NI 43-101 Preliminary Economic Assessment

Mechanized Mining of the West Reef Resource, Prestea Underground Mine, Prestea, Ghana

May 3, 2012

Golden Star Resources Ltd.

10901 W. Toller Drive, Suite 300
Littleton, CO 80127-6312 USA

Endorsed by QP’s
Martin P. Raffield, Ph.D., P.Eng.
S. Mitchel Wasel, BSc AusIMM (CP)

Contributors
Yan Bourassa, M.Sc., P.Geo.
Mark Thorpe, Ph.D.
William F. Tanaka
John Miller
Jerry Agala
Samuel Agyemang
Daniel Elvera
# Table of Contents

1 Introduction (Item 2) .................................................................................................................. 1-1
   1.1 Golden Star Resources ........................................................................................................ 1-1
   1.2 Terms of Reference and Purpose of the Report ............................................................... 1-2
   1.3 Sources of Information ....................................................................................................... 1-2
   1.4 Site Inspections .................................................................................................................. 1-2

2 Property Description and Location (Item 4) ......................................................................... 2-1
   2.1 Property Location .............................................................................................................. 2-1
   2.2 Mineral Titles and Agreements ......................................................................................... 2-2
   2.3 Royalties and Encumbrances ............................................................................................ 2-3
   2.4 Environmental Liabilities .................................................................................................. 2-3
   2.5 Operating Permits Required ............................................................................................. 2-3

3 Accessibility, Climate, Local Resources and Infrastructure (Item 5) ......................................... 3-4
   3.1 Infrastructure and Physiography ....................................................................................... 3-4
   3.2 Topography, Elevation and Vegetation ............................................................................. 3-4
   3.3 Climate and Length of Operating Season ......................................................................... 3-4
   3.4 Access to Property ............................................................................................................ 3-4
   3.5 Surface Rights .................................................................................................................. 3-4
   3.6 Local Resources and Infrastructure .................................................................................. 3-5

4 History (Item 6) ......................................................................................................................... 4-6
   4.1 Prior Ownership ................................................................................................................ 4-6
   4.2 Past Exploration and Development .................................................................................. 4-6
   4.3 Historic Mineral Resource and Reserve Estimates .......................................................... 4-7
   4.4 Historic Production .......................................................................................................... 4-7

5 Geologic Setting and Mineralization (Item 7) ....................................................................... 5-9
   5.1 Regional Geology ............................................................................................................ 5-9
   5.2 Property Geology ............................................................................................................ 5-14

6 Deposit Type (Item 8) ............................................................................................................. 6-19

7 Exploration (Item 9) ............................................................................................................... 7-20

8 Drilling (Item 10) .................................................................................................................... 8-1

9 Sample Preparation, Analyses and Security (Item 11) .............................................................. 9-1

10 Data Verification (Item 12) .................................................................................................... 10-1
   10.1 Duplicates (2004 - 2006) ............................................................................................... 10-1
   10.2 Duplicates (2006 - 2008) ............................................................................................... 10-1
   10.4 Screen Fire Assay checks (2007) .................................................................................. 10-3
   10.5 Blanks ............................................................................................................................ 10-4
   10.7 Gannet standards (2007 - 2008) .................................................................................. 10-5
   10.8 Conclusions ................................................................................................................... 10-8

11 Mineral Processing and Metallurgical Testing (Item 13) ........................................................... 11-1
   11.1 Samples .......................................................................................................................... 11-1
   11.2 Testwork ....................................................................................................................... 11-1
# Table of Contents

11.3 Results .................................................................................................................. 11-2

12 Mineral Resources (Item 14) .................................................................................. 12-1
  12.1 Data sources ........................................................................................................... 12-1
  12.2 Data cutting/filtering ............................................................................................. 12-1
  12.3 Basic statistical tests ............................................................................................... 12-1
  12.4 3D Variographic analysis ....................................................................................... 12-3
  12.5 Block Model Grade Interpolation ......................................................................... 12-7
  12.6 Resource Classification ......................................................................................... 12-7
  12.7 Mineral Resource Statement .................................................................................. 12-9

13 Mineral Reserve Estimation (Item 15) .................................................................... 13-11

14 Mining Methods (Item 16) ..................................................................................... 14-12
  14.1 Introduction ............................................................................................................ 14-12
  14.2 Selection of Mining Method .................................................................................. 14-15
    14.2.1 Cut-off Grade Calculation ............................................................................... 14-15
    14.2.2 Geotechnical Design ..................................................................................... 14-15
    14.2.3 AVOCA Mining Method ................................................................................ 14-19
  14.3 Stope Design ........................................................................................................ 14-21
  14.4 Development Design ............................................................................................ 14-22
    14.4.1 Main Access Ramp ......................................................................................... 14-23
    14.4.2 Central Shaft Upgrade ................................................................................... 14-24
    14.4.3 New Hoisting Shaft ...................................................................................... 14-24
    14.4.4 Backfill Supply Development ....................................................................... 14-25
    14.4.5 Stope Development ....................................................................................... 14-25
  14.5 Potentially Mineable Resources .......................................................................... 14-26
  14.6 Mining Operations ............................................................................................... 14-26
    14.6.1 Development ................................................................................................. 14-26
    14.6.2 Drilling and Blasting ....................................................................................... 14-26
    14.6.3 Mucking and Hauling .................................................................................... 14-26
    14.6.4 Backfill ........................................................................................................... 14-26
    14.6.5 Mining Equipment Fleet ................................................................................. 14-26
  14.7 Production Schedule ............................................................................................ 14-27
    14.7.1 Assumptions ................................................................................................... 14-27
    14.7.2 Schedule ........................................................................................................ 14-27
  14.8 Mine Services ....................................................................................................... 14-28
    14.8.1 Ventilation ..................................................................................................... 14-28
    14.8.2 Underground Electrical Supply .................................................................... 14-28
  14.9 Manpower ........................................................................................................... 14-28

15 Recovery Methods (Item 17) .................................................................................. 15-5

16 Project Infrastructure (Item 18) ............................................................................. 16-1
  16.1 Road Access ......................................................................................................... 16-1
  16.2 Power Supply ........................................................................................................ 16-1
  16.3 Water Supply ........................................................................................................ 16-1
  16.4 Mine Dewatering .................................................................................................. 16-1
  16.5 Waste Dumps ........................................................................................................ 16-2
  16.6 Bogoso Oxide Plant .............................................................................................. 16-2
16.7  Offices...................................................................................................................... 16-2
16.8  Mine Rescue............................................................................................................. 16-2

17  Market Studies and Contracts (Item 19)................................................................. 17-4
18  Environmental Studies, Permitting and Social or Community Impacts (Item 20) .... 18-5
  18.1  Environmental and Social Setting.......................................................................... 18-5
  18.2  Environmental Studies and Authorizations......................................................... 18-6
        18.2.1  Regulatory Framework .............................................................................. 18-6
        18.2.2  Environmental Approvals ......................................................................... 18-7
        18.2.3  Approach to Environmental Permitting ................................................... 18-9
  18.3  Approach to Environmental and Social Management .......................................... 18-9
  18.4  Key Environmental and Social Issues................................................................... 18-10
        18.4.1  Legacy Issues ............................................................................................. 18-10
        18.4.2  Community Sensitivities ......................................................................... 18-10
        18.4.3  Resettlement .............................................................................................. 18-11
        18.4.4  Unauthorized Small Scale Mining ............................................................... 18-11
        18.4.5  Community Expectations .......................................................................... 18-11
  18.5  Closure Planning and Cost Estimate .................................................................... 18-12

19  Capital and Operating Costs (Item 21) ..................................................................... 19-13
  19.1  Capital Costs ...................................................................................................... 19-13
  19.2  Operating Costs ................................................................................................. 19-14

20  Economic Analysis (Item 22) .................................................................................. 20-15
  20.1  Model Inputs ...................................................................................................... 20-15
  20.2  Project Economic Results .................................................................................. 20-15
        20.3  Sensitivity ..................................................................................................... 20-1

21  Adjacent Properties (Item 23) ................................................................................ 21-2

22  Other Relevant Data and Information (Item 24). ....................................................... 22-3

23  Interpretation and Conclusions (Item 25) ............................................................... 23-4

24  Recommendations (Item 26) .................................................................................. 24-6

25  References (Item 27) .............................................................................................. 26-8

List of Tables

Table 2: Capital cost summary (US$000s) .............................................................................. V
Table 3: Operating cost summary ....................................................................................... VI
Table 5.1: Tarkwaian sedimentary sequences and estimated thicknesses (Perrouty et al, 2012) .... 5-11
Table 7.1: Channel Sample results 17 Level West Reef Drive .............................................. 7-20
Table 10.1: Standards used and summary results at Prestea UG in 2007-2008 ....................... 10-6
Table 11.1: West Reef drillhole samples for metallurgical testing ........................................ 11-1
Table 12.1: Summary statistics for the Prestea underground resource domains ....................... 12-2
Table 12.2: Semi-variogram modeling results for the Main Reef zone .................................. 12-4
Table 12.3: Semi-variogram modeling results for the WR zone ..................................................... 12-5
Table 12.4: Semi-variogram modeling results for the MR Stope domain ....................................... 12-5
Table 12.5: Block model dimension parameters (lower left corner) ............................................... 12-7
Table 12.6: Estimated mineral resources ....................................................................................... 12-10
Table 14.1: Cut-off grade estimate ................................................................................................ 14-15
Table 14.2: West Reef geotechnical domains ................................................................................ 14-17
Table 14.3: Mining equipment fleet ............................................................................................... 14-27
Table 14.4: Production schedule .................................................................................................. 14-1
Table 14.5: Mobile equipment ventilation requirements ................................................................. 14-1
Table 14.6: Maximum connected load ............................................................................................. 14-2
Table 14.7: Hourly manpower ......................................................................................................... 14-3
Table 15.1: Bogoso Oxide Plant process flow chart ........................................................................ 15-1
Table 18.1: Primary Environmental Approvals Needed for Mining Operations ............................. 18-6
Table 18.2: Existing and Pending Environmental Approvals .......................................................... 18-8
Table 19.1: Capital cost summary (US$000s) ............................................................................... 19-13
Table 19.2: Operating cost summary ............................................................................................. 19-14
Table 20.1: Economic model parameters ....................................................................................... 20-15
Table 20.2: Economic Model ........................................................................................................... 20-1
Table 20.3: Project sensitivity NPV 5% (US$000's) ......................................................................... 20-1

List of Figures

Figure 1: Prestea mining area including stoping........................................................................... III
Figure 2-1: Map of Ghana................................................................................................................ 2-1
Figure 2-2: Prestea mining lease .................................................................................................... 2-2
Figure 4-1: Historic Prestea Underground Mine Production........................................................... 4-8
Figure 5-1: The West African Craton (Perrouy et al, 2012)............................................................. 5-9
Figure 5-2: Radiometric age data histograms (Perrouy et al, 2012)................................................ 5-11
Figure 5-3: GSR Prestea concession .............................................................................................. 5-13
Figure 5-4: Lithologies hosting the Prestea deposit ....................................................................... 5-15
Figure 5-5: Mineralization styles and structural features characterizing the Prestea deposit ........ 5-18
Figure 8.1: 17 Level drill plan ........................................................................................................ 8-1
Figure 8.2: 24 Level drill plan ......................................................................................................... 8-2
Figure 8.3: West Reef Indicated (green) and Inferred(red) blocks with drill traces .......................... 8-3
Figure 8.4: West Reef Long section with drill hole pierce points ................................................... 8-4
Figure 8.5: West Reef drill X Section 8000N showing reef and drill hole intersections ................. 8-5
Figure 8.6: West Reef drill X Section 8250 N showing reef and drill hole intersections ............ 8-6
Figure 10-1: Prestea DD 2006 duplicates; HARD plot and regression ...................................... 10-1
Figure 10-2: Prestea DD 2008 Fire Assay duplicates; HARD plot ........................................... 10-2
Figure 10-3: Prestea screen fire assay analysis 2006 ................................................................. 10-2
Figure 10-4: Screen Fire Assay checks (2007) ....................................................................... 10-3
Figure 10-5: Prestea DD 2008 Screen Fire Assay duplicates; HARD plot ............................. 10-4
Figure 10-6: Results of blank analysis, January to March 2008 ............................................... 10-5
Figure 10-7: HARD and regression plots for Gannet standard samples, TWL Jan-Aug 2006 ...... 10-5
Figure 10-8: Standard analysis results for ST5369 ................................................................. 10-6
Figure 10-9: Standard analysis results for ST05/2297 ............................................................... 10-7
Figure 10-10: Standard analysis results for ST5343 ................................................................. 10-7
Figure 10-11: Standard analysis results for ST5355 ................................................................. 10-8
Figure 10-12: Standard analysis results for ST322 ................................................................. 10-8
Figure 12-1: Log scale QQ plot and associated raw data histogram for the MR zone .......... 12-2
Figure 12-2: Log scale QQ plot and associated raw data histogram for the WR zone .......... 12-2
Figure 12-3: Main Reef Omni-directional (left) and directional (right) semi-variograms in the plane of the mineralization .......................................................... 12-3
Figure 12-4: Omni-directional semi-variogram and the variogram map in the plane of the WR zone ..................................................................................................... 12-4
Figure 12-5: Experimental directional semi-variograms in the four principal directions in the plane of the WR mineralization with associated model semi-variograms ................................仍然不完全，12-4
Figure 12-6: Omni-directional semi-variogram produced from samples logged as stope fill material in the Main Reef domain ................................................................. 12-5
Figure 12-7: VLP view from the east (footwall) of the Main Reef Block Model showing the distribution of Au grade values after kriging and the available drillholes traces .................. 12-6
Figure 12-8: VLP view from the east (footwall) of the West Reef Block Model showing the distribution of Au grade values after kriging and the available drillholes traces .................. 12-6
Figure 12-9: VLP view from the east (footwall) of the Main Reef Block Model showing the distribution of Block Classification categories (green = Indicated, red = Inferred) ............. 12-8
Figure 12-10: VLP view from the east (footwall) of the West Reef Block Model showing the distribution of Slope Regression values after kriging ............................................. 12-8
Figure 12-11: VLP view from the east (footwall) of the West Reef Block Model showing the distribution of Block Classification categories (green = Indicated, red = Inferred) ............. 12-9
Figure 14-1: Long section of Prestea mining area looking east ............................................... 14-12
Figure 14-2: Prestea mining area including stoping (extent of Tuapim stoping unknown) .......... 14-12
Figure 14-3: Long section of Prestea UG Mine showing West Reef resource target .............. 14-13
Figure 14-4: Isometric view of Central Shaft and West Reef resource (looking NE) .............. 14-14
Figure 14-5: West Reef indicated and inferred resource (looking east) .............................. 14-14
Figure 14-6: Conceptual view of AVOCA mining method (long section view) ....................... 14-20
Figure 14-7: West Reef stopes - 17L to 24L (isometric looking east) ...................................... 14-21
List of Appendices

Appendix A
Certificate of Authors
Summary (Item 1)

Golden Star Resources Ltd (“GSR”) is a Canadian Federally-incorporated, international gold mining and exploration company producing gold in Ghana, West Africa. GSR also conducts gold exploration in other countries in West Africa and in South America.

The Prestea Underground Mine is an inactive underground gold mine located 15km south of the Bogoso mine and adjacent to the town of Prestea. The property consists of two usable access shafts and extensive underground workings and support facilities. Access to the mine site is via a paved road from Tarkwa.

The Prestea Underground Mine was mined from the 1870’s until 2002 when mining ceased following an extended period of low gold prices in the late 1990s and early 2000s. The Prestea Underground Mine has produced approximately nine million ounces of gold, the second highest production of any mine in Ghana. The underground workings are extensive, reaching depths of approximately 1,450 meters and extending along a strike length of nine kilometers. Underground workings can currently be accessed via two surface shafts, one near the town of Prestea (Central Shaft) and a second approximately four kilometers to the southwest at Bondaye.

GSBPL now 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 Golden Star.

The West Reef mineral resource consists of a steeply dipping, narrow vein structure between 17L and 24L, accessible through the Prestea Central Shaft.

PEA Highlights:

- West Reef has an Indicated Mineral Resource of 874,000 tonnes grading 18.07 grams per tonne (g/t) for 508,000 ounces of gold and the orebody is open along strike and down dip
- In addition, West Reef has an Inferred Mineral Resource of 510,000 tonnes grading 11.58 grams per tonne (g/t) for 190,000 ounces of gold and the orebody is open along strike and down dip
- Factoring in mining recovery, dilution, stope and development design, and based on the Indicated Mineral Resources and Inferred Mineral Resources; the potentially mineable resources total 1.84 million tonnes at a grade of 7.8 g/t
- The PEA contemplates a 1,200 tonnes per day mining operation (including mineralized material from development) using the AVOCA mechanized mining method
- Material will be processed at the Bogoso oxide processing plant to produce up to 97,000 ounces of gold per year at full operation and a life-of-mine gold production of 437,000 ounces
- Life-of-mine cash operating costs (before royalty and taxes) are estimated at $600 to $700 per ounce
- Capital costs, including a decline and hoisting shaft, are estimated at approximately $115 million
Golden Star Resources Ltd.  
Mechanized Mining of the West Reef Resource, Prestea Underground Mine   
NI 43-101 Preliminary Economic Assessment  

- Net present value at $1,500/oz gold price and 5% discount rate is $107 million (post-tax)
- Internal rate of return of 21%

**Geology**

The Prestea concession lies on the western margin of the Ashanti greenstone belt, which is located in the West-African craton. The greenstone belt is composed primarily of paleoproterozoic metavolcanic and metasedimentary rocks that are divided into the Birimian Supergroup and the Tarkwa Group. Both units are intruded by abundant granitoids and host numerous hydrothermal gold deposits such as the Obuasi and Prestea mines and paleoplacer deposits such as the Tarkwa and Teberebie Mines.

The Prestea deposit can be classified as an orogenic mesothermal gold deposit where two main types of gold mineralization have been identified. The most common type of mineralization is fault-fill quartz veins along fault zones and second order structures, while the second type of mineralization is associated with brecciated zones hosted in iron-rich volcanic lenses.

**Mineral Resource and Reserve**

The West Reef resource estimate was conducted by SRK Consulting using a drillhole database provided by Golden Star Resources. The database contained a total of 128 underground drillholes which targeted the West Reef.

The block model was prepared by Dr. John Arthur, C.Geol., and an independent Qualified Person as defined by NI43-101.

The classified Mineral Resource Statement for the global resources contained in the West Reef Structure is presented in Table 1. Mineral resources are not mineral reserves and do not have demonstrated economic viability.


<table>
<thead>
<tr>
<th>Resource Category</th>
<th>Tonnage (tonne)</th>
<th>Gold Grade (gpt)</th>
<th>Contained Gold (ounce)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Indicated</td>
<td>874,000</td>
<td>18.07</td>
<td>508,000</td>
</tr>
<tr>
<td>Inferred</td>
<td>510,000</td>
<td>11.58</td>
<td>190,000</td>
</tr>
</tbody>
</table>

*reported at 2.3 g/t gold cut-off estimated using 2011 year end economic assumptions All figures rounded to reflect the relative accuracy of the mineral resource estimate.

There are no current Proven or Probable Minerals Reserves hosted with the West Reef structure or at the Prestea Underground project.

**Underground Mining**

There is an extensive infrastructure of vertical shafts, inclined shafts, horizontal development, raises and stoping developed along the 9km of strike length of the various orebodies from Prestea in the north to Tuapim in the south. Figure 1 shows a long section view of this development and Figure 15.2 indicates the extent of historical stoping operations on the Main Reef, West Reef and Footwall Reef throughout the area.

May 3, 2012
For the purposes of this PEA, only the West Reef resource between 17L and 24L has been evaluated for potential mineability. The access and material movement infrastructure has been designed to reach 30L in order to facilitate future exploration programs.

Both indicated and inferred resources are incorporated in the design, schedule and economic evaluation.

The West Reef resource averages 1.5m true width and ranges from 0.5m to 3.5m wide.

It is proposed that material mined at Prestea Underground Mine will be transported by road to Golden Star Resources Bogoso Mine and processed in the current operating Oxide Plant.

A cut-off grade of 3.1g/t has been used to define the West Reef potentially mineable resource. This cut-off grade is calculated using a gold price of $1,250/oz, mining cost of $90/t, processing cost of $15/t and an administration cost of $7/t.

In July 2007, SRK Consulting (UK) Ltd prepared a geotechnical assessment for the West Reef that proposed mechanized mining could be undertaken using longhole methods with a maximum stope size of 20m on strike x 20m high x 3.5m vein width including dilution. SRK estimated that for this stope size, 1m of dilution would be generated on both the hangingwall and the footwall.

The AVOCA mining method has been applied to the West Reef resource with a stoping production rate of 1,000tpd of mineable resource.

Access to the West Reef resource will be via a new Main Access Decline driven from surface above the resource and via the currently operating Prestea Central Shaft. The Prestea Central Shaft requires significant rehabilitation work to operate at full capacity.

A new raisebored hoisting shaft will be developed from surface to 30L in the vicinity of the Main Access Decline to provide material hoisting to surface.

The AVOCA mining method requires a waste backfill supply. Once stoping operations commence, all the waste generated underground will be used for backfill. In addition, a wastepass will be developed in proximity to the Main Access Decline, to supply waste material to the stopes from surface. In order to limit contamination of the blasted mineralized material with the waste backfill, a “skin” of cemented waste will be applied at the end of the backfilling cycle.

The production schedule includes a four-year pre-development period during which the Central Shaft will be rehabilitated, the Main Access Decline developed, the hoisting shaft developed and
the waste and mineralized development carried out. In steady-state production, the stoping will produce approximately 1,000tpd of mineralized material which will be hoisted to surface in the new shaft.

**Processing**

West Reef material will be trucked to GSR’s Bogoso Oxide Plant in ‘on-road’ haul trucks. For the most part, this will be on a dedicated, private haul road, minimizing interaction with public traffic.

Mineralized material will be stockpiled on the existing Bogoso ROM stockpile and fed to the Oxide Plant crusher by loader. As Prestea Underground Mine feed will displace currently fed open pit ore, no additional processing plant infrastructure will be required as a result of this project.

**Tailings**

Processing tails will be deposited on the currently operated TSF2 tailings storage facility and/or later approved facilities. TSF2 is a conventional tailings storage facility.

**Environmental and Community Considerations**

The Prestea community is supportive of the effort to reopen the underground operation; this support will pave the way for easier permitting with the Environmental Protection Agency, which is considering community input to project development as a key factor.

Due to the limited footprint associated with the development, environmental considerations are deemed manageable and environmental approval for an operating permit should be granted within the normal timelines. The main environmental consideration will be the ongoing management of the discharge water, for which options to address other local (non Golden Star) water pollution problems as part of an overall management plan are being developed.

**Infrastructure**

The Prestea concession is situated directly southwest of, and contiguous with the Bogoso concession. The underground mine property is adjacent to the town of Prestea, which is situated approximately 20 km south of the town of Bogoso, the capital of the newly created Prestea Huni Valley District of the Western Region. Bogoso is 35 km from Tarkwa, an important mining center for the region, and a further 85 km from the port city of Takoradi on the Gulf of Guinea. Accra, the capital of Ghana, is located approximately 370 km by road east/southeast of Prestea.

