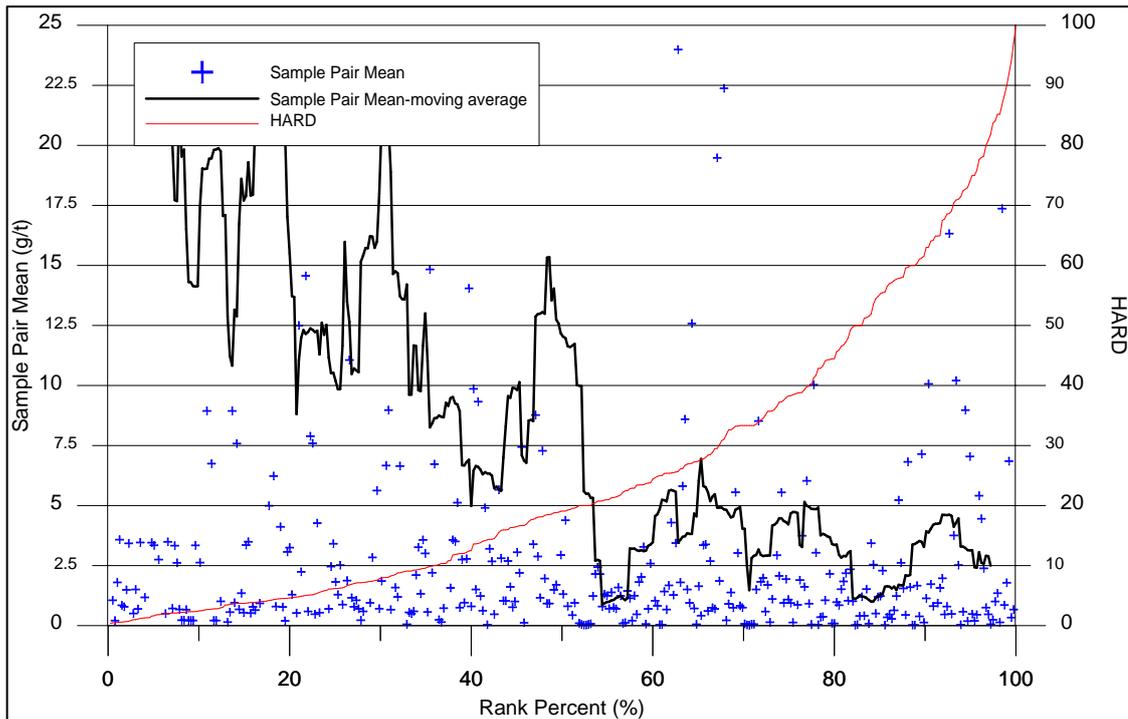
Duplicate samples are composed of coarse reject sample material which has been returned by the independent off site laboratories. Approximately 10% of the coarse rejects returned to site are selected for duplicate analysis. The sample selection concentrates on assays greater than 0.2 g/t. The duplicate samples are rebagged and given a new unique sample number and then resubmitted to the laboratory for a second analysis. It is these sample pairs that are used to determine the accuracy of the lab and repeatability of the sample results.

The results from these duplicates are useful in indicating problems with sample preparation and splitting and are also indicative of the inherent variability of grade within a sample size volume which has implications for the modelling of semi-variograms and estimation of nugget variance.

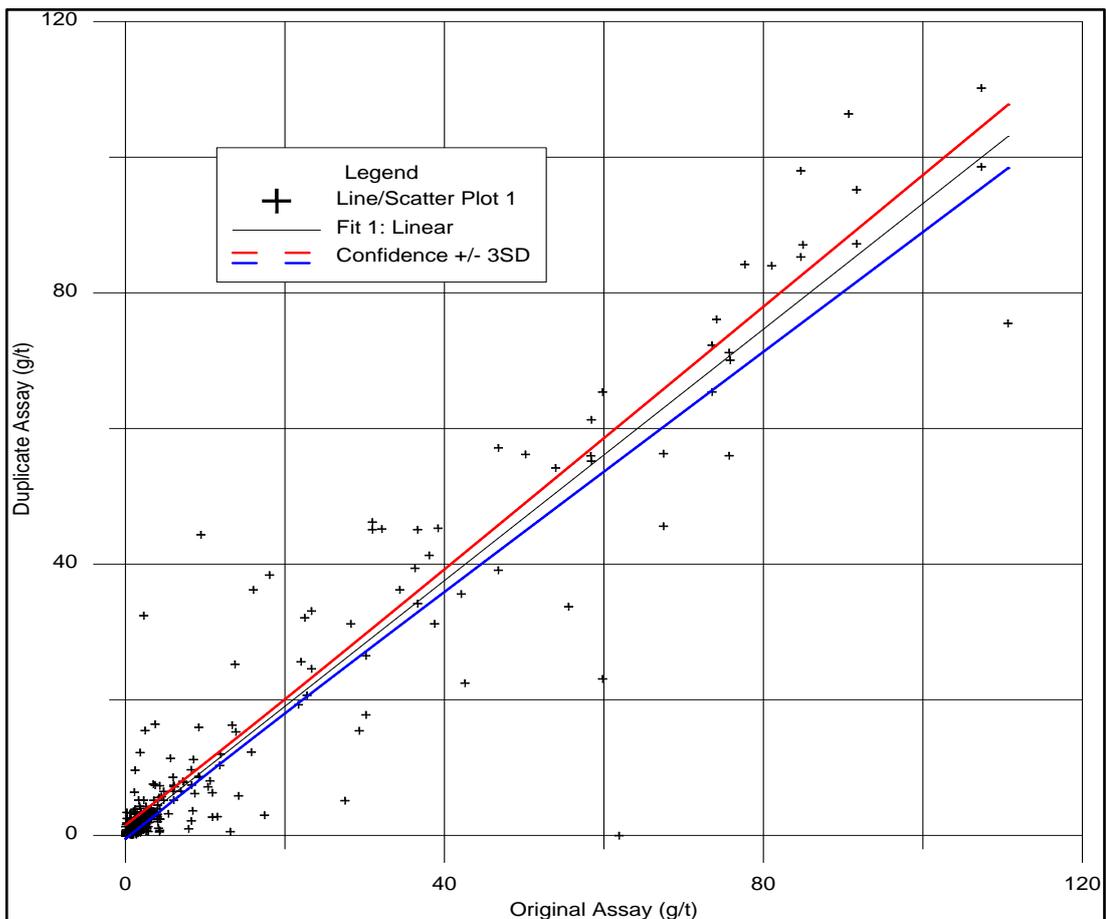
#### 11.3.1 West Reef Underground Drilling 2006

This work has shown that reproducibility is relatively poor for the underground sampling data from Prestea as shown in Figure 11-2 and Figure 11-3. This is in part due to the difficulty in producing sufficient sample material from the small diameter core. The high grade of the deposit also contributes to the variability with only 50 % of the sample pairs exhibiting a 'Half Absolute Relative Difference' (HARD) value of 20 % or less.

However, there is a clear trend for the sample pairs with the highest variability to have an average grade of less than 5 g/t. Given that the current block COG for the Mineral Resource is 3.08 g/t the majority of the high variability pairs will be occurring in the lower grade areas of the deposit and it is likely that the effect of this variability will be to cause some local dilution issues where low grade material is included within the mineralisation. However, the majority of the higher grade sample pairs show relatively good reproducibility.



**Figure 11-2** Prestea West Reef underground DD exploration duplicates HARD plot



**Figure 11-3** Prestea West Reef underground exploration duplicates correlation plot

### 11.3.2 Plant North area Main Reef and West Reef surface exploration

The results from the duplicate sampling generally show a positive trend with the majority of the sample pairs exhibiting HARD values of less than 20 %. There is a correlation between lower grades and higher HARD values indicating greater variability in the lower grade areas of the orebody. However, a number of the sample pairs exhibit average grades below the current model cut off grade and care should be taken to make sure representative mineralised intersections are used for these studies in future.

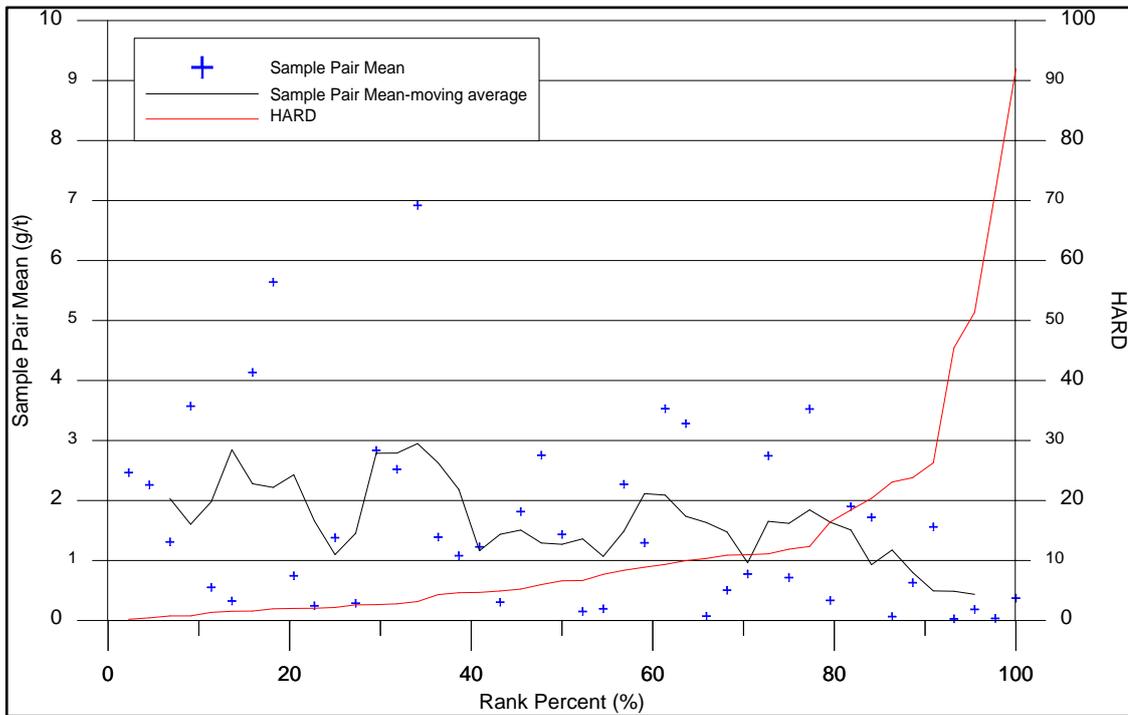
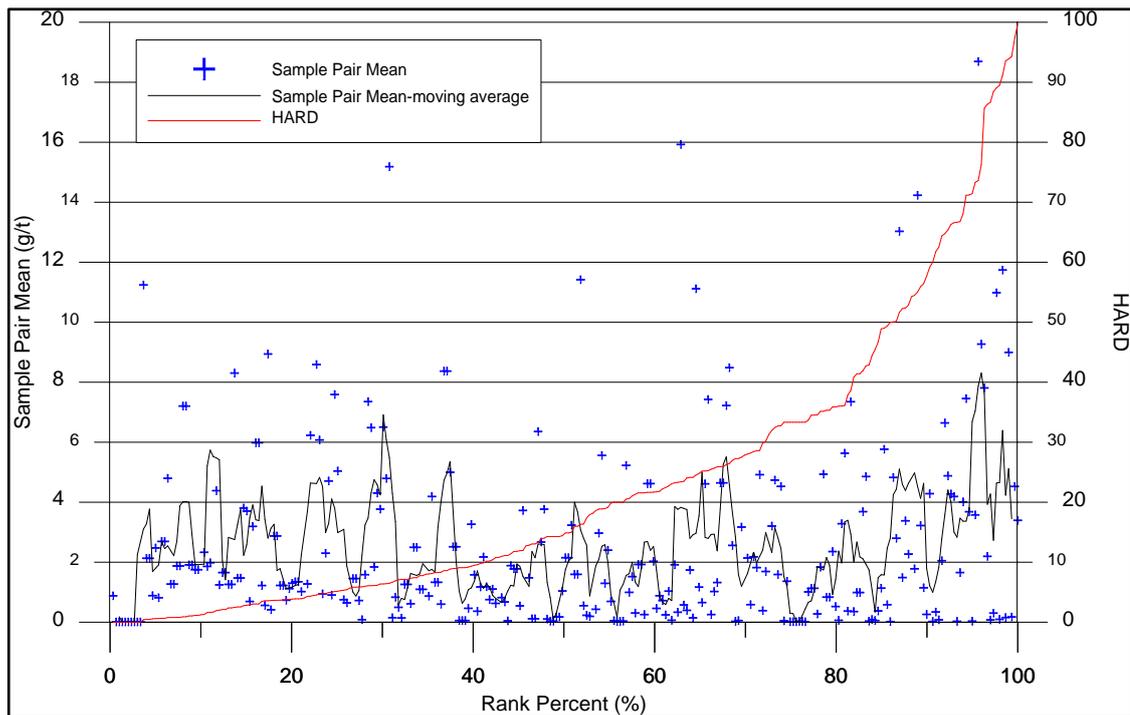


Figure 11-4 Prestea Main Reef RC duplicate HARD plot



**Figure 11-5 Prestea Main Reef DD duplicate HARD plot**

## 11.4 Blanks

Blanks were inserted in the samples sent for Screen Fire Assay (“SFA”) and used as a check on the efficiency of the laboratory. This method is useful for highlighting contamination problems and also cross labelling when samples are mislabelled in the laboratory. The blanks were prepared from RC chips known to be devoid of mineralization filtered to 0.01 ppm. A total of 35 Blank samples were inserted in different batch of samples sent as part of the SFA testwork. The laboratory values range from 0.01 to 0.03 ppm with two values being 0.04 and 0.05 ppm and the lab mean value is 0.02 ppm suggesting there is not a significant issue with contamination at the laboratory and SRK consider the results to be acceptable for use in Mineral Resource estimation.

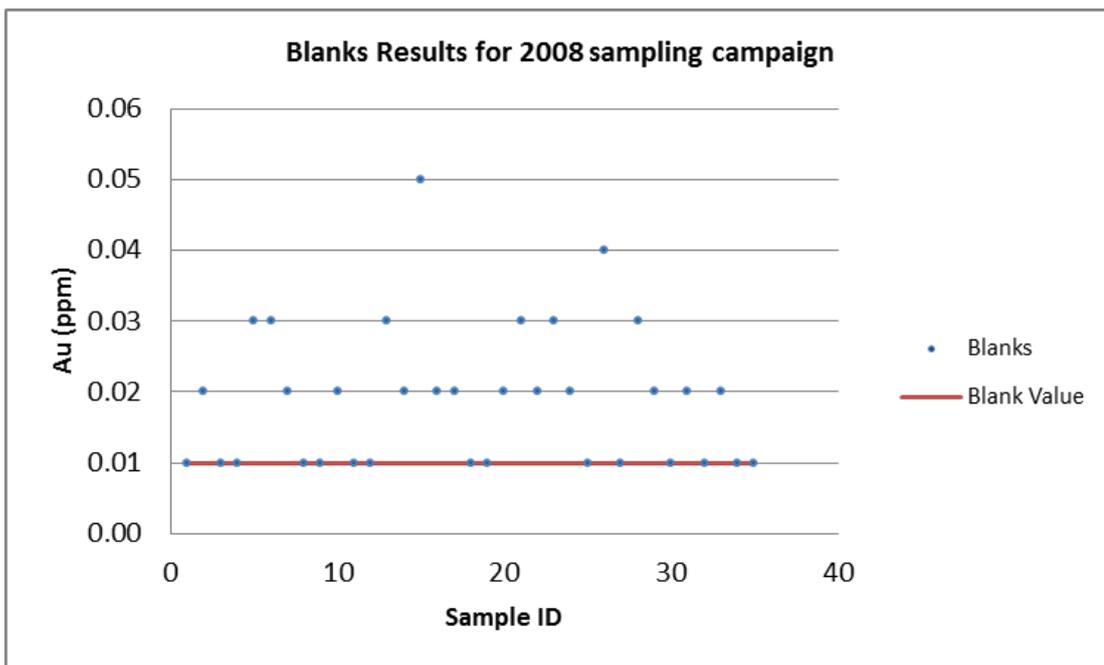


Figure 11-6 Results of blank analysis, January to March 2008

### 11.5 Gannet Standards

Standards are used for checking the precision and accuracy of the laboratory. A total of 161 gannet standard samples comprising 5 different grades were used as control samples for the Fire Assay standards. The performance accuracy of the lab is shown in Table 11-1 and Figure 11-7 to Figure 11-11.

The general results appear to be good with most results lying within 2 Standard Deviations of the certified value. There is a tendency for overestimation with only the lower grade standard being consistently underestimated. The overestimation by the laboratory is not considered significant by SRK being generally less than 2 %, and appears to be consistent suggesting an issue with the laboratories internal standards used for calibration.

Table 11-1 Standards used and summary results at Prestea WRP

Standard ID	Number	Certified Value	Lab mean	Accuracy Performance (% Bias)	Comment
ST5343	35	0.208	0.207	-0.48	Negative Bias
ST322	37	1.04	1.06	1.92	Positive Bias
ST5355	34	2.37	2.41	1.69	Positive Bias
ST05/2297	21	2.56	2.59	1.17	Positive Bias
ST5359	34	3.91	3.94	0.77	Positive Bias

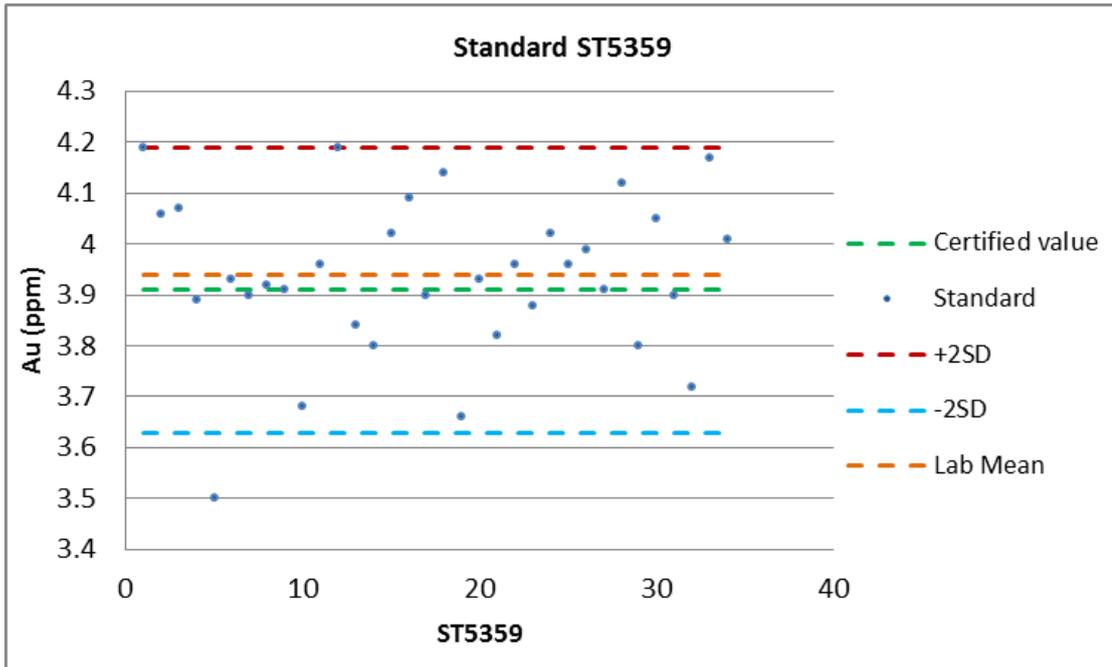


Figure 11-7 Standard analysis results for ST5359

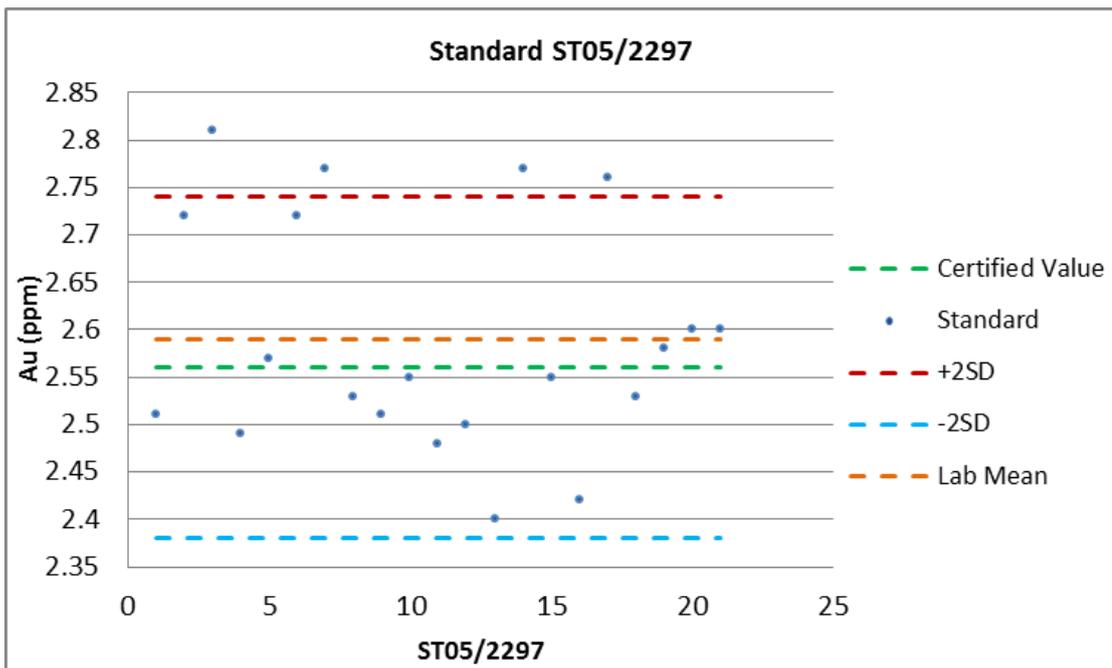


Figure 11-8 Standard analysis results for ST05/2297

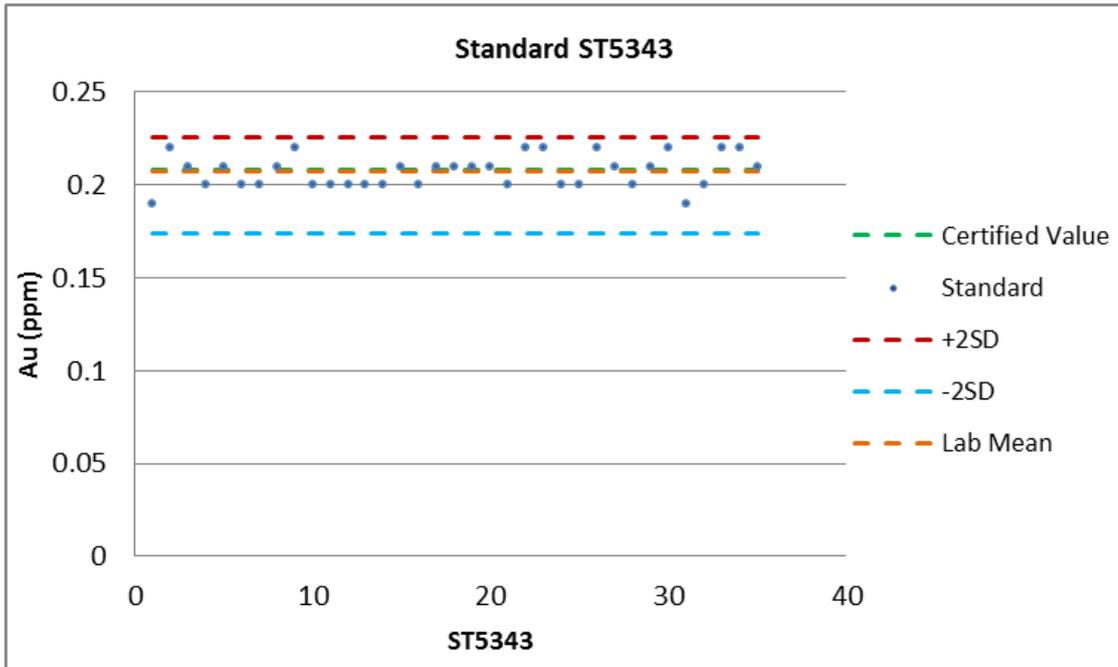


Figure 11-9 Standard analysis results for ST5343

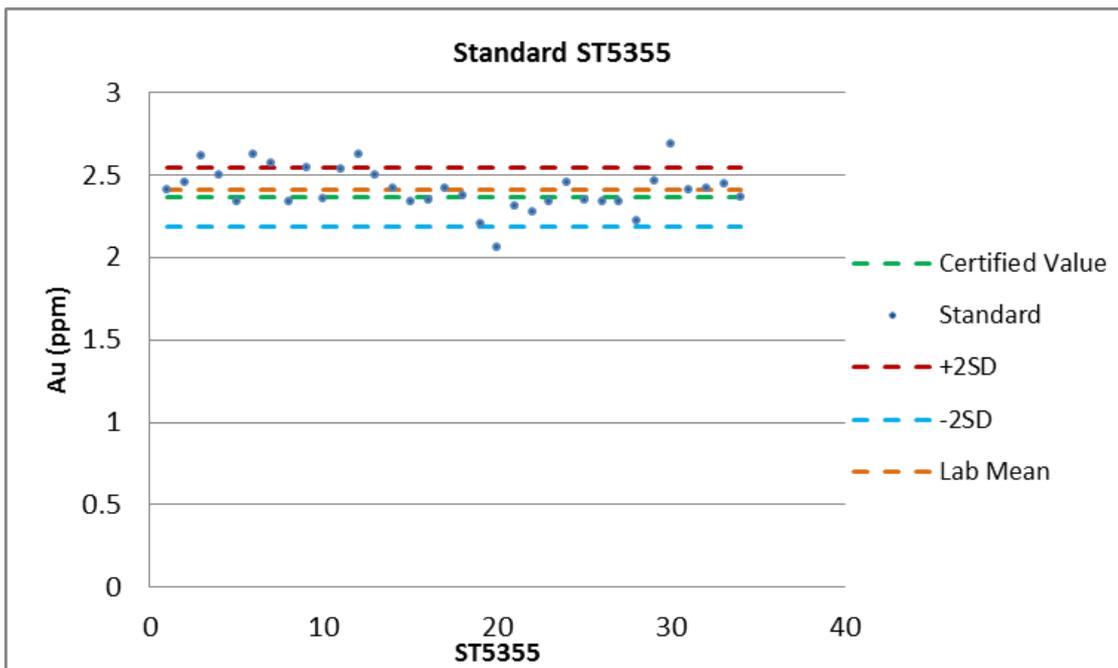


Figure 11-10 Standard analysis results for ST5355

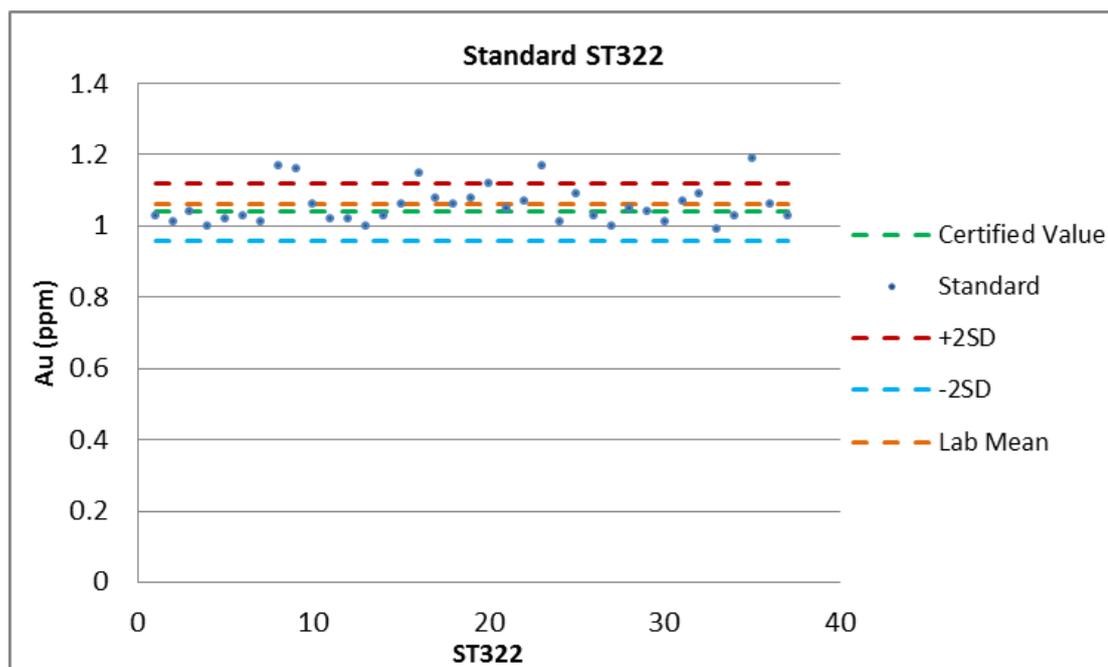
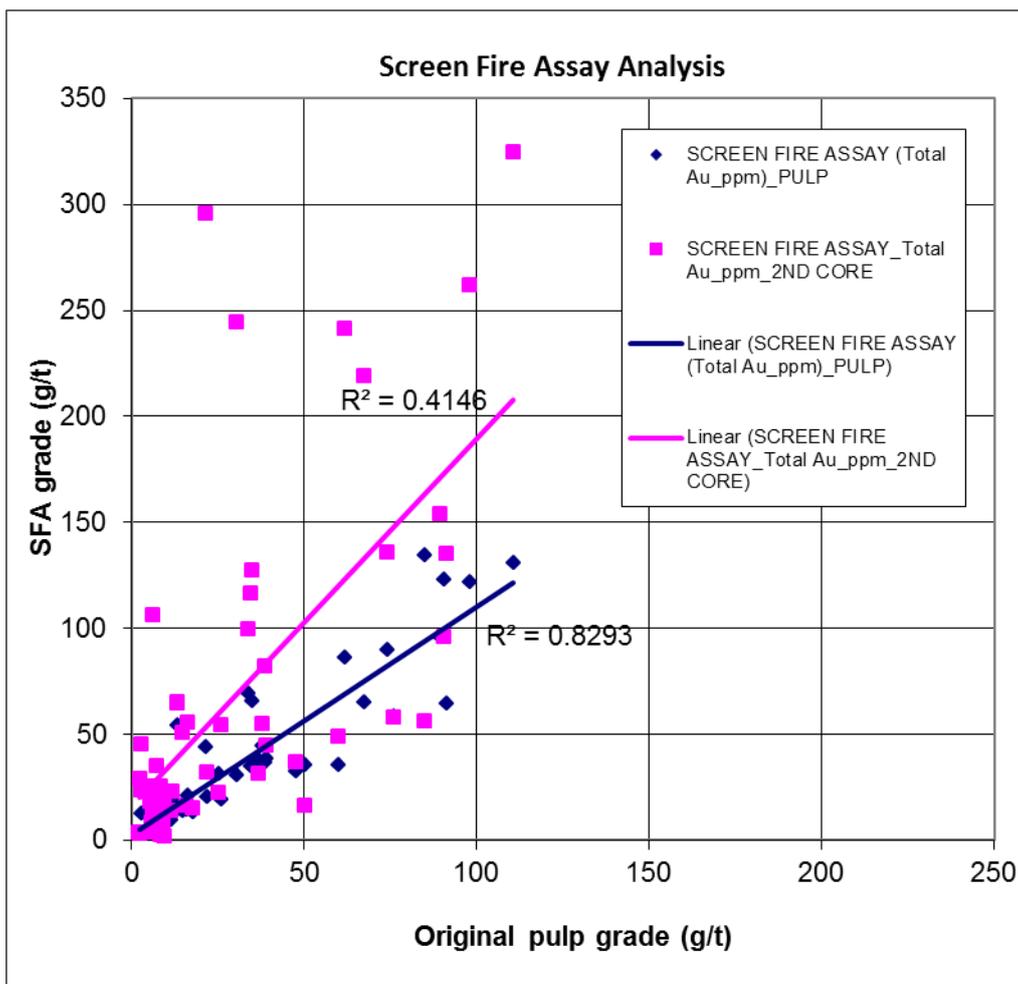


Figure 11-11 Standard analysis results for ST322

## 11.6 Screen Fire Assay checks

Additional drilling was carried out on 24 L at Prestea on cross sections 284 and 287 and a number of the original sample pulps were re-sent for SFA in 2008. The initial results indicated a slight overestimation by the SFA with respect to the original Fire Assay values ("FA"). However, the sample size used for the initial SFA assay was generally lower than 250 g and in some cases was lower than the original FA sample size. As a result the second half of 54 selected core samples were prepared and sent as duplicate samples for SFA using a 1 000 g charge in order to better define the effect of coarse gold on the final estimates.

The results from the assay of the SFA duplicates produced using a sample charge of 1 000 g produces a significant difference in grade compared with the original sample pulp. The difference for those original pulps with values of 20 g/t or less are similar to those produced by the SFA of the original pulps. However, above 20 g/t the difference in grade between the original pulp and the duplicate core SFA (1 000 g sample) become significant. The average difference indicates a 200 % increase in grade compared with the original sample assay. However, this includes low grade samples where a small difference can exaggerate the percentage difference. For those original assays with a grade above 10 g/t the average increase in grade of the SFA assay is 160 % and for samples above 20 g/t the average increase is 155 %.



**Figure 11-12 Results from screen fire assay analysis based on 250 g (Pulp) and 1 000 g (2nd core) sample charges**

SRK consider the difference between the FA and SFA (1 000 g) results to be expected given the high grade and nuggety nature of the West Reef and Main Reef deposits. However, the extreme grades indicated by some of the SFA assays indicate that it is likely that the current Mineral Resource is being affected by a bias which could lead to an underestimation of the grade of the Prestea deposits based on the current sampling regime.

**11.7 Conclusions**

The QAQC results for the Prestea deposits show a high degree of reproducibility for those samples above the cut off grade of the deposit. There is a higher degree of variability in the lower grade samples indicative of the high grade nature of the WR deposit and the nuggety nature of the ore. Gannet standard values indicate good quality control and a high level of accuracy in the laboratory. However the lack of high grade standards means that the accuracy of the high grade assay results is something which should be checked but is not considered material to the final Mineral Resource estimate for the WRP.

The Screen Fire Assay work demonstrates that, although coarse gold may be present in the higher grade areas of the Prestea deposit, it is unlikely to have a significant effect on the overall grade interpolation. However, SRK would recommend that future SFA work is carried out using a suitable sample size of at least 250 g in order to improve confidence in the estimates provided.

SRK also considers that the samples used for the standard analysis to date have average grades either at or lower than the COG used for modelling the deposit (and at which it will ultimately be mined), more suitable sample intersections be used for duplicate and replicate analysis in the future.

## 12 MINERAL PROCESSING AND METALLURGICAL TESTING (ITEM 13)

### 12.1 Introduction

GSBPL is planning to process the Prestea WRP ore in the Bogoso Processing plant situated some 16 km away from Prestea, close to the Chujah open pit operation. The WRP underground ore will be trucked from storage bins at the planned RHS. The starting assumption was that the Prestea WRP ore will be processed through the OC as a blend with other ores although it is noted that it could be processed separately in campaigns.

The construction of the existing processing facility at Bogoso was completed in 1991, which consisted of: a CIL circuit to treat the oxidised material at a rate of 1.36 Mtpa; and a flotation, fluidized bed roasting and CIL circuit with a design capacity of 0.9 Mtpa. Billiton encountered operational difficulties with the fluidized bed roaster, as a result of which the flotation circuit and roaster were shut down in 1994 and the operation was then focussed solely on the oxide ore. The resulting standalone CIL plant had a capacity of approximately 2 Mtpa.

GSR acquired Bogoso in 1999, and since that time has operated a nominal 1.5 Mtpa CIL processing plant to process oxide and other non-refractory ores. In July 2007, GSBPL completed construction and development of a new nominal 3.5 Mtpa processing facility at Bogoso/Prestea that uses BIOX® technology to treat refractory sulphide ore.

### 12.2 Historical Testwork

In March 2008, John W. MacIntyre and Associates Pty Ltd. (“JMA”) provided a report to GSBPL titled, ‘**Prestea Underground Metallurgical Testwork – Prefeasibility Study Stage**’. The report describes the metallurgical test work undertaken at that time to determine the process characteristics of the West Reef and the Footwall Reef. This section summarizes the JMA report. As the FS only applies to West Reef material, no summary of the Footwall Reef results is provided. The testwork for the study was conducted at AMMTEC in Perth, Australia.

Twelve West Reef diamond drill core samples were composited into Upper, Mid, Lower and Master Composites. The Upper Composite consisted of samples from drillholes that commenced on 17 L. The Lower Composite consisted of samples from 24 L drillholes, and the Mid Composite contained samples from both 17 L and 24 L drillholes. The head grades of the composites ranged from 14.8 to 30.9 g/t Au.

The amount of amalgam gold recovered from the West Reef Upper, Mid and Lower samples was fairly consistent, ranging from 5.0 to 6.3 g/t Au, averaging 5.7 g/t Au or 31.6% for an 18.1 g/t Au average head grade. The West Reef Composite sample recovered appreciably more gravity gold, that is 16.5 g/t Au or 75 % of the total gold. The JMA report does not provide any commentary on the difference in amalgam gold between the individual composites and the Master Composite.

The three West Reef samples were found to be only mildly preg-robbing. There was an average of only 0.08 g/t Au that was preg-robbed using new carbon and an average of only 0.21 g/t Au preg-robbed using loaded carbon.

The CIL recovery using fresh carbon averaged 98.3% for the Upper, Mid and Lower samples. The CIL recovery using loaded carbon recovery was only marginally lower by 0.7 % and averaged 97.6 % for the Upper, Mid and Lower samples.

The 24 hour cyanide consumption for the West Reef samples varied from 1.16 to 1.48 kg/t and averages 1.31 kg/t. The 24 hour lime consumption varied from 0.81 to 0.86 kg/t and

averaged 0.84 kg/t.

As summarised in the JMA report, the Prestea West Reef ore presents as a relatively free-milling ore, with a reasonably high gravity-recoverable component, and a relatively low preg-robbing potential. The head grades were somewhat higher than the current Mineral Reserve Grade (9.61 g/t Au), and the reagent consumption in cyanidation were not particularly high for material of this head grade.

## 12.3 2013 Testwork Program

### 12.3.1 Objective

The metallurgical testwork program undertaken for the purposes of the FS was to determine the potential to process the Prestea WRP ore through the OC at Bogoso with a focus on understanding:

- The presence of any refractory component(s) in the WRP ore;
- The presence of any significant preg-robbing component(s) in the WRP ore;
- Expected recoveries under typical OC processing operating conditions; and
- The operating cost to process the Prestea WRP ore through the Bogoso OC.

In the absence of any historical core the FS testwork was conducted on samples of diamond drill core from the underground geotechnical drilling program that was undertaken in late 2012 and early 2013. The testwork was conducted at SGS Lakefield laboratory in Canada.

### 12.3.2 Samples

Samples from eight drillholes were available. The aim was to sample them in such a way as to represent the mineralised shear zone that will be mined. The shear zone consists mainly of quartz within in a softer matrix of graphite. Six of the holes were from 17 L, and the remaining two were from 24 L. The samples submitted were of half core, and were provided as intervals of up to 1 m core length, so as to provide data for the geological database. The principle in sampling the holes was to include all of the Quartz Vein ("QV") mineralisation, all Footwall ("FW") and Hangingwall ("HW") mineralisation within the Shear Zone ("SZ"), as well as 0.5 to 1.0 m of additional "dilution skin" outside of the SZ.

A total of 61 interval samples were provided for testwork, in two consignments; the first consisting of 42 samples from five 17 L drillholes, and the second consisting of 19 samples from one 17 L and two 24 L drillholes.

For comparison purposes, a sample of Pampe Fresh ore was also provided for testwork. Pampe Fresh ore is one of the current OC feedstocks, and so the aim in parallel testing Pampe Fresh ore was to allow the opportunity to assess the results of the testwork on the Prestea WRP ore in the context of testwork on an ore source with which the Bogoso operation is familiar. The Pampe Fresh sample was taken from a surface stockpile of the material.

On the basis of the interval sample head assays, five Prestea WRP composite samples were prepared for the laboratory testwork program. Three composites were prepared initially from the first consignment of five 17 L drillholes, and the subsequent two composites were prepared from the second consignment of the one 17 L and two 24 L drillholes.

The composites were prepared on the basis of a 1.4 m true mining width (i.e. of QV) and a total of 1 m of true width of combined FW and HW dilution, i.e. 42 % dilution. The initial three composites varied according to the proportions of HW and FW that made up the dilution material. The first composite used a 'typical' FW:HW ratio of 1:1, and the other composites tested what was anticipated to represent the likely limits of this ratio, namely 2:1 FW:HW and 2:1 HW:FW.

Superimposed on these criteria was a composite weight target of 20 kg. The latter two composites used a 1:1 FW:HW ratio, and focussed on generating samples of closer to the expected diluted ore feed grade (approximately 10 g/t Au), as the initial composites had been of higher grades due to the high grade nature of the QV intervals in the initial five drillhole samples. One of the latter composites was composed of intervals from the two 24 L drillholes only, and the other was made up of intervals from all three drillholes in the second consignment.

### 12.3.3 Testwork

#### *Initial Interval Testwork*

The individual drillhole interval samples were submitted for head assays in order to provide information of which to base a compositing program for the main body of the testwork. The samples were crushed to -6 mesh (3.36 mm) rather than a typical -10 mesh (1.68 mm), as a Bond Ball Mill Work Index (“BWi”) Test was scheduled for the subsequent composite samples and this test requires a -6 mesh feed size. The head assays conducted were as follows:

- Gold grade, using a modified screen fire assay procedure. A sub-sample of approximately 200 g was pulverised to a point where approximately 10% of the sample was +150 mesh (105 µm). The entire +150 mesh fraction was fire assayed, and duplicate 30 g charge fire assays were conducted on the -150 mesh material;
- Total Organic Carbon (“TOC”); and
- Preg-Robbing Index (“PRI”). A 20 g portion of the sample was pulverised to a nominal -106 µm. 10 g of the subsample was bottle rolled with 20 ml of a caustic cyanide solution for one hour, with the remaining 10 g simultaneously bottle rolled with 20 ml of a gold spiked caustic cyanide solution. The gold spiked solution was spiked with 20 ppm of Au, and the PRI was calculated from the ratio of the filtrate solution assays from the two bottle roll tests as follows:

$$\text{PRI} = \frac{(\text{spike grade} + \text{non spiked final solution grade} - \text{spiked final solution grade})}{(\text{spike grade} + \text{non spiked final solution grade})}$$

SAG Mill Comminution (“SMC”) tests were also undertaken ahead of the composite formation, as these tests require intact diamond core pieces. Selected intervals were identified for this testwork, and suitable core pieces were taken from each interval. Where several intervals were ‘combined’ for the SMC test, the core pieces from each interval were tracked separately through the test and returned to their respective intervals at the completion of the test prior to being crushed to -6 mesh ahead of the head assays.

#### *Composite Testwork*

The following testwork was conducted on the five Prestea WRP and one Pampe Fresh composite samples:

- BWi, at a closing screen size of 100 mesh (150 µm);
- 25 element head assay;
- Preg-Robbing Test. This is an SGS standard procedure, with 1 kg of ground ore slurried in 1.5 l of a 10 ppm gold stock solution. NaOH is added to maintain a pH of 11 throughout the 24 hour duration of the test. Solution samples are taken for assay after 1, 3, 6 and 24 hours and assayed for Au. No cyanide is added to the test;
- Gravity separation at a grind size of 80% -150 µm; a two stage process using a Knelson Concentrator followed by a Mozley table separator, targeting a gravity concentrate mass recovery of 0.01 to 0.1%;

- Bottle roll cyanidation tests on the gravity tailings, reground to 80% -75 µm. Leaching conditions: 40% solids, pH 10.5 to 11, 0.5 kg/t initial NaCN addition, 48 hours with intermediate sampling at 8 and 24 hours. Parallel tests were conducted with and without the addition of 10 g/l of carbon, i.e. Carbon-in-Pulp (“CIP”) vs. CIL format;
- Tailings characterisation tests;
- Atterberg Limits;
- Particle size distribution (sieves and hydrometer); and
- Consolidated Drained Direct Shear Test.

### 12.3.4 Results

The individual interval head assay results are shown in Table 12-1.

**Table 12-1 Drillhole Interval Head Assays**

Drillhole	Lithology	Sample Number	From (m)	To (m)	Au (g/t)	TOC (%)	PRI
GT17-274S1	FW dilution	GT17-274S1FW1	131.06	131.7	0.19	1.30	5.0
	FW	GT17-274S1FW2	131.7	132.6	0.60	1.99	25.0
	FW in SZ	GT17-274S1FW3	132.6	133.0	0.45	1.97	35.0
	QV	GT17-274S1QV1	133.0	133.2	455	0.43	32.0
	HW in SZ	GT17-274S1HW1	133.2	133.83	0.87	2.08	40.0
	HW	GT17-274S1HW2	133.83	134.8	0.19	1.63	20.0
	HW dilution	GT17-274S1HW3	134.8	135.44	3.88	1.95	30.0
GT17-274S2	FW	GT17-274S2FW1	269.3	269.8	0.71	2.32	25.0
	FW	GT17-274S2FW2	269.8	270.9	0.14	1.89	30.0
	FW (QV)	GT17-274S2QV1	270.9	271.8	12.6	0.58	16.0
	QV	GT17-274S2QV2	271.8	272.65	45.0	0.23	-2.9
	QV	GT17-274S2QV3	272.65	273.5	38.5	0.21	-6.7
	QV	GT17-274S2QV4	273.5	274.35	84.1	0.25	-60.7
	QV	GT17-274S2QV5	274.35	257.2	69.4	0.83	3.8
	QV	GT17-274S2QV6	257.2	267.05	9.44	1.01	10.0
	QV	GT17-274S2QV7	267.05	276.85	7.01	0.65	0.0
	HW	GT17-274S2HW1	276.85	277.95	0.91	1.95	45.0
	HW	GT17-274S2HW2	277.95	279.05	0.23	1.75	40.0
GT17-280S1	SZ	GT17-280S1SZ1	279.4	280.38	0.05	1.86	35.0
	SZ	GT17-280S1SZ2	280.38	281.36	0.17	2.14	55.0
	SZ	GT17-280S1SZ3	281.36	282.35	0.19	1.99	30.0
	SZ	GT17-280S1SZ4	282.35	283.34	0.58	2.26	50.0
	SZ	GT17-280S1SZ5	283.34	284.33	0.24	1.99	40.0
	HW	GT17-280S1HW1	284.33	285.31	0.21	1.55	40.0
GT17-280S2	FW	GT17-280S2FW1	244.11	245.03	0.20	2.08	40.0
	FW	GT17-280S2FW2	245.03	245.95	0.32	1.87	25.0
	FW	GT17-280S2FW3	245.95	246.87	1.61	1.49	15.0
	QV	GT17-280S2QV1	246.87	247.86	20.0	0.35	-4.3
	QV	GT17-280S2QV2	247.86	248.46	no	sample	
	QV	GT17-280S2QV3	248.46	249.45	66.8	0.28	16.1
	QV	GT17-280S2QV4	249.45	250.44	76.8	0.58	0.0
	QV	GT17-280S2QV5	250.44	251.3	74.8	0.23	-11.1
	HW	GT17-280S2HW1	251.3	252.3	1.19	1.70	15.0
	HW	GT17-280S2HW2	252.3	253.16	0.06	1.45	15.0

Drillhole	Lithology	Sample Number	From (m)	To (m)	Au (g/t)	TOC (%)	PRI
GT17-287S1A	FW	GT17-287S1AFW1	219.6	220.2	0.29	1.89	0.0
	FW	GT17-287S1AFW2	220.2	220.8	0.32	1.91	15.0
	FW	GT17-287S1AFW3	220.8	221.4	3.08	1.79	20.0
	QV	GT17-287S1AQV1	221.4	222.3	128	0.40	-15.2
	QV	GT17-287S1AQV2	222.3	222.5	no	sample	
	QV	GT17-287S1AQV3	222.5	223.4	34.1	0.37	-7.4
	QV	GT17-287S1AQV4	223.4	223.9	no	sample	
	QV	GT17-287S1AQV5	223.9	224.3	42.6	0.25	-15.4
	HW	GT17-287S1AHW1	224.3	224.9	3.16	0.47	-10.0
	HW	GT17-287S1AHW2	224.9	225.5	1.01	0.79	-5.0
	HW	GT17-287S1AHW3	225.5	226.1	0.95	3.68	5.0
GT17-287S2	FW	GT17-287S2FW1	290.6	291.55	0.23	1.45	25.0
	FW	GT17-287S2FW2	291.55	292.5	0.75	1.62	10.0
	QV	GT17-287S2QV1	292.5	293.33	45.2	0.31	16.7
	QV	GT17-287S2QV2	293.33	294.16	17.1	0.54	0.0
	QV	GT17-287S2QV3	294.16	295.0	1.32	0.37	0.0
	HW	GT17-287S2HW1	295.0	295.55	1.08	0.79	0.0
	HW	GT17-287S2HW2	295.55	296.4	0.37	0.71	5.0
GT24-274S1	FW dilution	GT24-274S1FW1	167.85	168.25	0.03	1.86	55.0
	FW in SZ	GT24-274S1FW2	168.25	168.6	0.17	1.63	40.0
	FW in SZ	GT24-274S1FW3	168.6	169.0	no	sample	
	QV	GT24-274S1QV1	169.0	169.83	34.7	0.38	12.9
	QV	GT24-274S1QV2	169.83	170.66	45.9	0.21	5.4
	QV	GT24-274S1QV3	170.66	171.5	28.5	0.47	87.3
	HW in SZ	GT24-274S1HW1	171.5	172.12	1.87	0.96	0.0
	HW dilution	GT24-274S1HW2	172.12	172.52	0.54	0.83	5.0
GT24-274S2	FW dilution	GT24-274S2FW1	154.73	155.2	0.24	1.51	15.0
	FW	GT24-274S2FW2	155.2	156.13	0.07	2.84	60.0
	QV	GT24-274S2QV1	156.13	156.7	2.78	0.43	0.0
	HW	GT24-274S2HW1	156.7	157.1	no	sample	
	HW	GT24-274S2HW2	157.1	157.93	0.39	1.09	10.0
	HW	GT24-274S2HW3	157.93	158.4	0.11	2.42	60.0
Pampe Fresh		PPSMETFR001			1.34	0.53	40.9

The make-up of the composite samples are provided in Table 12-2.

**Table 12-2 Composite Sample Details**

Composite	Designation	Samples Used	FW Dilution (%)	HW Dilution (%)	Expected Grade (g/t Au)
1	1:1 FW:HW	GT17-274S1FW1 GT17-274S1HW3 GT17-274S2FW2 GT17-274S2QV1 GT17-274S2QV3 GT17-274S2QV4 GT17-274S2QV5 GT17-274S2QV6 GT17-274S2QV7 GT17-280S2HW1	24.0	24.0	19.0
2	1:2 FW:HW	GT17-274S2QV2 GT17-280S2FW1 GT17-280S2QV1 GT17-280S2QV3 GT17-280S2QV4 GT17-280S2HW2 GT17-287S1AHW2	14.2	28.6	30.5
3	2:1 FW:HW	GT17-274S1FW2 GT17-274S1HW2 GT17-280S2QV5 GT17-287S1AFW3 GT17-287S1AQV1 GT17-287S1AQV3 GT17-287S1AQV5	28.8	17.0	39.7
4	24 L	GT24-274S1QV1 GT24-274S1QV3 GT24-274S2FW2 GT24-274S2QV1 GT24-274S2HW2	23.9	23.9	13.3
5	17 + 24 L	GT17-287S2QV2 GT17-287S2QV3 GT24-274S1FW1 GT24-274S1FW2 GT24-274S1QV2 GT24-274S1HW2 GT24-274S2HW3	21.6	25.2	13.1
6	Pampe Fresh	PPSMETFR001	n/a	n/a	1.3

The results of the SMC Tests are shown in Table 12-3.

**Table 12-3 SMC Test Results**

Sample	Drop Weight Index (kWh/m <sup>3</sup> )	JK A * b parameter	JK t <sub>a</sub> parameter	Hardness Percentile (%)
GT17-274S2QV1				
GT17-274S2QV2				
GT17-274S2QV3				
GT17-274S2QV4	3.5	75.1	0.75	22
GT17-274S2QV5				
GT17-274S2QV6				
GT17-274S2QV7				
GT17-280S2QV1	3.0	82.1	0.85	19
GT17-280S2QV3	3.7	70.0	0.69	25
GT17-280S2QV4	3.8	69.3	0.68	25
GT17-280S2QV5	2.4	78.0	0.76	21
GT24-274S1QV1				
GT24-274S1QV2	4.9	54.0	0.53	40
GT24-274S1QV3				
GT24-274S2FW1				
GT24-274S2FW2				
GT24-274S2HW2	7.8	37.0	0.33	70
GT24-274S2HW3				
Pampe Fresh	2.7	96.2	0.97	14

The Drop Weight Index is a measure of an ore's resistance to impact breakage, where a smaller number indicates less resistance, i.e. a 'softer' ore. The JK A\*b parameter is an analogous figure, where a larger number indicates a "softer" ore. The JK t<sub>a</sub> parameter is a measure of an ore's resistance to abrasion breakage, and again a larger number indicates a 'softer' ore. The hardness percentile reflects the particular samples' position on the database of all SMC tests results. The results therefore indicate that both the 17 L Prestea WRP and Pampe Fresh samples are relatively 'soft', with the Pampe Fresh sample being slightly softer than the Prestea WRP samples.

However, the results for the two 24 L Prestea WRP samples indicate that the QV sample is significantly "harder" than the corresponding 17 L samples, in terms of its resistance to both impact and abrasion breakage, and that the FW and HW combined sample is harder still.

The results of the BWi Tests for all six composites are shown in Table 12-4.

**Table 12-4 BWi Test Results**

<b>Composite</b>	<b>BWi (kWh/t)</b>
1 (Prestea 17 L)	15.4
2 (Prestea 17 L)	15.8
3 (Prestea 17 L)	15.8
4 (Prestea 24 L)	15.8
5 (Prestea 17 L and 24 L)	15.8
6 (Pampe Fresh)	12.6

The five Prestea WRP samples had BWi values averaging 15.7 kWh/t, which indicates an ore with a moderately high grinding energy requirement. The BWi value for the Pampe Fresh ore indicates a relatively soft ore with respect to its grinding energy requirement.

The head assays for the composites are shown in Table 12-5.

The difference between each set of repeat Au assays indicates the presence of coarse, free gold. The Au assays were close to the expected values for Composites 1, 3, 4 and 5, but were lower than the expected value for Composite 2 and higher for Composite 6 (see Table 12-2 for the expected values). The TOC assays were close to the expected values.

SRK notes that the remaining assays do not indicate any potentially problematic behaviour, with the possible exception of As, indicating the presence of arsenopyrite, which is the principal refractory gold host in the Bogoso region. However, the As assays for the Prestea WRP samples were relatively low, with the exception of Composite 5, whose As assay was higher, and similar to that for the Pampe Fresh sample, and which may suggest some refractory component for these samples – while Pampe is designated as an OC ore source for Bogoso, it is known to carry a variable refractory component.

The results of the gravity separation segment of the gold recovery tests are summarised in Table 12-6. Where two results are shown for a Composite, the first is from the initial test, which was used to generate the sample for the initial CIP and CIL tests, and the second is from the subsequent test that was used to generate the sample that was leached ahead of tailings characterisation testwork.

**Table 12-5 Head Assays for Composite Samples**

Element	Unit	Composite 1	Composite 2	Composite 3	Composite 4	Composite 5	Composite 6
		Prestea 17L	Prestea 17L	Prestea 17L	Prestea 24L	Prestea 24&17L	Pampe Fresh
Au 1	g/t	22.0	24.1	41.8	24.4	14.8	1.92
Au 2	g/t	15.2	21.2	37.0	16.9	15.0	3.80
Au 3	g/t				9.6		
Au 4	g/t				5.9		
Au (average)	g/t	18.6	22.7	39.4	14.2	14.9	2.86
Ag	g/t	8.2	4.6	1.5	1.1	<0.9	<0.5
Cu	ppm	120	40	40	240	60	30
Fe	%	3.22	2.39	2.47	3.37	3.44	3.50
Zn	ppm	120	120	<100	160	110	<100
As	ppm	610	490	300	300	1600	1900
Sb	ppm	<20	<20	<20	<20	<20	<20
Te	ppm	<4	<4	<4	<50	<50	<4
Se	ppm	<10	<10	<10	<20	<20	<10
Hg	ppm	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3
C	%	1.73	1.36	1.26	2.05	1.92	0.80
TOC	%	0.99	0.71	0.83	1.40	0.97	0.49
S	%	0.54	0.42	0.50	0.71	0.88	0.41
SiO <sub>2</sub>	%	70.9	78.4	78.8	71.8	69.1	70.3
Al <sub>2</sub> O <sub>3</sub>	%	10.7	7.55	8.04	9.60	11.4	13.8
MgO	%	1.69	1.28	1.27	1.73	1.88	1.06
CaO	%	1.50	1.43	1.00	1.42	1.63	0.93
Na <sub>2</sub> O	%	2.36	1.57	1.76	1.92	3.23	2.66
K <sub>2</sub> O	%	1.29	1.05	1.05	1.33	1.27	1.61
TiO <sub>2</sub>	%	0.41	0.29	0.29	0.36	0.40	0.64
P <sub>2</sub> O <sub>5</sub>	%	0.07	0.06	0.06	0.06	0.08	0.06
MnO	%	0.05	0.05	0.04	0.06	0.05	0.05
Cr <sub>2</sub> O <sub>3</sub>	%	0.04	0.04	0.04	0.03	0.02	0.06
V <sub>2</sub> O <sub>5</sub>	%	0.02	0.01	0.01	0.02	<0.01	0.03
LOI	%	5.80	4.41	4.29	5.51	5.28	4.20

**Table 12-6 Gravity Separation Test Results**

Item	Unit	Composite 1		Composite 2		Composite 3		Composite 4	Composite 5	Composite 6	
		Prestea 17L		Prestea 17L		Prestea 17L		Prestea 24L	Prestea 24&17L	Pampe Fresh	
Gravity Concentrate Weight	%	0.025	0.102	0.032	0.123	0.070	0.097	0.074	0.062	0.073	0.133
Gravity Concentrate Au Assay	g/t	45400	12100	61100	14600	38200	29000	12200	9880	3220	1400
Gravity Tailings Au Assay <sup>1</sup>	g/t	3.22	3.47	5.03	2.47	5.73	3.17	2.94	5.63	1.21	1.26
Gravity Au Recovery	%	78.1	78.0	79.6	87.9	82.3	89.8	75.6	52.0	65.9	59.7
Calculated Head Au Assay	g/t	14.7	15.8	24.6	20.5	32.4	31.2	12.0	11.7	3.55	3.13
Measured Head Au Assay	g/t	18.6		22.7		39.4		14.2	14.8	2.86	

1. calculated from gravity tailings CIP test

The Au recoveries achieved to the target mass recovery of 0.05 to 0.10 % was 65.9 % for the Pampe Fresh sample, and ranged from 52.0 to 82.3 % for the Prestea WRP samples. The 17 L composites reported higher gravity gold recoveries than the composites containing 24 L ore. The repeat gravity tests produced higher mass recoveries to the gravity concentrate, which for the Prestea WRP samples tended to result in a higher gold recovery; the gold recovery for the Pampe Fresh sample was not significantly different.

SRK understands that gravity Au recoveries of the order of 60 % are typically achieved for ores processed through the Bogoso OC, however given the higher recoveries and higher head grade of the Prestea WRP material, this corresponds to a greater quantity of physical gold that will potentially report to the gravity concentrate. Given that the downstream process route for gravity gold at Bogoso consists of manual tabling and then smelting, SRK believes that the existing facility will be able to cater for the greater volume of gravity recoverable gold delivered by processing the Prestea WRP ore.

SRK notes that there was a reasonably good level of agreement between the calculated and assayed head grades for these tests.

The results of the cyanidation tests are summarised in Table 12-7. Again, where two CIL results are shown for a Composite, the first is from the initial test and the second is from the subsequent CIL test used to generate sample for tailings characterisation.

**Table 12-7 Cyanidation Test Results**

Item	Unit	Composite 1			Composite 2			Composite 3			Composite 4		Composite 5		Composite 6		
		Prestea 17L			Prestea 17L			Prestea 17L			Prestea 24L		Prestea 24&17L		Pampe Fresh		
		CIP	CIL	CIL	CIP	CIL	CIL	CIP	CIL	CIL	CIP	CIL	CIP	CIL	CIP	CIL	CIL
Grind Size P <sub>80</sub>	µm	88	81	84	85	82	85	77	81	82	77	79	76	74	85	109	121
CN Recovery																	
8 hr	%	77	-	-	86	-	-	87	-	-	52	-	68	-	15	-	-
24 hr	%	78	-	-	87	-	-	88	-	-	53	-	69	-	15	-	-
48 hr	%	78.3	67.0	90.2	88.1	94.9	88.9	88.7	95.5	90.4	54.3	86.1	70.5	90.5	15.6	69.8	56.3
Gravity + CN Recovery	%	95.2	92.5	97.8	97.6	98.9	98.7	98.0	99.2	99.0	88.8	96.6	85.8	95.4	71.2	89.3	82.4
CN Residue Au Grade	g/t	1.15	0.37	0.33	0.56	0.28	0.26	0.60	0.28	0.29	1.34	0.40	1.60	0.54	1.01	0.37	0.54
Calculated CN Head Au	g/t	5.30	1.12	3.37	4.71	5.19	2.34	5.31	6.22	3.02	2.93	2.87	5.42	5.68	1.20	1.22	1.24
NaCN Consumption	kg/t	0.62	0.50	1.50	0.90	0.75	1.68	0.82	0.79	1.45	0.12	0.25	0.14	0.34	0.62	0.33	0.93
Lime Consumption	kg/t	0.37	0.40	0.41	0.35	0.28	0.33	0.30	0.30	0.37	0.60	0.53	0.42	0.48	0.72	0.81	0.99

The Prestea WRP samples exhibited cyanidation recoveries ranging from 54.3 to 88.7 % under CIP conditions, and 67.0 to 95.5 % under CIL conditions. The overall recoveries (i.e. cyanidation plus gravity) ranged between 85.8 and 98.0% under CIP conditions, and 92.5 to 99.2 % under CIL conditions. The 8 and 24 hr intermediate results for the CIP tests also indicate rapid kinetics, with little additional recovery achieved after 8 hrs.

