APPENDIX 2.12.13

COFFEY GEOTECHNICS LIMITED
CAGL HYDROGEOLOGY REPORT

coffey geotechnics
SPECIALISTS MANAGING THE EARTH

AYANFURI GOLD PROJECT: HYDRO-GEOLOGICAL REVIEW

Perseus Gold
Ghana

GEOHARR01077AA_AB Rev B
8 June 2009

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SPECIALISTS MANAGING THE EARTH

8 June 2009

Perseus Gold
30 Ledgar Street
BALCATTA WA 6021

Attention: Mr B Marwood

Dear Sir

RE: Ayanfuri Gold Project: Hydrogeological Review

Attached please find the results of hydrogeological analyses of data received from the dewatering of the Abnabna and Fobinso North Pits, and our assessment of hydrogeological issues affecting the feasibility of re-opening these and other pits forming the Ayanfuri project, Ghana.

Please do not hesitate to contact the undersigned should you have any query concerning this report.

For and on behalf of Coffey Geotechnics Ltd

M.O.Hillman

Senior Principal

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EXECUTIVE SUMMARY

Coffey Geotechnics Pty Ltd (Coffey) has completed a hydrogeological assessment of the feasibility of dewatering proposed mining operations for the Ayanfuri Gold project, Ghana, for Perseus Mining Limited NL. This work has involved a review of available reports, and of field and laboratory test data collected by mine site personnel; a visit to the project site; and collation and interpretation of data collected from mine site personnel during the dewatering of two existing pits.

Ayanfuri is likely to generate excess water in the initial years of operation and over the life of the project as the stored water in the pits is removed ahead of mining activities. Some of this water will be used for dust suppression with the balance discharged into the Flotation Tailings Storage Facility (FTSF) and used in the process plant.

Trial pit dewatering was undertaken as a means of accessing the base of two pits for resource drilling purposes (the existing Abnabna and Fobinso North pits), and has provided a valuable mining scale test of hydrogeological conditions at Ayanfuri.

Licencing approval was received to dewater Ayanfuri pits and dispose of the pumped water into natural streams that ultimately drain to the Ofin River. The approved discharge rate was $0.35m^3/s$ up to a maximum $5x10^6m^3$ per year, until December 2008. The purpose for which the licence was sought, was dewatering to enable exploratory drilling to be undertaken from within the pits. The licence has now expired. Licence conditions were met based on records from the dewatering available for this study.

The impact of the dewatering was monitored both through pit water balance data and also through a number of exploration boreholes acting as groundwater monitoring bores adjacent each pit. Water balances were undertaken taking into account dewatering rates, storage volume for different pit elevations, and contributions from rainfall and evaporation, and the groundwater leakage rate into the pits over the course of the testing was assessed as 700kL/d (Fobinso North) and 500kL/d (Abnabna).

The water yielding conditions in the pits are judged to be dictated by fracture systems/ jointing in the rock and are non-homogeneous and anisotropic. Nevertheless based on observations of monitoring bore performance, and the absence of data suggesting major linear hydrological features, the interconnection of such fractures/ jointing can be interpreted in terms of an overall permeability, and an overall storativity. The adopted figures based on this analysis were a permeability of k=0.1m/d and a specific yield of S_y=0.02 for the 30m below standing water level, reducing to k=0.01m/d and S_y=0.005 for greater depth.

This report estimates the combined average dewatering requirements during the initial 3 years of pit operations following removal of stored waters in Abnabna, Fobinso North and Fobinso South to be 2350kL/d based on average monthly rainfall and evaporation figures. This figure will need to be reviewed as part of overall mine water balance analyses on an annual basis.

The design for sizing of pit dewatering infrastructure will need to be based on sufficient capacity to remove runoff from large individual rainfall events or series of events. Pumping capacity sufficient to remove runoff from a 5 year return event in 10 days, or a 100 year return event in 30 days, will require combined pump capacities of 250kL/hour at the start of mining, increasing to 850kL/hour at the ultimate pit, based on a consideration of pit envelopes, rainfall recurrence intervals, and likely groundwater intersections. This capacity will be distributed across a number of pumping systems, with three pumping systems required at the commencement of mining to accommodate the three existing pits Abnabna, Fobinso North and Fobinso South, but with more systems added as the mine grows.