Electrical power for Prestea Underground Mine is supplied from the National Grid (GRIDCo) via the Prestea substation. In the event of power outage from the national grid, two emergency power units, one at Central Shaft and the other at Bondaye Main shaft are available to supply limited power to essential units of the mine.

Potable water supplied for use on the mine is pumped from the mine pump station which consists of two bore-holes, one of a depth of 46 meters and the other of 20 meters deep.

The mine dewatering is carried out through the two main shafts – Prestea Central Shaft and Bondaye Main Shaft. Currently a combined average daily pumping rate of 5 Ml per day is achieved.
Waste rock hauled up the Main Access Decline and hoisted through Central Shaft highway trucks to be dumped on the Beta Boundary South Waste Dump approximately 4km to the south of Central Shaft.

**Capital Costs**

Table 2 presents the capital cost items for the West Reef mining.

The capital costs presented are to a PEA level of accuracy and are expected to be within ±40%. Given the preliminary nature of the study all costs have a contingency of 25% applied. All costs are in Q1 2012 US dollars.

**Table 2: Capital cost summary (US$000s)**

<table>
<thead>
<tr>
<th>Description</th>
<th>Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>Connecting X/Cut - Ramp to Wpass</td>
<td>2,033</td>
</tr>
<tr>
<td>Haulage to Shaft</td>
<td>2,054</td>
</tr>
<tr>
<td>Hoisting Shaft (RB 4.5m)</td>
<td>12,017</td>
</tr>
<tr>
<td>Main Orepass (RB 2.0m)</td>
<td>2,077</td>
</tr>
<tr>
<td>Main Access Decline</td>
<td>70,529</td>
</tr>
<tr>
<td>Main Decline VR Xcut</td>
<td>1,143</td>
</tr>
<tr>
<td>Decline VR (DR 1.5x1.5m)</td>
<td>894</td>
</tr>
<tr>
<td>Stoppe Edge VR (RB 1.2m)</td>
<td>1,691</td>
</tr>
<tr>
<td>Decline WP (DR 1.5x1.5m)</td>
<td>170</td>
</tr>
<tr>
<td>New Shaft - Hoisting and Headframe</td>
<td>5,000</td>
</tr>
<tr>
<td>Ventilation</td>
<td>1,000</td>
</tr>
<tr>
<td>Pumping</td>
<td>500</td>
</tr>
<tr>
<td>Prestea Central Shaft/Hoist Rehab</td>
<td>4,800</td>
</tr>
<tr>
<td>Backfill Infrastructure</td>
<td>300</td>
</tr>
<tr>
<td>Surface Infrastructure</td>
<td>750</td>
</tr>
<tr>
<td>Other costs</td>
<td>9,860</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>114,818</strong></td>
</tr>
</tbody>
</table>

**Operating Costs**

PEA level operating costs were estimated as follows:

- **Mining costs** – based on a preliminary contractor tender document obtained from a Ghana-based international mining contractor. These costs include stope development and stope mining costs;
- **Haulage costs** – based on current haulage contracts in place for the Bogoso Mine;
- **Processing costs** – based on current operating costs for the Bogoso Oxide Plant where all the West Reef material will be processed; and,
- **G&A costs** – based on current Bogoso Mine G&A costs.
Table 3 summarizes the operating costs incorporated in the economic analysis.

**Table 3: Operating cost summary**

<table>
<thead>
<tr>
<th>Description</th>
<th>Total cost (US$000s)</th>
<th>Unit cost</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Mining Costs</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Stope Bypass Connections</td>
<td>12,088</td>
<td>5,700 /m</td>
</tr>
<tr>
<td>Stope Bypass Drift</td>
<td>55,407</td>
<td>5,700 /m</td>
</tr>
<tr>
<td>Stope Orepass (DR 1.5x1.5m)</td>
<td>264</td>
<td>1,000 /m</td>
</tr>
<tr>
<td>Stope Orepass Xcut</td>
<td>481</td>
<td>5,700 /m</td>
</tr>
<tr>
<td>Mineralized Development</td>
<td>59,545</td>
<td>6,200 /m</td>
</tr>
<tr>
<td>Stope Tonnes</td>
<td>93,474</td>
<td>66 /t-processed</td>
</tr>
<tr>
<td><strong>Total Mining Costs</strong></td>
<td>221,258</td>
<td>120 /t-processed</td>
</tr>
<tr>
<td><strong>Haulage Costs</strong></td>
<td>9,222</td>
<td>5 /t-processed</td>
</tr>
<tr>
<td><strong>Processing Costs</strong></td>
<td>27,667</td>
<td>15 /t-processed</td>
</tr>
<tr>
<td><strong>G&amp;A Costs</strong></td>
<td>12,911</td>
<td>7 /t-processed</td>
</tr>
<tr>
<td><strong>Total Operating Cost</strong></td>
<td>271,058</td>
<td>147 /t-processed</td>
</tr>
</tbody>
</table>

**Indicative Economic Results**

Project net present value at a discount rate of 5% is $107 million with an internal rate of return of 21%. The payback period is 6.3 years from the time of initial investment. Total operating cost is estimated to be $620 per ounce produced.

The project is most sensitive to changes in gold price followed next by operating cost and then capital cost.

**Conclusion**

The Prestea Mine has a long history of underground stoping production and the West Reef area has good potential as a consistent, 1,000tpd production area to supply high-grade material to the Bogoso Oxide Plant.

**Recommendations**

The findings of this PEA provide compelling arguments to move the study to the FS design stage. The following are the recommendations for advancing the project in the individual areas:

**Resource**

- Further drilling along strike and at depth could expand the current resource and upgrade the inferred material to the indicated category.

**Underground Mining**

- Geotechnical logging of all available drill core in the West Reef area;
- Identification and geotechnical evaluation of a suitable portal location for the Main Access Decline and site for the new raisebored hoisting shaft;
- FS level underground design and scheduling work;
- Detailed backfill requirements and testing.

**Process and Tailings**
- Detailed FS-level metallurgical testing to be carried out using current drill core, new core drilling or bulk sampling from accessible underground exposures;
- Metallurgical testing to include a final assessment of the amount of dilution expected from the stoping method applied;

**Infrastructure**
- Evaluate Central Shaft rehabilitation requirements
- Evaluate hoist and headframe upgrade requirements;
- Trade-off study to compare 1,500tpd hoisting upgrade requirements in the Central Shaft to the development of a new raisebored hoisting shaft;

**Environment and Infrastructure**
- Initiate community consultation for the development of the underground operation and determine the methods for including community concerns within the project design and operation
- Develop the environmental and socioeconomic baselines for the operation including a community health assessment
- Complete the environmental permitting process with the appropriate involvement of stakeholders and regulators such that stakeholder concerns are addressed in the design and environmental management plan for the project.

**Preliminary Budget**
- Feasibility Study for current Indicated Mineral Resources in the West Reef area - $1.5 million
- Drilling of 40 resource upgrade holes in West Reef area - $2.5 million
1 Introduction (Item 2)

1.1 Golden Star Resources

Golden Star Resources Ltd (“GSR”) is a Canadian Federally-incorporated, international gold mining and exploration company producing gold in Ghana, West Africa. GSR also conducts gold exploration in other countries in West Africa and in South America. GSR was established under the Canada Business Corporations Act on May 15, 1992 as a result of 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. GSR’s principal office is located at 10901 West Toller Drive, Suite 300, Littleton, Colorado 80127, with registered and records offices located at 333 Bay Street, Bay Adelaide Center, Box 20, Toronto, Ontario M5H 2T6.

GSR owns controlling interests in two gold properties in southwest Ghana:

- Through a 90% owned subsidiary, Golden Star (Bogoso/Prestea) Limited (“GSBPL”), GSR owns and operates the Bogoso/Prestea gold mining and processing operations (“Bogoso/Prestea”) located near the town of Bogoso, Ghana. GSBPL operates a gold ore processing facility at Bogoso/Prestea with a capacity of up to 3.5 million tonnes of ore per annum, which uses bio-oxidation technology to treat refractory sulfide ore (“Bogoso sulfide plant”). In addition, GSBPL has a carbon-in-leach (“CIL”) processing facility located next to the sulfide plant, which is suitable for treating oxide gold ores (“Bogoso Oxide Plant”) at a rate up to 1.5 million tonnes per annum. Bogoso/Prestea produced and sold 140,504 ounces of gold in 2011 and 170,973 ounces of gold in 2010; and,

- Through another 90% owned subsidiary, Golden Star (Wassa) Limited (“GSWL”), GSR owns and operates the Wassa open-pit gold mine and carbon-in-leach processing plant (“Wassa”), located approximately 35 km east of Bogoso/Prestea. The design capacity of the carbon-in-leach processing plant at Wassa (“Wassa processing plant”) is nominally 3.0 million tonnes per annum but varies depending on the ratio of hard to soft ore. GSWL also owns the Hwini-Butre and Benso concessions (“HBB”) in southwest Ghana. Ore from the HBB mines is sent to Wassa for processing. The Hwini-Butre and Benso concessions are located approximately 80 km and 50 km, respectively, south of Wassa along the Company’s dedicated haul road. Wassa/HBB produced and sold 160,616 ounces of gold in 2011 and 183,931 ounces of gold in 2010.

GSR also holds interests in several gold exploration projects in Ghana and elsewhere in West Africa including Sierra Leone, Niger and Côte d’Ivoire, and in South America exploration properties are held and managed in Brazil.

The Prestea Underground Mine is an inactive underground gold mine located 15km south of the Bogoso mine and adjacent to the town of Prestea. The property consists of two usable access shafts and extensive underground workings and support facilities. Access to the mine site is via a paved road from Tarkwa.

The Prestea Underground Mine was mined from the 1870’s until 2002 when mining ceased following an extended period of low gold prices in the late 1990s and early 2000s. The Prestea Underground Mine has produced approximately nine million ounces of gold, the second highest
production of any mine in Ghana. The underground workings are extensive, reaching depths of approximately 1,450 meters and extending along a strike length of nine kilometers. Underground workings can currently be accessed via two surface shafts, one near the town of Prestea (Central Shaft) and a second approximately four kilometers to the southwest at Bondaye.

GSBPL now 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 Golden Star.

GSR continues to dewater the Prestea Underground Mine, and is currently refurbishing the Central Shaft and assessing services on 12, 17 and 24 levels.

1.2 Terms of Reference and Purpose of the Report

This PEA is intended for the use of GSR to further the evaluation of the Prestea Underground Mine by estimating resources in accordance with the Canadian Institute of Mining, Metallurgy and Petroleum (CIM) classification system. A mining method and access development strategy is proposed, in addition to infrastructure and processing options. The capital and operating costs and production parameters have been used to generate indicative economics.

The report includes the mining of indicated mineral resources and inferred mineral resources that are considered too speculative, geologically, to have economic considerations applied to them. Therefore, this material cannot be classified as Mineral Reserves and the term “potentially mineable resource” is used in lieu of “reserves”.

This Preliminary Economic Assessment has been prepared in accordance with the guidelines provided by the National Instrument 43-101 (NI 43-101) Standards of Disclosure for Mineral Projects.

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

1.3 Sources of Information

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

- NI 43-101 compliant resource estimation reports prepared by SRK (UK) Ltd.;
- Geotechnical assessment report prepared by SRK (UK) Ltd.;
- Metallurgical assessment report prepared by JMA Ltd;
- Various in-house and external geological reports and papers;
- Data archives at the Prestea Underground Mine site offices;

1.4 Site Inspections

S. Mitchel Wasel is the QP responsible for Sections 5, 6, 7, 8, 9, 10 and 12 of this report. Mr. Wasel is based in Takoradi, Ghana and is employed by GSR as Vice President of Exploration. He has visited the site on numerous occasions over the past 10 years, the last time on May 2, 2012.

Martin Raffield is QP responsible for sections 1 through 4, 11 and 13 through 25 of this report. He is based at the corporate office in Denver Colorado and employed by GSR as Senior Vice
President, Technical Services. Dr. Rafffield has visited the site several times over the past year since he joined Golden Star and last visited the site on January 12, 2012.
2 Property Description and Location (Item 4)

2.1 Property Location

The Prestea concession is located in the western region of Ghana approximately 200 kilometers from the capital Accra and 50 kilometers from the coast of the Gulf of Guinea. The map in Figure 2.1 shows the location of the Prestea area along with road infrastructure, major urban centers and surface hydrology.

Source: United Nations undated

Figure 2-1: Map of Ghana

The map in Figure 2.2 illustrates the outline of the Prestea mining lease along with geographic latitude and longitude of each points of the mining lease.
2.2 Mineral Titles and Agreements.

The Prestea concession is a mining lease that was issued to Prestea Gold Resources (PGR) on June 29, 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 below 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 km², which represents only a portion of the entire 116 km² Prestea Mining Lease. A joint operating agreement was signed in January 2002 between Bogoso Gold Limited, a subsidiary of Golden Star Resources incorporated under the laws of Ghana, and Prestea Gold Resources. An amount of USD 2,100,000 was paid to Prestea Gold Resources as a first option payment. This agreement granted Bogoso Gold Limited the right to develop and operate the Prestea underground mine while also setting out the protocols and procedures to be observed by Bogoso Gold Limited and Prestea Gold Resources in the day-to-day operations of the surface and underground mining operations.

A second agreement entitled Memorandum of Agreement was signed on March 14, 2002 between Prestea Gold Resources Limited, Bogoso Gold Limited, Prestea Goldfields Limited, the State Gold Mining Company Limited, 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 Prestea Underground Mine at the time and to consolidate the management of the underground mine. The agreement also defined the conditions for the Prestea
Underground Mine to be put under care and maintenance, which include mine dewatering and shaft maintenance along with number of employees required. The Prestea Underground Mine has remained under care and maintenance since the signature of the agreement.

2.3 Royalties and Encumbrances

Royalties associated with the Prestea Mining lease are defined under Section 21 of the mining lease that was issued to Prestea Gold Resources on June 29, 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.

On September 7, 2010, a letter with reference number C.108 was issued to Golden Star Resources by the Internal Revenue Service of Ghana stipulating that Royalties were to be raised from 3% to 5% with retroactive effect from March 19, 2010. This 5% royalty is the only royalty associated with the Prestea mining lease.

The only other financial obligation related to the Prestea mining lease is a rent for land usage, which is defined under Section 20 of the mining lease that was issued to Prestea Gold Resources on June 29, 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 $0.50 per square kilometer.

2.4 Environmental Liabilities

The existing environmental liabilities associated with the Prestea underground operation were included in an indemnity granted to the joint venture. All the existing surface and underground liabilities associated with the Prestea underground mine, are, therefore, not of material consequence to the development project. It is expected that some of the liabilities will be transferred to the development company once operations commence. However, when compared to the existing asset retirement obligations in place for GSBPL, these liabilities are considered immaterial.

2.5 Operating Permits Required

To develop the Prestea Underground, an environmental approval for the project is required. The permitting process is as follows:

- Submission of an EA2 to the EPA to register the project
- Submission of a draft Environmental Scoping Report and Terms of Reference for EPA comment
- Completion of an EIA with the submission of a draft EIS for EPA comment
- Potential public hearing
- Revision and submission of the EIS
- Issuance of the Environmental Permit.
3 Accessibility, Climate, Local Resources and Infrastructure (Item 5)

3.1 Infrastructure and Physiography
Local population centers are located at Bogoso Town in the north of the Bogoso Concession, and Prestea Town in the center of the Prestea Concession. Bogoso is located on the main road from Tarkwa to Kumasi. There is a tarred road between Bogoso and Prestea. The Prestea Town is located adjacent to the Plant North Deposit and the backfilled workings and offices are within the outskirts of the town. The Main Shaft complex at Prestea is also located within the Town limits.

3.2 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. There are two rainy seasons between April-June and September-November. The average annual rainfall in the immediate project area is 2,030 mm. The heavy rains during the rainy season do not adversely affect the operation, although care needs to be taken on haul roads during heavy rain. The climate is tropical with average temperatures ranging from between 21°C and 32°C.

3.3 Climate and Length of Operating Season
As the Project is an underground mine, the climate has very little implication for the operations. In the tropical environment, work on the surface can continue year round with short breaks during storm events. However, most storms are short-lived and may be experienced through most of the year. The rainy season may affect the underground dewatering efforts.

3.4 Access to Property
Access to the property is by tarred road and it is, therefore, easily accessible from Accra (6 to 7 hours), Tarkwa (1 to 2 hours) and the major port at Takoradi (3 to 4 hours). There are airports at Kumasi and Takoradi, which provide daily services to the International Airport at Accra. Kumasi is situated some 4 hours 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. The road, however, remains in poor condition but is passable throughout the year.

3.5 Surface Rights
Prestea Gold Resources (PGR) was granted the PGR Mining Lease by the Government on 29, June 2001 conferring on PGR the exclusive right to conduct underground gold mining operations with the Prestea Concession Areas below a depth of 150 m below sea level for a period of 30 years effective from the date of the PGR Mining Lease. The area of the underground lease mirrors that of the surface mining lease at a total of 129 km².

Bogoso Gold Limited (BGL) was granted the BGL Mining Lease by the Government on 29, June, 2001 conferring on the company the exclusive right to conduct surface gold mining...
operations over the Prestea Concession Area for a period of 30 years effect from the date of the BGL Mining Lease. Golden Star Resources subsequently renamed BGL to GSBPL. Therefore, the surface rights to the area remain within GSR. The mining lease is registered under 2799/2001 in the Ghana lands registry.

3.6 Local Resources and Infrastructure

The Project is in an area where mining has occurred more or less continuously since the late 1800s. The Project is the expansion of an existing underground mining operation. Therefore, the required services, infrastructure and community support are already in place. The following are relevant to the assessment of resources and infrastructure:

- Surface access to the Project is via the public road network that extends on to the Project site;
- Electricity and water are available – electricity 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 mineralized material will be carried out at the existing GSBPL Oxide Plant;
- Tailings storage will be in the existing GSBPL tailings storage facility;
- Any waste rock generated at the site will be co-disposed with the surface mining waste associated with the GSBPL Prestea South Project; and,
- The extensive history of mining in the local Project area and also in Ghana provide opportunities to obtain skilled underground workers. Any additional training requirements can be sourced within Ghana. Currently, GSBPL has several workers being trained at the Obuasi underground mine.
4 History (Item 6)

4.1 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 region were consolidated under the management of Prestea Gold limited, a subsidiary of the State Gold Mining Corporation.

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 State Gold Mining Corporation 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 Prestea Gold Resources Limited. The mine operated for 3 years until a permanent closure in early 2002 due to depressed gold prices and financial difficulties, the mine has remained under care and maintenance since the 2002 closure.

4.2 Past Exploration and Development

Ariston Mining established most of the current infrastructure and underground development prior to nationalization in the late 1950’s. The Prestea Underground Mine workings extends over a distance of 9 km along strike and down to a maximum depth of about 1,400 meters. 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 1,238m below surface to 30 Level. 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 was trammed to Central Shaft to loading pockets located below 20L, 25L, and 30L, 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 1,300-1,600t/day.

Bondaye Shaft extends to a depth of 1,103m, 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 level 23 to level 35 and was used as the primary access to level 35, the lowest developed level in the mine. No 6 shaft extends from level 24 to level 31.

During the Ariston Mining period, exploration consisted mainly in driving crosscuts from the main footwall drive across the 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.
Exploration drilling targeting the West Reef structure essentially started in the 1970’s and continued until the closure of the mine in 2002. Over the life of the mine between 1938 and 2002, a total of 966 underground holes were drilled at Prestea.

4.3 Historic Mineral Resource and Reserve Estimates

Previous operators of Prestea (Barnex JCI Ltd.) have historically classified a certain amount of material as a Mineral Resource. This historical resource was reviewed by SRK, which reported this data in a 2003 report to GSR. 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 this PEA.

NI 43-101 compliant reserves have not been reported historically for the Prestea Underground Mine.

4.4 Historic 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 Tuappim concessions located to the south of Anfargah. These concessions were acquired by Ghana Main Reef Limited in 1933 and operated continually 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 State Gold Mining Corporation [SGMC] was established under the State Gold  Mining Corporation 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.

Accurate 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 million t of ore for the recovery of 5.95 million ozs of gold. The average ore grade is estimated to have been 11 g/t. In addition the Brumasi Mine is reported to have produced 307,000 t yielding 230,000 ozs of gold for an average grade of 23.3 g/t. Prior to the amalgamation with Prestea, Ghana Main Reef produced about 2 million t of ore for approximately 1.0 million ozs at an estimated ore grade of 15 g/t. Total production from the area, excluding the Buesichem open cut is estimated to be in
excess of 19 million t and 7.18 million ozs of gold. This estimate is slightly lower than the Ghana Chamber of Mines which has recorded approximately nine million ounces of gold produced from the Prestea area since 1877.

Production from Prestea peaked at 446,372 t in 1964 when 166,973 ozs 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 in 1927. Production endured a serious decline throughout the mid to late 1970’s due to a lower amount of stopes being developed and lack of underground development to access new ground. The mine closed down in 2002 and has remained under care and maintenance since.

![Historic Prestea Underground Mine Production](image)

**Figure 4-1: Historic Prestea Underground Mine Production**
5 Geologic Setting and Mineralization (Item 7)

5.1 Regional Geology

The content of this section describing the regional geological setting has been summarized from Perrouty et al. 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 (Fig. 5.1) and host numerous hydrothermal gold deposits such as the Obuasi and Prestea mines and paleoplacer deposits such as the Tarkwa and Teberebie Mines.

![Figure 5-1: The West African Craton (Perrouty et al, 2012)](image)

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.