The CIL tests indicate an improvement in recovery under CIL conditions. The magnitude of the improvement was relatively small for Composites 2 and 3, however it was greater for Composites 4 and 5, the composites containing 24 L ore. This suggests that preg-robbing may become more significant with depth.

There was something of an inconsistency in the Composite 1 results. The initial CIL test indicated a lower recovery than the CIP test; however the repeat test indicated an improvement in recovery over the CIP case. The solids residue grades for the two CIL tests were very similar, and were lower than the solid residue grade for the CIP test, indicating an improvement in recovery. However, the calculated head grade for the first CIL test was low, 1.12 g/t Au compared to 5.30 g/t Au for the CIP test and 3.37 g/t Au for the second CIL test. The calculated head grade is based on the solid residue, final solution and carbon assays, and so it would appear that the low calculated head grade for the first CIL sample, and hence the low recovery, was probably due to an error in the carbon assay for this test. As standard laboratory practice is to assay such carbon samples in their entirety, it is not possible to further investigate the low recovery reported for this test. The second CIL test does however, indicate that there was an improvement in gold recovery under CIL conditions for this composite.

The test on the Pampe Fresh sample (Composite 6) exhibited both a lower recovery than for the Prestea WRP samples, and also a significant difference between the CIP and CIL test recoveries, indicating a significantly greater degree of preg-robbing behaviour with this ore than for the Prestea WRP samples. The lower overall recoveries (71 % for CIP and 86 % for CIL) also suggest the presence of a minor refractory component in this material. This is consistent with the slightly higher As content of this sample (see Table 12-5). While the Prestea WRP Composite 5 had a similar As content to the Pampe Fresh sample, there was no indication of refractory behaviour for the Prestea WRP sample.

The Bogoso site laboratory uses a Preg-Robbing Index based on the difference between CIP and CIL format recoveries, as follows:

$$\text{Preg-Robbing Index} = (\text{CIL Recovery} - \text{CIP Recovery}) / \text{CIL Recovery} * 100$$

On the basis of the cyanidation stage recoveries only, and using average figures for those samples with two CIL results, the Bogoso Preg-Robbing Index values for the composites are:

- Composite 1: -0.4 %;
- Composite 2: 4.1 %;
- Composite 3: 4.6 %;
- Composite 4: 36.9 %;
- Composite 5: 22.1 % and
- Composite 6: 75.3 %.

These results indicate that there was more preg-robbing exhibited by the samples containing 24 L ore, but that overall the level of preg-robbing in the Prestea WRP samples was lower than for the Pampe Fresh sample.

The results of the SGS preg-robbing tests are summarised in Table 12-8.

**Table 12-8 Preg-Robbing Test Results**

Item	Unit	Comp #1	Comp #2	Comp #3	Comp #4	Comp #5	Comp #6
		Prestea 17L	Prestea 17L	Prestea 17L	Prestea 24L	Prestea 24&17L	Pampe Fresh
Au Adsorbed after							
1 hr	%	9.0	8.5	15.2	n/a	n/a	17.1
3 hr	%	7.0	5.1	9.0	n/a	n/a	20.7
6 hr	%	4.2	4.1	3.0	n/a	n/a	22.1
24 hr	%	4.4	1.3	-6.6	n/a	n/a	22.5

These results show a significant difference between the values for the Prestea WRP samples, which were relatively low and reduced over time, and those for the Pampe Fresh sample, which were both higher, and increased over the course of the test.

The cyanide consumption for the Prestea WRP sample tests averaged 0.76 kg/t. While this is higher than the average of 0.63 kg/t for the Pampe Fresh tests, it is still a relatively low figure, particularly considering the high head grade of this material. The average lime consumption for the Prestea WRP sample tests was 0.40 kg/t, a low figure and lower than the average for the Pampe Fresh sample tests of 0.84 kg/t. At the time of writing of this report, no results were available from the tailings characterisation testwork.

### 12.3.5 Conclusions

The FS metallurgical testwork results indicate that the Prestea WRP ore is non-refractory and not significantly preg-robbing, with high Au recoveries reported under both CIP and CIL operating conditions, following the removal of the gravity recoverable component. It is therefore considered to be suitable for processing through the Bogoso OC.

The results of the FS testwork on the Prestea WRP samples are similar to those reported from the historical work (see Section 12.2), namely a relatively free-milling ore, with a reasonably high gravity-recoverable component, and a relatively low preg-robbing potential. The proportion of gravity recoverable gold in the WRP ore is relatively high, at approximately 80 % for the samples for which results are available. The cyanidation leach kinetics were also relatively rapid. The reagent consumptions in leaching – cyanide and lime – were reasonable and relatively low respectively. Compared to the sample of Pampe Fresh ore tested, the Prestea WRP ore exhibits a higher gravity recovery and a higher overall recovery, significantly less preg-robbing, similar leach kinetics, a slightly higher cyanide consumption and a lower lime consumption. The Prestea WRP ore is somewhat harder than the Pampe Fresh ore, and there is evidence that the Prestea WRP ore becomes harder with depth.

### 12.4 Feasibility Study Assumptions

The metallurgical testwork program is still ongoing and the FS was progressed before the bulk of the testwork results were received. Several key assumptions were therefore made for the FS analysis, subject to confirmation by the testwork as follows:

- The Prestea WRP ore can be processed through the OC;
- The overall gold process recovery is 90 %; and
- The operating cost to process the Prestea WRP ore through the OC will be no higher than the recent historical processing cost.

The metallurgical testwork results received to date indicate that the Prestea WRP ore is non-refractory and not significantly preg-robbing, with high Au recoveries reported under both CIP and CIL operating conditions, following the removal of the gravity recoverable component. It is therefore suited to processing through the OC.

## 13 MINERAL RESOURCE ESTIMATES (ITEM 14)

### 13.1 Introduction

The Prestea Underground Mine consists of a number of separate deposits (reefs) some of which have been mined historically and some which are considered exploration targets. The following figure shows the currently defined outlines of the principal deposits in relation to the Plant North Pit. This open pit targeted the Main Reef (“MR”) and its subsidiary Footwall Reef (“FR”). Data validation and additional underground and surface drilling carried out during the period December 2005 to December 2007 led to the development of updated geological models for the MR, FR and the West Reef (“WR”) and those Mineral Resources contained within the Shaft Pillar (“SP”). The historic underground operations were concentrated on the MR and WR. GSR have conducted a detailed exploration campaign along the length of the MR deposit but this has largely concentrated on assessing the potential for further open pit operations (within 200 m from surface).

A portion of the MR, FR and WR Mineral Resource has been classified as Indicated based on the continuity of grade and the distribution of the recent drilling.

The West Reef deposit which lies to the south of the Central Shaft area has been worked historically (Figure 13-1). Production records and historic sampling identified this deposit as having good prospects for future exploitation as an underground resource.

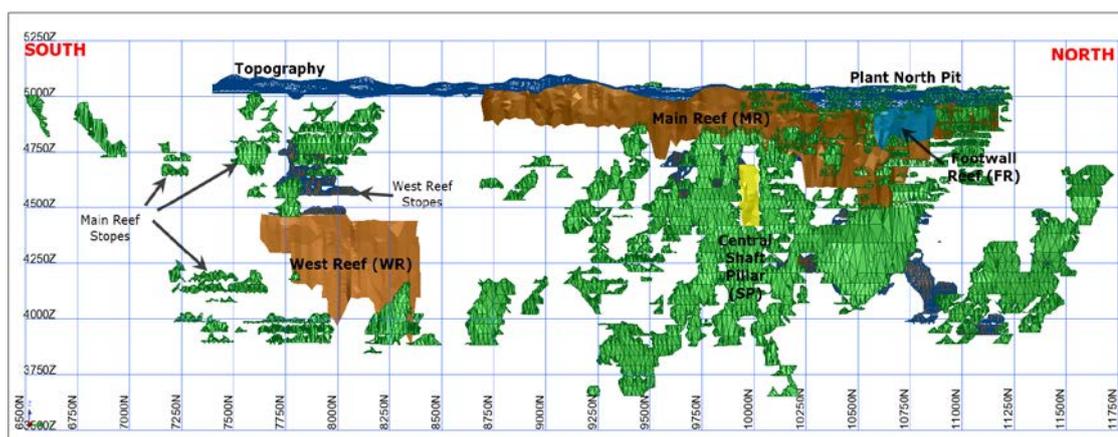


Figure 13-1 Long section looking west showing the Prestea deposits currently defined

### 13.2 Data Sources

SRK were provided with GEMS project directories containing the Prestea data. These directories contain the relevant drill hole databases, geological wireframes, oxidation and topographic surfaces and Block Model parameters. Additional information was provided as Excel spread sheets documenting QAQC data and results of density determinations.

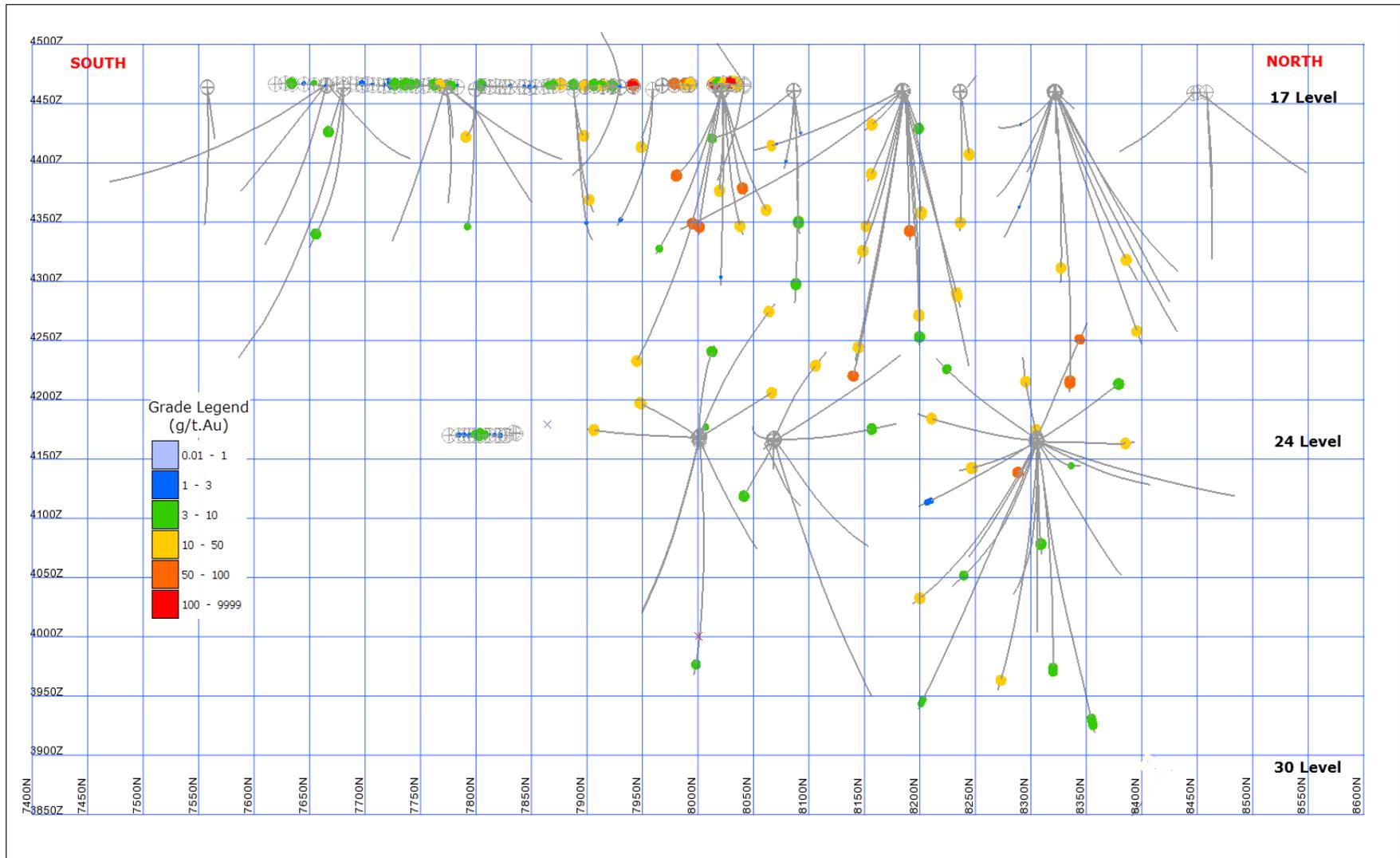
### 13.3 Basic Statistical Tests

Statistics were produced for the various reef domains present at Prestea. The results presented here are based on the horizontal thickness reef composite values and therefore the individual composites lengths vary depending on the reef thickness. The MR, FR and HW statistics are mostly from surface diamond drilling. The WR statistics are derived from underground drill holes and channel sampling collared at locations along 17 and 24 Levels and targeting reef intersections as deep as the 30 L.

**Table 13-1 Summary Statistics for the PUG Resource Domains**

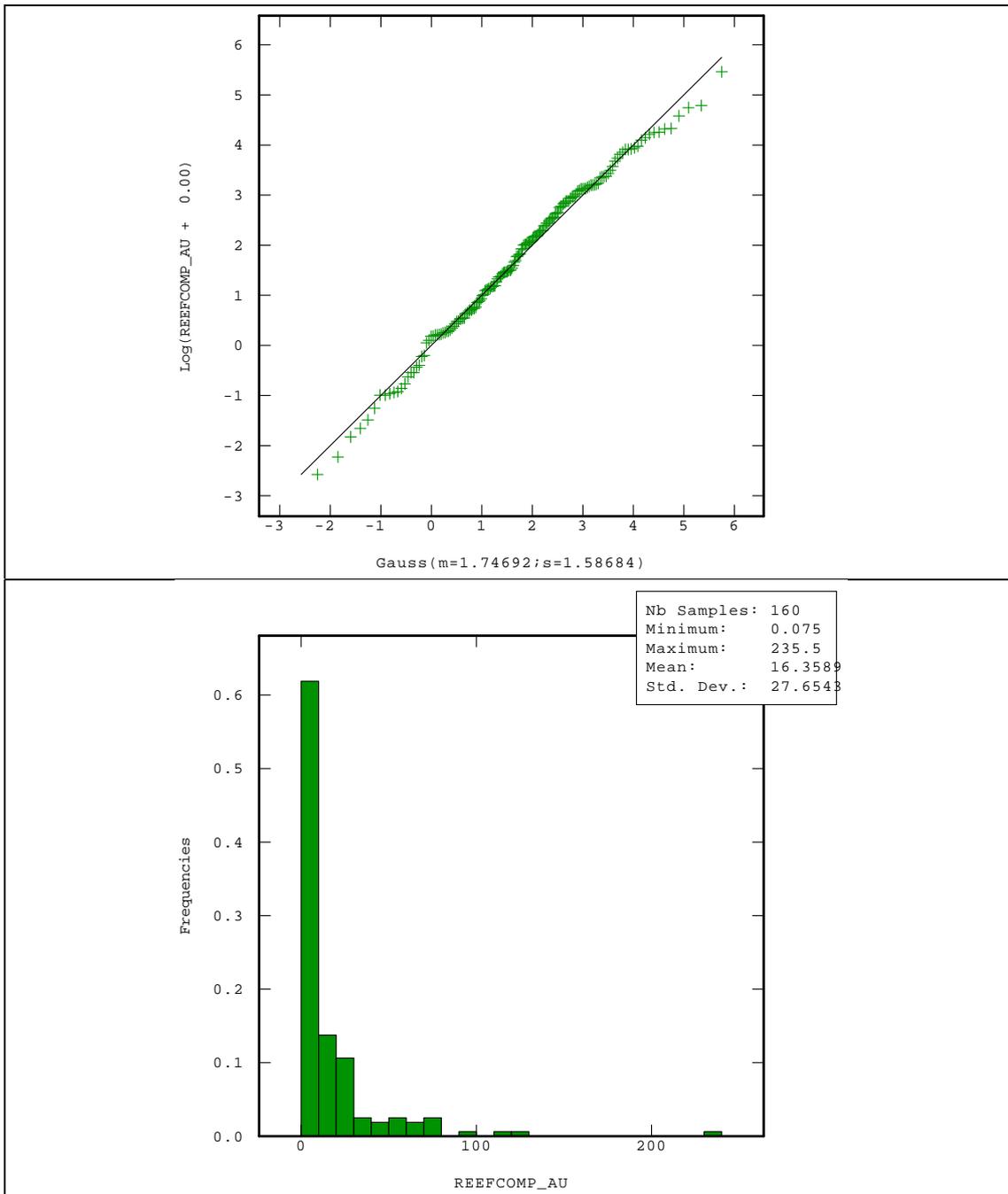
Domain	Count	Min (g/t)	Max (g/t)	Mean (g/t)	Std. Dev.	Variance	CV
Main Reef	700	0.0	108.72	7.72	9.9	97.6	1.3
West Reef	160	0.1	235.5	16.36	27.7	764.8	1.7
Foot Wall	79	0.1	108.7	9.68	17.5	305.3	1.8
Hanging Wall	13	1.4	5.9	3.01	1.5	2.1	0.5
Shaft Pillar	222	0.2	72.3	8.71	9.3	86.9	1.1

The above statistics highlight the relatively high grade of the shoots present in the West Reef when compared with the other domains present at Prestea. The following Vertical Longitudinal Projection (“VLP”) shows a representation of the grade distribution within the outlines of the WR domain for each of the reef thickness composites and highlights the relatively continuous nature of the high grade shoots over lateral and vertical distances in excess of 100 m.



**Figure 13-2 West Reef VLP looking west showing the distribution of reef composite grades and preponderance of cross cut sampling on 17 L**

The following Figure 13-3 QQ plot and histogram shows an approximate log-normal data distribution in the WR. The WR has a significantly higher grade than the MR and the drilling has confirmed the continuity of these high grades both along strike and down dip between levels.



**Figure 13-3 Log scale QQ plot and associated reef composite data histogram for the West Reef deposit**

### 13.4 Data Capping/filtering

The WR data has not been capped for grade interpolation as the production and use of reef thickness composites has implicitly applied a data cutting and smoothing to the original raw data statistics by combining individual high grades

Studies were conducted looking at capping at 100 g/t and 50 g/t but it was concluded that this

would bias the resulting estimates given that the WR appears to be a high grade shoot and there are definite trends or shoots of high grade continuity within the domain (Figure 13-2).

The MR and FR deposits were cut to 30 g/t following studies which showed that high grade outliers are having a material effect on the variance of the data and can adversely affect the quality of the resulting semi-variograms and hence the confidence in the final kriged estimate.

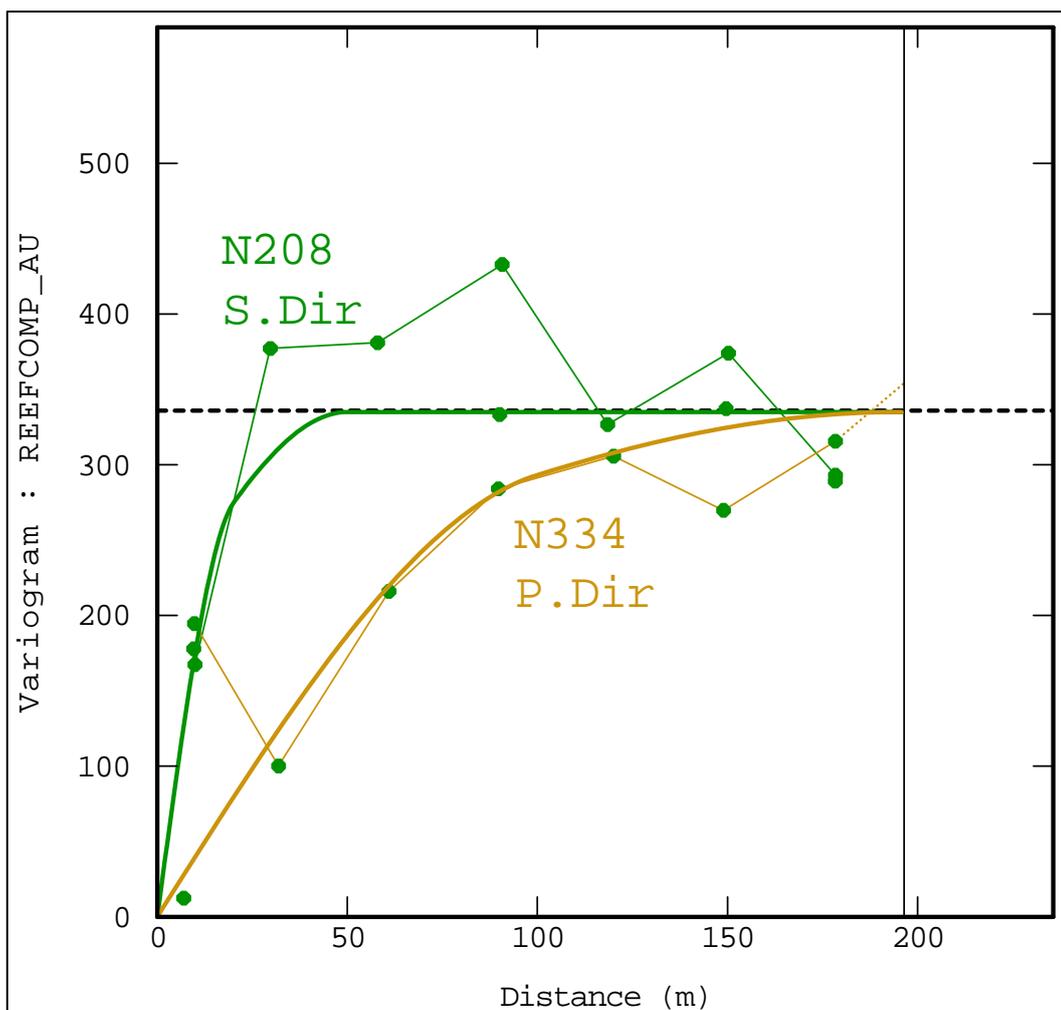
## **13.5 3D Variographic analysis**

### **13.5.1 West Reef**

The WR has been drilled out on relatively close spaced centres and this has resulted in reasonable quality semi-variograms being modelled in the four principle directions within the plane of the deposit which appear to be highlighting a plunge to the mineralization of approximately 42° to the north-west in the plane of the structure with a well-developed anisotropy of up to 200 m along this plunge and approximately 50 m perpendicular to this to the south-west.

The following plot Figure 13-4 shows the experimental semi-variograms produced in the principle and secondary directions derived from analysis of the average dip and strike of the WR domain. The plane of the orebody was assumed to lie on a strike of 005° with a dip of 60° to the west. The best directions for continuity of grade were calculated towards 334° along a plunge of 42° to the north-west in the plane of the structure. The secondary direction to this is plunging 34° to the south-west (208°) in the plane of the structure.

Modelling of the experimental semi-variograms produced an anisotropic model with a significantly higher range in the principal direction of almost 200 m compared to only 50 m in the secondary direction. This is partly a result of the data distribution as shown in Figure 13-2 where the majority of the reef intersections occur in the northern upper area of the domain. Additional sampling in the 24 and 30 Levels in the south of the WR deposit may result in better quality semi-variograms in the secondary direction.



**Figure 13-4 Directional semi-variograms produced in the principal directions in the plane of the West Reef deposit with associated model semi-variograms**

**Table 13-2 Semi-Variogram Modelling Results for the West Reef deposit**

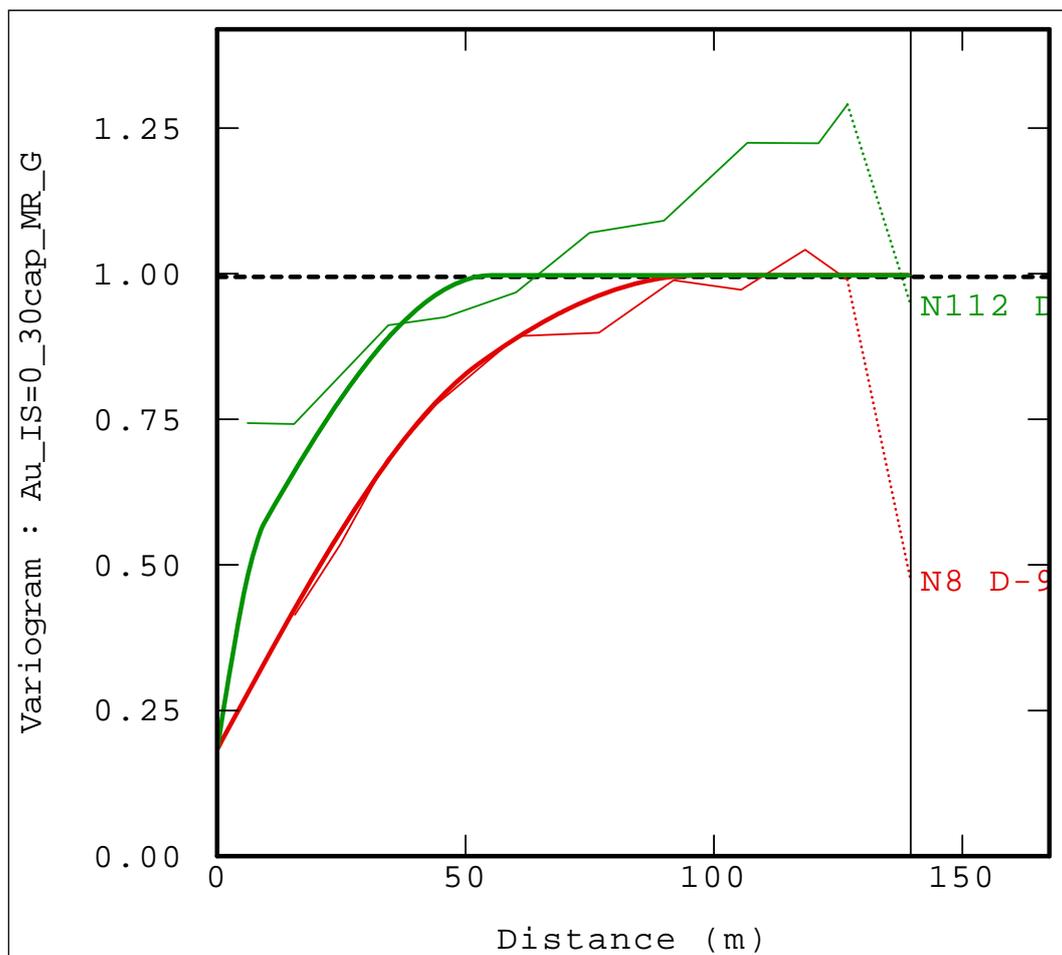
Domain	Structure	Variance	Principle Direction plunge 42° to 334°	Secondary Direction plunge 34° to 208°
WR	nugget (C <sub>0</sub> )	0		
WR	spherical (C <sub>1</sub> )	195	100m	20 m
WR	spherical (C <sub>2</sub> )	140	195m	50 m

### 13.5.2 Main Reef and Footwall

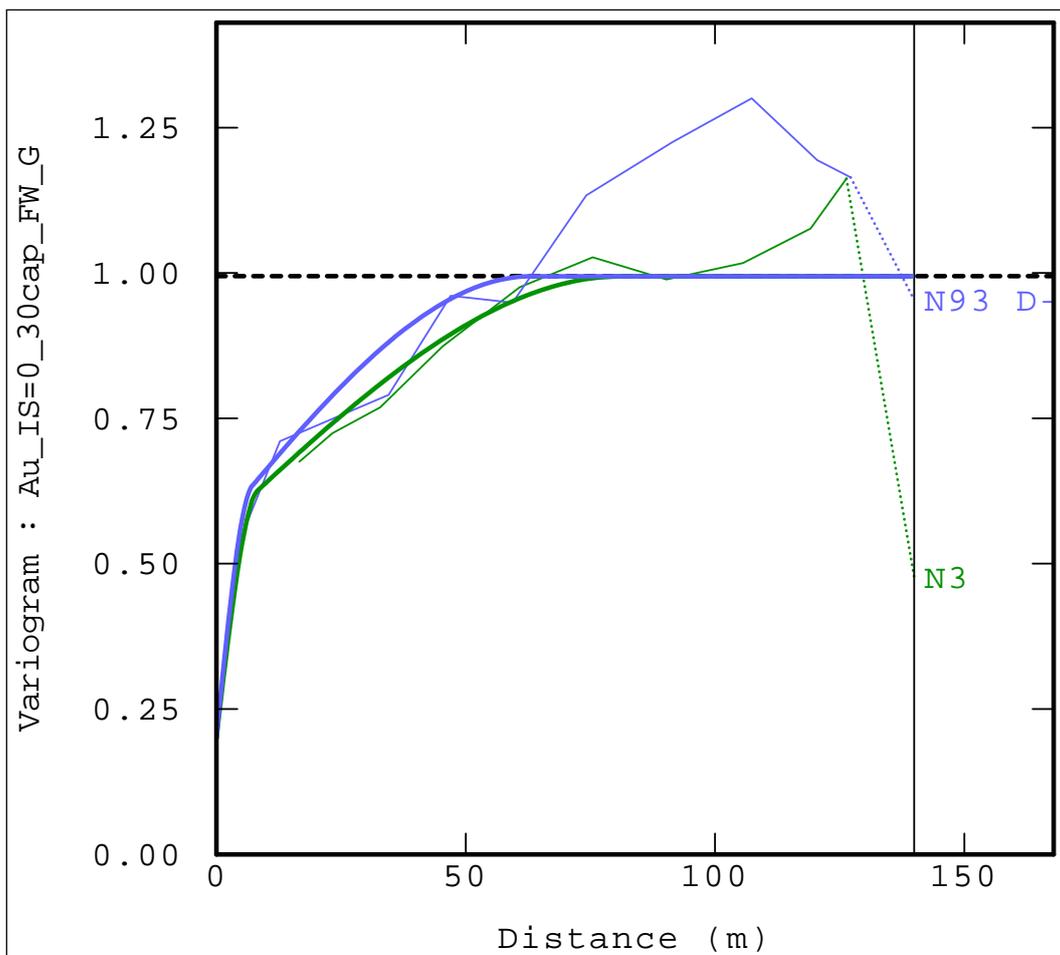
The MR semi-variograms produced good directional information and the maximum modeled range was 100 m using a lag of 15 m. The primary direction was modeled as a shallow plunge to the north roughly along strike of the orebody. The down dip direction also produced relatively good quality semi-variograms due to the increased amount of data available from the underground drilling. A maximum range of 55 m was modeled in this direction.

The footwall structure has sufficient sample intersections from the underground drilling to allow production of good quality semi-variograms for this structure. The models exhibited an almost isotropic nature with only a minor extension of the range in the along strike direction.

Once again the principle direction was modeled with a range of approximately 100 m.



**Figure 13-5 MR semi-variogram along strike (N8) and down-dip (N112) directions. Gaussian anamorphosis transformation**



**Figure 13-6 FR semi-variogram along strike (N3) and down-dip (N93) directions. Gaussian anamorphosis transformation**

**Table 13-3 Semi-Variogram Modelling Results for the Main Reef deposit**

Domain	Structure	Variance	Principle Direction plunge 00° to 005°	Secondary Direction plunge 60° to 275°
MR	nugget (C <sub>0</sub> )	13.5		
MR	spherical (C <sub>1</sub> )	10.8	90m	44m
MR	spherical (C <sub>2</sub> )	21.3	105m	57m

**Table 13-4 Semi-Variogram Modelling Results for the Footwall deposit**

Domain	Structure	Variance	Principle Direction plunge 00° to 005°	Secondary Direction plunge 60° to 275°
FR	nugget (C <sub>0</sub> )	10.8		
FR	spherical (C <sub>1</sub> )	13.0	9.2m	9.2m
FR	spherical (C <sub>2</sub> )	10.7	103m	52m

### 13.6 Block Model Grade Interpolation

Grade interpolation has been performed using ordinary kriging for all underground domains at Prestea. The MR, WR, FR and ST domains were interpolated directly, the HW and SP domains were filled using the geostatistical parameters derived from the MR analysis owing to lack of sufficient data points within these domains. The FW and HW are parallel structures to the MR structure and are assumed to form part of the MR mineralized domain and thus share its grade distribution characteristics. The WR is regarded as a separate structure from the MR to the north, given its location in the hangingwall of the main shear structure and the higher grades found within the WR deposit. Deposit contacts are interpreted as hard boundaries for the individual domains for the purpose of grade interpolation. As a result the composites used for the interpolation are clipped to the boundaries of the wireframe model.

Blocks were interpolated using an Ordinary Kriging algorithm in the Geovariance Isatis® software. Block size is 12.5 m x 25 m x 25 m (XYZ) and kriging was carried out in two phases. The first search was based on the ranges estimated from the experimental semi-variogram models and the second search was expanded to allow all remaining blocks in the model to be assigned a grade. Only those blocks filled in the first search pass were assigned an Indicated classification category, subject to additional kriging quality parameter results being met.

**Table 13-5 WR Kriging Search Parameters**

Search	Radius (m)			Samples	
	Strike	Dip	Perpendicular	Min	Max
a	200	100	20	5	20
b	500	500	50	2	20

**Table 13-6 MR Kriging Search Parameters**

Search	Radius (m)			Samples	
	Strike	Dip	Perpendicular	Min	Max
a	100m	60m	20m	3	16
b	500m	500m	50m	3	16

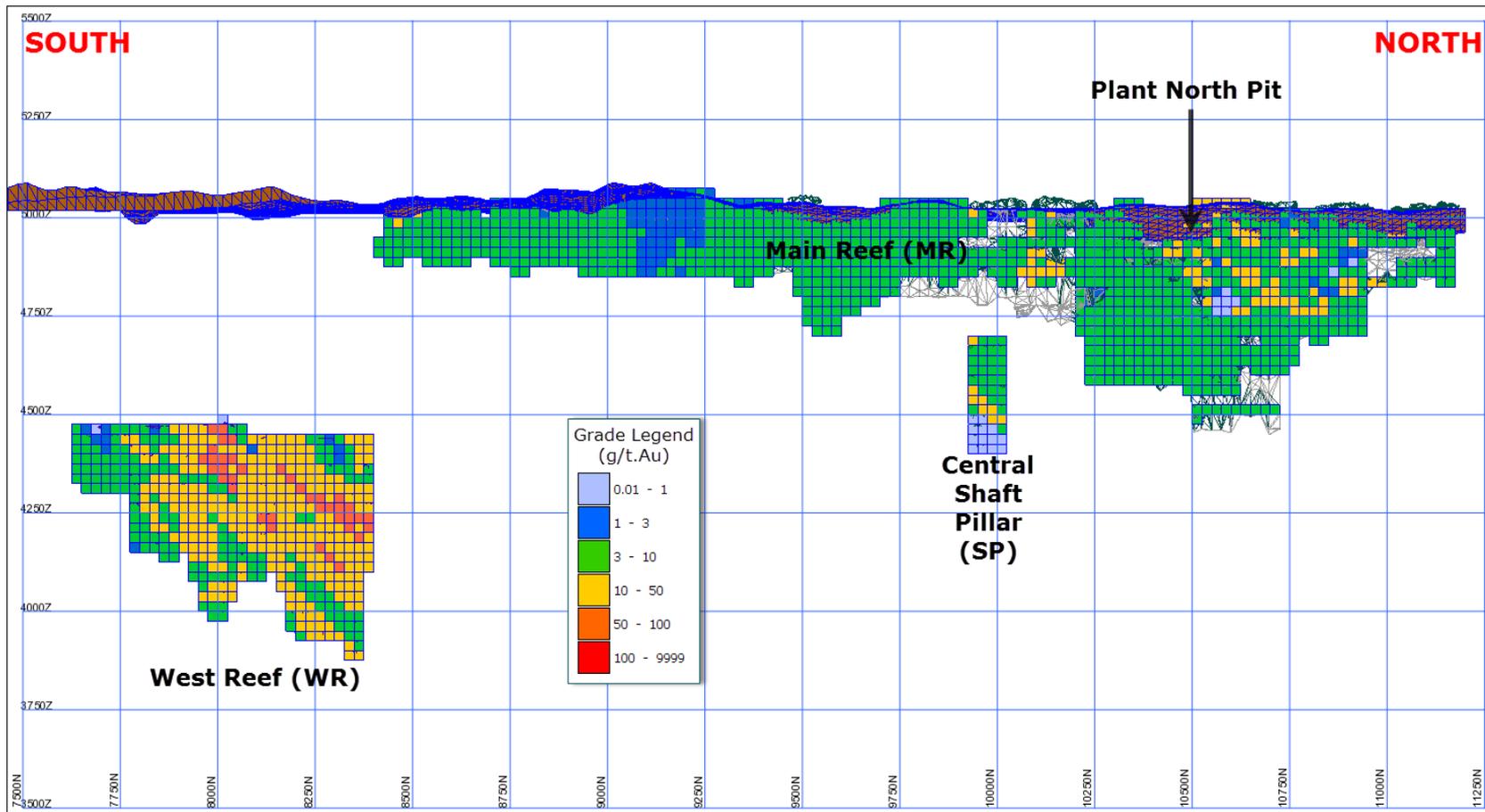
**Table 13-7 FR Kriging Search Parameters**

Search	Radius (m)			Samples	
	Strike	Dip	Perpendicular	Min	Max
a	100m	60m	20m	3	16
b	500m	500m	50m	3	16

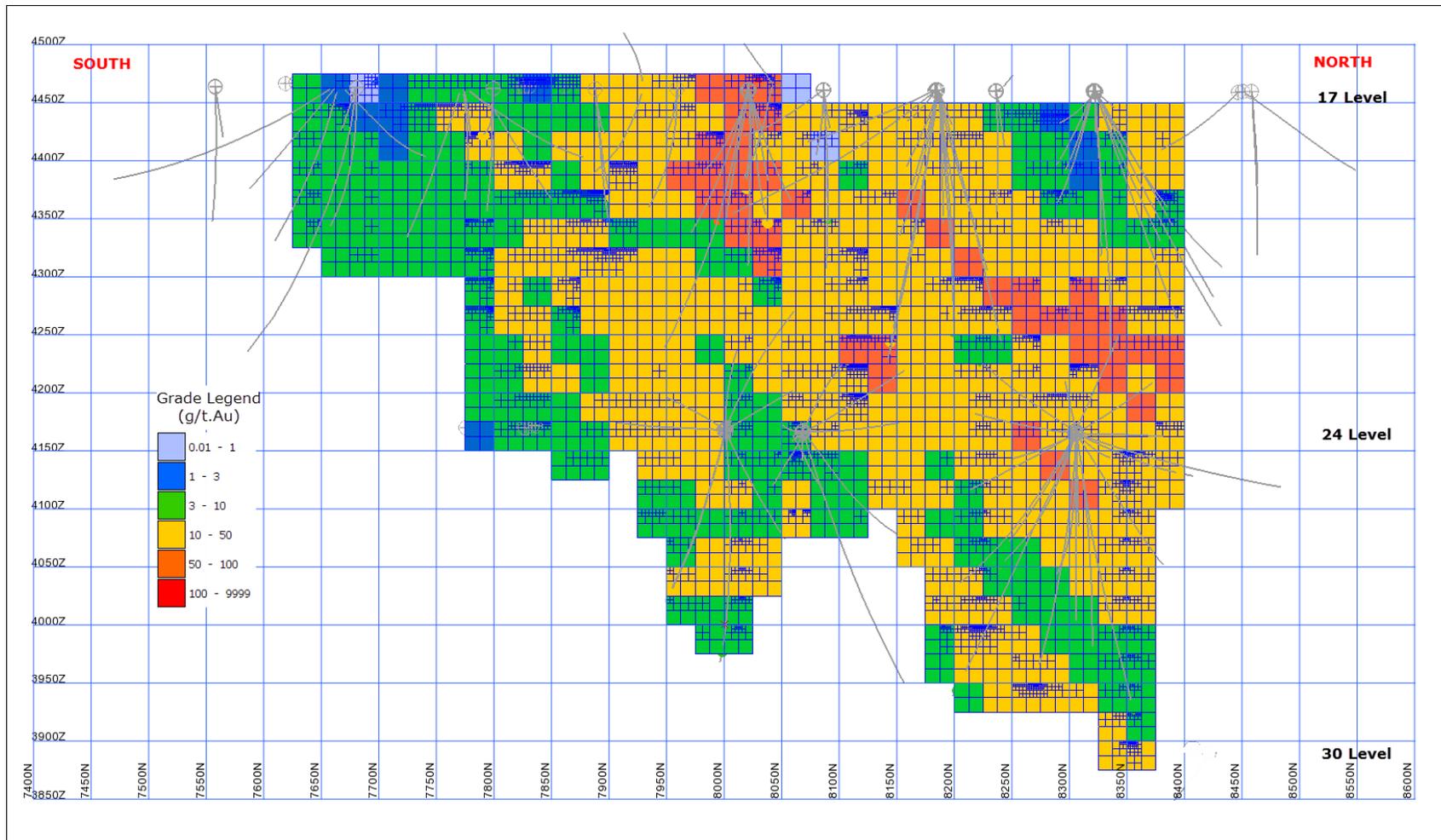
**Table 13-8 Block Model Dimension Parameters (lower left corner)**

Coordinate	Value	No. of blocks	Spacing (m)
x	11600	92	12.5
y	7400	152	25
z	3800	56	25
Rotation	000°		

Figure 13-7 shows a representation of the grade distribution in the Prestea deposits viewed from the Footwall. Figure 13-8 is a more detailed plot of the WR deposit showing the relative distribution of drill holes used for the interpolation. The plunging structure can be clearly seen as zones of high grade dipping to the north.



**Figure 13-7 Long Section looking west from the footwall, showing schematically the block grade distribution of the Prestea deposits highlighting the relatively high grade of the West Reef**



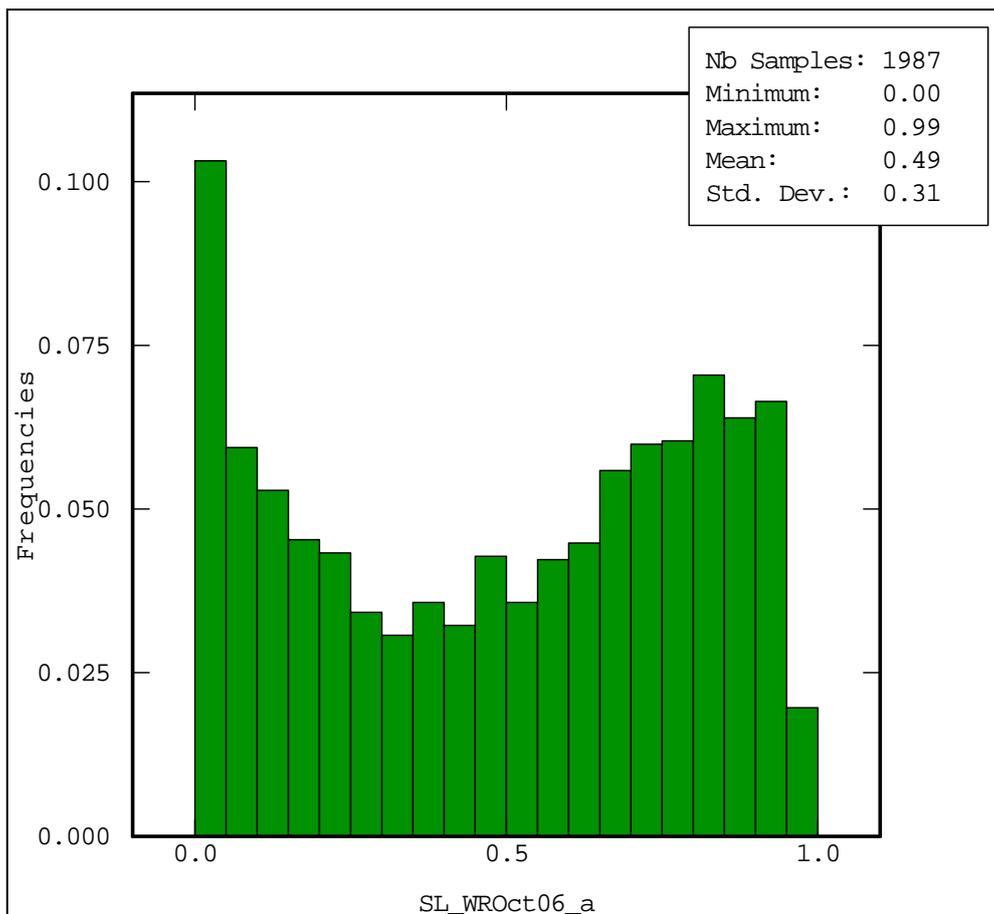
**Figure 13-8 VLP view from the east (footwall) of the West Reef Block Model showing the distribution of Au grade values after kriging and the available drill hole traces**

### 13.7 Resource Classification

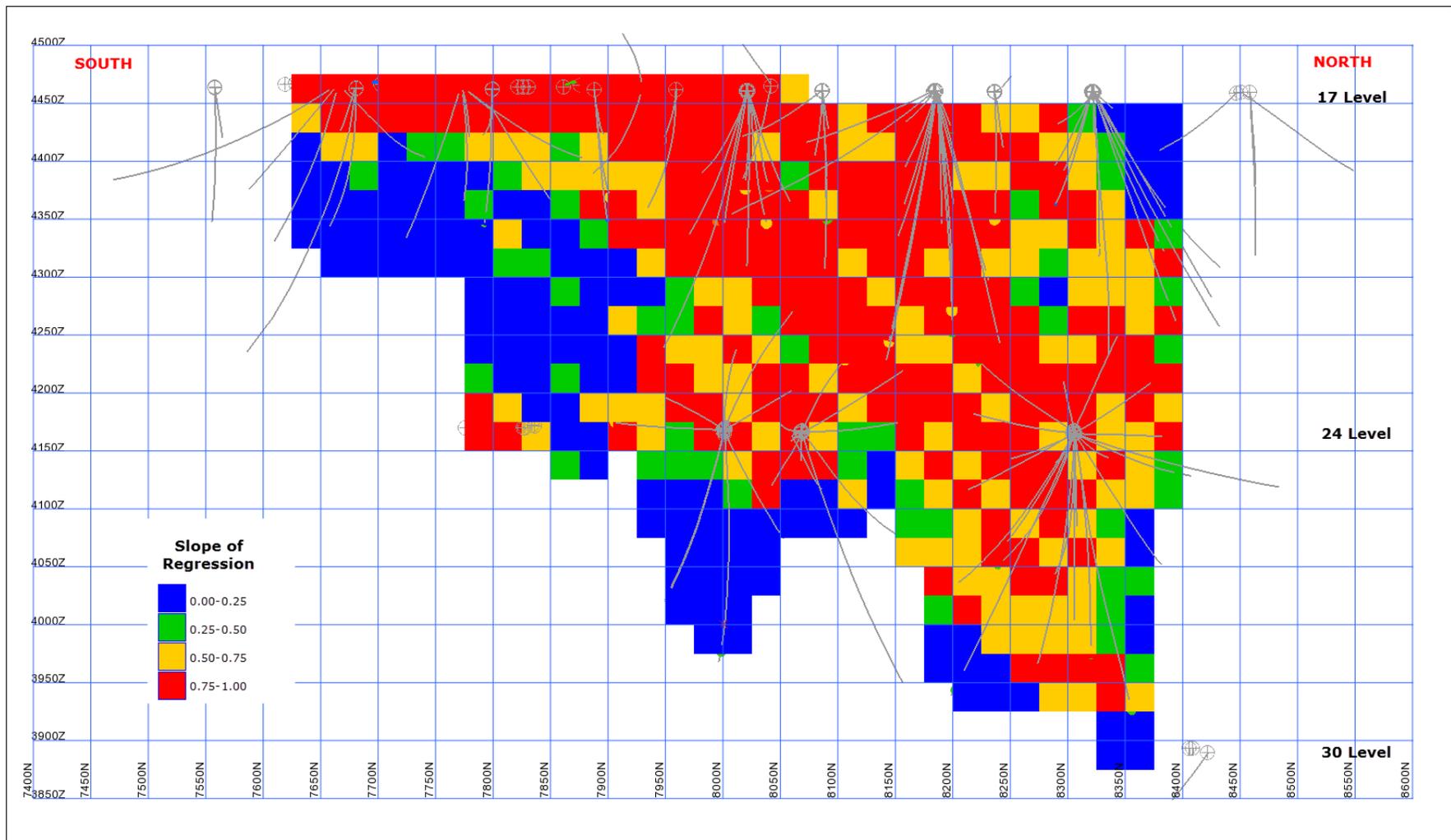
Mineral Resource classification is typically a subjective concept, industry best practices suggest that resource classification should consider both the confidence in the geological continuity of the mineralized structures, the quality and quantity of exploration data supporting the estimates and the geostatistical confidence in the tonnage and grade estimates. Appropriate classification criteria should aim at integrating both concepts to delineate regular areas at similar resource classification.

SRK is satisfied that the geological modelling honours the current geological information and knowledge. The location of the samples and the assay data are sufficiently reliable to support resource evaluation. The sampling information utilised for the resource classification was acquired primarily by DD core, RC and Reverse Air Blast (“RAB”) drilling on sections spaced at 25 to 50 m.

Classification was initially based on calculating a slope of regression ( $Z/Z^*$ ) value for individual blocks. All blocks filled using the wider search (search b) are assigned an Inferred classification category. Wireframes were constructed around blocks with a slope of regression (SL) value of generally greater than 0.8 and these blocks were assigned an Indicated category. However, the construction of the classification wireframe did not strictly adhere to the outline of the blocks with a SL value of  $>0.8$ , and there are areas where blocks of lower reliability are included in the Indicated wireframe for the purposes of continuity and where visual examination of the model in conjunction with the drill hole intercepts indicated that a high degree of confidence could be applied rather than relying solely on the statistical variable. At the WR, the large number of mineralisation intersections both along strike and down dip contribute to the increased confidence in the block grades. At MR, the number of blocks with a  $Z/Z^*$  value of greater than 50 % was low and the classification here has been based largely on the visual confirmation of grade continuity from analysis of drillholes sections.



**Figure 13-9 Histogram of Slope of Regression values for the West Reef after kriging using the short range search radius**



**Figure 13-10 VLP view from the east (footwall) of the West Reef Block Model showing the distribution of Slope of Regression values after kriging**

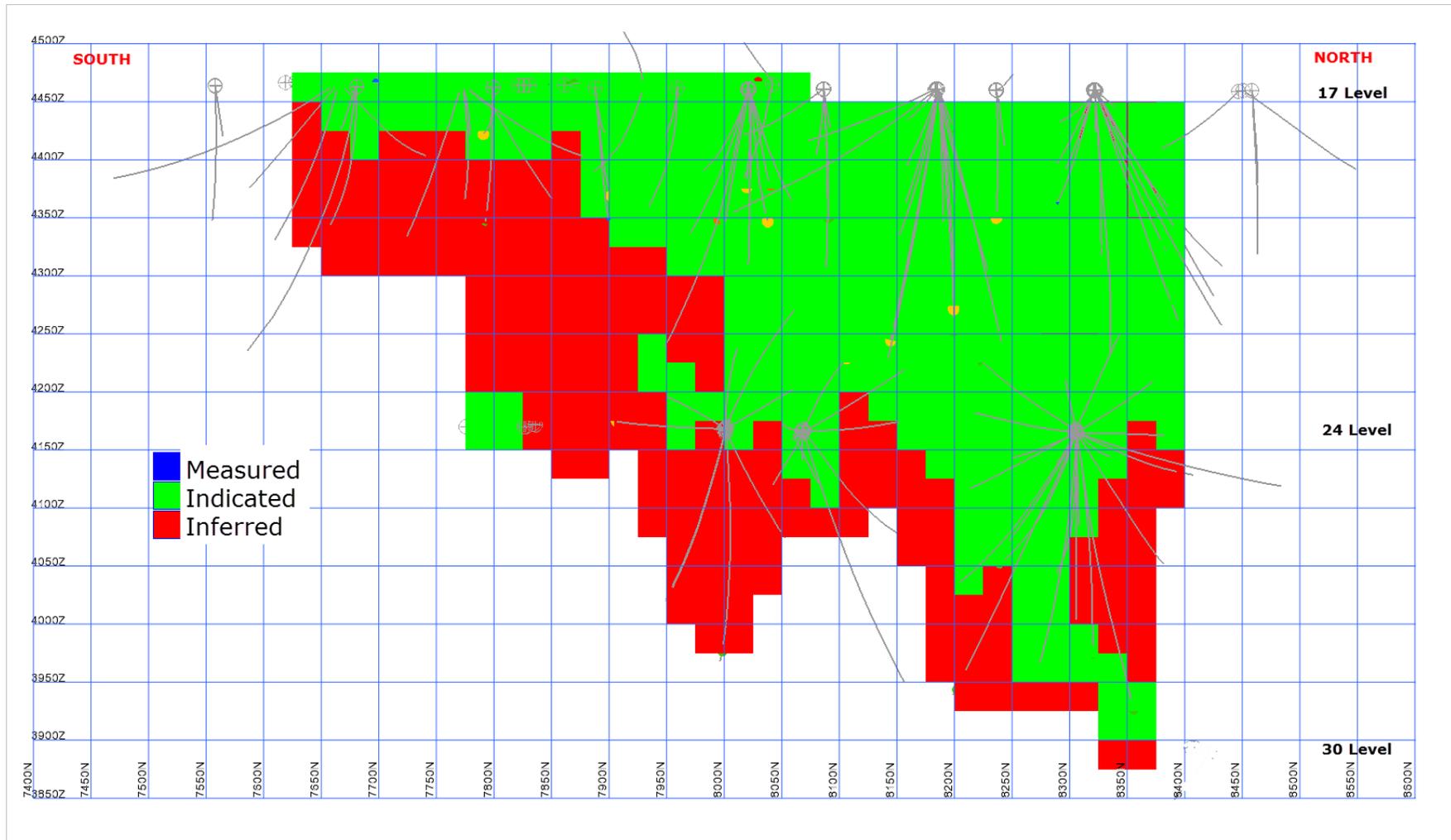


Figure 13-11 VLP view from the east (footwall) of the West Reef Block Model showing the distribution of Block Classification categories.

### 13.8 Mineral Resource Statement

Mineral Resources are reported inclusive of the material which makes up the Mineral Reserves, which are presented in Section 14 of this report. The “reasonable prospects for eventual economic extraction” requirement generally implies that the quantity and grade estimates meet certain economic thresholds and that the Mineral Resources are reported at an appropriate cut-off grade, taking into account extraction scenarios and processing recoveries. In order to meet this requirement, SRK considers that major portions of the Prestea deposits are amenable for underground extraction.

The Mineral Resource statement has been prepared using a block cut off grade of 3.08 g/t based on a US\$ 1 750 /oz gold price and appropriate costing data to produce a Mineral Resource which matches the requirements that the deposit should have “reasonable prospects for economic extraction” as defined by the CIM.

The statement was prepared by Dr. John Arthur who is a Qualified Person pursuant to National Instrument 43-101 and independent from GSBPL. The effective date of the Mineral Resource Statement is 1 May 2013. The Mineral Resource Statement for Prestea Underground, is given below in Table 13-9.

In declaring the Mineral Resources for the PUG deposits, SRK notes the following:

- The identified Mineral Resources in the block model are classified according to the CIM definitions for Measured, Indicated and Inferred categories and are constrained by a block cut off grade calculated using a gold price of US\$ 1 750 /oz and below the end of year topographic surface. The Mineral Resources are reported in-situ without modifying factors applied and are inclusive of the estimated Mineral Reserves;
- The Mineral Resource models have been depleted using appropriate topographic surveys and underground stope data, to reflect mining until the 1 May 2013;
- The Mineral Resources were estimated using block models. The composite grades were capped where this was deemed necessary, after statistical analysis. Ordinary Kriging was used to estimate the block grades. The search ellipsoids were orientated to reflect the general strike and dip of the modelled mineralisation;
- Block model tonnage and grade estimates were classified according to the CIM Definition Standards for Mineral Resources and Mineral Reserves (December 2005). The basis of the Mineral Resource classification included confidence in the geological continuity of the mineralised structures, the quality and quantity of the exploration data supporting the estimates, and the geostatistical confidence in the tonnage and grade estimates. Three-dimensional solids were modelled reflecting areas with the highest confidence, which were classified as Measured and Indicated Mineral Resources;
- All figures are rounded to reflect the relative accuracy of the estimate. All composites have been capped where appropriate; and
- Mineral Resources are not Mineral Reserves and do not necessarily demonstrate economic viability.

**Table 13-9 Prestea Underground Mineral Resource Statement 1 May 2013**

Orebody	MEASURED			INDICATED			INFERRED		
	Tonnes (kt)	Grade g/t Au	Content (koz Au)	Tonnes (kt)	Grade g/tAu	Content (koz Au)	Tonnes (kt)	Grade (g/t Au)	Content (koz Au)
Main Reef	-	-	-	325	6.02	63	2,955	6.08	580
West Reef*	-	-	-	863	18.27	507	510	11.62	190
Footwall	-	-	-	375	7.60	92	240	8.28	65
Hangingwall	-	-	-	-	-	-	60	3.2	5
Shaft Pillar	-	-	-	-	-	-	375	9.04	110
JCI Blocks	-	-	-	-	-	-	1,045	8.68	290
<b>Total</b>	-	-	-	<b>1,563</b>	<b>13.17</b>	<b>661</b>	<b>5,185</b>	<b>7.44</b>	<b>1,240</b>

\* The mineral reserves reported in this feasibility study relate to the mining of the West Reef resources only.

## 14 MINERAL RESERVE ESTIMATES (ITEM 15)

### 14.1 Introduction

The Mineral Reserves were estimated based only on the Mineral Resources that were classified as Indicated. In order to convert them to Mineral Reserves the wireframes were subjected to a detailed mine planning exercise based on the selected mining method of MCF which allows for a high proportion of orebody extraction by mining the deposit in a series of horizontal slices. This is described in further detail below and in Section 15.

### 14.2 Estimation Methodology

#### 14.2.1 Preliminary Cut-off Grade

The first step was to apply a preliminary in-situ cut-off grade to the indicated resource blocks to determine how many of the blocks would be sub economic to extract. These blocks would then be excised from the mine plan. The preliminary cut-off grade analysis assumed a number of parameters taken from the PEA and SRK's experience of similar projects. These are summarised in the table below.