Abnabna and Fobinso pit crests are close to natural drainage water paths. Adequate bunding will be required around such pits to protect them from inundation should water levels rise significantly in the natural drainage systems during an exceptional wet season. This situation will be exacerbated as pit envelopes are widened. As mining proceeds diversion of Asuafa Stream is proposed, to alleviate this risk.

Dewatering requirements for Esuaja and Fetish pits have not been considered in detail in this report, as these pits are not mined until, at the earliest, well into year 3 of the mining schedule.

The water quality in the pits during the dewatering was slightly acidic. Information available to date suggests the acidity is generated from near surface acid soils, and the breakdown of organic matter. It is possible the acidity observed has some contribution from acid sulphate conditions. During the original mining of these pits, it is understood that water quality of dewatering waters remained excellent.

As the mines deepen, it is anticipated that sulphide ore will be exposed, and the risk of acid sulphate conditions will increase. It is recommended that mine planning allow for cycling of dewatering water through the FTSF before moving to the process circuit.. It is anticipated that rainfall inflows significantly larger than average rainfall conditions may require some release of pumped waters straight to the environment. However this should only be done if monitoring of water quality is able to demonstrate that the water quality is suitable for discharge to the environment (it meets negotiated EPA criteria). Lime dosing should be available to maintain pH>6.

A new discharge licence will be required when deepening of the mines proceeds. Licencing will need to be sought from the EPA for the disposal of large volume inflows (primarily rainfall inflows) to the environment subject to acceptable water quality parameters and impacts on local surface “flooding”. Given the very low salinity of water in the region but the slightly elevated arsenic, criterion for acceptable changes in groundwater should be sought based on the discharge creating no significant deterioration in water quality in the receiving waters (Ofin River) for water disposed from the mine. We anticipate that the circumstances under which a release is required would also correspond with a period of high stream and River flow.

The impact on stream water quality from previous mining activities at Ayanfuri should be noted, as it will not be practical to separate this impact from the impact of the proposed dewatering (and mining activities). Stabilisation of old mine waste rock dumps to significantly reduce erosion and resulting water course turbidity should be considered.

It should be noted that high rates of dewatering required to drain the currently full pits creates a risk of ‘rapid drawdown’ loading on pit walls reducing wall stability. Similarly, as the pits are expanded across current stream alignments, the water within the streams during periods of flow will both increase recharge to the pits and possible dewatering volumes, and also will result in higher potentiometric pressures in pit walls reducing their stability. Advice from a specialist pit geotechnical consultant confirming the risks involved should be sought.

Dewatering below the pit floor is expected to require in pit dewatering systems because of the generally low permeabilities at depth (i.e. floor sumps and slope toe drains). However the probability exists that significant water yielding structural discontinuities in the deeper bedrock will be encountered, and these should be intersected outside the pit and pumped to an elevation below pit floor levels to assist in draining the pit.

Base line surface, pit and groundwater sampling and testing should be collected to ensure the range of seasonal conditions has been adequately understood. The report outlines monitoring requirements for such base line data collection, together with monitoring requirements for on-going mining.

1 INTRODUCTION

Perseus Mining Limited is assessing the feasibility of re-opening a decommissioned gold project located close to the town of Ayanfuri in Ghana, West Africa (the Ayanfuri prospect). Coffey Geotechnics Ltd has been commissioned to conduct a review of available hydrogeological data and advise on mine site dewatering requirements for long term mining of this orebody.

This report is prepared and is to be read subject to the terms and conditions contained in our proposal dated 28 March 2009. Our advice is based on the information stated and on the assumptions expressed herein. Should that information or the assumptions be incorrect then Coffey Geotechnics Ltd shall accept no liability in respect of the advice whether under the law of contract, tort or otherwise.