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 ± 6 Ma and 2266 ± 2 Ma. Detrital zircons in the metasediments indicate the initiation of their deposition between 2142 ± 24 Ma 2154 ± 2 Ma. The Kumasi Group was intruded by the late sedimentary Suhuma granodiorite at 2136 ± 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 5.1). The Kawere Group located at the base of the Tarkwaian super group is composed of conglomerates and sandstones with a thickness varying between 250 m 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, 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 1300 m thick (Pigois et al., 2003). U/Pb and Pb/Pb geochronology dating of detrital zircons provide a maximum depositional age of 2132 ± 2.8 Ma for the Kawere formation and 2132.6 ± 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 ± 4 Ma from 71 concordant zircons of the Banket formation. According to all concordant zircons histogram (161 grains) and their uncertainties (Fig. 5.2), a reasonable estimation for the start of the Tarkwaian sedimentation could be as young as 2107 Ma.
Table 5.1: Tarkwaian sedimentary sequences and estimated thicknesses (Perrouty et al, 2012)

<table>
<thead>
<tr>
<th>Tarkwaian Unit</th>
<th>Dompim quartzites</th>
<th>Dompim phylites</th>
<th>Huni sandstones</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1000 ft (300 m)</td>
<td>1500 ft (450 m)</td>
<td>-</td>
</tr>
<tr>
<td>Huni sandstones</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>600 ft (100 m)</td>
<td>-</td>
<td>&lt; 200 m</td>
</tr>
<tr>
<td>Deletrite silt</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Thickness</th>
<th>4500 ft (1370 m)</th>
<th>1370 m</th>
<th>&gt; 1300 m</th>
</tr>
</thead>
<tbody>
<tr>
<td>Banket Group</td>
<td>Mineralized conglomerates</td>
<td>2100 ft (640 m)</td>
<td>100 - 180 m</td>
</tr>
<tr>
<td></td>
<td>Sandstones</td>
<td>500 - 1000 ft (160 - 300 m)</td>
<td>20 - 90 m</td>
</tr>
<tr>
<td></td>
<td>Suumblantero</td>
<td>100 - 300 ft (30 - 90 m)</td>
<td>150 - 600 m</td>
</tr>
<tr>
<td></td>
<td>Conglomerates levels</td>
<td>1000 ft (300 m)</td>
<td>150 - 350 m</td>
</tr>
<tr>
<td></td>
<td>Interbedded with sandstones and phylites</td>
<td>-</td>
<td>250 - 700 m</td>
</tr>
<tr>
<td></td>
<td>-</td>
<td>250 - 700 m</td>
<td></td>
</tr>
</tbody>
</table>

Figure 5-2: Radiometric age data histograms (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 2180–2150 Ma (Eoeburnean) and 2130–2070 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 Mponor 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 Archean and Paleoproterozoic basement. In southwestern 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 ± 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 500–650 °C and 5–6 kbar (John et al., 1999), dated at 2092 ± 3 Ma (Oberthür et al., 1998).
Source: Golden Star, 2012

Figure 5-3: GSR Prestea concession
5.2 Property Geology

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 Tarkwain litho-structural assemblage, the tectonic breccia assemblage, the graphitic Birimian sedimentary assemblage and the undeformed Birimian sedimentary assemblage. A simplified geology map in Figure 5.3 illustrates the relationship between the Tarkwain and Birimian litho-structural assemblages.

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 Tarkwain sediment clasts. Volcanic lenses illustrated on Figure 5.4 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 5.4 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 show in pictures B and C from Figure 5.4, 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 5.4 illustrates typical beddings of siltstones intercalated with wacke sub-units.
Figure 5-4: Lithologies hosting the Prestea deposit

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 level 30 at crosscut 204N. E: Hand sample from level 24 of mafic volcanic rocks. F: Footwall tectonic breccia from Plant North Pit.
The Prestea Mine 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 deforming events have been described and observed by several authors throughout the West African shield including Milesi, Alibone and Perrouty. The D1 deforming event at Prestea affects the older volcano-sedimentary Birimian and was generated during an extensional phase. The D2 deforming 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 events, resulting in strike-slip movement along the major D2 faults, the development of regional scale fold (Figure 5.5) and of 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 deforming 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 5.5.

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 deforming 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 Prestea Mine 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 level 17 from crosscut 307-308S shows that the tectonic breccia located in the footwall of the Main Reef fault has undergone intense shearing during the D3 and D4 deforming 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.

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 5.5 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 gouge is commonly associated to the mineralized quartz veins and is also generally mineralized, although in most cases at lower grades then the associated quartz veins. Quartz veins are typically one to two meters wide, but widths up to 5 meters 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 2-10% acicular arsenopyrite crystals and 1-5% 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 5.5 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 (10-25 meters) and stretched along a North-South trend, sub-parallel to the main foliation. On average the lenses will be 50-100 meters long and locally up to 300 meters. 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 hangingwall, 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 1.5m 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 5-5: Mineralization styles and structural features characterizing the Prestea deposit
A: Reef style mineralization (Fault fill quartz veins) from hole UC 1044 at a depth of 130 meters. B: Reef style mineralization (Fault fill quartz veins) from the Spur Reef Fault, level 7 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.
6 Deposit Type (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 Archean 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 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 one hundred metres. Generally, the weathering profile typically consists of a lateritic surface, a saprolitic horizon, a transitional zone and a deeper primary sulphide zone.
7 Exploration (Item 9)

The Prestea underground West Reef structure was the last area to be mined by PGR in 2002. The subsequent exploration of the West Reef underground structure has been planned and managed by Golden Star Resources Ltd and was initiated in 2004. The 17 level West Reef drive exposes the vein structure from 7618 N to the south to 8065 N to the north which represents a distance of approximately 450 meters. Along the West Reef drive the back has been sampled approximately every 5 meters using a 2 x 2 inch channel sample which was cut using a compressed 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 level reef drive averaging 2.4 m width with composite grades ranging from 0.1 g/t to 127 g/t. The results are summarized in Table 7.1.

Table 7.1: Channel Sample results 17 Level West Reef Drive

<table>
<thead>
<tr>
<th>Channel #</th>
<th>X</th>
<th>Y</th>
<th>Z</th>
<th>LEVEL</th>
<th>FROM</th>
<th>TO</th>
<th>INTERVAL</th>
<th>Grade g/t</th>
</tr>
</thead>
<tbody>
<tr>
<td>17WR_01A</td>
<td>11949.0</td>
<td>8041.3</td>
<td>4464.9</td>
<td>17</td>
<td>0.0</td>
<td>2.6</td>
<td>2.6</td>
<td>0.6</td>
</tr>
<tr>
<td>17WR_02</td>
<td>11946.0</td>
<td>8034.2</td>
<td>4466.3</td>
<td>17</td>
<td>0.0</td>
<td>1.9</td>
<td>1.9</td>
<td>6.2</td>
</tr>
<tr>
<td>17WR_02A</td>
<td>11946.3</td>
<td>8034.5</td>
<td>4467.1</td>
<td>17</td>
<td>0.0</td>
<td>1.9</td>
<td>1.9</td>
<td>6.5</td>
</tr>
<tr>
<td>17WR_03</td>
<td>11945.0</td>
<td>8029.1</td>
<td>4466.6</td>
<td>17</td>
<td>0.0</td>
<td>1.3</td>
<td>1.3</td>
<td>127.1</td>
</tr>
<tr>
<td>17WR_03A</td>
<td>11944.9</td>
<td>8028.8</td>
<td>4466.8</td>
<td>17</td>
<td>0.0</td>
<td>1.3</td>
<td>1.3</td>
<td>1.7</td>
</tr>
<tr>
<td>17WR_03B</td>
<td>11945.0</td>
<td>8029.7</td>
<td>4466.5</td>
<td>17</td>
<td>0.0</td>
<td>1.5</td>
<td>1.5</td>
<td>1.1</td>
</tr>
<tr>
<td>17WR_04</td>
<td>11943.9</td>
<td>8022.1</td>
<td>4466.2</td>
<td>17</td>
<td>0.0</td>
<td>2.0</td>
<td>2.0</td>
<td>20.2</td>
</tr>
<tr>
<td>17WR_04A</td>
<td>11944.2</td>
<td>8022.8</td>
<td>4467.0</td>
<td>17</td>
<td>0.0</td>
<td>2.1</td>
<td>2.1</td>
<td>3.9</td>
</tr>
<tr>
<td>17WR_05</td>
<td>11943.3</td>
<td>8018.0</td>
<td>4466.3</td>
<td>17</td>
<td>0.0</td>
<td>2.3</td>
<td>2.3</td>
<td>5.3</td>
</tr>
<tr>
<td>17WR_05A</td>
<td>11943.4</td>
<td>8018.2</td>
<td>4467.0</td>
<td>17</td>
<td>0.0</td>
<td>2.3</td>
<td>2.3</td>
<td>9.0</td>
</tr>
<tr>
<td>17WR_06</td>
<td>11943.0</td>
<td>8015.0</td>
<td>4466.6</td>
<td>17</td>
<td>0.0</td>
<td>2.4</td>
<td>2.4</td>
<td>64.9</td>
</tr>
<tr>
<td>17WR_06A</td>
<td>11943.2</td>
<td>8015.2</td>
<td>4466.6</td>
<td>17</td>
<td>0.0</td>
<td>2.0</td>
<td>2.0</td>
<td>1.7</td>
</tr>
<tr>
<td>17WR_06B</td>
<td>11943.1</td>
<td>8014.0</td>
<td>4466.3</td>
<td>17</td>
<td>0.0</td>
<td>2.8</td>
<td>2.8</td>
<td>22.2</td>
</tr>
<tr>
<td>17WR_07</td>
<td>11937.5</td>
<td>7992.6</td>
<td>4466.2</td>
<td>17</td>
<td>0.0</td>
<td>3.0</td>
<td>3.0</td>
<td>37.4</td>
</tr>
<tr>
<td>17WR_07A</td>
<td>11937.5</td>
<td>7993.1</td>
<td>4466.5</td>
<td>17</td>
<td>0.0</td>
<td>2.8</td>
<td>2.8</td>
<td>63.4</td>
</tr>
<tr>
<td>17WR_07B</td>
<td>11937.3</td>
<td>7992.3</td>
<td>4466.1</td>
<td>17</td>
<td>0.0</td>
<td>3.1</td>
<td>3.1</td>
<td>13.9</td>
</tr>
<tr>
<td>17WR_08</td>
<td>11936.1</td>
<td>7987.9</td>
<td>4466.0</td>
<td>17</td>
<td>0.0</td>
<td>3.1</td>
<td>3.1</td>
<td>74.9</td>
</tr>
<tr>
<td>17WR_08A</td>
<td>11936.3</td>
<td>7988.2</td>
<td>4466.0</td>
<td>17</td>
<td>0.0</td>
<td>3.2</td>
<td>3.2</td>
<td>69.5</td>
</tr>
<tr>
<td>17WR_08B</td>
<td>11936.3</td>
<td>7988.3</td>
<td>4466.0</td>
<td>17</td>
<td>0.0</td>
<td>3.0</td>
<td>3.0</td>
<td>28.7</td>
</tr>
<tr>
<td>17WR_09</td>
<td>11934.7</td>
<td>7977.8</td>
<td>4466.0</td>
<td>17</td>
<td>0.0</td>
<td>2.5</td>
<td>2.5</td>
<td>31.4</td>
</tr>
<tr>
<td>17WR_09A</td>
<td>11934.7</td>
<td>7977.8</td>
<td>4466.0</td>
<td>17</td>
<td>0.0</td>
<td>2.3</td>
<td>2.3</td>
<td>53.2</td>
</tr>
<tr>
<td>17WR_10</td>
<td>11933.1</td>
<td>7967.1</td>
<td>4465.6</td>
<td>17</td>
<td>0.0</td>
<td>3.0</td>
<td>3.0</td>
<td>42.1</td>
</tr>
<tr>
<td>17WR_10A</td>
<td>11933.1</td>
<td>7967.4</td>
<td>4465.5</td>
<td>17</td>
<td>0.0</td>
<td>2.9</td>
<td>2.9</td>
<td>1.8</td>
</tr>
<tr>
<td>17WR_10B</td>
<td>11933.1</td>
<td>7967.6</td>
<td>4465.6</td>
<td>17</td>
<td>0.0</td>
<td>2.8</td>
<td>2.8</td>
<td>18.4</td>
</tr>
<tr>
<td>17WR_11</td>
<td>11928.6</td>
<td>7941.2</td>
<td>4464.9</td>
<td>17</td>
<td>0.0</td>
<td>2.2</td>
<td>2.2</td>
<td>116.9</td>
</tr>
<tr>
<td>17WR_11A</td>
<td>11928.4</td>
<td>7940.7</td>
<td>4465.0</td>
<td>17</td>
<td>0.0</td>
<td>1.6</td>
<td>1.6</td>
<td>6.2</td>
</tr>
<tr>
<td>17WR_11B</td>
<td>11928.0</td>
<td>7942.0</td>
<td>4464.8</td>
<td>17</td>
<td>0.0</td>
<td>2.8</td>
<td>2.8</td>
<td>57.8</td>
</tr>
<tr>
<td>17WR_12</td>
<td>11926.1</td>
<td>7923.3</td>
<td>4464.9</td>
<td>17</td>
<td>0.0</td>
<td>2.1</td>
<td>2.1</td>
<td>108.0</td>
</tr>
<tr>
<td>17WR_12A</td>
<td>11925.9</td>
<td>7922.8</td>
<td>4464.7</td>
<td>17</td>
<td>0.0</td>
<td>2.1</td>
<td>2.1</td>
<td>6.4</td>
</tr>
<tr>
<td>17WR_12B</td>
<td>11925.8</td>
<td>7922.2</td>
<td>4464.6</td>
<td>17</td>
<td>0.0</td>
<td>2.5</td>
<td>2.5</td>
<td>34.9</td>
</tr>
<tr>
<td>17WR_13</td>
<td>11925.2</td>
<td>7913.9</td>
<td>4464.7</td>
<td>17</td>
<td>0.0</td>
<td>2.4</td>
<td>2.4</td>
<td>51.3</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>---</td>
<td>---</td>
<td>---</td>
<td>---</td>
<td>---</td>
<td>---</td>
<td>---</td>
<td>---</td>
<td></td>
</tr>
<tr>
<td>17WR_13A</td>
<td>11925.2</td>
<td>7913.5</td>
<td>4464.7</td>
<td>17</td>
<td>0.0</td>
<td>2.3</td>
<td>2.3</td>
<td></td>
</tr>
<tr>
<td>17WR_13B</td>
<td>11925.0</td>
<td>7914.4</td>
<td>4464.9</td>
<td>17</td>
<td>0.0</td>
<td>2.2</td>
<td>2.2</td>
<td></td>
</tr>
<tr>
<td>17WR_14</td>
<td>11924.3</td>
<td>7906.1</td>
<td>4464.9</td>
<td>17</td>
<td>0.0</td>
<td>2.1</td>
<td>2.1</td>
<td></td>
</tr>
<tr>
<td>17WR_14A</td>
<td>11924.3</td>
<td>7906.4</td>
<td>4464.9</td>
<td>17</td>
<td>0.0</td>
<td>2.4</td>
<td>2.4</td>
<td></td>
</tr>
<tr>
<td>17WR_15</td>
<td>11923.2</td>
<td>7898.7</td>
<td>4464.7</td>
<td>17</td>
<td>0.0</td>
<td>2.1</td>
<td>2.1</td>
<td></td>
</tr>
<tr>
<td>17WR_15A</td>
<td>11923.1</td>
<td>7898.1</td>
<td>4464.8</td>
<td>17</td>
<td>0.0</td>
<td>1.8</td>
<td>1.8</td>
<td></td>
</tr>
<tr>
<td>17WR_15B</td>
<td>11923.2</td>
<td>7898.9</td>
<td>4464.7</td>
<td>17</td>
<td>0.0</td>
<td>2.3</td>
<td>2.3</td>
<td></td>
</tr>
<tr>
<td>17WR_16</td>
<td>11923.6</td>
<td>7887.5</td>
<td>4465.2</td>
<td>17</td>
<td>0.0</td>
<td>2.7</td>
<td>2.7</td>
<td></td>
</tr>
<tr>
<td>17WR_16A</td>
<td>11923.6</td>
<td>7887.9</td>
<td>4465.2</td>
<td>17</td>
<td>0.0</td>
<td>2.8</td>
<td>2.8</td>
<td></td>
</tr>
<tr>
<td>17WR_17</td>
<td>11923.4</td>
<td>7875.9</td>
<td>4465.6</td>
<td>17</td>
<td>0.0</td>
<td>2.9</td>
<td>2.9</td>
<td></td>
</tr>
<tr>
<td>17WR_18</td>
<td>11921.8</td>
<td>7869.7</td>
<td>4465.1</td>
<td>17</td>
<td>0.0</td>
<td>1.4</td>
<td>1.4</td>
<td></td>
</tr>
<tr>
<td>17WR_19</td>
<td>11921.4</td>
<td>7865.1</td>
<td>4464.9</td>
<td>17</td>
<td>0.0</td>
<td>2.7</td>
<td>2.7</td>
<td></td>
</tr>
<tr>
<td>17WR_20</td>
<td>11923.4</td>
<td>7861.5</td>
<td>4464.6</td>
<td>17</td>
<td>0.0</td>
<td>3.0</td>
<td>3.0</td>
<td></td>
</tr>
<tr>
<td>17WR_21</td>
<td>11922.0</td>
<td>7853.3</td>
<td>4464.3</td>
<td>17</td>
<td>0.0</td>
<td>3.3</td>
<td>3.3</td>
<td></td>
</tr>
<tr>
<td>17WR_22</td>
<td>11922.0</td>
<td>7848.3</td>
<td>4464.0</td>
<td>17</td>
<td>0.0</td>
<td>2.9</td>
<td>2.9</td>
<td></td>
</tr>
<tr>
<td>17WR_23</td>
<td>11922.2</td>
<td>7843.4</td>
<td>4464.2</td>
<td>17</td>
<td>0.0</td>
<td>3.1</td>
<td>3.1</td>
<td></td>
</tr>
<tr>
<td>17WR_24</td>
<td>11922.7</td>
<td>7838.8</td>
<td>4464.3</td>
<td>17</td>
<td>0.0</td>
<td>2.7</td>
<td>2.7</td>
<td></td>
</tr>
<tr>
<td>17WR_25</td>
<td>11924.4</td>
<td>7830.9</td>
<td>4464.7</td>
<td>17</td>
<td>0.0</td>
<td>3.2</td>
<td>3.2</td>
<td></td>
</tr>
<tr>
<td>17WR_26</td>
<td>11923.9</td>
<td>7826.3</td>
<td>4464.8</td>
<td>17</td>
<td>0.0</td>
<td>2.5</td>
<td>2.5</td>
<td></td>
</tr>
<tr>
<td>17WR_27</td>
<td>11923.7</td>
<td>7821.5</td>
<td>4464.6</td>
<td>17</td>
<td>0.0</td>
<td>2.3</td>
<td>2.3</td>
<td></td>
</tr>
<tr>
<td>17WR_28</td>
<td>11922.6</td>
<td>7817.3</td>
<td>4464.9</td>
<td>17</td>
<td>0.4</td>
<td>3.2</td>
<td>2.8</td>
<td></td>
</tr>
<tr>
<td>17WR_29</td>
<td>11919.9</td>
<td>7811.9</td>
<td>4464.5</td>
<td>17</td>
<td>0.0</td>
<td>2.5</td>
<td>2.5</td>
<td></td>
</tr>
<tr>
<td>17WR_30</td>
<td>11916.9</td>
<td>7807.9</td>
<td>4465.0</td>
<td>17</td>
<td>0.0</td>
<td>1.8</td>
<td>1.8</td>
<td></td>
</tr>
<tr>
<td>17WR_31</td>
<td>11916.1</td>
<td>7804.1</td>
<td>4464.9</td>
<td>17</td>
<td>0.0</td>
<td>3.0</td>
<td>3.0</td>
<td></td>
</tr>
<tr>
<td>17WR_32</td>
<td>11915.9</td>
<td>7782.9</td>
<td>4464.6</td>
<td>17</td>
<td>0.0</td>
<td>2.6</td>
<td>2.6</td>
<td></td>
</tr>
<tr>
<td>17WR_33</td>
<td>11916.1</td>
<td>7776.9</td>
<td>4464.9</td>
<td>17</td>
<td>0.0</td>
<td>2.3</td>
<td>2.3</td>
<td></td>
</tr>
<tr>
<td>17WR_34</td>
<td>11917.3</td>
<td>7767.0</td>
<td>4465.3</td>
<td>17</td>
<td>0.0</td>
<td>2.3</td>
<td>2.3</td>
<td></td>
</tr>
<tr>
<td>17WR_35</td>
<td>11917.6</td>
<td>7762.5</td>
<td>4465.7</td>
<td>17</td>
<td>0.0</td>
<td>1.9</td>
<td>1.9</td>
<td></td>
</tr>
<tr>
<td>17WR_36</td>
<td>11918.7</td>
<td>7757.2</td>
<td>4465.9</td>
<td>17</td>
<td>0.0</td>
<td>1.8</td>
<td>1.8</td>
<td></td>
</tr>
<tr>
<td>17WR_37</td>
<td>11919.1</td>
<td>7752.2</td>
<td>4465.2</td>
<td>17</td>
<td>0.0</td>
<td>2.3</td>
<td>2.3</td>
<td></td>
</tr>
<tr>
<td>17WR_38</td>
<td>11918.7</td>
<td>7745.9</td>
<td>4465.5</td>
<td>17</td>
<td>0.0</td>
<td>2.1</td>
<td>2.1</td>
<td></td>
</tr>
<tr>
<td>17WR_39</td>
<td>11917.0</td>
<td>7741.3</td>
<td>4465.7</td>
<td>17</td>
<td>0.0</td>
<td>2.3</td>
<td>2.3</td>
<td></td>
</tr>
<tr>
<td>17WR_40</td>
<td>11916.5</td>
<td>7736.4</td>
<td>4465.7</td>
<td>17</td>
<td>0.0</td>
<td>3.0</td>
<td>3.0</td>
<td></td>
</tr>
<tr>
<td>17WR_41</td>
<td>11915.2</td>
<td>7732.2</td>
<td>4465.7</td>
<td>17</td>
<td>0.0</td>
<td>2.6</td>
<td>2.6</td>
<td></td>
</tr>
<tr>
<td>17WR_42</td>
<td>11915.6</td>
<td>7726.8</td>
<td>4465.6</td>
<td>17</td>
<td>0.0</td>
<td>2.4</td>
<td>2.4</td>
<td></td>
</tr>
<tr>
<td>17WR_43</td>
<td>11914.2</td>
<td>7721.9</td>
<td>4466.3</td>
<td>17</td>
<td>0.0</td>
<td>2.5</td>
<td>2.5</td>
<td></td>
</tr>
<tr>
<td>17WR_44</td>
<td>11914.2</td>
<td>7716.7</td>
<td>4465.4</td>
<td>17</td>
<td>0.0</td>
<td>2.5</td>
<td>2.5</td>
<td></td>
</tr>
<tr>
<td>17WR_45</td>
<td>11912.2</td>
<td>7712.2</td>
<td>4465.9</td>
<td>17</td>
<td>0.0</td>
<td>2.9</td>
<td>2.9</td>
<td></td>
</tr>
<tr>
<td>17WR_46</td>
<td>11912.0</td>
<td>7706.6</td>
<td>4466.1</td>
<td>17</td>
<td>0.0</td>
<td>2.4</td>
<td>2.4</td>
<td></td>
</tr>
<tr>
<td>17WR_47</td>
<td>11911.3</td>
<td>7701.8</td>
<td>4466.8</td>
<td>17</td>
<td>0.0</td>
<td>1.7</td>
<td>1.7</td>
<td></td>
</tr>
<tr>
<td>17WR_48</td>
<td>11910.6</td>
<td>7697.1</td>
<td>4466.2</td>
<td>17</td>
<td>0.0</td>
<td>2.1</td>
<td>2.1</td>
<td></td>
</tr>
<tr>
<td>17WR_49</td>
<td>11909.9</td>
<td>7692.1</td>
<td>4466.5</td>
<td>17</td>
<td>0.0</td>
<td>2.6</td>
<td>2.6</td>
<td></td>
</tr>
<tr>
<td>17WR_50</td>
<td>11909.7</td>
<td>7687.1</td>
<td>4466.4</td>
<td>17</td>
<td>0.0</td>
<td>2.4</td>
<td>2.4</td>
<td></td>
</tr>
<tr>
<td>17WR_51</td>
<td>11907.2</td>
<td>7679.5</td>
<td>4466.4</td>
<td>17</td>
<td>0.0</td>
<td>2.9</td>
<td>2.9</td>
<td></td>
</tr>
<tr>
<td>17WR_52</td>
<td>11906.3</td>
<td>7674.6</td>
<td>4466.8</td>
<td>17</td>
<td>0.0</td>
<td>2.9</td>
<td>2.9</td>
<td></td>
</tr>
<tr>
<td>17WR_53</td>
<td>11902.5</td>
<td>7654.1</td>
<td>4465.9</td>
<td>17</td>
<td>0.0</td>
<td>2.2</td>
<td>2.2</td>
<td></td>
</tr>
<tr>
<td>17WR_54</td>
<td>11901.0</td>
<td>7644.7</td>
<td>4466.9</td>
<td>17</td>
<td>0.0</td>
<td>2.2</td>
<td>2.2</td>
<td></td>
</tr>
</tbody>
</table>
The results from the 17 level 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 17 and 24 level, 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 level the West Reef was encountered on a small reef drive on 24 level, approximately 300 m below 17 level. Even though the structure is present; no fault-filled vein is developed at that depth. Drilling from 24 level has delineated wider vein widths to the north of this reef drive eluding to a steep northern plunge of the higher grade mineralized zone hosted in the West Reef structure. Prior to 30 level being flooded two hangingwall crosscuts were excavated for drill access to test the Main Reef between 30 and 35 levels. In the 270S 30 level crosscut the West Reef was sampled intersecting a horizontal width of 5.8 m grading 3.1 g/t and 5.0 m at a grade of 3.3 g/t gold on the north and south sides of the excavation respectively. Neither of these samples have been included in the current West Reef resource estimates but they do suggest that the structure continues to depth below 24 level.
8 Drilling (Item 10)

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 level, 10 drill stations were established along the Main Reef footwall access where fan drilling was conducted dominantly horizontally and down dip. (Figure 8.1) The up dip portion of the West Reef remains to be tested between 12 and 17 levels and remains one of the priority drill targets. The 17 level 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 meters.