**Table 14-1 Assumptions for Preliminary Breakeven Cut-off Grade (In-situ)**

Item	Unit	Value
Royalty	%	5
Refining cost	\$/oz	1
Dilution	%	40
Ore Mining Cost	\$/t ore	80
Ore Haulage Cost	\$/t ore	5
Process Cost	\$/t ore	15
Plant Recovery	%	90
General & Administration	\$/t ore	7

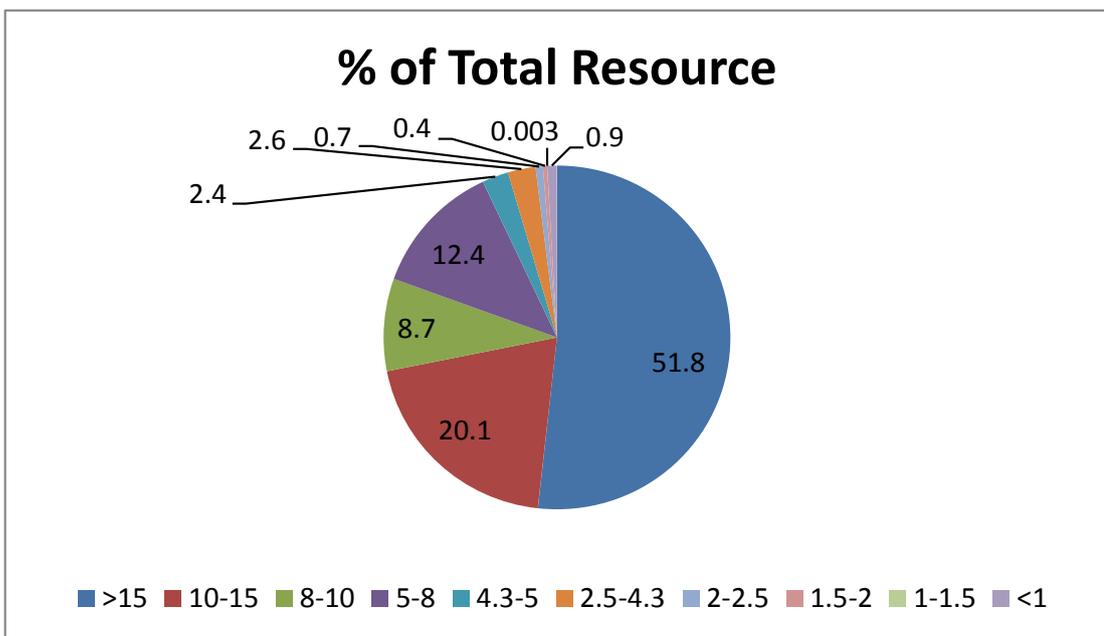
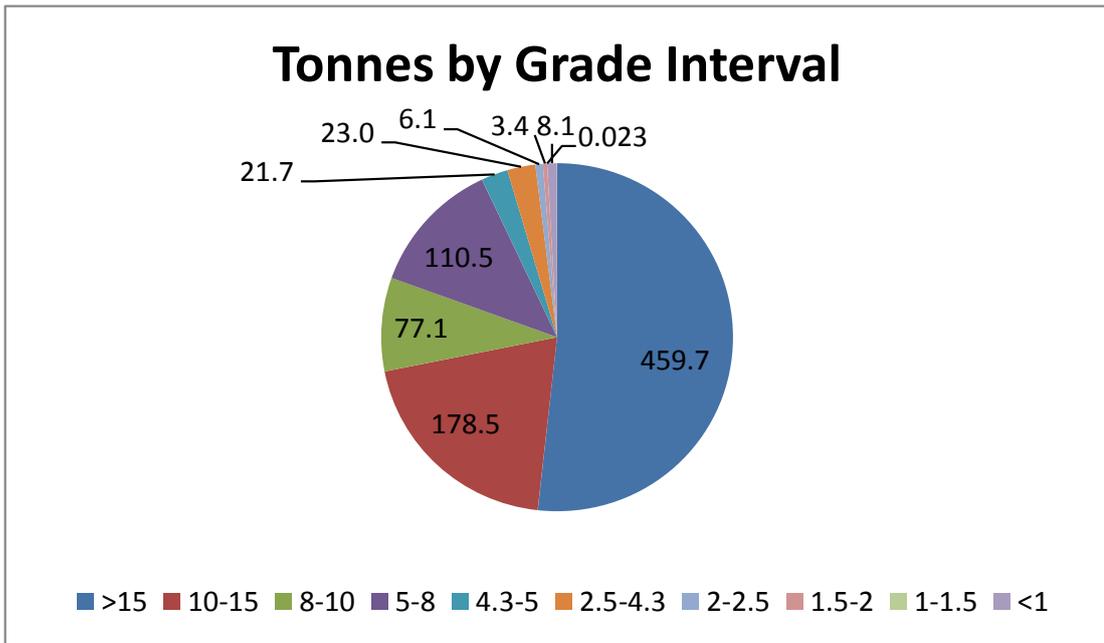
Using a gold price of US\$ 1 500 /oz an in-situ break even cut-off grade of 4.3 g/t is calculated. When this cut-off grade is applied to the available Indicated Resource the conclusion is that at total of 40.6 kt is excluded from a total resource of 888.1 kt at zero cut-off grade. This represents 4.6 % of the currently defined Indicated resource. Another consideration is that all of the WR must be drilled blasted and mucked in order to access the adjacent ore along strike. Therefore it is possible to consider incremental cut-off grades for the WRP. The process plant at Bogoso has sufficient capacity to take extra feed material so if ore carries enough grade to cover transport and processing costs then this material will not be considered to be waste and can be processed. The assumptions for this cut-off grade calculation are summarised in the table below:

**Table 14-2 Assumptions for Preliminary Incremental Cut-off Grade (In-situ)**

Item	Unit	Value
Royalty	%	5
Refining cost	\$/oz	1
Dilution	%	40
Ore Mining Cost	\$/t ore	
Ore Haulage Cost	\$/t ore	5
Process Cost	\$/t ore	15
Plant Recovery	%	90
General & Administration	\$/t ore	7

Using a gold price of US\$ 1 500 /oz an in-situ incremental cut-off grade of 1.1 g/t is calculated. When this cut-off grade is applied to the available Indicated Resource the conclusion is that a total of 8 kt is excluded from a total resource of 888.1 kt at zero cut-off grade. This represents 0.9 % of the currently defined indicated resource. The figures below illustrate the proportions of the resource tonnage which exist at certain grade intervals. Figure 14-2 shows that over 80 % of the resource tonnage has an in-situ grade of greater than 8 g/t and 93 % of the resource has a grade greater than 5 g/t.

**Figure 14-1 CoG Analysis – Resources Tonnes Split by Grade Interval**



**Figure 14-2 CoG Analysis for WRP Mineral Reserves**

Based on the above analysis, SRK concludes that there is no significant quantity of low grade material within the WR orebody that needs to be excised as part of the mine planning exercise. The WR orebody is a high grade shoot that warrants an approach to mining that targets a very high level of extraction. SRK considers that an appropriate strategy would be to send low grade material <4.3 g/t and >1.1 g/t to the mill as incremental ore and any material <1.1 g/t would be an insignificant quantity and could be either stockpiled or used as fill underground.

### 14.2.2 Stope Planning

Various drift profiles were appropriately assigned to the orebody according to ore width to determine the amount of dilution that is expected. On average the dilution skin that has been planned over the LoM using this process is equivalent to mining out a unit that is 2.4 m wide containing a 1.5 m wide orebody. Using the following formula which uses Waste and Ore widths,  $W/(W+O)$ , the expected dilution is 40 % and applying the alternative dilution formula  $W/O$  a dilution of 68 % is estimated. This level of dilution is considered appropriate for this type of orebody when benchmarked against other, similar operations. The wireframes for the planned stopes were queried against the block model and the total planned dilution came out to be 42.7 % using the  $W/(W+O)$  formula.

The dilution is assumed to carry zero grade and the application of an additional mining recovery factor of 95 % (5 % ore loss) allows for gold lost on the floor of drives and in the backfill. The LoM plan development design and subsequent production schedule had mining, processing and G&A costs applied to it in a financial model along with royalties and taxes. A base case gold price of US\$ 1 500 /oz was used for determining the Mineral Reserves. The revenues and costs were then used to calculate the project financial results.

SRK notes that in order to fully convert Mineral Resources into Mineral Reserves in accordance with the CIM Code, appropriate assessments and studies must be undertaken in a variety of fields that can impact on extraction viability. SRK notes the following:

- **Tailings disposal.** SRK has undertaken a review of the tailings facility and estimates that there is sufficient capacity to allow processing of the Mineral Reserves; and
- **Environmental management.** SRK has carried out a review of environmental matters as part of this planning exercise and is obliged to consider such aspects in the context of Reserve reporting. SRK considers that the management approach to this the WRP and track record are sufficient for the Reserve classification.

### 14.3 Mineral Reserve Statement

The Mineral Reserves have been prepared in accordance with CIM standard definitions for Proven Mineral Reserves and Probable Mineral Reserves. The Measured and Indicated Mineral Resources reported above include those Mineral Resources modified to estimate the Mineral Reserves.

The Mineral Reserve has been estimated using accepted industry practices for underground mines, including the identification of the optimal final ore envelope(s) based on the selected MCF mining method, appropriate modifying factors and Cut-off Grade (“CoG”) calculations based on detailed cost estimation. The identified ore bodies were subjected to detailed mine design, scheduling and the development of a cash flow model incorporating the company’s technical and economic projections for the mine for the duration of the LoM plan. A base case gold price of US\$ 1 500 /oz was used for the Reserves.

Any mineralisation which occurs below the cut-off grade or is classified as an Inferred Mineral Resource not considered as Mineral Reserves and is treated as mineralised waste for the

purposes of the LoM plan. The GSBPL Mineral Reserve Statement as of 1 May 2013 is presented below in Table 14-3.

**Table 14-3 GSBPL Mineral Reserve Statement for WRP, 1 May 2013**

Category	Quantity (kt)	Grade (g/t Au)	Metal Content (koz Au)
Proven	-	-	-
Probable	1,434	9.61	443
<b>Total Mineral Reserves</b>	<b>1,434</b>	<b>9.61</b>	<b>443</b>

The QP with overall responsibility for reporting of Mineral Reserves is Mr Michael Beare, a Corporate Consultant (Mining Engineering) with SRK. Mr Beare has 20 years' experience in the mining industry and has been involved in the reporting of Mineral Reserves on various properties in Europe and Africa during the past ten years.

The MCF method allows for a high proportion of orebody extraction by mining the WR deposit in a series of horizontal slices. On average the dilution skin that has been planned over the LoM using this process is equivalent to a mining width of 2.4 m containing a 1.5 m wide orebody which results in an average planned dilution of 42.7%. The dilution is assumed to carry zero grade and in addition to an allowance for ore losses of 5% has been applied. The realisation of the above Mineral Reserve is dependent on the specified underground development, mining methods and equipment where necessary to achieve planned production rates and efficiencies.

The Mineral Reserve for the WRP has been determined using a CoG based on the TEM prepared by SRK. The parameter inputs for the Mineral Reserve CoG are summarised below in Table 14-4.

**Table 14-4 Input Parameters for Mineral Reserve CoG**

Item	Unit	Value
Royalty	%	5
Refining cost	\$/oz	5.00
Ore Mining Cost	\$/t ore	125.37
Ore Haulage Cost	\$/t ore	5.52
Process Cost	\$/t ore	15.00
Plant Recovery	%	90
General & Administration	\$/t ore	19.29
Contingency	\$/t ore	16.67

The graph in Figure 14-3 provides the CoG for Mineral Reserves at the WRP for a range of gold prices. Based on the anticipated costs, recoveries and a gold price of USD\$ 1,500/oz an operating CoG of 4.7 g/t Au is estimated which is less than the planned mining grade by a substantial margin.

SRK notes that the incremental cut-off grade at US\$ 1 500 /oz when revised with inputs from the TEM is 1.02 g/t. In this case all of the inputs are as presented in Table 14-4 but mining costs and contingency are zero. SRK concludes that applying an incremental cut-off grade to the indicated resource result in no significant tonnage of material to be excised from the LoM plan.

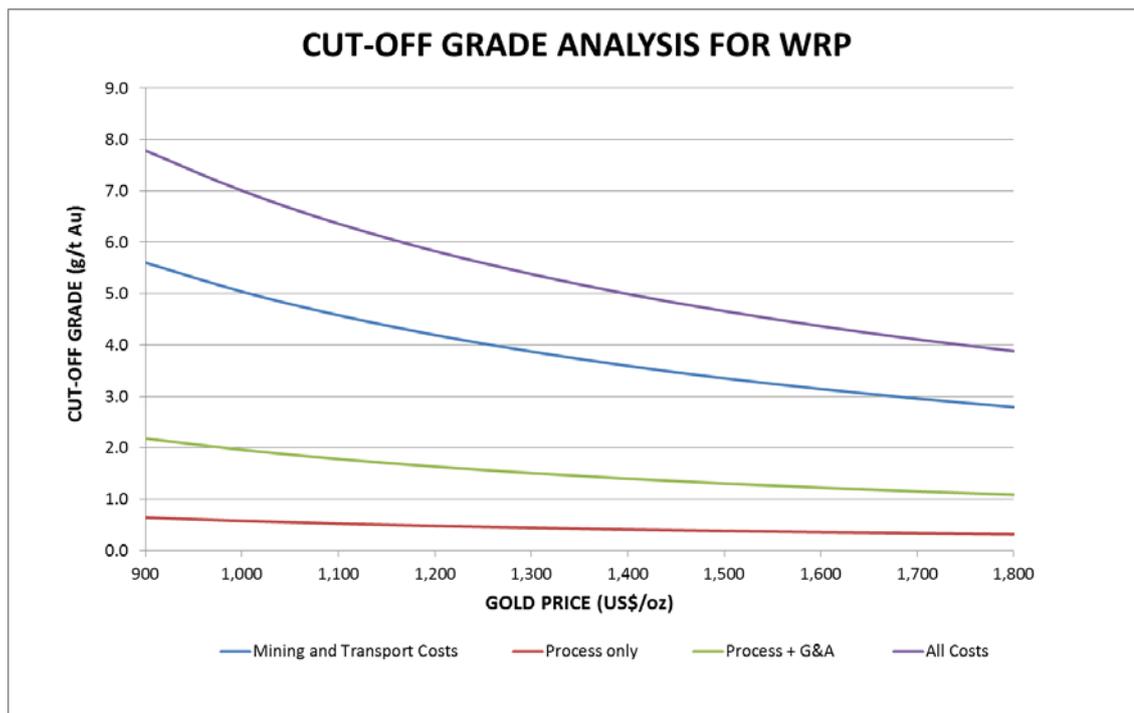


Figure 14-3 CoG Analysis for WRP Mineral Reserves

## **15 MINING METHODS (ITEM 16)**

### **15.1 Introduction**

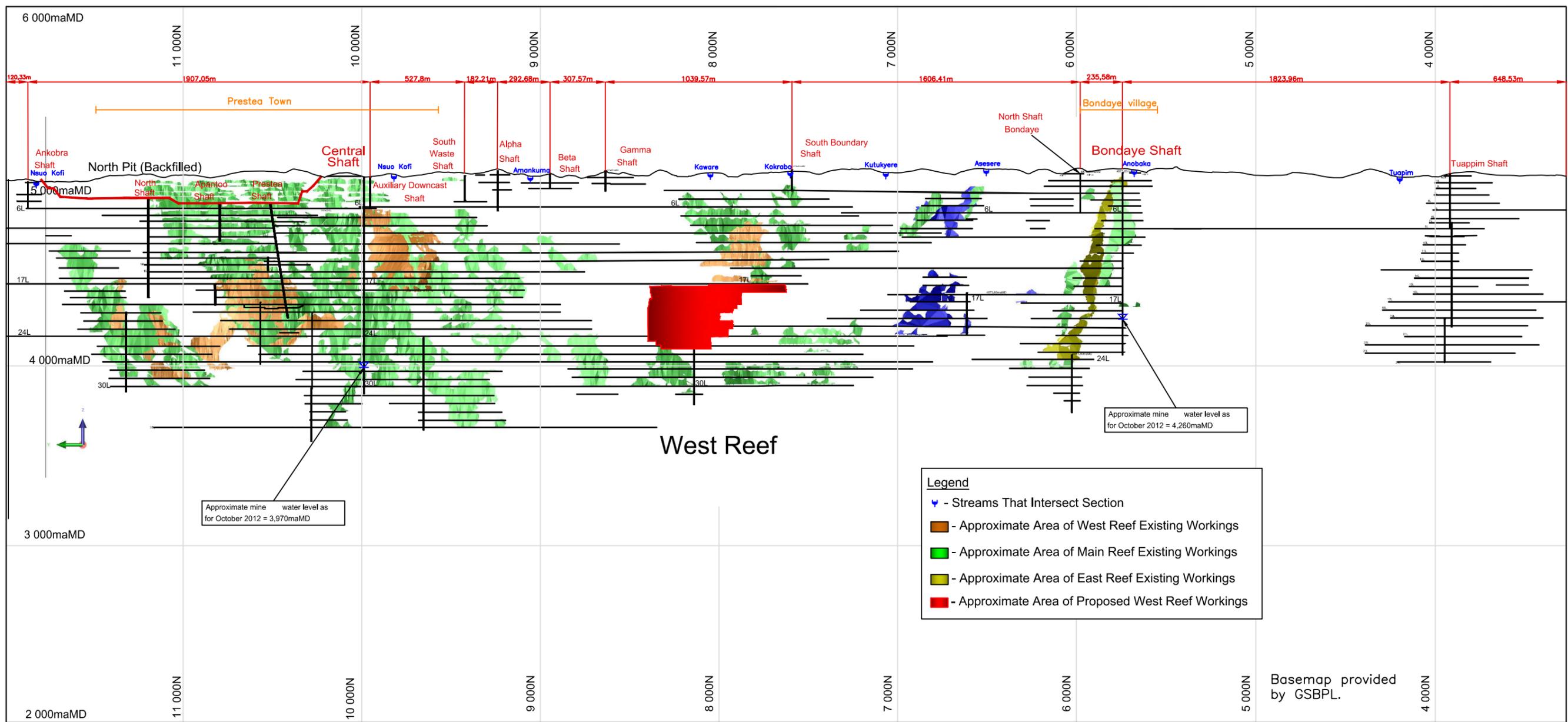
The PUG has been historically mined for more than 100 years by a number of mining companies. The mining operation extends over a strike length of about 6 km on the Ashanti Trend and the mine has been exploited down to a maximum depth of about 1 450 m over a portion of that strike length. Previous underground operations ceased in early 2002, following an extended period of low gold prices and the mine has been on C&M since that time.

The principal WR orebody under consideration for the FS is located approximately 2 km south of the Prestea Central Shaft at a depth of between approximately 600 and 1 100 m below surface. Access to the West Reef ore body is via Central Shaft on the existing 17 L and 24 L main access levels.

A long section of the existing workings is provided in Figure 15-1 below. The key access to PUG is via the Central Shaft which is currently in reasonable working order. The shaft is currently undergoing refurbishment of the internal steel work to allow rock hoisting to recommence. The second important opening is the Bondaye Shaft to the south which is currently only used for pump access and emergency egress due to the poor condition of the shaft steelwork. It is envisaged that the Bondaye Shaft will be refurbished to allow it to function as a second form of egress until such time as a new opening to the mine is constructed.

The approach to mining the West Reef at Prestea requires flexibility so a conventional trackless drill and blast operation is considered the most appropriate. Primary development will be carried by electric-hydraulic drill jumbos with mucking by diesel loaders into trucks.

The results of the FS technical work are presented in the following sections.



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PRESTEA WRP FEASIBILITY STUDY



Longitudinal View of the Prestea Underground Mine Workings

Figure 15-1

### 15.1.1 Prestea Orebodies Description

Mineralization at Prestea occurs as refractory and non-refractory gold in quartz reefs and disseminated gold in sulphide impregnated zones. Three major quartz vein channels, adjoined by graphitic fault gouges with carbonaceous / broken quartz materials, have been the principal source of historical production. They are the Main, East and West Reefs. They occur as discontinuous lenses, trend at N249° and dip on average 65° to the northwest.

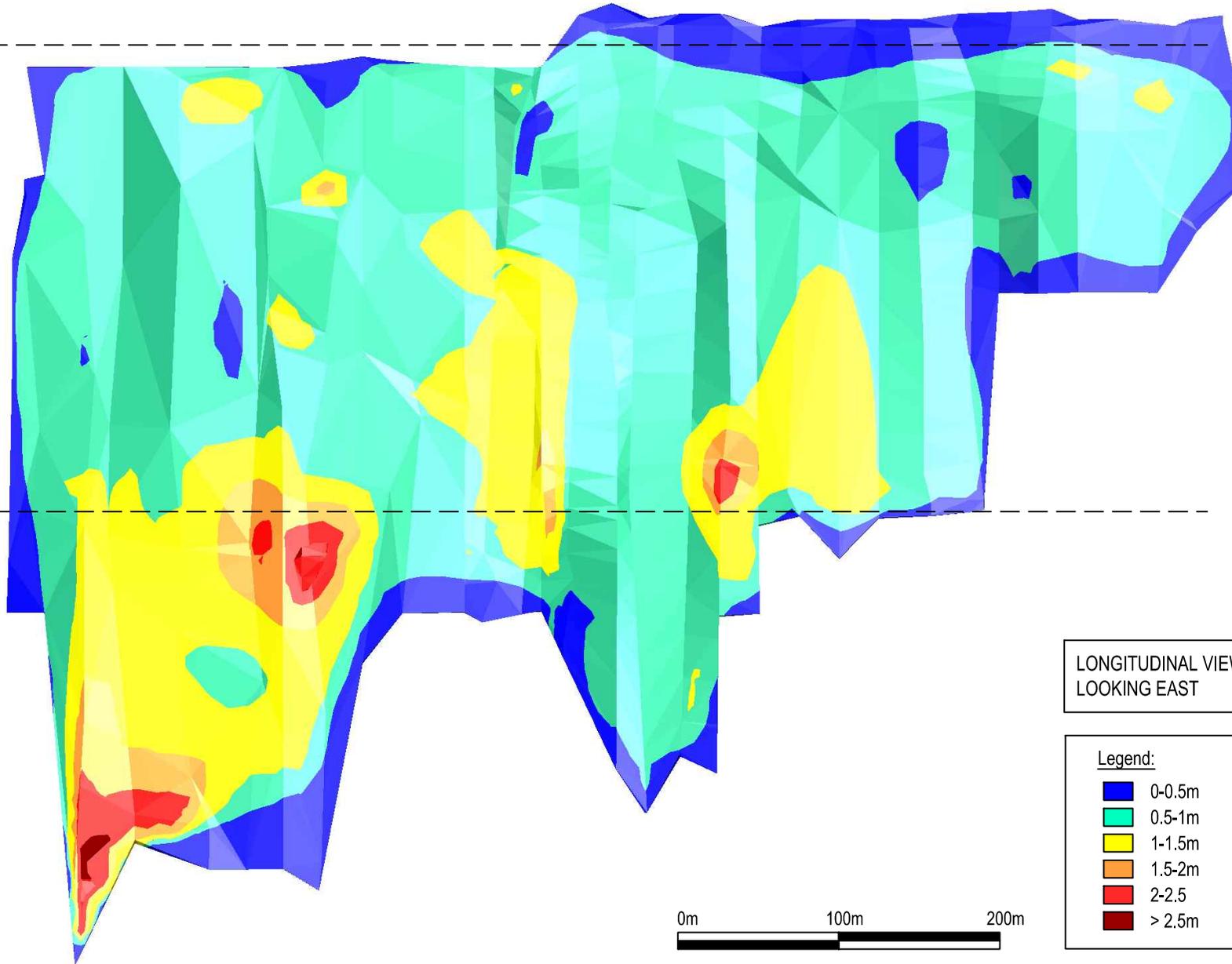
The West Reef is a steeply dipping laminated quartz vein within a graphitic shear zone running sub-parallel to and in the hangingwall of the Main Reef. The West Reef orebody is a tabular structure that dips at an average angle of 65° from horizontal and has an average thickness of 1.5 m. Locally the thickness varies between 1.5 m to 3 m in places and the orebody dip can vary from 55 to 65°. Figure 15-2 provides long and section views of the West Reef RP orebody.

A key feature of the West Reef orebody is the ground conditions. The country rocks on either side of the orebody are competent volcanic rocks considered ideal for hosting access excavations. However, the West Reef itself is a package of rocks comprising a hard quartz reef within a suite of argillaceous, graphitic schists. The schists are laminated parallel to the reef and are typically present on either side of the payable quartz reef.

17 Level

350m

24 Level



LONGITUDINAL VIEW  
LOOKING EAST

Legend:

- 0-0.5m
- 0.5-1m
- 1-1.5m
- 1.5-2m
- 2-2.5
- > 2.5m

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Prestea WRP FS

Not To Scale



Long View of West Reef Orebody Thickness

Figure  
15-2

### 15.1.2 Historic Mining Methods

Historically, a number of methods have been used at Prestea. Essentially, all have been non mechanized methods using hand-held compressed air powered rock drills. The principal mining method has been an inclined rill and fill and to a lesser extent, shrinkage stoping has been used. All stoped ore was loaded via chutes onto rail cars on the stope bottom level. In some cases, the haulage way is located on the reef itself and in other cases, in the FW of the reef.

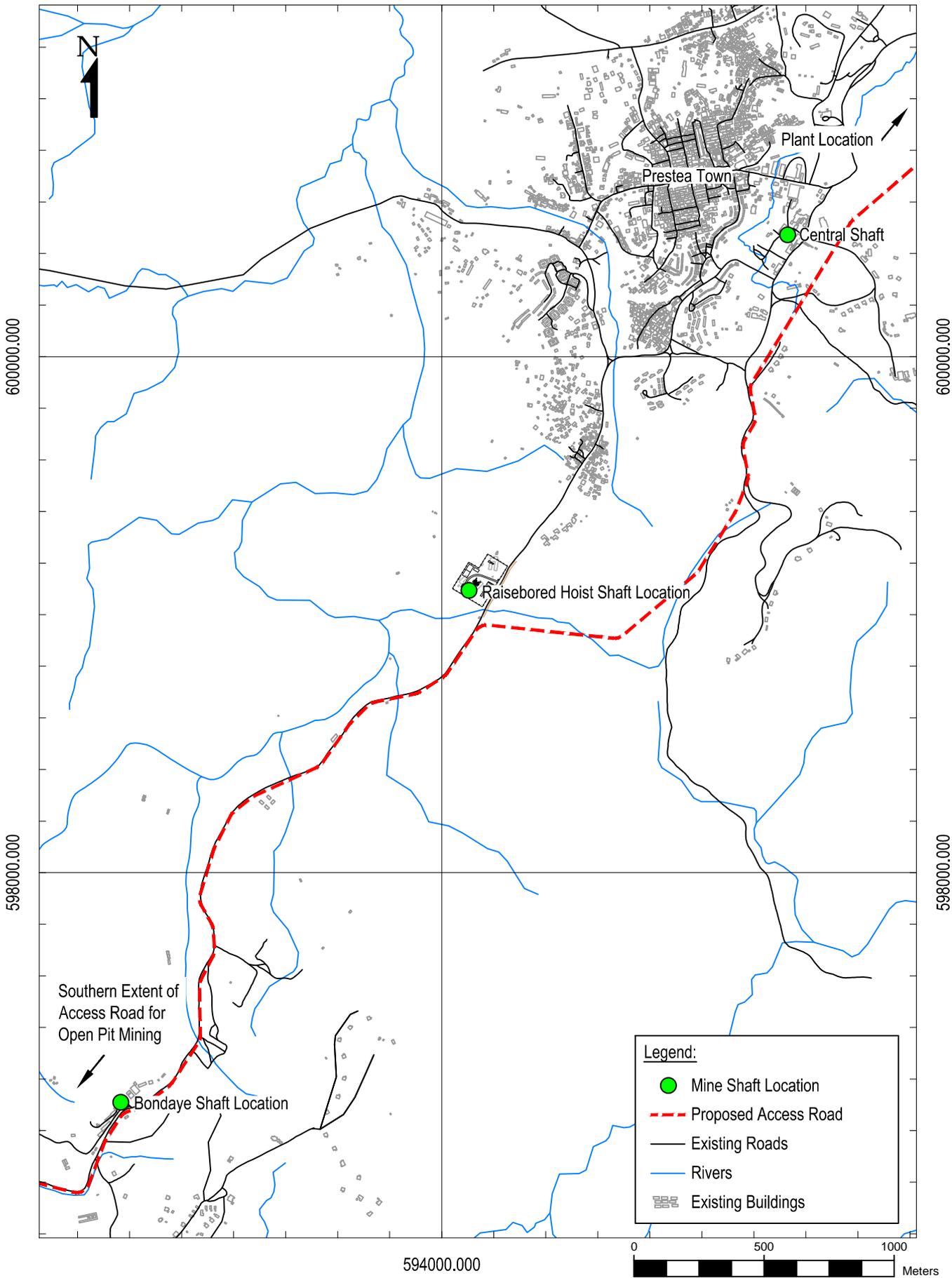
The inclined drift and fill method involved ladder raise access from the haulage level and establishment of a sill drift above the level. Ore would then be slashed from the back to create a cone of ore centrally in the stope. Filling would typically be via a centrally located stope raise to the haulage level above. Backfill was typically waste rock although in the upper levels some sand tailings were used. To obtain enough waste for backfill it was sometimes necessary to mine waste chambers specifically for that purpose. The waste rock, when tipped down the raise, would form a cone inside the stope. Timbers would be placed over the waste and the next blast of ore would then proceed with the broken ore rolling down the timbers to the chute below. Productivity per stope was likely low, significant ore was unrecovered in pillars.

### 15.1.3 Existing Mine Infrastructure

#### ***Surface Infrastructure***

Figure 15-3 shows a plan of the Prestea Mine and the locations of the key shafts and site access.

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P:\U4935 PRESTEA FS\PROJECT\CAD\REVISED REPORT FIGURES - JUNE 2013 REVISION\CHRIS BRAY REPORT FIGURE\FIG.15-3 - PLAN VIEW OF MINE AREA.DWG

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Prestea WRP FS

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Plan View of Mine Area

Figure 15-3

### **Central Shaft**

Central Shaft was sunk in 1935. It is a rectangular, steel sett shaft 7.5 m x 3.0 m and sunk down to the 30 L at a depth of 1204.5 m below collar level (“bcl”), with skip loading pockets at just below 20 L (708.5 m bcl) and 25 L (941.8 m bcl) levels.

The shaft is generally unlined having been excavated through competent rock, although there are some sections of concrete where loose ground occurred.

The shaft has 4 compartments, where compartments 1 and 2 are designated for the skip hoisting with a maximum skip capacity of 7 t. Compartments 3 and 4 house the double deck man and materials cages, each with a capacity of 15 men per deck and rails at 18” gauge for small tubs and material trollies.

Central Shaft has been on care and maintenance for about twelve years and has been the subject of previous reports by other third parties during this time. These previous reports identified various infrastructure issues and problems and there have been significant rehabilitation and repair efforts. The FS investigations indicate the current condition of the Central Shaft with recommendations for the works required for it to become fully operational.

### **Bondaye Shaft**

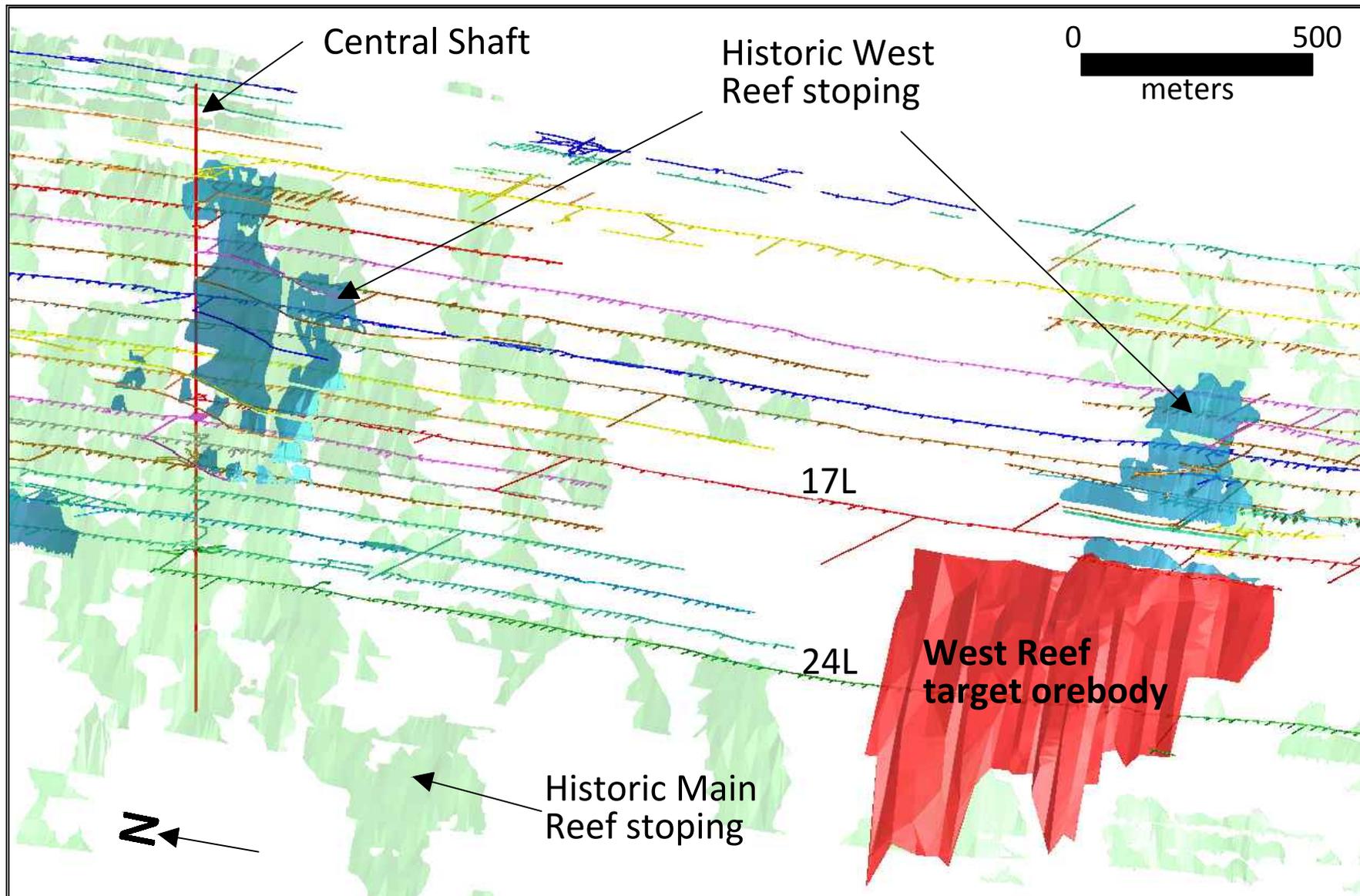
Bondaye Shaft, also known as Bondaye Main Shaft, is rectangular in construction and has been sunk to a depth of 1 012 m bcl, according to mine drawings. The shaft is currently equipped with steel setts and has cross sectional dimensions of approximately 3.9 m x 1.6 m. The shaft has four compartments, two service conveyance, one services and one ladder way. Bondaye Shaft requires repairs to the steelwork to be fully operational but is currently used for essential access to the pumps close to the shaft and for emergency egress.

### **Horizontal Development**

The West Reef is situated between Central Shaft and Bondaye Shaft and is accessible from existing levels and haulages. Refer to Figure 15-4 for details. The top access for the West Reef mining area is on 17 L and the reef dips at approximately 65° to just above 30 L. Table 15-1 below summarises the dimensions of 17 L. The level is currently equipped with 457 mm steel track in an operable but poor condition served by electric locomotives. The level also has services in the form of water and compressed air piping.

**Table 15-1 Existing FW Drift dimensions for 17 L**

<b>Measurement</b>	<b>Width (m)</b>	<b>Height (m)</b>
Average	2.85	2.49
Minimum	1.8	1.7
Maximum	3.8	3.2



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Prestea WRP FS

Not To Scale



Isometric View of Existing Workings Showing the West Reef

Figure 15-4

**Ventilation**

SRK notes that PUG is old and is complex having been expanded over many years. There are many small shafts, raises, and assorted connections. The relevant ones must be taken into account for planning purposes, as they will provide points of leakage and short circuiting of ventilation air from the intake to the return. It should be noted that not all connections to surface are currently known due to the activities of small scale miners in the area.

There is a single upcast shaft, known as the South Waste Shaft. This circular shaft of 4.7 m diameter shaft has a cross sectional area of 17.5 m<sup>2</sup>. The main fan is a single Aerex Model 287 WZF radial bladed fan with a 485 kW motor which provides all the primary airflow for the PUG. The fan and motor have recently failed and are in the process of being replaced. Provision is made in the capital estimate to replace the fan and the switchgear because the fan is required to serve the WRP during its construction and early development phases.

**Underground Dewatering**

The existing underground pumping systems for the Central Shaft (Figure 15-5) and Bondaye Shaft (Figure 15-6) are unreliable and require investment due to the following:

- There is currently a large variety of pump types and pump manufacturers which requires a large stock of a variety of spare parts. Pump spares are difficult to source as some of the pumps are old and obsolete;
- There are a large variety of pump motors operating at various voltages, with some motors obsolete and not complying with standards normally in use at underground mines;
- Electrical switchgear is generally obsolete and not compliant to modern electrical standards; and
- The current settling facilities are inadequate for handling dirty mine return water once production commences in the WRP.

However, it should be noted that failure of the pump system results in the mine slowly beginning to flood. Given the slow rise in the water level that would be expected there is considered sufficient time to effect the necessary repairs. The existing pumping system requires work but it is not considered a high risk issue for the WRP.

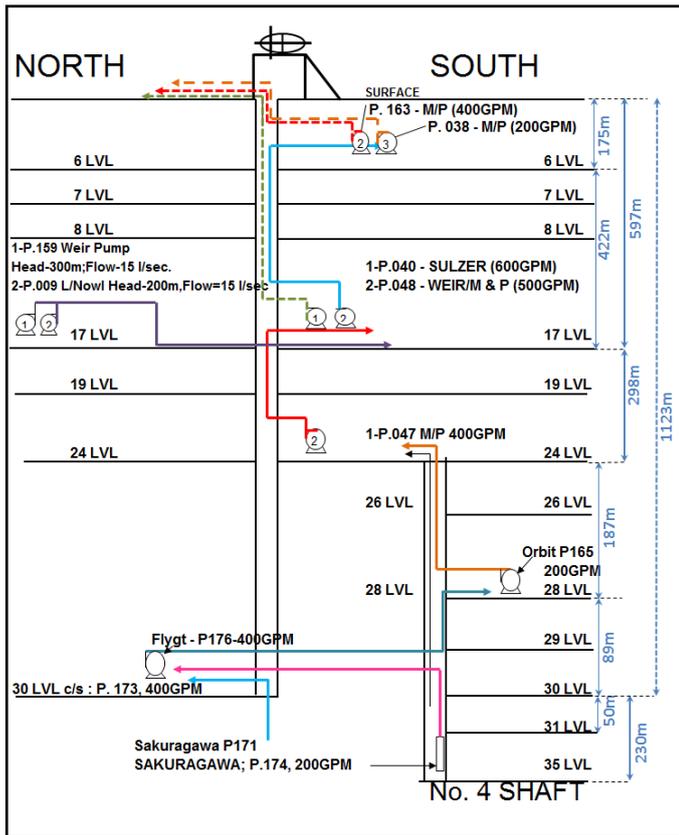


Figure 15-5 Schematic of existing dewatering system at the Central Shaft

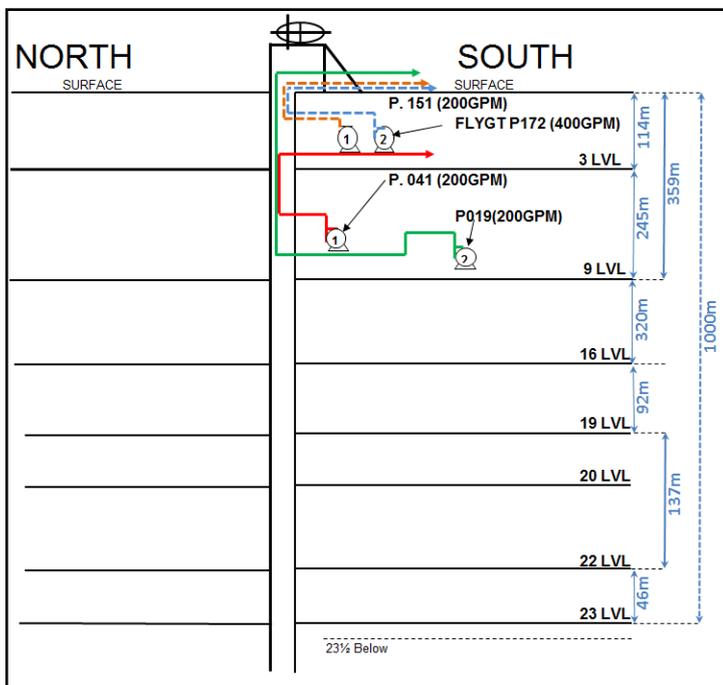


Figure 15-6 Schematic of existing dewatering system at the Bondaye Shaft

### **Electrical Infrastructure**

The current mine workings at Prestea have the electrical power supplied from the Ghana National Grid, GRIDCO. The GRIDCO transformer yard is situated 1 km from the Central Shaft and does not require modifications for the WRP. The existing Prestea main surface substation is heavily loaded, but is sufficient to provide power to the local town, Prestea offices and workshops, winders (Central and Bondaye), the fan on the South Waste Shaft, the existing compressors and the existing pumping system. The PUG system will however require an upgrade in order to do the following:

- Adhere to Ghanaian electrical regulations;
- Provide reliable power to the pumps that maintain the water level in the Prestea Mine;
- Facilitate the activities required for the implementation of the WRP such as provide power to the Central Shaft winder during the early works for the WRP; and
- Integrate with the WRP installations at the location for the new shaft infrastructure.

## **15.2 Mining Method Selection**

The following mining method options were considered for selection to take through to the FS mine design for the WRP:

- Longhole Open Stopping;
- Avoca Mining Method (“AMM”);
- Shrinkage Stopping;
- Conventional Underhand and Overhand Stopping;
- Captive Cut and Fill (“CCF”); and
- Mechanised Cut and Fill or MCF.

The following points summarise the key considerations in selecting the mining method for the WRP:

- Longhole Open Stopping (AMM, if fill is placed as part of the extraction sequence). SRK notes that longhole stopping has been rejected mainly on account of excessive dilution as a result of the weak graphitic hangingwall and footwall material and the fact that when the high cost drilling through variable ground is considered, other methods cost the same but offer less dilution;
- SRK notes that the shrinkage stopping is not a suitable approach due to the fact that it is low productivity, labour intensive, delays broken ore for long periods and is less safe than other methods. There is also the risk of substantial sidewall failures when the stope is drawn. This could result in loss of ore because the resulting oversize may be difficult to remove;
- CCF is not attractive due to its labour intensive nature and the fact that piped backfill is not available for the WRP; and
- Conventional methods whether underhand or overhand are also unattractive due to the fact that these methods are labour intensive and involve men in stopes. Adequate control of footwall and hangingwall dilution would also be difficult to achieve. The narrow width of the stopes would make installation of effective ground support challenging.

Based on the points above and SRK’s experience of operating underground mines in similar ground conditions SRK concludes that MCF is the most suitable method to apply to the WRP.

Due to the high average in-situ grades, in the region of 18 g/t Au, the MCF method allows for maximum extraction of the WRP Mineral Resources with the use of backfill and mining on a continuous sequence basis.

### 15.2.1 Mechanised Cut and Fill (MCF) Stopping

The undercut MCF method is essentially drifting on either side of a central access ramp to the end of a panel. Mining commences at the bottom of a panel and progresses upwards. As each set of drifts are completed, they are filled with backfill, typically cemented rock fill for sill pillars and waste rock for other areas. After the fill is placed, the access ramp is slashed upwards to mine the next lift. After the new access is complete, the next lift is taken working on the fill from the lift below. The benefits of MCF are as follows:

- High level of orebody recovery. The ore is drilled with short holes so mining can be selective with low dilution from blasting;
- There is not the risk of losing costly drill strings in stopes so this method can cost the same or less than longhole open stoping. This is a key consideration given the variable ground conditions expected in the West Reef;
- The risk of dilution resulting from large scale stope wall failures is eliminated. The walls and back of the extraction drifts can be supported as development progresses. Dilution is limited to the minimum size of excavation required to cater for the LHD equipment; and
- It is a safer method than shrinkage or underhand or overhand methods. This is due to the fact that a stable, even working platform is provided by the fill. Drilling can be completed by a single boom jumbo which is more productive and safer than hand held methods.

The drawbacks of this method are:

- Works best with piped backfill. This type of fill is not available for the WRP but waste rock can be used as a suitable alternative;
- Productivity is limited to the number of headings and how quickly they can be rotated; and
- The cyclical nature of MCF means that services have to be installed and re-installed from the same access. However, all the methods considered require preparation and this is not a material issue.

### 15.2.2 Detailed Description of MCF

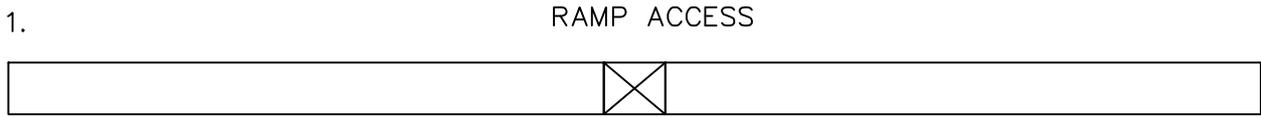
MCF is the mining method considered to be the most appropriate and lowest risk (from a dilution and operating cost perspective) based on the current level of information on the orebody. The approach is a simple one and is illustrated in Figure 15-7 below. The key steps are:

- A cross cut decline (V-ramp) will be driven from each footwall drive downwards at a gradient of minus 20 % to intersect the ore at the base of a 22.5 m high panel (5 mW x 3.5 mH lifts plus one final 5 m lift using an upper retreat method);
- Upon reaching the orebody, drifts are driven north and south along the strike of the reef to a maximum of 150 m from the access;
- The reef drives are developed to be a minimum of 2.4 mW (based on true orebody width) and 3.5 mH. They will be systematically supported with split sets and mesh as standard. The drive geometry will be modified to accommodate the mining equipment. Development profiles are illustrated below in Figure 15-8. SRK notes that the drift width will be widened under geological control according to the ore width. In order to recover the entire high grade vein material, SRK has planned that some additional dilution will be incurred. Another point to consider is the profile of the loader; due to the height of the cab it is necessary to take part of the footwall to increase the width of the drift that is

available;

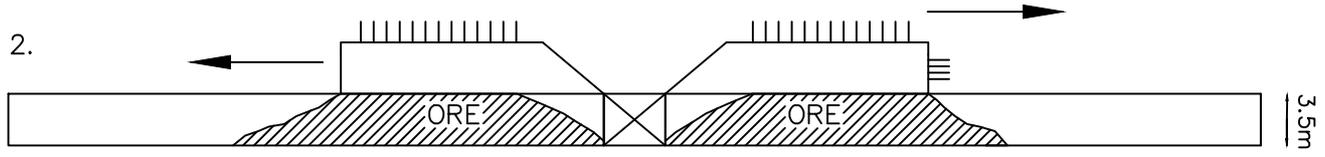
- Excavation of the ore drives north and south will proceed until the extent of each panel is reached. In most cases this will result in a maximum tramming distance of 150 m in the orebody. This is considered to be a maximum for the equipment employed so as to maintain efficient mucking cycles. Ventilation will be forced through a flexible duct in each reef drive. The drives will be driven by single boom jumbos. Rock support will be installed with handheld drills following mucking of the broken ore;
- Once an ore drive has reached the end of a panel, an in-stope ramp (from blasted ore) will be created from the access to re-establish the north and south breast headings. Ore will be breasted down into the void below. Only swell ore will be mucked out with a final ore mucking cycle once the ore-drives reach their limits; and
- Once all ore is removed, the V-ramp access will have its backs stripped to re-access the top of the now 7 m high drift. Backfilling with either Cemented Rock Fill ("CRF") or Waste Fill (WF) will then commence. Once filling is complete, a new breasting sequence can begin. It has been planned to use CRF above the sill pillars at the bottom of each 22.5 m high panel with the remainder being unconsolidated WF. This allows the pillars to be recovered from beneath the fill when the top of the panel is reached. A cement content of 7 % has been used for cost estimation in the FS, although geotechnical work has indicated that 4 to 7 % is appropriate.

The method will not involve large production blasts but will be a series of small rounds in various headings at shift end. Each round would use 150 to 200 kg of Ammonium Nitrate Fuel Oil (ANFO) or emulsion explosives and approximately 12 detonator delays. SRK has included a central blasting system so that rounds could be appropriately staggered to reduce vibration effects. Explosives would be 90 % air loaded ANFO and 10 % packaged emulsion for the wet holes. SRK has assumed for planning purposes that all rounds would need to be drilled with a full burn-cut. In reality, the space between the back of the previous lift and the top of the fill is expected to provide a void such that burn cuts will not be required in all cases.



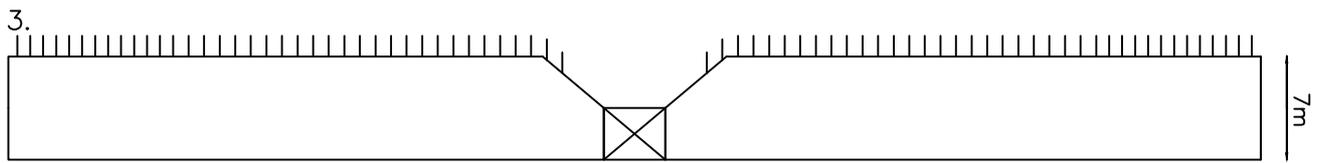
Develop ore drives

- 3.5m high North and South

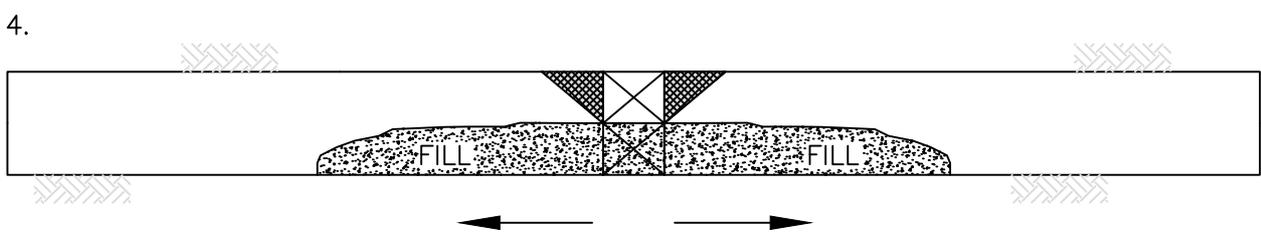


Drive breasts North and South

- use ore as a ramp access
- muck swell only
- support with advance



- At the end of each panel, all ore can be mucked
- No remotes are required
- Back is fully supported



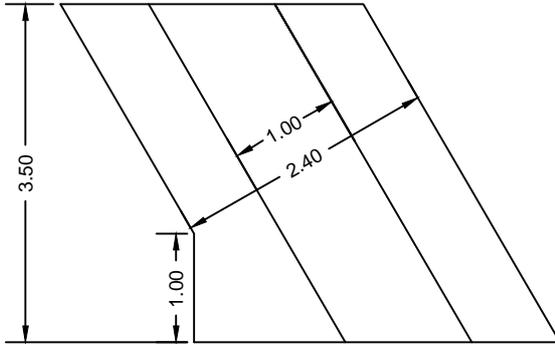
- Slash back of access for next lift
- Mine ore 'triangles'
- Bring in waste rock fill
- End tip with LHD
- Paint grade lines on wall
- Compact fill surface

LONGITUDINAL  
VIEW LOOKING  
TOWARDS FW

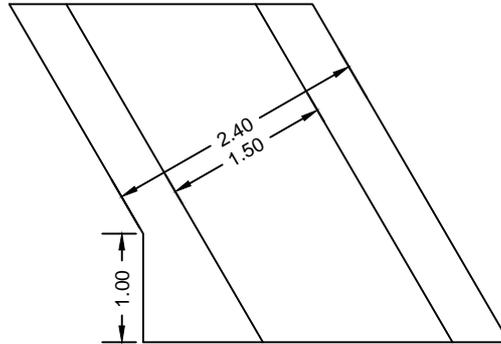
5. After fill is complete, repeat from step 2

JUNE 2013	U4935	PRESTEIA WRP FS	NTS
		Proposed Mechanized Drift and Fill Method	Figure 15-7

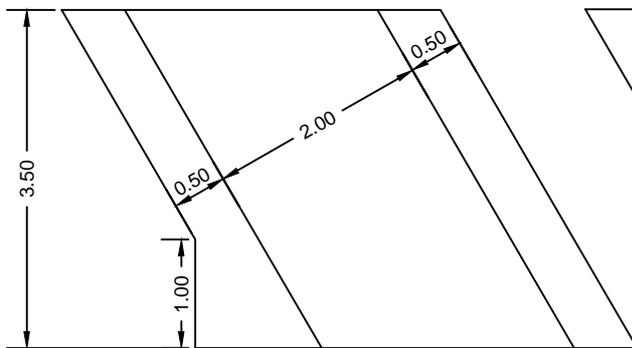
1 m Orebody



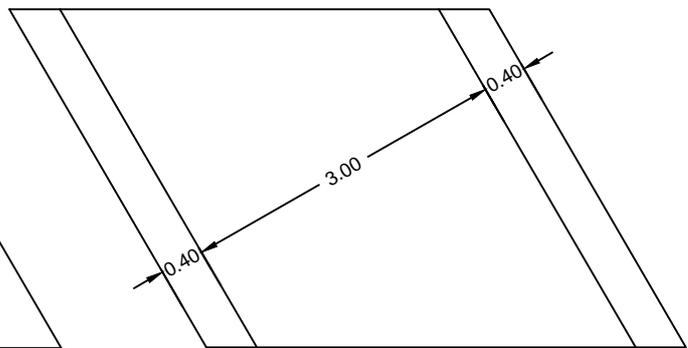
1.5 m Orebody



2 m Orebody



3 m Orebody



Where ore body thickness increases, SRK expects fewer structural features.

All Dimensions shown in Metres.

## 15.3 Geotechnical

### 15.3.1 Introduction

SRK has conducted a feasibility level geotechnical study in support of re-commencement of mining of the West Reef orebody at the Prestea underground mine. The geotechnical study comprised the drilling and detailed geotechnical logging, sampling and testing of a number of cored boreholes collared on the 17 L and 24 L to intersect the footwall, orebody and hangingwall of the West Reef mineralization.

Based on the outcome of the Preliminary Economic Assessment (PEA) it was concluded that the available data was insufficient for FS design work and that the following would be required:

1. Detailed re-logging of borehole core as the current logging method were not considered suitable for underground mining of narrow orebodies as the method did not identify the narrow footwall and hangingwall shears that will control the stability and size of stopes; and
2. Testing of core for Unconfined Compressive Strength (UCS), Young's Modulus and Poisson's Ratio.

Once this information was collected detailed geotechnical analysis and numerical modelling would need to be undertaken to support a feasibility level mine design. Based on these recommendations and in discussion with GSR it was initially decided that SRK would:

- Review core photography;
- Undertake a site visit to re-log West Reef core intersections and carry out underground geotechnical mapping on 17 L and 24 L;
- Collect bulk samples from underground for laboratory testing; and
- Develop geotechnical design parameters for range of mining methods and development strategies proposed.

During the study development period GSR decided to carry out an additional core drilling campaign primarily to obtain samples for metallurgical testing. This drilling would also serve the purpose of providing the necessary geotechnical data for the FS. It is noted that the original resource definition drilling mineralized intersections were not available because they had been used for assay and metallurgical testwork purposes. The finalised FS work programme therefore comprised:

1. Review of the proposed drilling programme developed by the GSR exploration department;
2. A site visit by two SRK geotechnical engineers to review geotechnical core logging procedures and provide geotechnical core logging training to exploration geologists;
3. Preparation of geotechnical core sampling procedures and develop a laboratory testing programme for determination of UCS, Young's Modulus, Poisson's Ratio and discontinuity shear strength;
4. QA/QC checks on geotechnical logging data by comparing completed geotechnical logs transmitted to SRK with core photographs;
5. The development of rock mass and structural geotechnical characteristics for each of the West Reef geotechnical domains; and
6. Empirical and numerical analyses to develop appropriate stable mine design criteria to inform mine design.

The West Reef geotechnical drilling campaign focused on the drilling of 15 boreholes. Six boreholes were planned to be drilled from the 17 L and nine from the 24 L. At the time of writing a total of eight holes had been completed in this ongoing program.

### 15.3.2 Results

The West Reef rock mass is generally strong and competent. However there are a number of sheared and broken zones adjacent to and within the orebody that will control the size and stability of stopes as well as ore dilution. These potential geotechnical related problems were identified at an early stage of the feasibility study and a pragmatic choice of mining method largely neutralised these problems. A MCF method has been selected that limits stope height to 7 m for the first four lifts and 9m for the last lift.

The  $Q'$  value of the orebody and adjacent hangingwall and footwall materials, taking into account the presence of the weak zones, has a value of 6, making the rock mass of fair quality. This compares with a  $Q$  value in excess of 100 (extremely good rock mass) for the surrounding non broken and non-sheared rock mass. Using stability graph empirical analyses it has been confirmed that the design unsupported lift and stope back dimensions should be stable. Table 15-2 presents the results of the stability graph analysis for the stope back. The table rows represent increasing horizontal stope widths. The stope width range encompasses the full range of horizontal stope dimensions that are likely to be created in West Reef. The columns represent the increasing strike length of the mined stope. The legend on the right of the table indicates that the stope back is likely to become potentially unstable when its hydraulic radius increases above 6.2. It can be seen that all of the stope dimensions considered the hydraulic radii lie with the range of hydraulic radii predicted to give stable stope conditions.

Table 15-3 presents the results of the stability graph analysis for the stope walls. The results are presented in a way that simulates the excavation of a single panel from bottom to top. The first 3.5 m high panel is shown to be stable for the full range of strike lengths analysed. If the stope remains unfilled then as the stope height is increased the stope becomes increasingly unstable as the vertical height increases beyond 10 m and the stope strike length advances more than 40 m. This analysis confirms that support, in the form of wall bolting and subsequent rock filling will be integral to ensure the viability of this mining method. Backfilling of each lift with rock fill will obviously prevent the failure of the stope walls. Split sets will also be used to support the drift walls after each round is blasted. SRK considers that it is vital to keep the graphitic material pinned back so that it is not allowed to fail back towards planes of weakness in the drift sidewalls. Similar operations have demonstrated that split sets with steel straps is effective in avoiding such unplanned dilution.

Allowance has been made for the cost of installing mesh in the stope backs to catch any small pieces of graphitic material that may become dislodged. Rock support measures in the orebody will not require cable bolts. However, wider parts of the west reef will require additional bolts to maintain the overall spacing but larger scale instability is not expected.

Rock support in the form of rebar and split sets has been planned for all waste development in the WRP. Due to the competent ground conditions it is expected that this may not be necessary from a stability perspective but SRK considers that including the cost of such measures is necessary for an FS.

**Table 15-2 Stability Graph Results – Slope Back**

<b>Orebody</b>															
<b>Hydraulic Radii for Various Slope Geometries</b>															
OB Thickness	Slope Length (m)												<b>N</b>	<b>3.0</b>	
Stope Span (m)	10	20	30	40	60	80	100	120	140	160	180		Key		Hydraulic Radii (m)
1	0.45	0.48	0.48	0.49	0.49	0.49	0.50	0.50	0.50	0.50	0.50		Stable	3.84	
1.5	0.65	0.70	0.71	0.72	0.73	0.74	0.74	0.74	0.74	0.74	0.74		Unsupported Transitional	6.2	
2	0.83	0.91	0.94	0.95	0.97	0.98	0.98	0.98	0.99	0.99	0.99		Stable with Support	9.1	
2.5	1.00	1.11	1.15	1.18	1.20	1.21	1.22	1.22	1.23	1.23	1.23		Supported Transitional	11.0	
3.35	1.25	1.43	1.51	1.55	1.59	1.61	1.62	1.63	1.64	1.64	1.64		Unstable	11.0	
4.04	1.44	1.68	1.78	1.83	1.89	1.92	1.94	1.95	1.96	1.96	1.98				
4.39	1.53	1.80	1.91	1.98	2.05	2.08	2.10	2.12	2.13	2.14	2.14				
5.5	1.77	2.16	2.32	2.42	2.52	2.57	2.61	2.63	2.65	2.66	2.67				

**Table 15-3 Stability Graph Results – Slope Walls**

<b>Hangingwall and Footwall</b>															
<b>Hydraulic Radii for Various Slope Geometries</b>															
Vertical	Wall/Slope Length (m)												<b>N</b>	<b>1.7</b>	
Wall Height	10	20	30	40	60	80	100	120	140	160	180		Key		Hydraulic Radii (m)
22.5	3.53	5.45	6.66	7.49	8.56	9.21	9.66	9.98	10.22	10.41	10.57		Stable	3.10	
17.5	3.25	4.82	5.75	6.35	7.11	7.55	7.85	8.06	8.22	8.34	8.44		Unsupported Transitional	5.2	
14	2.99	4.27	4.98	5.43	5.97	6.28	6.48	6.63	6.73	6.81	6.88		Stable with Support	8.2	
10.5	2.64	3.58	4.07	4.37	4.71	4.90	5.03	5.11	5.17	5.22	5.26		Supported Transitional	10.1	
7	2.13	2.71	2.98	3.14	3.31	3.41	3.47	3.51	3.54	3.56	3.58		Unstable	10.1	
3.5	1.36	1.57	1.66	1.70	1.75	1.78	1.80	1.81	1.81	1.82	1.82		Ore body dip	70.00	

The results of the 2D numerical stress analysis show that for the interpreted geological and rock mass strength conditions the stoping panels generally remain stable for the proposed mining sequence. As expected strength factors reduce with depth due to the increase in mining induced stresses. It may be possible that for the lower panels (panel 4195 and below) the CRF sill pillars and the last panel left below the sill pillars may experience some degree of instability that may make drilling and extraction challenging due to the fractured nature of the ground.

The modelled stability of the CRF sill pillars is valid only providing the modelled strength can be attained. However due to the generally limited span of the sill pillars and the fact that the mining sequence dictates that the mining will retreat (out-of-plane of the model) so the time spent underneath the sill pillar once extraction is completed will be minimal.

Sill mats may be needed where strength factor is less than 1.0 but this may be required only to prevent drop out of key blocks. In these circumstances, because of the limited stope spans it will be possible to construct a mat of chain link mesh pinned to the side walls of the stope and/or cable bolts stretched across the stope and grouted into the footwall and hangingwall.

The mining sequence will introduce a closure position in the central part of the West Reef orebody. SRK recommends that this is modelled in 3D when site specific data from the University of Mines and Technology (UMaT), Tarkwa, on Young's Modulus and Poisson's Ratio is available from the ongoing program. SRK further notes that the condition of the orebody at the closure position will need to be monitored during mining to support the modelling work and check for any significant stress build up.

### 15.3.3 Conclusions

Based on the geotechnical work carried out for the FS, SRK concludes the following:

- Split set rock bolt support of the walls of each lift has been recommended largely to control wall dilution rather than for wall support;
- To achieve the required strength range for the sill pillars cement content should be in the region of 4 to 7 %; and
- The stress modelling indicates that the stopes will remain stable under the proposed mining conditions. However, the factors of safety of mine and fill elements reduce below unity towards the base of the West Reef where mining induced stresses will be highest. It is noted therefore, that there may be a requirement to introduce sill mats at the base of the sill pillars in the lower part of the West Reef to improve stability of the sill pillar when working beneath it. The mine elements subject to mining induced stresses are the sill pillars which are planned to be mined by retreat from the accesses upon completion of a panel. If the pillars have failed they may be shattered and difficult to drill and extract safely. Should the results of 3D modelling demonstrate that this will be the case then it may be necessary to change the pillar dimensions, leave the pillars behind or alter the mining sequence.