2 BACKGROUND

Reference should be made to Anglogold Ashanti Ghana Limited 2006 for an outline of the proposed development. In brief, the Ayanfuri Project is to comprise a conventional open-cut mine and 2 Mtpa Carbon-In-Leach (CIL) facility processing predominantly granite hard rock, non-refractory gold ore.

Previously, Cluff Mining Ghana Ltd, and subsequently Ashanti Goldfields Corporation, operated 23 open-cut pits and a central gold heap leach processing facility on the site, processing the (then) depleted oxide ores. The mine was closed in early 2001. The new operation will mine and process ores won from below the existing pits and continue regional exploration with a view to generating additional reserves.

The pits of interest at the time of preparation of this report (refer Perseus 2006) were:

- Esuajah South and North Pit
- Abnabna
- Fetish South
- Fobinso South and North
- Chirawewa Group

A pre-feasibility hydrogeological report, prepared on the basis of a review of hydrogeological data made available to Coffey and a site visit, was prepared by Coffey Geotechnics Pty Ltd (Perth) - report reference GEOTHERD08308AA-AA dated 22 August 2007. The pre-feasibility report also reported on hydrogeological studies undertaken for a second prospect, located at Grumesa. This second prospect is not considered further in the current report. Primary data sources used for this prefeasibility study included:

- Anglogold Ashanti Ghana Limited 2006 provided an overview of the project, site conditions including previous pit development, and proposed pit locations and geometries.
- Anglogold Ashanti Ghana Limited (undated) provided significantly greater detail on site conditions relating to groundwater and the existing pits.
- Kuma 2007 presents considerable hydrogeological data (including groundwater quality analyses) together with an interpretation of hydrogeological conditions.

- Perseus 2006 outlines proposed mining plans and illustrates proposed pit envelopes for Fobinso, Abnabna, and Esuajah pits.

Further baseline data collected by Mr Crisler Ankrah including baseline water sampling and testing, and the measurement of water table elevations in open exploration boreholes, was collated immediately prior to and during the site visit. This data was supplemented by limited hand testing of pit water quality using a field pH, temperature and conductivity meter.

The Chirawewa Group is not included in the current mining schedule (see Table 4).

3 FURTHER TESTING

3.1 Dewatering of Existing Pits

Subsequent to the prefeasibility hydrogeological report, the existing Abnabna and Fobinso North pits were dewatered to enable resource drilling to be undertaken from within the pits. In order to do this, a licence had been sought for discharging the pumped water to existing natural drainage systems. The water discharge licence issued by Department of Water Resources allowed up to $5x10^6$ m^3/ annum of groundwater discharge from the pits, subject to the discharge meeting EPA Standards. The licence refers to a combined discharge rate of $0.35m^3/s$ from four pumps to enable the pits to be dewatered for the purposes of undertaking the resource investigation. The licence had a finite life (to December 2008), and was therefore not valid for on-going mine dewatering activities.

3.2 Data Collection

During the course of pit dewatering, Perseus collected records on Abnabna and Fobinso North pit dewatering including:

- Quantities pumped pit water levels and pit water quality on a weekly basis;
- Groundwater elevations in inclined exploration bores in the vicinity of the two pits;
- Daily rainfall records for Dunkwa;
- Pit survey data showing surface areas for water table elevations at 1m intervals.

In addition, data was collected on pit water levels for other pits including Fobinso South. Water samples were collected from selected pits in March 2009 for comprehensive laboratory analyses following the completion of the dewatering program.

The data collected during dewatering of the pits and subsequent to dewatering was collated by Coffey for the purpose of preparing this report.

Appendix A presents data collated at the time of the pre-feasibility study, and includes records of water quality sampling in a number of Ayanfuri pits, and the results of field pH and conductivity testing by Coffey during their 2007 site visit. Standing water table elevations from inclined exploration boreholes cased as piezometers at that time, are also presented in Appendix A.