Figure 8-1: 17 Level drill plan
On 24 level, which is approximately 300 meters below 17 level, drilling was conducted from three drill chambers, 274S, 284S and 287S. (Figure 8.2) The drilling from the three drill stations enabled the West Reef to be tested approximately 550 meters along its strike length as well as up and down dip.

Figure 8.2: 24 Level drill plan

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 meters 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 meters 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 meter grid whereas inferred resources exceed the 25 meter drill hole spacing (Figures 8.3 and 8.4).

Figure 8.3: West Reef Indicated (green) and Inferred (red) blocks with drill traces
Figure 8.4: West Reef Long section with drill hole pierce points

Several representative drill sections have been included below (Figures 8.5 and 8.6) showing the attitude of the West Reef and the relatively consistent dip and gold tenures.
Figure 8.5: West Reef drill X Section 8000N showing reef and drill hole intersections
Figure 8.6: West Reef drill X Section 8250 N showing reef and drill hole intersections
9 Sample Preparation, Analyses and Security

(Item 11)

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

Channel samples were collected using a double diamond blade Cheetah compressed air driven
rock saw. This saw produced a channel sample roughly 50 mm deep by 50 mm wide. The
samples used for the resource estimate were those from 17 level only. 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
meter blocks and mark ups on the individual boxes. Discrepancies were 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 overall core recovery between drilling runs. Following the geotechnical drilling,
the core was logged by the geologist with an emphasis on structure, lithology, alteration and
mineralization. All of the core has been orientated with a spear orientation device and this was
used to take structural measurements while the core was logged.

Sampling was laid out by the geologist logging the core and was based on geological contacts
with samples in mineralized zones generally not exceeding one meter. 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 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 process
bags with standards and blanks were inserted in the sample numbering sequence and recorded on
the laboratory dispatch sheets. Every 20th sample submitted to the laboratory were accompanied
by a sample standard and a blank to check the precision of the analysis. Additional checks were
done on samples after receipt of laboratory results (see discussion in Section 10).

Depending on the year samples were dispatched to SGS Laboratories or Transworld Laboratories
in Tarkwa, Western Region, Ghana. Transworld Laboratories is no longer in operation and SGS
Laboratories is not internationally accredited but does conform to ISO 17025 quality standards.
Samples were organized in the core logging facilities where they were checked and put into
numeric order. Laboratory transport collected samples at site, loading checks carried out by GSR
personnel and observed by laboratory personnel. Sample turnaround and dispatch were 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 were
stored for up 12 months and then destroyed. The other half of the core was stored at the secure
core storage facility at Bogoso where it remains as a reference for validation and cross checking
should the need arise.

May 3, 2012
The processing, handling, analysis and storage of the samples for the Prestea underground are within or exceed industry standards.
10 Data Verification (Item 12)

The data verification excerpts in italics below are from two SRK Consulting (UK) reports compiled in October 2006 and December 2007. The 2006 SRK report entitled: "Updated Mineral Resource Estimate at the Prestea and Bogoso Projects, Ghana" covers the QAQC studies on drilling conducted between 2004 and Oct 2006. The later QAQC analysis is summarized in the NI 43-101 Technical Report entitled: Mineral Resource Estimation at Prestea Underground Mine, December 2007. Only the sections that are relevant to the West Reef underground resource estimate have been extracted and included in this PEA.

10.1 Duplicates (2004 - 2006)

Reproducibility is poor for the underground sampling data from Prestea. 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 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 5g/t. Given that the current block COG for the Mineral Resource is 3.4g/t the majority of the high variability pairs will be occurring in the lower grade areas of the orebody 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 orebody. However, the majority of the higher grade sample pairs show relatively good reproducibility.

![Figure 10-1: Prestea DD 2006 duplicates; HARD plot and regression](image)

10.2 Duplicates (2006 - 2008)

Two separate samples prepared from a single coarse reject after sample splitting and on site preparation. The results are useful in indicating problems with sample preparation and splitting. 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 used average a grade below the current model cut-off grade and care should be taken to make sure representative mineralized intersections are used for these studies in future.
10.3 Screen Fire Assay checks (2004 -2006)

Additional drilling was carried out on Level 24 at Prestea on cross sections 284 and 287 and a number of samples were re-sent for screen fire assay. The following figures show the graphical results of the comparisons between the original FA and the subsequent SFA results. The correlation plot shows a slight overestimation by the SFA with respect to the FA. SRK consider the difference between the FA and SFA results to be expected given the high grade and nuggety nature of the West Reef and Main Reef deposits.

**Figure 10-3: Prestea screen fire assay analysis 2006**

The following plot shows the correlation between grade difference and SFA sample size. It is clear that the smaller samples are producing the largest variation in grade. In general the sample charge used for SFA should be at least 250g compared to the 50g charge used for FA. In the case of the Prestea samples, all the charges are less than 250g and a number are lower than 50g. The apparent differences between the two datasets seen in the HARD and correlation plots...
are being influenced by the bias introduced by using inadequate sample sizes for the analysis. SRK do not consider the high grades at Prestea to be an issue in terms of grade estimation and consider that the kriging process is robust enough to handle the high grades and lessen their local influence on block grades.

**Figure 10-4: Screen Fire Assay checks (2007)**

### 10.4 Screen Fire Assay checks (2007)

Additional drilling was carried out on Level 24 at Prestea on cross sections 284 and 287 and a number of the original sample pulps were re-sent for screen fire assay (SFA). 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 250g and in some cases was lower than the original FA sample size. As a result, GSR then prepared the second half of 54 selected core samples and sent these duplicate samples for SFA using a 1000g charge in order to better define the effect of coarse gold on the final estimates. The following figures illustrate the difference in results from these two approaches.

The results from the assay of the duplicate produced from the second half core using a sample charge of 1000g produces a significant difference in grade compared with the original sample pulp. The difference for those original pulps with values of 20g/t or less are similar to those produced by the SFA of the original pulps. However, above 20g/t the difference in grade between the original pulp and the duplicate core SFA (1000g 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 10g/t the average increase in grade of the SFA assay is 160% and for samples above 20g/t the average increase is 155%.
SRK consider the difference between the FA and SFA 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 will lead to an underestimation of the in-situ grade of the Prestea orebodies.

10.5 Blanks

Mainly used as a check on the efficiency of the laboratory. Useful for highlighting contamination problems and also cross labelling when samples are mislabelled in the laboratory.

Blanks or samples without mineralization were inserted in the samples sent for Screen Fire Assay. The blanks were prepared from RC chips known to be devoid of mineralization filtered to 0.01ppm. 35 Blank samples were inserted in different batch of samples sent for SFA. The lab values range from 0.01 to 0.03ppm with two values being 0.04 and 0.05ppm and the lab mean value is 0.02ppm.

The results suggest 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.

The following figure shows the correlation between expected and actual values for a number of GANNET international standards submitted to the TWL laboratories by GSR as part of the QAQC procedure. The HARD plot shows that generally the variance is low with only one sample out of the 36 tested achieving a HARD value of greater than 10%. The overall statistical average is 2.8% HARD. The sample which shows the highest value is a low-grade standard (0.208g/t) and therefore a small difference in grade will have commensurately larger impact reflected by the HARD value of 18%.

Figure 10-7: HARD and regression plots for Gannet standard samples, TWL Jan-Aug 2006

10.7 Gannet standards (2007 - 2008)

Used for checking the precision and accuracy of the laboratory. 161 gannet standard samples comprising 5 different grades were used as control samples for the Fire Assay different batch of samples. The performance accuracy of the lab is shown below and the individual charts in the following figures.
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. Prior to mid 2007 the variability in results was higher but this has improved in the latter part of 2007 and throughout the 2008 sampling. The only standard to show significant deviation from the expected was the ST5355 (2.37g/t) which exhibited a low grade analysis in the early part of 2008 but this appears to have been related to only a small number of assays and the more recent assays have been in line with the expected.

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 or a minor contamination issue in the laboratory.

**Table 10.1: Standards used and summary results at Prestea UG in 2007-2008**

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

**Figure 10-8: Standard analysis results for ST5369**
Figure 10-9: Standard analysis results for ST05/2297

Figure 10-10: Standard analysis results for ST5343
Overall, (2004-2006) the QAQC results for the Bogoso and Prestea orebodies show a high degree of reproducibility with >80% of the data pairs exhibiting a HARD value of 20% or less indicating that the sampling protocols are optimal for the orebody. Gannet standard values indicate good quality control and a high level of accuracy in the laboratory.

The Screen Fire Assay work demonstrates that, although coarse gold may be present in the higher grade areas of the Prestea orebody, 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 250g in order to improve confidence in the estimates provided.
Overall, (2007 -2008) the QAQC results for the Prestea orebodies show a high degree of reproducibility with >80% of the data pairs exhibiting a HARD value of 20% or less indicating that the sampling protocols are optimal for the orebody. Gannet standard values indicate good quality control and a high level of accuracy in the laboratory.

The Screen Fire Assay work demonstrates that, although coarse gold may be present in the higher grade areas of the Prestea orebody, 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 250g in order to improve confidence in the estimates provided.

SRK also recommend that suitable sample intersections be used for duplicate and replicate analysis. A large number of the samples used for the recent analysis have average grades significantly lower than the COG used for modeling the orebody and at which it will ultimately be mined and therefore could be considered to be inappropriate.
11 Mineral Processing and Metallurgical Testing
(Item 13)

In March 2008, John W. MacIntyre and Associates Pty Ltd. (“JMA”) provided a report to GSR titled, Prestea Underground Metallurgical Testwork – Prefeasibility Study Stage. The report describes the metallurgical test work undertaken to determine the process characteristics of the West Reef and the Footwall Reef through the Bogoso process plants. This section summarizes the JMA report. This PEA makes reference only to West Reef material and as such no summary of the Footwall Reef results will be provided.

11.1 Samples

GSR supplied 12 West Reef samples in the form of ½ NQ diameter (47.5mm) diamond drill core. These samples included 0.3m of hangingwall dilution and 0.5m of footwall dilution. Table 11.1 provides a summary of the samples supplied to JMA. The Upper, Mid and Lower designation refers to the location of the drill hole intersection between 17L and 30L.

Table 11.1: West Reef drillhole samples for metallurgical testing

<table>
<thead>
<tr>
<th>Location</th>
<th>Drill hole</th>
<th>From</th>
<th>To</th>
<th>Length</th>
<th>Diluted drill hole grade</th>
<th>Composite Grade</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>m</td>
<td>m</td>
<td>g/t</td>
<td>g/t</td>
<td>Assayed</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Calculated</td>
</tr>
<tr>
<td>Upper</td>
<td>UC17-274S6</td>
<td>238.11</td>
<td>240.85</td>
<td>2.74</td>
<td>7.57</td>
<td>30.9</td>
</tr>
<tr>
<td></td>
<td>UC17-274S7</td>
<td>239.34</td>
<td>242.20</td>
<td>2.86</td>
<td>11.83</td>
<td>23.95</td>
</tr>
<tr>
<td></td>
<td>UC17-280S13</td>
<td>300.00</td>
<td>305.00</td>
<td>5.00</td>
<td>52.32</td>
<td></td>
</tr>
<tr>
<td></td>
<td>UC17-280S14</td>
<td>195.80</td>
<td>198.20</td>
<td>2.40</td>
<td>28.7</td>
<td></td>
</tr>
<tr>
<td></td>
<td>UC17-280S4</td>
<td>239.00</td>
<td>242.40</td>
<td>3.40</td>
<td>31.29</td>
<td></td>
</tr>
<tr>
<td>Mid</td>
<td>UC17-280S1</td>
<td>349.60</td>
<td>352.60</td>
<td>3.00</td>
<td>74.23</td>
<td>23.1</td>
</tr>
<tr>
<td></td>
<td>UC17-274S15</td>
<td>162.00</td>
<td>164.50</td>
<td>2.50</td>
<td>3.44</td>
<td>15.28</td>
</tr>
<tr>
<td></td>
<td>UC17-274S25</td>
<td>142.00</td>
<td>145.00</td>
<td>3.00</td>
<td>5.07</td>
<td></td>
</tr>
<tr>
<td></td>
<td>UC17-284S4</td>
<td>177.00</td>
<td>181.00</td>
<td>4.00</td>
<td>11.85</td>
<td></td>
</tr>
<tr>
<td>Lower</td>
<td>UC24-274S14</td>
<td>253.20</td>
<td>256.00</td>
<td>2.80</td>
<td>3.78</td>
<td>14.8</td>
</tr>
<tr>
<td></td>
<td>UC24-274S2</td>
<td>179.40</td>
<td>183.00</td>
<td>3.60</td>
<td>32.27</td>
<td>14.13</td>
</tr>
<tr>
<td></td>
<td>UC24-284S6</td>
<td>197.00</td>
<td>199.50</td>
<td>2.50</td>
<td>5.74</td>
<td></td>
</tr>
</tbody>
</table>

11.2 Testwork

Initial testwork consisted of the following evaluations for the Upper, Mid and Lower composites:

- Grind establishment;
- Full scan head assay;
- Diagnostic leach; and,
- Mineralogy.
Subsequently, a composite consisting of equal portions of Upper, Mid and Lower was also tested.

11.3 Results

Table 11.1 depicts the reconciliation between the diluted drill hole grades and the assayed and calculated grades. The calculated grades were derived from the gravity, float and CIL testwork completed by JMA. It is not uncommon to see such a variation between the various head grades for high gold grade samples that only have a small proportion of sulphide gold (are for West Reef samples) and have a high proportion of gravity and cyanide soluble gold.

The sulphide sulphur grade averaged 0.72%. There was very little variation in the samples, with the grade ranging from 0.62% to 0.95%.

The average arsenic grade was 1,236 ppm with a range from 342 to 1,943 ppm. Relationships have previously been established between the arsenic grade and the amount of refractory (solid solution) gold contained in other Bogoso ore types. These arsenic concentrations indicate that there may be between 0.22 to 0.60 g/t of refractory gold in these samples.

The average organic carbon grade for the three West Reef samples is 0.46%.

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 and averaged 5.7 g/t or 31.6% for a 18.1 g/t average head grade. The West Reef Composite sample (a blend of all three Upper, Mid and Lower samples) recovered appreciably more gravity gold, 16.5 g/t or 75% of the total gold. The 22.0 g/t calculated head for the West Reef Composite sample was slightly higher than the 18.1 g/t average calculated head grade for the three individual West Reef samples despite the fact this sample contained appreciably more amalgam gold.

All three West Reef samples were only mildly preg robbing. An average of only 0.08 g/t gold was preg robbed using new carbon for the Bogoso Oxide Plant option and an average of only 0.21 g/t of gold preg robbed using loaded carbon.

The amount of sulphide gold was determined by ashing the elution residue and an aqua regia digestion test. An average of 0.14 g/t of sulphide gold was measured for the West Reef samples.

The amount of silicate gold was determined by conducting a fire assay on the aqua regia residue. An average of 0.06 g/t of silicate gold was measured for the West Reef samples.

Mineralogical analysis indicated that 79% of the pyrite and 91% of the arsenopyrite were free, that is, they occurred as liberated grains.

The West Reef leach rate values of (0.12) and (0.23) were considered extremely fast.

The 24 hour cyanide consumption for the West Reef varied from 1.16 kg/t to 1.48 kg/t and averaged 1.31 kg/t. The 24 hour lime consumption varied from 0.81 kg/t to 0.86 kg/t and averaged 0.84 kg/t.

The new carbon recovery for the Bogoso Oxide Plant process route was consistently high and averaged 98.3% for the Upper, Mid and Lower samples. The loaded carbon recovery was only marginally lower by 0.7% and averaged 97.6% for the Upper, Mid and Lower samples. For the purposes of the PEA overall process plant recovery of 95% was assumed.
12 Mineral Resources (Item 14)

The following text in italics has been extracted verbatim from the SRK Consulting (UK) NI 43-101 Technical report entitled: Mineral Resource Estimation at Prestea Underground Mine, December 2007.

The SRK 2007 report conducted resource estimates on a number of underground zones; only the West Reef Resource is the object of further work in this report and considered for development at this point in time.

Data validation and additional underground drilling carried out during the period December 2005 to December 2007 have led to the development of updated geological models for the Main Reef (MR) and Footwall (FW). The Resource domains also include the hangingwall structures to the MR (HW), the West Reef (WR) and those Mineral Resources contained within the shaft pillar (SP).

GSR have digitised the available stope information from underground plans and sections and SRK have used this along with assayed intersections of stope fill material in the drill logs to establish a Mineral Resource estimate for the stope fill material. This material accounts for some 27% of the gold contained in the Inferred Mineral Resource category. The shaft pillar domain does not contain any samples and the grade interpolation for the Main Reef was used to fill blocks in this domain.

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

12.1 Data sources

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

12.2 Data cutting/filtering

The data has not been capped for grade interpolation. The relatively low number of high grade values and the high average grade of the individual orebodies means that the influence of the high grade outliers is effectively dealt with during the kriging process.

12.3 Basic statistical tests

Statistics were produced for the various reef domains based on the horizontal thickness reef composite values. The MR, FW and HW statistics are mostly from surface diamond drilling. The WR statistics are derived mostly from underground drillholes collared at locations along the 17, 24 and 30 levels.
Table 12.1: Summary statistics for the Prestea underground resource domains

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>MR</td>
<td>700</td>
<td>0.00</td>
<td>108.72</td>
<td>7.72</td>
<td>9.9</td>
<td>97.6</td>
<td>1.3</td>
</tr>
<tr>
<td>WR</td>
<td>160</td>
<td>0.10</td>
<td>235.5</td>
<td>16.36</td>
<td>27.7</td>
<td>764.8</td>
<td>1.7</td>
</tr>
<tr>
<td>FW</td>
<td>79</td>
<td>0.1</td>
<td>108.7</td>
<td>9.68</td>
<td>17.5</td>
<td>305.3</td>
<td>1.8</td>
</tr>
<tr>
<td>HW</td>
<td>13</td>
<td>1.4</td>
<td>5.9</td>
<td>3.01</td>
<td>1.5</td>
<td>2.1</td>
<td>0.5</td>
</tr>
<tr>
<td>ST</td>
<td>222</td>
<td>0.2</td>
<td>72.3</td>
<td>8.71</td>
<td>9.3</td>
<td>86.9</td>
<td>1.1</td>
</tr>
</tbody>
</table>

The following figures show the roughly log normal data distribution in the MR and WR. The WR has a significantly higher grade than the MR orebody and recent drilling has confirmed the continuity of these high grades both along strike and down dip between levels. The stope fill material exhibits a relatively constant grade and reflects the waste grade from the early 20th century when operation cut off grades were significantly higher than present day.

Figure 12-1: Log scale QQ plot and associated raw data histogram for the MR zone

Figure 12-2: Log scale QQ plot and associated raw data histogram for the WR zone
12.4 3D Variographic analysis

Semi-variograms were produced for the Main Reef, West Reef and the Stope material logged during the MR drilling. The MR semi-variograms produced poor directional information and the maximum modeled range was only 30m. The isotropic plot produced a range of 100m using a lag of 25m but the distance of reliability is poor in all but the along strike direction for this orebody due to the lack of drill intersection in the down dip orientation. As a result, it was decided to use the results from the directional semi-variograms calculated using a lag of 10m for the grade interpolation. This leads to a significant portion of the MR orebody being classified as Inferred.

The West Reef has been substantially drilled out on relatively close spaced centres and this has resulted in good quality semi-variograms being modeled in the four principle directions within the plane of the orebody which appear to be highlighting a plunge to the mineralization of approximately 45° to the north with a well developed anisotropy of up to 200m along this plunge and approximately 50m perpendicular to this.

The footwall, hangingwall and shaft pillar domains were kriged using the parameters from the Main Reef as there was insufficient data available in the individual domains for production of reliable semi-variograms. The stope material was modeled and kriged using the resulting model but the reliability of this information is questionable until such time as physical surveying of these areas can be carried out and as a result all stope material was excluded from the final Mineral resource statement.