## 15.4 Access Options for WRP

### 15.4.1 Introduction

An important objective of the FS on the West Reef was to determine the optimal way to access the orebody from surface. SRK therefore undertook an option study which examined three access alternatives and compared them in terms of ease of construction, timing and cost. Another consideration was the implications on the ongoing underground activities at Prestea. These include exploration drilling, maintenance of the dewatering system and some

shaft refurbishment. Three options were considered to access the orebody from surface as follows:

- Refurbishment of the Central Shaft;
- A new decline from surface; and
- A new raisebored hoisting shaft (RHS) from surface.

The option study scheduled the development and construction activities and applied costs to each of the alternatives. Murray Roberts Cementation provided design and cost input for the new hoisting shaft option and Alan Auld Engineering provided input on the Central Shaft rehabilitation option. It is noted that each option would necessitate significant ventilation upgrades from the current arrangements because the existing drifts and raises are too small for the volumes of air required for trackless equipment. Details of each access alternative are described in the following subsections.

#### 15.4.2 Access Options Comparison

Each option was evaluated in detail to estimate capital costs and development time. The estimate of capital costs are summarised in Table 15-4 and the development time in Table 15-5. SRK notes that the costs for each option are very similar and fall within 10 % of each other.

**Table 15-4 Capital Cost Estimate Summary of Access Options**

Option	Cost US\$ million
1. Drive a new Decline	114.8
2. Refurbishment of Central Shaft	107.9
3. Raisebored Hoisting Shaft	111.6

**Table 15-5 Summary of Access Options Duration for Completion**

Option	Duration
1. Drive a new Decline	54 months
2. Refurbishment of Central Shaft	52 months
3. Raisebored Hoisting Shaft	39 months

#### 15.4.3 Access Options Discussion

Refurbishment of the Central Shaft would seem to be the obvious choice as an access option to the WRP. However, there are a number of drawbacks to this approach:

- In order to properly repair the Central Shaft so that it can fully service the West Reef requirements for ore and waste handling, much of the steel that has been replaced in the last few years will need to be removed because the shaft compartments are not large enough to sling the mining equipment down to 17 L. The shaft has also not been plumbed recently. A full replacement of shaft steelwork is a slow undertaking mainly due to the fact that there is a large mass of corroded steel work that needs to be safely removed. It should be noted removing this steel and re-supporting the shaft would take as long as raiseboring a new shaft;
- In order to service the pumps and provide access to the deepest parts of the mine for exploration drilling, the refurbishment of the Central Shaft must be developed below the 17 L to 24L. This will require additional investment that would not be incurred with the RHS option. There are also scheduling and interference considerations that could delay

- rock hoisting from 17 L if there are activities that need to take place to re-equip the Central Shaft to function below 17 L;
- After the Central Shaft has been upgraded, 17 L would need to be stripped out to dimensions of at least 4.5 m x 4.5 m. This is to allow larger ventilation volumes to be handled and to facilitate movement of larger equipment between the West Reef and the Central Shaft;
  - Upon completion of stripping 17 L to a wider cross section, the West Reef ore and waste would need to be transported to the shaft. This will involve a 2 km tram which will add to operating costs. Men would also need to be transported the 2 km. This would reduce effective shift time compared to the RHS option where men would alight the shaft on 17 L at the West Reef location;
  - Central Shaft is situated in Prestea town where there is a lack of space for dumping waste which would force the operation to transport waste rock to a distant storage facility, increase operating costs and further impact on the environment;
  - The ventilation quantities required for the WRP are considerable and would require either a dedicated vent raise to surface or an internal raise between 6 L and 17 L to be driven. The internal raise option would also require substantial stripping of 6 L but would allow the existing exhaust on the South Waste Shaft to be used. This would avoid the surface impact of the RHS option but would make the Central Shaft the subject of a lot more surface activity and attendant social issues. The stripping of 6 L would also create issues relating to access, timing and waste rock handling; and
  - The prolonged shutdown that would be required to re-configure the Central Shaft is likely to make regular access to maintain the pumping stations at the mine difficult. The situation is exacerbated by the fact that the Bondaye Shaft is in poor condition and will itself be closed for refurbishment at some point during commencement of the WRP.

The above factors make the option of re-furbishing the Central Shaft relatively unattractive for the WRP from an operational perspective. The option of a new decline from surface offers far less technical challenges than a shaft option. With a decline all equipment and materials can simply be driven in and out of the mine. The shaft option requires large mining equipment be dismantled and slung down the shaft above or below the skip. This is itself is not a difficult operation but there is more potential for complications with these additional actions.

The shaft access option is generally more engineering intensive than a decline as it is a bespoke project requiring specialist designers, contractors and equipment. A decline in comparison can be developed based on a simple design using 'off the shelf' mining equipment. However, the key drawback with a decline is that it would take the longest of all the options and cost about the same when the full cost of a box-cut and contractor development is introduced. In the opinion of SRK, the lead time of 4.5 years precludes the use of a decline for the WRP.

The RHS option of using a new opening to surface is attractive for a number of reasons:

- The issues associated with upgrading the Central Shaft can be avoided and that shaft can be used for access in the short and medium term to maintain the pumps and provide access for preparatory works for the WRP. This means that repairs to the Central Shaft do not need to involve a complete re-configuration, avoiding a lengthy shutdown;
- The RHS can be designed to serve the exact needs of the WRP and allow easy slinging of equipment down the shaft;
- The RHS would be a new downcast shaft to provide ventilation directly to the WRP. The contaminated air from the WRP would be exhausted to surface through a new raisebored

ventilation shaft close to the RHS. This approach separates the WRP from the historical workings so that in the event of a fire at the West Reef the smoke would not endanger workers elsewhere in the mine complex; and

- Men and materials could travel directly to the vicinity of the West Reef avoiding the need to travel 2 km from the Central Shaft. This results in more working time being available in each shift.

#### **15.4.4 Conclusions from the Access Option Study**

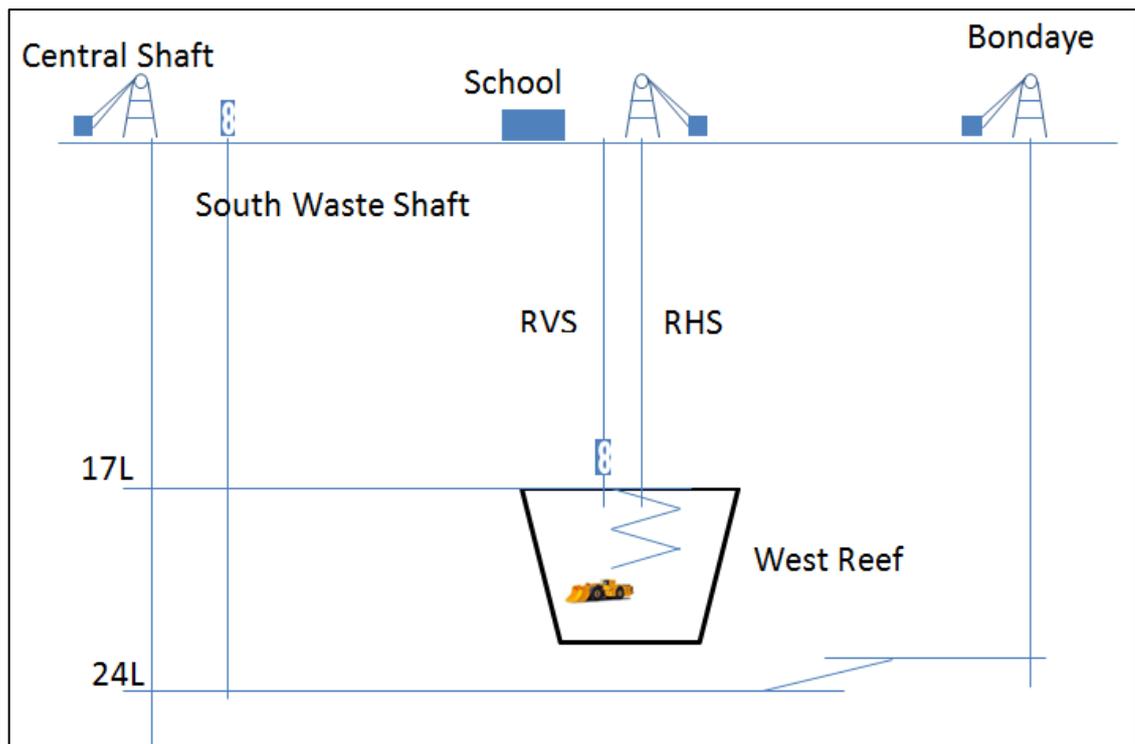
Based upon the analysis completed, SRK concludes the following:

- All three access options will cost approximately US\$ 110 million when all factors are considered;
- A new decline offers the slowest access to the ore and for this reason it is not an access option that is attractive;
- The option to re-furbish the Central Shaft is not attractive due to the long lead time. In order to re-equip the shaft to allow equipment slinging and high speed winding a significant period will be required when the shaft is not available to access the underground workings. This would prevent C&M of the underground pumping operation from continuing. There are also other technical issues with obtaining sufficient ventilation and social issues relating to the use of the shaft in an urban environment;
- The RHS option is the most attractive alternative due its relatively rapid access directly to the ore and non-interference with ongoing operations; and

Based upon the analysis completed, SRK recommends that the RHS option should be used as the base case access option for the FS and should be the option considered for detailed engineering.

#### **15.4.5 Description of Selected Access Option - RHS**

MRC provided detailed design input to to the selected option with the concept of developing a new 4.8 m diameter RHS to be developed from a new surface location down the centre of the West Reef strike length. The 660 m deep shaft would be situated in the footwall of the West Reef and Figure 15-9 provides a schematic of the RHS Access Option.



**Figure 15-9 Schematic of Raisebored Hoisting Shaft (RHS)**

The RHS Access Option is described with the following key points:

- The shaft would be used for both production winding and man-riding. It would also be designed to allow the trackless mining equipment to be lowered to 17 L at the West Reef location;
- For rapid construction and lower capital cost, no conveyors or crushers would be installed at the underground loading pocket. It is planned that an LHD would load the skip through a simple grizzly and weighing flask arrangement;
- The shaft would allow all new services to be reticulated underground and would enable the West Reef to be an independent 'mine within a mine';
- A RVS from surface would need to be developed for this option, immediately after the RHS has been completed;
- Steel guides would be used for shaft equipping; and
- An estimate of the cost undertaken by MRC indicated that it would cost US\$ 52 million and take 39 months to complete preparation work and construct both the RHS and RVS.
- A geotechnical drill hole recently drilled along the centre line of the RHS to verify the ground conditions indicates that a 50 m pre-sink is required which was the assumption made by MRC during their cost and scheduling exercise for the FS.

## 15.5 Mine Design

### 15.5.1 Primary Access

The mine design undertaken by SRK was completed in Geovia Surpac planning software (Surpac). The RHS will be the primary access for men and materials and will also carry all of the ore and some waste rock to surface. The finished diameter will be 4.8 m and it will be lined with up to 100 mm of shotcrete where required. The RHS and RVS will both require a 50 m pre-sink to reach bed rock suitable for raiseboring. The proposed RVS has a diameter of 3.8 m as dictated by ventilation requirements for the WRP. The RVS depth is 653 m, which coincides with the return air collector level situated on the first level below 17 L. SRK has incorporated workshops on the 17 L to maintain the trackless fleet.

A lip-pocket type of arrangement where a Load-Haul-Dump unit (LHD) fills a measuring flask with ore through a grizzly will be used to load skips with ore at the shaft. In this case trucks would tip into a bin at a higher level the ore would be extracted by the LHD from a draw point at the base of the bin.

Decline access in the FW of the orebody provided the most flexible and appropriate solution to access the sublevels required for production using trackless equipment. All lateral development will be undertaken using electric-hydraulic drill jumbos with mucking by diesel LHDs into 30 t diesel trucks. The decline from 17 L to 24 L is a vertical distance of 350 m and the ramp will be driven at a constant gradient of minus 15%. Decline development will be advanced on 3.3 m length rounds at 4.8 mH x 4.5 mW. The ramp will have safety cut-outs excavated every 30 m along the ramp. The FW drives will be driven to the same dimensions as the decline to facilitate truck loading in the drives close to the V-ramp accesses. These excavations will also be provided with safety cut-outs spaced every 30 m.

As the decline is developed it will be necessary to carry the exhaust ventilation raise downwards with each loop of ramp. This will be achieved by drop raising a 4 m x 4 m excavation using the longhole drill rig. Close to the end of each FW drift a 4 m x 4 m raise will be driven to the footwall drift above. This completes the exhaust ventilation loop allowing air to enter the FW drift from the ramp and be exhausted through dedicated return airways to surface.

The new waste development required for the WRP will be connected to the existing 17 L in several places to allow access initially for an LHD and drills to develop the excavations necessary for the development of the RHS and the RVS and to provide additional airflow to the WRP during initial development on 17 L and during subsequent production. The bulk of intake air for the WRP will come down the RHS but the effect of the RVS main fan will be to draw in a proportion air from other parts of the mine from 17 L north and south.

The total metres that are required for the WRP are tabulated below in Table 15-6.

**Table 15-6 Summary of Development Requirements**

<b>Item</b>	<b>Unit</b>	<b>Total</b>
Ramp Access	(m)	3,696
Haulage Drive	(m)	6,173
Crosscut	(m)	7,381
<b>Total Lateral Waste Development</b>	<b>(m)</b>	<b>17,250</b>
Vent Raises Inter-level	(m)	757
<b>Total Vertical Waste Development</b>	<b>(m)</b>	<b>757</b>
<b>Total Waste Development</b>	<b>(m)</b>	<b>18,007</b>
Ramp Access	(kt)	216
Haulage Drive	(kt)	361
Crosscut	(kt)	320
<b>Total Lateral Waste Development</b>	<b>(kt)</b>	<b>898</b>
Vent Raises Inter-level	(kt)	32
Total Vertical Waste Development	(kt)	32
<b>Total Waste Development</b>	<b>(kt)</b>	<b>930</b>

Table 15-7 summaries the development sizes that have been applied in the mine design.

**Table 15-7 Summary of Development Dimensions**

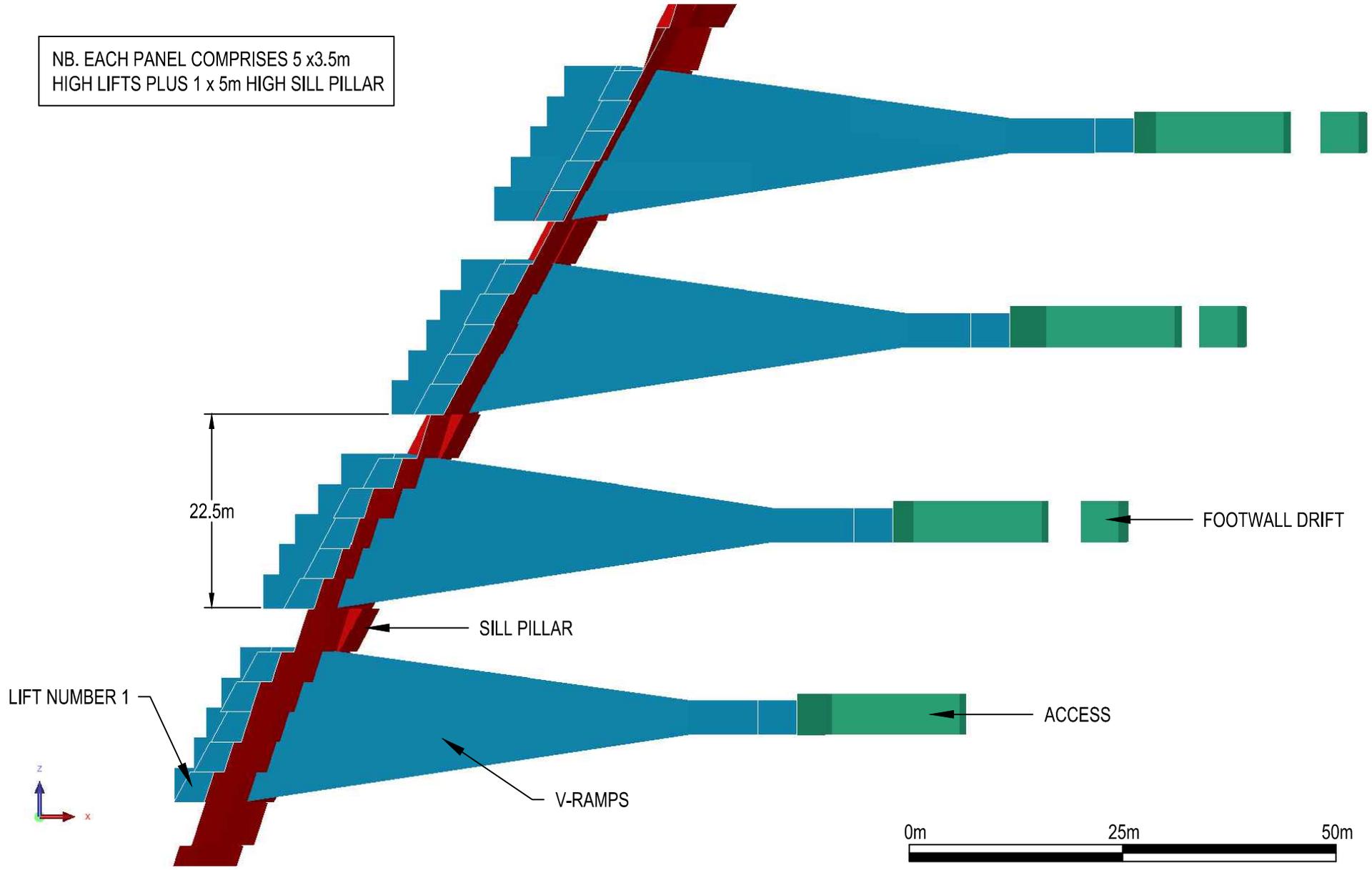
<b>Heading</b>	<b>Width (m)</b>	<b>Height (m)</b>	<b>Comments</b>
Decline	4.5	4.8	
Footwall drive	4.5	4.8	
V-ramp access	4.0	4.0	
Ore drift	2.4	3.5	Minimum width
Remuck bay	4.5	4.8	15 m long (to allow trucks to reverse)
Safety cut out	2.0	2.0	1.5 m deep, spaced every 30 m on FW drives and ramp
Ramp vent raise	4.0	4.0	
Return raises	4.0	4.0	

### 15.5.2 Stope Access

The decline allows vertical access to the sublevel elevations for each panel. From the decline, lateral access is provided by the footwall drifts. Access to the ore from the footwall drives will be provided by the V-ramps. The V-ramps are planned to be driven by the twin boom jumbos although in practice this work could be undertaken using single boom units.

The V-ramps will be driven at a gradient of minus 20 % to the base of each panel. The V ramps will have dimensions of 4 mH x 4 mW to allow the 4 m<sup>3</sup> LHDs access to the remuck bays situated in the hangingwall. The remuck bays will be where the 1.5 m<sup>3</sup> loaders will deposit ore mucked from the ore drifts. Views of a V-ramp illustrating the geometry are shown in Figure 15-10 and Figure 15-11.

NB. EACH PANEL COMPRISES 5 x 3.5m  
HIGH LIFTS PLUS 1 x 5m HIGH SILL PILLAR



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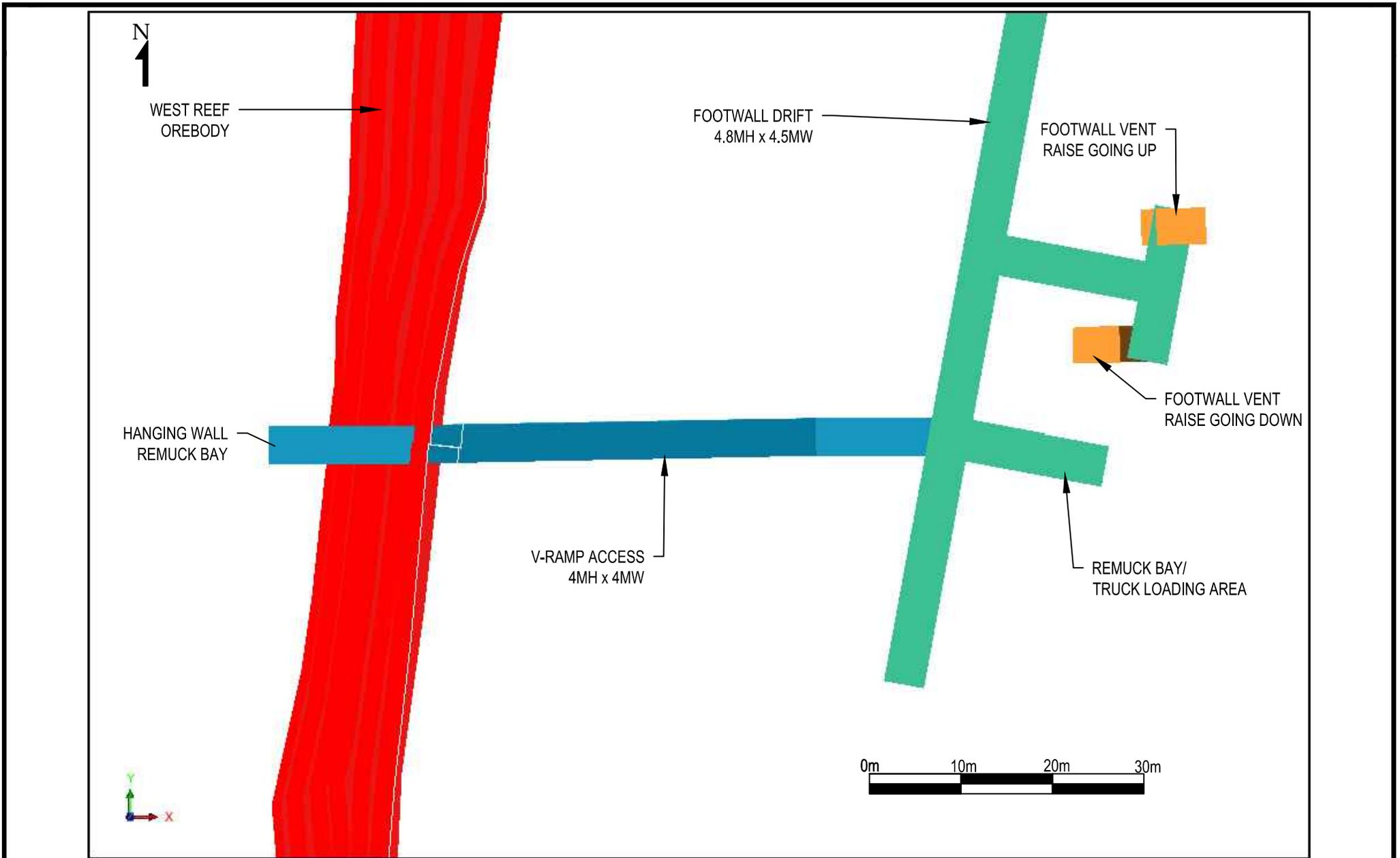
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Cross-Section of a V-Ramp

Figure 15-10



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Plan View of a V-Ramp

Figure 15-11

Table 15-8 below summarises the key results for the stope access requirements.

**Table 15-8 Summary of Stope Access Requirements**

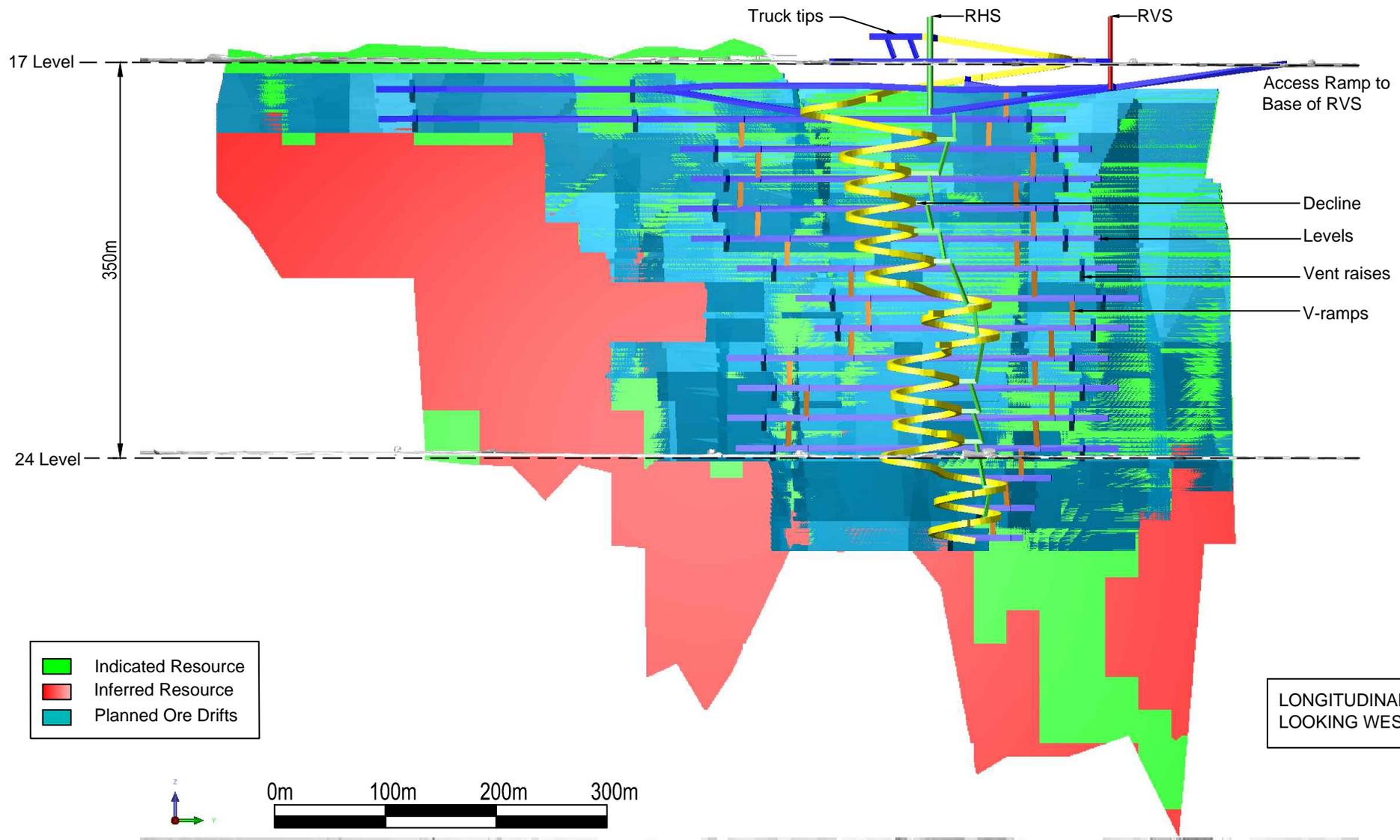
<b>Item</b>	<b>Unit</b>	<b>Total</b>
Ramp Access	(m)	3,696
Haulage Drive	(m)	6,173
Crosscut	(m)	7,381
<b>Total Lateral Waste Development</b>	<b>(m)</b>	<b>17,250</b>
Ramp Access	(kt)	216
Haulage Drive	(kt)	361
Crosscut	(kt)	320
<b>Total Lateral Waste Development</b>	<b>(kt)</b>	<b>898</b>

### 15.5.3 Stope Design

The mineable limits for the WRP stope design were defined by the extent of the Indicated Resources. Figure 15-12 shows the planned stope extraction against the Indicated Resources. No extraction has been planned below 24 L because the strike length of available reef material is too short.

The width of the WRP orebody averages 1.5 m and varies between 0.5 m and 2.5 m. Figure 15-2 illustrates the variation in thickness across the WR orebody as it is currently defined. The planned mining method requires a development width of at least 2.4 m to accommodate a diesel loader of 1.5 m<sup>3</sup> bucket capacity. This was the starting point for the design which aims to keep unplanned dilution to a minimum by accepting some planned dilution on both sides of the ore. This approach maximises orebody recovery and takes account of the fact that there are some discontinuities in the hangingwall which is expected to form a natural breaking plane in some areas. It is noted that generally mineralisation is confined to the reef package and the wall rocks are not mineralised. The drifts will be mined under geological control and when the orebody fattens the drifts will be widened accordingly.

The stopes for the WRP were designed in Surpac by digitising centre lines within the ore wireframe. It should be noted that 'stopes' in this context are simple ore drives following the orebody strike. The profiles that were subsequently applied to the strings followed the expected width of the orebody. This approach simulates the planned extraction and allowed the resulting drifts to be queried against the block model to report a diluted tonnage and grade.

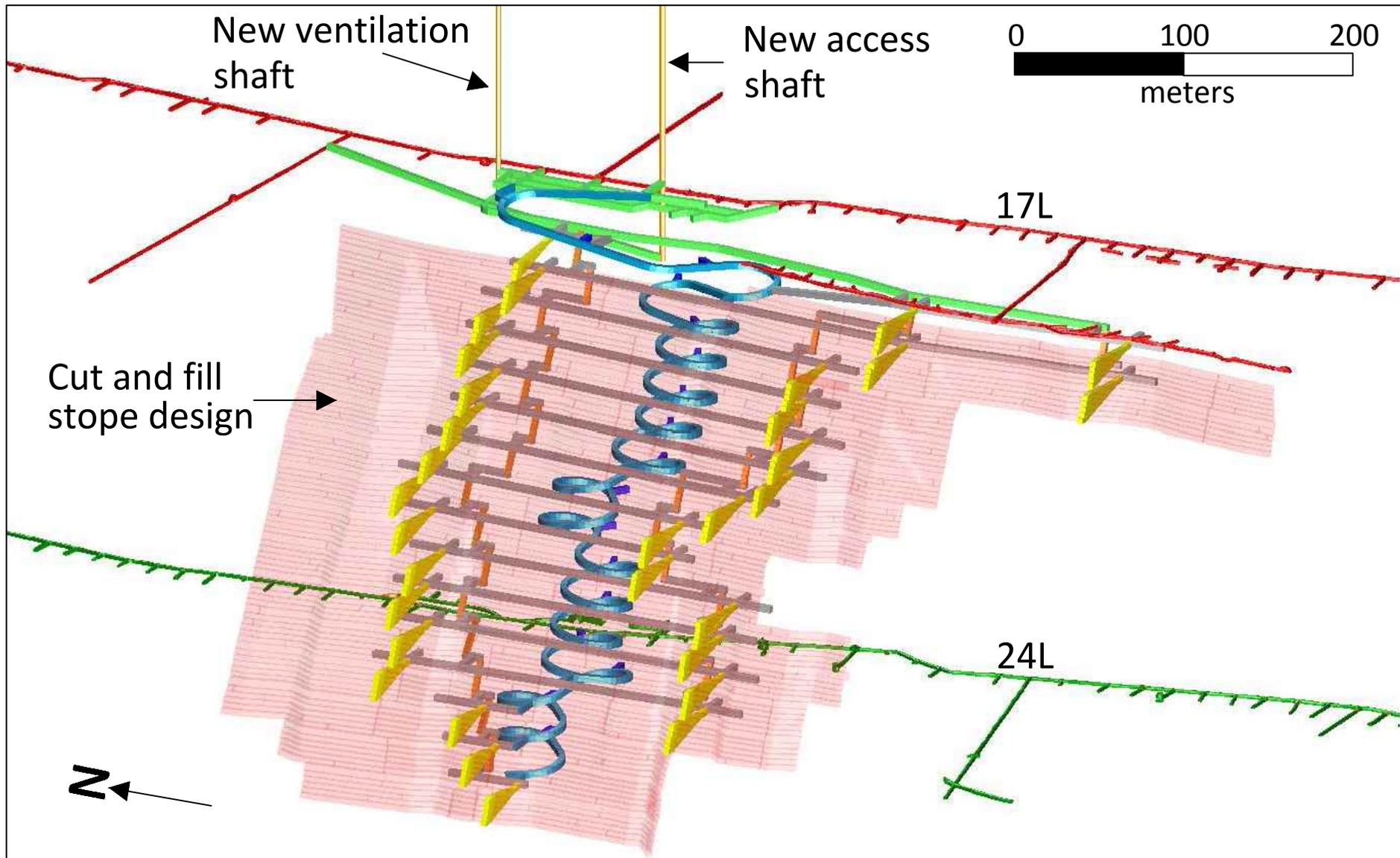


LONGITUDINAL VIEW  
LOOKING WEST

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Prestea WRP FS

Not To Scale



Longitudinal View of Planned Workings

Figure  
15-13

Table 15-9 below summarises the key results from the stope design.

**Table 15-9 Summary of Stope Design**

Item	Unit	Value
West Reef Resource	t	874,000
West Reef Resource	g/t	18.1
LoM Ore tonnes	t	1,433,874
RoM grade (includes 5% loss)	g/t	9.61
Estimated tonnes of dilution	t	559,874
Resource ounces	koz	507,819
Reserve ounces	koz	443,171
Estimated planned dilution W/(W+O)	%	43

## 15.6 Development and Production Schedule

### 15.6.1 Scheduling Methodology

MineSched is a software planning tool integrated with Surpac that has been applied to the WRP mine design for the purposes of the FS. The software allows the user to schedule development and production stopes in detail and plan a development and mining sequence. The detailed schedule in MineSched was used in conjunction with cost drivers to generate an integrated technical economic model (TEM).

MineSched is first applied to the underground development design to develop a sequence and priority for each excavation. For selective mining methods such as MCF, this allows development scheduling of both the ore and waste/infrastructure headings. Development scheduling was optimised by applying priorities to certain headings. Using the software SRK was able to visualise and interact with the data in 3D. SRK has applied development profiles that take account of the orebody thickness and equipment dimensions when mining. The software interrogated these against the block model to generate average grades for each ore development drive. MineSched contains scheduling tools that allow different scheduling parameters to be applied to the various tasks in order to evaluate the impact on project performance indicators. Using this approach SRK was able to optimise the decline development rate to ensure that as much of the waste rock from development as possible is used for backfill. The tool was also used to level the production rate by restricting the commissioning of new production panels.

### 15.6.2 Scheduling Inputs

The key scheduling inputs used in the FS with respect to development and production and the associated equipment requirements are as follows:

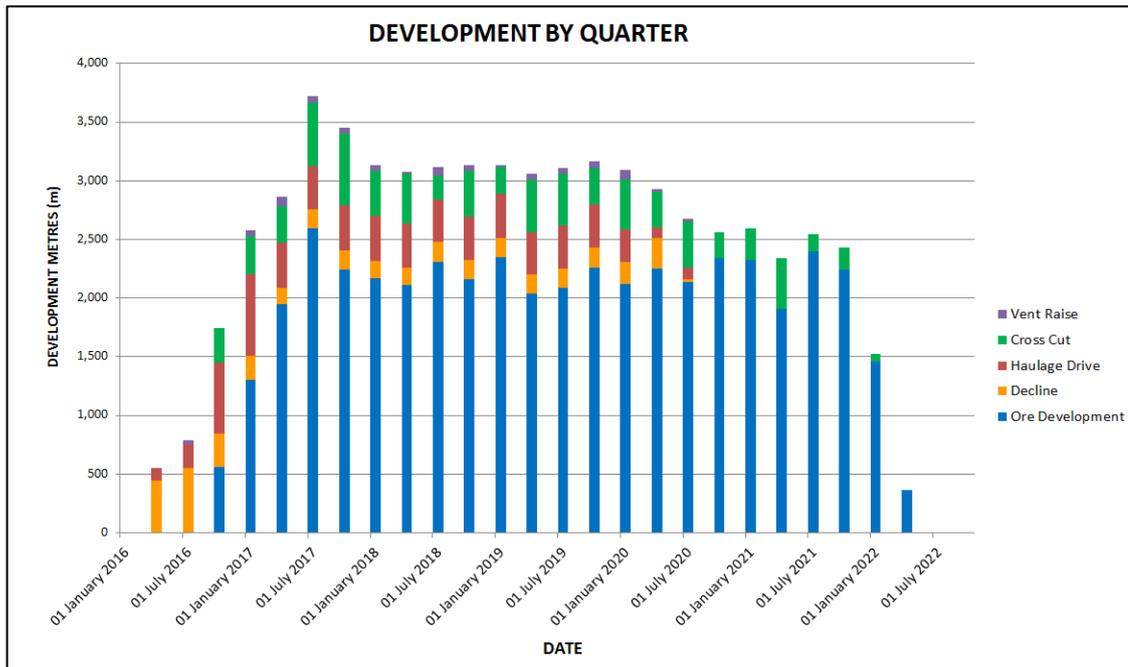
- Operating days per year = 350 days
- Single boom drill jumbo advance = 9.6 m/day (max of 4.8 m/day in a single heading)
- Twin boom drill jumbo advance = 10 m/day (max of 3.1 m/day in a single heading)
- Total backfilling capacity = 400 m<sup>3</sup>/day
- Waste filling rate (single heading) = 100 m<sup>3</sup>/day
- CRF filling rate (single heading) = 85 m<sup>3</sup>/day
- Raise bore pilot hole drilling = 11.6 m/day
- Reaming 3.8 m diameter = 6.0 m/day
- Reaming 4.8 m diameter = 4.2 m/day
- Twin boom jumbo total metres per month (max. from multiple headings) = 322 m

- Single boom jumbo total metres per month (max. from multiple headings) = 296 m
- Single or twin boom jumbo total metres per month (max. in a single heading) = 110 m
- Truck tonnes per month (max.) = 14,182 t/month
- LHD (1.5 m<sup>3</sup>) tonnes per month (max.) = 7,110 t /month
- LHD (4 m<sup>3</sup>) tonnes per month (max.) = 24,024 t/month

**15.6.3 Schedule Results**

The underground development necessary to meet the production planning objectives has been scheduled in detail using MineSched for the life of the operation. The first 12 months (of mechanised development) of the schedule provide for the development of the first three production levels from a total of eight V-ramps. Following this the mine should be cashflow positive. The second year expands on this and the number of working areas reaches a point where full production is expected to be reached after just another 3 months of development. Figure 15-14 provides the physical development schedule on a quarterly basis commencing in 2016. The schedule is based on a single twin-boom jumbo with a maximum daily rate of 10 m/day and restricted to 3.1 m/day in any single heading. There is a period of 12 months where the waste capacity is around 20 % higher than the capacity of one jumbo. At the same time the requirements for the single boom jumbos are low and SRK recommends that rather than bringing in a second twin boom for this period the single boom jumbos are used make up the shortfall. The primary and secondary development requirements comprising the decline ramps, ore drives, haulages, cross-cuts and vent raises total some 5.6 km for the 1st year and 13 km in the 2nd year.

The maximum twin and single boom jumbo per year required to complete the required development are provided in Figure 15-15.

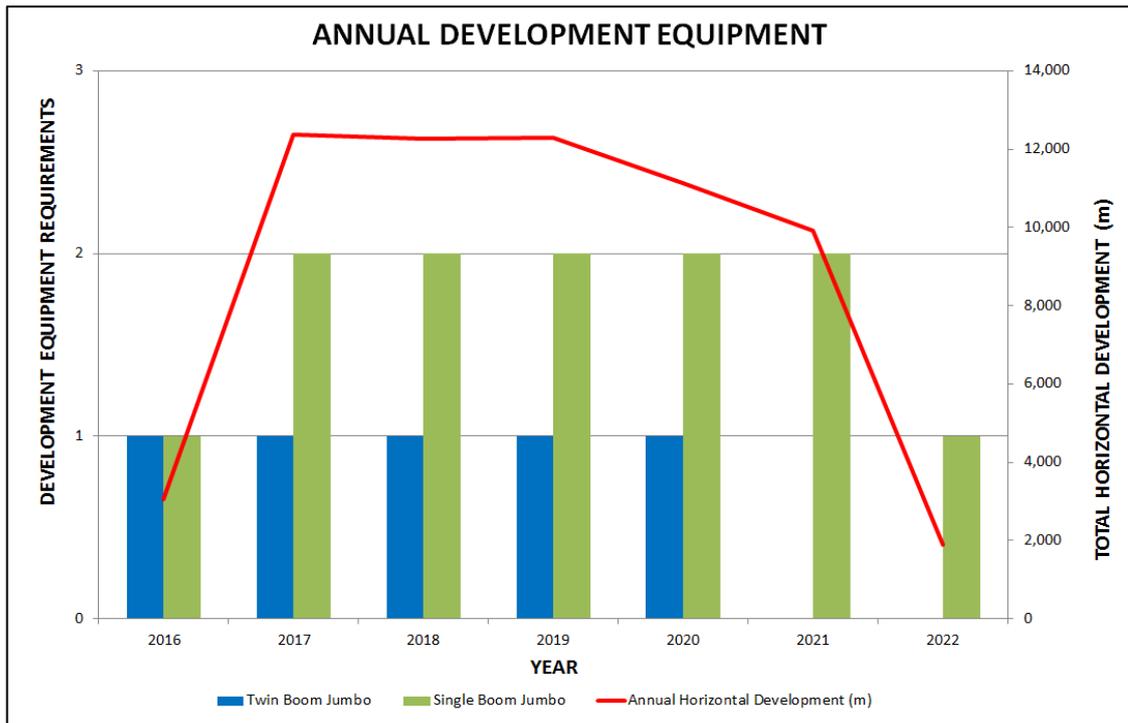


**Figure 15-14 Development Schedule by Quarter**

Table 15-10 below summarises the key results from the mine planning exercise in terms of physical quantities.

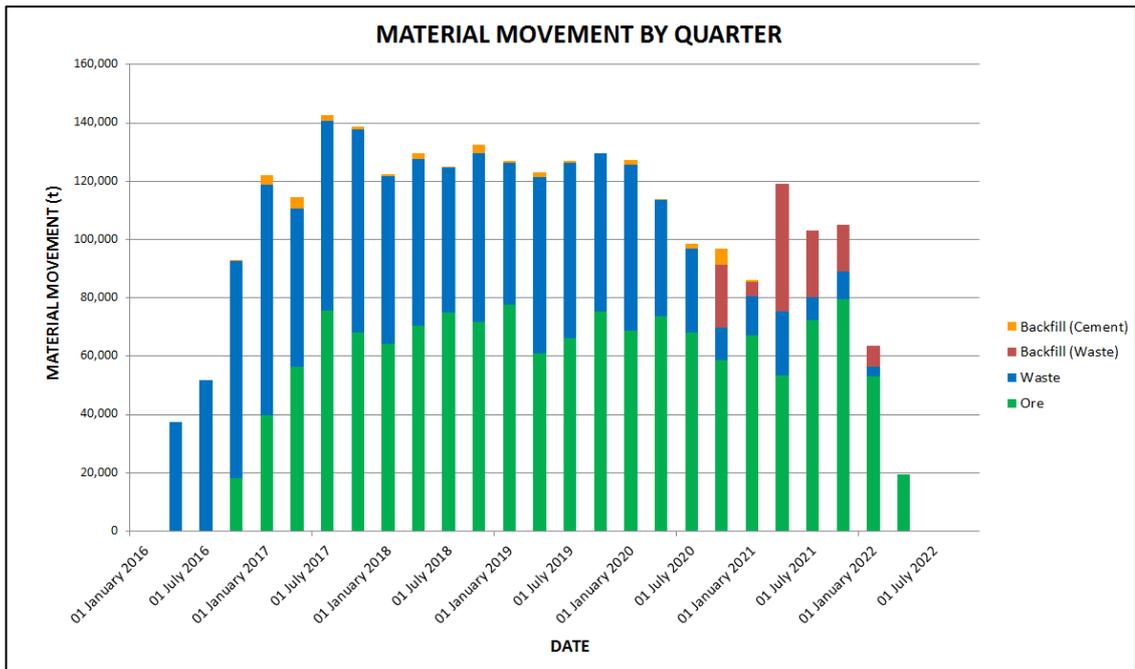
**Table 15-10 Summary of Annual Physicals**

			2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
<b>Base Case a - Raisebore</b>	Units	Total/Ave										
<b>Ore</b>												
Ore drive	(m)	45,697	0	0	0	564	8,104	8,743	8,739	8,852	8,870	1,825
Mined Grade	(g/t)	10.12	0.00	0.00	0.00	8.89	8.59	9.21	10.74	11.36	10.66	9.93
Mining Losses	(%)	95.0%	95.0%	95.0%	95.0%	95.0%	95.0%	95.0%	95.0%	95.0%	95.0%	95.0%
Tonnes Milled	(kt)	1,434	0	0	0	18	240	281	280	269	273	73
Head Grade	(g/t)	9.61	0.00	0.00	0.00	8.44	8.16	8.75	10.21	10.79	10.12	9.44
Content In Ore Milled	(koz)	443	0	0	0	5	63	79	92	93	89	22
Process Recovery	(%)	90.0%	90.0%	90.0%	90.0%	90.0%	90.0%	90.0%	90.0%	90.0%	90.0%	90.0%
<b>Au Recovered</b>	<b>(koz)</b>	<b>399</b>	<b>0</b>	<b>0</b>	<b>0</b>	<b>4</b>	<b>57</b>	<b>71</b>	<b>83</b>	<b>84</b>	<b>80</b>	<b>20</b>
<b>Waste</b>												
Ramp Access	(m)	3,696	0	0	0	1,278	650	638	661	469	0	0
Haulage Drive	(m)	6,173	0	0	0	922	1,840	1,486	1,458	467	0	0
Crosscut	(m)	7,381	0	0	0	289	1,785	1,406	1,438	1,347	1,050	67
Total Lateral Waste Development	(m)	17,250	0	0	0	2,489	4,275	3,530	3,557	2,283	1,050	67
Total Vertical Waste Development	(m)	757	0	0	0	31	233	185	178	129	0	0
<b>Total Waste Development</b>	<b>(m)</b>	<b>18,007</b>	<b>0</b>	<b>0</b>	<b>0</b>	<b>2,520</b>	<b>4,508</b>	<b>3,715</b>	<b>3,735</b>	<b>2,412</b>	<b>1,050</b>	<b>67</b>
Ramp Access	(kt)	216	0	0	0	75	38	37	39	27	0	0
Haulage Drive	(kt)	361	0	0	0	54	108	87	85	27	0	0
Crosscut	(kt)	320	0	0	0	13	77	61	62	58	46	3
Total Lateral Waste Development	(kt)	898	0	0	0	141	223	185	186	113	46	3
Total Vertical Waste Development	(kt)	32	0	0	0	1	10	8	8	6	0	0
<b>Total Waste Development</b>	<b>(kt)</b>	<b>930</b>	<b>0</b>	<b>0</b>	<b>0</b>	<b>142</b>	<b>233</b>	<b>193</b>	<b>194</b>	<b>119</b>	<b>46</b>	<b>3</b>
<b>Backfill</b>												
CRF	(m <sup>3</sup> )	95,766	0	0	0	1,468	32,993	18,021	10,824	30,027	2,434	0
WF	(m <sup>3</sup> )	267,971	0	0	0	0	64,474	39,983	56,711	34,771	67,103	4,929
<b>Total Backfill</b>	<b>(m<sup>3</sup>)</b>	<b>363,738</b>	<b>0</b>	<b>0</b>	<b>0</b>	<b>1,468</b>	<b>97,466</b>	<b>58,004</b>	<b>67,535</b>	<b>64,798</b>	<b>69,537</b>	<b>4,929</b>
Rock in CRF	(kt)	180	0	0	0	3	62	34	20	56	5	0
Cement in CRF	(kt)	30	0	0	0	0	10	6	3	9	1	0
CRF Total	(kt)	209	0	0	0	3	72	39	24	66	5	0
WF	(kt)	559	0	0	0	0	134	83	118	72	140	10
<b>Total Backfill</b>	<b>(kt)</b>	<b>768</b>	<b>0</b>	<b>0</b>	<b>0</b>	<b>3</b>	<b>207</b>	<b>123</b>	<b>142</b>	<b>138</b>	<b>145</b>	<b>10</b>



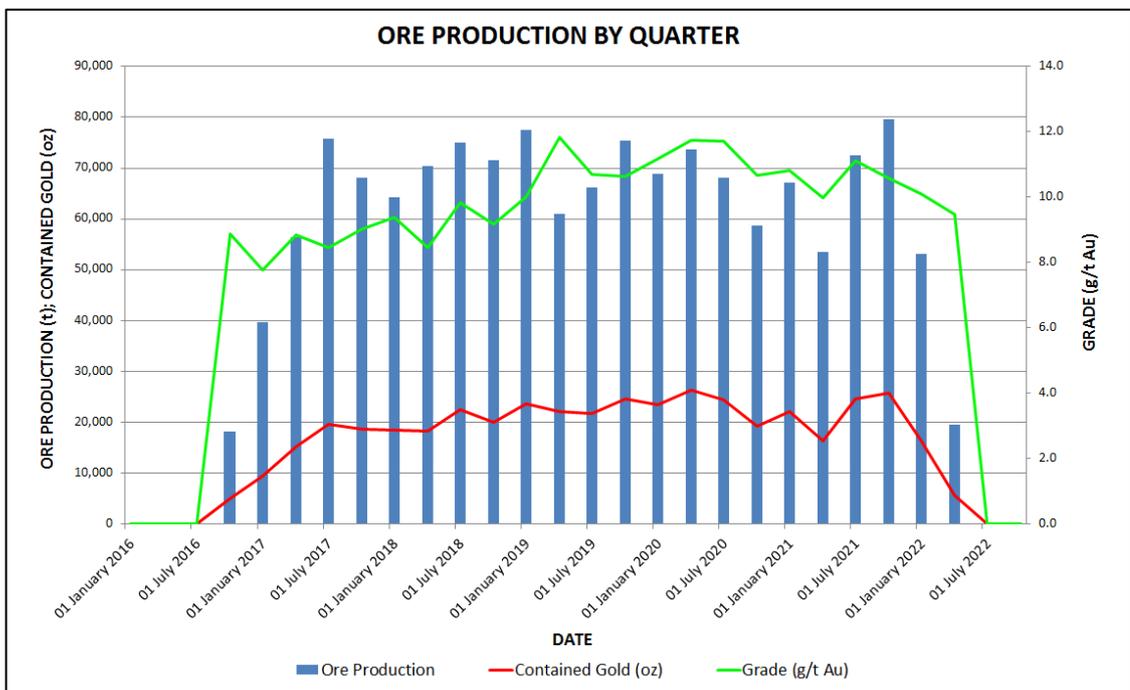
**Figure 15-15 Annual Development Equipment**

Figure 15-16 provides the material movement requirements quarterly for ore, waste and backfill (including cement). The graph shows waste material is generated at the start of the schedule due for the decline and required capital development and ore production commences at the end of 2016. A portion of the waste generated underground is used for backfill purposes throughout the mine life. However, the final 2 years require waste to be mined underground for backfill. The majority of waste will be stored on the surface at the RHS in an engineered facility.



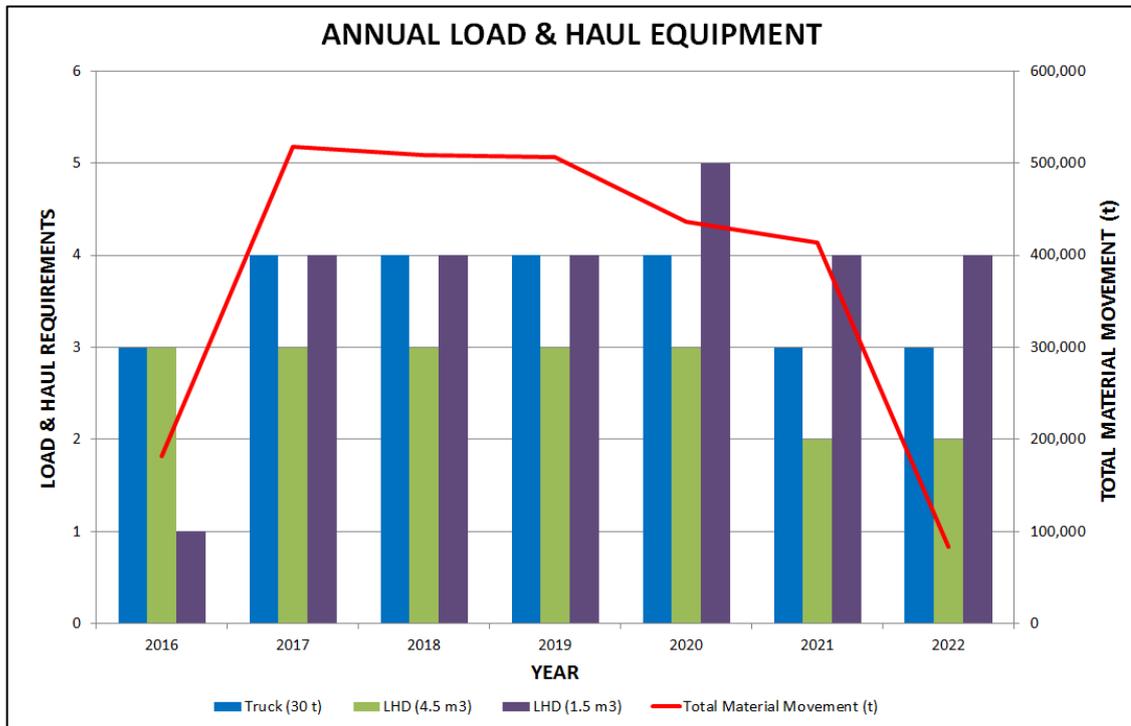
**Figure 15-16 Material Movement by Quarter**

Figure 15-17 shows the WRP ore production by quarter, commencing at the end of 2016 and finishing in the first half of 2022. The gold grade starts above 8 g/t Au and remains above this for the LoM, generally increasing to a peak in early 2019. Ore production tonnes average 205 ktpa over the LoM and peak at 280 kt in 2018.



**Figure 15-17 Ore Production by Quarter**

The annual load and haul equipment requirements for the WRP are provided in Figure 15-18 have been determined based on estimated operating hours and shows generally stable truck and loader numbers over the LoM. The graph also shows the total annual material movement which is relatively smooth over the same period as expected.



**Figure 15-18 Annual Load & Haul Equipment**

The manpower requirement for the WRP (excluding the surface G&A staff) is provided in Figure 15-19 per quarter. The maximum manpower required is 268, including 38 expats for the first two years only. Following the expat period, manpower averages 220 for the remaining LoM. It should be noted that the manpower estimates do not include any staff involved in the surface haulage of the ore from Prestea to Bogoso or processing at Bogoso. The surface haulage would be undertaken by a contractor and the processing would be on a toll treatment basis at the Bogoso process facility. At least a further 100 workers would be required if the existing G&A staff, surface haulage and processing activities are considered.

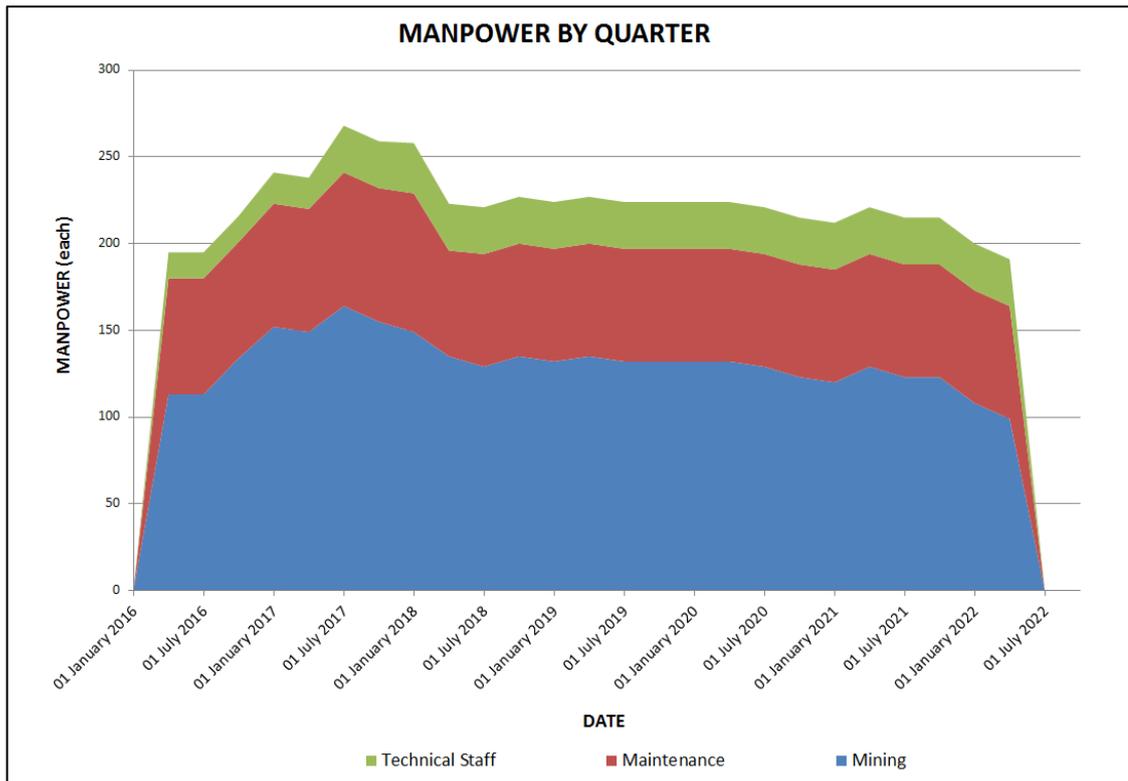


Figure 15-19 Manpower by Quarter

### 15.6.4 Summary and Conclusions

Table 15-11 below shows a number of Key Performance Indicators (“KPIs”) that have been generated as a result of the generation of the LoM plan for the WRP. The design and schedule from Surpac/MineSched calculates an average of 43 % dilution. The WRP orebody has an average thickness of 1.5 m which is diluted to 2.4 m in the mine design. A simple calculation indicates a dilution of 38 % which provides confidence that the software is working correctly.

The FS technical work has determined that an average production rate of 250 ktpa (Including ramp up and tail) containing 70 koz Au can be attained from the WR orebody using modern trackless mining methods. The sink rate required to maintain this is only 4.7 m vertical per month which equates to 31 m of ramp development. SRK considers this production rate to be low risk and notes that there is potential to increase production volumes for the WRP.

**Table 15-11: Summary of WRP KPI's**

Description	Units	Quantity
LoM Ore tonnes from Surpac	t	1,433,874
RoM grade (includes 5% loss)	g/t Au	9.61
Estimated tonnes of dilution	t	559,874
Estimated planned dilution W/(W+O)	%	42.7
Estimated planned dilution W/O	%	74.6
Waste development metres (lateral + vertical))	m	20,709
Ore development metres	m	45,697
Ore tonnes per metre of total dev.	t/m	21.53
Average annual production	tpa	249,369
Average monthly production	t	20,781
Total metres of dev required per month	m	950
Metres of ore dev required per month	m	662
Metres of waste dev required per month	m	288
vertical metres		350
Ore tonnes per vertical metre	t/m <sub>vertical</sub>	4,097
Vertical sink rate required	m/mth	4.7
Ramp metres per month to meet sink rate	m/mth	31.1
RoM Gold production (pre-processing)	oz/mth	6,422
RoM Gold production (pre-processing)	oz/yr	77,065

## 15.7 Ventilation

### 15.7.1 Introduction

SRK has carried out a detailed analysis of ventilation requirements for the WRP using Ventsim software (“Ventsim”). The aim of this analysis is to determine fan, duct and airway sizes for the LoM plan. The principal objectives of the ventilation design will be to remove the diesel fumes from mechanised mobile equipment and remove blasting fumes from the workings and provide for a reasonable re-entry period. The ventilation system has also to keep the Wet Bulb (WB) temperature below 32.5°C to adhere to Ghanaian mining regulations.

It should be noted that the SRK scope of work was limited to the WRP ventilation circuit which with the exception of some small quantities of air drawn in on 17 L is a stand-alone system. The existing fan on the South Waste Shaft is critical to provide short term requirements for the preparation works for the WRP. However, as soon as the RVS is commissioned it is no longer a critical requirement for the WRP. SRK notes that GSBPL has engaged Mine Ventilation Services Inc (MVS) to model the old areas of the mine and prepare a ventilation upgrade plan. The costs of this upgrade of the ventilation in the old areas have been included in the FS capital cost estimates.

### 15.7.2 Ventilation Quantities

The airflow requirements for the WSP have been estimated based on the underground equipment scheduled as per Table 15-12. There are a number of methods for determining the ventilation requirements and considering that the removal of diesel fumes are the primary concern the calculation is based on a diesel dilution rate of 0.06 m<sup>3</sup>/s/kW of diesel engine flywheel power using the entire fleet with their modelled availability and utilisation.

**Table 15-12 Air requirements for the Planned Equipment**

Equipment	Type	Engine Size (kW)	Fleet	Availability	Utilisation	m <sup>3</sup> /s
LHD (small)	Sandvik LH203	78	5	85%	100%	19.9
LHD (large)	Sandvik LH410	220	3	85%	70%	23.6
Truck (30 t)	Sandvik TH430	293	4	85%	75%	44.8
Twin Boom Jumbo	Sandvik DD321	110	1	85%	15%	0.8
Single Boom Jumbo	Sandvik DD210	38	3	85%	15%	0.9
Kubota Tractor	MX4600	35	10	85%	60%	10.7
Mine Grader	CAT12M	118	1	85%	60%	3.6
Service IT's	CAT924K	105	2	85%	75%	8
Normet - Chargeup		96	2	85%	75%	7.3
Normet - Cement	Utimec	120	1	85%	75%	4.6
Leakage (15%)						18.6
Contingency						7.2
<b>Total Airflow required (m<sup>3</sup>/s)</b>						<b>150</b>

SRK notes that in order to support the proposed fleet an estimated primary air flow of approximately 150 m<sup>3</sup>/s is required.