Appendix B presents results from Water Balance Assessments. Appendix C presents Monitoring Bore Hydrographs and Appendix D presents the results of field Water Quality Testing during the Resource Drilling Dewatering project and results from March 2009 sampling and laboratory testing. Major ions recorded in this later testing have been combined with the earlier 2007 for comparative purposes.

4 SITE CONDITIONS

4.1 Meteorological

4.1.1 Rainfall

Kuma 2007 describes rainfall conditions in the region, with an effective 2 wet season “peaks”. Mean annual rainfall for the Dankwa meteorological station (46 years of continuous record 1963 to 2008) is about 1500mm. There is some evidence of a decline in rainfall in the region over this period, however rainfall in 2006, 2007 and 2008 was 1708mm, 1614mm and 1577mm respectively. The wettest periods of the year are in June, and again in September/October. Peak monthly rainfall of in excess of 520mm was recorded in June 1968, and again in September 1968, an exceptionally wet year with some 2,428mm of rainfall recorded for the 12 months. The driest months are December to February. In 1997/1998 just 4mm of rainfall was recorded in these 3 months. In 1982/83 less than 90mm was recorded over a 5 month period November to March inclusive. Table 1 presents average monthly rainfall data for Dankwa on Offin Meteorological Station.

Coffey Mining 2007 has used open water body evaporation rates as set out in Table 1.

	Jan	Feb	Mar	Apr	May	June	July	Aug	Sep	Oct	Nov	Dec	Year
Rain	13	51	138	170	195	233	133	92	170	175	98	38	1505
Evap	152	124	135	130	142	107	109	94	99	122	130	127	1469

TABLE 1 MONTHLY RAINFALL AND EVAPORATION (mm)

Rainfall intensity, duration and frequency data summarised in Table 2 is from Dankwa (1974) for a meteorological station at Kumasi. The rainfall records for Ayanfuri is likely to be wetter than at Kumasi based on maps presented in Dankwa (1974), but on the other hand, the 1974 predictions are likely to be conservative in an environment where rainfall has been decreasing over the last 3 decades. Kuma 2007 provided an estimate of rainfall magnitudes for a 24 hour event, and varying return periods. The Kuma 2007 figures are lower than those presented in Table 2.

SAL Consult 2009 has also interpreted 24 hour rainfall intensity/ recurrence interval figures using 30 years rainfall data from 1979 to 2008. The analysis did not include available rainfall data from Dankwa meteorological station from 1963 to 1979. This period included very wet months in September 1963, June 1968 and September 1968, which had they been included in the analysis, would have resulted in larger rainfall magnitudes. Whilst it may be reasonable to state that observations of the last 3 decades of rainfall over Ghana have suggested a period of drying, caution must be applied in treating monsoons and other episodic effects, as there is an argument that such events are becoming more ferocious with “climate change”.

The Dankwa (1974) figures used in the Coffey 2007 report, have been re-used for the current study.

RAINFALL INTENSITY (mm)	Return Period (years)					
Duration (hours)	**5**	**10**	**15**	**25**	**50**	**100**
0.2	27	31	33	35	38	42
0.4	47	51	57	62	68	74
0.7	66	73	80	86	94	103
1	77	84	94	102	112	122
2	91	107	120	130	147	162
3	99	116	124	136	151	175
6	116	137	149	165	184	206
12	125	149	165	183	207	216
24	128	152	171	189	213	232

Based on Dankwa 1974

TABLE 2: RAINFALL RECURRENCE ESTIMATES

4.2 Surface Conditions

Anglogold Ashanti Ghana Limited 2006 and Kuma 2007 both describe the surface conditions in which this site lies. Reference should be made to these earlier documents.

Based on the above documents and our site observations we make a number of observations.

The mine site is in comparatively rugged terrain, with catchments well defined and stream systems that vary from well defined channels to broader, low gradient ‘wetland’ areas.