Figure 12-3: Main Reef Omni-directional (left) and directional (right) semi-variograms in the plane of the mineralization
Table 12.2: Semi-variogram modeling results for the Main Reef zone

<table>
<thead>
<tr>
<th></th>
<th>Structure</th>
<th>Variance</th>
<th>Range 1</th>
<th>Range 2</th>
<th>Range 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>nugget ($C_0$)</td>
<td>0</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>spherical ($C_1$)</td>
<td>31.8</td>
<td>14m</td>
<td></td>
<td>9m</td>
<td></td>
</tr>
<tr>
<td>spherical ($C_2$)</td>
<td>29.7</td>
<td>31m</td>
<td></td>
<td>17m</td>
<td></td>
</tr>
</tbody>
</table>

Orientation

Figure 12-4: Omni-directional semi-variogram and the variogram map in the plane of the WR zone

Figure 12-5: Experimental directional semi-variograms in the four principal directions in the plane of the WR mineralization with associated model semi-variograms
Table 12.3: Semi-variogram modeling results for the WR zone

<table>
<thead>
<tr>
<th>Domain</th>
<th>Structure</th>
<th>Variance</th>
<th>Range 1</th>
<th>Range 2</th>
<th>Range 3</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>nugget ($C_0$)</td>
<td>0</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>spherical ($C_1$)</td>
<td>195</td>
<td>100m</td>
<td>20m</td>
<td></td>
</tr>
<tr>
<td></td>
<td>spherical ($C_2$)</td>
<td>140</td>
<td>195m</td>
<td>50m</td>
<td></td>
</tr>
<tr>
<td></td>
<td>spherical ($C_3$)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Orientation</td>
<td></td>
<td>00° to 005</td>
<td>60° to 275°</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Figure 12-6: Omni-directional semi-variogram produced from samples logged as stope fill material in the Main Reef domain

Table 12.4: Semi-variogram modeling results for the MR Stope domain

<table>
<thead>
<tr>
<th>Domain</th>
<th>Structure</th>
<th>Variance</th>
<th>Range 1</th>
<th>Range 2</th>
<th>Range 3</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>nugget ($C_0$)</td>
<td>40.2</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>spherical ($C_1$)</td>
<td>11.63</td>
<td>26m</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>spherical ($C_2$)</td>
<td>35.14</td>
<td>175m</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>spherical ($C_3$)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Orientation</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

The following figures indicate the grade distribution in the Main Reef and West Reef orebodies and show the relative distribution of drillholes used for the interpolation in each case. The plunging structure can be clearly seen in the West Reef plot as areas of high grade dipping to the north. The poorer quality estimate for the Main Reef is highlighted by the relative lack of visible structures and more uniform block grade distribution.
Blocks defined as resources and Reserves by the previous operators of JCI have been provided to GSR in the form of VLP sections and spreadsheets. SRK and GSR have previously reviewed this data (October 2003), and have included a portion of these blocks in the previous Mineral Resource Statements for Prestea as Inferred Mineral Resources. The current wireframes models based on the updated drilling carried out by GSR have covered a number of these blocks and a
revised estimate of the remaining JCI Blocks has been made based on those blocks which lie outside the current wireframes and south of cross cut 308 on the West reef. The revised tonnage contained within these blocks amounts to some 1.05Mt at a grade of 8.69 and they have retained their Inferred classification category.

### 12.5 Block Model Grade Interpolation

Grade interpolation has been performed using ordinary kriging for all underground domains at Prestea. The MR, WR, FW 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 given its geographical location in the Hangingwall of the main shear structure and the higher grades found within the WR orebody. Orebody contacts are interpreted as hard boundaries for the individual domains.

<table>
<thead>
<tr>
<th>Prospect Coordinate</th>
<th>Value</th>
<th>No. of Blocks</th>
<th>Spacing (m)</th>
</tr>
</thead>
<tbody>
<tr>
<td>x 11600</td>
<td>92</td>
<td>12.5</td>
<td></td>
</tr>
<tr>
<td>y 7400</td>
<td>152</td>
<td>25</td>
<td></td>
</tr>
<tr>
<td>z 3800</td>
<td>56</td>
<td>25</td>
<td></td>
</tr>
</tbody>
</table>

### 12.6 Resource Classification

Classification was initially based on calculating a slope of regression (Z/Z*) value for individual blocks. All blocks filled using the wider search were assigned an Inferred classification category. Wireframes were constructed around blocks with a SL value of generally greater than 0.5 and these blocks were assigned an Indicated category. The construction of the classification wireframe did not strictly adhere to the outline of the blocks with a slope value of 0.5 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 drillhole intercepts indicated that a high degree of confidence could be applied rather than relying solely on the statistical variable.

In the case of Main Reef, the number of blocks with a Z/Z* value of greater than 50% was very small and the classification here has been based largely on the visual confirmation of grade continuity from analysis of drillholes sections. This is largely due to the short range and search applied during the kriging process. At West Reef, the large number of orebody intersections both along strike and down dip are contributing the increased confidence in the block grades.
Figure 12-9: VLP view from the east (footwall) of the Main Reef Block Model showing the distribution of Block Classification categories (green = Indicated, red = Inferred)

Figure 12-10: VLP view from the east (footwall) of the West Reef Block Model showing the distribution of Slope Regression values after kriging
12.7 Mineral Resource Statement

Golden Star’s 2011 year-end resource statement differs from SRK’s 2008 independent statement due to adjustments to gold price, mining costs and other parameters. The resource statement presented here was produced from the SRK 2008 block model using $1,500 gold price, $75/t mining costs, $10.50/t processing costs, $5.00/t administration costs and a recovery of 85%.

The PEA is preliminary in nature, it includes Inferred Mineral Resources that are considered too speculative geologically to have economic considerations applied to them that would enable them to be categorized as mineral reserves, there is no assurance that the PEA will be realized and mineral resources that are not mineral reserves do not have demonstrated economic viability.

In Table 12.6, the Mineral Resource estimate for Prestea underground is reported by individual mineralized zones. Only the West Reef Indicated and Inferred material was considered in this PEA.

There is a certain amount of material which was classified as a Mineral Resource by the previous operators of Prestea. SRK have previously reviewed and reported this data (October 2003) which consists of simple volumetric estimates based on VLP block grades and thickness and this material has been included in the following Mineral Resource statement in the Inferred classification category as ‘JCI Blocks’.

Figure 12-11: VLP view from the east (footwall) of the West Reef Block Model showing the distribution of Block Classification categories (green = Indicated, red = Inferred)
Table 12.6: Estimated mineral resources

<table>
<thead>
<tr>
<th>Domain</th>
<th>Indicated Mineral Resource</th>
<th>Inferred Mineral Resource</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Tonnes (kt)</td>
<td>Grade (g/t)</td>
</tr>
<tr>
<td>Main Reef</td>
<td>373</td>
<td>5.45</td>
</tr>
<tr>
<td>West Reef</td>
<td>874</td>
<td>18.07</td>
</tr>
<tr>
<td>Footwall</td>
<td>394</td>
<td>7.36</td>
</tr>
<tr>
<td>Shaft Pillar</td>
<td>373</td>
<td>9.04</td>
</tr>
<tr>
<td>JCI Blocks</td>
<td>1,045</td>
<td>8.68</td>
</tr>
<tr>
<td>Total</td>
<td>1,641</td>
<td>12.63</td>
</tr>
</tbody>
</table>

* The Prestea Underground resource was estimated using a $1,500 per ounce gold price and an economic gold cut-off of 2.3 g/t.
13 Mineral Reserve Estimation (Item 15)

There are no current Proven or Probable Mineral Reserves at the Prestea Underground Mine.
14 Mining Methods (Item 16)

14.1 Introduction

There is an extensive infrastructure of vertical shafts, inclined shafts, horizontal development, raises and stoping developed along the 9km of strike length of the various orebodies from Prestea in the north to Tuapim in the south. Figure 14.1 shows a long section view of this development and Figure 14.2 indicates the extent of historical stoping operations on the Main Reef, West Reef and Footwall Reef throughout the area.

Figure 14-1: Long section of Prestea mining area looking east

Figure 14-2: Prestea mining area including stoping (extent of Tuapim stoping unknown)

Figure 14.3 shows the Prestea Underground Mine in the area of interest between the Central Shaft and the West Reef resource target for this preliminary economic assessment. The West Reef resource is situated between 17 and 30L, approximately 1.6km south of the Central Shaft.

Figure 14.4 shows an isometric view looking north-east. The Main Reef, dipping at approximately 70º to the west, is relatively consistent in dip and strike orientation. The West Reef, in the hangingwall of the Main Reef, dips at approximately 65º west in the resource target area. The horizontal distance between the two reef planes is approximately 230m at 17L.
For the purposes of this PEA, only the West Reef resource between 17L and 24L has been evaluated for potential mineability. The access and material movement infrastructure has been designed to reach 30L in order to facilitate future exploration programs.

Both indicated and inferred resources are incorporated in the design, schedule and economic evaluation.

Figure 14.5 shows the distribution of indicated and inferred resources within the West Reef resource.

The West Reef resource averages 1.5m true width and ranges from 0.5m to 3.5m wide.

It is proposed that mineralized material mined at Prestea Underground Mine will be transported by road to Golden Star Resources Bogoso Mine and processed in the current operating Oxide Plant.
Figure 14-4: Isometric view of Central Shaft and West Reef resource (looking NE)

Figure 14-5: West Reef indicated and inferred resource (looking east)
14.2 Selection of Mining Method

14.2.1 Cut-off Grade Calculation

Table 14.1 presents the cut-off grade estimate. The costs in the cut-off grade are based on the estimates made at the outset of the project and do not necessarily replicate the final economic parameters used in the economic model.

The mining cost of $90/t represents estimated contractor mining rates and is based on discussions with contracting companies and other mines in Ghana. Process and G&A costs are based on current Bogoso Oxide Plant and mine operating results.

A gold price of $1,250/oz is used to represent the three-year historical average selling price.

Mill recovery of 95% for West Reef material is based on testing of West Reef material carried out in 2008 and discussed in detail in Section 11 of this report.

A 5% royalty on net revenue is payable to the Government of Ghana.

A cut-off grade of 3.1g/t was applied to the diluted resource, to identify potentially mineable material.

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Amount</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mining and haulage cost</td>
<td>90.00</td>
<td>$/t</td>
</tr>
<tr>
<td>Process and tailings cost</td>
<td>15.00</td>
<td>$/t</td>
</tr>
<tr>
<td>G&amp;A cost</td>
<td>7.00</td>
<td>$/t</td>
</tr>
<tr>
<td><strong>Total cost</strong></td>
<td><strong>112.00</strong></td>
<td>$/t</td>
</tr>
<tr>
<td>Gold price</td>
<td>1250</td>
<td>$/oz</td>
</tr>
<tr>
<td>Mill recovery</td>
<td>95.0%</td>
<td></td>
</tr>
<tr>
<td>Refinery Charges</td>
<td>1.00</td>
<td>$/oz</td>
</tr>
<tr>
<td>Royalty</td>
<td>5%</td>
<td></td>
</tr>
<tr>
<td>Net oz value</td>
<td>1127</td>
<td>$/oz</td>
</tr>
<tr>
<td>Cut-off grade</td>
<td>3.1</td>
<td>g/t</td>
</tr>
</tbody>
</table>

14.2.2 Geotechnical Design

In July 2007 SRK Consulting (UK) Ltd. completed a PEA-level geotechnical evaluation of the West Reef rockmass in the area of interest of this report. The following text in italics is extracted from this report titled: Prestea Underground Mine Geotechnical Study Part 2 – West Reef Geotechnics (U3186), July 2007.

Data

Findings are based on the following data sources:

- Information provided by GSR regarding general and local geological conditions in the Prestea area.
- Review of sections showing the West Reef, borehole traces and lithological units.
- Review of borehole core geological logs and core photographs.
- West Reef Q’ rock mass condition and quality assessment values.
• Assesment of stable unsupported stope spans using the Modified Stability Graph Method (Hutchinson and Diederichs, 1996).
• The West Reef ore drives on 17 and 24 Level and access drives on 30 Level, visited on 21 April 2007.
• West Reef exposures on various cross-cuts were also viewed, mainly in low-grade areas away from the main resource block.

Only minimal viewing of drill cores was undertaken for this assessment. The recommendations and conclusions presented in this report are preliminary guidelines only. Accordingly, the design parameters presented herein should only be used for preliminary mining evaluation purposes. Further geotechnical assessment will be required if the project advances to a more detailed evaluation/design phase, including:

• Laboratory test work to confirm assumed rock strengths. (This has a relatively minor impact on stope span calculations but has a major impact on pillar strengths).
• Additional, more detailed geotechnical logging of existing core to refine rock mass classification results in and adjacent to the West Reef (this has a major impact on stope span and pillar strength calculations).
• Continuing geotechnical review of proposed stoping methods and designs.

Geotechnical Conditions

Observations of rock mass damage and general ground conditions underground suggest that virgin stress magnitudes of between 35MPa to 45MPa at 1000m depth are appropriate for preliminary investigations.

The graphitic sheared rock units are estimated to have intact rock strengths of between 5 to 10MPa. The less altered stronger country rocks are estimated to have intact rock strengths of around 120 MPa.

Within the ore zone and immediate hangingwall and footwall boundaries, graphitic gouge filled faults are common. The hangingwall and footwall rocks were found to have medium to strong foliation with localized zones of jointing and faulting (Figures 2 and 3).

Rock Quality Designation (RQD) values range from 0% (very poor) to 100% (excellent), with the ore zone consistently having lower RQD values than the surrounding hangingwall and footwall rocks.

Defect surfaces are reported to range from slickensided planar to smooth and undulating. Defect surface alteration is reported to range from surface staining to clay fractions.

Geotechnical Domains

Preliminary appraisal of stable unsupported stope spans and estimates of dilution for the West Reef orebody was based on assessment of three (3) geometrically defined domains (as listed in Table 14.2).
Table 14.2: West Reef geotechnical domains

<table>
<thead>
<tr>
<th>Domain</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Stope Footwall</td>
<td>Rock mass immediately bordering (~ 3m where lode width ≤3m and ~ 6m where</td>
</tr>
<tr>
<td></td>
<td>lode width &gt;3m) lode footwall boundary.</td>
</tr>
<tr>
<td>Stope Back</td>
<td>Rock mass encompassed by lode boundary.</td>
</tr>
<tr>
<td>Stope Hangingwall</td>
<td>Rock mass immediately bordering (~ 3m where lode width ≤3m and ~ 6m where</td>
</tr>
<tr>
<td></td>
<td>lode width &gt;3m) lode hangingwall boundary.</td>
</tr>
</tbody>
</table>

Discussion on Results of Stability Graph Assessment

Given the prevalence of graphite rich sheared rock units in the West Reef area, the assessed unsupported stable stope limits appear to be fairly realistic.

Empirical design methods such as the Modified Stability Graph Method make broad generalizations about rock mass characteristics. West Reef stope stability will most likely be controlled by areas of geological complexity (for example graphitic shear zones with fault gouge and intensely foliated rocks) which cannot be considered using this technique. Final stope design must, however, place strong emphasis on the possible adverse influence of such factors. Structural mapping of ore drives will provide much of the data currently missing but would still miss structures between levels. Monitoring of early stope performance will be critical in this regard.

Improved rock mass capacity resulting from cable bolt reinforcement theoretically enables larger stable stope spans (greater hydraulic radii). Due to the often sheared and graphitic nature of the West Reef rocks, cable bolt reinforcement of stope sidewalls would have limited effectiveness in controlling rock mass unraveling and as such may not be a practical consideration.

Discussion on Results of Dilution Estimates

Pre-mining, dilution estimates are difficult to accurately quantify without the benefit of physical observation and analysis of historic mining and stope performance. Results presented are therefore considered appropriate for preliminary mining evaluation purposes only.

West Reef stope hangingwall and footwall dilution will most likely be controlled by the undercut/overhang created by the ore drives used to access the lode. With longhole mining methods ore drive width will generally be greater than lode width, resulting in undercut/overhanging stope walls. Low compressive stress conditions (and possibly tensile conditions) can develop in undercut/overhanging stope walls, resulting in rock mass failure and increased stope dilution. The graphitic material would not be reinforceable with cable bolts and cable bolting of walls in narrow stopes is generally inefficient due to the narrow drilling angles.

In these circumstances, the undercut hangingwall and footwall immediately above the drives will tend to fail (to the width of the ore drive). Ore drive widths should therefore be matched to orebody width by the use of specialized narrow-vein equipment or by the use of hand-held drilling.

Mining Methods

The West Reef is a quartz-graphite shear zone with competent footwall and hangingwall country rocks. The graphite material in the shear zone is wider than the resource boundaries determined.
by sampling grades. Graphitic shear material might have to form the hangingwall or footwall of the stope in order to maximize the mined grade of the reef. In some cases the minimum mining widths might also exceed the lode boundary.

The narrow width of the orebody and the potential for dilution from the graphitic material, limit the possible mining methods to:

- **Longhole bench stoping** with short sub-level intervals and short strike lengths, with or without fill. Pillar dimensions would have to be determined from numerical modelling for the unfilled options, with an initial estimate of 25% for permanent pillars.

- **Hand-held mining methods** such as scraper-cleaned fatback cut and fill, shrinkage, leading stoping (e.g. rolling scatter-pile, or mine-clean-fill). Support of the backs and walls can be undertaken in each of these methods, with the benefit of reduced dilution. The stope spans will be controlled by the effectiveness of wall bolting and the availability of fill, and if fill is not available the stopes could be as small as 20m x 20m.

- **Narrow mechanised fatback cut and fill**, with small LHD/bogger cleaning, hand-held or single boom drilling, captive or decline access.

The geotechnical evaluation has been used to estimate the potential stoping spans (hydraulic radii) that can be mined and the dilution associated with mining at such spans. The geotechnical dilution does not take into account the dilution that would occur due to undulating or offset reef contacts.

Mechanized stoping is likely to result in an estimated dilution thickness of 1m from the hangingwall and 1m from the footwall. Hand-held mining might only result in dilution of 0.3m from the hangingwall and 0.5m from the footwall (for 3m lifts). These estimates are based on core photographs and core logging. Hand-held stoping will tend to include support of the exposed rock mass using bolts and mesh for the backs and shoulders and bolts for the walls. This support would also form the basic support for all ore drives and should include SS33 or SS38 splits sets and 4mm x 100mm x 100mm weldmesh.

Support of walls in shrinkage stopes should consist of 1.5m cement grouted 16mm or 20mm rebars or Gewi bars (shorter lengths if limited by narrower stoping widths).

Other factors to consider in the choice of mining method are equipment access, service provision, hoisting capacity, fill availability, ventilation, orebody continuity, offsetting and undulations and grade. Stress conditions will be manageable with designs and extraction sequencing suited to the conditions.

**Sequencing**

The combination of high stress levels and a weak orebody means that ground control problems could be magnified by poor extraction sequencing. Outside-in sequences finishing with a small pillar at the access cross-cut should be avoided. The preferred regional sequence from current information is top-down, South-North. This could involve stoping bottom-up from 24 to 17
Level, then bottom-up from 30 to 24 Level, then bottom-up from 35 to 30 Level etc. The stope, pillar and fill designs and sequencing options for stoping up to and holing into 17 Level and 24 Level will require geotechnical input and modeling to assess the impact on ground conditions. Permanent pillars or cemented sill pillars could be required below or on 17 and 24 Levels.

Summary

The above recommendations are based on a brief external review of a very limited amount of data, and therefore must be used with great caution. To increase confidence and understanding, further geotechnical investigation and data collection, including improved geotechnical logging of drill cores and UCS testing of major rock units, is strongly recommended. Existing core needs to be re-logged to take into account the narrow ore and mining widths. Future drill core should also be logged in more detail, especially either side of the orebody boundaries. No UCS testing has been undertaken to date and a test program is required for 6 samples from each major rock type forming the orebody, hangingwall and footwall. The testing should include UCS, Young’s Modulus and Poisson’s Ratio.

The data indicates that although unsupported 20m x 20m spans would remain stable for mechanized stoping, there would be an estimated 1m dilution from the footwall and 1m from the hangingwall.

In terms of hand-held mining the dilution could be better controlled as spans are smaller and it will be possible to install support into the walls. Dilution would be of the order of 0.3m from the hangingwall and up to 0.5m from the footwall. The logging was not undertaken in sufficient detail to accurately quantify this dilution and these are estimates. Hand-held mining would also provide flexibility when following undulations and offsets in the reef contacts.

14.2.3 AVOCA Mining Method

This PEA was prepared with the specific goal of evaluating a high-productivity mechanized mining method. Based on the geotechnical assessment described in the previous section, it was decided to use an AVOCA method with sub-levels spaced 20m apart and with open spans before backfilling limited to 20m. The mine design incorporates 1m of footwall dilution and 1m of hangingwall dilution for all mineralized areas with a minimum mining width of 2.5m.

Figure 14.6 presents a schematic view of the AVOCA stoping method. Some of the benefits of the method are as follows:

- Ability to adjust open stope size to suite local ground conditions. In good ground the stope length can be opened up beyond 20m and in poor ground fill can be applied to limit the open stope span;
- Backfill cycle and drilling cycle are concurrent, reducing production cycle time;
- High degree of flexibility; and,
- Center-out method pushing stress concentration towards orebody extents.

Some negative effects of the method are as follows:

- Footwall waste bypass development requirements are high; and,
- Mining can only commence on the next level up once the lower level is complete.
<table>
<thead>
<tr>
<th>Step</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Develop on-reef sublevels spaced 20m vertical</td>
</tr>
<tr>
<td>2.</td>
<td>Develop central access from footwall bypass and slot raise</td>
</tr>
<tr>
<td>3.</td>
<td>Longhole drill stope</td>
</tr>
<tr>
<td>4.</td>
<td>Blast and muck from lower level</td>
</tr>
<tr>
<td>5.</td>
<td>Longhole drill</td>
</tr>
<tr>
<td>6.</td>
<td>Blast and muck from lower level</td>
</tr>
<tr>
<td>7.</td>
<td>Clean 20m x 20m stope</td>
</tr>
<tr>
<td>8.</td>
<td>Introduce waste backfill from footwall top access</td>
</tr>
<tr>
<td>9.</td>
<td>Apply thin skin of cemented waste backfill</td>
</tr>
<tr>
<td>10.</td>
<td>Longhole drill stope</td>
</tr>
<tr>
<td>11.</td>
<td>Blast and muck from lower level</td>
</tr>
<tr>
<td>12.</td>
<td>Clean stope</td>
</tr>
<tr>
<td>13.</td>
<td>Backfill stope and longhole drill</td>
</tr>
</tbody>
</table>

**Figure 14-6: Conceptual view of AVOCA mining method (long section view)**

**LEGEND**
- Basted material
- LHD
- Waste backfill
- Longhole drill
- Cemented waste backfill
- Drilling
14.3 Stope Design

The stope design process for the preparation of this PEA was as follows:

1. Slice West Reef resource wireframe between 17L and 24L into 20m high blocks;
2. Design on-reef development to follow mineralization on each sublevel;
3. Design stopes between sub-levels, including 1m footwall dilution and 1m hangingwall dilution around the mineralized wireframe;
4. Divide stope blocks into 20m strike length panels;
5. Evaluate the panels against the resource block model for total mined tonnes and diluted grade; and,
6. Remove the panel designs that did not meet the 3.1g/t cut-off grade criteria.

Figure 14.7 shows the stope and on-reef development design between 17L and 24L overlaying the mineralized resource wireframe.

Figure 14-7: West Reef stopes - 17L to 24L (isometric looking east)

For scheduling and access development purposes, the stoping area has been divided into four quadrants. The AVOCA mining method is a bottom-up method with each panel mining centre-
out on two faces. Splitting the West Reef domain into four quadrants will give the ability to mine from eight faces, as shown in Figure 14.8.