### 15.7.3 Stages of Primary Ventilation Circuit Development

SRK has divided the analysis of primary ventilation requirements at the Prestea mine into stages as described in the following sections in accordance with the proposed mining schedule. The WRP ventilation circuit has been predominantly designed as being independent from the rest of the PUG.

#### **Stage 1 – Preparation works and Raiseboring**

A bulkhead will be installed on 17 L south of the existing West Reef access drive with an exhausting fan capable of 20 to 25 m<sup>3</sup>/s. This stage is based on utilising the existing ventilation network in the PUG. Ventilation is required to prepare 17 L for the planned underground development works and raiseboring activities. This circuit consists mainly of Central, South Waste (exhaust), auxiliary downcast and Bondaye shafts.

Fresh air from the Central Shaft and auxiliary downcast will be drawn along the 17 L by the fan located in the bulkhead acting as a system booster. The exhaust air will enter the raise to the south of the bulkhead and travel up to join exhaust air travelling to the base of the south waste exhaust system. Possible routes for recirculation will need to be monitored once the system is in operation and sealed as necessary. This is illustrated in Figure 15-20.

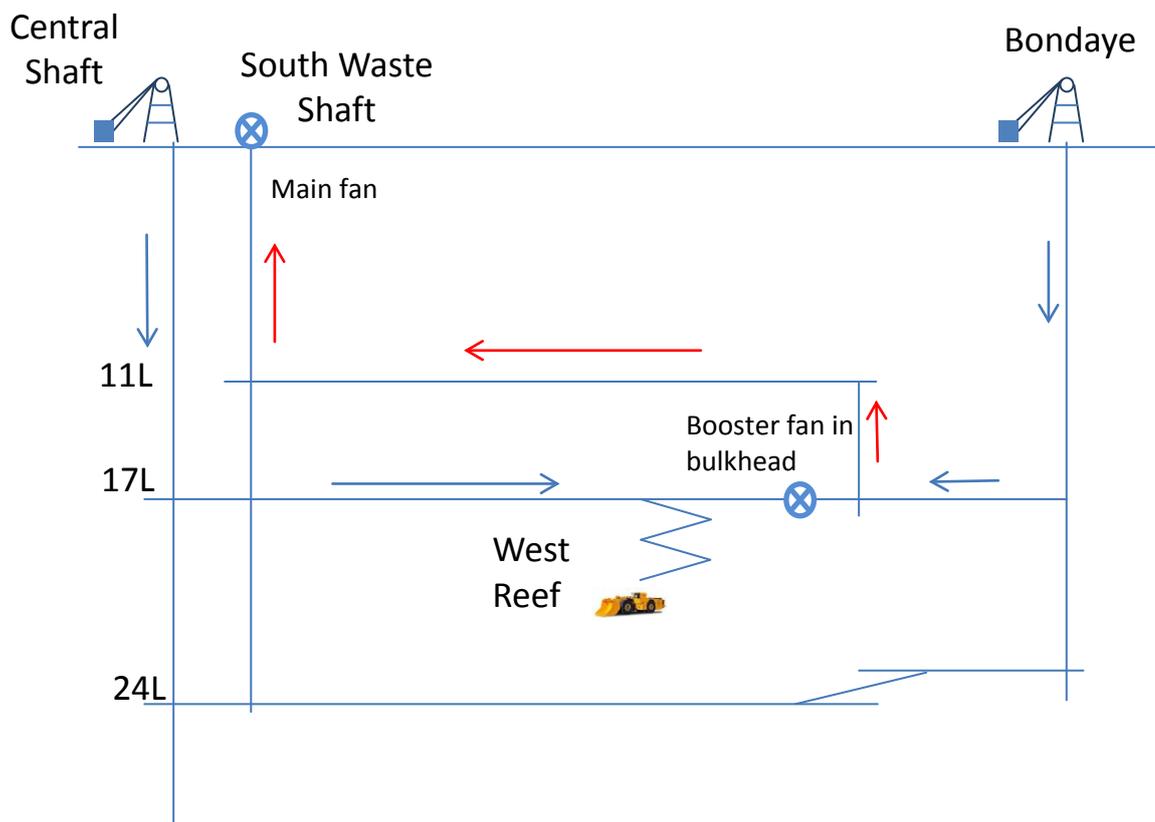
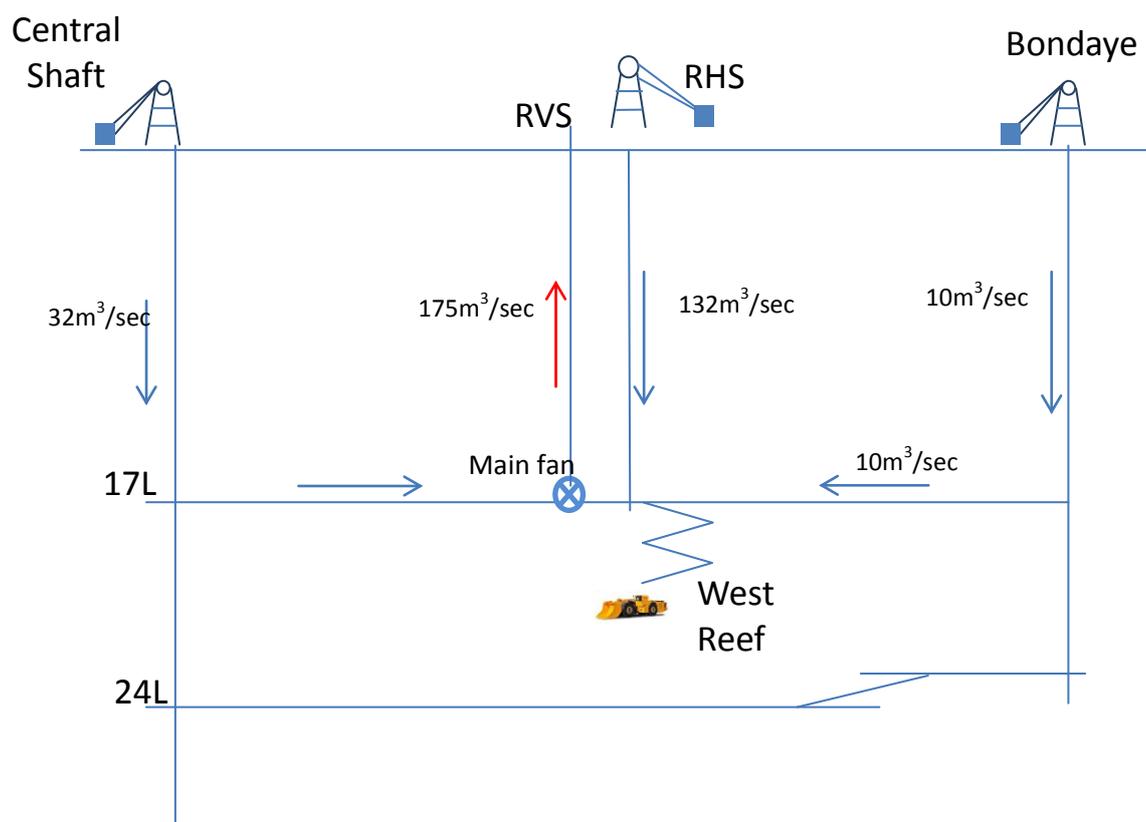


Figure 15-20 Schematic of Stage 1 Ventilation Circuit looking east

#### **Stage 2 – Completion of RHS and RVS**

This stage commences when both the RHS and RVS are complete and a standalone primary circuit has been established with the exception being that intake air of  $32 \text{ m}^3/\text{s}$  from the Central Shaft and  $10 \text{ m}^3/\text{s}$  from Bondaye shafts is included (the latter as a fixed flow). The Stage 2 ventilation circuit is shown in Figure 15-21.



**Figure 15-21 Schematic of Stage 2 Ventilation Circuit**

An exhaust ventilation system has been modelled with the fan located underground to reduce the surface noise footprint. The primary fan modelled for this duty is a Flakt Woods 2.8 m diameter axial flow unit with an installed motor rating of 530 kW. SRK has evaluated that this fan has capacity to ventilate the mine at both extremes of the mine life.

### **Stage 3 – Steady State Operations**

In this stage the primary ventilation drives are complete and main circuit is extended. The RHS delivers 120 to 130 m<sup>3</sup>/s of fresh air from surface directly to the top of the West Reef where air exits at the following locations:

- Workshop level;
- Drive connected to the decline and loading-tipping area; and
- Fresh air raise at the bottom of the RHS.

There are three regulators installed at the workshop level to control air movements to provide fresh air for shaft loading and to put the refuelling bay and welding bays under direct exhaust ventilation. An airflow of 15 m<sup>3</sup>/s is exhausted directly to the return from the workshop. The remaining fresh air from the RHS is joined by intake air from the Bondaye and Central shafts which feeds the production levels below.

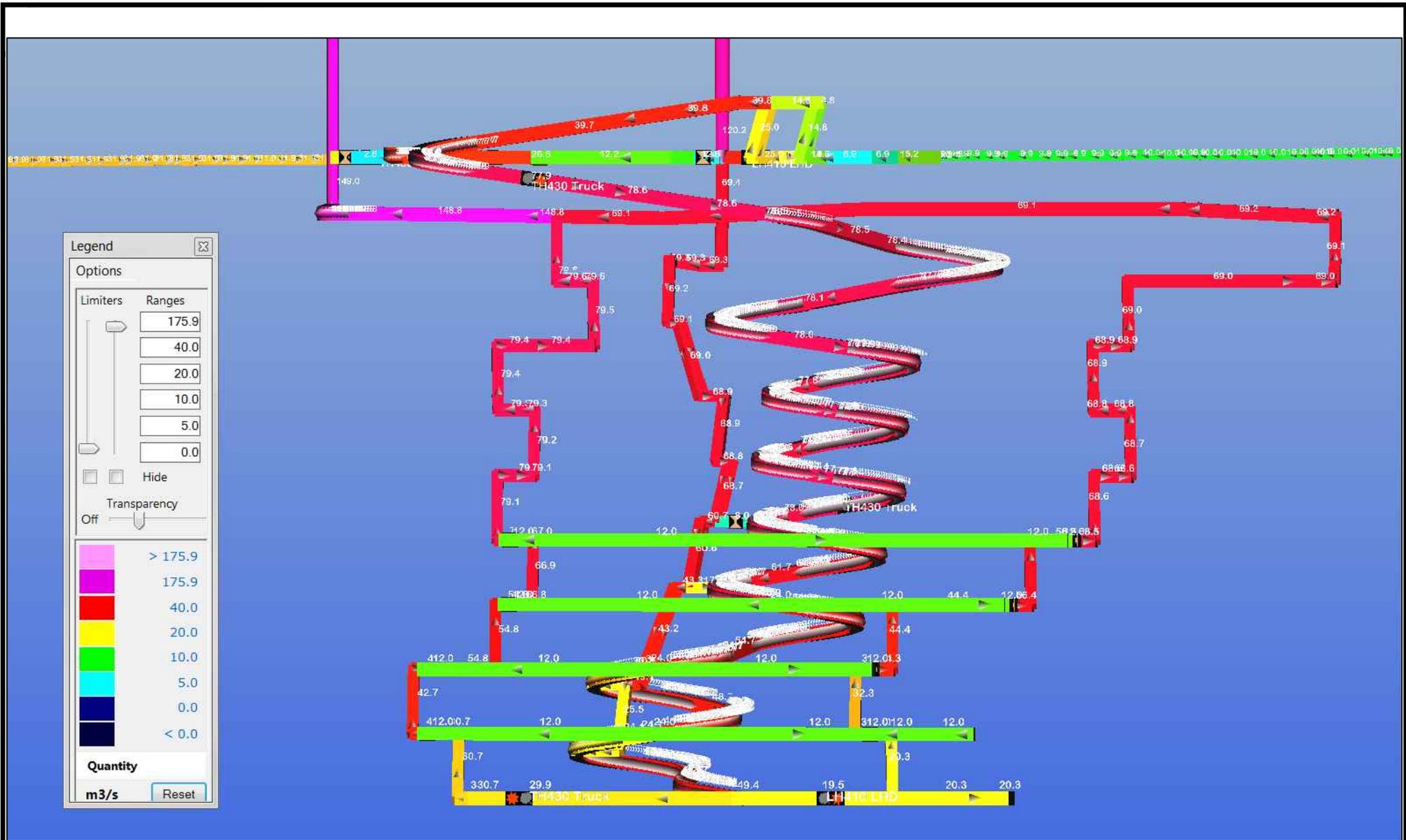
The decline receives 78 m<sup>3</sup>/s of fresh air, whilst a further 70 m<sup>3</sup>/s of fresh air is sourced through the enlarged ladderway, resulting in approximately 148 m<sup>3</sup>/s being of fresh air being available for the production levels.

Each level has regulators at both the north and south end to restrict exhaust airflow down to

12 m<sup>3</sup>/s; hence 24 m<sup>3</sup>/s enters each level access. Contaminated air is directed via 4 m x 4 m ventilation raises up to the exhaust drive and further out of the mine via the RVS.

A fresh air intake (fitted with an escape ladderway) at the bottom of the RHS has dimensions of 4 m x 4 m to provide sufficient supporting fresh airflow. Fresh air will be drawn off the raise into the decline as the fresh air flow reduces from the production levels as required. Ghanaian regulations limit the air velocity in travelling ways to 6 m/s and SRK would not recommend above this due to the likely dry and therefore potentially dusty decline environment.

Using this approach, 4 production levels can be serviced using a total of 96 m<sup>3</sup>/s which leaves 54 m<sup>3</sup>/s for the base production level and for driving the decline heading and establishing lower levels. A view of the Stage 3 ventilation circuit provided in Figure 15-22.



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### Stage 3 Vent Circuit Flows

Figure  
15-22

### 15.7.4 Secondary Ventilation

#### ***Decline and Footwall Haulages***

For driving the blind decline headings SRK has modelled the use of twin stage high pressure 110 kW (2 x 55 kW), 1 254 mm diameter secondary fans for development with 1 000 mm flexible PVC ducting. In order to provide fresh air down the decline during development, twin fans with independent 1 000 mm double ducting systems have been applied. Each duct provides 16 m<sup>3</sup>/s of fresh air to be used as required.

#### ***Ore Development***

The ore drifts will be ventilated by 30 kW fans situated in footwall drive prior to the exhaust raises that will produce around 10 to 11 m<sup>3</sup>/s each. Secondary ventilation is carried out with the fan units installed at the both north and south ends of a haul drive. Each fan ventilates two headings (ore drives through the one V-ramp) using a T-piece and 800 mm diameter ducting. Each ore drive heading requires 4.7 m<sup>3</sup>/s of air to service the LHD unit which has the largest requirement for ventilation in this heading. It is possible to exchange the 800 mm ducting for 1 000 mm ducting in these ore-drives as there is sufficient machine clearance.

## 15.8 Electrical

A new surface transformer station will be constructed at the RHS for use on surface and to supply underground. The primary electrical reticulation voltage will be 11 kV and the primary low voltage is 1 000 V.

The principal power drawing components of the WRP will be the RHS winders, the fan underground in the RVS, secondary fans, pumps and compressors as well as lighting and the drill jumbos. SRK calculate that the peak power running load at RHS is 2.7 MW with an installed load of 5 MW. The key electrical loads are listed in the table below:

**Table 15-13 Running and installed electrical loads at RHS**

Total mining related loads - maximum at full production		
	<b>Total kW Running</b>	<b>Total kW Installed</b>
<b>Total Load (kW)</b>	2,679	5,028
<b>Power Factor (pf)</b>	0.85	0.85
<b>Total Load (kVA)</b>	3,152	5,915

SRK has estimated the energy consumption for the installed loads based upon their expected utilisation. The results are presented in Figure 15-23 below; this includes on-going Bondaye and Central Shaft requirements, specifically the dewatering pumps.

SRK has provided in the budget for an additional diesel generator unit of 1 500 kVA which allows for critical activities such as service cage winder operation, ventilation and pumping to be continued through any power outages from the national grid.

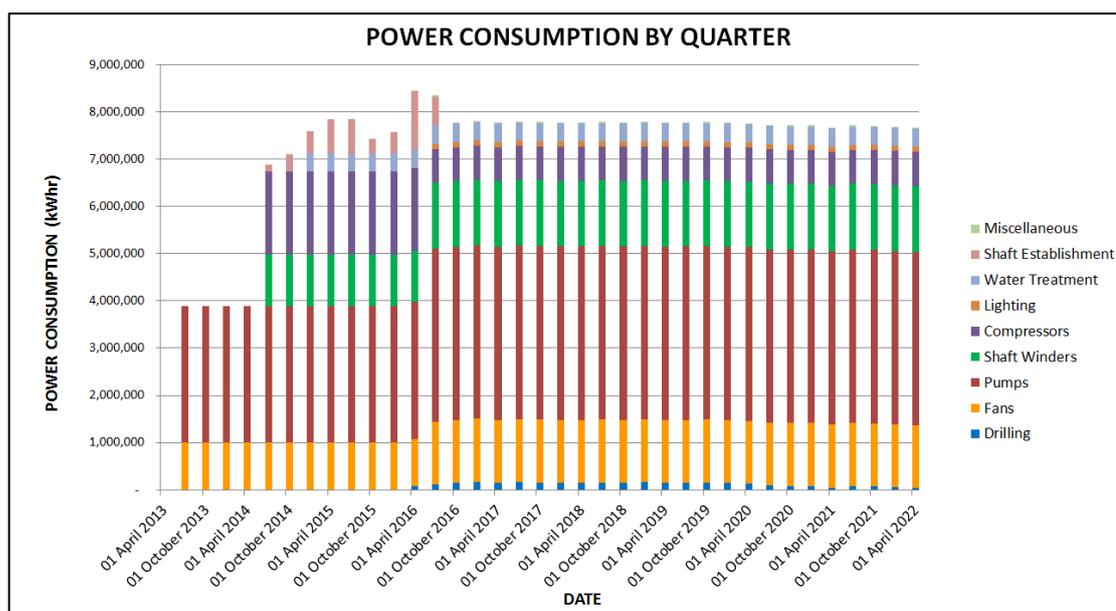


Figure 15-23 Quarterly Power Consumption (kWhr) for the WRP LoM plan

## 15.9 Dewatering

The strategy adopted by SRK for the WRP is simple and based upon the strategy of:

1. Contain the existing water ingress as close to surface as possible and pump it out. In this manner pumping costs will be kept to a minimum. Additional spare pumps, motors and an upgrade to the existing electrical infrastructure are required to maintain the existing dewatering network for the historic workings. This approach allows GSBPL to continue discharging contaminated water at surface under existing permits through the current operating systems; and
2. Maintain the WRP as a standalone operating mine within PUG, responsible for its own services and as far as is practical not dependent on the existing infrastructure. This WRP system will have a capacity of 20 lps.

Available evidence indicates that the WR orebody is relatively dry in terms of ground water ingress to the mine. As a result, the planned dewatering strategy involves the following:

- Face pumps on the ramp and in the accesses to the ore drives will deliver water to a skid mounted Mono pumps in series that will pump up to 17 L. It is noted that the ore drives will be driven on a positive gradient of 3 % from the V-ramps in order to facilitate drainage; and
- A settling sump on 17 L will receive the water and either return it back to the WRP as service water or pump it to surface. The WRP is expected to be a net producer of water in the short term and a net consumer of water in the long term. Top up service water will be provided by the existing pipe system which reticulates service water along 17 L in steel pipe.

SRK sees the current dewatering strategy for the rest of the Prestea Mine as being adequate and has made allowance for additional spares to this system and an entirely new system for the WRP discharging via the RHS to a surface reverse osmosis treatment facility.

## 16 RECOVERY METHODS (ITEM 17)

### 16.1 Introduction

The current processing facility at Bogoso/Prestea consists of: a BIOX<sup>®</sup> circuit, which recovers gold from refractory ores by cyanidation of a flotation concentrate subjected to bio-oxidation of the sulphide minerals; and an OC, a conventional CIL plant for gold recovery from non-refractory ore.

Commercial gold production from the Bogoso/Prestea operation commenced in late 1990 in a circuit with a design capacity of approximately 1.4 Mtpa. Following commissioning on oxidised ore, this plant commenced processing refractory sulphide ore in 1991 producing a flotation concentrate which was oxidised by roasting, the roasted calcine and flotation tailings were then cyanide leached in separate circuits.

This operation ran until 1994, when processing of sulphide ore was halted due to a significant mechanical failure of the roaster. From that point, the plant continued to operate, treating oxide, transition and non-refractory sulphides ore as these became available.

In 2001, GSBPL commissioned a FS to evaluate bio-oxidation as the means for oxidising the sulphides. This FS was based around the existing milling and flotation circuit. A further FS was commissioned in 2004, which considered an expanded operation as by that time GSBPL had obtained the rights to further resources in the area. This FS was completed in 2004 and led to construction of the BIOX<sup>®</sup> plant in 2005. The BIOX<sup>®</sup> plant commenced commercial operations in 2007 and GSBPL plans to treat ore from the PUG WRP through the OC.

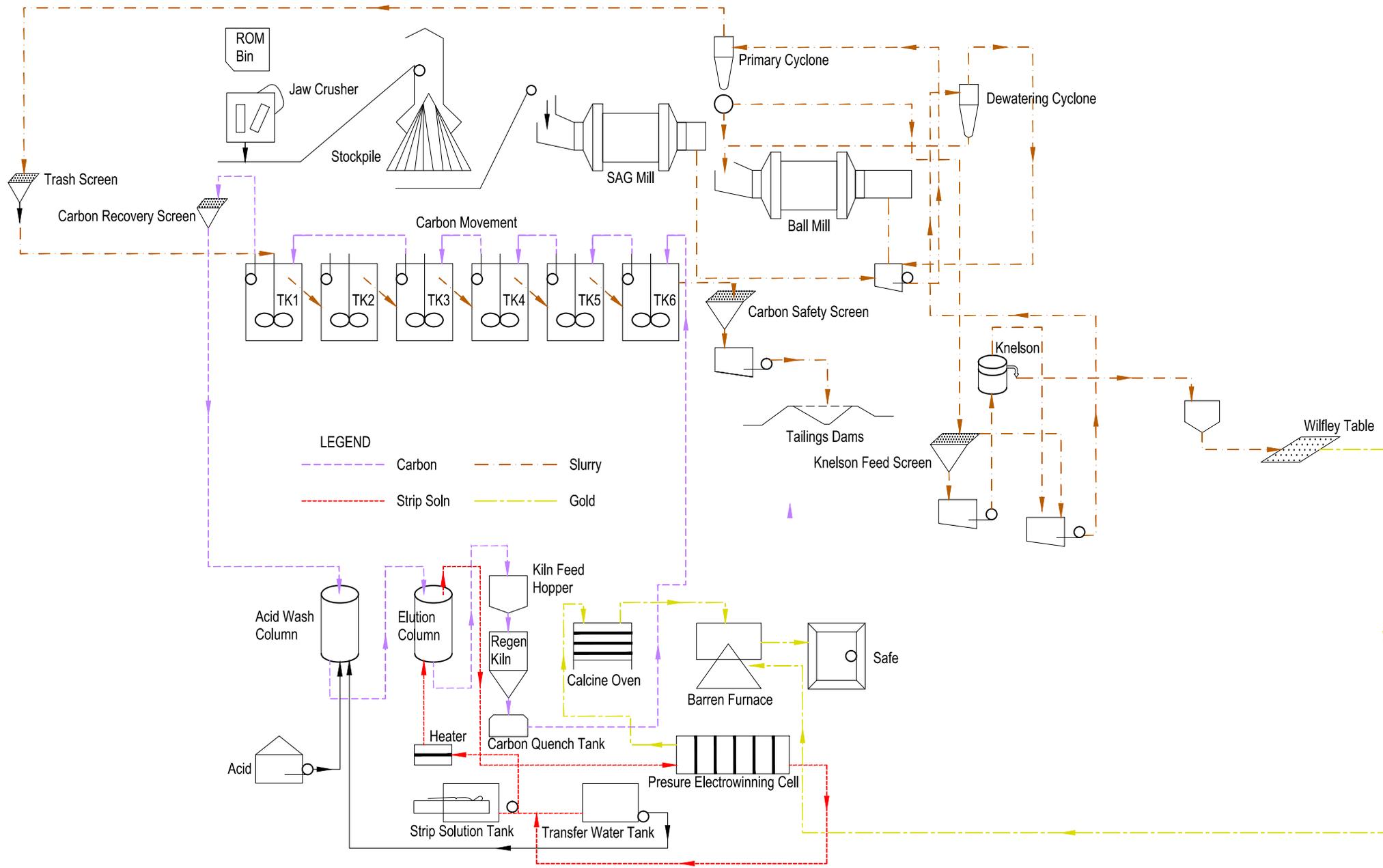
### 16.2 Oxide Circuit

While the Oxide CIL circuit has been operated intermittently since the commencement of the BIOX operation in 2007, the plant recommenced continuous operation at the beginning of 2012 with primary ore feed from the non-refractory Pampe open pit ore and secondary feed from Bogoso North and Chujah Main open pit oxides.

The main features of the Oxide circuit, which had an original design capacity of approximately 1.4 Mtpa are:

- The comminution circuit is the circuit from the original plant; an open circuit jaw crusher followed by two stage grinding using a 5.2 m diameter, 4.85 m EGL SAG mill fitted with a 1.5 MW motor operating in open circuit, followed by a 4.2 m diameter, 5.4 m EGL ball mill also fitted with a 1.5 MW motor operating in closed circuit with cyclones, producing a product with a nominal grind size of 80% -60 to -75 µm.
- A gravity circuit, consisting of two 30" Knelson Concentrators operating in parallel, treats a portion of the cyclone underflow. The concentrate from the Knelsons is manually upgraded using a Gemeni table to produce a gravity concentrate that is smelted. The gravity circuit was installed in early 2012, using equipment that was already on site.
- The CIL circuit consists of 6 x 1 200 m<sup>3</sup> tanks and associated equipment (i.e. agitators, intertank screens) that were obtained second hand from the Obotan Project in 2004.
- The elution circuit is based on a 5 t carbon batch, and was constructed in 2007.

A schematic representation of the Oxide circuit is shown in Figure 16-1.



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Ores are processed in blends or in separate campaigns based on their recovery and preg-robbing characteristics. Campaigns typically have durations of between two weeks and two months.

The Oxide circuit has a current throughput target of the order of 1.1 Mtpa (approximately 3 000 tpd). This is lower than the original design figure due to ore properties, which are generally harder, more grind sensitive and slower leaching than the ore types on which the plant was originally designed.

The residence time in the CIL circuit is between 17 and 21 hours with the 6 x 1 200 m<sup>3</sup> tanks, depending on the slurry % solids used. A seventh tank is due to be added in early 2013, which will increase the residence time by a further approximately 3 to 3.5 hours, providing either further residence time, or the ability to have one tank off-line for maintenance on a regular basis without compromising the overall circuit residence time. Further refurbishment improvements are planned for the cyclones, elution circuit and mills.

### 16.3 Processing Philosophy

With the FS metallurgical testwork indicating that the Prestea WRP ore is neither refractory nor significantly preg-robbing, it will be possible to treat the ore in the Bogoso Oxide circuit as a blend component with other non preg-robbing ores. In other words, there seems no compelling reason to consider campaign processing the WRP ore. Not having to campaign process the WRP ore will have several advantages:

- As the WRP ore will have a grade significantly higher than the other Oxide circuit feedstocks available at the time, there will be a clear cashflow incentive to process the WRP ore immediately on delivery to the Bogoso plant; and
- Were the WRP ore to be campaign processed, its higher grade would be likely to cause bottlenecks in the circuit, especially around the gravity circuit and in the elution circuit.

With a nominal production rate from the WRP operation of 700 tpd, and with a total plant production rate for the Oxide circuit of the order of 3 000 tpd, blend feeding the WRP ore will therefore mean that it will be diluted by a factor of the order of 2:1 with other non-refractory ores. As this dilutes the WRP ore through the circuit it will significantly lessen the impact on the circuit of the higher grade and ore hardness of the WRP ore. Further:

- While the WRP ore was harder than the comparison Pampe Fresh ore (see Section 12.3.4), diluting it with softer ores will reduce this difference. In addition, the harder WRP ore will provide grinding media in the SAG mill for the other ore types;
- SRK understands that the Oxide circuit currently produces a product of the order of 80 % -60 to -75 µm. While the harder WRP ore is therefore likely to come out of the grinding circuit slightly coarser than this, the testwork produced high Au recoveries at grind sizes of 80 % -77 to -88 µm, i.e. coarser than the current production target;
- At an expected head grade of the WRP ore delivered to the plant of 10 g/t Au, and assuming that the other ores for blending have head grades of the order of 2 g/t Au, the blended plant feed grade will be of the order of 4 to 4.5 g/t;
- Assuming a 60 % gravity recovery for the other ore feed, and 80% for the WRP ore, the amount of gold recovered by the Knelson Concentrators will be of the order of 2.5 to 3 times that which would be recovered without the WRP ore in the blend. Such an increase can be catered for in the subsequent tabling and smelting operations, by operating these processes for longer periods;
- Under these assumptions, the impact of the WRP ore on the gravity tailings grade will be to increase it by approximately 50 %. This will therefore increase the loaded carbon Au

grade by a similar amount, i.e. 50 %. The existing 5 t elution circuit is expected to absorb this increase in gold loading; and

- The kinetic data for the Prestea WRP samples from the CIP tests indicate that the Prestea WRP ore will reach its maximum leach recovery at the current Oxide circuit residence time of 17 to 21 hours.

SRK notes that delivering the high grade WRP ore to the Bogoso RoM stockpile and storing it could pose a security / theft risk. However, given the relatively modest ore production rate of the WRP and the likely desire to feed it to the plant as soon as it is delivered, there should be sufficient space inside the well-guarded perimeter fence, close to the OC crushed ore stockpile. In addition, given that the ore will be passed through a 300 mm grizzly underground, there should be no requirement to further crush the ore ahead of it being fed to the Oxide SAG Mill. Therefore, ore delivered to Bogoso could be fed directly onto the mill feed conveyor from the stockpile (CV2) via the existing emergency feed hopper on CV2.

## **17 PROJECT INFRASTRUCTURE (ITEM 18)**

### **17.1 Introduction**

The WRP does not require substantial infrastructure in terms of roads and other facilities. The WRP is situated in a long established mining town that is generally well served with roads and power infrastructure.

### **17.2 Roads**

The WRP is located in a developed part of Ghana close to Prestea town with well established paved and unpaved road infrastructure. Two roads are required to service the operation as described below.

A 180 m road has been planned for the WRP site to allow heavy vehicles to enter the RHS collar area. This road has been assumed to be 5 m wide and comprising of 0.5 m of compacted gravel. In addition, an allowance has also been made to import gravel for the whole fenced area.

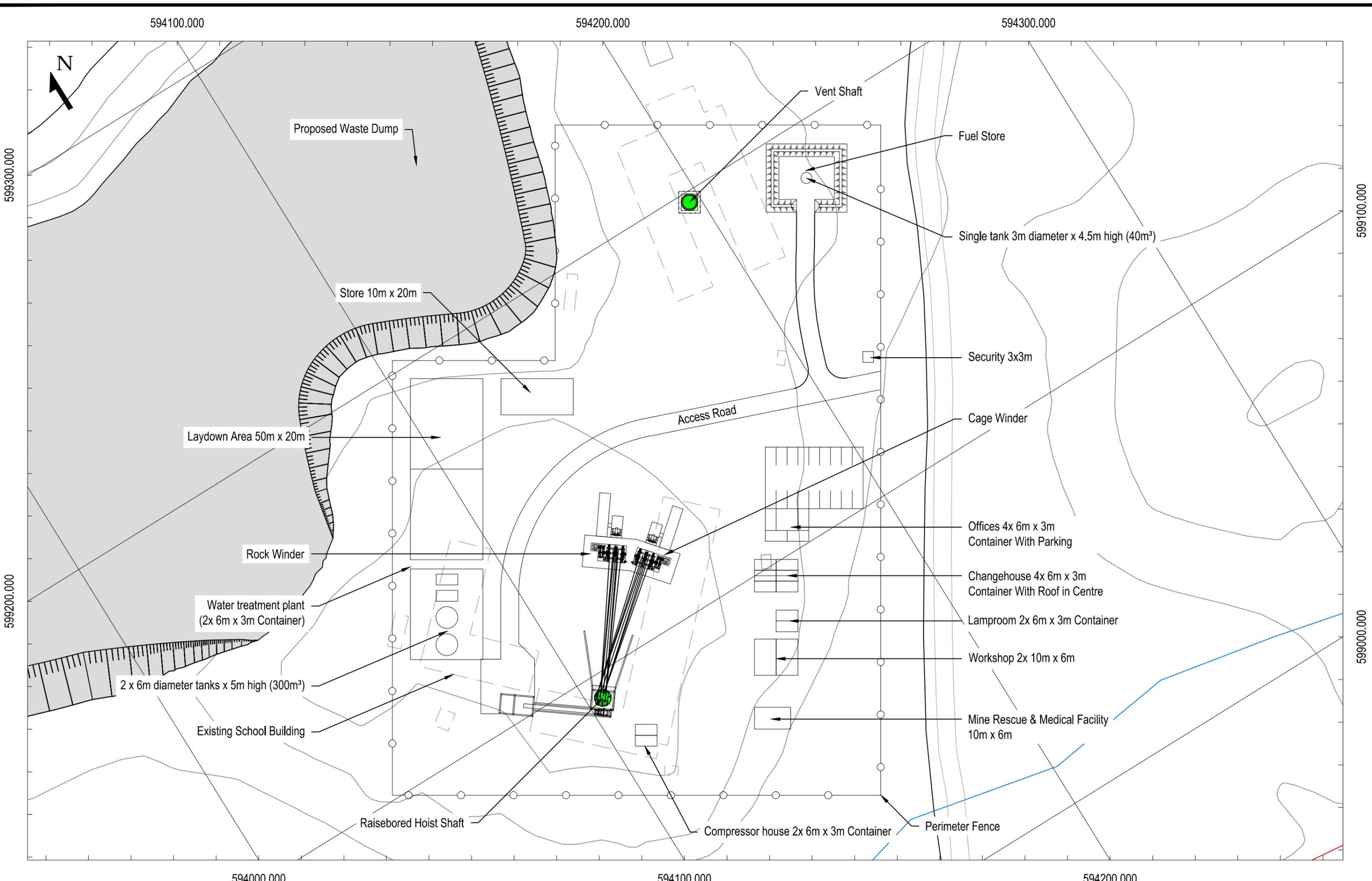
The haul to the Bogoso processing plant is 16 km and is part national highway and part private GSR haul road. The road alignment has been planned to service GSR's Prestea South Mbease Nsuta Project ("PSMNP") that will also truck ore to the Bogoso plant. The capital cost of this road is covered by the PSMNP although some operating costs for maintenance have been applied in the financial model for the WRP. The operating costs consist of a fixed monthly operating cost of US\$ 40k for road repair and a trucking charge of 22.5 USc/tkm.

### **17.3 Shaft Complex Surface Layout**

Facilities have been designed for the surface area at the collar of the RHS and RVS infrastructure. These include the waste storage facility, a change house, maintenance workshops, a water treatment plant, offices, laydown areas, warehouse, security checkpoint and fuel storage tanks. The facilities are shown in Figure 17-1 which also illustrates the location of the current school buildings which shown as the lightly hatched boxes around the collar locations for both shafts.

### **17.4 School Relocation**

Relocation of the secondary school currently situated on the site of the proposed RHS is a key requirement of the WRP. The shafts cannot be constructed without relocation of the school. A suitable location has been found as part of an ongoing planning process initiated by GSBPL in conjunction with the school authorities, government and local civic leaders. Draft designs have been prepared for the FS and cost estimates have been included in the schedule of capital costs for the WRP.



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### Raisebored Hoisting Shaft Surface Layout

Figure 17-1

P:\U4935 PRESTEA FS\PROJECT\CAD\REVISED REPORT FIGURES - JUNE 2013 REVISION\CHRIS BRAY REPORT FIGURES\FIG 17-1 - RAISEBORED HOIST SHAFT SURFACE LAYOUT.DWG

## 17.5 Electrical

### 17.5.1 Introduction

The WRP has been designed to be independent from the existing electrical infrastructure of the historic workings. This has been possible due to the geographical location of the West Reef resource and surface infrastructure.

The system has been designed in this FS according to Ghanaian mining regulations and to most efficient mining standards. The primary high voltage for reticulation is 11 kV and for low voltage 1 000 V. The key electrical loads installed will be for the two new winders at the RHS, ventilation fans, air compressors, dewatering pumps and the electric-hydraulic drills.

The existing electrical infrastructure both on surface and underground has been in existence for between 20 and 60 years with the last 20 years having seen very limited maintenance. GRIDCO the national electrical distributor has a main transformer yard just 1 km from the Central Shaft. They have 25 MVA transforming capacity from 161 to 34.5 kV. This transformer has only been in place for 2 to 3 years but it is not known if it was new when installed.

Previous to the installation of this transformer (reducing to 33 kV) voltage was reduced to 55 kV by GRIDCO for distribution. The changeover caused some significant problems at the Prestea main substation or 'Job 600'. The incoming voltage is stepped down to 3.3 kV initially at Job 600 which then feeds the following:

- Central Shaft surface;
- Central Shaft underground;
- Prestea township; and
- Through a step up transformer the 55 kV overhead line to Bondaye.

An existing overhead power line runs within 150 m of the planned RHS. This line currently runs 55 kV to the Bondaye Shaft There are two concerns with this current system:

- The initial step-down transformers have insufficient spare capacity to power the new shaft site; and
- The Job 600 substation and associated controls are old and in poor condition and without major capital investment will have lower availability and reliability than a new installation.

SRK notes that system reliability is not expected to be a material issue due to the fact that there is adequate provision for labour and materials to effect repairs. It is further noted that should the pumps stop due to electrical problems there is ample capacity in the lower levels of the mine to store water until such time as the electrical issue is resolved.

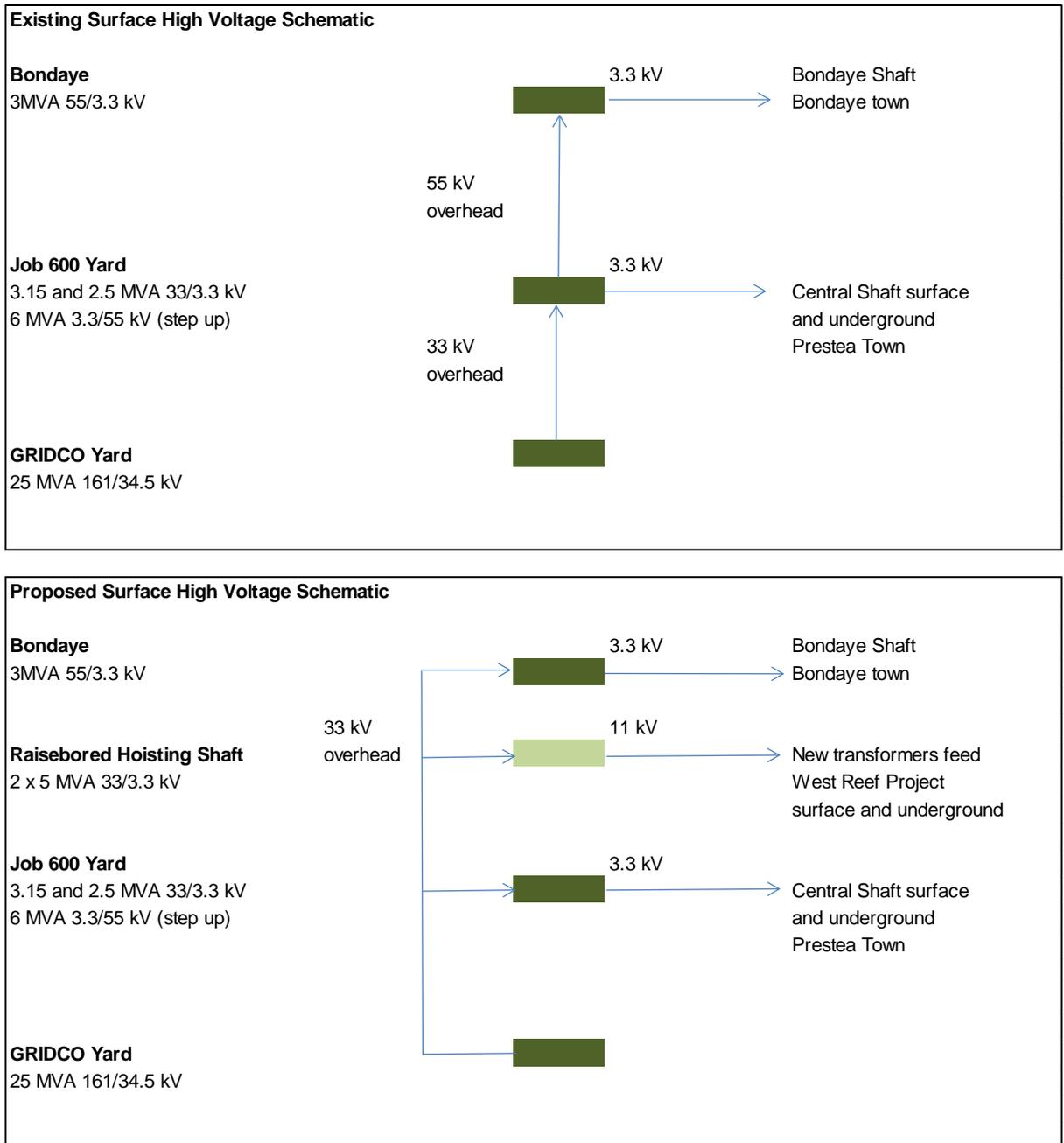
The proposed solution is to have the incoming supply from GRIDCO (the national grid supplier) bypass the Job 600 yard and continue at 33 kV in the existing Bondaye line to service the RHS and all new underground installations. The main 33 kV to 11 kV transformers will be located at the RHS site. Central Shaft load requirements that remain to support the West Reef shall be connected through the Job 600 substation. Since power will continue at 33 kV to Bondaye, a new 33/3.3 kV transformer will be required at Bondaye. This new system removes remnants of the old 55 kV high voltage, retains both Prestea and Bondaye on 3.3 kV and introduces 11 kV at the RHS. The key upgrades required are:

- Install a by-pass feed for the 33 kV at the Job 600 yard (and remove the step-up transformer from the system);
- Install a spur line off the existing overhead to the RHS; and

- Replace the 55/3.3 kV with 33/3.3 kV at Bondaye.

The main cost components are to replace the 3.3 kV circuit breakers and motor starters. The cost of replacement has been included in the capital cost estimates for the FS.

**Figure 17-2 High Voltage Incoming Supply Changes**



## 17.6 Waste Storage Facilities

In general all waste rock produced from the WRP will be kept underground and used for backfill. The exception to this is during the early years of the WRP when there are not sufficient voids available to allow filling to commence. In this case the waste rock will be transported to surface.

In the first year of project development 100 kt will be hoisted up the Central Shaft. Due to a lack of suitable and existing sites on surface in close proximity it has been determined that all

the waste rock will be transported to the dump site location at the RHS where an engineered facility will be constructed. Even though a geochemical examination of the rock types by SRK suggests negligible acid generating potential this facility will be constructed to contain any problematic material so that run off can be treated appropriately. During the ramp up of production in the early years there is also an excess of waste rock. This will necessitate a further 300 kt of material to be hoisted up the RHS and stored on surface.

## 17.7 Ore Stockpiles

No surface ore stockpiles are planned at the WRP as all the ore will be trucked directly from the shaft ore bin within a few hours to the Bogoso plant where it will be blended in with other feed material on the Run of Mine (RoM) pad. Buffering capacity will consist of orepasses underground below the truck tips and the surface ore and waste bins.

## 17.8 Tailings Storage Facilities

### 17.8.1 Introduction

The tailings from both the open pit and underground operations at the Prestea Mine will be processed in the same facilities at Bogoso and the tailings will be delivered to the the present Tailings Storage Facility (TSF), termed TSF2.

TSF2 is a paddock type facility consisting of four Cells. A total of 17 embankments separate the four Cells. The WRP will generate approximately 1.4 Mt of tailings waste which will be deposited in Cells 1 and 2 of TSF2 over a 7 year period. Although the testing on the new Prestea tailings is not fully completed, it is anticipated that the tailings will be coarser than presently deposited in the TSF2. TSF1 has already been completed and presently serves as a water storage facility. Table 17-1 below shows the planned tailings production rate from the WRP LoM plan.

**Table 17-1 WRP Tailing Production Rates (ktpa)**

2016	2017	2018	2019	2020	2021	2022	Total
58	240	281	280	269	273	33	1,434

SRK was requested to review TSF2 with respect to the suitability to store the tailings from the WRP. To fulfil this task, SRK has performed a site visit in October 2012, and has reviewed the existing reports:

- *Golden Star Bogoso/Prestea Limited - Tailings Storage Facility 2 Site Investigation Factual Report, Knight Piésold, March 2011;*
- *Golden Star Bogoso/Prestea Limited - TSF2, Design Report, Knight Piésold, March 2011;*
- *Golden Star Bogoso/Prestea Limited – Stage IV Raise Design Report, Knight Piésold, March 2011; and*
- *Golden Star Bogoso/Prestea Limited – TSF2 Operational Audit Period: August to October 2011, Knight Piésold, November 2011.*
- *Golden Star Bogoso/Prestea Limited – TSF2 Operational Audit Period: May to July 2012, Knight Piésold, August 2012.*
- *Bogoso TSF2 – Currently Permitted maximum storage Capacity assessment (Rev A):Memorandum, Knight Piésold , 19<sup>th</sup> July 2012, and*
- *Golden Star Bogoso/Prestea Limited – TSF2 Operational Audit Period: August to October 2012, Knight Piésold, January 2013.*

SRK has not performed any direct site investigation nor lab testing for the subject TSF with the exception of the request for the tailings waste testing which is still in progress at the time

of writing.

### 17.8.2 Site Description of TSF2

The tailings from the existing Bogoso operation are stored in the TSF2 as the TSF1 has already been completed and presently serves as a water storage facility. TSF2 is a paddock type facility consisting of four cells. A total of twelve embankments separate the four cells;

The tailings deposition management at Bogoso can be described as follows:

- TSF2 is a paddock type facility consisting of four cells. Cell 1, Cell 2 and Cell 2A impound cyanide bearing floatation tailings, and Cell 3 impounds non-cyanide BIOX® tailings.
- No tailings are being deposited in Cells 1 and 2 at present.
- Cell 2A's tailings sub-aqueous deposition takes place via spigots.
- Cell 3's tailings deposition management changes have led to generally firm and evenly formed beaches and reasonable tailings particles segregation, suggesting good discharge practises.

Based on the memorandum by KP dated January 2013, Table 17-2 below shows the allowable elevations for the each embankment around cells 1, 2, 2A and 3.

**Table 17-2 Permitted elevations for TSF2 as of June 13, 2012 (Knight Piésold, 2013)**

Cell	Embankment	Maximum Elevation (mRL)
1 & 2	1, 2, 3, 4,	90.8
	5, 6, 7, 8, 9	91.8
2A	11,12	83.3
3	13, 16, 17, 18, 19, 20	86.0

According to KP the remaining volumes within each respective cells within TSF2 is as shown in Table 17-3.

**Table 17-3 Volumes in TSF2 (Knight Piésold, 2012)**

Cell	Volume (Mm <sup>3</sup> )	Dry Density (t/m <sup>3</sup> )	Capacity (Mt)	Throughput since survey (Mt)	Remaining Capacity (Mt)
1 & 2	9.6	1.30	12.48	0.000	12.48
2A	3.7	0.9	3.33	0.506	2.82
3	8.9	1.35	12.02	2.060	9.96

From the information above, it could be seen that the tailings tonnage from Prestea (1.4 Mt) to be stored is only a small portion of the facility's remaining capacity (11 %), available in Cells 1 and 2. The final capacity of Cells 1 and 2 will depend on the removal of excess water from the subject cells to create competent tailings beaches capable of supporting upstream embankment construction and successful raise of the embankments to permitted elevations.

### 17.8.3 Embankment Design and Construction

The embankment design considered the following aspects: slopes geometry, construction materials, raised stages, emergency spillways and stability analyses. Stage IV embankment design details and criteria for TSF2 are as follows:

- The embankments were designed to retain tailings and to control seepage from a centrally located pond;
- All embankment crests are 10 m wide. The different methods for raising embankments were chosen in accordance with the field investigation, and are summarised in Table 17-4 below;
- The upstream constructions necessitate 0.5 m rock-fill built onto the tailings beach to

form a stable construction platform for the embankment raise;

- All crests are topped by 150 mm of lateritic gravel wearing course and are graded at 2 % slope to allow drainage;
- A 1.3 m freeboard is allowed at each construction stage (greater than the after storm minimum freeboard estimated to 800 mm);
- A storm water analysis was conducted to size emergency spillways for a 1:100 years/24h event;
- Cut-off trenches are excavated in the foundation beneath the downstream toe of the embankments extensions; and
- Downstream sumps are raised and submersible pumps are installed in the sumps for dewatering.

**Table 17-4 TSF2 embankments construction methods and slopes Stage IV design (based on previously listed KP documents)**

Cell / Embankment	Construction Method	Slopes	Windrow	
<b>CELL 2A</b>	5,6,7	Centreline	Upstream 2H:1V Downstream 2H:1V	Upstream and Downstream
	8	Upstream	Upstream 2H:1V Downstream 2.5H:1V	Upstream and Downstream
	11	Downstream	Upstream 2H:1V Downstream 2.5H:1V	Downstream
	12	Centreline	Upstream 2H:1V Downstream 2.5H:1V	Downstream
	12A	Starter dam after removal of topsoil and foundation preparation	Upstream 2H:1V Downstream 2.5H:1V	Downstream
	15	Upstream	Upstream 2H:1V Downstream 2.5H:1V	Downstream
<b>CELL 3</b>	13	Upstream	Upstream 2H:1V Downstream 2.5H:1V	Downstream
	14,9	Upstream	Upstream 2H:1V Downstream 2.5H:1V	Upstream and Downstream
	16	Downstream	Upstream 2H:1V Downstream 2.5H:1V	Downstream
	19,20	Centreline	Upstream 2H:1V Downstream 2.5H:1V	Downstream

Stability analyses were performed by KP for drained, undrained and post-liquefaction scenarios in static and pseudo-static conditions. The following can be noted:

- Seismic regional data is quoted as 'low seismic activity' and a 0.1 g ground acceleration was used for seismic modelling;
- After site investigation measurements, it appears that the shear strength tailings parameter values used for the stability analyses were overestimated. The other assumed parameters are relatively conservative compared to in-situ measurements; and
- Liquefaction analyses assumed that the pond would be at least 100 m from the wall, but in some cases this is not achieved. SRK recommends analysis based on seasonal and achieved operational pond levels.

#### 17.8.4 Water Management

TSF1 and TSF2 have been used for water storage with significant inputs relating to rainfall on the associated TSF catchments, water contained in process tailings and plant surface drainage water. As a consequence there is a significant surplus of water in the TSF1 and TSF2, which needs to be managed. The water treatment plant was built to treat cyanide water contained on Cells 1, 2 and 2A. The plant was commissioned in Q4 2012 and has continued to treat cyanide water from Cell 1, 2 and 2A as well as from Buesichem pit.

##### Drainage, Seepage and Monitoring

The drainage system consists of blanket drains, toe drains, slope face drains within the embankments and upstream/downstream seepage sumps. The following has been noted in the reviewed reports:

- The decant system consists of clarified supernatant water returned to the plant via barge pumps (operative capacity 800 m<sup>3</sup>/h);
- The only upstream drainage tower for Cells 1, 2 and 2A has now been fully submerged with tailings in front of Embankment 11, and is therefore inoperative;
- Seepage through the external embankments became an issue for several embankments since 2010. Historically poor water and tailings management have led to a high phreatic surface within the ponds;
- Water level in Cell 2A has trended up in 2013. In Jan 2013 level was around 78mRL and currently at 80 MRL;
- SRK emphasizes KP's comments concerning seepage issues around embankments 1,2,11 and 13. SRK agrees with the solutions presented by KP in the operational audits documents (Knight Piésold 2013) including completion of secondary confinement drainage works...
- The monitoring system includes 13 piezometers, monitoring bores and survey pins.

#### 17.8.5 Post Construction Site Observations

KP regularly undertakes inspections of the site and SRK notes several points from the August to October 2012 audit report that followed the construction of the Stage IV raise:

- Embankment 12A of Cell 2A was constructed as a temporary embankment. For future lifts, the current ramp will need to be removed and the embankment will need to be reconstructed to the appropriate design. Whilst embankment 12A is not active, management of tailings deposition in this area is needed to enable construction of the permanent embankment;
- Embankments 19 and 20 of Cell 3 were constructed as upstream raises in contradiction to the centreline construction design intent;
- There were no emergency spillways constructed on Cells 1, 2 and 2A, despite designs and construction drawings being submitted to GSBPL;
- It is noted that the high water volume seeping through Cell 3 is reacting with the embankments' construction rock, resulting in acid forming conditions and very low pH downstream of the facility.

#### 17.8.6 SRK Comments and Recommendations

The concept of storing the tailings from the WRP relies on the use of approved tailings storage facilities including the existing TSF2 (Cells 1, 2 and 2A) which is presently storing tailings from the Bogoso mine. In the FS economic analysis it has been assumed that Bogoso operation will offset the costs of Prestea tailings within the US\$ 15/t RoM

compensation cost. SRK considers that the commingling of the tailings in the TSF2, from Bogoso and Prestea mines will not create any new constructability issues providing that the facility continues to be managed and constructed in line with design and supernatant pond levels maintained at operational levels through water management and treatment.

SRK notes that the successful operation of the TSF2 (Cells 1, 2 and 2A) including volume capacity availability, with regard to WRP, will depend on:

- Proper beach construction and adherence to the original design of sub-aerial deposition. In the past the beach construction below water resulted in low densities of tailings and this scenario should be avoided in the future;
- Continuing the successful deposition strategy employed in recent years - i.e. beaches built up in 300 mm lifts allowing for consolidation, with rotation operated spigots and tailings deposited sub-aerially a substantial distance from the embankments. All upstream embankments should be built on solid, non-liquefiable (dilative) material;
- Management of the supernatant ponds through good tailings and water management practices, catchment minimisation and continued treatment of water through the detoxification water treatment plant. These practices reduce seepage and geotechnical risks with the TSF;
- In order to maintain the phreatic surface at a suitable level within the cells, it is recommended that automatic pumps be installed to the upstream tower and sump locations to aid in draining the tailings mass and removing water to the pond. The slope stability analysis should be updated for the embankments where water table is significantly higher than predicted in the original design;
- Slope stability of the TSF2 facility should be assessed yearly with factual as-built geometries, strength of materials and real piezometric levels. The liquefaction potential of embankment (densities) should be frequently verified to prevent failure; and
- The volumetric analysis should be regularly undertaken to ensure that the adequate storage volume is achieved at the permitted elevations for TSF2. In addition, the densities achieved should be verified for each cell for the remaining Bogoso and WRP LoM plan.

## 17.9 Dewatering

### 17.9.1 Introduction

SRK hydrogeologists visited site in October 2012 to collect site data and undertake underground inspections of the workings and dewatering system.

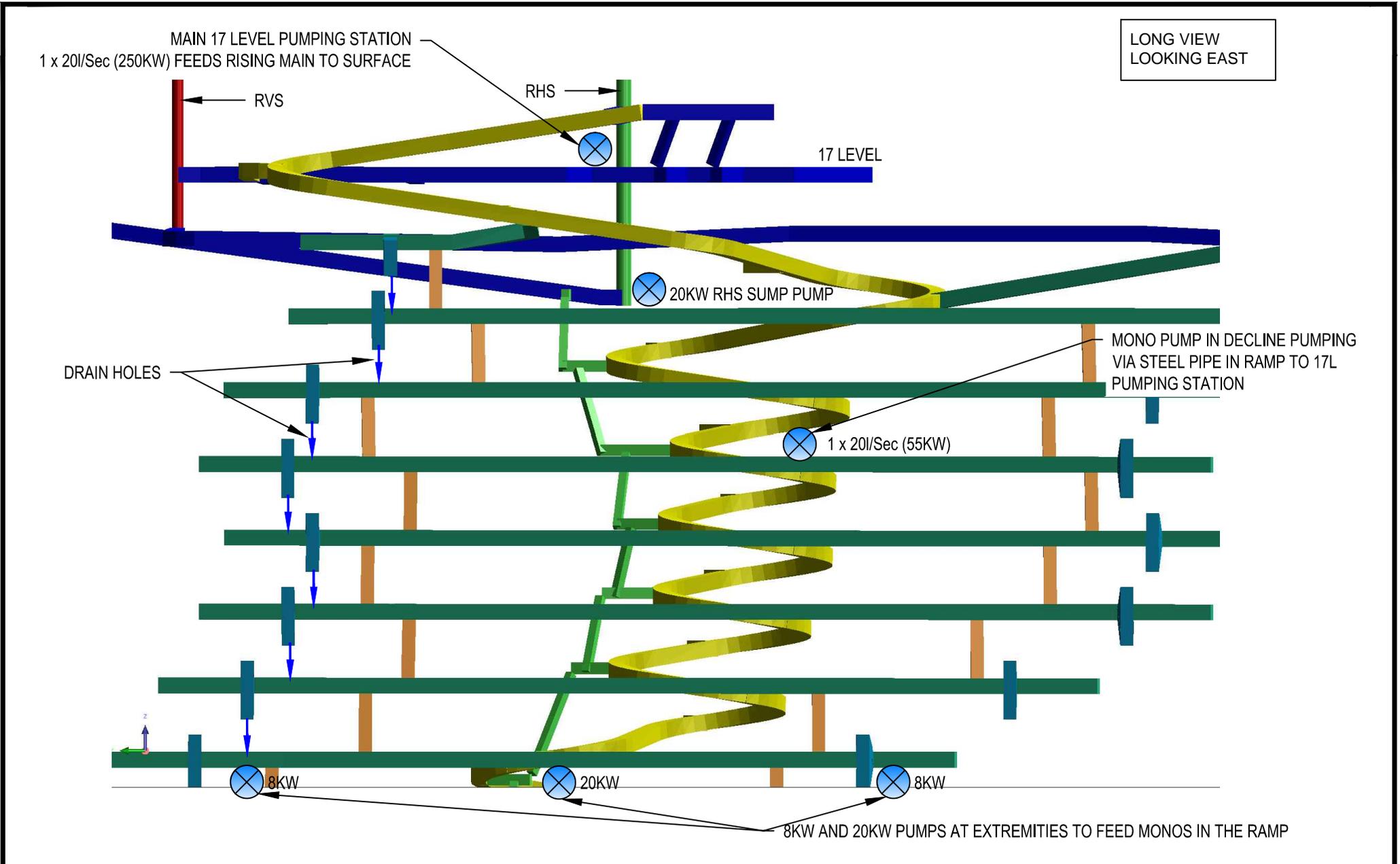
The existing Central and Bondaye shaft dewatering systems shall be maintained and will pump historic workings mine water through those shafts to surface. This system needs to maintain water levels in the historic workings to below the 24 L to ensure that water levels in the mine do not impact West Reef mining activities.

Ground water and service water that is required to be handled as a consequence of West Reef mining will have its own independent system. The main components of the new system as displayed in Figure 17-3 are:

- A 200 mm rising main in the RHS, one spare rising main will also be installed;
- An all-electric pump network at 1,000 V;
- 1 x primary pump in the primary pump station on 17 L near the truck tips (including settlers and some storage);
- Helical screw travelling pumps with feed hoppers for primary lifting through decline piping

to 17 L pump station;

- 8 and 20 kW submersible electric pumps for face and secondary pumping requirements (generally pumping to the helical screw pumps);
- 150 mm steel rising main in the decline and class 12 (12 bar) HDPE pump lines otherwise; and
- Drain holes in the production levels to simplify the pumping network.



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		West Reef Key Dewatering Infrastructure	Figure 17-3

### 17.9.2 Water Quality

Water quality predictions by SRK are summarised in Table 17-5. West Reef mine water reporting to surface will initially discharge into a holding facility before treatment in a reverse osmosis / precipitation facility situated adjacent to the RHS. Following treatment, water will be released to the environment.

**Table 17-5 Predicted Hydrochemistry of WRP 17 L to 24 L**

Determinand*	Unit	Deep groundwater system	
		Indicative depth below ground level = 600 to 1,000 m Likely range in concentration	
Temperature*	°C	31	
pH	pH units	7.5 to 8.2	
Conductivity	µS/cm	2,000 to 7,000	
TDS	mg/l	1,000 to 7,000	
Sulphate	mg/l	1,500 to 5,000	
Arsenic	ug/l	1,100 to 5,400	
Calcium	mg/l	120 to 500	
Lithium	ug/l	40 to 300	
Magnesium	mg/l	300 to 1,000	
Manganese	ug/l	2,000 to 6,000	
Potassium	mg/l	2 to 8	
Sodium	mg/l	30 to 150	
Sulphide	ug/l	700 to 1,300	
Strontium	ug/l	700 to 2,700	
Uranium	ug/l	0.5 to 1	

### 17.9.3 Prestea Indemnity on Historic Mine Waters

The Government granted GSBPL an indemnity for pre-existing environmental liabilities at the Prestea Mine lease area in 2001. It is GSBPL's view that the continued pumping of historic mine water during the duration of West Reef mining continues to fall under the coverage of this indemnity. SRK considers this to be a reasonable approach and has assumed this for the FS.

### 17.9.4 Existing Dewatering infrastructure (Central and Bondaye shafts)

The existing dewatering infrastructure for the Central and Bondye Shafts will not change materially from that which is currently installed and will be maintained during the life of the WRP. From Central Shaft the average mine water abstraction over the last five years has been 44 litres per second (lps) which is handled by a system capacity of 76 lps. Bondaye has an average abstraction on 32 lps with a current capacity to handle 50 lps.