![Figure 14-8: Four AVOCA mining areas between 17L and 24L](image)

### 14.4 Development Design

The access development concept for the West Reef is as follows:

1. Main Access Ramp decline developed between Main Reef and West Reef from surface to 30L using mechanized methods. This Ramp will be the primary equipment and material access to the West Reef;
2. Central Shaft hoisting and shaft steel infrastructure upgrade to utilize the shaft for limited waste hoisting from 17L and 24L during West Reef preparation. The Shaft will be the primary personnel access route during mining of the West Reef;
3. Incline and decline development of Main Access Ramp from 17L using handheld or small mechanized methods. The waste from this development will be hoisted up the Central Shaft;
4. Develop a raisebore hoisting shaft from surface to 30L. The shaft would be developed in two stages (surface to 17L, then 17L to 30L). The shaft would be supported with remote-applied shotcrete as necessary depending on ground conditions. In general the rockmass
conditions outside the mineralized areas are very competent. The shaft would be equipped with a rope-guided hoisting arrangement from a loading pocket on 30L. Mined material from the stopes between 17L and 24L would be fed down an internal orepass to 30L, into a loading pocket and hoisted up the shaft.

14.4.1 Main Access Ramp

Figure 14.9 shows the 4.5m wide x 4.0m high Main Access Ramp from surface to 30L. The Ramp will be developed down from surface and up and down from 17L. A ventilation raise will be developed on the north side of the ramp. During development the raise will exhaust via a fan set up on surface and the ramp will intake fresh air. The ventilation raise will be developed using a Machine Roget pilot hole with longhole slashing to 2m x 2m.

Figure 14-9: Main Access Infrastructure (isometric view looking NE)
14.4.2 Central Shaft Upgrade

The Central Shaft is a rectangular, four compartment shaft measuring approximately 3.5m x 8.0m. The shaft is equipped with steel infrastructure supporting wooden guides. The shaft has two 2.5m x 1.6m cage compartments, two 1.5m x 1.6m skip compartments and two 0.6m x 1.6m service compartments.

The majority of the shaft steelwork is supported with bearing sets located at the shaft stations, however some recent shaft rehabilitation work over the past 15 years has added some bunton sets. Over the past three years GSR has undertaken a systematic steelwork replacement of sets and posts to improve the steelwork infrastructure. Currently the following work is required to prepare the shaft for personnel access:

- Steel replacement - surface to 6 level
- Steel replacement - 10 to 12 level
- Bearer set replacement - 7 to 25 level

A production hoist and a service hoist run skips and cages in counterbalance. The following work is required to prepare the hoists for personnel access:

- Purchase new ropes
- Purchase, installation & testing of PLC control systems for both hoists
- Sheave wheel rehabilitation
- Purchase new cages

The Central Shaft will be utilized as the primary personnel access route during mining of the West Reef resource and for limited waste hoisting operations during the development phase.

14.4.3 New Hoisting Shaft

Figure 15.9 shows the location of the raisebored hoisting shaft located to the south-west of the Main Access Ramp. The development process for the shaft will be as follows:

1. Drill pilot hole from surface to 17L using directional drilling methodology to ensure a vertical hole;
2. Develop to pilot hole on 17L;
3. Attach reaming head and ream shaft to surface at 4.5m diameter;
4. Construct headframe on surface and install hoist;
5. Install work platform in shaft and apply ground support as required;
6. Place headcover in shaft above 17L;
7. Develop raisebore chamber below shaft on 17L;
8. Drill pilot hole from 17L to 30L;
9. Develop to pilot hole on 30L;
10. Attach reaming head and ream shaft from 30L to 17L at 4.5m diameter;
11. Remove 17L head cover;
12. Use work platform to install ground support in shaft as required between 17L and 30L;
13. Raisebore 2.4m diameter orepass raise from 20L to 30L;
14. Develop and install 30L loading pocket arrangement;
15. Install rope guides and skipping arrangement;

This new hoisting system will be used for removing material destined for the processing plant.

14.4.4 Backfill Supply Development

Figure 14.9 shows a backfill raise that follows the Main Access Ramp. This 2m x 2m raise will be developed in the same manner as the ventilation raise and will be used to deliver waste rock from surface to the stopes for backfilling purposes.

14.4.5 Stope Development

Figure 14.10 shows the stope development layout consisting of:

- development following the potentially mineable resource;
- bypass development on each sublevel approximately 25m in the footwall of the mineralization; and,
- crosscut development connecting the mineralization drives to the footwall bypass.

The crosscuts access the ends and center of each mining area as shown on Figure 14.8.

![Stope development layout](image)
14.5 Potentially Mineable Resources

The mine design process results in a potentially mineable resource of 1.84Mt @ 7.8g/t. Before process recovery, the resource contains 460koz of gold. This potentially mineable resource includes stope dilution of 2m width at zero grade, development dilution of 5% and an overall mining recovery of 95%.

The potentially mineable resources are reported above a cut-off grade of 3.1g/t using a gold price of $1,250/oz.

14.6 Mining Operations

14.6.1 Development

Development mining will be undertaken primarily using twin boom jumbos. Handheld development or small single boom jumbos may be used to initiate the early ramp and infrastructure development from 17L and 24L before the Main Access Ramp from surface reaches these levels.

14.6.2 Drilling and Blasting

Stope drilling will be undertaken using mechanized production drill rigs drilling 76mm diameters blastholes. Blasting will take place primarily in down-holes using emulsion explosives.

14.6.3 Mucking and Hauling

Development mucking will use 12.5T payload LHD’s to load 45T underground haul trucks. During the initial ramp development, the trucks will haul to a surface waste dump. Once the mine is in production, the majority of development waste will be used for stope backfill.

Stope mucking will be carried out using 17T payload LHD’s dumping into a stope orepass system in the footwall at the center of gravity of the stoping. 45T underground haul trucks will transport mined material to the shaft orepass on 20L and 24L. Material will be hoisted via the new raisebored hoisting shaft and delivered to a truck loadout bin on surface. Road haulage trucks will then transport the material to the Bogoso Oxide Plant.

14.6.4 Backfill

The AVOCA mining method uses waste backfill obtained from waste development or sent underground via the backfill raise (Figure 15.9), delivered to the stope by LHD from the center crosscut in each stope block. The backfill is built out on both sides of the central crosscut as the stopes advance on either side. In order to limit contamination of the blasted mineralized material with the waste backfill, a “skin” of cemented waste will be applied at the end of the backfilling cycle. The cemented backfill will be produced by spraying a cement/water slurry into the bucket of the LHD dumping the backfill into the stope.

14.6.5 Mining Equipment Fleet

Table 14.3 shows the mining equipment fleet selection. Note the equipment make is provided for example purposes as no decision has yet been made regarding supplies.
Table 14.3: Mining equipment fleet

<table>
<thead>
<tr>
<th>Mobile Plant</th>
<th>Use</th>
<th>Number</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sandvik DD420-60 Jumbo</td>
<td>Development Drilling</td>
<td>2</td>
</tr>
<tr>
<td>Sandvik DI430-7 C Longhole Rig</td>
<td>Production Drilling</td>
<td>1</td>
</tr>
<tr>
<td>Atlas Copco 91 RH</td>
<td>Shaft Raiseboring</td>
<td>1</td>
</tr>
<tr>
<td>Atlas Copco 34 RH</td>
<td>General Raiseboring</td>
<td>1</td>
</tr>
<tr>
<td>Caterpillar R2900 loader</td>
<td>Development Bogging</td>
<td>2</td>
</tr>
<tr>
<td>Caterpillar R1700 loader</td>
<td>Development and Production Bogging</td>
<td>1</td>
</tr>
<tr>
<td>Caterpillar AD45 truck</td>
<td>Haulage</td>
<td>6</td>
</tr>
<tr>
<td>Normet 1610B Emulsion charge up</td>
<td>Development and Production Charging</td>
<td>1</td>
</tr>
<tr>
<td>Caterpillar 12G Grader</td>
<td>Road Maintenance</td>
<td>1</td>
</tr>
<tr>
<td>Volvo L120 IT</td>
<td>Services</td>
<td>3</td>
</tr>
<tr>
<td>Toyota Tray Back</td>
<td>Services and Transport</td>
<td>16</td>
</tr>
<tr>
<td>Toyota Wagon</td>
<td>Transport</td>
<td>2</td>
</tr>
</tbody>
</table>

14.7 Production Schedule

14.7.1 Assumptions

The following is a list of operational and productivity assumptions utilized in the preparation of the mining schedule:

- Contractor mining using locally sourced labor;
- Stope productivity 125tpd per AVOCA face or 250t/d per panel. There are four panels available, thus the overall production rate is 1,000t/d of mineralized material.
- Development productivity:
  - Mechanized development single heading 5.7m/day
  - Mechanized development multiple headings 6.5m/day
  - Handheld development 2.5m/day
  - Overall raisebore shaft development, support and equipping rate 1.5m/day
  - 2m x 2m drop raise 10m/day
  - Orepass raisebore 2.2m/day
  - Ventilation raisebore 2.2m/day
- Assumed that current ongoing Central Shaft rehabilitation and hoist upgrades are complete in time to use for the West Reef mining project;

14.7.2 Schedule

Table 14.4 presents the annual results for the development and stoping schedule used in the preparation of the economic model. Preparatory development commences in 2013. Stope production commences in 2017 and is completed in 2022.
### Table 14.4: Production schedule

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Main Access Decline</td>
<td>m</td>
<td>12,173</td>
<td>5,492</td>
<td>5,314</td>
<td>1,366</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hoisting shaft (RB 4.5m)</td>
<td>m</td>
<td>1,176</td>
<td>375</td>
<td>272</td>
<td>529</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Main Orepass (RB 2.0m)</td>
<td>m</td>
<td>415</td>
<td></td>
<td></td>
<td>29</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>386</td>
</tr>
<tr>
<td>Connecting X/cut - ramp to wpass</td>
<td>m</td>
<td>518</td>
<td>126</td>
<td>36</td>
<td>239</td>
<td>64</td>
<td>21</td>
<td>21</td>
<td>13</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Main decline VR xcut</td>
<td>m</td>
<td>363</td>
<td>70</td>
<td>93</td>
<td>180</td>
<td>21</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Decline vent raise (4.5m)</td>
<td>m</td>
<td>669</td>
<td>354</td>
<td>314</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Decline vent raise (DR 1.5x1.5m)</td>
<td>m</td>
<td>648</td>
<td>45</td>
<td>45</td>
<td>378</td>
<td>180</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Stope bypass connections</td>
<td>m</td>
<td>2,121</td>
<td>165</td>
<td>222</td>
<td>474</td>
<td>438</td>
<td>417</td>
<td>404</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Stope bypass drift</td>
<td>m</td>
<td>9,720</td>
<td>319</td>
<td>1,053</td>
<td>1,047</td>
<td>2,037</td>
<td>2,037</td>
<td>2,164</td>
<td>1,063</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Stope orepass (DR 1.5x1.5m)</td>
<td>m</td>
<td>264</td>
<td>105</td>
<td>60</td>
<td>20</td>
<td>79</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Stope orepass xcut</td>
<td>m</td>
<td>84</td>
<td>11</td>
<td>27</td>
<td>6</td>
<td>41</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Development on mineable resource</td>
<td>m</td>
<td>9,604</td>
<td>709</td>
<td>1,005</td>
<td>2,039</td>
<td>2,046</td>
<td>2,114</td>
<td>1,690</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Decline wastepass (DR 1.5x1.5m)</td>
<td>m</td>
<td>648</td>
<td>293</td>
<td>355</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Decline wastepass (DR 1.5x1.5m)</td>
<td>m</td>
<td>323</td>
<td>44</td>
<td>108</td>
<td>170</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Connecting X/cut - ramp to wpass</td>
<td>m</td>
<td>112</td>
<td>56</td>
<td>56</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Access Decline Extension</td>
<td>m</td>
<td>1,800</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Haulage to shaft</td>
<td>m</td>
<td>417</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Stope edge vent raise (RB 1.2m)</td>
<td>m</td>
<td>676</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>128</td>
<td>225</td>
</tr>
<tr>
<td>Stope mined tonnes</td>
<td>t</td>
<td>1,416,273</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Stopping g mined</td>
<td>g</td>
<td>11,691,440</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Stopping grade</td>
<td>g/t</td>
<td>8.26</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Development mineralized tonnes</td>
<td>t</td>
<td>428,163</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Development g mined</td>
<td>g</td>
<td>2,625,807</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Development grade</td>
<td>g/t</td>
<td>6.13</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
14.8 Mine Services

14.8.1 Ventilation

The Central Shaft and the Main Access Decline will provide fresh air intake to the West Reef area between 17L and 30L during mining operations. Exhaust air will be directed from the stopes to exhaust raises driven in the footwall on the north and south extents of the mining area. On 17L the exhaust will be directed to the Ramp Ventilation Raise and to the hoisting shaft for outlet to surface.

Primary ventilation fans will be located at the top of the Ramp Ventilation Raise and the new hoisting shaft to drive the system. Secondary fans will be located underground as required.

Based on the proposed underground fleet shown in Table 14.5 and 0.06m³/s per kW rated diesel power, a total airflow of approximately 370 m³/sec will be required including 25% contingency.

Table 14.5: Mobile equipment ventilation requirements

<table>
<thead>
<tr>
<th>Description</th>
<th>Number of Units</th>
<th>Power Per Unit (kW)</th>
<th>Utilization/ Availability</th>
<th>Airflow Required m³/sec</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cat R2900 Loader</td>
<td>2</td>
<td>321</td>
<td>100%</td>
<td>39</td>
</tr>
<tr>
<td>Cat R1700 Loader</td>
<td>1</td>
<td>123</td>
<td>100%</td>
<td>7</td>
</tr>
<tr>
<td>Cat AD45 Truck</td>
<td>6</td>
<td>438</td>
<td>100%</td>
<td>158</td>
</tr>
<tr>
<td>2 Boom Jumbo</td>
<td>3</td>
<td>110</td>
<td>20%</td>
<td>4</td>
</tr>
<tr>
<td>1 Boom Jumbo</td>
<td>4</td>
<td>66</td>
<td>20%</td>
<td>3</td>
</tr>
<tr>
<td>Longhole Rig</td>
<td>1</td>
<td>66</td>
<td>20%</td>
<td>1</td>
</tr>
<tr>
<td>Grader</td>
<td>1</td>
<td>110</td>
<td>100%</td>
<td>7</td>
</tr>
<tr>
<td>Tool Carrier</td>
<td>3</td>
<td>110</td>
<td>100%</td>
<td>20</td>
</tr>
<tr>
<td>Light Vehicles</td>
<td>16</td>
<td>97</td>
<td>60%</td>
<td>56</td>
</tr>
<tr>
<td>Charge Wagon</td>
<td>1</td>
<td>130</td>
<td>20%</td>
<td>2</td>
</tr>
<tr>
<td><strong>Subtotal</strong></td>
<td></td>
<td></td>
<td></td>
<td><strong>295</strong></td>
</tr>
<tr>
<td><strong>Contingency</strong></td>
<td></td>
<td></td>
<td></td>
<td><strong>74</strong></td>
</tr>
<tr>
<td><strong>TOTAL EQUIPMENT</strong></td>
<td></td>
<td></td>
<td></td>
<td><strong>369</strong></td>
</tr>
</tbody>
</table>

14.8.2 Underground Electrical Supply

Table 14.6 and 14.7 provide an estimate of the amount of electrical power required underground during both the mining of the initial access decline development and subsequently during steady state mining operations.

A ring feeder system will be developed between the Main Access Decline and Central Shaft to ensure a constant power supply.
Table 14.6: Decline development connected load

<table>
<thead>
<tr>
<th>Description</th>
<th>Qty</th>
<th>Unit Rating</th>
<th>Installed Power</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>kW</td>
<td>kW</td>
</tr>
<tr>
<td>Twin boom jumbo</td>
<td>1</td>
<td>110</td>
<td>110</td>
</tr>
<tr>
<td>Raisebore</td>
<td>1</td>
<td>575</td>
<td>575</td>
</tr>
<tr>
<td>Compressor</td>
<td>1</td>
<td>315</td>
<td>315</td>
</tr>
<tr>
<td>Ventilation fan</td>
<td>2</td>
<td>220</td>
<td>440</td>
</tr>
<tr>
<td>Pump station</td>
<td>2</td>
<td>55</td>
<td>110</td>
</tr>
<tr>
<td>Submersible pump</td>
<td>4</td>
<td>20</td>
<td>80</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td></td>
<td></td>
<td><strong>1,630</strong></td>
</tr>
</tbody>
</table>

Table 14.7: Maximum connected load

<table>
<thead>
<tr>
<th>Description</th>
<th>Qty</th>
<th>Unit Rating</th>
<th>Installed Power</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>kW</td>
<td>kW</td>
</tr>
<tr>
<td>Twin boom jumbo</td>
<td>2</td>
<td>110</td>
<td>220</td>
</tr>
<tr>
<td>Production drill</td>
<td>1</td>
<td>75</td>
<td>75</td>
</tr>
<tr>
<td>Raisebore</td>
<td>1</td>
<td>160</td>
<td>160</td>
</tr>
<tr>
<td>Compressor</td>
<td>1</td>
<td>315</td>
<td>315</td>
</tr>
<tr>
<td>Primary ventilation fan</td>
<td>2</td>
<td>500</td>
<td>1000</td>
</tr>
<tr>
<td>Secondary ventilation fan</td>
<td>2</td>
<td>220</td>
<td>440</td>
</tr>
<tr>
<td>Secondary ventilation fan</td>
<td>3</td>
<td>180</td>
<td>540</td>
</tr>
<tr>
<td>Secondary ventilation fan</td>
<td>3</td>
<td>110</td>
<td>330</td>
</tr>
<tr>
<td>Pump station</td>
<td>12</td>
<td>55</td>
<td>660</td>
</tr>
<tr>
<td>Submersible pump</td>
<td>1</td>
<td>350</td>
<td>350</td>
</tr>
<tr>
<td>Ancilliary equipment</td>
<td>1</td>
<td>100</td>
<td>100</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td></td>
<td></td>
<td><strong>4,190</strong></td>
</tr>
</tbody>
</table>

### 14.9 Manpower

Tables 14.8 and 14.9 provide estimates of hourly and salaried manpower requirements to operate the West Reef mining area and supporting infrastructure. A total of 29 salaried management employees will be required. A total of 256 hourly employees will be required for continuous operations with two day shift and 2 night shift rotations.
Table 14.8: Salaried manpower

<table>
<thead>
<tr>
<th>Description</th>
<th>Number</th>
</tr>
</thead>
<tbody>
<tr>
<td>General Manager</td>
<td>1</td>
</tr>
<tr>
<td>Mine Manager</td>
<td>1</td>
</tr>
<tr>
<td>Mine General Foreman</td>
<td>1</td>
</tr>
<tr>
<td>Shift Foreman</td>
<td>6</td>
</tr>
<tr>
<td>Maintenance Superintendent</td>
<td>1</td>
</tr>
<tr>
<td>Maintenance General Foreman</td>
<td>1</td>
</tr>
<tr>
<td>Maintenance Shift Foreman</td>
<td>3</td>
</tr>
<tr>
<td>Maintenance Planner</td>
<td>1</td>
</tr>
<tr>
<td>Technical Services Manager</td>
<td>1</td>
</tr>
<tr>
<td>Senior Mine Engineer</td>
<td>1</td>
</tr>
<tr>
<td>Planner</td>
<td>2</td>
</tr>
<tr>
<td>Senior Geologist</td>
<td>1</td>
</tr>
<tr>
<td>Mine Geologist</td>
<td>2</td>
</tr>
<tr>
<td>Geotechnical Engineer</td>
<td>1</td>
</tr>
<tr>
<td>Surveyor</td>
<td>4</td>
</tr>
<tr>
<td>Safety Officer</td>
<td>1</td>
</tr>
<tr>
<td>Environmental Officer</td>
<td>1</td>
</tr>
<tr>
<td><strong>TOTAL</strong></td>
<td><strong>29</strong></td>
</tr>
</tbody>
</table>
### Table 14.9: Hourly manpower

<table>
<thead>
<tr>
<th>Description</th>
<th>Number of personnel</th>
<th>Crew 1</th>
<th>Crew 2</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>D/S</td>
<td>N/S</td>
</tr>
<tr>
<td><strong>Mine Operations</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Production Drill Operator</td>
<td>2 2 2 2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Blaster</td>
<td>2 2 2 2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>LHD Operator</td>
<td>3 3 3 3</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Jumbo Operator</td>
<td>3 3 3 3</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mine Helper</td>
<td>10 10</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Haul Truck Driver</td>
<td>6 6 6 6</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mine Construction</td>
<td>3 3 3 3</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Road Maintenance</td>
<td>2 2 2 2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fuel / Lube Truck</td>
<td>1 1 1 1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Backfill Operator</td>
<td>4 4 4 4</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pump Operator</td>
<td>2 2 2 2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Loading Pocket Attendant</td>
<td>1 1 1 1</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Underground Maintenance</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Electrician</td>
<td>1 1 1 1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Diesel Mechanic</td>
<td>1 1 1 1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mechanic</td>
<td>1 1 1 1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Helper</td>
<td>4 4 4 4</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Machinist / Welder</td>
<td>1 1 1 1</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Surface Operations</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hoist Operators</td>
<td>2 2 2 2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Banksman</td>
<td>1 1 1 1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cage Tenders</td>
<td>2 2 2 2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Shaft Maintenance</td>
<td>2 2 2 2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Backfill Operators</td>
<td>2 2 2 2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lamproom Attendant</td>
<td>1 1 1 1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Change House Attendant</td>
<td>1 1 1 1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bin Attendant</td>
<td>2 2 2 2</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Surface Maintenance</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Electrician</td>
<td>1 1 1 1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mechanic</td>
<td>1 1 1 1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Helper</td>
<td>2 2 2 2</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>TOTAL</strong></td>
<td></td>
<td>256</td>
<td></td>
</tr>
</tbody>
</table>
15 Recovery Methods (Item 17)

GSBPL operates a processing plant approximately 15km from the Prestea Underground Mine. It contains two separate processing circuits; one for non-refractory material and another for refractory material utilizing BIOX® technology. Based on testwork to date, it is expected that the ore from West Reef will be processed through the non-refractory circuit, the Bogoso Oxide Plant.

A schematic flow sheet of the Oxide Plant is shown in Figure 15.1.

The Bogoso Oxide Plant is designed to treat 1.35Mtpa of oxide ore. The processes involved are comminution (crushing and milling), CIL, elution and electrowinning.

800mm ROM ore is fed to a 400tph Kemco C160 Jaw crusher by CAT988 front-end loaders via a vibrating grizzly. The grizzly bars with opening of 150mm allow material of -150mm to bypass the crusher and report to the crushed ore stockpile. The crushed material with a P80 of 150mm is stockpiled (4000t) and fed to a 1500kw 5200mm x 4850mm Morgardshammer SAG mill via slot feeder.

The SAG mill operates in open circuit while a 1500KW 4200mm x 5400mm Morgardshammer ball mill operates in closed circuit with a cluster of cyclones. The ball mill cyclone underflow is fed to the gravity circuit consisting of two 30” Knelson concentrators and the tails returns to the ball mill via a set of dewatering cyclones.