During the FS, SRK has considered replacing this system in conjunction with replacing the electrical system with the benefits of:

- Lower operating cost system; and
- Improved reliability.

The reliability of the system was examined purely from the perspective of potential effect on the West Reef mining. The mine had a period of no dewatering (reported to be July to September 2010) when there were incoming voltage problems and what might have been downstream effects on motors in the system and their need for replacement. The mine

suffered ground water increases and lost access to the lower levels. Since then the mine has been able to dewater and has started recovering lost levels. It is noted that with the spare pumps and motors now on site that the pumping system whilst using the historic workings below 24 L as a sump can maintain water levels acceptable for West Reef mining at an overall system availability of 60 to 70 %.

### **17.9.5 Water Storage in Historic Mining Voids**

The available void space in the lower workings was examined (in conjunction with some inflow rates to assess storage capacity. The net estimated storage volume between 28 L and 24 L is 750,000 m<sup>3</sup> which at an average water inflow rate of 76 lps provides 114 days storage.

### **17.9.6 West Reef Standalone system**

The WRP shall have a standalone dewatering system. The West Reef area in observation is relatively dry. Ground water ingress is most likely to occur through any major geological structures encountered. SRK notes the following with regard to the water balance:

- Service water for drills and dust suppression has been estimated at 4 to 5 lps;
- An allowance for ground water must be made and has been assumed at 10 lps; and
- A significant proportion of this water is likely to exit the mine with the waste and ore rock streams. Hence dewatering requirements are low.

For the FS a dewatering and treatment system capable of handling 20 lps (Inclusive of an estimated 7 lps recirculating) from the mine has been designed.

#### ***Primary Pump Station and Rising Main***

The primary pumping station for West Reef shall be installed in its own excavation on the 17 L, not far from the truck tips and the mobile fleet workshop. On surface water will discharge into a holding facility before water treatment.

The pump selected is a Vogel MPE100.1 11 stage ring section pump capable of 20 lps over a total head of 650 m. There is planned to be a single pump unit in use though the station will be prepared with two base plates to facilitate future additions and the upfront purchase will be for two pumps, though only one motor and controls.

Mine water from the workings shall be delivered to a primary settling sump that can be accessed by a LHD for periodic silt clean-out. From this sump a skimming submersible pump shall pump cleaner water around to a 9 m<sup>3</sup> feed hopper in the main pump chamber. Any overflow will gravitate back to the settling sump.

The feed hopper shall feed the pump via mercury float switches or other PLC control. The pump will discharge through non-return valves initially into schedule 80 pipe into the hoisting shaft. At the half way point the piping shall reduce in rating to schedule 40 as the pressure reduces.

#### ***Secondary Pumping***

Delivering mine water to the primary pump station settling sump shall be via a simple network of submersible pumps and helical screw “mono” style pumps. The helical screw pump selected is a TF103 which has a duty of 20 lps over 180 m total head. These pumps will be located adjacent to the main decline and pump through the steel rising main to the main settling sump near 17 L.

### **17.9.7 Water Treatment Facility**

A stand-alone water treatment plant is required to treat surplus water from the WRP. The

plant will be situated at the collar of the RHS to receive water from the rising main in the RHS. The water will have already undergone some settling underground in a sump that will have removed the coarsest grit and sand particles.

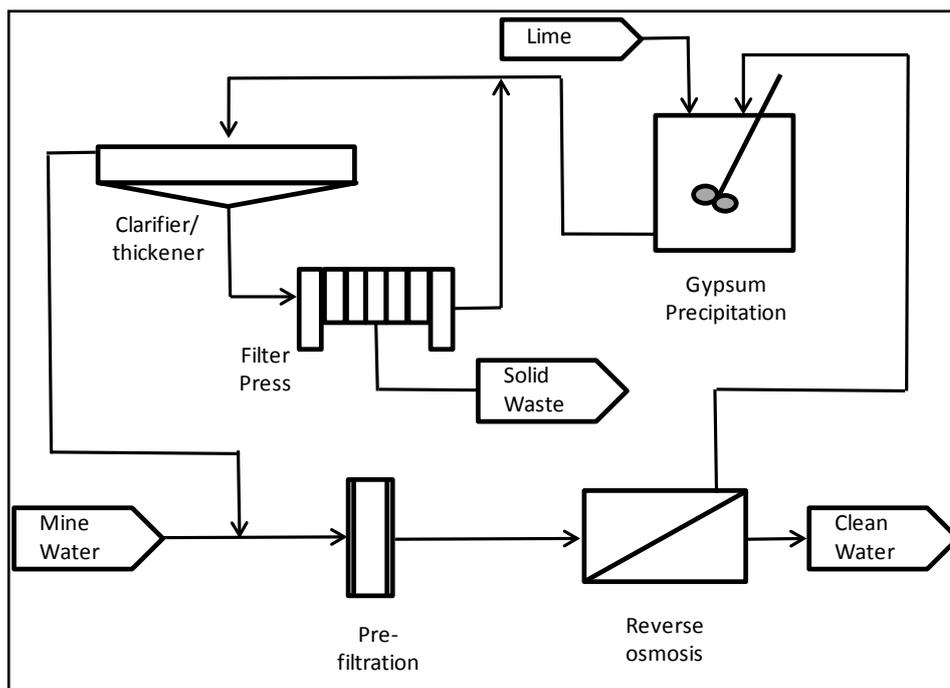
For the water treatment design it is concluded from the investigation work that a constant discharge of 20 lps (including recirculating stream) will require treatment and that this discharge will have a chemistry indicated in Table 17-5. For an initial design assessment purpose the worst chemistry is taken, i.e. the highest contamination levels, as there is insufficient confidence in the data supplied to produce this estimation.

Reviewing the above information and the water quality objectives set by the Ghanaian EPA the most suited technology to treat the water to the required water quality objectives is Reverse Osmosis ("RO"). This is due to the potential salinity of the water and the need to remove the excess of sulphates from the water. In addition, this technology will also remove all the metal contaminants as well.

To prolong the life of the RO membranes pre-filtration is recommended and in addition the resulting brine (or waste) from the RO will also require further treatment before disposal. Based on the worst case water chemistry the RO treatment scheme will recover nearly 12 lps clean water of the initial 20 lps feed. The remaining water, circa 8 lps, will be passed as brine from the system and this will contain all the removed contaminants but is still as a highly saline solution that will require further treatment.

For the brine treatment a gypsum precipitation circuit is recommended whereby the excess sulphate and metal ions are precipitated by the addition of hydrated lime ( $\text{Ca}(\text{OH})_2$ ) to the brine. The addition of this chemical will form gypsum (calcium sulphate) and metal hydroxides, both of which are very environmentally stable. Based on the 8 lps flow of brine this will produce of the order of 23 tpd of solid waste. A schematic of the overall process is in Figure 17-4.

After the gypsum and metal hydroxides are precipitated they are passed through a clarifier for liquid solid separation. The solids will then be dewatered by a filter press and will then require disposal underground or in an appropriately engineered facility. This could be in the proposed waste dump which will need to accommodate waste rock that is potentially acid generating. The clarified water is then returned to water feed inlet of the RO plant for retreatment. The plant will be containerised to minimise on site set up and associated civils costs.



**Figure 17-4 Proposed Water Treatment Plant Flowsheet**

Based on the estimated worst case water chemistry it is estimated that of the 20 lps fed into the treatment 12 lps will pass through the plant treated. Therefore 8 lps of brine will then be processed by the gypsum precipitation circuit and this will produce of the order of 23 tpd of solid waste. However, if the water quality is better than predicted then more water will pass through the treatment plant treated and vice versa. In addition, if the water quality improves the loading on the gypsum precipitation circuit will also reduce. It is also recommended that a minimum 4 hrs of water storage is maintained on surface to minimise any impacts on the water treatment should underground pumping issues arise. With the addition of some buffering capacity for periods when water pumped from underground is intermittent SRK has estimated that 300 m<sup>3</sup> of pond capacity is provided on surface. This has been assumed to be in the form of a lined earth pond 2 m deep measuring 15 m x 15 m.

## 18 MARKET STUDIES AND CONTRACTS (ITEM 19)

SRK notes that there is no change from the PEA where it was stated that all gold production will be shipped to a South African gold refinery in accordance with long-term sales contract currently in place for GSBPL's Bogoso Mine. The gold is shipped in the form of doré bars which average approximately 90 % Au with the remaining portion being silver and base metal impurities. SRK understands that the sales price is based on the London p.m. fix on the day of the shipment to the refinery.

## 19 ENVIRONMENTAL STUDIES, PERMITTING, AND SOCIAL OR COMMUNITY IMPACT (ITEM 20)

### 19.1 Introduction

The Prestea area has a long gold mining history; starting in the 18th Century, with official mining underway by about 1887. Early mechanised operations at Brumasi, Prestea Central, and Bondaye included the use of steam-powered drills, explosives for tunnelling, and timbering. By 1929, the Ariston and Gold Coast Main Reef Mines were operational on the area covered by the current Prestea concession.

By 1965, the gold mines at Prestea had been acquired by the Government of Ghana through the SGMC and the local mines were held by Prestea Goldfields Limited. Mining was predominantly underground; the shafts, headgear, tailings, rock waste dumps, roads, and other infrastructure remain as evidence of these activities. Prestea Goldfields Limited continued operation until the 1990s, when the operations were privatized and eventually awarded to PGR in 2000. PGR operated for a short period and ceased operations in 2002.

Immediately PGR's operations ceased, New Century Mines ("NCM"), a three partner joint venture, consisting of the Ghana Government, GSBPL, and PGR was formed to take over the rights held by PGR on the Prestea concession. The underground mine was placed on care and maintenance by NCM, while GSBPL commenced studies on the potential for the re-opening of the underground operations.

Mining activities that have taken place on the Prestea concession since that time include:

- Re-processing of historic tailings and dumps by Prestea Sankofa Gold Limited ("PSGL");
- GSBPL surface mining operations at the Buesichem (now used for water storage) and Plant North pits (now backfilled),
- Unauthorised small scale mining activities (locally called Galamsey),
- Unauthorized mining activities using mechanized equipment, and
- Recommencement of the Prestea Underground Mine – Phase 1 operations. SRK notes that this is re-opening of the Prestea Mine excluding the WRP. These activities focus on the recovery of relatively small quantities of ore from historical stopes.

Since March 2002, PUG has been under C&M and GSBPL wishes to commence production involving mechanised mining methods. Operations would be in both remnant (Phase 1) and new mining areas (WRP) and would incorporate a range of new infrastructure including surface waste dumping, raise-bore development of hoisting and ventilation shafts, a backfill system, water treatment, and increased ore transportation. In mid-2012, GSBPL commenced the environmental and socioeconomic permitting for the Prestea WRP, which is Phase 2 of the operations at the Prestea underground mine.

#### 19.1.1 Location and Accessibility

The Project is in the Prestea Huni Valley District of the Western Region of Ghana. It is

primarily located within a 2 km radius of the Prestea Township, and some 16 km south of GSBPL Bogoso plant site. In the north, the Project starts south of Nankaba Village, a suburb of the Prestea Township, and extends to the Bondaye Shaft some 3 km to the south. The project site is accessible by public road from Tarkwa through Bogoso and on to Prestea.

The Project area is dominated by a range of low rolling hills rising some 30 to 100 m above the surrounding lowlands and valleys. Although local drainage is varied and greatly disturbed by unauthorized small scale mining operations, drainage from the project ultimately flows eastwards and southwards towards Ankobra River.

### **19.1.2 Historic Environmental Liability and Indemnity**

In June 2001, BGL acquired the surface and mineral rights to gold and other associated mineral substances within the Prestea Mining Lease. This area had been subjected to over 100 years of mining activity and BGL's acquisition agreement provides indemnity from the Government of Ghana for the environmental liabilities emanating from these activities. Golden Star Resources later renamed BGL to GSBPL.

In order to quantify the nature of the existing liability at the time of the agreement of indemnity with the Government of Ghana, audits were completed and documented as registers of environmental liabilities. GSBPL continues to actively monitor the nature, scale, and impact of these liabilities to fully understand the pre-existing conditions.

GSBPL recognises the pre-existing extensive environmental impact of both historic mining and modern day unauthorized small-scale mining and illegal medium-scale mining activities throughout the Prestea Concession. GSBPL expects to predominantly locate its WRP mining activities in new underground development and, therefore, will be able to isolate its underground mining activities from those of its predecessors, including the state owned mining companies.

Whilst there are pre-existing impacts across the concession for which GSBPL is indemnified, GSBPL will be in a unique position, at reclamation of its operations, to make an overall improvement in environmental conditions within the Prestea concession. Given the heavily urbanised nature of the Prestea community, and to a lesser extent the area around the Bondaye community, GSBPL also has the potential for a broader range of next (post-mining) land uses than is typical for most mining areas i.e. establishment of sports fields.

### **19.1.3 Environmental and Socioeconomic Permitting**

Since acquisition of the mineral concession in December 2001, GSBPL has undertaken a series of impact assessment studies on the Prestea concession to support the permitting of its various mining projects.

GSBPL completed an environmental scoping report in August 2012 for submission to the EPA as part of the WRP permitting process. The 'Prestea Underground Mine Environmental Scoping Report and Terms of Reference' describe the baseline (environment and socioeconomic), the various project infrastructure and mining alternatives that were under investigation, identifies potential social and environmental effects, and outlines the structure for the EIA.

Golder Associates (Ghana) Limited ("Golder") has been commissioned by GSBPL to undertake an EIA and produce an EIS for the permitting of the proposed expansion of the Prestea WRP.

The expanded project will require around 20 ha of land for development and will extend approximately 9 km along strike in a north-south direction beneath the Prestea Township, to a

current known extent of 1.4 km of depth, with a project lifetime estimated at 10 years. The project is expected to share key infrastructure with GSBPL's planned PSMNP, which is an open pit complex within the Prestea Concession.

The EIA is being produced in accordance with Environmental Assessment Regulations, LI1652, which is the principal enactment under Ghana's Environmental Protection Agency Act 1994. It should be highlighted here that given the 100 years of mining activity in the Prestea area and the associated environmental effects, GSBPL holds indemnity granted by the Government of Ghana for the environmental liabilities emanating from these historic activities that occurred prior to GSBPL's purchase of the PUG.

It is anticipated that there will be both potential environmental and social benefits and impacts associated with the project implementation which will be considered and, where appropriate, enhanced or mitigated.

## **19.2 Environmental and Social Setting**

### **19.2.1 Climate**

A south western equatorial climate type characterizes the Prestea area. The area is affected by moist, southwest monsoon winds and the northeast trade winds (Harmattan), which blow over the Sahara desert from the northern sub-tropical high-pressure zone. The mean monthly temperature ranges from 24°C to 25°C.

The annual rainfall pattern includes major and minor rainy seasons occurring from April to June and from October to November, respectively. The mean rainfall is in the region of 1,790 mm, with the monthly rainfall ranging from a minimum of 33 mm in January to a maximum of 253 mm in June. Relative humidity does not vary greatly throughout the year, ranging from 70 to 90 %. As a result of the seasonal rainfall pattern, evaporation losses are higher during the drier months of the year.

Daily wind recorded at the GSBPL weather station indicates the prevailing wind direction to be from the south and southwest, with wind speeds of about 10 km/hr.

### **19.2.2 Topography, soils and land use**

The Prestea concession is within the Ankobra River drainage basin. The local elevation ranges from 30 m above sea level at the Ankobra River to over 200 m on the hills to the north of Bogoso. The reach of the Ankobra River near Prestea is highly polluted and affected by extensive unauthorized small scale mining (Knight Piésold, 2002). Marshlands are associated with several streams; many have been created or extended by damming and the diversion of streams by 'unauthorized small scale mining' and illegal medium scale mining activity, Figure 19-1.



**Figure 19-1 Unauthorized mining on the Ankobra River**

The land use capability of an area is related to the soils present combined with the prevailing climate, and the land gradient. The soils in the area are nutrient-poor and have experienced high rates of leaching due to the climate. In the past, the leaf litter of the rain forests that covered the area was the main source of nutrients for these soils. The majority of the area in the project footprint has been disturbed, so reducing the agricultural land use capability.

Soils of the Prestea concession area are of variable quality. The functionality of these soils for agricultural use is to a large degree dependent on the organic additions provided from the vegetation. Within the study site most of the natural soils have either been removed or affected by previous mining activity, forest timber removal, or rotational subsistence farming, thus contributing to soil erosion and nutrient depletion (Scott Wilson, 2003). Therefore, the additional impact on the soil is low compared to the effect of previous and on-going mining activities.

Common land uses in the area include residential, commercial, agricultural, forestry, agroforestry (palm oil and rubber plantations), and unauthorized small-scale mining operations.

### **19.2.3 Geochemistry**

The Prestea deposits lie within the West African Pre-Cambrian shield, a geological formation that hosts the Birimian and the Tarkwaian sequences. Gold mineralization is associated in some cases with reactive sulphide minerals, with the potential for acid rock drainage (“ARD”). The issue of ARD generation from existing or future operation of mine and processing facilities has been identified as a key area of environmental concern for GSR. The need for proactive ARD management was formerly identified by independent audits as early as 1994 (EAU, 1994), where discrete but widespread pools of ARD were found in several mining areas, typically in association with sulphide bearing material deposited on the surface.

Following from these findings, a series of programs have been conducted by GSR to

progressively expand knowledge of the country rock geochemistry. These geochemical assessments found that the geology and ARD potential of rock is complicated by extensive in-situ weathering and by the degree of structural and chemical alteration that has occurred within the shear zone hosting the gold mineralisation. Owing to these effects, the original lithology does not always determine the ARD potential; however the graphitic phyllite is considered to be more conducive to weathering and potential ARD, as it is less competent than other rock types.

The studies targeting the PSMNP pits concluded that the majority of the primary waste rock generated from the project will have potential for ARD. However, as no primary ABA data are available for the Prestea Underground Mine, and as the underground project will extend beyond the depths of the nearby PSMNP pits, GSR's approach is to: conduct standard static geochemical test work to confirm the conceptual model developed by SENES in 1999; and conduct test work on the immediate hanging wall and footwall of the proposed West Reef mining operations. This approach will provide confidence in the reasonable scientific hypothesis that the same weathering controls on the Bogoso geology is valid for the contiguous Prestea geology. This approach will simultaneously provide primary static geochemical test data for the quantification of the mine water impacts associated with the proposed West Reef operations.

In regards to tailings, the various studies found that the vast majority of the tailings in the TSF's are oxide tailings and overall the characteristics of the tailings in the TSF's were not acid generating. Additionally, the TSF1 closure plan indicates that the volume and characteristics of the seepage from the TSF's is suitable for treatment through an engineered treatment marsh, and that reduction of infiltration will be achieved through effective surface drainage on the tailings surface (Knight Piésold 2007). GSBPL undertakes periodic assessments of tailings geochemistry and rheology.

For the purposes of the FS, it has been assumed that the entirety of the primary (and transition) waste rock generated from the project will have a potential for ARD generation and any rock materials of this type that are brought to the surface will be encapsulated in a purpose-designed, waste rock storage facility.

The parallel process of investigation that is being completed to support the documentation of the EIS for the project, as well as to inform on management decision making, will evaluate the following feasible alternatives for PAG waste management:

1. Full encapsulation of all surface transported primary and transitional waste in a dedicated and purpose build waste rock storage facility (base case), designed and constructed in accordance with the GSR Standard for Rehabilitation and Closure (so limiting oxidation of minerals leading to ARD);
2. Temporary surface storage and preferential backfilling of PAG/mineralised wastes as structural fill in underground voids;
3. Backfilling of surface transported primary and transitional waste in mined out pits of the Prestea South Mbease Nsuta project; and
4. Placement of waste rock in a combination of 1), 2) and 3) above, as well as a conventional waste rock dump for any waste not considered to be PAG / mineralised.

The findings of the geochemical testing program will inform on the approach selected for implementation that will be required to be justified to and approved by the regulatory agencies, via the submission of the environmental impact statement and issuance of a permit for the project.

## 19.2.4 Air quality

### ***Existing Air Environment***

The air quality within the project area is degraded to some extent and is affected by the seasonal Harmattan winds, use of wood and charcoal for cooking, burning of domestic refuse, mining, logging, and agricultural practices. The impacts of the anthropogenic activities on air quality are generally localized and do not contribute substantially to a regional degradation of air quality.

Golden Star has been monitoring dust deposition across the Bogoso and Prestea concessions since early 2004, with monitoring points selected to represent receptor groups across the concessions (e.g. schools, communities, employees). To complement the dust depositional data, GSR also collects monthly air quality data for contaminants (NO<sub>x</sub>, SO<sub>x</sub>, CO, CO<sub>2</sub>), Total Suspended Particulate (“TSP”), and particulate matter in the sub 10 µm size range (inspirable) (PM<sub>10</sub>).

Monitoring results from 2004 to present reflect the wet and dry climatic cycles, with local minor variation related to discrete sources such as roads and local ground disturbing activities. Expanded monitoring in 2011 and 2012 continued to reflect the seasonal Harmattan effects on air quality. Throughout the baseline monitoring, NO<sub>x</sub>, primarily sourced from vehicle emissions, continued to be non-existent (fully dispersed) at the monitoring locations.

### ***Predicted Air Quality***

In characterising the dispersion potential of the site, reference was made to hourly average meteorological data modelled for the period January 2007 to December 2011. The data were generated by the air quality model for a coordinate set within the Prestea mine. The methodology for identification of potential air quality effects of the proposed project was based on:

- An emissions inventory, where the emission rates from each of the proposed sources were calculated;
- Atmospheric dispersion modelling, and
- Evaluation of predicted impacts.

The predicted ground level concentrations for PM<sub>10</sub>, TSP, NO<sub>x</sub>, SO<sub>2</sub> and CO meet the Ghanaian EPA NAAQS during the construction phase. During operations, typical mitigation strategies for the control of air quality at the surface will include underground dust suppression using water, chemical dust suppression, and equipment selection based on emission criteria.

## 19.2.5 Noise and Vibration

### ***Existing Noise Environment***

Noise in the project area has been evaluated since 2003 using routine and targeted (including attended) monitoring proximal to existing and proposed infrastructure, as well as locations considered to be of value to the community. These data were used as background conditions.

The principal sources of anthropogenic noise within and around the project site currently are traffic, residential, small scale commercial enterprises, entertainment centres, and unauthorized small scale mining workings. In general, monitoring demonstrates that the background levels of noise routinely exceed the EPA day time and night time noise levels in all monitored business and residential locations.

### ***Predicted Noise Impacts and Mitigation***

Noise modelling utilising the ISO 9613 calculation method was used to calculate predicted noise level at nearby receptors considering a 'worst-case' scenario. The impact arising from all identified noise sources operating simultaneously has been assessed, even though this may happen infrequently, or for particular phases.

The predictions indicate that at the South Waste Shaft, EPA, and day and night time limits will be met. For the RHS and Bondaye Town, the day limits will be met and with mitigation, the night limits will be achieved.

In Prestea town, the night noise limit will be met with mitigation. During the construction and operational phases, the daytime level will exceed the fixed limit of 55 dB(A); however with the permitted adjustment (-5 dB for an event not exceeding 15 minutes duration in any given 1 hour period) for intermittent noise events (primarily the rock tipping), the limit will be achieved.

### ***Cumulative Impacts – Environmental Noise***

Cumulative noise impacts are predicted to arise at locations close to other mining projects within the area. In particular the surface mining, unauthorized small scale mining activities, and tailings reclaim areas within the study area have the potential to give rise to cumulative noise effects. It is considered that such activities will typically generate noise levels higher than those predicted for the Prestea Underground project. Given that the average LAeq noise levels measured at the Prestea Garden Hill Hotel and in Bondaye Town are in excess of 60 dB during both the daytime and the night-time periods, it is considered that the project will not contribute excessively at these locations; the predicted noise levels due to the project are at least 5 dB below measured ambient levels.

### ***Existing Sources of Ground Vibration***

Vibrations within the project area are generally restricted to the movement of trucks to the Prestea Sankofa operations, unauthorised blasting by unauthorized small scale miners, and general vehicle traffic on the motor roads.

During field visits conducted by specialist consultants in 2010, it was observed that unauthorized small scale mining activity was on the increase and blasting was observed as increasingly being carried out by these miners. Following ongoing increases in unauthorized small scale mining activity, and observations during the baseline structural surveys, baseline vibration monitoring was conducted in late 2012 and recorded evidence of unauthorized small scale miners blasting within the Prestea concession. Targeted monitoring of these sources continues as the Company becomes aware of the locations of such activities. These data will be incorporated into the project EIS baseline studies.

### ***Baseline Structural Assessments***

Most of the houses in Prestea and surrounds are of sub-standard construction and have previously suffered from various degrees of deterioration (Agbeno, 2006). In a 2013 structural assessment program, guidance was sought from the Minerals Commission and consultants to record prevailing condition, structure types, construction methods and materials, as well as sources that may affect the structural integrity of these buildings.

The study found that many Prestea buildings were constructed of: landcrete, wattle and daub, mud, and sandcrete. These buildings are more sensitive to blast vibrations than modern residential structures.

### ***Air-Blast Overpressure (Air Vibration)***

Blast induced air vibration effects are primarily influenced by the prevailing weather conditions

at the time of the blast and less so by the factors influencing ground vibrations. Underground mine blasting operations typically do not generate surface air vibration effects and it is not expected that there will be a requirement for any blasting for surface development.

#### ***Predicted Vibration Impacts and Mitigation***

Data for previous blasting on the concession (Agbeno, 2006) were used for ground vibration predictions. The impact assessment was based on a 'worst case' scenario assuming maximum explosive weights per delay period, and minimum distances between the source and receptor.

Although it is not expected that near surface blasting will be required for ore mining, and the new ventilation and hoisting shafts are proposed to be installed using raise-boring techniques. However, some near surface blasting will be required to support the pre-sink activities for the raise boring. These blasts are expected to meet the vibration requirements locally and will occur only for the pre-sink phase of the shaft development and not during the much longer mining operations.

Modelling indicates that, even for development blasting in the upper reaches of the mine, under the worst case scenario, ground and air vibration levels will be low and do not require any particular mitigation strategies.

As drift and fill blasting will occur at depths of some 650 m or more, it is expected that all such blasting will achieve the ground vibration limits. Should mitigations be required in the future for remnant mining closer to the surface, ground vibration effects can be reduced by reducing the maximum charge weight per delay.

#### ***Cumulative Impacts - Blast Vibration***

While the blasting may introduce temporary strains a few times each week for one or two seconds, strain levels produced in a household by changes in temperature and humidity (environmental changes), as well as those produced by regular household activities (Dowding, 1985), occur frequently (at least daily). These, and numerous studies of repeated blasting on structures (Stagg et al. 1984, Siskind et al. 1980), concluded that repeated blasting over several decades, producing peak vibration levels well in excess of the guideline limit, were required to cause cosmetic threshold cracking to occur. By ensuring that blasting continues to remain within the national guideline limits, there would not be any noticeable cumulative effect on structures associated with the blasting operations.

### **19.2.6 Drainage and Water Resources**

#### ***Surface Water Resources***

The Prestea concession lies within the Ankobra River drainage system, which has an approximate catchment area of 3,300 km<sup>2</sup>. Illegal medium-scale, and unauthorized small scale mining, activities (Knight Piésold 2002) have environmentally degraded much of the project area. As a result, the natural drainage channels have been disturbed; especially in proximity to the RHS/RVS site.

Rainfall intensity in the Prestea area can be heavy. The infiltration characteristics of the soil have been altered by human activities, especially in the valleys. Compounded by illegal mining, the carrying capacities of the streams have reduced, leading to flooding in some areas.

Within the Prestea community, surface drainage and sewage control is almost non-existent. Therefore, extensive organic loadings and silt enter the surface drainage channels, further degrading the local surface water quality.

### ***Groundwater Resources***

Groundwater in the Prestea and Bondaye areas occurs primarily in weathered regolith aquifers that contain and transmit groundwater along zones of secondary permeability, which are often discrete and irregular, and occur as fractures, faults, lithological contacts, and zones of deep weathering. Groundwater bores in the Prestea concession demonstrate that aquifer horizons are associated with weathered and fractured argillaceous rocks at the base of the weathered layer. The Tarkwaian system has shallower aquifer horizons than the Birimian system; yields are higher in the Birimian than in the Tarkwaian.

Groundwater gradients are general towards the Ankobra River. This is influenced by the orientation of the water bearing strata, and the joints, faults and other structural features that provide the secondary porosity of the aquifer. Recharge of the aquifer strongly correlates with rainfall.

### ***Underground Mining and Ground Water***

After the cessation of the underground mining by PGR, the workings have been dewatered into the surface streams through pumping at two locations; the Prestea Central Shaft and the Bondaye Main Shaft. GSBPL retains data on dewatering volumes and quality dating back to January 2003.

In spite of the large volume of dewatering associated with the underground mine workings that can be traced back about a century, nearby water supply boreholes continue to yield suitable volumes of water for local domestic water supply. The Plant North Pit, which had been excavated to some 80 m below ground level, saw little groundwater ingress during its operations. Also, no effects on the local water supply boreholes adjacent to the Plant North pit were observed.

It can, thus, be concluded that while the effect of the underground mine workings is felt in groundwater levels above the workings, groundwater levels in wells less than 1 km to the west, supplying water to the Prestea area, remain at more or less constant levels, a reflection of the discontinuous nature of the groundwater aquifers in the area.

### ***Water Quality***

GSBPL commenced water quality monitoring in the Prestea concession in 2003 as part of the baseline data collection for the Plant North project; regional data earlier than this time are also available. Over 20 sites have been monitored routinely since this time and demonstrate the following typical surface water characteristics:

- Extensive anthropogenic influences associated with sewage and small miner activity reducing the environmental values of surface water;
- Elevated arsenic concentrations in groundwater that comes into contact with the Prestea ore body;
- Naturally elevated iron concentrations in ground water; and
- Poor surface water quality in the major surface water courses as affected by unauthorized small miner activity that is exacerbated in the dry season when flows approach or reach zero in many ephemeral streams.

The historical monitoring data will be summarised within the project EIS.

## **19.2.7 Biodiversity**

### ***Baseline Ecological Environment***

Prestea falls within the rainforest bioclimatic zone. It has been estimated since 2003, that less than 25 % of the original rainforest remained in Ghana (Scott Wilson, 2003). The project area

lies in the moist evergreen forest type of Hall and Swaine (1981); there is none of this forest left in the project area as it has all been previously disturbed by logging, farming, and unauthorized small scale mining activity. Patches of secondary forest are present in some limited areas that are not generally accessible for farming. The vegetation cover has been seriously altered within the concession. The vegetation types typically encountered are: secondary forest, secondary thicket, farm re-growth, farmland, and marshes or freshwater swamp forest. No secondary forest will be disturbed for the Project, with proposed infrastructure to be sited at existing mine compounds or in 'brownfields' areas.

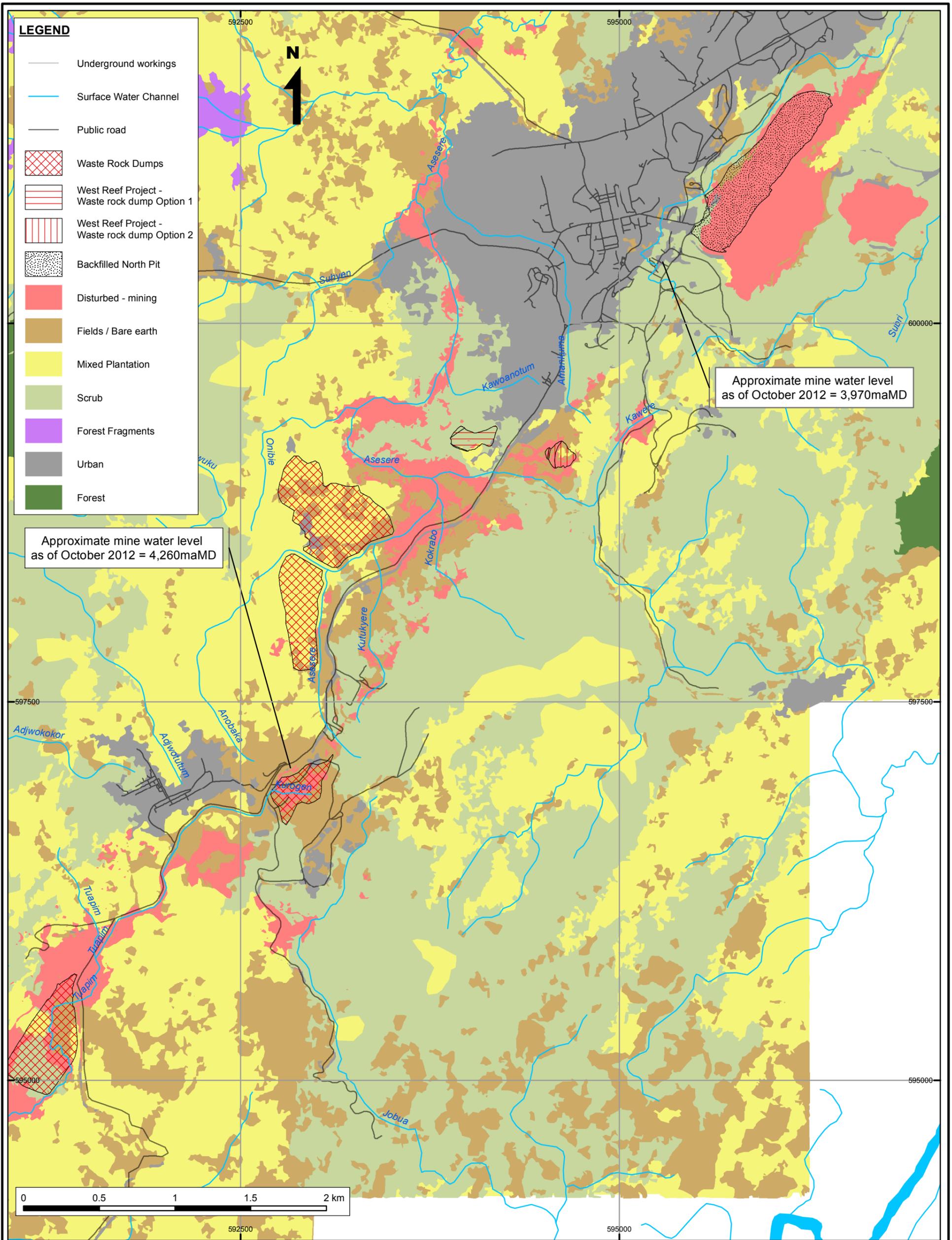
Previous studies indicate that the Prestea area is of low ecological value, with no endangered or threatened flora species being recorded (Samax Ltd & GNPC 1993, EMA 1993, Owusu 2001, Owusu & Attuquaefio 2001). Four species of fauna were identified and/or their presence confirmed by the local people in the study area. This was further supported by field investigations undertaken by specialist consultants in 2001, 2004 and 2006 (Scott Wilson, 2003, Owusu et al. 2004, AERC 2006). The 2001 and 2002 due diligence audits by KP, chronicle the extent and degree of environmental degradation, evident at that time, from historic and unauthorised mining activities across the Prestea concession. It is estimated that when the roaster was formerly in operation in Prestea, its demand would have been approximately 5 158 m<sup>3</sup> or 1,590 logs per annum (ECMP, 1994).

The surrounding township and the historic mining operations caused negative impacts on both the flora and fauna of the Asuo Kofi stream. The water quality of this stream is poor and its ecological integrity has been severely degraded (Scott Wilson, 2003). Whilst some aquatic life was observed at the confluence with the Ankobra River during field studies in 2002, it was considered that this aquatic life came from the Ankobra River rather than the Asuo Kofi (Scott Wilson, 2003). With the increasing intensity of unauthorized small scale mining activity on the Ankobra River, it is now considered that, in proximity to the Prestea Township, there is limited use of this aquatic system by the remaining ecological resources.

#### ***Predicted Impacts to Ecological Condition and Ecosystem Services***

Deforestation and forest fragmentation are evident across the Prestea concession (Figure 19-2). These impacts are clearly traced to previous removal of the vegetation cover for farming, historic mining operations, and extensive unauthorized small scale mining (AERC, 2013). The attendant loss of habitat and local demand for bush meat has also caused a decline in the populations of wildlife, according to independent sources.

The area of land-take required for the project, as well as the use of previously developed or disturbed areas (brownfields) ensures that the impacts to ecological condition and ecosystem services are insignificant. The closure phase of the project will provide GSBPL with the opportunity to conduct rehabilitation activities that may enhance and return an ecosystem to an area or complete the transformation to a land use that has been selected by the local stakeholder community.



JUNE 2013	U4935	PRESTEA	
		<b>Prestea Concession – February 2011 Land Cover and Vegetation Classification</b>	<b>Figure 19-2</b>

### 19.2.8 Social Setting

The communities and organisations identified through the socioeconomic studies are located in the Prestea Huni-Valley District of the Western Region of Ghana. The 2010 population census (GSS, 2012) reported the population of the Prestea Huni-Valley District as 159 304 people, with 37 % of this population residing in the urban centres of Bogoso and Prestea. More recent data, collated in 2011 indicate a population in the Prestea catchment of 38 390 in the Himan catchment of 17 074, and in the Bondaye catchment of 1 923.

### 19.2.9 Administrative structures and demography

#### ***Government Structures***

The Prestea-Huni Valley District (“PHVD”) was created in 2008, with Bogoso the district administrative capital. The district hosts a number of important mining operations. The Prestea-Huni Valley District Assembly is headed by the District Chief Executive (“DCE”), who is appointed by the Government. Two thirds of the 80 Assembly members are elected with one third appointed by the central government. There is a District Coordinating Director, who has the responsibility of coordinating the activities of the centralised and the decentralised departments in the District.

#### ***Traditional Authority***

The Wassas belong to the large Akan ethnic group of Ghana; they live in the Western Region of Ghana and are sub-divided into the Wassa Amenfi, Wassa Fiase, and Wassa Mphohor Paramountcy. A Paramount Chief rules each traditional area, or paramountcy. In Ghana, the traditional authorities have important roles to play in governance as:

- Leaders of their subjects who mobilize them for the development of their areas;
- Custodians of stool lands and traditional heritage; and
- Local arbitrators for settlement of disputes.

Benso is the Traditional Capital of Wassa Fiase; within the project area the Wassa Fiase Traditional Area is ruled by the Himan and Nsuta Mbease Divisional Chiefs. The Chief is advised by a number of elders, who hold several key roles including those of second in command and linguist (the spokesman between the Chief and the community). Each Paramount Chief will appoint a number of ‘caretakers’ or sub-chiefs (known as Adikro) to take care of the land on his behalf and act as his representatives.

The lands of the Divisional Chiefs are known as Stool Lands. The Land Tenure System indicates how land is owned and used by the community members collectively. In rural areas, the Divisional Chiefs, through their Adikro, tend to be the custodians and generally lease lands to the community members. In return, the Chief (or landowner) receives a portion of what is produced from the land.

#### ***Communities in the Project Area***

The key civil administrative bodies in the project area are the Bondaye Area Council and the Prestea Urban Council. The area council covers a number of settlements that individually do not exceed a population of 3 000 and, therefore, whose area is predominantly rural in character. Urban councils are created for urban settlements whose population exceeds 15 000 (Ministry of Local Government and Rural Development, 1996). The Prestea Urban Council has the responsibility for providing basic services like water, electricity, schools, and ablution facilities to the community. Its main source of revenue comes from a common fund from the DCE.

Some funding for the Prestea Huni-Valley District Assembly is generated from royalties paid by mining companies in the District. These royalties are paid directly to the national government and a proportion goes to the District. A number of urban councils convene under the District Assembly (under the direction of the Ministry of Local Government). Prestea is divided into zones, each represented by unit committees. These elected members comprise the Urban Council and operate within each area. The Bondaye Area Council functions in a similar way.

### **Demographics**

Census data indicate that the average Ghanaian household size in 2010 was 4.4 (GSS, 2012). In 2010, some 38 % of the population were under the age of 15 years, and 57.3 % fell within the ages of 15 to 64. Socioeconomic surveys of the Project Affected Persons (“PAP”) / communities in 2011/2012 found lower numbers of very young and elderly people in the Prestea area than the broader Ghanaian population.

The gender distribution data from the 2010 population census for Ghana showed that, in the Western Region, the number of males is approximately equal to the numbers of females (GSS, 2012). Data from the PAP communities’ census identified residents as hailing from across Ghana and internationally, with Fante, Nzema, and Wassa’s predominating. Only 5 % of PAP households interviewed (2011/2012) said they were indigenes of their various communities.

Whilst periods of immigration to an area have the potential to dilute culture and traditions, it is pertinent to note that the project area presently accommodates a wide range of people of differing ethnic origins and cultural backgrounds. The expected minor modifications in population demographics that may result from the project are not expected to have a detrimental effect on culture or traditions.

### **Livelihoods and economy**

The PHVD has had a long history of mining and its economy is dominated by mining and related activities. The other main economic activities are forestry and agriculture. The people outside the formal sector engage in cash crop and subsistence farming, and unauthorized mining. Other sources of employment include government, financial services, trading, and artisanal activities.

Unauthorized mining is a source of livelihood for many of the local population and migrants. In a media article in September 2012, the Minerals Commission indicated that there were an estimated 1 million unauthorized small scale miners in Ghana (of a population of 25 million). In a 2011/2012 survey of PAP’s, over 26 % reported small scale mining as their occupation.

Of the PAP households surveyed in 2011/2012, some 41 had overall household monthly income of more than 600 Ghanaian Cedi (“GH¢”). A few respondents (16) had less than GH¢ 200 per month. Some 4.3 % of the PAP community reported being unemployed. This compares favourably to the 11.2 % unemployment rate recorded by the 2000 population census<sup>1</sup>.

### **Access to water and energy**

Available water sources recorded at various communities surveyed included stream, pipe, and sachet. All respondents, however, bought sachet water to supplement the available

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<sup>1</sup> Ghana Statistical Service. 2000 Population census data. [www.statsghana.gov.gh](http://www.statsghana.gov.gh)

water sources – more specifically when away from their homes.

Respondents to the PAP surveys indicated that they typically used electricity or kerosene as their energy source for lighting. Most respondents used charcoal and firewood for cooking, whilst some use LPG.

### ***Health***

The health services in the Prestea Huni-Valley District are offered at three main levels; hospitals, sub-district clinics and community clinics. The District Hospital is the Prestea Government Hospital and provides services including; out-and in-patient care, maternity, dental, laboratory, X-ray and surgery, in addition to an expanded programme on immunization, management of epidemics, and public information and education. There are several private health delivery facilities at Prestea. GSBPL has constructed clinics in Bondaye and Bogoso. Communities are also serviced by a variety of traditional healers.

### ***Prevailing Health Conditions***

Interviews with a cross section of community members and data from the Ghana Health Service (Prestea Government Hospital) revealed the prevalence of the following diseases; malaria, acute respiratory condition, oral conditions, skin conditions, hypertension, diarrhoea, typhoid, intestinal worms, and anaemia, with malaria typically accounting for over 40% of the total cases (2008 through 2010).

The Prestea WRP (Phase 2) environmental and socioeconomic studies incorporate a review, for due diligence purposes, of the baseline health condition of the residents of the project area. This data will be collated from Government records and interviews with Ghana Health Services medical practitioners.

### ***Sanitation***

Kumasi Ventilated Improved Pit (“KVIP”) latrine, tipping bucket latrines, and pan latrines are the main sanitation facilities available. Where latrines are not available, people use nearby bushes in a free range fashion. The lack of adequate toilet facilities is compounded by stagnant waters, overgrown bushes, a lack of storm drains, improperly located domestic waste disposal sites and general environmental degradation, much of which is a result of illegal mining (AERC, 2013).

### ***Education***

The Prestea area is serviced by the Prestea Goldfields International School. Residents in the Bondaye area use educational facilities at Bondaye. The PAP surveys found most people had some education, with 10 % having received no schooling. 56 % had junior high school or higher education levels. A survey by the GSS (2001) of child labour indicated that 27 % of 5 to 17 year olds in the Western Region were affected.

### ***Access to land***

The 1992 Constitution of Ghana provides for three categories of land ownership or land holding - customary (stool/skin) lands (78 %); state lands (or public land) (20 %); and vested lands (or public land) (2 %). Customary lands are lands that are managed by the Traditional Authorities. The right to use or dispose of use-rights over land is governed by the customary laws of the community in question. Private lands, a fourth category, are the residual of customary and state lands that are family/clan lands or individually owned (Ministry of Lands and Forestry 2004).

The laws of Ghana do not allow individuals or group of individuals to acquire or own land freehold. Rather, access to land is available only under leasehold with differing duration of the

leasehold. As the lands within the Prestea concession are mineralized, they are State-owned with the mineral rights granted to GSBPL under the Minerals and Mining Act, 703, 2006. The Constitution of Ghana (1992), State Lands Act (1962), Minerals and Mining Act 703 (2006), Minerals and Mining (Compensation and Resettlement) Regulations (2012), Mining and Environmental Guidelines, Environmental Protection Agency Act 490 (1994) and Environmental Assessment Regulations (1999) each have provisions pertaining to land access, including land acquisition, land and farm compensation and resettlement.

### **19.3 Legal, Regulatory and Policy Framework**

#### **19.3.1 Environmental and Social Legislation Pertaining to Mining Projects**

The Mining Act (Act 703 of 2006) requires that mines obtain environmental approvals from relevant environmental agencies as outlined in Table 19-1.

Ghanaian environmental legislation is well developed and is enforced by the EPA. The overarching Act that regulates the environmental regime of Ghana is the EPA Act (Act 490 of 1994). The main legal framework used by the EPA for regulating and monitoring mineral operations is the Environmental Assessment Regulations, Legal Instrument 1652 of 1999 (LI 1652). The EPA grants environmental approvals for projects, in the form of an Environmental Permit, based on the findings of an environmental impact assessment, which also covers social aspects, as documented in an EIS report. For a mine, an EIS report must include a reclamation plan (Regulation 14 of LI 1652) and a provisional EMP. The EIS is subject to a public exhibition period, public hearing and review by the EPA before a permit can be granted. An EMP must be submitted within 18 months of commencement of operations and must be approved by the EPA.

**Table 19-1 Primary Environmental Approvals Needed for Mining Operations**

Regulatory institution	Approvals that have to be obtained	Reporting, inspections and enforcement
<p>The Environmental Protection Agency (EPA) Established under the Environmental Protection Agency Act, 1994 (Act 490), the EPA is responsible for among other things, the enforcement of environmental regulations.</p>	<p>Environmental Permit In accordance with Section 18 of the Mining Act (Act 703 of 2006) and the Environmental Assessment Regulations, 1999 (LI 1652) of the EPA, a holder of a mineral right requires an environmental permit from the EPA in order to undertake any mineral operations. In most cases, an EIS is to be submitted to the EPA for the approval of a mining project. Environmental management plan (EMP) An EMP must be submitted within 18 months of commencement of operations and updated every three years (Regulation 24 of LI 1652). Environmental Certificate This must be obtained from the EPA within 24 months of commencement of an approved undertaking (Regulation 22 of LI 1652). Approved reclamation plan Mine closure and decommissioning plans have to be prepared and approved by the EPA; Provisional plans are submitted in the EIS(Regulation 14 of LI 1652). Reclamation bond Mines must post a reclamation bond based on an approved reclamation plan (Regulation 22 of LI 1652). The reclamation bond is often part of the environmental permit.</p>	<p>Annual reports Mines must submit annual environmental reports to the EPA. Inspections The EPA undertakes regular inspections to ensure that mineral right holders are compliant with permit conditions and the environmental laws generally. Enforcement The EPA is empowered to suspend, cancel or revoke an Environmental Permit or certificate and/or even prosecute offenders when there is a breach.</p>
<p>Water Resources Commission (WRC) Established under the Water Resources Commission Act, 1996 (Act 522), the WRC is responsible for the regulation and management of the use of water resources.</p>	<p>Approvals for water usage Under Section 17 of the Mining Act (Act 703 of 2006), a holder of a mineral right may obtain, divert, impound, convey and use water from a watercourse or underground reservoir on the land of the subject of the mineral right, subject to obtaining the requisite approvals under Act 522. The Water Use Regulations, 2001 (LI 1692) regulate and monitor the use of water.</p>	<p>Inspection The WRC has power to inspect works and ascertain the amount of water abstracted. Enforcement Both Act 522 and L.I. 1692 prescribe sanctions for breaches.</p>
<p>Forestry Commission</p>	<p>In accordance with Section 18 of the Mining Act (Act 703 of 2006), a holder of a mining right must obtain necessary approvals from the Forestry Commission.</p>	

### 19.3.2 Stakeholder Engagement

Key stages of consultation that remain for the Prestea Underground Phase 2 operations include the following:

- Feedback to key stakeholders on the finalisation of project designs and environmental and social controls;
- Submission of the EIS to regulatory agencies;
- EIS public exhibition period; and
- EPA public hearing following EIS public exhibition.

### 19.3.3 Resettlement and Land Acquisition

The preparation of the Resettlement Action Plan (“RAP”) for the Prestea projects is in accordance with the relevant legal and regulatory framework operating in Ghana and the International Finance Corporation Performance Standard 5.

The project RAP provides a detailed comparison of the Ghanaian requirements and those of the IFC Performance Standard 5, for engagement, consultation, negotiation, agreements, compensation, land acquisition and access, and resettlement. This comparison, and the RAP more broadly, provides full details of the social processes that have been completed and scheduled, as well as details of socioeconomic surveys, demographic and census surveys, and records of engagements, e.g. meeting minutes.

### 19.3.4 Status of Project Permitting

#### ***West Reef Project***

On 30 May 2012, GSBPL submitted a project registration form EA2 to the EPA in respect of the WRP. In August 2012, the EPA advised that an environmental impact assessment should be conducted as the basis for consideration for an environmental approval.

In parallel, and in order to expedite underground mining activities, GSBPL made application to the Minerals Commission for the re-start of the PUG - Phase 1, using traditional mining methods. To support this application, GSBPL submitted a mine operating plan (MOP) to the Minerals Commission in July 2012. Following the support of the Mines Inspectorate Division, GSBPL applied for and received an environmental permit for the PUG Phase 1 operations.

In July 2012, GSBPL engaged Golder to conduct an environmental and socioeconomic impact assessment for the PUG Project Phase 2 operations (the WRP under another name). These impact assessments are well advanced and are presently being updated to reflect the modified scope of work as a result of the evolution of the technical studies to FS level.

To support the Prestea Underground Project and the GSBPL PSMNP (a surface mining project of several pits that overlays the Prestea Underground mine), GSBPL has developed, with the assistance of specialised consultants from AERC and later Golder, a RAP. The PUG Phase 2 and PSMNP will share surface infrastructure and, as such, land and farm compensation and resettlement aspects overlap the two projects. The Prestea Projects Resettlement Action Plan was submitted to the Prestea Huni-Valley District Assembly in November 2012 and approval is pending the public hearings for the two projects.

#### ***GSBPL General Operations***

Regulatory approvals held or being permitted by GSBPL and pertaining to the Prestea Underground Project are listed in Table 19-2.

In accordance with LI 1652, GSBPL submitted an updated EMP for its operations to the EPA in December 2011, ahead of the expected expiry of the previous EMP. GSBPL was

subsequently invoiced by the EPA and payment was made for the Environmental Certificate in March, 2013. GSBPL is yet to be issued with the updated Environmental Certificate for the operation of the overall project.

**Table 19-2 Existing and Pending Regulatory Approvals Pertaining to Prestea Mine**

Status	Type of approval	Approval
Existing	Mining leases	<ul style="list-style-type: none"> <li>Mining Lease WR 348B/87 (21st August 1987) and WR 368/88 (16th August 1988) (Bogoso Lease Area). <i>Site of Bogoso processing plant.</i></li> <li>Mining Lease WR 3218/2001 (29th June 2001) (Prestea Lease Area). <i>Site of Prestea Underground Mine.</i></li> </ul> <p>These stipulate conditions for the encroachment of mining activities on community infrastructure, the disturbance of vegetation, the conservation of resources, reclamation of land and prevention of water pollution.</p>
	Environmental	<ul style="list-style-type: none"> <li>Environmental permit EPA/EIA/147 (Sulphide Project). <i>Operation of the Bogoso Processing Plant.</i></li> <li>Environmental permit EPA/EIA/188 (Tailings Storage Facility II Extension)</li> <li>Environmental permit EPA/EIA/804 (Prestea underground gold mining project Phase 1)</li> </ul>
	Water use	<ul style="list-style-type: none"> <li>EPA Approval letter CM 8/7 of September 2011 to use the Buesichem Pit for TSF water storage.</li> <li>Approval letter CM 81/8 of October 2012 for the storage of process water in the Buesichem Pit.</li> <li>Water Resources Commission permit for water use and abstraction from ground water. Most of the water used in the process is recycled from the tailings storage facility.</li> <li>Water Use Permit WRC (GSBPL ID 228/11) issued on 1-Jan-11 and valid to 31-Dec-13 was received from WRC on 4-Apr-11.</li> </ul>
Pending	Environmental	<ul style="list-style-type: none"> <li>Prestea South Mbease Nsuta Project: Updated EIS submitted to EPA in March 2013, and public exhibition period commenced in April 2013.</li> <li>Prestea Projects Resettlement Action Plan (RAP): The RAP was submitted to the Prestea Huni Valley District Assembly in November 2012.</li> </ul>
	Water use	<ul style="list-style-type: none"> <li>A Water Treatment Plant letter report was submitted to EPA on 22<sup>nd</sup> June 2011. Approval from EPA was received (verbal) in November, 2012 and process water treatment plant is operating</li> </ul>
Documents to be submitted	Environmental	<ul style="list-style-type: none"> <li>Environmental Impact Statement for the Prestea Underground (West Reef Project) Phase 2 to the EPA for review and approval.</li> </ul>

### 19.3.5 International Requirements

#### ***Environment and Conservation***

The Government of Ghana is a party to a number of international treaties relating to the environment, notably:

- Ramsar Convention on Wetlands of International Importance - regulated under the Wetland Management (Ramsar Sites) Regulations 1999 of the Wild Animals

Preservation Act 1961 (Act 43) providing for the establishment of Ramsar sites within Ghana. There are five designated Ramsar sites along the coast of Ghana. There are no Ramsar sites in the project area;

- Convention of International Trade in Endangered Species (“CITES”); and
- United Nations Framework Convention on Climate Change.

In regards to protected areas, Ghana has one UN Biosphere Reserve and two World Heritage Convention Sites (UNESCO 2009); these are not in or near the project area. According to the World Resources Institute, EarthTrends (2003) in a country profile for Ghana, it was reported that Ghana has more than 1,000 IUCN-management protected areas including 317 Forest Reserves. The nearest Forest Reserves to the Prestea Concession are the Ben West Block and Bonsa River Forest Reserves more than 25 km from the concession boundary. These reserve areas do not overlay the concession and there are no international protection programmes specifically covering the project area.

### ***Human Rights***

In 2005 GSR, with the full support of its Board of Directors wrote to the UN Secretary General as a statement of commitment to adoption of the United Nations Global Compact. GSR has now reported for six successive years (starting for year 2006) on its implementation of the UN Global Compact, and GSR continues to integrate the UN Global Compact principles into its business activities ([www.unglobalcompact.org](http://www.unglobalcompact.org)). Espoused within the UN Global Compact is support for the following:

- Universal Declaration of Human Rights;
- International Labour Organization's Declaration on Fundamental Principles and Rights at Work;
- Rio Declaration on Environment and Development; and
- United Nations Convention Against Corruption.

Through its annual public Corporate Responsibility Report (formerly Sustainable Development Report), GSR details ways in which the company is contributing to advance Ghana's performance in regards to the Millennium Development Goals.

### ***Anti-Corruption***

The Government of Ghana was designated as Extractive Industries Transparency Initiative (“EITI”) compliant in 2010. In support of the EITI, GSR publically reports on an annual basis on the payments made by the company to the Government of Ghana. As at the end of 2012, GSR businesses have made significant contributions to the people of Ghana through Government payments:

- GSBPL Life to date: Over US\$ 107 million;
- GSWL Life to date: Over US\$ 116 million; and
- In 2012 OASL, Traditional Authorities, Stool Lands, and District Assemblies had expected royalty distributions from our operations of over US\$ 2.5 million.

GSBPLs parent company GSR, being registered in the US and Canada is subject to the US Dodd–Frank Wall Street Reform and Consumer Protection Act, the US Corruption of Foreign Officials Act and the Canadian Corruption of Foreign Public Officials Act. Internal GSR policies address these items for GSR management.

### ***Voluntary Codes***

Golden Star Resources has adopted a number of voluntary international codes and standards of practice pertaining to corporate responsibility:

- Tailings storage facilities - International Committee on Large Dams (“ICOLD”);
- Gold mining and processing - World Gold Council Responsible Gold Standard; and
- Resettlement, land acquisition, and compensation - International Finance Corporation Performance Standard 5 on involuntary resettlement.

As GSR has adopted these voluntary standards and codes, a key component of GSR’s corporate assurance includes independent review, audit, and/or validation of conformance to the principles ascribed herein.

### **19.3.6 Golden Star Corporate Commitment**

Golden Star Resources has policies pertaining to the environment, community relations and human rights, and health, safety, and wellbeing. These policies enunciate the commitment of the company to appropriate corporate governance, are reviewed annually, and are endorsed by the company President / CEO.

#### ***Policy on the Environment***

Golden Star is committed to meeting or surpassing regulatory requirements in all of its exploration, development, mining and closure activities while safeguarding the local environment for our stakeholder communities and future generations.

#### ***Policy on Community Relations and Human Rights***

Golden Star is committed to being a part of the community in which it operates by maintaining and building strong relationships with other members of the community based on mutual respect and recognition of each other’s rights, together with an active partnership and long term commitment to the betterment of the community and local economic development. GSBPL supports and respects the protection of international human rights.

#### ***Policy on Safety, Health and Wellbeing***

Golden Star values and is committed to safety and employee wellbeing. GSR believes that job-related injuries and illnesses are unacceptable.

#### ***Golden Star Development Foundation***

The primary vehicle for our social investments is the community-led Golden Star Development Foundation, which is funded annually with US\$ 1/oz Au produced and 0.1% of pre-tax profit. Under the foundation umbrella, GSBPL works with local Community Mine Consultative Committees (“CMCC”), government bodies, and third-party NGOs (among others) to strategize and implement a variety of community development projects and programs.

In 2012, GSR contributed over US\$ 0.38 million to the Foundation, bringing contributions to date to over US\$ 2.3 million. The Foundation carried out a wide array of projects in 2012, with costs totalling US\$ 0.37 million.

#### ***Golden Star Oil Palm Plantation***

GSOPP is a community-based oil palm plantation company established in 2006 as a non-profit subsidiary of Golden Star Resources. The program adopts the small-holder concept of sustainable agribusiness, which addresses environmental, food access, and community concerns. Initially, development is sponsored by Golden Star as part of its local economic development program. The plantations are later able to become self-supporting and the smallholder farmers pay back the start-up loans to GSOPP to allow for further development.

GSR commits US\$ 1/oz Au produced to the program, resulting in over US\$ 3.6 million in funding to date. To date, GSOPP has established 790 ha of plantation, 100 ha of out-grower plantations, and had, for 2012, produced and sold over 3 800 tonnes of oil palm fruit.

### ***Golden Star Skills Training Employable Program***

Education and training initiatives are extended to our community out-reach programs, with a view of imparting lasting educational benefits to our stakeholder communities. The Golden Star Skills Training and Employability Programme (“GSSTEP”) provides training to young people in practical and technical skills in sectors unrelated to mining, contributing to the diversification of the local economy’s employment base. This programme has also been integrated into many of the negotiated resettlement agreements that conform to the International Finance Corporation’s Performance Standard 5 on involuntary resettlement. Golden Star further provided scholarships for over 120 needy students attending secondary school in 2012.

### ***Corporate Responsibility***

Golden Star has long recognized that our people’s talents are our greatest asset, as people are central to realizing our corporate responsibility goals as well as our overall business success. Reflective of our mission and values, we commit to engaging with each other based on a foundation of mutual respect, honesty, and transparency. Accordingly, GSR is dedicated to providing a safe and healthy working environment for our employees, including one that promotes personal and professional development, respects fundamental human rights, and affirms international labour standards.

In accordance with our commitment to the UN Global Compact, GSR supports and respects internationally proclaimed human rights within our sphere of influence. As per GSR internal policy on Community Relations and Human Rights (confirmed 28 March 2013), GSR works to create a culture that makes the protection of human rights an integral part of the short and long-term operations, including the performance management systems.

In 2011, GSR began preliminary work for conducting a human rights desk top review in conjunction with our top 5 suppliers. This work progressed on in 2013, with results reported to the GSR Sustainability Committee. This will help to further ensure that GSR is not complicit in any human rights abuses – directly or indirectly.

Building on training covering human rights matters for our Human Resources personnel – and later our wider workforce – GSR developed a similar program covering matters related to harassment and discrimination awareness and prevention.

In 2011, GSR began implementing a number of major safety risk management programs to further embed safety management into our operations. These programs were further embedded into our operations in 2012, including:

- GSR’s Safety Risk Management Program, which includes: embedding of the GSR safety risk matrix; provision of safety risk assessment and job hazard analysis training; conduct of facilitated multi-disciplinary safety risk assessment workshops; and development of site safety risk registers;
- Provision of upgraded fire response equipment, including fire tenders stationed at each operation, and additional fire response training; and
- Implementation of additional controls for driver speed management across our operations, including: fitting of GPS vehicle trackers, use of speed alert cameras/signage, and stringent disciplinary outcomes for the failure to adhere to rules.

Golden Star is dedicated to engaging in accurate, transparent, and timely two-way consultation with local stakeholders in order to communicate on our business, and address the needs of local partners. Regular dialogue with stakeholders – including but not limited to public meetings, open houses, and sensitization forums – is central to understanding key issues and concerns related to our operations, and, in turn, helps us to realize sustainable solutions suitable to the stakeholders.