The milling product, i.e. the ball mill cyclone overflow of P80 of 75µm at 40% solids goes over a trash screen, and feeds a Carbon-in-Leach (CIL) circuit.

The CIL circuit consists of six 1200m³ leach and adsorption tanks where lime, sodium cyanide, oxygen/hydrogen peroxide and activated carbon are added in various proportions to enhance the leaching process. Optimum cyanide addition is achieved by the use of the Automatic Cyanide analyzer/controller, TAC 2000. Activated carbon is advanced from the back tanks and recovered at the head tank as carbon loaded with gold. The slurry exiting the last tank of the CIL plant gravitates to a carbon safety screen, which ensures that all carbon is retained within the circuit. Screen oversize (carbon) is recovered and returned to the circuit, screen undersize reports to the final tailings hopper where it is pumped to the cyanide tailings storage facility. All water used in the oxide milling circuit is tailings dam return water.

On a daily basis loaded carbon is recovered and screened to remove residual slurry and sent to the elution circuit via an acid wash stage. Acid washing of the carbon with dilute hydrochloric acid facilitates the removal of inorganic material, which can prevent effective adsorption of gold onto carbon. Following the acid wash, the carbon is rinsed with water to remove any remaining acid.

The cleaned loaded carbon is transferred to a 5T elution column where gold is stripped from the carbon using the pressurized Zadra elution system. The resulting gold bearing caustic solution is pumped to electrowinning cells, which operates in closed circuit with the elution column. The cathodes of the cell are made of steel wool, onto which the gold is deposited forming a mixture of iron and metallic gold. On a weekly basis the cathodes are removed, washed and the concentrate calcined for a minimum of 12hrs at 750°C. The calcined material is fluxed with various compositions of borax, nitrates, sodium carbonate and silica, smelted and cast into bullion bars, which contain gold and small amounts of silver.
Barren or eluted carbon is regenerated in a 275kg/hr electric kiln at temperatures of 650 –750 degrees Celsius in an inert atmosphere in order to remove organic material that cannot be removed by acid washing.

Bulk chemicals used in the milling process include cyanide, lime, carbon and hydrochloric acid. Several other chemicals are used in the mill; however their quantities are relatively small. These include borax, nitre, sodium carbonate, silica, hydrogen peroxide, lead nitrate and sulphamic acid.
Table 15.1: Bogoso Oxide Plant process flow chart
16 Project Infrastructure (Item 18)

16.1 Road Access

The Prestea concession is situated directly southwest of, and contiguous with the Bogoso concession. The underground mine property is adjacent to the town of Prestea, which is situated approximately 20 km south of the town of Bogoso, the capital of the newly created Prestea Huni Valley District of the Western region. Bogoso is 35 km from Tarkwa an important mining center for the region and a further 85 km from the port city of Takoradi on the Gulf of Guinea. Accra, the capital of Ghana, is located approximately 370 km by road southeast of Prestea.

16.2 Power Supply

Electrical power for Prestea Underground Mine is supplied from the National Grid (GRIDCo) via the Prestea substation.

The mine power is supplied from two transformers 10F1 and 10F2. The 10F1 transformer supplies 33KV and 10F2 supplies 55KV.

The 33KV power is fed through overhead lines to Central Shaft Job 600 substation. The 33KV power is then stepped down to 3.3KV through two transformers to two distribution boards.

The Central Shaft Board A has two 95mm² feeders, one of which provides 3.3KV power to underground and the other to such areas as the Prestea Government hospital, residential areas, bore holes, compressors, Central Shaft service hoist and the other half to the Prestea community.

The Board B feeds 3.3KV power to the Central Shaft production hoist, compressors, emergency feeder supply low voltage to central shaft, South Waste Vent Fan Feeder.

For power distribution on the surface one 3MVA transformer at the slime substation supplies 440volts to the mines’ general office and part of the Prestea community.

In the event of power outage from the national grid, two emergency power units, one at Central Shaft and the other at Bondaye Main shaft are available to supply limited power to essential units of the mine. A 1.5 MW 440V generator set at the Job 600 transformer supplies 440V power supply to central shaft workshop, offices and general lighting and Prestea Government Hospital.

The same 440V power is stepped up through a 440V/3.3KV transformer that supplies power to feed Job 600 Board B to enable dewatering pumps and the Central Shaft service hoist to operate.

16.3 Water Supply

Potable water supplied for use on the mine is pumped from the mine pump station which consists of two bore-holes, one of a depth of 46 meters and the other of 20 meters deep.

The pump station has two centrifugal pumps installed, 480gal/min (109m³/h) to serve as main distribution pumps to supply Central Shaft.

16.4 Mine Dewatering

The mine dewatering is carried out through the two main shafts – Prestea Central Shaft and Bondaye Main Shaft. Currently a combined average daily pumping rate of 5 Ml per day is achieved. Three new pumps are to be installed at Bondaye Main Shaft 3 and 9 levels and Central Shaft 6 levels within the year to improve pumping capacities.
At the Prestea Central Shaft, there are five pump stations located on the following levels:

- 6 Level - water inflow comes from the southern drive and two pumps stationed here discharge to the surface at a head of 200 meters;
- 17 Level - an 8-stage Sulzer pump discharges directly to surface at a head of 600 meters;
- 24 Level - currently has one Mather & Platt 7-stage Plurovane pump discharging to 17 Level central sump; and,
- 30 Level and below is dewatered via a series of submersible pumps drawing from the No 4 Shaft. Currently the bottom part of the mine is flooded 25 meters below 27 Level. Plans are advanced to dewater below 30 Level by the end of 2012.

In the Bondaye Main Shaft five pump stations are located at the following levels:

- 3 Level - two pumps discharging to surface at a head of 130 meters; and,
- 9 Level - two pumps pumping water from Tuapim shaft and from 9 Level south drive discharging directly to the surface at 130 meters head.

### 16.5 Waste Dumps

Waste rock hauled up the Main Access Decline and hoisted through Central Shaft highway trucks to be dumped on the Beta Boundary South Waste Dump approximately 4km to the south of Central Shaft.

### 16.6 Bogoso Oxide Plant

West Reef material will be trucked to the Bogoso Oxide Plant in ‘on-road’ haul trucks. For the most part, this will be on a dedicated, private haul road, minimizing interaction with public traffic.

Mineralized material will be stockpiled on the existing Bogoso ROM stockpile and fed to the Oxide Plant crusher by loader. As Prestea Underground Mine feed will displace currently fed open pit ore, no additional infrastructure will be required as a result of this project.

Gold recovered will be shipped off site for refining. Processing tails will be deposited on the currently operated TSF2 tailings storage facility and/or later approved facilities. TSF2 is a conventional tailings storage facility.

### 16.7 Offices

There are two office locations for the project - a fenced one-storey multi office building referred to as General Office and located close to the Prestea sports stadium and a single storey office building located at the Prestea Central Shaft.

### 16.8 Mine Rescue

In compliance with the statutory requirements of the establishment of a Mine Rescue Brigade, Prestea Underground Mine currently has a well-equipped Mine Rescue Station.

There are ten (10) sets of Proto MK 5 SCBA for initial Rescue Training. Another ten (10) sets of BG 4 SCBA are also available with their repair kits and Booster pumps for emergency rescue operations.
Currently, there are two 5-man teams Rescue Brigade operational. There is a well-situated Mine Rescue Gallery for Training and Practices.
17 Market Studies and Contracts (Item 19)

All gold production will be shipped to a South African gold refinery in accordance with a long-term sales contract currently in place for GSR’s Bogoso Mine. The gold is shipped in the form of dore bars which average approximately 90% gold by weight with the remaining portion being silver and other metals. The sales price is based on the London P.M. fix on the day of the shipment to the refinery.
18 Environmental Studies, Permitting and Social or Community Impacts (Item 20)

18.1 Environmental and Social Setting

The GSR Prestea Underground Project operational area is within the moist tropical rainforest area of the Western Region of Ghana. The mean annual rainfall is in the order of 2,000 mm. There are two rainy seasons, a major rainy season from April to June and then a minor rainy season in October and November. These have operational effects for the surface areas due to the heavy, episodic events that effectively slow down or stop surface activities. The rainy seasons also correspond with an increased inflow of water to the underground mines through the various surface expressions of the workings, many caused by unauthorized mining activity.

The high rainfall in the area means that there are very few limitations on water supply. Rainfall may be limited during the dry season (December to March) with monthly rainfalls as low as 0 mm; However, the dewatering water from the underground would be able to supply any surface working water requirements for localized dust control.

The Project is within the town of Prestea, with a population of approximately 34,000 (2,000 Ghana Census). The Prestea community developed over the past 100+ years adjacent to the mining operation and many of the houses in the town are former mine houses. There is generally a poor level of infrastructure development despite the many decades of commerce in the region. In addition to these two large communities, there are a number of smaller communities in the Prestea areas (e.g. Bondaye and Himan) with populations of up to 3,000 people.

The major sources of income to these communities are working for and supporting the GSBPL operation, subsistence and cash-crop agriculture and unauthorized small-scale mining (galamsey). The use of the area over many years for shifting agriculture has resulted in an extensive mosaic of farms, secondary growth, and plantations of mainly oil palm.

The natural vegetation of the region is a transition between wet evergreen and moist evergreen rainforest. The original vegetation cover in the project area has been removed. Secondary forests occur on some steep slopes that are unsuitable for farming and are used as a source of domestic fuel wood and wood for buildings. In general, the disturbed nature of the areas around the Project limit concerns over forest removal and endangered species.

The drainage in the Project area is mostly creeks that are highly affected by discharges from the communities and by the workings associated with unauthorized small scale mining. As such, the ecological value of the surface water is limited and would be classified as highly polluted. These streams are all within the Ankobra River Basin. The much larger Ankobra River is highly polluted and, near Prestea, is affected by extensive unauthorized mining activity (both small and medium scale). Marshlands are associated with several streams; many have been created or extended by damming and the diversion of streams by unauthorized small scale miners. Groundwater occurs in secondary aquifers and chemically reflects the highly-mineralised host rock mineralogy.
### 18.2 Environmental Studies and Authorizations

#### 18.2.1 Regulatory Framework

The Mining Act (Act 703 of 2006) is the governing legislation for Ghana’s minerals and mining sector. It requires that mines obtain environmental approvals from relevant environmental agencies as outlined in Table 18.1. Ghanaian environmental legislation is well developed and is enforced by the Environmental Protection Agency (EPA).

**Table 18.1: Primary Environmental Approvals Needed for Mining Operations**

<table>
<thead>
<tr>
<th>Regulatory institution</th>
<th>Approvals that have to be obtained</th>
<th>Reporting, inspections and enforcement</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>The Environmental Protection Agency (EPA)</strong> Establishing under the Environmental Protection Agency Act, 1994 (Act 490), the EPA is responsible for among other things, the enforcement of environmental regulations.</td>
<td>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.</td>
<td>Annual reports Mines must submit annual environmental reports to the EPA.</td>
</tr>
<tr>
<td></td>
<td>Approved 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).</td>
<td>Inspections The EPA undertakes regular inspections to ensure that mineral right holders are compliant with permit conditions and the environmental laws generally.</td>
</tr>
<tr>
<td></td>
<td>An Environmental Certificate This must be obtained from the EPA within 24 months of commencement of an approved undertaking (Regulation 22 of LI 1652).</td>
<td>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.</td>
</tr>
<tr>
<td></td>
<td>Approved reclamation plan Mine closure and decommissioning plans have to be prepared and approved by the EPA (Regulation 14 of LI 1652).</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Reclamation bond Mines must to post a reclamation bond based on an approved reclamation plan (Regulation 22 of LI 1652).</td>
<td></td>
</tr>
<tr>
<td><strong>Water Resources Commission (WRC)</strong> Establishing under the Water Resources Commission Act, 1996 (Act 522), the WRC is responsible for the regulation and management of the use of water resources.</td>
<td>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 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.</td>
<td>Inspection The WRC has power to inspect works and ascertain the amount of water abstracted.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Enforcement Both Act 522 and L.I. 1692 prescribe sanctions for breaches.</td>
</tr>
<tr>
<td><strong>Forestry Commission</strong></td>
<td>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.</td>
<td></td>
</tr>
</tbody>
</table>

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 findings of an environmental impact assessment, which also covers social aspects, are documented in an Environmental Impact Statement (EIS), which is submitted in draft to the EPA for review. On receipt of comments, the EIS is finalized for submission to the...
EPA, which grants environmental approval for projects in the form of an Environmental Permit. For a mine, an EIS report must include a reclamation plan (Regulation 14 of LI 1652) and a provisional Environmental Management Plan (EMP). The EIS may be subject to a public hearing and is subject to public and EPA review before a permit is granted. An EMP must be submitted within 18 months of commencement of operations and must be approved by the EPA.

All mines in Ghana are required to have a reclamation plan (Regulation 14 of LI 1652). Mines are also required to submit an EMP within 18 months of the start of operations and then update their EMPs every 3 years with a submission to the EPA for approval (Regulation 24 of LI 1652). In addition, mines have to submit annual environmental reports (Regulation 25 of LI 1652), and monthly environmental returns of the environmental parameters monitored to EPA. Comments are also expected in cases where monitored values exceed limits and, as appropriate, a project is to provide the measures to prevent further occurrences.

The EPA is empowered to suspend, cancel or revoke Environmental Permits where the holder is in breach of LI 1652, the permit conditions or the mitigation commitments in the EMP. Contravention of these regulations, failure to comply with directives of the EPA and failure to submit annual environmental reports is an offence that can result in fines or imprisonment.

During the care and maintenance period for the Prestea Underground Mine, the reporting and any work carried out was submitted to the EPA through the GSBPL monthly returns and the annual environmental report for the GSBPL operations.

Guidelines and standards relevant to the mining industry have been made under the EPA Act. These include the Mining and Environmental Guidelines (1994), which provide guidance on the contents of an EIS, EMP and Reclamation Plan. They also include guidelines on environmental impact assessment procedures, effluent and emission standards, ambient quality and noise levels and economic instruments.

The EPA conducts routine monitoring of environmental parameters for mining operations and the results obtained are cross-checked with the monthly return values submitted by operations and compared relevant standards.

The Minerals Commission has an Inspectorate Division, established under Section 101 of the Mining Act (Act 703 of 2006) has a mandate to regulate and oversee mining in Ghana. It also carries out compliance monitoring; this covers all aspects of mining operations, not only mining.

**18.2.2 Environmental Approvals**

Environmental approvals held by GSR for the Prestea Underground Project are listed in Table 18.2. The environmental permits stipulate various environmental and community management requirements. In general, compliance with the permit conditions appears good and is well managed through ongoing reviews and monitoring and implementation of corrective actions as required.

GSR continues to work to permit various components of its operations and has several projects either pending EPA document review or is working to complete the various requirements of the permitting process as outlined in Table 18.2.
### Table 18.2: Existing and Pending Environmental Approvals

<table>
<thead>
<tr>
<th>Status</th>
<th>Type of approval</th>
<th>Approvals</th>
</tr>
</thead>
</table>
| Existing        | Mining leases    | • Mining Lease WR 348B/87 (21st August 1987) and WR 368/88 (16th August 1988) (Bogoso Lease Area)  
                   |                  | • Mining Lease WR 3218/2001 (29th June 2001) (Prestea Lease Area)  
                   |                  | • Mining Lease LVB 14181/07 (July 2007) (Pampe Lease Area)  
                   |                  | 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. |
| Environmental   |                  | • Environmental permit EPA/EIA/044 (Buesichem & Buesichem North mining project)  
                   |                  | • Environmental permit EPA/EIS/PN/059 (Brumasi mining project)  
                   |                  | • Environmental permit EPA/EIA/069 (Prestea Plant North mining project)  
                   |                  | • Environmental permit EPA/EIA/147 ( Sulphide Project)  
                   |                  | • Environmental permit EPA/EIA/188 ( Tailings Storage Facility II Extension)  
                   |                  | • Environmental permit EPA/EIA/219 (Pampe)  
                   |                  | • Temporal grant permit EPA/EIA/317 (TSF II Water Dilution and Discharge)  
                   |                  | • Environmental permit EPA/EIA/340 (Remining of Tailings Storage Facility 1)  |
| Water use       |                  | • EPA Approval letter of September 2011 to use the Buesichem Pit for TSF water storage.  
                   |                  | • 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. |
| Pending         | Environmental    | • Prestea South Project: Revised EIS submitted to EPA on 19th April, 2011.  
                   |                  | • Prestea South Project: RAP in final draft; the RAP is being updated to reflect additional PAPs identified during field validation process with submission planned December 2011.  
                   |                  | • Dumasi Expansion Project: Environmental Scoping Report submitted to the EPA. The EIS can be submitted on reaching a negotiated resettlement agreement with the Dumasi community – negotiations are ongoing.  
| Water use       |                  | • Water Treatment Facilities (P2W) letter report submitted to EPA on 22nd June 2011. |
18.2.3 Approach to Environmental Permitting

The permitting for the Project will be synchronized with the Project feasibility study. The Project will require the following series of permits and approvals that will generally be as follows:

- Submission of the EA2 form to register the Project with the EPA
- Submission of the Environmental Scoping Report and Terms of Reference to the EPA
- Response from the EPA on the Environmental Scoping Report and Terms of Reference
- Development of the environmental impact assessment
- Completion of the Draft Environmental Impact Statement for submission to the EPA
- Response from the EPA to the EIS
- Submission of the Environmental Impact Statement (modified to address the EPA response)
- Payment of the permitting fees
- Issuance of the environmental permit for the Project.

18.3 Approach to Environmental and Social Management

GSR takes a precautionary approach to environmental and social management. This approach aims to address the risks associated with the various GSR operations for both potential environmental and socioeconomic effects. By using a precautionary approach, GSR is able to minimize adverse effects and optimize the positive socioeconomic effects of its operations.

GSR is a signatory to the International Cyanide Management Code (ICMC) and is fully certified. The confirmation of this has been posted on the ICMI web page for all stakeholders to review.

Environmental management at GSR and at the Project is addressed through an EMS developed along the lines of an ISO 14001 EMS with monitoring and reporting requirements addressing both the legal and corporate needs. Environmental management requirements will be included in the Project EMP, which is required 18 months following the start up of mining operations and then every 3 years thereafter. The EMP will address the valued environmental and socioeconomic components of the project and includes, among other things, the following:

- Impact identification;
- Management of environmental impacts (current and projected);
- Monitoring;
- Environmental action plans;
- Economic benefits action plan; and
- Rehabilitation and closure plan.

Community management is carried out through a range of initiatives, all of which aim to engage the community and understand their needs and desires, while providing an approach to manage expectations. GSR through GSBPL has established Community Mine Consultative Committees (CMCCs) within the local communities (one each for the Prestea, Bogoso, and Pampe concessions). The committees comprise a range of local community and opinion leaders, which are the major conduit of communication both to and from GSBPL, and will carry out the same
function for the Project. The CMCCs are responsible for selecting development projects and assisting the operations understand community concerns and needs. Development opportunities for the stakeholder communities are funded by the Golden Star Development Foundation. Projects for funding are selected by the communities and then forwarded to the CMCCs for assessment. The CMCCs then select the projects to be recommended to the Development Foundation for funding.

The GSBPL Community Affairs Department is responsible for ensuring that community consultation is carried out in advance of project development, and that the closure plans for the various project components include community input the next land use. As such, the development of the Project will include an extensive community consultation program. In general, the project has broad community support.

18.4 Key Environmental and Social Issues

This section only highlights environmental and social issues that could affect the Project permitting, operations or maintenance of approvals, issues that are of concern to local communities and/or issues with management costs that may affect the value of the assets. Environmental and social impacts that can be managed readily without remarkable cost are not discussed here.

18.4.1 Legacy Issues

When GSR (GSBPL) took over the Prestea concession, the Government of Ghana issued an environmental indemnity for historical environmental damage prior to granting of the mining lease in June 2001. This included the existing surface workings and waste disposal areas that resulted from the long history of mining in the area as well as the discharges from the various shafts to keep the underground mines dry. Most of the historical tailings are now difficult to find as they are covered with vegetation or the land has been converted to other uses. Any expressions of tailings at the surface allow their legal removal for re-processing by the Sankofa Mining Company, which has a small CIL plant in Prestea.

However, some other legacy issues are now included in the GSR (GSBPL) asset retirement obligations including some of the older pits, which are relatively minor when compared to the larger pits and waste dumps that have been developed over the past 12 years of operation.

The environmental legacy associated with the Project is essentially zero. The main potential environmental liability is associated with the dewatering of the underground mines. This water does not meet the EPA Guidelines for the discharge of effluent to the receiving environment. However, GSR is currently indemnified for this dewatering. How the dewatering indemnity will be handled with the re-start of the operation is currently unclear but it is GSR’s position that the indemnity will remain in place. This has to be negotiated with the EPA.

18.4.2 Community Sensitivities

The main socioeconomic concern for most stakeholders is employment. Although GSR is unable to employ all the people seeking work, there is a local hiring policy in place that provides affirmative action for the employment of local stakeholder communities. All vacant positions are advertised locally first and then nationally. Local people are used exclusively for unskilled positions, and as much as possible for all other positions within the operation. The Project will draw the majority of its required workforce from within the greater Prestea community. Training
for local employees to work in the underground operations is already underway with 83 people receiving training at the Obuasi underground mine.

Other community concerns include access to land, and noise and blasting effects. However, these are minor for the Project as the mine is underground and blasting will be on a small scale when compared to the open pit operations. The land requirement for the Project should not be extensive with limited surface expressions for infrastructure beyond the areas already developed. These community sensitivities and the fact the mining and the community have been intertwined for many decades requires a focused effort on the Company’s part to maintain harmony. Through extensive outreach programs, the establishment of community committees and support for local infrastructure through the Golden Star Development Foundation, GSR is able to maintain a reasonable operating environment.

**18.4.3 Resettlement**

GSBPL has a number of community resettlement projects in various stages of planning and execution. GSBPL is committed to adhering to the IFC Performance Standard 5 and Ghanaian laws in preparation of the Resettlement Action Plans (RAP). It is expected that resettlement associated with the Project will be limited to, at most, a few residential structures.

**18.4.4 Unauthorized Small Scale Mining**

Galamsey is the local name for unauthorized small-scale mining. It is often associated with environmental degradation, safety hazards, and general community and social concerns. GSR has reported that galamsey in the area of the Project has little potential to affect the operations. In general, the removal of the galamsey from the work areas is not a problem, when asked to leave, they move on to other areas.

Galamsey operations are beyond the control of the regulatory authorities, so there is no requirement for environmental management, reclamation bonding, and site clean-up. These operations divert and dam streams, and wash ore directly in the watercourses, thereby affecting aquatic flora and fauna as well as drinking water sources. They use mercury and cyanide in their metal processing operations, which can cause air and water pollution. They undertake uncontrolled blasting that can result in air blast and ground vibrations that damage community structures.

**18.4.5 Community Expectations**

The local community of Prestea provided the source of employees for the majority of the underground workforces for the past century. At the time of closure of the most recent underground operation, there were about 2000 people employed. However, the approach being taken by GSR for the Project will result in employee numbers that will be less than the previous levels, which were much higher than could be sustained and, hence, contributed in the closure of the mining operations.

The Prestea population has a collective memory of these employment levels. Therefore, GSR will need to appropriately manage community employment expectations through the initial clean up and production from the existing operation and the development and commissioning of the Project.
18.5 Closure Planning and Cost Estimate

The Project surface expression is expected to be limited as most of the waste will be stored underground and the infrastructure associated with the Project is minimal. The rehabilitation and closure of the support facilities (e.g. processing plant, tailings storage facility, ore transportation corridor) are covered under the GSBPL asset retirement obligations. Any waste rock that needs to be managed on surface for the development of the access will be incorporated into the Beta Boundary South pits and dumps and, as such, will be rehabilitated under that area of the lease asset retirement.

The preliminary rehabilitation and closure estimates will be based on the following:

- No allowance for scrap value.
- Progressive closure will be integrated with ongoing operations.
- Costs will be based on a mix of current contractor rates and work being undertaken directly by the operation.
- No provision for ongoing treatment of water. The underground mine will be allowed to flood to the natural level.
- Community post-closure issues will not be included.

The environmental impact assessment will require a preliminary rehabilitation and closure plan. Pursuant to the issuance of an environmental permit, GSR expects the EPA to request either a reclamation bond for the project or a modification to the existing GSBPL reclamation bond through the reclamation security agreement.
19 Capital and Operating Costs (Item 21)

19.1 Capital Costs

The capital costs presented are to a PEA level of accuracy and are expected to be within ±40%. Given the preliminary nature of the study all costs have a contingency of 25% applied. All costs are in Q1 2012 US dollars.

Table 19.1: Capital cost summary (US$000s)

<table>
<thead>
<tr>
<th>Description</th>
<th>Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>Connecting X/Cut -Ramp to Wpass</td>
<td>2,033</td>
</tr>
<tr>
<td>Haulage to Shaft</td>
<td>2,054</td>
</tr>
<tr>
<td>Hoisting Shaft (RB 4.5m)</td>
<td>12,017</td>
</tr>
<tr>
<td>Main Orepass (RB 2.0m)</td>
<td>2,077</td>
</tr>
<tr>
<td>Main Access Decline</td>
<td>70,529</td>
</tr>
<tr>
<td>Main Decline VR Xcut</td>
<td>1,143</td>
</tr>
<tr>
<td>Decline VR (DR 1.5x1.5m)</td>
<td>894</td>
</tr>
<tr>
<td>Stope Edge VR (RB 1.2m)</td>
<td>1,691</td>
</tr>
<tr>
<td>Decline WP (DR 1.5x1.5m)</td>
<td>170</td>
</tr>
<tr>
<td>New Shaft - Hoisting and Headframe</td>
<td>5,000</td>
</tr>
<tr>
<td>Ventilation</td>
<td>1,000</td>
</tr>
<tr>
<td>Pumping</td>
<td>500</td>
</tr>
<tr>
<td>Prestea Central Shaft/Hoist Rehab</td>
<td>4,800</td>
</tr>
<tr>
<td>Backfill Infrastructure</td>
<td>300</td>
</tr>
<tr>
<td>Surface Infrastructure</td>
<td>750</td>
</tr>
<tr>
<td>Other costs</td>
<td>9,860</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>114,818</strong></td>
</tr>
</tbody>
</table>

The following capital cost items have been obtained from a preliminary contractor tender document obtained from a Ghana-based international mining contractor:

- Horizontal drift development;
- Shaft raiseboring; and,
- Vertical drop raises and raiseboring.

Hoisting and headframe costs are based on recent discussions with shaft design consultants. Ventilation, pumping, backfill and surface infrastructure costs are based on internal GSR design estimates with input from equipment suppliers.

Other costs relate to rental agreements for the shaft and hoisting infrastructure, feasibility study costs and other owner costs.
19.2 Operating Costs

PEA level operating costs were estimated as follows:

- Mining costs – based on a preliminary contractor tender document obtained from a Ghana-based international mining contractor. These costs include stope development and stope mining costs;
- Haulage costs – based on current haulage contracts in place for the Bogoso Mine;
- Processing costs – based on current operating costs for the Bogoso Oxide Plant where all the West Reef material will be processed; and,
- G&A costs – based on current Bogoso Mine G&A costs.

Table 19.2: Operating cost summary

<table>
<thead>
<tr>
<th>Description</th>
<th>Total cost (US$000s)</th>
<th>Unit cost</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Mining Costs</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Stope Bypass Connections</td>
<td>12,088</td>
<td>5,700 /m</td>
</tr>
<tr>
<td>Stope Bypass Drift</td>
<td>55,407</td>
<td>5,700 /m</td>
</tr>
<tr>
<td>Stope Orepass (DR 1.5x1.5m)</td>
<td>264</td>
<td>1,000 /m</td>
</tr>
<tr>
<td>Stope Orepass Xcut</td>
<td>481</td>
<td>5,700 /m</td>
</tr>
<tr>
<td>Mineralized Development</td>
<td>59,545</td>
<td>6,200 /m</td>
</tr>
<tr>
<td>Stope Tonnes</td>
<td>93,474</td>
<td>66 /t-processed</td>
</tr>
<tr>
<td><strong>Total Mining Costs</strong></td>
<td><strong>221,258</strong></td>
<td><strong>120 /t-processed</strong></td>
</tr>
<tr>
<td><strong>Haulage Costs</strong></td>
<td>9,222</td>
<td>5 /t-processed</td>
</tr>
<tr>
<td><strong>Processing Costs</strong></td>
<td>27,667</td>
<td>15 /t-processed</td>
</tr>
<tr>
<td><strong>G&amp;A Costs</strong></td>
<td>12,911</td>
<td>7 /t-processed</td>
</tr>
<tr>
<td><strong>Total Operating Cost</strong></td>
<td><strong>271,058</strong></td>
<td><strong>147 /t-processed</strong></td>
</tr>
</tbody>
</table>
20 Economic Analysis (Item 22)

20.1 Model Inputs

Table 20.1: Economic model parameters

<table>
<thead>
<tr>
<th>Description</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mine Life</td>
<td>10 years</td>
</tr>
<tr>
<td>Gold Recovered</td>
<td>437 k ounces</td>
</tr>
<tr>
<td>Gold Price</td>
<td>$1,500 per ounce</td>
</tr>
<tr>
<td>Mill Recovery</td>
<td>95%</td>
</tr>
<tr>
<td>Royalty</td>
<td>5%</td>
</tr>
<tr>
<td>Income Tax</td>
<td>35%</td>
</tr>
<tr>
<td>Discount Rate</td>
<td>5%</td>
</tr>
</tbody>
</table>

The total mine life for the West Reef resource is 10 years, including a four year pre-development phase. The mine will have a nominal production rate of 1,000t/day.

The projected revenues are based on a market gold price of $1,500/oz.

Mill recovery through the Bogoso Oxide Plant is expected based on test results to be 95%.

The economic analysis present post-tax results with a 35% tax rate. The Government of Ghana has indicated that in 2012 the corporate income tax rate will increase from 25% to 35% for mining companies, and capital allowances (tax depreciation) will be deductible at a flat rate of 20% over a five year period instead of an 80% deduction in the year that the capital spending was incurred.

A government royalty of 5% of gross revenue is also included.

January 1, 2012 is the effective date used for the economic indicators. Project assumes 100% equity.

20.2 Project Economic Results

Table 20.2 presents the after-tax economic model results.

Project net present value at a discount rate of 5% is US$107 million with an internal rate of return of 21%. The payback period is 6.3 years from the time of initial investment. Total operating cost is estimated to be US$620 per ounce produced. A constant gold price of US$1,021 is needed to achieve a net present value of zero at 5%.

The cash profile for the project is summarized in Figure 21.1.
## Table 20.2: Economic Model

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Gold Ounces Sold</td>
<td>-</td>
<td>-</td>
<td>6,756</td>
<td>8,364</td>
<td>40,832</td>
<td>93,265</td>
<td>97,126</td>
<td>91,060</td>
<td>73,689</td>
<td>26,202</td>
<td>437,295</td>
<td></td>
</tr>
<tr>
<td>Gold Price</td>
<td>1,500</td>
<td>1,500</td>
<td>1,500</td>
<td>1,500</td>
<td>1,500</td>
<td>1,500</td>
<td>1,500</td>
<td>1,500</td>
<td>1,500</td>
<td>1,500</td>
<td>1,500</td>
<td>1,500</td>
</tr>
<tr>
<td>Revenue</td>
<td>-</td>
<td>-</td>
<td>10,134</td>
<td>12,546</td>
<td>61,248</td>
<td>139,898</td>
<td>145,689</td>
<td>136,591</td>
<td>110,534</td>
<td>39,303</td>
<td>655,942</td>
<td></td>
</tr>
<tr>
<td>Royalty @ 5%</td>
<td>-</td>
<td>-</td>
<td>(507)</td>
<td>(627)</td>
<td>(3,062)</td>
<td>(6,995)</td>
<td>(7,284)</td>
<td>(6,830)</td>
<td>(5,527)</td>
<td>(1,965)</td>
<td>(32,797)</td>
<td></td>
</tr>
<tr>
<td>Net Revenue</td>
<td>-</td>
<td>-</td>
<td>9,627</td>
<td>11,918</td>
<td>58,186</td>
<td>132,903</td>
<td>138,404</td>
<td>129,761</td>
<td>105,007</td>
<td>37,338</td>
<td>623,145</td>
<td></td>
</tr>
<tr>
<td>Mining Costs</td>
<td>-</td>
<td>(1,821)</td>
<td>11,338</td>
<td>13,466</td>
<td>32,125</td>
<td>48,159</td>
<td>48,767</td>
<td>40,691</td>
<td>18,879</td>
<td>6,013</td>
<td>221,258</td>
<td></td>
</tr>
<tr>
<td>Haulage Costs</td>
<td>-</td>
<td>-</td>
<td>(159)</td>
<td>(226)</td>
<td>(834)</td>
<td>2,059</td>
<td>2,057</td>
<td>2,002</td>
<td>1,430</td>
<td>(456)</td>
<td>(9,222)</td>
<td></td>
</tr>
<tr>
<td>Processing Costs</td>
<td>-</td>
<td>-</td>
<td>(477)</td>
<td>(678)</td>
<td>(2,503)</td>
<td>(6,177)</td>
<td>(6,170)</td>
<td>(6,005)</td>
<td>(4,291)</td>
<td>(1,367)</td>
<td>(27,667)</td>
<td></td>
</tr>
<tr>
<td>G&amp;A Costs</td>
<td>-</td>
<td>-</td>
<td>(223)</td>
<td>(316)</td>
<td>(1,168)</td>
<td>(2,883)</td>
<td>(2,879)</td>
<td>(2,803)</td>
<td>(2,002)</td>
<td>(638)</td>
<td>(12,911)</td>
<td></td>
</tr>
<tr>
<td>Total Operating Costs</td>
<td>-</td>
<td>(1,821)</td>
<td>(12,196)</td>
<td>(14,686)</td>
<td>(36,630)</td>
<td>(59,278)</td>
<td>(59,872)</td>
<td>(51,500)</td>
<td>(26,602)</td>
<td>(8,472)</td>
<td>(271,058)</td>
<td></td>
</tr>
<tr>
<td>Income Taxes @ 35%</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>(6,189)</td>
<td>(26,871)</td>
<td>(9,756)</td>
<td>(42,816)</td>
</tr>
<tr>
<td>Operating Cash Flow</td>
<td>-</td>
<td>(1,821)</td>
<td>(2,569)</td>
<td>(2,768)</td>
<td>21,556</td>
<td>73,626</td>
<td>78,532</td>
<td>72,072</td>
<td>51,533</td>
<td>19,109</td>
<td>309,270</td>
<td></td>
</tr>
<tr>
<td>Capital Expenditures</td>
<td>-</td>
<td>(34,217)</td>
<td>(41,521)</td>
<td>(19,691)</td>
<td>(10,562)</td>
<td>(3,879)</td>
<td>(1,137)</td>
<td>(1,020)</td>
<td>(1,092)</td>
<td>(1,020)</td>
<td>(680)</td>
<td>(114,818)</td>
</tr>
<tr>
<td>Free Cash Flow</td>
<td>-</td>
<td>(34,217)</td>
<td>(43,342)</td>
<td>(22,260)</td>
<td>(13,330)</td>
<td>17,677</td>
<td>72,488</td>
<td>77,512</td>
<td>70,980</td>
<td>50,513</td>
<td>18,429</td>
<td>194,452</td>
</tr>
</tbody>
</table>

Net Present Value @ 5%  107,477  
IRR, %  21%  
Payback, years  6.3  

May 3, 2012
20.3 Sensitivity

The project is most sensitive to changes in gold price followed next by operating cost and then capital cost.

Table 20.3: Project sensitivity NPV5% (US$000's)

<table>
<thead>
<tr>
<th>Description</th>
<th>-10%</th>
<th>-5%</th>
<th>Base</th>
<th>+5%</th>
<th>+10%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gold Price</td>
<td>79,144</td>
<td>93,406</td>
<td>107,477</td>
<td>121,481</td>
<td>135,484</td>
</tr>
<tr>
<td>Grade</td>
<td>79,144</td>
<td>93,406</td>
<td>107,477</td>
<td>121,481</td>
<td>135,484</td>
</tr>
<tr>
<td>Operating Costs</td>
<td>120,166</td>
<td>113,822</td>
<td>107,477</td>
<td>101,133</td>
<td>94,725</td>
</tr>
<tr>
<td>Capital Expenditures</td>
<td>114,681</td>
<td>111,079</td>
<td>107,477</td>
<td>103,875</td>
<td>100,274</td>
</tr>
</tbody>
</table>
21 Adjacent Properties (Item 23)

GSR’s Bogoso Mine is currently mining or preparing to mine open pit deposits adjacent to the Prestea Underground Mine along the mineralization corridor to the north and south.
22 Other Relevant Data and Information (Item 24)

There is no further additional data and information to report.
23 Interpretation and Conclusions (Item 25)

The Prestea Mine has a long history of underground stoping production and the West Reef area has good potential as a consistent, 1,000tpd production area to supply high-grade material to the Bogoso Oxide Plant.

The following presents the interpretation and conclusions to this PEA:

**Geology**

- Mineralization hosted along the West Reef structure is confined to quartz-carbonate veins developing within the fault. These fault-filled veins are characterized by laminated textures with stylolitic features and smoky to translucent quartz crystals. Late fault gouge is commonly associated to the mineralized quartz veins and is also generally mineralized, although in most cases at lower grades then the associated quartz veins. Quartz veins are typically one to two meters wide.

**Resource**

- The mineral resources have been classified using logic consistent with the CIM definitions incorporated in NI 43-101. The quality of the geological information satisfies sufficient criteria for the mineral resource to be classified into Indicated and Inferred categories;

- The PEA is preliminary in nature, it includes Inferred Mineral Resources that are considered too speculative geologically to have economic considerations applied to them that would enable them to be categorized as mineral reserves, there is no assurance that the PEA will be realized and mineral resources that are not mineral reserves do not have demonstrated economic viability.

**Underground Mining**

- An underground design and schedule has been conceptualized for mining the West Reef between 17L and 24L;

- The AVOCA mining method with waste backfill appears to be a suitable mining method;

**Process and Tailings**

- The material mined from the West Reef potentially mineable resource would be milled in the currently operating Bogoso Oxide Plant. Tailings disposal would be as per the current plant tailings disposal.

**Infrastructure**

- Significant infrastructure is in place due to the mining history;

- GSR is currently operating and rehabilitating the Central Shaft; dewatering the mine and carrying out cleanup operations; and,

- All access, pumping, hoisting and electrical infrastructure require significant expenditure to bring them up to current safety and productivity standards.
**Environment**

- Community support and the willingness of the EPA to include community considerations in the review and approval of the environmental impact statement mean that it is believed that permitting of the underground development will be achievable within the normal timelines.

- There are no environmental considerations that should prevent environmental approval by the EPA and the subsequent operation of the project within the required environmental guidelines.

**Economics**

- The economic analysis in this preliminary assessment contains inferred resources, which are considered too speculative geologically to have economic considerations applied to them that would enable them to be categorized as mineral reserves. There is no certainty that the preliminary assessment will ever be realized. Mineral resources that are not mineral reserves do not have demonstrated economic viability; and,

- The NPV5% of $107 million after tax, demonstrates an attractive project and suggests that the project should progress to the FS study phase.
24 Recommendations (Item 26)

The findings of this PEA provide compelling arguments to move the study to the FS design stage. The following are the recommendations for advancing the project in the individual areas:

**Resource**
- Further drilling along strike and at depth could expand the current resource and upgrade the inferred material to the indicated category.

**Underground Mining**
- Geotechnical logging of all available drill core in the West Reef area;
- Identification and geotechnical evaluation of a suitable portal location for the Main Access Decline and site for the new raisebored hoisting shaft;
- FS level underground design and scheduling work;
- Detailed backfill requirements and testing.

**Process and Tailings**
- Detailed FS-level metallurgical testing to be carried out using current drill core, new core drilling or bulk sampling from accessible underground exposures;
- Metallurgical testing to include a final assessment of the amount of dilution expected from the stoping method applied;

**Infrastructure**
- Evaluate Central Shaft rehabilitation requirements
- Evaluate hoist and headframe upgrade requirements;
- Trade-off study to compare 1,500tpd hoisting upgrade requirements in the Central Shaft to the development of a new raisebored hoisting shaft;

**Environment**
- Initiate community consultation for the development of the underground operation and determine the methods for including community concerns within the project design and operation
- Develop the environmental and socioeconomic baselines for the operation including a community health assessment
- Complete the environmental permitting process with the appropriate involvement of stakeholders and regulators such that stakeholder concerns are addressed in the design and environmental management plan for the project.

**Preliminary Budget**
- Feasibility Study for current Indicated Mineral Resources in the West Reef area - $1.5 million
- Drilling of 40 resource upgrade holes in West Reef area - $2.5 million
25 Date and Signature


The format and content of the report are intended to conform to Form 43-101F1 of National Instrument 43-101 (NI 43-101) of the Canadian Securities Administrators.

Dated this 3rd day of May, 2012.

(Signed and Sealed) “Martin P. Raffield”

Dr Martin P. Raffield, P.Eng., PhD.
10901 W. Toller Drive, Suite 300
Littleton, CO 80127-6312
U.S.A.

Telephone: 303-830-9000
Email: mraffield@gsr.com

(Signed) “S. Mitchell Wasel”

S. Mitchell Wasel, BSc, AusIMM (CP)
223 Chapel Hill Road
Takoradi, Ghana

Telephone: +233 244 311 491
Email: mwasel@gsrg.com
26 References (Item 27)


Junner N.R., (1940), *Geology of the Gold Coast and Western Togoland*, Gold Coast Geological Survey, Memoir No. 11.

Kitson, A.E., (1928), *Provisional geological map of the Gold Coast and Western Togoland, with brief descriptive notes thereon*, Gold Coast Geological Survey, Bulletin No. 2.


Appendix A

Certificates of Authors
CERTIFICATE of AUTHOR

I, Martin Raffield, Ph.D., P.Eng. do hereby certify that:

1. I am Senior Vice President, Technical Services of:
   Golden Star Resources Ltd.
   10901 W. Toller Drive, Suite 300
   Littleton, CO 80127-6312 USA

2. I graduated with a BSc degree in Exploration and Mining Geology in 1989 and a PhD in Mining Engineering in 1993 both from the University of Wales, UK;

3. I am a licensed professional engineer registered with Professional Engineers Ontario - PEO License No.: 100061761;

4. I have worked as a mining engineer for a total of 19 years since my graduation from university;

5. I have read the definition of “qualified person” set out in National Instrument 43-101 (“NI 43-101”) and certify that by reason of my education, affiliation with a professional association (as defined in NI 43-101) and past relevant work experience, I fulfill the requirements to be a “qualified person” for the purposes of NI 43-101;

6. I am responsible for the preparation of all (except Sections 5, 6, 7, 8, 9, 10 and 12) of the report titled, NI 43-101 Preliminary Economic Assessment - Mechanized Mining of the West Reef Resource, Prestea Underground Mine May 3, 2012;

7. I last visited the Prestea Underground Mine for a day on Jan 12, 2012;

8. I have had involvement with the property since joining GSR in August 2011;

9. I am not aware of any material fact or material change with respect to the subject matter of the Preliminary Assessment that is not reflected in the Preliminary Assessment, the omission to disclose which makes the Preliminary Assessment misleading;

10. I am employed by GSR, thus I am not independent of the issuer;

11. I have read National Instrument 43-101 and Form 43-101F1, and the Technical Report has been prepared in compliance with that instrument and form;

12. I consent to the filing of the Technical Report with any stock exchange and other regulatory authority and any publication by them for regulatory purposes, including electronic publication in the public company files on their websites accessible by the public, of the Technical Report; and,

13. As of the date of this certificate, to the best of my knowledge, information and belief, the Technical Report contains all scientific and technical information that is required to be disclosed to make the Technical Report not misleading.

Dated this 3rd day of May, 2012.

(Signed) “Martin P. Raffield”

________________________
Dr Martin P. Raffield, P.Eng., PhD.
I, S. Mitchell Wasel do hereby certify that:

14. I am Vice President of Exploration for:
   Golden Star Resources Ltd.
   10901 W. Toller Drive, Suite 300
   Littleton, CO 80127-6312 USA

15. I graduated with a BSc degree in Geology in 1988 from the University of Alberta, Canada;

16. I am an accredited chartered professional in geology certified by the AusIMM.

17. I have worked as a geologist for a total of 24 years since my graduation from university;

18. I have read the definition of “qualified person” set out in National Instrument 43-101 (“NI 43-101”) and certify that by reason of my education, affiliation with a professional association (as defined in NI 43-101) and past relevant work experience, I fulfill the requirements to be a “qualified person” for the purposes of NI 43-101;

19. I am responsible for the preparation and review of Sections 5, 6, 7, 8, 9, 10 and 12 of the report titled, NI 43-101 Preliminary Economic Assessment - Mechanized Mining of the West Reef Resource, Prestea Underground Mine May 3, 2012;

20. I last visited the Prestea Underground Mine for one day on May 2, 2012;

21. I have had involvement with the property since GSR acquired the property in 2001;

22. I am not aware of any material fact or material change with respect to the subject matter of the Preliminary Assessment that is not reflected in the Preliminary Assessment, the omission to disclose which makes the Preliminary Assessment misleading;

23. I am employed by GSR, thus I am not independent of the issuer;

24. I have read National Instrument 43-101 and Form 43-101F1, and the Technical Report has been prepared in compliance with that instrument and form;

25. I consent to the filing of the Technical Report with any stock exchange and other regulatory authority and any publication by them for regulatory purposes, including electronic publication in the public company files on their websites accessible by the public, of the Technical Report; and,

26. As of the date of this certificate, to the best of my knowledge, information and belief, the Technical Report contains all scientific and technical information that is required to be disclosed to make the Technical Report not misleading.

Dated this 3rd day of May, 2012.

(Signed) “S. Mitchell Wasel”

____________________________
S. Mitchell Wasel BSc Geology AusIMM (CP).