Golden Star assumed the role as a catalyst for sustainable economic development in the communities in which operations are situated. Doing so enhances relationships with partners by maximizing the benefits that accrue to the stakeholder communities. Accordingly, GSR makes regular investments in local communities that go beyond traditional philanthropy, namely by adopting a strategic approach to social investment. This helps to create lasting, meaningful benefits for local communities and contributes to a positive long-term legacy surrounding our operations.

#### **19.4 Approach to Management**

#### **19.5 Management Commitment**

In support of the company policies, GSR demonstrates its management commitment through provision of appropriate and dedicated specialist human resources in the disciplines of environment, safety, health, community affairs and resettlement. In 2012, GSBPL employed 64 dedicated personnel in the disciplines of environment, communities, safety, health, and security, representing over 6 % of the total employees. HSEC expenditure in 2012 represented over 3 % of total operating expenditure.

GSR supports achievement of its corporate policies by providing training and development for its workforce with over 68 000 personnel hours committed to this personal development.

The annual GSR Corporate Responsibility report summarises these commitments as well as providing a statement on progress in implementing the UN Global Compact ([www.gsr.com](http://www.gsr.com)).

#### **19.6 Impact Assessment and Approach**

The environmental and socioeconomic impact assessment process for the PUG Phase 2 (WRP) operations is advancing as scheduled, with the majority of the baseline studies now completed and draft impact assessments compiled for key aspects and impacts. The impact assessment team is now undertaking iterations of the various impact assessment models to refine and define the mitigations to be implemented for the project and to reflect the engineering changes in the project that evolved as a result of the FS. Upon conclusion of these design parameters, the EIS will be documented for submission to regulatory agencies. As the EIS was not completed at the time of finalising the FS report SRK was not able to comment on the quality of the report and how it will be received by the EPA. However given GSR's experience in environmental and social impact assessments for other projects SRK thinks that it is reasonable to assume that the EIA report will meet the Ghanaian environmental requirements.

GSBPL has, wherever possible, sought to minimise or avoid the displacement of people or assets. As intended by the national regulations, GSBPL has incorporated a number of project design features to remove potentially adverse impacts on the surrounding local communities and assets.

GSBPL maintains an EMP for its operations in accordance with LI 1652. The EMP is updated every three years to reflect current operations. Following the issuance of an environmental permit for a new project, GSBPL is required to provide an EMP or incorporate the project into an updated EMP within 18 months. The environmental permit requires conformance to the commitments made within the EIS and additionally sets permit conditions for key aspects of environmental and social management. The regulatory framework governing the EMP requires the document to address all key aspects and impacts and document the mitigations, monitoring, and validation that will be conducted to ensure conformance. Thus, there is a regulatory transition from the Environmental Permit to a detailed EMP.

The GSBPL EMP states GSBPL's corporate commitments and requirements, and details preventative and mitigative actions, based on the hierarchy of control, to minimise impact to host communities and the environment in the context of the operations. For each key aspect and impact, as identified from impact assessment processes, the document details management controls and implementation accountabilities with the organisation.

GSBPL has an environmental management system aligned to ISO14001; the development, implementation, and embedding of the EMS is supported by a dedicated environmental team. Within the business, and already accountable for activities on the Prestea concession, are the Environmental Services Manager, Community Affairs and Sustainable Development Manager and a Resettlement Superintendent. Most of these positions report directly to the GSR Ghana - Managing Director, and each have dedicated teams supporting them. Site Managers are also supported by dedicated corporate HSEC personnel, including a group level manager and a senior vice president.

GSBPL has a stakeholder engagement plan and supporting framework. Additionally there are project-specific engagement plans for the Prestea Underground Phase 1 project, the Prestea Underground Phase 2 project (WRP) and the PSMNP (surface mining project on the Prestea Concession). There are sufficient resources in place or planned to implement these stakeholder engagement plans. GSBPL has recognised that additional resources may be required to support the full implementation of the Prestea projects resettlement action plan, and GSBPL has demonstrated experience in obtaining these resources from elsewhere within the GSR business and externally as required.

## 19.7 Land Acquisition

Every effort has been made to remove or minimize local community effects. However, where land used for farming or habitation (whole or partial) will be required, GSBPL will adhere to all the applicable laws governing this through compliance with their Farm Compensation and Land Acquisition procedures.

Since 2005, a substantial crop compensation programme has been carried out for the Prestea projects (PSMNP and WRP). To date, over GH¢ 1 million have been paid for crops covering some 472 ha (including compensation for the transport route). In total, over 733 farmers were compensated. Figure 19-3 illustrates the extensive areas of compensation that have been successfully negotiated and paid. It is possible that further areas of compensation may be required for the project. Any further compensation associated with the project will be carried out in accordance with the aforementioned GSR procedures.

## 19.8 Identification of Project Affected Persons

Project impact assessments recognise that the project may result in the physical and / or economic displacement of people and property. These potential effects have been identified as falling within the following categories:

- People or entities, whose houses and/or property would, in part or in total, be affected due to their location within or proximity to the project footprints. This could include permanent or temporary loss of use;
- People, whose agricultural and/or residential land would, in part or in total, be affected due to its location within or proximity to the project footprints; This could include permanent or temporary loss of use;
- People, whose crops (annual or perennial) and trees would, in part or in total, be affected due to its location within or proximity to the project footprints;
- People at any relocation sites and on relocated roads, including those outside the projects operational areas; and
- Public and private institutions in the operational areas and at any relocation sites.

The impact assessments identified suitable mitigation measures to address the potentially adverse impacts. The impact mitigation for those whose homes or properties could be affected by the project are described more fully in the RAP, which focuses on these people (including entities) and who are referred to collectively as PAP's.

From a review of the environmental impact assessments, GIS maps, and socioeconomic baseline data collected in 2007 and 2011, a list of potential PAP's was developed. This was verified by site visits. Assets of business, communities, or households that may be affected by the project include:

- Structures owned by SGMC within the projects footprints or immediate environs;
- Privately owned structures within the projects footprints or nearby environ;
- Crops and / or land owned or tenanted within the project footprints and environs; and
- Other structures owned by SGMC and subject to the sublease and optional purchase agreement with GSBPL (a list of properties and structures is provided in the RAP) and required to support the development of the Prestea projects.

Since the majority of the structures affected do not belong to the residents, the current owners, SGMC, were considered in detail within the RAP.

Moreover, through the socio-economic survey conducted as part of the Prestea Projects RAP, over 100 household heads and some of their household members have been made aware of the on-going RAP preparation (submitted to the appropriate authority in November 2012) and the possible need to vacate their accommodation (note only some few are legal tenants). Details of consultations with PAP's, including minutes of formal consultations, as well as summaries of the socioeconomic surveys can be found in the Prestea Projects RAP.

### ***SGMC Structures***

There are some 138 properties owned by SGMC, subject to the GSBPL sublease and optional purchase agreement that may be affected by the project. It is expected that as project plans develop further, additional PAP's may be identified.

### ***Other Locations - Moratorium***

Any subsequently identified PAP's that privately own structures (that are habitable), or assets, or have crops or land affected by the Prestea projects, at the time of the submission of the Resettlement Action Plan (November 2012), will be subject to the processes, protocols, and entitlements as defined in the Prestea Projects RAP.

For occupiers of properties subject to the SGMC/PGL/GSBPL sublease and optional purchase agreement, GSBPL will not attribute PAP status to any persons that illegally occupy structures that it rents, post the date of the submission of the RAP (November 2012). Only

those persons, who were residents of the SGMC properties prior to the date of submission of the Prestea Projects RAP (date of moratorium), will be subject to the processes, protocols and entitlements as defined in the approved Prestea Projects RAP.

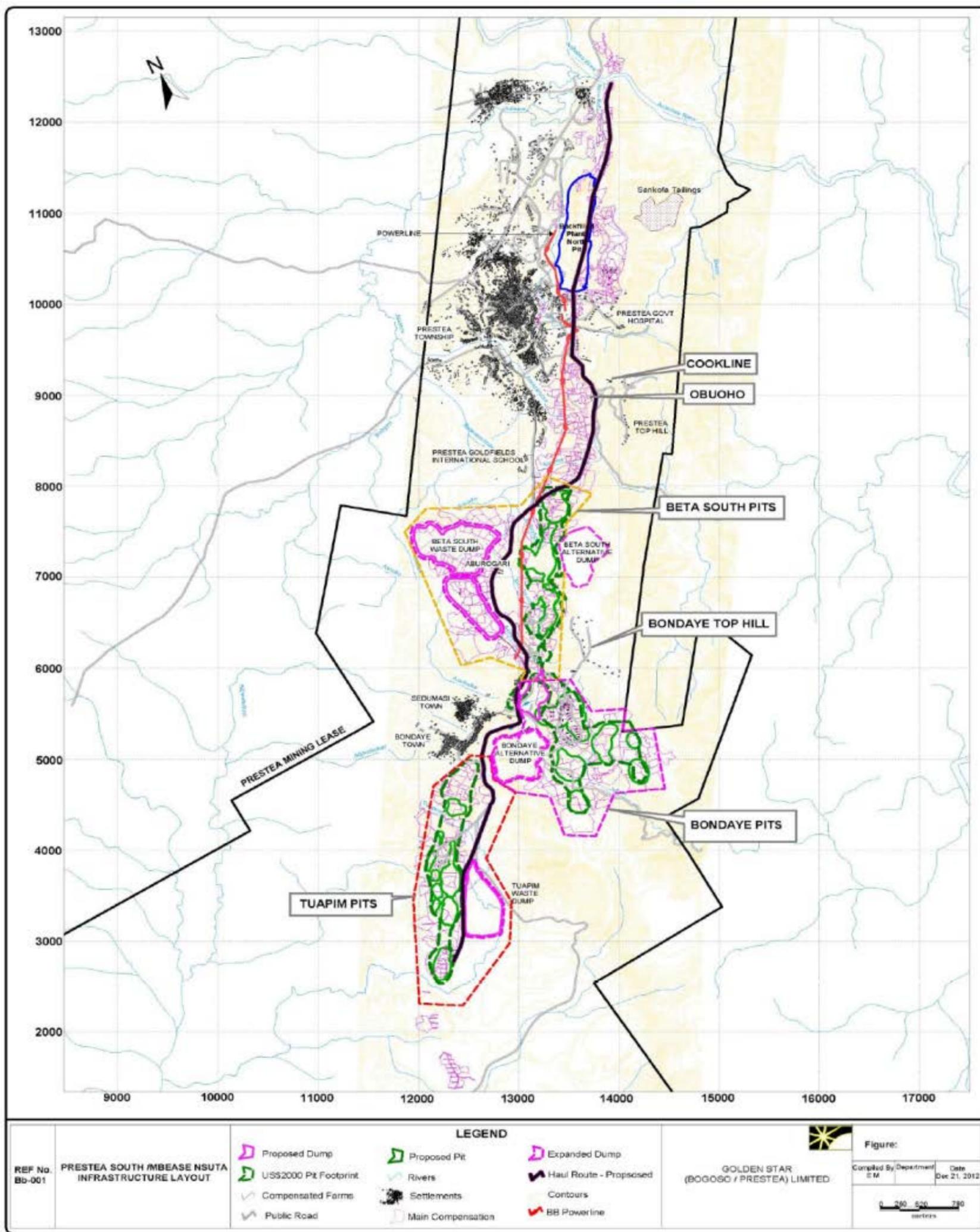


Figure 19-3 Prestea Concession – Compensated Areas

## 19.9 Security

In the context of the project, security is provided by dedicated security personnel. GSBPL, through their security provider, ensures these personnel are appropriately trained. Community and worker security, health and safety are addressed by legislative instruments and supporting approvals processes. Established in 1993, as directed by the Ghana constitution, Ghanaians may also refer any matters pertaining to human rights and justice to the Commission on Human Rights and Administrative Justice (“CHRAJ”) for independent investigation.

## 19.10 Stakeholder Engagement

### 19.10.1 Overview of Consultation Approach - Stakeholders

Consultations on the need for possible resettlement of identified PAP’s commenced in October 2006. Various concerns about both the Prestea Projects and the resettlement of affected hamlets and communities were raised. Consultations continued throughout 2007 to 2009 with numerous efforts to hold a public hearing on the PSMN project. Consultations continued in 2010 and in 2012 as updated socioeconomic and environmental impact assessments were progressed.

The impact assessment and associated consultation identified specific elements of the Prestea Projects for further design review. In 2010 and 2011, GSBPL advanced the design, particularly in relation to the transportation route shared by both the PSMNP and the WRP projects, and in late 2011 updated the socioeconomic baseline data. In 2012, GSBPL finalised a number of project design aspects, started the collection of further socioeconomic data, and undertook further consultation to communicate these aspects to stakeholders.

The design assessments enabled GSBPL to understand the relative importance of the Valued Socioeconomic Components (“VSEC”) potentially affected by the project, and identify project designs to avoid or minimise impacts to the VSEC’s whilst maximising benefits. The majority of the community concerns associated with the Prestea Projects, and more specifically, with the transportation of ore have been addressed in the context of the Prestea concession mining projects.

### 19.10.2 Overview of Consultation Approach - PAP’s

Stakeholder consultations were held throughout the Prestea area through the environmental and socioeconomic impact assessment processes with socioeconomic data initially collected in 2007 from then identified potentially affected communities (29 households in total) (AERC, 2008). Following project delays resulting from consultation for the surface operations, an updated RAP was documented in 2010.

In 2011, GSBPL undertook a systematic review and data validation of the surface and underground projects, and identified PAP’s that had previously not been identified. Additionally, finalisation of key project aspects resulted in some communities being reclassified as not affected and others being classified as potentially affected.

As a result of these processes of validation, a further socioeconomic survey was conducted in 2011 with the objective of endeavouring to survey 100 % of PAP households (some 100 households). In order to achieve this objective, PAP communities were visited extensively in August and September 2011. Further surveys were completed in Q3 2012 to reflect further plan evolution for the surface and underground projects (subject of this FS).

Project affected communities were visited numerous times throughout 2011 to ensure that survey information employed in the 2012 RAP was as current as possible, and to validate

data accuracy. Late optimisations of the transport route resulted in a small number of PAP's being visited in 2012. The socioeconomic data provided in the Prestea Projects RAP are aggregates of these 2011 and 2012 data.

### **19.10.3 Project Permitting Notifications**

In the course of the development of the project, there have been a number of public notification and advertisements of key permitting milestones communicated to the community in print and radio media. These are summarised following:

- 2011 – Various meetings with the Minister for Lands and Natural Resources on the project evolution;
- 2011 / 2012 – Underground tours provided to key institutional and Traditional authorities stakeholders;
- 30 May 2012 - Submission of project registration form (EA2) for the PUG phase 2 operations to the EPA;
- August 2012 – Mine Operating Plan for Phase 1 operations submitted to the Minerals Commission;
- 12 September 2012 – Environmental Scoping Report submitted to the EPA and copied to the Minerals Commission; and
- November 2012 – Submission of Prestea Projects Resettlement Action Plan to the Prestea Huni-Valley District Assembly and EPA.

Throughout this period, the NCM Prestea general office and GSBPL information centres have been available to local stakeholders to respond to queries and address concerns. Additionally, regulatory submissions can be obtained by stakeholders from the EPA.

### **19.11 Summary of key stakeholder issues**

The most frequently discussed and critical stakeholder issues have been with respect to the following:

- Local employment and contracting;
- Potential project impacts (dust, noise, vibration, land acquisition) and mitigation measures;
- Land acquisition, resettlement and compensation;
- Mediation and agreement for building mutual trust between GSBPL and the community;
- Alternative livelihoods and community development interventions; and
- Negotiations with small scale miners and ceding parts of Prestea concession to relocate small scale miners.

### 19.11.1 Grievance Mechanism

GSBPL maintains a grievance mechanism enabling catchment communities to document concerns and grievances for investigation / action. The mechanism is well publicised by GSBPL and used actively by the community and other stakeholders. Details of registered grievances and their resolution are recorded and reported internally and to the regulators.

### 19.12 Substantive Issues

Substantive environmental and social issues identified for the project are as follows:

- Potential acid generating materials and their management;
- Avoidance of cumulative impacts to aspects subject to the Environmental Indemnity Agreement;
- Illegal occupation of SGMC structures;
- Interactions with activities of illegal and unauthorized small scale miners; and
- Safety of community members adjacent to mine workings.

#### 19.12.1 Acid Rock Generation

It has been identified by historic studies that transitional rock and fresh rock in the geological region are Potentially Acid Generating (PAG). Mine waters for the existing Prestea underground mine show evidence of ARD, neutral leaching, as well as saline drainage. To mitigate for these potential impacts, the proposed project design incorporates the construction of a fully encapsulated waste rock dump for management of potentially acid generating waste rocks. GSBPL also has the opportunity to preferentially backfill these materials within the underground mine voids (as allowed by mine scheduling). Should the PSMNP proceed, GSBPL would also have the alternative of backfilling these materials within the pit voids as part of the expected backfilling.

#### 19.12.2 Cumulative Impacts to Areas of Historic Liability

The Government of Ghana is accountable for the rectification of the historic environmental degradation of the Prestea Concession. Should the proposed GSBPL underground mine activities contribute to a further deterioration of environmental conditions, then it would be expected that the Government of Ghana would seek to transfer its liabilities to GSBPL. This could have substantive cost implications for the project.

#### 19.12.3 Illegal occupation of SGMC structures

Whilst the Project RAP initially focuses on mine structures and privately owned structures within the project footprint, there are 138 SGMC structures subject to the SGMC/PGL/GSBPL sub-lease and purchase option agreement (2007).

In the course of the development of the Prestea Projects (PSMNP and WRP), GSBPL will exercise this agreement as required, and as such, SGMC are identified within the Project RAP as one of the parties potentially affected by the development of the Prestea projects. Additionally, occupiers of the SGMC structures at the date of submission of the RAP were included within the scope of the RAP. Occupiers seeking to illegally reside within an SGMC property legally tenanted by GSBPL after the date of submission of the RAP (moratorium date) will not be included in the scope of the RAP. In this manner, GSBPL has sought to discourage persons from re-occupying SGMC properties for which it is the tenant.

The extensive consultation undertaken to date for the project has highlighted the concerns of the community in relation to occupancy of the various residential structures for which SGMC is the owner, and GSBPL is the tenant.

#### 19.12.4 Interactions with Activities of Illegal Miners

Interactions with the activities of unauthorized small scale miners and illegal medium scale miners could lead to the following:

- Physical intersection between un-surveyed historic workings and the associated risk of inrush of water and flooding of the WRP;
- Actions of the Government of Ghana, including the National Security Council and perceived involvement of GSBPL in the actions taken by these groups to regulate the activities of unauthorised miners; and
- Ability of unauthorized small scale miners and their supporters to jeopardise the project through political means e.g. an unauthorized small scale mining operator/supporter will not complain that the workings are being disturbed by the mine (given his activities are not legal). However they may make spurious claims of other impacts to jeopardise activities in the area intersecting with his interests. These conflicts of interest, pose engagement and relationship issues for GSBPL.

##### ***Safety of community members adjacent to mine workings***

Accidents involving local communities due to trucks on the haulage road, leading to community uprising, potential loss of social license to operate and the temporary inability to deliver ore to the processing plant.

#### 19.13 Closure Requirements and Costs

The closure requirement will be outlined in the reclamation bonding document that is expected to be similar to other such documents currently held by GSBPL. Based on this assumption, the following infrastructure will be rehabilitated at the closure of the operation:

- Waste rock storage facilities (assumed to be PAG);
- Fuel storage area;
- Water treatment plant (containerized);
- WRP Headframe and winders;
- WRP Workshops; and
- Other containerized infrastructure.

Excluded from the rehabilitation are the following:

- Shared infrastructure with the Prestea South Project;
- Infrastructure required by communities (e.g. access roads); and
- Existing infrastructure covered under the indemnity.

The rehabilitation and closure will assume that the site will be returned to the community as a building site to the extent possible. This assumption is based on the request that the Plant North pit back-filled site be retained by the community as a building site. The costs associated with the rehabilitation are those used in the end 2012 asset retirement obligations calculations that were reviewed by a third party auditor. There are not expected to be any long-term community obligations within the closure and rehabilitation costs.

#### 19.13.1 Risks

In the development of the project, risk assessment workshops were conducted by Golder Associates (EIS consultant), and SRK Consulting (FS consultant) in conjunction with Golden Star Resources and GSBPL team members, to identify risks with the potential to affect the project or the company. Risks were recorded in a risk register, and ranked in inherent and residual conditions. Only material environmental and social risks (i.e. those that may stop the

project or have significant cost implications) have been discussed in this section.

### **19.13.2 Permitting Schedule cannot match the Construction Schedule**

There is a risk of project construction activities being delayed due to the environmental permit not having been obtained prior to the construction commencement date. GSR average for obtaining mining permits is longer than 365 days on recent projects. It is generally accepted that the West Reef Project is desired by the authorities but the exact timing of the permitting is unclear. There are various environmental approvals needed for the mining operation and the refusal of any of these permits by government could delay the commencement of the mine and have serious cost implications. Broad community support for this development project means that such delays are considered unlikely.

### **19.13.3 Regulatory Evolution**

Sovereign risk that is manifested as changing and un-formalised expectations of regulators 'enforced' through project permitting, e.g. EPA have recently retracted Environmental Permits (of a peer company) to modify operating conditions to best practices from a previous position of industry standard practice.

As part of the environmental management for the site, adaptive management is included. This allows the site personnel to adjust to ongoing changes in regulations and EPA requirements. More recently, some requirements for tailings storage in Ghana changed. In response to this, GSR staff worked with the engineering consultant to develop a more cost-effective approach to the particular situation. This re-design will then be submitted to the EPA for approval. In many areas, the environmental management at the site exceeds the legal requirements. Therefore, the site is well-placed to predict these changes and stay ahead of the advancing legislation.

### **19.13.4 Loss of Community Support**

This could be caused by a number of different issues as outlined below.

#### ***Lack of transparency with respect to flow of project revenues to the local authority***

Failure by Government to redirect royalties and government payments to entitled parties, including Traditional Authorities and Stool Lands, leads to a stakeholder agitation / campaign against GSBPL to motivate for action, which could threaten the company's community support.

GSBPL will continue its active reporting in accordance with the EITI and Dodd-Frank reporting requirements, including presentation of these data to traditional leaders and community representatives through the Community Mine Consultative Committees and communications directly to the public (e.g. Annual Corporate Responsibility Report). Additionally, GSR has policies relating to anti-bribery and anti-corruption including Business Conduct and Ethics Policy, Code of Ethics for Directors and Officers, Corporate Control Policy, and a Whistle-blower Policy.

#### ***Unmet expectations: negotiations***

There are risks associated with expectation management, specifically in areas that are subject to negotiation (e.g. Prestea Goldfields International School). The previous negotiations for the relocation of the school are described in the Prestea South Mbease Nsuta Project Draft Environmental Impact Statement (AERC, 2013) and Prestea Projects Resettlement Action Plan (GSBPL, 2012). This issue needs to be managed carefully as per the provisions of the RAP. The school has a special social / cultural significance to the community and, therefore, clear communications will be required for the results of any

negotiations.

***Unmet expectations: job creation***

The community expects that the expansion of the underground operation would result in high levels of job creation. However the proposed WRP would need around 240 new workers, as some positions are already filled. Lower than expected employment openings could lead to resentment from community members. This could become a difficult aspect to manage. Mitigation options for this include additional GSSTEP programs and a focus on local purchases for food and equipment. The newly signed community agreements clearly state the expectations for local hiring as related to unskilled work and are an important tool in the management of community expectations.

Communications with stakeholders are ongoing with quarterly meetings. Therefore, any material changes in operations can be quickly communicated to stakeholders and the expectations within those groups thereby managed. GSBPL will develop a stakeholder engagement plan that will also assist in the management of this risk. It will be the role of the community liaison team at GSR.

***Obstruction from unauthorized small scale miners***

The perception or allegation that GSBPL is involved in, or associated with, the actions of Government officers or security forces in removing / regulating unauthorised miners, i.e. small scale miners could be promoted. Associated supporters would start a campaign against GSBPL accusing the company of arranging/supporting any actions of the National Security Council as the Government increases its enforcement of law in regards to illegal mining.

It was reported during stakeholder meetings that the artisanal miners see the start of the underground mine leading to loss of opportunity for unauthorized small scale mining. Unauthorized small scale miners are generally against the start of underground mine but have not openly expressed their views. During stakeholder meetings they have been seen to raise other issues to motivate against the project.

GSBPL will mitigate this risk through the following actions:

- Documentation of a detailed RAP;
- Conduct of independent surveys and associated payments of a comprehensive farm compensation program;
- GSBPL has implemented a strategy, supported by the Minerals Commission, to provide alternative land for small scale mining, to enable interested residents of Prestea to have such a livelihood, whilst reducing the risk to their health and safety of interacting with the large-scale mining proposed by the Prestea Underground phase 2 operations (WRP); and
- Development of a Security Agreement with the Government of Ghana to minimise risks associated with the actions of Government security forces on the Prestea Concession.

**19.13.5 Entanglement of WRP with other Prestea Projects**

The reliance of the PUG on other GSBPL infrastructure (e.g. tailings storage facility and processing plant) places it at risk if there are environmental and/or social risks associated with this existing infrastructure that have not been identified.

In addition, communities do not differentiate between the WRP from other Prestea Projects. Risks to community support on any of the Prestea Projects will ultimately affect the proposed underground project. GSBPL would manage this risk by ensuring that similar environmental and social standards are maintained across all its operations.

### **19.13.6 Transfer of Historic Liabilities**

In order to reduce its liability or influence for environmental improvement, the Government of Ghana / regulators place pressure on GSBPL to remediate historically disturbed lands, manage PCBs and other environmental contaminants, encapsulate / backfill historic waste and tailings piles, treat underground mine water discharges (e.g. from Bondaye or Central shafts) that are each subject to the environmental indemnity components of the lease acquisition agreement. There could also be a move to enforce strict water quality requirements on water bodies that are outside the mines' control (i.e. where unauthorized small scale mining activities are taking place)

The WRP design has taken cognisance of this risk, to ensure separation of the project infrastructure from the areas/aspects of greatest historic liability (subject to the indemnity). Key actions incorporated into the project design to prevent and mitigate for this risk include the following:

- Documentation in the form of due diligence audits (Knight Piésold 2001 & 2002) of the pre-existing environmental liabilities and existing environmental degradation in accordance with the terms of the indemnity agreement;
- Almost a decade of baseline monitoring data on the volume and quality of waters that are dewatered from the historic mining voids in accordance with the terms of the concession purchase agreement;
- Provision of a dedicated dewatering system for the West Reef mining area - to maintain separation of the water used in West Reef mining from the water that is present in the historic voids and is dewatered in accordance with the purchase agreement; and
- Allowance for the development of a dedicated waste rock dump, at a location remote to the historic waste rock and tailings areas, to limit potential interactions between this infrastructure and that covered by the scope of the indemnity agreement.

### **19.13.7 Full Water Treatment at Prestea**

Ghana EPA specifies full water treatment at Prestea. This would add around US\$ 6 million to capital costs and several million dollars annually to operating costs. The mitigation for this is to present the WRP as a 'mine within a mine.'

### **19.13.8 National Water Quality Regulations Not Met**

Since there is a considerable amount of unauthorized small miner activity in the Prestea concession there is a risk that surface water bodies close to the WRP may display poor water quality (due to sewage, elevated arsenic levels and elevated iron concentrations). This could prevent the project from meeting national surface water quality requirements. However, this risk is expected to be quite low since water monitoring at strategic locations has been taking place since 2003 and the mine will continue to monitor water quality in the vicinity of the WRP.

### **19.13.9 Unrest Resulting from Eviction of Illegal Occupants from SGMC Structures**

Community agitation resulting from the implementation of the RAP, specifically the eviction of non-legal occupiers of SGMC dwellings has the potential to materially affect the Project through impacts to project schedule.

The extensive consultation undertaken to date for the project has highlighted the concerns of the community in relation to occupancy of the various residential structures for which SGMC is the owner, and GSBPL is the tenant. Whilst there is clear documentation to confirm SGMC ownership, including a High Court ruling to that effect, the implementation of the RAP will need to be carefully managed to ensure that occupants (non-legal occupiers) are treated with

respect and are supported as per the terms of the RAP.

As the SGMC has limited personnel and experience in RAP implementation, it is expected that GSBPL may need to provide support, in the form of guidance and resources to SGMC, to ensure that the GSR adopted standards (IFC Performance Standard 5) are maintained throughout these interactions.

#### **19.13.10 Failure to Develop Prestea Underground Project**

Failure by the company to develop the Prestea Underground Mine results in major reputational risk to Golden Star and GSBPL including loss of Government support, loss of trust by the community and resulting impact on future project development and permitting.

In order to manage this risk, GSBPL will develop a stakeholder engagement plan that will allow the reasons for the delay in development to be explained at an appropriate level. These would include institutional shareholders, GSR staff and contractors, and community stakeholders.

#### **19.13.11 Acid Rock Drainage**

Whilst management of PAG rock can affect the environment and have increased operating costs, the controls that have been incorporated into the project design reduce the risk levels.

#### **19.13.12 School Relocation Delayed**

If there is delay in construction of the replacement building for the Prestea Goldfields International School, it could delay the access to the land required for the project construction. The mitigation for this is to have timely availability of funds, identification of alternative site, and timely construction of replacement school. If this is the case, the School Board and the community members will be motivated to relocate to the new buildings without any delay to the WRP.

#### **19.13.13 Flooding of the Mine from Historic Surface and Underground Workings**

There is a risk of the historical Ankobra and Beta shafts, which are located in a depression close to a stream, possibly flooding the main mine workings through the in-rush of water from these historic surface and underground workings. This may also take place through tunnels dug by artisanal miners. GSBPL would manage this by ensuring that existing cavities on the surface that may connect with the underground workings are properly sealed.

### **19.14 Recommendations and Way Forward**

#### **19.14.1 Summary**

The corporate responsibility (environmental and social) planning for the Prestea WRP has been extensive. The corporate responsibility team was an integral part of the design engineering team, so allowing for a seamless approach to corporate responsibility planning within the Project. This interaction allowed for a complete assessment of options for the project components and their interaction with the environment and socioeconomic fabric of the Project area.

With the WRP FS completed, the environmental permitting may continue with the incorporation of the designs of the project and then the assessment of the environmental effects and the residual environmental effects following the implementation of the mitigation measures and strategies. To allow the impact assessment to be completed, the baselines within the project area were developed. The project area has been extensively disturbed; urbanization, small scale farming, and extensive unauthorized mining (small and medium scale) have essentially removed most of the environmental resources. The baseline socioeconomic studies showed an impoverished neighbourhood with relatively low levels of education and poor economic stability.

The main potentially adverse socioeconomic effect of the project is the need to resettle the Prestea Goldfields International School. This is currently located immediately over the location for the RHS. However, negotiations with key stakeholders and the school board of trustees provided an opportunity to consider the resettlement of the school to another location selected by the community. This would allow the mutual benefit of access to the land and a new school for the community to be realized.

Adaptive management for corporate responsibility allowed the incorporation of the resettlement requirements into a Prestea Projects RAP. This RAP combines the resettlement / relocation requirements for the Prestea South Project (surface mining) and the Prestea WRP operations. As such, the Prestea Huni Valley local authorities is able to review the requirements for all the current projects in the area, allowing an optimized approach for both RAP review and approval, and then implementation. The project affected people (PAP) would also have a single window approach for concerns associated with the RAP, so allow for improved response times and an overall elevated level of understanding with the PAP.

#### **19.14.2 Additional Studies**

With the commissioning of the PUG Project Phase 1 recovering some remnant ore from the mine, expectations within the stakeholder communities are high. Therefore, regular meetings with key stakeholder groups (CMCC and other) will be held to update the broader stakeholder community on developments within the Project and allow the population to understand the processes of approval and project development. Some additional studies for the EIS are required including the following:

- Additional air quality modelling to reflect the changes to the project parameters;
- Specialist studies in the area of the key surface infrastructure to determine if there are any valued environmental components and valued socioeconomic components;
- Risk assessment for development and safety management, more specifically with the interaction with the un-surveyed unauthorized small mining workings;
- Expansion of detailed studies to the location of the waste rock dump;
- Evaluation of the acid generation potential for the waste rock that will be moved to surface; and
- Opportunities for synergies with other GSBPL projects.

## 20 CAPITAL AND OPERATING COSTS (ITEM 21)

### 20.1 Introduction

The following sections outline SRK's approach to the estimation of capital and operating costs for the financial evaluation of the LoM plan for the WRP.

### 20.2 Capital Costs

Capital costs for the WRP have been derived principally from planned equipment requirements and estimates for major infrastructure such as the shafts, relocation of the International School and mine closure. The mining equipment capital is primarily expended early in the life of the operation, though it also includes replacement of major mining equipment at four years of age. Sources and total capital requirements for the life of mine are given in Table 20-1 and Table 20-2 respectively.

**Table 20-1 Sources for Capital Cost Estimate**

Item	Method of estimation	Source
Predevelopment projects	From quotes and first principles	GSBPL
School re-location	In-house estimate	GSBPL Construction Manager
Raisebored Hoisting Shaft (RHS) cost estimate	From quotes and first principles	MRC
Raisebored Ventilation Shaft (RVS) cost estimate	From quotes and first principles	MRC
Surface buildings at RHS	From quotes and first principles	MRC
Mine Equipment fleet	Budget quotes from suppliers	Sandvik Tamrock, Clemcorp Ltd
Central Shaft Upgrade	Worked up from survey and current costs	AAE
Bondaye Shaft Upgrade	Worked up from survey and current costs	G.L. Tiley Ltd
Electrical and Pump costs	Supplier quotes	Prepared by Redden Mining from a variety of Aus./ Nz. suppliers
Water treatment plant	Supplier quotes	SRK obtained quotes from a UK based supplier.
Closure costs	Estimate from first principles	GSBPL / SRKs database of similar projects.

**Table 20-2 Capital Cost Breakdown for WRP**

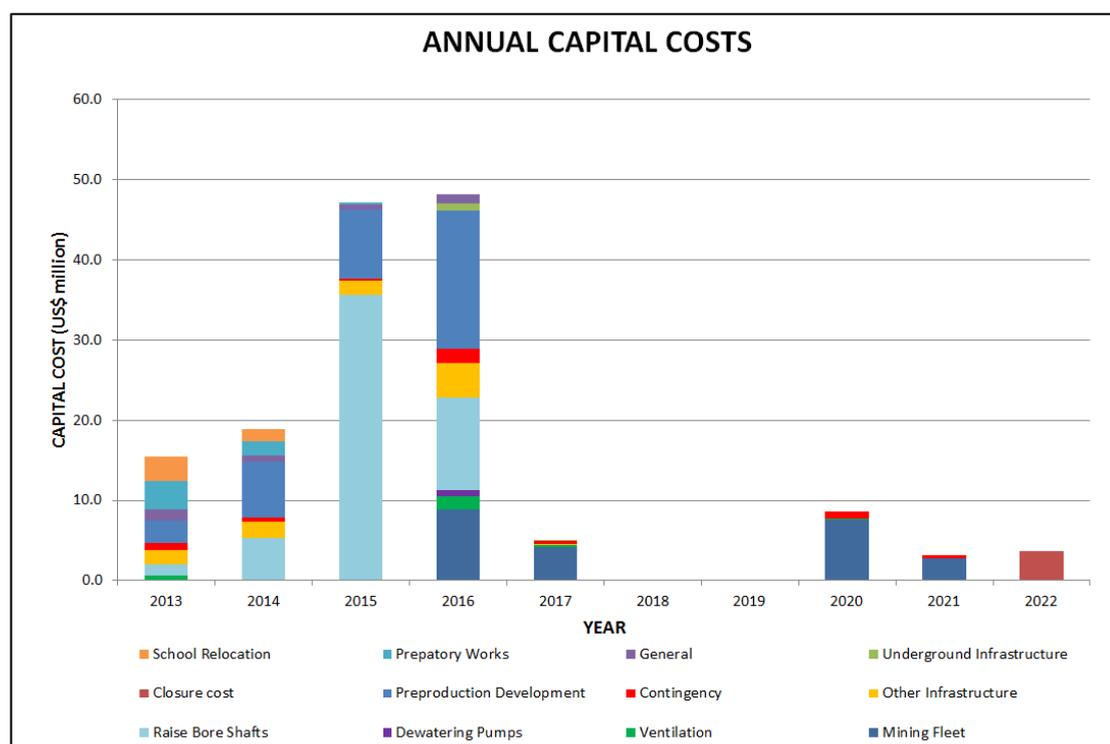
<b>Capital Costs</b>	<b>LoM (US\$ million)</b>
<b>Mining Fleet</b>	<b>23.45</b>
Sandvik TH430	5.21
Sandvik 400 (LH410)	4.44
Sandvik 151 (LH203)	4.39
Sandvik DD321	0.83
Sandvik DD210	2.15
Sandvik DL210-5	1.43
Tool Carrier (CAT 924K)	0.77
Explosive loader (Normet Chermec 6605 B)	1.69
Road Grader (Cat 12M)	0.70
Normet Concrete Agitator	0.84
Tractor (Kubota MX4700)	1.00
<b>Ventillation</b>	<b>2.70</b>
Existing surface fans	0.60
New Primary fans (west reef VR)	1.37
West reef auxiliary fans	0.18
Auxillary fan (type 2)	0.55
<b>Dewatering Pumps</b>	<b>0.80</b>
Existing pumps - spares	0.16
West reef pump station	0.26
Auxillary west reef pumps	0.38
<b>Raise Bore Shafts</b>	<b>53.79</b>
17 level preparation	1.30
RHS and ventilation geotech holes	0.40
Shaft Establishment	52.09
<b>Preparatory Works</b>	<b>5.65</b>
Central Shaft steelwork upgrade	2.57
Bondaye Shaft Upgrade	1.16
Transport Waste	0.11
Construct Waste Storage Facility	0.17
Central & bondaye shaft winder repairs	1.65
<b>UG Infrastructure</b>	<b>0.94</b>
Refuge Chambers	0.34
Sat - Stat refueling station	0.30
Underground Workshop Equipment	0.30
<b>Other Infrastructure</b>	<b>10.00</b>
Current Electrical infrastructure upgrade	2.53
New RHS electrical infrastructure - Surface	1.56
New west Underground electrical infrastructure	2.57
Accommodation	1.25
Water treatment plant	2.00
Tailing cost capital	0.00
Access Road	0.04
Fuel tank	0.05

Capital Costs	LoM (US\$ million)
<b>General</b>	<b>3.83</b>
Tech services - software etc	0.56
Consultants	1.73
First fill spares	0.50
Permitting - EIS & Public Hearing	0.65
Owners Project Team (pre-development only)	0.39
<b>Contingency - Capital</b>	<b>4.91</b>
Contingency Rate*	5%
<b>Relocation of international school</b>	<b>4.50</b>
<b>Closure cost</b>	<b>3.69</b>
<b>Sub Total Capital (US\$)</b>	<b>114.26</b>
<b>Capitalised Operating Cost (US\$)**</b>	<b>35.79</b>
<b>Total Project Capital (US\$)</b>	<b>150.05</b>

\* Contingency has not been applied to the school relocation, shaft construction and closure costs because these estimates already have contingency incorporated.

\*\* Capitalised operating costs include 10 % contingency as applied to all operating costs.

A breakdown of capital expenditure for the life of the underground mine including replacement capital is provided in Figure 20-1.



**Figure 20-1 Annual Capital Costs for WRP**

The estimated Capital costs total US\$ 150.1 million over the LoM which includes a 10 % contingency on all capital items except the following:

- School Relocation. This estimate was built up by GSBPL and contains at least 10 % contingency;
- Shaft complex construction. SRK considered that the estimate prepared by MRC contained adequate levels of contingency added by the designers for tender purposes;

and

- Closure Costs.

This results in an average contingency rate of 5% on the Total Capital.

The cost and time to construct the RHS, RVS and related ancillary work has been estimated for the FS in detail by underground contractors, MRC at US\$ 53.8 million which is the largest capital expenditure comprising 35.8 % of the total over the LoM. The mining fleet capital (15.6 %) is primarily expended early in the life of the operation, though it also includes replacement of major mining equipment after four years of operation.

Pre-Production development has been capitalised and comprises the first 9 months of development activities scheduled for Q2 2016 to Q4 2016, totalling US\$ 35.8 million or 23.9 % of the total estimated capital costs and covers:

- Equipment operating costs;
- Labour;
- Direct per metre costs for explosives, ground support, services, ventilation, etc.; and
- Power.

The mine development work includes:

- Completing workshops;
- Establishing truck tips for shaft loading;
- Establishing the ventilation connection drive to link ore production with the RVS;
- Establishing the 17 L pump station;
- Ramp and haulage way development;
- Initial ventilation and escapeway raises; and
- The initial ore headings to establish production.

A total of US\$ 6.7 million for new electrical infrastructure and upgrade work to existing systems is included in the FS estimate which includes:

- US\$ 2.5 million to upgrade existing infrastructure on surface and underground in the Central and Bondaye shafts;
- US\$ 1.6 million for surface transformers at the RHS and changes to the existing network to support the new feed to this area; and
- US\$ 2.6 million for WRP underground infrastructure including transformers, high voltage switchgear, cabling, low voltage distribution and starter boxes, the leaky feeder communications and the centralised blast system.

**Table 20-3 LoM Capital Expenditure**

<b>Capital Breakdown</b>	<b>Capital Expenditure (US\$ million)</b>	<b>% Capital</b>
Mining Fleet	23.5	15.6%
Ventilation Fans	2.7	1.8%
Dewatering Pumps	0.8	0.5%
Raisebored Shafts	53.8	35.8%
Preparatory Works	5.7	3.8%
Underground Infrastructure	0.9	0.6%
Other Infrastructure	10.0	6.7%
General	3.8	2.6%
Contingency (5 %)	4.9	3.3%
School Relocation	4.5	3.0%
Closure Cost	3.7	2.5%
<b>SubTotal – Capex (US\$ million)</b>	<b>114.3</b>	<b>76.1%</b>
Preproduction Development	35.8	23.9%
<b>Total Project Capital (US\$ million)</b>	<b>150.1</b>	<b>100.0%</b>

## 20.3 Operating Costs

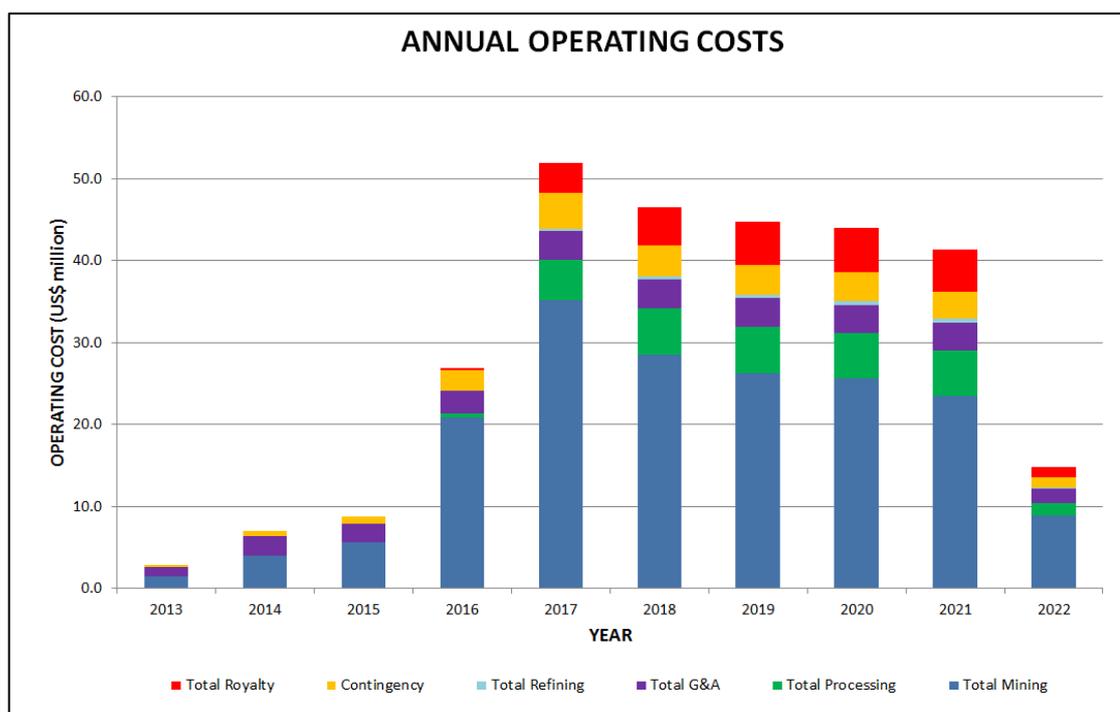
SRK has derived the operating costs for the WRP from first principles and a breakdown of operating expenditure for the life of the underground mine is provided in Figure 20-2. The LoM breakdown per tonne milled is provided in Table 20-4 which totals US\$ 179.3 /t milled (excluding preproduction). The underground mine operating costs comprise 61.4 % of the total operating costs and includes development costs (excluding preproduction), equipment, power, labour and Maintenance and Repair Contract (“MARC”) costs. Power costs are significant (26 %) and are based on requirements to dewater the historic workings and operate the existing primary fan and a power cost of US\$ 0.178 /kWhr from the main grid, supplied by GRIDCO.

SRK notes that labour costs constitute 25 % of the mine operating costs (excluding royalties and contingency) at US\$ 60.5 million over the LoM or US\$ 42.2/t ore. SRK notes that many of the salaries are on a par or above those paid in Organisation for Economic Co-operation and Development (OECD) countries. This illustrates the impact of the recent mining boom on salaries in Ghana.

SRK believes that to introduce a new mining method to the existing workforce and specifically because it is mechanised, that it is key to utilise experienced expatriate workers for a period of at least two years. These experienced workers have been factored into the mining, maintenance and electrical teams. The total cost of expatriate labour for the WRP is US\$ 16.7 million or 28 % of the total labour costs (US\$ 60.5 million) which equates to US\$ 11.6 /t ore.

An operating cost of US\$ 5.5 /t is required for transporting the ore 16 km to the Bogoso plant and US\$ 15 /t processing costs is based on a review of metallurgical testwork of WR samples and current operating costs at the process facilities.

A 10 % contingency has been included for operating costs to allow for small items and omissions from the estimate. The royalty payable to the government equates to US\$ 20.9 /t milled.



**Figure 20-2 Annual Operating Costs for WRP**

**Table 20-4 LoM Unit Operating Cost Breakdown (US\$/t milled)**

Operating Cost Breakdown		LoM Operating Cost (US\$/t milled)	% Operating Cost
<b>Total Mining</b>		<b>125.4</b>	61.4%
	Direct Costs	26.2	
	Mining Fleet	24.7	
	Power	32.6	
	Labour	36.5	
	MARC	5.3	
<b>Total Processing</b>		<b>20.5</b>	10.0%
	Trucking to plant	5.5	
	Processing Cost	15.0	
<b>Total G&amp;A</b>		<b>19.3</b>	9.4%
	G&A Labour	5.6	
	Current G & A	5.7	
	Water treatment chemical cost	4.5	
	Rental for head gear	3.1	
<b>Total Refining</b>		<b>1.5</b>	0.7%
<b>Contingency (10%)</b>		<b>16.7</b>	8.2%
<b>Total Royalty</b>		<b>20.9</b>	10.2%
<b>Total Operating Cost (US\$/t milled)</b>		<b>204.3</b>	100.0%
<b>Total Operating Cost, excluding Preproduction (US\$/t milled)</b>		<b>179.3</b>	

Table 20-5 provides a summary breakdown of the operating costs per troy ounce of gold produced.

**Table 20-5 Summary of LoM Unit Operating Costs (US\$/oz Au)**

<b>Operating Cost Summary</b>	<b>LoM Operating Cost (US\$/oz Au)</b>
Total Mining	450.8
Total Processing	73.8
Total G&A	69.4
Total Refining	5.6
Contingency	59.9
Total Royalty	75.0
<b>Total Operating Cost (US\$/oz Au)</b>	<b>734.4</b>
<b>Total Operating Cost, excluding Preproduction (US\$/oz Au)</b>	<b>644.7</b>

## 21 ECONOMIC ANALYSIS (ITEM 22)

### 21.1 Introduction

SRK has assessed the WRP economics by constructing an independent TEM and using the mining schedule and cost estimation to determine the viability of the project. The TEM reflects capital and operating expenditures commencing 1 April 2013 going forward in real terms US\$ where there is no allowance for inflation or escalation on capital and operating costs, inputs or revenues. A discount rate of 5 % and gold price of US\$ 1 500/oz has been specified by GSBPL for the Base Case (the “Base Case”) to determine the Net Present Value (“NPV”). The following summary points have also been considered in the TEM:

- expressed in post-tax and pre-financing terms which assumes 100 % equity;
- Corporate tax rate of 35 %;
- Windfall Profits Tax (“WPT”) based on an interpretation of the calculation provided by the Client;
- An opening assessed tax loss of US\$ 400 million has been included in the TEM as advised by the Client. This figure represents the full losses incurred at both Prestea and Bogoso operations. This results in no corporation tax being payable for the WRP;
- VAT is not included;
- Does not include any acquisition costs or previous expenses from the owner;
- Capital investment is depreciated on an annual fixed percentage basis as per the fiscal regime of Ghana. It has been assumed that all capital items have been fully depreciated and at the end of the mine life there is no terminal value to consider; and
- Reflects funding to be available for construction by 1 September 2013.

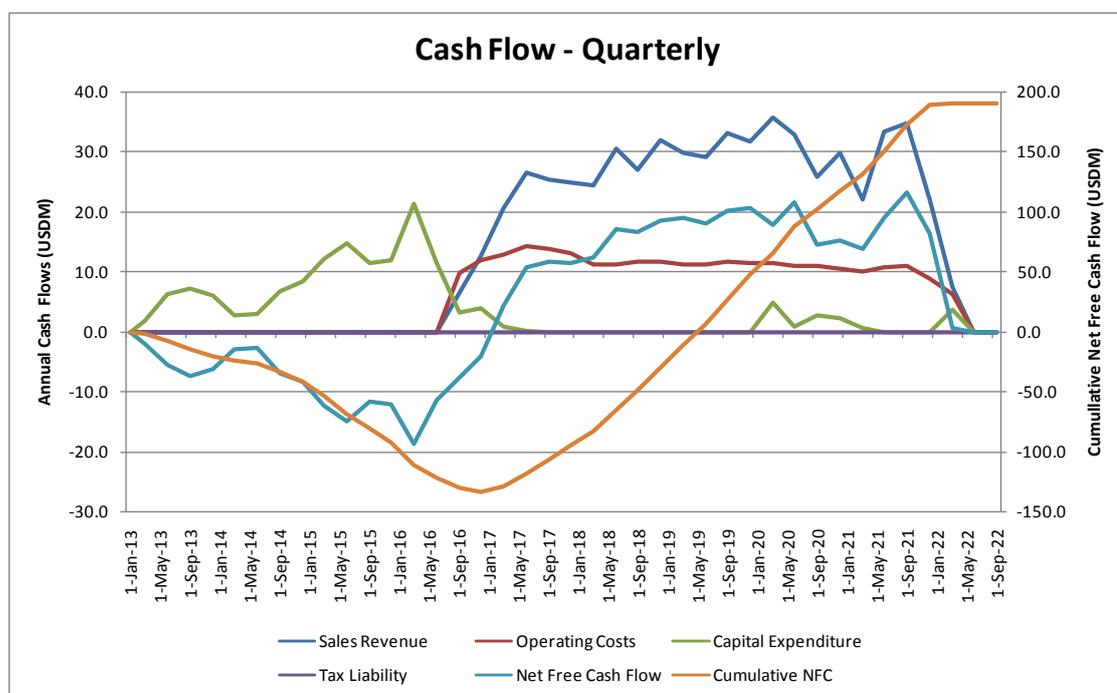
### 21.2 TEM Results

Table 21-1 provides a summary breakdown of the key financial parameters for the TEM over the LoM plan for the Base Case.

**Table 21-1 Summary of LoM Financial Parameters**

Revenue	(US\$ million)	598
Operating Costs	(US\$ million)	-257
<b>Operating Profit</b>	<b>(US\$ million)</b>	<b>341</b>
Tax Liability	(US\$ million)	
Capital Expenditure	(US\$ million)	-150
<b>Cash Flow</b>	<b>(US\$ million)</b>	<b>191</b>
Ore Produced	(kt)	1,434
Waste Mined	(kt)	930
Contained Au	(koz Au)	443
Recovered Au	(koz Au)	399
Mining Cost	(US\$/t ore)	-125.4
Processing Cost	(US\$/t ore)	-20.5
G&A Cost	(US\$/t ore)	-19.3
Refining Cost	(US\$/t ore)	-1.6
Contingency	(US\$/t ore)	-16.7
Royalty	(US\$/t ore)	-20.9
<b>Total</b>	<b>(US\$/t ore)</b>	<b>-204.3</b>
Revenue	(US\$/oz Au)	1,500
Operating Costs	(US\$/oz Au)	-734.4
<b>Operating Profit</b>	<b>(US\$/oz Au)</b>	<b>765.6</b>

Figure 21-1 provides a cashflow analysis over the LoM which shows the the majority of capital expenditure in the first 4 years and sales revenue commencing after 3.5 years based on a starting date of 1 April 2013. Table 21-2 presents a summary of the results of TEM for the WRP.



**Figure 21-1 Quarterly Cash Flow over the LoM**

**Table 21-2 Base Case Cash Flow Summary for the WRP**

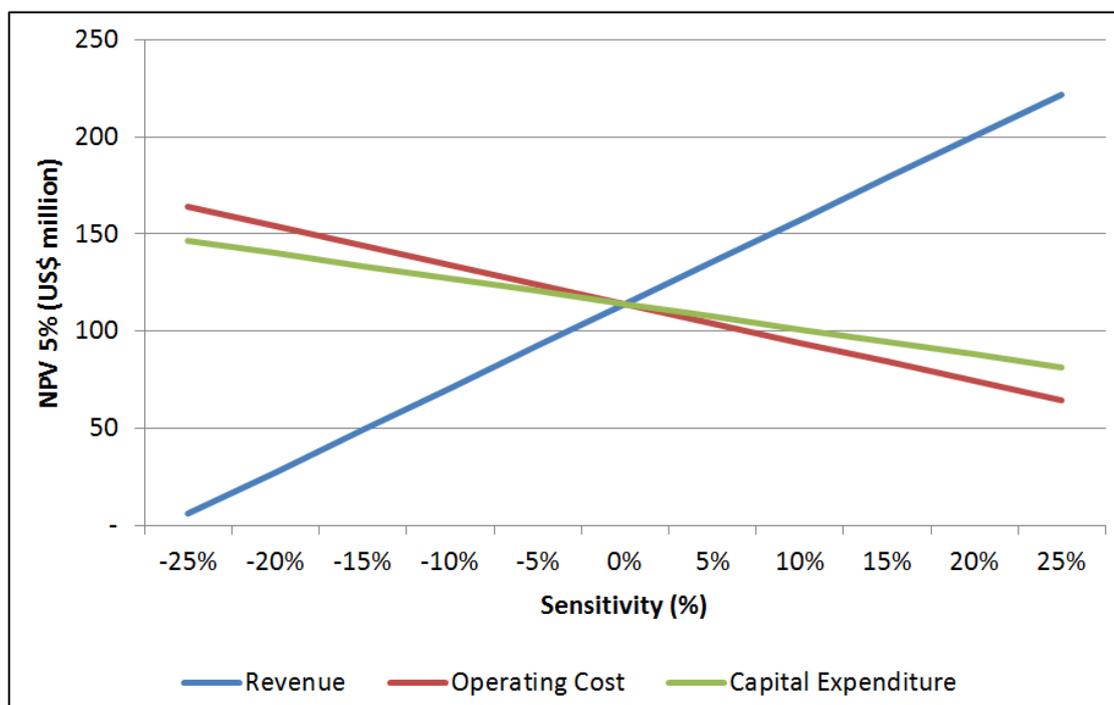
Year		Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10	
Period - Beginning		2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	
	Units	Total/Ave										
<b>Production</b>												
Total Lateral Waste Development	(m)	17,250	0	0	0	2,489	4,275	3,530	3,557	2,283	1,050	67
Total Vertical Waste Development	(m)	757	0	0	0	31	233	185	178	129	0	0
Total Waste Development	(m)	18,007	0	0	0	2,520	4,508	3,715	3,735	2,412	1,050	67
Ore drive	(m)	45,697	0	0	0	564	8,104	8,743	8,739	8,852	8,870	1,825
Tons Milled	(kt)	1,434	0	0	0	18	240	281	280	269	273	73
Head Grade	(g/t)	9.61	0.00	0.00	0.00	8.44	8.16	8.75	10.21	10.79	10.12	9.44
Content In Ore	(koz)	443	0	0	0	5	63	79	92	93	89	22
Process Recovery	(%)	90.00%	90.00%	90.00%	90.00%	90.00%	90.00%	90.00%	90.00%	90.00%	90.00%	90.00%
Au Recovered	(koz)	399	0	0	0	4	57	71	83	84	80	20
<b>Macro Economics</b>												
Gold Price	(USD/oz)	1,500	1,500	1,500	1,500	1,500	1,500	1,500	1,500	1,500	1,500	1,500
<b>Revenue</b>												
Gold Revenue	(USDm)	598.2	0.0	0.0	0.0	6.7	84.9	106.8	124.0	126.1	119.9	29.8
<b>Total Revenue</b>	<b>(USDm)</b>	<b>598.2</b>	<b>0.0</b>	<b>0.0</b>	<b>0.0</b>	<b>6.7</b>	<b>84.9</b>	<b>106.8</b>	<b>124.0</b>	<b>126.1</b>	<b>119.9</b>	<b>29.8</b>
<b>UNIT OPERATING COSTS, Real</b>												
Total Mining	(USD/t milled)	125.37	0.00	0.00	0.00	1,143.70	146.81	101.32	93.67	95.15	85.88	121.57
Total Processing	(USD/t milled)	20.52	0.00	0.00	0.00	25.19	20.60	20.31	20.31	20.38	20.36	21.90
Total G&A	(USD/t milled)	19.29	0.00	0.00	0.00	156.61	14.37	12.32	12.37	12.86	12.70	23.83
Total Refining	(USD/t milled)	1.55	0.00	0.00	0.00	1.36	1.31	1.41	1.64	1.73	1.63	1.52
Contingency	(USD/t milled)	16.67	0.00	0.00	0.00	132.69	18.31	13.54	12.80	13.01	12.06	16.88
Total Royalty	(USD/t milled)	20.86	0.00	0.00	0.00	18.32	17.71	18.99	22.15	23.42	21.97	20.48
<b>Total Operating Cost</b>	<b>(USD/t milled)</b>	<b>204.26</b>	<b>0.00</b>	<b>0.00</b>	<b>0.00</b>	<b>1,477.86</b>	<b>219.12</b>	<b>167.89</b>	<b>162.95</b>	<b>166.55</b>	<b>154.59</b>	<b>206.19</b>
<b>Total Operating Cost (Excluding Capitalised Opex)</b>	<b>(USD/t milled)</b>	<b>179.30</b>										
Total Mining	(USD/oz)	450.76	0.00	0.00	0.00	4,682.21	621.59	400.13	317.15	304.73	293.18	445.18
Total Processing	(USD/oz)	73.79	0.00	0.00	0.00	103.12	87.23	80.19	68.78	65.28	69.50	80.20
Total G&A	(USD/oz)	69.35	0.00	0.00	0.00	641.14	60.86	48.65	41.88	41.18	43.34	87.26
Total Refining	(USD/oz)	5.56	0.00	0.00	0.00	5.56	5.56	5.56	5.56	5.56	5.56	5.56
Contingency	(USD/oz)	59.95	0.00	0.00	0.00	543.20	77.52	53.45	43.34	41.68	41.16	61.82
Total Royalty	(USD/oz)	75.00	0.00	0.00	0.00	75.00	75.00	75.00	75.00	75.00	75.00	75.00
<b>Total Operating Cost</b>	<b>(USD/oz)</b>	<b>734.41</b>	<b>0.00</b>	<b>0.00</b>	<b>0.00</b>	<b>6,050.22</b>	<b>927.76</b>	<b>662.97</b>	<b>551.71</b>	<b>533.43</b>	<b>527.72</b>	<b>755.03</b>
<b>Total Operating Cost (Excluding Capitalised Opex)</b>		<b>644.66</b>										
<b>OPERATING COSTS, Real</b>												
Total Mining	(USDm)	179.8	1.47	4.04	5.63	20.83	35.20	28.49	26.22	25.63	23.43	8.83
Total Processing	(USDm)	29.4	0.00	0.00	0.00	0.46	4.94	5.71	5.69	5.49	5.55	1.59
Total G&A	(USDm)	27.7	1.16	2.31	2.31	2.85	3.45	3.46	3.46	3.46	3.46	1.73
Total Refining	(USDm)	2.2	0.00	0.00	0.00	0.02	0.31	0.40	0.46	0.47	0.44	0.11
Contingency	(USDm)	23.9	0.26	0.64	0.79	2.42	4.39	3.81	3.58	3.50	3.29	1.23
Contingency Rate	(%)	10%	10%	10%	10%	10%	10%	10%	10%	10%	10%	10%
Total Royalty	(USDm)	29.9	0.00	0.00	0.00	0.33	4.25	5.34	6.20	6.31	5.99	1.49
<b>Total Operating Costs</b>	<b>(USDm)</b>	<b>292.9</b>	<b>2.9</b>	<b>7.0</b>	<b>8.7</b>	<b>26.9</b>	<b>52.5</b>	<b>47.2</b>	<b>45.6</b>	<b>44.9</b>	<b>42.2</b>	<b>15.0</b>
<b>Total Operating Cost (Excluding Capitalised Opex)</b>	<b>(USDm)</b>	<b>257.1</b>	<b>0.0</b>	<b>0.0</b>	<b>0.0</b>	<b>9.7</b>	<b>52.5</b>	<b>47.2</b>	<b>45.6</b>	<b>44.9</b>	<b>42.2</b>	<b>15.0</b>
<b>CAPITAL COSTS, Real</b>												
Mining Fleet	(USDm)	23.5	0.0	0.0	0.0	8.8	4.2	0.0	0.0	7.6	2.8	0.0
Ventilation	(USDm)	2.7	0.6	0.0	0.0	1.6	0.3	0.0	0.0	0.1	0.0	0.0
Dewatering Pumps	(USDm)	0.8	0.0	0.0	0.0	0.8	0.0	0.0	0.0	0.0	0.0	0.0
Raise Bore Shafts	(USDm)	53.8	1.4	5.3	35.7	11.5	0.0	0.0	0.0	0.0	0.0	0.0
Preparatory Works	(USDm)	5.7	3.6	1.8	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0
UG Infrastructure	(USDm)	0.9	0.0	0.0	0.0	0.8	0.1	0.0	0.0	0.0	0.0	0.0
Other Infrastructure	(USDm)	10.0	1.8	2.1	1.7	4.4	0.0	0.0	0.0	0.0	0.0	0.0
General	(USDm)	3.8	1.3	0.7	0.6	1.2	0.0	0.0	0.0	0.0	0.0	0.0
Contingency - Capital	(USDm)	4.9	0.9	0.5	0.2	1.8	0.5	0.0	0.0	0.8	0.3	0.0
Contingency Rate	(%)	15%	15%	15%	15%	15%	15%	15%	15%	15%	15%	15%
Capitalised Operating Cost	(USDm)	35.8	2.9	7.0	8.7	17.2	0.0	0.0	0.0	0.0	0.0	0.0
Relocation of international school	(USDm)	4.5	3.1	1.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Closure cost	(USDm)	3.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3.7
<b>Total Project Capital</b>	<b>(USDm)</b>	<b>150.1</b>	<b>15.5</b>	<b>18.8</b>	<b>47.1</b>	<b>48.2</b>	<b>5.1</b>	<b>0.0</b>	<b>0.0</b>	<b>8.6</b>	<b>3.1</b>	<b>3.7</b>
<b>Capitalised Operating Cost</b>	<b>(USDm)</b>	<b>35.8</b>	<b>2.9</b>	<b>7.0</b>	<b>8.7</b>	<b>17.2</b>	<b>0.0</b>	<b>0.0</b>	<b>0.0</b>	<b>0.0</b>	<b>0.0</b>	<b>0.0</b>
<b>Total Initial Capital</b>	<b>(USDm)</b>	<b>90.6</b>	<b>12.6</b>	<b>11.9</b>	<b>38.4</b>	<b>27.7</b>	<b>0.0</b>	<b>0.0</b>	<b>0.0</b>	<b>0.0</b>	<b>0.0</b>	<b>0.0</b>
<b>Total Sustaining Capital</b>	<b>(USDm)</b>	<b>23.7</b>	<b>0.0</b>	<b>0.0</b>	<b>0.0</b>	<b>3.3</b>	<b>5.1</b>	<b>0.0</b>	<b>0.0</b>	<b>8.6</b>	<b>3.1</b>	<b>3.7</b>
<b>WORKING CAPITAL, Real</b>												
<b>Working Capital</b>	<b>(USDm)</b>	<b>0</b>	<b>-1</b>	<b>0</b>	<b>0</b>	<b>-2</b>	<b>4</b>	<b>2</b>	<b>2</b>	<b>-2</b>	<b>3</b>	<b>-6</b>
<b>Economics, Real: BASE DATE 01 January 2013</b>												
Sales Revenue	(USDm)	598	0	0	0	7	85	107	124	126	120	30
Operating Costs	(USDm)	257	0	0	0	10	53	47	46	45	42	15
Operating Profit - EBITDA	(USDm)	341	0	0	0	-3	32	60	78	81	78	15
Tax Liability	(USDm)	0	0	0	0	0	0	0	0	0	0	0
Capital Expenditure	(USDm)	150	15	19	47	48	5	0	9	3	4	4
Working Capital	(USDm)	0	-1	0	0	-2	4	2	2	-2	3	-6
<b>Net Free Cash Flow</b>	<b>(USDm)</b>	<b>191</b>	<b>-15</b>	<b>-19</b>	<b>-47</b>	<b>-49</b>	<b>23</b>	<b>58</b>	<b>76</b>	<b>75</b>	<b>71</b>	<b>17</b>

Table 21-3 provides an NPV sensitivity analysis for gold prices ranging from US\$ 1 100 to 1 700 per troy ounce and a discount rate, ranging from 0 to 15%. SRK notes that at 5 % discount rate the post-tax NPV is US\$ 114 million and the IRR is 22.7% with a Base Case gold price of US\$ 1 500 /oz. At US\$1 300 /oz Au the NPV<sub>5%</sub> drops to US\$ 59 million and at US\$ 1 700 /oz Au it increases to US\$ 169 million.

**Table 21-3: NPV Sensitivity (Au price vs Discount Rate)**

Discount Rate	0%	5%	8%	10%	12%	15%
NPV (US\$ million) @ US\$1 100/oz Au Price	40	5	-10	-17	-23	-30
NPV (US\$ million) @ US\$1 300/oz Au Price	115	59	36	23	13	0
NPV (US\$ million) @ US\$1 500/oz Au Price	191	114	81	64	49	31
NPV (US\$ million) @ US\$1 700/oz Au Price	267	169	127	104	85	61

Figure 21-2 provides an NPV sensitivity chart for mine operating costs; capital expenditure and commodity sales price for the Base Case. The WRP NPV is most sensitive to revenue (grade or gold price) and has a moderate sensitivity to capital and operating costs. The breakeven gold price assuming a 5 % discount rate is US\$ 1 084 /oz. This is the gold price when the NPV is zero using a 5 % discount rate.



**Figure 21-2: Base Case NPV Sensitivity Analysis**

The TEM is shown to report a positive economic outcome and support the Mineral Reserve estimate for the WRP for GSBPL. The Project payback period is 6 years from start of project development (3 years from start of ore production) with a maximum drawdown of US\$ 134 million incurred at the end of the fourth year if the commencement date is considered for 1 April 2013.

### 21.3 Benchmarking

SRK undertook an internal benchmarking exercise to understand the comparison of the WRP against other similar African and International operating underground mines from a production

rate, grade and operating cost perspective which concluded that:

- Unit costs (US\$/t ore) at WRP are fairly high when compared to other mines, but this is to be expected because the ore tonnage production rate is low;
- Mine site cash costs (US\$/oz Au) at WRP are low when compared to the other mines.
- The WRP is a high grade mining project;
- The WRP is in the lower third of projects with respect to UG mining costs in terms of US\$/oz; and
- With respect to MCF mines, the WRP is in the lower third of projects with respect to UG mining costs in terms of US\$/oz.

## 22 ADJACENT PROPERTIES (ITEM 23)

GSBPL's Bogoso Mine is currently mining open pits adjacent to the Prestea Mine and WRP along the mineralisation corridor to the north and south.

## 23 OTHER RELEVANT DATA AND INFORMATION (ITEM 24)

### 23.1 Hydrogeology

#### 23.1.1 Introduction

SRK has conducted a FS level hydrogeological study in support of re-commencement of mining of the West Reef orebody at the PUG. The zone of interest consists of a steeply dipping, narrow vein structure situated between levels 17 and 24/25 and located in between the existing Central and Bondaye Shafts. This zone is understood to contain a proposed mineable ore volume in the order of 541 500 m<sup>3</sup> and the mine design estimates that the proposed West Reef development will result in an approximate additional 637 600 m<sup>3</sup> of mine void between ground surface and 24/25 L.

#### 23.1.2 Groundwater Flow

The region in which Prestea lies is composed predominantly of Paleoproterozoic metavolcanic and metasedimentary rocks, which are intruded by granitoids. The metasediments are generally compact with little or no primary porosity. Groundwater flow and storage is considered to be greatest in the weathered zones overlying the metasediments and in zones that are fractured and fissured.

The weathered zones generally have the highest permeability ranging from 0.05 m/d to 3.4 m/d with an average of around 0.9 m/d and are exploited via hand dug wells and boreholes as a potable source of water. The deeper, less weathered bedrock with low fracture density has a low bulk permeability of around 0.004 m/d ( $4.6 \times 10^{-8}$  m/d) although in brecciated, fractured shear zone areas this may be around 0.1 m/d to 0.2 m/d ( $1.2 \times 10^{-6}$  to  $2.3 \times 10^{-6}$  m/d).

Average annual groundwater recharge is considered to be between 122 and 160 mm (between 0.0003 and 0.0004 m/d).

The groundwater flow regime is considered to be predominantly influenced by the rock mass foliation, or schistosity, with higher permeabilities oriented north northeast-south southwest and sub-vertically (dipping westerly 60 to 70°).

The PUG and associated mine dewatering, together with the rock mass anisotropy is likely to have produced an elongate zone of pore water depressurisation in the bedrock extending over 8 km and trending parallel to the main geological structural trend of NNE-SSW. The cone of depression is unlikely to extend for great distances (i.e. over 500 m) in an easterly-westerly direction due to permeability in the deeper bedrock being much lower in this direction as a

result rock mass/permeability anisotropy. It is expected that vertical downward hydraulic gradients occur within the zone of depressurisation.

### 23.1.3 Groundwater Hydrochemistry

The geology of Ghana is dominated by crystalline silica-based basement rocks, with sulphide mineralisation, and weathered zones resulting in groundwater which is naturally acidic (pH<6.5), low in total hardness and salinity and naturally enriched with arsenic and iron. Groundwater is predominantly a Ca–HCO<sub>3</sub> type followed by a Ca–Na–HCO<sub>3</sub>–NO<sub>3</sub>–Cl type. There is natural hydrochemical stratification in the groundwater. The shallow groundwater system, associated with the regolith and transition zone, has generally lower concentrations of cation and anion species than groundwater in the deeper hydrogeological unit.

The Prestea area has been subject to intensive mining, both licensed and unauthorised, and dewatering for the past 100 years comprising underground and open pit mining. This intensive mining activity continues to have a significant effect on groundwater hydrochemistry and groundwater flow regime.

### 23.1.4 Hydrology

The PUG lies within the Ankobra River catchment. This catchment is drained by numerous streams and creeks which drain the surface surrounding the Prestea underground mine. These streams are often extensively worked by unauthorised small-scale mining activity resulting in silting of surface water channels and influencing surface water hydrochemistry.

Surface water channels shows signs of being affected by small-scale and previous large-scale mining activity resulting in silting of surface water channels and surface water hydrochemistry with elevated concentrations of Total Dissolved Solids (“TDS”), Total Suspended Solids (“TSS”), sulphate, manganese, iron and arsenic.

There are two distinctive wet seasons separated by a trough in rainfall during the month of August; the main wet season is from March to July and a second wet season occurs from September to November. Average annual rainfall varies between 1 459 and 2 194 mm with an average of around 1 764 mm.

### 23.1.5 Existing Mine Water Management at PUG

PUG is currently dewatered under a C&M programme which has been in place since early 2002 when mining activity ceased.

Dewatering is undertaken via electrically powered submersible pumps and pump stations located at various mine levels; back-up generators are in place in case of National Grid power outages. The current dewatering system configurations at Central Shaft and Bondaye Shaft permit a maximum of approximately 6 532 m<sup>3</sup>/d (76 lps) and 4 361 m<sup>3</sup>/d (50 lps), respectively, to be pumped to surface. Average annual abstraction volume from PUG is 1.9 Mm<sup>3</sup> which equates to an annualised daily average of 5 264 m<sup>3</sup> (61 lps).

The data available (between August 2006 and August 2012) indicate that the greatest volume of mine water abstracted in any year was during 2010 with a total of 3.1 Mm<sup>3</sup> of mine water. During the same year it is estimated that a total of 13 129 152 kWh was used to abstract this volume of mine water which equates to an energy consumption of around 4.3 kWh/m<sup>3</sup> of mine water.

Abstraction data available indicate that there is a correlation with pump rates from the mine and rainfall suggesting that there is a direct connection with surface water.

Mine water is pumped from the mine workings to the surface. Mine water from Central Shaft is discharged in to an engineered reed bed system prior to gravity discharge to the natural

surface water environment in to the Nsuo Kofi stream. Mine water from Bondaye Shaft is discharged directly to the natural surface water environment in to the Anobaka stream. Both the Nsuo Kofi and Anobaka streams flow in to the Ankobra River.

The mine water discharge from the current C&M dewatering operations at Central and Bondaye Shaft regularly exceeds the Ghanaian EPA/Akobon and IFC guidelines for mining effluent for EC, TDS, sulphide and dissolved and total arsenic and occasionally exceeds the IFC guidelines for mining effluent for total copper, nickel and iron.

It is noted that the current mine water discharge from existing Prestea underground mine workings is currently indemnified by the Ghanaian EPA against non-compliance with Ghanaian effluent guideline limits. This indemnity will remain in place for mine water abstracted from existing mine workings but will not apply to mine water abstracted from new mine workings associated with the WRP.

### **23.1.6 Mine Water Management for the WRP**

The existing dewatering regime and system at Central and Bondaye Shafts will remain in place throughout the operational life of the WRP with a separate dewatering regime and system installed for the WRP.

There is uncertainty as to whether the WRP zone is already dewatered by the existing dewatering regime at Central and Bondaye shafts. If this is the case then the above mine water inflow rate estimate is likely to be much lower. Nonetheless, the West Reef dewatering system will be designed to abstract 20 lps which is much greater than the estimated mine water inflow rates of 828 m<sup>3</sup>/d and 1 050 m<sup>3</sup>/d (between 9.5 lps and 12.2 lps).

Groundwater/mine water from the West Reef is expected to have naturally elevated TDS concentrations and is highly likely to require treatment prior to discharge to comply with Ghanaian and IFC guideline limits for mining effluent.

Dewatering to 28 L, i.e. below the proposed base of the WRP, will provide flood storage in the event of failure of complete dewatering system failure at Prestea mine. Analysis has demonstrated that even with the most conservative estimate of mine water inflow, a period of 31 consecutive days would elapse before mine water levels reached the base of the WRP (24/25 L).

### **23.1.7 Recommendations**

A number of recommendations are made to better quantify and address aspects which have a direct influence on the requirements for the dewatering system and mine water treatment and have the potential for impact on the environment. Some of these recommendations are as follows:

- Robustly quantify current mine water abstraction volumes via use of flow meters;
- Undertake sampling of groundwater from geotechnical boreholes for hydrochemical analysis to confirm the hydrochemistry of West Reef mine water;
- Monitor flow rates and groundwater pore pressure in geotechnical boreholes that intersect the West Reef to semi-quantify groundwater inflow rates and groundwater response to dewatering and recharge events;
- Undertake flood risk assessments for the surrounding streams to identify mine workings susceptible to flooding and surface water ingress and to assess flood risk to streams receiving mine water discharge;
- Carry out leaching tests on proposed waste rock fill to assess likely impact on groundwater environment and mine water treatment process;

- Review, addend and amend as necessary, the current mine water, groundwater and surface water monitoring regime to ensure cost-effective use of sampling resources, compliance with Ghanaian EPA and IFC guideline limits and to improve operational aspects of the mine; and
- Undertake surface and underground engineering works to help reduce surface water ingress in to the mine workings.

## 23.2 Risks and Opportunities

### 23.2.1 Risks

As part of the FS process, SRK has undertaken a project wide Risk Assessment in conjunction with GSBPL. This comprised the compilation of a project risk register followed by discussions with the team on site which analysed the likelihood and impact of the risks. This allowed the risks to be ranked and mitigation measures planned. The following bullet points summarise the key results of these discussions but it is noted that the Risk Assessment Process needs to be revised at regular intervals through the life of the WRP:

- Electrical power interruptions either from national supplier or through aging GSBPL infrastructure. Provisions have been made in the FS for back-up generators for key facilities and for refurbishment and replacement of critical electrical infrastructure;
- Illegal personnel access into the workings and securing access to the site. A package of security measures will be implemented as part of the WRP to manage illegal access to the Prestea Mine and WRP. Currently GSR employs a comprehensive security system around it operations and lease areas including PUG;
- Community opposition due to lower than expected employment openings or less flow through of tax revenues to local government from central government. It will be the role of the community liaison team at GSBPL to manage expectations in the community through effective communication;
- Individual complaints against construction/operational activities for personal gain (vibration damage, fly-rock, dust). This is an issue that will require careful management through the implementation of the WRP. In mitigation GSR employs mechanisms to reduce this risk, including comprehensive monitoring and EPA engagement;
- Conversion to mechanised mining. The ability to successfully implement efficient mechanised mining being a significant change from past minng methods (operators, supervisors and management). Considerable allowances have been made in the FS budget to bring in expatriate teams to help train the workers in the initial years of the WRP. The long mining history in Ghana is helpful in this regard. It should also be noted that SRK has been conservative with respect to required operating hours for equipment in the cost estimates;
- Unrest of community by government evictions of squatters from GSBPL property. This is another issue that GSBPL's experienced community liason teams will have to deal with;
- GSBPL succumbs to political pressure on historical liabilities (water, waste dumps, and personnel health issues). There could be a cost impact here but it would not be expected to be significant;
- Ghana EPA specifies full water treatment at Prestea. This would add around US\$ 6 million to capital costs and several million annually on operating costs. The mitigation for this is to present the WRP as a 'mine within a mine.' The approach is to keep excess water from the WRP completely separate from the historical inflows to the rest of the Prestea mine. This involves stand-alone infrastructure for the WRP in terms

of sumps, pumps and piping. The WRP would use the RHS to reticulate any excess water to surface where it would be treated in an RO plant. The inflows from the historical workings are subject to an indemnity agreement and would be kept separate from the WRP and pumped through the existing infrastructure at Central and Bondaye shafts to surface where it will continue to be released to the environment without significant treatment.

- Security risk of surface trucking high grade ore. This will require careful management. Monitoring of the GPS tracking on trucks will be helpful to ascertain if drivers are stopping to unload ore;
- Mine ventilation system struggles to maintain temperatures below maximum allowable in high humidity. Additional technical studies have shown that the design of the ventilation system is adequate. However, different climatic conditions to those modelled could provide instances where statutory guidelines are exceeded. Should this be the case, fan upgrades and larger raises would probably be required or alternatively some form of refrigeration would need to be considered;
- Water quality inside mine's responsibility zone affected by illegal miners. This is another management issue that the community relations team will monitor;
- IFC performance standards cannot be met for Equator Principle backed lenders. Although this topic was discussed with GSBPL personnel, it is considered a low risk issue given the attention to detail that GSBPL have applied to their environmental and social processes;
- Entanglement with other GSBPL activities. (e.g. Haul road permitting). It may be the case that issues from other projects impact on the WRP. In the case of the haul road, it is noted that if construction of the new road was delayed, the trucks would be able to drive through Prestea town at a slow speed. There might be some cost implication of this but they would not be expected to be material. In general, to mitigate this risk GSBPL needs to apply the same high standard of environmental and social responsibility to all their projects;
- Raisebore cutter head loss (stuck) during back reaming. The mitigation for this is to make sure that ground conditions are well known prior to reaming and that a full pre-sink is completed to bedrock. The site investigation has started at the time of writing with one geotechnical hole being completed for the RHS;
- Failure of Central Shaft or Bondaye Shaft infrastructure. The ongoing work in the Central Shaft makes this unlikely. Although the Bondaye Shaft is in very poor condition, if there was a collapse there may not be much impact on the WRP because the only role it will serve is as an emergency egress in the short term. The mitigation for this is to proceed with the rehabilitation work on the Bondaye Shaft as soon as possible;
- Process plant recoveries not achievable. The results from the testwork indicate that the current plant should be capable of provided the planned recovery of 90 %. Further testwork with samples of the exact ore that will be blended with WRP material are required to fully confirm the exact recovery;
- Central Shaft upgrade requirements/schedule cannot be met by site team. This is considered to be a low risk item due to the fact this upgrade has been planned in detail and the team on site is well experienced. SRK notes that should this activity fall behind schedule then the mitigation is to mobilise additional resources to complete the necessary activities;
- Permitting schedule cannot match the construction schedule. GSBPL average >365 days on recent projects. It is generally accepted that the WRP is desired by the authorities but

the exact timing of the permitting is unclear. SRK notes that there is a risk that the permit may be delayed and this requires close monitoring. However, broad community support for the Project means that such delays are considered unlikely;

- School relocation not timely for the construction schedule. The mitigation for this is to have the funds available in a timely manner. GSBPL need to appropriately plan, tender, mobilise and segment that construction such that multiple areas can construct in parallel. If this is the case, SRK believes that the stakeholders in the school move will be motivated to construct and occupy the new buildings without any delay to the WRP;
- GSBPL ability to timely source suitably skilled personnel for project construction. The mitigation for this is to have the funds available in a timely manner. Additionally GSBPL should commit to competitive tenders with experienced and proficient contractors, which should reduce our risk. If this is the case, SRK believes that skilled personnel can be attracted without any delay to the WRP;
- GSBPL ability to meet the critical early schedule phases (let main raisebore contract for mobilisation). SRK considers that this a low risk issue due to the experience of the GSBPL team and their ability to outsource all or parts of the work to consultants and contractors;
- The perception or allegation that GSBPL is involved in, or associated with, the actions of Government officers or security forces in removing / regulating unauthorised miners, i.e. small scale miners could be promoted. Associated supporters would start a campaign against GSBPL accusing the company of arranging/supporting any actions of the National Security Council as the Government increases its enforcement of law in regards to illegal mining. It was reported during stakeholder meetings that the artisanal miners see the start of the underground mine leading to loss of opportunity for unauthorised small scale mining. Unauthorised small scale miners are generally against the start of underground mine but have not openly expressed their views. During stakeholder meetings they have been seen to raise other issues to motivate against the project. GSBPL will mitigate this risk through the following actions:
- There is a risk of the historical Ankobra and Beta shafts, which are located in a depression close to a stream, possibly flooding the main mine workings through the in-rush of water from these historic surface and underground workings. This may also take place through tunnels dug by artisanal miners. GSBPL would manage this by ensuring that existing cavities on the surface that may connect with the underground workings are properly sealed;
- The recently adopted localization policy of the Ghanaian government requires companies to transition positions from expatriate to national positions. In response to this, GSBPL has established a rigorous training program for people with the potential to step into higher management positions. Therefore, GSBPL continues to manage the need to reduce expatriate staff. If succession planning is not an option, GSBPL has the option to specifically target Ghanaian expatriates who may be interested in returning to Ghana to work; and
- Availability of raiseboring machine of required duty. SRK notes that this could be an issue, although unlikely given the slight downturn in the market. However, this point needs to be investigated as a priority during the project implementation phase.

### 23.2.2 Opportunities

SRK notes that there are a number of opportunities that exist to enhance the Project commercial and technical performance including:

- Additional Mineral Resources. The Prestea Mine contains remnants from historical mining that could be recovered to extend the WRP mine life or increase the annual production rate. In addition to this the Main Reef and West Reef at Prestea remain open at depth for a continuation of mining below existing and planned workings. There may also be other parallel orebodies. SRK considers that the potential for additional tonnages is significant and warrants further exploration;
- Faster Construction. The schedule for the RHS construction is considered to be reasonable and appropriate for an FS. However, there may be an opportunity to commission the shaft in a shorter time frame that may bring revenue forward by a quarter or possibly more; and
- Enhanced Productivity. The scheduling undertaken by SRK for the WRP FS has been reasonably conservative. It may be the case that with effective supervision and a well motivated workforce, higher rates of productivity can be achieved with a resulting improvement in WRP KPIs.

### 23.3 Project Schedule

Figure 23-1 shows a high-level project schedule for the key activities over the first three years of the WRP which includes the following important dates:

- |  |                 |
|--|-----------------|
| • Completion of RHS and RVS                        | End of Feb 2016 |
| • Commence decline from 17 L with mechanised fleet | End of Q2 2016  |
| • Commencement of ore mining                       | Q4 2016         |
| • Full production                                  | Q3 2017         |

This schedule is based on the MRC plan modified to fit the expected timeframe of the WRP at the time of writing.

ID	Task Name	Duration	Start	Finish	Pred	2014												2015												2016	
						Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb			
1	Central Shaft Hoist Repair	105 days	Mon 08/04/13	Fri 30/08/13		[Task bar]																									
2	BS Hoist	105 days	Mon 08/04/13	Fri 30/08/13		[Task bar]																									
3	Survey closure	105 days	Mon 08/04/13	Fri 30/08/13		[Task bar]																									
4	New vent fan (south waste)	105 days	Mon 08/04/13	Fri 30/08/13		[Task bar]																									
5	Drill geotechnical holes for Shafts	17 days	Mon 08/04/13	Tue 30/04/13		[Task bar]																									
6	Repair Central Shaft	235 days	Mon 08/04/13	Fri 28/02/14		[Task bar]																									
7	Repair Bondaye Shaft	235 days	Mon 08/04/13	Fri 28/02/14		[Task bar]																									
8	Rehab 17 Level	155 days	Mon 03/06/13	Fri 03/01/14		[Task bar]																									
9	Prepare and submit EIA	40 days	Mon 08/04/13	Fri 31/05/13		[Task bar]																									
10	EIA approval process	145 days	Mon 03/06/13	Fri 20/12/13	9	[Task bar]																									
11	Construct New School	236 days	Fri 05/04/13	Fri 28/02/14		[Task bar]																									
12	Move school and demolish buildings	10 days	Mon 03/03/14	Fri 14/03/14	11	[Task bar]																									
13	Earthworks for contractor set up	10 days	Mon 17/03/14	Fri 28/03/14	12	[Task bar]																									
14	Contractor on site	0 days	Mon 31/03/14	Mon 31/03/14	13	[Task bar]																									
15	17 Level development	175 days	Mon 31/03/14	Fri 28/11/14	13,6	[Task bar]																									
16	Complete pre-sink and civils	170 days	Mon 31/03/14	Fri 21/11/14	14	[Task bar]																									
17	Start Pilot hole for RHS	0 days	Mon 24/11/14	Mon 24/11/14	16	[Task bar]																									
18	Drill pilot hole	45 days	Mon 24/11/14	Fri 23/01/15	17	[Task bar]																									
19	Ream Raisebored Hoisting Shaft	110 days	Mon 26/01/15	Fri 26/06/15	18,1	[Task bar]																									
20	Headgear	45 days	Mon 29/06/15	Fri 28/08/15	19	[Task bar]																									
21	Equip Shaft	130 days	Mon 31/08/15	Fri 26/02/16	20	[Task bar]																									
22	Commission RHS	0 days	Mon 29/02/16	Mon 29/02/16	21	[Task bar]																									

Project: Critical Activities schedule Date: Tue 21/05/13	Task		Project Summary		Inactive Milestone		Manual Summary Rollup		Deadline	
	Split		External Tasks		Inactive Summary		Manual Summary		Progress	
	Milestone		External Milestone		Manual Task		Start-only			
	Summary		Inactive Task		Duration-only		Finish-only			

## 23.4 Project Implementation

There is no significant requirement for project infrastructure, process plant or tailings facility. The main part of the Project is the construction of the key mine access infrastructure which are the RHS and RVS facilities. The plan that has been discussed and presented in the FS is to use a contractor to construct the shafts which would allow the Owner to take two years to build a team to take on the mining. Allowances have been made for expatriate trainers in the workforce to assist with team development; in the short-term GSBPL has employed a project manager tasked with building a team to award and supervise the shaft contract.

## 24 INTERPRETATION AND CONCLUSIONS (ITEM 25)

### 24.1 Key Conclusions

Based upon the work completed for the FS, SRK concludes the following:

- The Prestea WRP has favourable economics and based on the assumed metal prices is considered robust in terms of the estimated operating margins and return on investment. The feasibility study work by SRK indicates an NPV of US\$ 114 million using the average base case gold price of US\$ 1 500/oz and a discount rate of 5 %. The payback period is estimated to be 6 years from start of project development (3 years from start of ore production);
- The WRP does not require substantial infrastructure in terms of roads, rail and port facilities. The Project is situated in a long established mining town that is generally well served with roads and power infrastructure;
- The FS technical work has determined that an average production rate of 250 ktpa (Including ramp up and tail) containing 70 koz Au can be attained from the Prestea orebody using modern trackless mining methods. The sink rate required to maintain this is only 4.7 m vertical per month which equates to 31 m of ramp development. SRK considers this production rate to be low risk and notes that there is opportunity for productivity improvements to increase production volumes;
- The option study showed that a new decline from surface is not warranted for the WRP. The study has concluded that the needs of the mine are best served by repairing the Central Shaft for the short and medium term in order to prepare for a RHS that will serve the WRP for both ore hoisting and man riding. The ventilation requirements for the WRP will be served by establishing a raisebored ventilation raise to surface that will remove contaminated air. Fresh air will be provided by the RHS and from other parts of the mine;
- The rock mass is generally of reasonable strength and rock mass quality. However, drift and fill stoping has been recommended for all of the orebody due to the low risk of unplanned dilution with this method;
- The FS LoM plan reports a Probable Mineral Reserve tonnage of 1.434 Mt from the Prestea operation at a run of mine grade of 9.61 g/t Au prepared in accordance with the CIM Code. This has been planned over a 7 year project life (23 quarters of ore production excluding the waste development period at project start-up) and is based on the 2013 Mineral Resource estimate with losses for mining recovery and dilution applied;
- A process recovery of 90 % in the Bogoso processing plant is considered achievable;
- SRK does not consider there to be significant issues associated with accommodating the WRP ore in the existing and planned tailings storage facilities at the Bogoso operation;
- The WRP area has been extensively disturbed as a result of urbanization, small scale farming and extensive unauthorized mining (small and medium scale). This has essentially removed most of the natural vegetation cover in the vicinity of the WRP. The baseline socioeconomic studies showed an impoverished neighbourhood with relatively low levels of education and poor economic stability. The main potentially adverse socioeconomic effect of the WRP is the need to resettle the Prestea Goldfields International School. This is currently located immediately over the location for the RHS. However, negotiations with key stakeholders and the school board of trustees have indicated that the relocation can be undertaken without adverse impact on the WRP;
- The economics of the Prestea WRP generally show little sensitivity to operating or capital costs. This can be attributed to the grade of the deposit giving high contained values and a strong operating margin per tonne;

- When benchmarked against other similar operations the estimated costs for the Prestea WRP are in the lower third in terms of production costs per ounce. In other words, if the gold price falls then two thirds of other gold producers will trade at a loss before the WRP;
- Average operating costs for Prestea WRP have been estimated to be US\$ 179/t ore (excluding capitalised operating costs and including contingency and Royalty) and US\$ 645/oz Au respectively. SRK notes that labour costs are considered to be fairly high by international standards; and
- Capital costs for fixed equipment and surface installations have been estimated to be US\$ 114 million over the mine life, with US\$ 91 million expended in the first three years of the WRP from Q2 2013 to Q3 2016 inclusive.

## 25 RECOMMENDATIONS (ITEM 26)

Based on the results of the FS, SRK recommends the following:

- Prestea continues with its planned programme of preparatory works at the mine with a view to progress development of the WRP by September 2013. SRK notes that contractor and equipment lead times need to be further investigated because this could be potentially be a constraint to a rapid start up;
- The parts of the WRP orebody that have not been considered for the Mineral Reserve estimate due to an Inferred Mineral Resource classification are delineated further by infill drilling with the aim of upgrading their classification;
- A detailed development plan is progressed for the first two years of the underground operation based on the results of continuing infill drilling and site investigation holes around the proposed shafts;
- Additional geotechnical work is undertaken in the future to verify the design parameters used in the FS and understand the stress constraints on the sill pillars and the changes through the mine life;
- Improve the understanding of the hydrogeology of the deposit through measurement of the pumped volumes and investigate the potential to reduce water inflow to the mine from surface features;
- Continue with implementation of programme relating to environmental and social management for the PUG WRP;
- Implement a safety plan to comply with Ghanaian regulations;
- Development of a comprehensive performance management plan to include tracking of all relevant project data including but not limited to development and production statistics; and
- Further development of capital costs with detailed quotes and competitive tenders to verify the FS estimates, assumptions and confirm lead times for major plant and equipment.

## 26 REFERENCES (ITEM 27)

The following list of publications and reports have been used as a reference for the purpose of the FS and completion of this NI 43-101 technical report for the GSBPL WRP:

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- *Golden Star Bogoso/Prestea Limited – Stage IV Raise Design Report, Knight Piésold, March 2011;*
- Golden Star Bogoso/Prestea Limited – TSF 2 Operational Audit Period: August to October 2011, Knight Piésold, November 2011.
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## **27 CERTIFICATES AND CONSENTS**

## CERTIFICATE

To accompany the report entitled: NI 43-101 TECHNICAL REPORT FOR THE PRESTEA WEST REEF FEASIBILITY STUDY, GHANA EFFECTIVE DATE 1ST MAY 2013, effective date 01 May 2013.

I, Michael J Beare, BSc, CEng, MIOM<sup>3</sup> residing at 17 Clos Halket, Canton, Cardiff, UK do hereby certify that:

- 1) I am a Corporate Consultant (Mining Engineering) with the firm of SRK Consulting (“SRK”) with an office at 5<sup>th</sup> Floor, Churchill House, Churchill Way, Cardiff, UK;
- 2) I am a graduate of the Camborne School of Mines, Cornwall, UK, with a First Class Honours degree (BEng) in Mining Engineering in 1992. I have practiced my profession continuously since 1992. I have been employed by SRK Consulting since February 2004 during which time I have project managed thirteen feasibility studies for mining operations with SRK, all of which are now either operating mines or are under construction. Ten of these projects were underground mines.
- 3) I am Member of the Institution of Mining, Metallurgy and Materials (IOM<sup>3</sup>) and a Chartered Engineer. My membership number is 33199.
- 4) I have undertaken a site visit 1-5<sup>th</sup> April 2013 as part of the studies and was responsible for the overall preparation and compilation of the technical report titled, NI 43-101 TECHNICAL REPORT FOR THE PRESTEA WEST REEF FEASIBILITY STUDY, GHANA EFFECTIVE DATE 1ST MAY 2013, and dated 01 May, 2013 relating to the Prestea West Reef Project.
- 5) I have read the definition of “qualified person” set out in National Instrument 43-101 and certify that by virtue of my education, affiliation to a professional association and past relevant work experience, I fulfil the requirements to be a “qualified person” for the purposes of National Instrument 43-101;
- 6) I am the co-author of this report and responsible for sections 1 to 6 inclusive and sections 15 to 27 inclusive;
- 7) I, as a qualified person, am independent of the issuer as defined in Section 1.5 of National Instrument 43-101;
- 8) I have had no prior involvement with the subject property;
- 9) I have read National Instrument 43-101 and confirm that this technical report has been prepared in compliance therewith;
- 10) SRK Consulting was retained by Golden Star Resources Ltd to prepare the Prestea West Reef Feasibility Study. This assignment was completed using CIM “Best practices” and Canadian Securities Administrators National Instrument 43-101 guidelines. The preceding report is based on a site visit and detailed technical work;
- 11) I have not received, nor do I expect to receive, any interest, directly or indirectly, in the Prestea West Reef Feasibility Study or securities of Golden Star Resources Ltd;
- 12) That, as of the date of this technical report, to the best of my knowledge, information and belief, this technical report contains all scientific and technical information that is required to be disclosed to make the technical report not misleading; and
- 13) I consent to the filing of the technical report with any stock exchange and other regulatory

authority and any publication for regulatory purposes, including electronic publication in the public company files on their websites accessible to the public of extracts from the technical report.

This signature for *Michael Beare* is valid for the purpose of signing documents on behalf of SRK Consulting (UK) Ltd.

---

**Mr Michael Beare**

Corporate Consultant (Mining Engineering),  
SRK Consulting (UK) Ltd.  
Cardiff, UK, 7<sup>th</sup> June 2013

Project number: UK4935

Cardiff, Wales, June 2013

To:

British Columbia Securities Commission  
Alberta Securities Commission  
Saskatchewan Financial Services Commission, Securities Division  
Manitoba Securities Commission  
Ontario Securities Commission  
Autorité des Marchés Financiers du Québec  
New Brunswick Financial and Consumer Services Commission  
Nova Scotia Securities Commission  
Prince Edward Island Superintendent of Securities  
Securities Commission of Newfoundland and Labrador  
Toronto Stock Exchange

### CONSENT of QUALIFIED PERSON

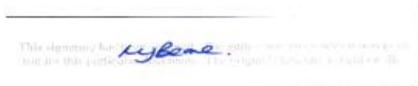
**Re: Technical Report titled "NI 43-101 TECHNICAL REPORT FOR THE PRESTEA WEST REEF FEASIBILITY STUDY, GHANA EFFECTIVE DATE 1ST MAY 2013" with an effective date of May 1, 2013**

I, Michael Beare, BSc, CEng, MIOM<sup>3</sup> consent to the public filing of the technical report titled "NI 43-101 TECHNICAL REPORT FOR THE PRESTEA WEST REEF FEASIBILITY STUDY, GHANA EFFECTIVE DATE 1ST MAY 2013," with an effective date of May 1, 2013 ("the Technical Report") by Golden Star Resources Ltd. ("Golden Star").

I also consent to any extracts from or a summary of the Technical Report in the press release titled "Golden Star Resources Publishes Positive Feasibility Study for Prestea Underground Mine West Reef Project" dated June 11, 2013 (the "Press Release") of Golden Star.

I certify that I have read the Press Release filed by Golden Star and that it fairly and accurately represents the information in the Technical Report for which I am responsible.

Dated this 7<sup>th</sup> day of June 2013



**Michael Beare, BSc, CEng, MIOM<sup>3</sup>**  
**Corporate Consultant (Mining Engineering)**

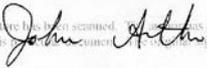
## CERTIFICATE

To accompany the report entitled: NI 43-101 TECHNICAL REPORT FOR THE PRESTEA WEST REEF FEASIBILITY STUDY, GHANA EFFECTIVE DATE 1ST MAY 2013, effective date 1<sup>st</sup> May 2013.

I, Dr John Arthur, BSc, MSc, PhD, CEng, CGeol, MIMMM, residing at 19 Cardiff Road, Dinas Powys, UK, CF64 4DH do hereby certify that:

- 1) I am a Principal Consultant (Geology) with the firm of SRK Consulting (“SRK”) with an office at 5<sup>th</sup> Floor, Churchill House, Churchill Way, Cardiff, UK;
- 2) I am a graduate of the University of Newcastle Upon Tyne, UK in 1987 (BSc Hons Geology) and the University of Leicester, UK in 1989 (MSc Mining Geology and Mineral Exploration) and qualified with a PhD from Cardiff University, UK in 1994. I have practised my profession continuously since 1994. I have been employed as a Geologist by SRK Consulting since 1996 where I have worked extensively on gold exploration, evaluation and resource modelling projects. My main area of expertise is Mineral Resource Estimation techniques;
- 3) I am a Professional Geoscientist registered with the Geological Society of London as a Fellow (FGS) and have achieved chartered status as a CGeol (membership number 1005744);
- 4) I am a Professional Engineer registered with the Institution of Materials, Mining and Metallurgy as a Member and have achieved chartered status as a CEng (membership number 50132);
- 5) I have personally inspected the Prestea Mine on several occasions the last being 23 – 27 January 2012. There has been no material change since that time;
- 6) I have read the definition of “qualified person” set out in National Instrument 43-101 and certify that by virtue of my education, affiliation to a professional association and past relevant work experience, I fulfil the requirements to be a “qualified person” for the purposes of National Instrument 43-101;
- 7) I am the co-author of this report and responsible for sections 7 to 14 inclusive of the report.
- 8) I, as a qualified person, am independent of the issuer as defined in Section 1.5 of National Instrument 43-101;
- 9) I have had no prior involvement with the subject property.;
- 10) I have read National Instrument 43-101 and confirm that this technical report has been prepared in compliance therewith;
- 11) SRK Consulting was retained by Golden Star Resources Ltd to prepare the Prestea West Reef Feasibility Study. This assignment was completed using CIM “Best practices” and Canadian Securities Administrators National Instrument 43-101 guidelines. The preceding report is based on a site visit and detailed technical work;
- 12) I have not received, nor do I expect to receive, any interest, directly or indirectly, in the Prestea West Reef Feasibility Study or securities of Golden Star Resources Ltd;
- 13) That, as of the date of this technical report, to the best of my knowledge, information and belief, this technical report contains all scientific and technical information that is required to be disclosed to make the technical report not misleading; and

- 14) I consent to the filing of the technical report with any stock exchange and other regulatory authority and any publication for regulatory purposes, including electronic publication in the public company files on their websites accessible to the public of extracts from the technical report.



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**Dr John Arthur (PhD, CGeol, CEng, MIMMM)**

Principal Consultant (Geology),

SRK Consulting (UK) Ltd.

Cardiff, UK, 7<sup>th</sup> June 2013

Project number: UK4935

Cardiff, Wales, June 2013

To:

British Columbia Securities Commission  
Alberta Securities Commission  
Saskatchewan Financial Services Commission, Securities Division  
Manitoba Securities Commission  
Ontario Securities Commission  
Autorité des Marchés Financiers du Québec  
New Brunswick Financial and Consumer Services Commission  
Nova Scotia Securities Commission  
Prince Edward Island Superintendent of Securities  
Securities Commission of Newfoundland and Labrador  
Toronto Stock Exchange

#### CONSENT of QUALIFIED PERSON

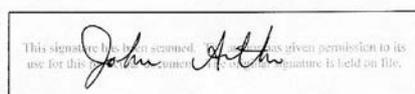
**Re: Technical Report titled "NI 43-101 TECHNICAL REPORT FOR THE PRESTEA WEST REEF FEASIBILITY STUDY, GHANA EFFECTIVE DATE 1ST MAY 2013" with an effective date of May 1, 2013**

I, Dr John Arthur, PhD, CGeol, CEng, MIMMM consent to the public filing of the technical report titled "NI 43-101 TECHNICAL REPORT FOR THE PRESTEA WEST REEF FEASIBILITY STUDY, GHANA EFFECTIVE DATE 1ST MAY 2013," with an effective date of May 1, 2013 ("the Technical Report") by Golden Star Resources Ltd. ("Golden Star").

I also consent to any extracts from or a summary of the Technical Report in the press release titled "Golden Star Resources Publishes Positive Feasibility Study for Prestea Underground Mine West Reef Project" dated June 11, 2013 (the "Press Release") of Golden Star.

I certify that I have read the Press Release filed by Golden Star and that it fairly and accurately represents the information in the Technical Report for which I am responsible.

Dated this 7<sup>th</sup> day of June 2013



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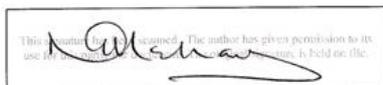
**Dr John Arthur PhD, CGeol, CEng, MIMMM**  
**Principal Consultant (Geology)**

## CERTIFICATE

To accompany the report entitled: NI 43-101 TECHNICAL REPORT FOR THE PRESTEA WEST REEF FEASIBILITY STUDY, GHANA EFFECTIVE DATE 1ST MAY 2013, effective date 01 May 2013.

I, Neil Marshall, BSc (Hons), MSc, CEng, MIOM<sup>3</sup> residing at 4 Pentwyn, Radyr, Cardiff, UK do hereby certify that:

- 1) I am a Corporate Consultant (Geotechnical Engineering) with the firm of SRK Consulting (“SRK”) with an office at 5<sup>th</sup> Floor, Churchill House, Churchill Way, Cardiff, UK;
- 2) I am a graduate of the University of Portsmouth, UK, with an Honours degree (BSc) in Engineering Geology and Geotechnics in 1979 and an MSc (DIC) in Engineering Rock Mechanics from Imperial College, UK in 1982. I have practiced my profession continuously since 1979. I have been employed by SRK Consulting since February 1998 during which time I have project managed numerous geotechnical investigation and analysis programmes for open pit and underground mining Feasibility Studies.
- 3) I am Member of the Institute of Mining, Metallurgy and Materials (IOM<sup>3</sup>) and a Chartered Engineer. My membership number is 50266.
- 4) I have undertaken a site visit 6-15<sup>th</sup> September 2012 as part of the studies.
- 5) I have read the definition of “qualified person” set out in National Instrument 43-101 and certify that by virtue of my education, affiliation to a professional association and past relevant work experience, I fulfil the requirements to be a “qualified person” for the purposes of National Instrument 43-101;
- 6) I am the co-author of this report and responsible for Section 15.3
- 7) I, as a qualified person, am independent of the issuer as defined in Section 1.5 of National Instrument 43-101;
- 8) I have had prior involvement with the subject property, completing a Pre-Feasibility Study on the West Reef in 2007.
- 9) I have read National Instrument 43-101 and confirm that this technical report has been prepared in compliance therewith;
- 10) SRK Consulting was retained by Golden Star Resources Ltd to prepare the Prestea West Reef Feasibility Study. This assignment was completed using CIM “Best practices” and Canadian Securities Administrators National Instrument 43-101 guidelines. The preceding report is based on a site visit and detailed technical work;
- 11) I have not received, nor do I expect to receive, any interest, directly or indirectly, in the Prestea West Reef Feasibility Study or securities of Golden Star Resources Ltd;
- 12) That, as of the date of this technical report, to the best of my knowledge, information and belief, this technical report contains all scientific and technical information that is required to be disclosed to make the technical report not misleading; and
- 13) I consent to the filing of the technical report with any stock exchange and other regulatory authority and any publication for regulatory purposes, including electronic publication in the public company files on their websites accessible to the public of extracts from the technical report.



---

**Mr Neil Marshall**

Corporate Consultant (Geotechnical Engineering),  
SRK Consulting (UK) Ltd.  
Cardiff, UK, 7<sup>th</sup> June 2013

Project number: UK4935

Cardiff, Wales, June 2013

To:

British Columbia Securities Commission  
Alberta Securities Commission  
Saskatchewan Financial Services Commission, Securities Division  
Manitoba Securities Commission  
Ontario Securities Commission  
Autorité des Marchés Financiers du Québec  
New Brunswick Financial and Consumer Services Commission  
Nova Scotia Securities Commission  
Prince Edward Island Superintendent of Securities  
Securities Commission of Newfoundland and Labrador  
Toronto Stock Exchange

### CONSENT of QUALIFIED PERSON

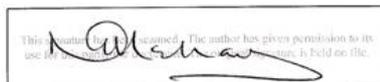
**Re: Technical Report titled “NI 43-101 TECHNICAL REPORT FOR THE PRESTEA WEST REEF FEASIBILITY STUDY, GHANA EFFECTIVE DATE 1ST MAY 2013” with an effective date of May 1, 2013**

I, Neil Marshall, BSc, MSc, CEng, MIOM<sup>3</sup> consent to the public filing of the technical report titled “NI 43-101 TECHNICAL REPORT FOR THE PRESTEA WEST REEF FEASIBILITY STUDY, GHANA EFFECTIVE DATE 1ST MAY 2013,” with an effective date of May 1, 2013 (“the Technical Report”) by Golden Star Resources Ltd. (“Golden Star”).

I also consent to any extracts from or a summary of the Technical Report in the press release titled “Golden Star Resources Publishes Positive Feasibility Study for Prestea Underground Mine West Reef Project” dated June 11, 2013 (the “Press Release”) of Golden Star.

I certify that I have read the Press Release filed by Golden Star and that it fairly and accurately represents the information in the Technical Report for which I am responsible.

Dated this 7<sup>th</sup> day of June 2013



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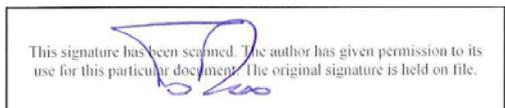
**Neil Marshall BSc, MSc, CEng, MIOM<sup>3</sup>**  
**Corporate Consultant (Geotechnical Engineering)**

## CERTIFICATE

To accompany the report entitled: NI 43-101 TECHNICAL REPORT FOR THE PRESTEA WEST REEF FEASIBILITY STUDY, GHANA EFFECTIVE DATE 1ST MAY 2013, effective date 01 May 2013.

I, Dr Anthony Rex, BSc (Hons), MSc, PhD, CGeol residing at 5 Holt Lane, Adel, Leeds, UK do hereby certify that:

- 1) I am a Corporate Consultant (Hydrogeology) with the firm of SRK Consulting (“SRK”) with an office at 5<sup>th</sup> Floor, Churchill House, Churchill Way, Cardiff, UK;
- 2) I am a graduate of the University of Southampton, UK, with an Honours degree in Geology in 1983 and a PhD in Geology and Geochemistry from the University of Leicester in 1987. I also graduated with an MSc in Hydrogeology from the University of Birmingham in 1991. I have practiced my profession continuously since 1983. I have been employed by SRK Consulting since January 2009 during which time I have acted as Project Director and Project Manager for numerous hydrogeological and water management investigations and studies for open pit and underground mining Feasibility Studies.
- 3) I am a Chartered Geologist. My Geological Society membership number is 1001078.
- 4) I have undertaken a site visit 1-5 October 2012 as part of the studies.
- 5) I have read the definition of “qualified person” set out in National Instrument 43-101 and certify that by virtue of my education, affiliation to a professional association and past relevant work experience, I fulfil the requirements to be a “qualified person” for the purposes of National Instrument 43-101;
- 6) I am the co-author of this report and responsible for section 23.1.
- 7) I, as a qualified person, am independent of the issuer as defined in Section 1.5 of National Instrument 43-101;
- 8) I have had no prior involvement with the subject property;
- 9) I have read National Instrument 43-101 and confirm that this technical report has been prepared in compliance therewith;
- 10) SRK Consulting was retained by Golden Star Resources Ltd to prepare the Prestea West Reef Feasibility Study. This assignment was completed using CIM “Best practices” and Canadian Securities Administrators National Instrument 43-101 guidelines. The preceding report is based on a site visit and detailed technical work;
- 11) I have not received, nor do I expect to receive, any interest, directly or indirectly, in the Prestea West Reef Feasibility Study or securities of Golden Star Resources Ltd;
- 12) That, as of the date of this technical report, to the best of my knowledge, information and belief, this technical report contains all scientific and technical information that is required to be disclosed to make the technical report not misleading; and
- 13) I consent to the filing of the technical report with any stock exchange and other regulatory authority and any publication for regulatory purposes, including electronic publication in the public company files on their websites accessible to the public of extracts from the technical report.



---

**Dr Anthony Rex**

Corporate Consultant (Hydrogeology),

SRK Consulting (UK) Ltd.

Cardiff, UK, 7<sup>th</sup> June 2013

Project number: UK4935

Cardiff, Wales, June 2013

To:

British Columbia Securities Commission  
Alberta Securities Commission  
Saskatchewan Financial Services Commission, Securities Division  
Manitoba Securities Commission  
Ontario Securities Commission  
Autorité des Marchés Financiers du Québec  
New Brunswick Financial and Consumer Services Commission  
Nova Scotia Securities Commission  
Prince Edward Island Superintendent of Securities  
Securities Commission of Newfoundland and Labrador  
Toronto Stock Exchange

#### CONSENT of QUALIFIED PERSON

**Re: Technical Report titled "NI 43-101 TECHNICAL REPORT FOR THE PRESTEA WEST REEF FEASIBILITY STUDY, GHANA EFFECTIVE DATE 1ST MAY 2013" with an effective date of May 1, 2013**

I, Dr Anthony Rex, PhD, MSc, BSc (Hons), CGeol consent to the public filing of the technical report titled "NI 43-101 TECHNICAL REPORT FOR THE PRESTEA WEST REEF FEASIBILITY STUDY, GHANA EFFECTIVE DATE 1ST MAY 2013," with an effective date of May 1, 2013 ("the Technical Report") by Golden Star Resources Ltd. ("Golden Star").

I also consent to any extracts from or a summary of the Technical Report in the press release titled "Golden Star Resources Publishes Positive Feasibility Study for Prestea Underground Mine West Reef Project" dated June 11, 2013 (the "Press Release") of Golden Star.

I certify that I have read the Press Release filed by Golden Star and that it fairly and accurately represents the information in the Technical Report for which I am responsible.

Dated this 7<sup>th</sup> day of June 2013

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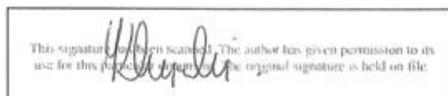
**Dr Anthony Rex PhD, MSc, BSc (Hons), CGeol**  
**Principal Consultant (Geology)**

## CERTIFICATE

To accompany the report entitled: NI 43-101 TECHNICAL REPORT FOR THE PRESTEA WEST REEF FEASIBILITY STUDY, GHANA EFFECTIVE DATE 1ST MAY 2013, effective date 01 May 2013.

I, Krzysztof Czajewski, BSc, APEGBC residing at 13 Uppercliff Drive, Penarth, Vale of Glamorgan, UK do hereby certify that:

- 1) I am a Principal Consultant (Tailings Engineering) with the firm of SRK Consulting (“SRK”) with an office at 5<sup>th</sup> Floor, Churchill House, Churchill Way, Cardiff, UK;
- 2) I am a graduate of the University of Saskatchewan, Canada, with a Bachelor of Science degree in Civil Engineering in 1989. I have practiced my profession continuously since 1989. I have been employed by SRK Consulting since February 2007 during which time I have undertaken numerous waste disposal engineering studies for various mining operations.
- 3) I am Member of the Association of Professional Engineers and Geoscientists of British Columbia, Canada (APEGBC). My membership number is 131396.
- 4) I have undertaken a site visit 15 to 19 October 2012 as part of the studies.
- 5) I have read the definition of “qualified person” set out in National Instrument 43-101 and certify that by virtue of my education, affiliation to a professional association and past relevant work experience, I fulfil the requirements to be a “qualified person” for the purposes of National Instrument 43-101;
- 6) I am the co-author of this report and responsible for sections 17.6 and 17.8.
- 7) I, as a qualified person, am independent of the issuer as defined in Section 1.5 of National Instrument 43-101;
- 8) I have had no prior involvement with the subject property;
- 9) I have read National Instrument 43-101 and confirm that this technical report has been prepared in compliance therewith;
- 10) SRK Consulting was retained by Golden Star Resources Ltd to prepare the Prestea West Reef Feasibility Study. This assignment was completed using CIM “Best practices” and Canadian Securities Administrators National Instrument 43-101 guidelines. The preceding report is based on a site visit and detailed technical work;
- 11) I have not received, nor do I expect to receive, any interest, directly or indirectly, in the Prestea West Reef Feasibility Study or securities of Golden Star Resources Ltd;
- 12) That, as of the date of this technical report, to the best of my knowledge, information and belief, this technical report contains all scientific and technical information that is required to be disclosed to make the technical report not misleading; and
- 13) I consent to the filing of the technical report with any stock exchange and other regulatory authority and any publication for regulatory purposes, including electronic publication in the public company files on their websites accessible to the public of extracts from the technical report.



---

**Mr Krzysztof Czajewski**

Principal Consultant (Tailings Engineering),

SRK Consulting (UK) Ltd.

Cardiff, UK, 7<sup>th</sup> June 2013

Project number: UK4935

Cardiff, Wales, June 2013

To:

British Columbia Securities Commission  
Alberta Securities Commission  
Saskatchewan Financial Services Commission, Securities Division  
Manitoba Securities Commission  
Ontario Securities Commission  
Autorité des Marchés Financiers du Québec  
New Brunswick Financial and Consumer Services Commission  
Nova Scotia Securities Commission  
Prince Edward Island Superintendent of Securities  
Securities Commission of Newfoundland and Labrador  
Toronto Stock Exchange

#### CONSENT of QUALIFIED PERSON

**Re: Technical Report titled "NI 43-101 TECHNICAL REPORT FOR THE PRESTEA WEST REEF FEASIBILITY STUDY, GHANA EFFECTIVE DATE 1ST MAY 2013" with an effective date of May 1, 2013**

I, Krzysztof Czajewski, BSc, APEGBC consent to the public filing of the technical report titled "NI 43-101 TECHNICAL REPORT FOR THE PRESTEA WEST REEF FEASIBILITY STUDY, GHANA EFFECTIVE DATE 1ST MAY 2013," with an effective date of May 1, 2013 ("the Technical Report") by Golden Star Resources Ltd. ("Golden Star").

I also consent to any extracts from or a summary of the Technical Report in the press release titled "Golden Star Resources Publishes Positive Feasibility Study for Prestea Underground Mine West Reef Project" dated June 11, 2013 (the "Press Release") of Golden Star.

I certify that I have read the Press Release filed by Golden Star and that it fairly and accurately represents the information in the Technical Report for which I am responsible.

Dated this 7<sup>th</sup> day of June 2013

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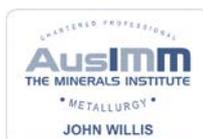
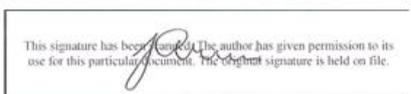
**Mr Krzysztof Czajewski BSc, APEGBC**  
**Principal Consultant (Tailings)**

## CERTIFICATE

To accompany the report entitled: NI 43-101 TECHNICAL REPORT FOR THE PRESTEA WEST REEF FEASIBILITY STUDY, GHANA EFFECTIVE DATE 1ST MAY 2013, effective date 01 May 2013.

I, Dr John Willis, PhD, BE (Met) (Hons), MAusIMM(CP) residing at 17 Cardinal Drive, Lisvane, Cardiff, UK do hereby certify that:

- 1) I am a Principal Consultant (Mineral Processing) with the firm of SRK Consulting (“SRK”) with an office at 5<sup>th</sup> Floor, Churchill House, Churchill Way, Cardiff, UK;
- 2) I am a graduate of the University of Queensland, Australia, with an Honours degree BE (Met) in Mineral Processing in 1985 and qualified with a PhD from the University of Queensland in 1994. I have practiced my profession continuously since 1986. I have been employed by SRK Consulting since January 2008 during which time I have been involved in numerous Feasibility Studies involving the development and management of metallurgical testwork programmes and the development of process flowsheets based on such testwork results.
- 3) I am Member and Chartered Professional of the Australasian Institute of Mining and Metallurgy (MAusIMM).
- 4) I have undertaken a site visit 15-19<sup>th</sup> October 2012 as part of the studies.
- 5) I have read the definition of “qualified person” set out in National Instrument 43-101 and certify that by virtue of my education, affiliation to a professional association and past relevant work experience, I fulfil the requirements to be a “qualified person” for the purposes of National Instrument 43-101;
- 6) I am the co-author of this report and responsible for sections 12 and 16.
- 7) I, as a qualified person, am independent of the issuer as defined in Section 1.5 of National Instrument 43-101;
- 8) I have had no prior involvement with the subject property;
- 9) I have read National Instrument 43-101 and confirm that this technical report has been prepared in compliance therewith;
- 10) SRK Consulting was retained by Golden Star Resources Ltd to prepare the Prestea West Reef Feasibility Study. This assignment was completed using CIM “Best practices” and Canadian Securities Administrators National Instrument 43-101 guidelines. The preceding report is based on a site visit and detailed technical work;
- 11) I have not received, nor do I expect to receive, any interest, directly or indirectly, in the Prestea West Reef Feasibility Study or securities of Golden Star Resources Ltd;
- 12) That, as of the date of this technical report, to the best of my knowledge, information and belief, this technical report contains all scientific and technical information that is required to be disclosed to make the technical report not misleading; and
- 13) I consent to the filing of the technical report with any stock exchange and other regulatory authority and any publication for regulatory purposes, including electronic publication in the public company files on their websites accessible to the public of extracts from the technical report.



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**Dr John Willis**

Principal Consultant (Mineral Processing),  
SRK Consulting (UK) Ltd.  
Cardiff, UK, 7<sup>th</sup> June 2013

Project number: UK4935

Cardiff, Wales, June 2013

To:

British Columbia Securities Commission  
Alberta Securities Commission  
Saskatchewan Financial Services Commission, Securities Division  
Manitoba Securities Commission  
Ontario Securities Commission  
Autorité des Marchés Financiers du Québec  
New Brunswick Financial and Consumer Services Commission  
Nova Scotia Securities Commission  
Prince Edward Island Superintendent of Securities  
Securities Commission of Newfoundland and Labrador  
Toronto Stock Exchange

#### CONSENT of QUALIFIED PERSON

**Re: Technical Report titled “NI 43-101 TECHNICAL REPORT FOR THE PRESTEA WEST REEF FEASIBILITY STUDY, GHANA EFFECTIVE DATE 1ST MAY 2013” with an effective date of May 1, 2013**

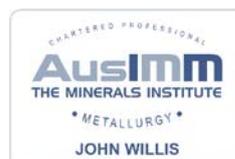
I, Dr John Willis, PhD, ME (Met) (Hons), MAusIMM(CP) consent to the public filing of the technical report titled “NI 43-101 TECHNICAL REPORT FOR THE PRESTEA WEST REEF FEASIBILITY STUDY, GHANA EFFECTIVE DATE 1ST MAY 2013,” with an effective date of May 1, 2013 (“the Technical Report”) by Golden Star Resources Ltd. (“Golden Star”).

I also consent to any extracts from or a summary of the Technical Report in the press release titled “Golden Star Resources Publishes Positive Feasibility Study for Prestea Underground Mine West Reef Project” dated June 11, 2013 (the “Press Release”) of Golden Star.

I certify that I have read the Press Release filed by Golden Star and that it fairly and accurately represents the information in the Technical Report for which I am responsible.

Dated this 7<sup>th</sup> day of June 2013

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**Dr John Willis PhD, ME (Met) (Hons), MAusIMM(CP)**  
**Principal Consultant (Mineral Processing)**