The Fetish Pits are near the headwaters of the Subin-Asuaa stream system. Esuajah South, about 1.5km downstream (to the north) is also adjacent to this stream. The stream is to the east of the Esuajah South pit, and poorly defined in this area (a wetland area is formed through which the stream water flows). The stream drains northwards into the Ofin River a further 7km downstream. The mean monthly run-off of the Subin stream at the Railway Bridge about 2.5km north of Ayanfuri ranged from 0.032m^3/s in January to 0.185m^3/s in June (refer Anglo Gold Ashanti (undated)).

The Abnabna Pit is adjacent a small tributary to the Asuafa Stream. The tributary joins the main branch of Asuafa Stream immediately east of the mine (less than 200m east), where the main branch has been straightened and “trained” by the former waste rock dump. The upstream catchment of the main Asuafa Stream is of the order of 10km^2.The Fobinso pits are a further 1km down stream, and to the east of the stream bed. Significant stream bed disturbance has been created in this area by galamsey, with the result that the original stream alignment is unrecognisable, and sediment is continually eroding, producing cloudy water (suspended solids).

The Asuafa Stream runs into the larger Akesoa Stream and then into Offin River some 5 to 6km down gradient of the Fobinso pits.

SAL Consult 2009 presents a review of major stream hydrological characteristics for this project.

4.3 Subsurface Conditions

4.3.1 Overall

The following extract from Anglo Ashanti Gold (undated) describes the site geology.

> The Ayanfuri site is underlain by the Lower Birimian metasediments intruded by granite porphyry intrusives. Prominent contact metamorphic aureoles demonstrate the intrusive nature of these granite bodies. The area is situated on a spur of the main gold belt in Ghana, the Ashanti - Prestea Gold Belt.
>
> The Ayanfuri area is geologically described as comprising a lower resistant unit of slightly metamorphosed sediments overlain by an upper unit of less resistant rocks. The two units are folded into a broad, gently southwest plunging, faulted syncline. The two units are intruded by small semi-concordant granitoids of indeterminate age. The major rock types include phyllites, metatuffs and metagreywackes of the Lower Birimian series. Further tectonism after deposition has resulted in intense folding and faulting.
>
> Fold axes strike NE-SW and NNE-SSW. Fold types range from open through isoclinal to overturned with the latter being associated with large strike faults. The major faults are parallel to the regional strike with NW-SE faulting often offset by the NE-SW faults. Most of the faults appear to be steeply dipping to vertical. Phyllites with talc sericite alteration are common. Associated with the talcose phyllite are carbonaceous schist horizons.
>
> The general trend of the underlying rocks in the area is 030-050 degrees. Dips are generally above 70 degrees and are directed either southeast or northwest.

The base of oxidation (defined as the first evidence of sulphides) is comparatively shallow (20m to 40m) and the transition zone less than 5m thick.

Geological structures mapped by Cluff Resources 1992 are illustrated in a plan of the geological setting and pit locations at Figure 4.

The following description of pit conditions has been based primarily on Anglo Ashanti Gold (untitled), supported by site observations during the recent site visit.

4.3.2 South Esuajah Pit

The pit was developed from a crest of elevation 172m MSL (above mean sea level) to a designed pit floor of 104m MSL, (a depth of 68m). It is ellipsoidal in shape with the major axis of about 250m running approximately north. The minor axis is about 150m. It has a perimeter of about 800m and an area of 5 hectares. The volume of material mined out of the pit is estimated to be approximately 2 million m^3.

The pit is filled with water up to 132m MSL (a depth > 20m) with high pit walls ranging between 10m and 25m. Any overflow from the pit water would join the nearby Danyami stream, which flows northerly to join the Ofin River – however there is some doubt as to whether this pit has as yet overflown. The pit periphery is overgrown with thick vegetation while creeping plants grow on parts of the pit slopes, making access to the pit only through the ramp. The pit has already acquired wetland ecology with aquatic life in the clear water and birds have made their nest in the vegetation around the pit. Present water sampling results indicate acceptable water quality.

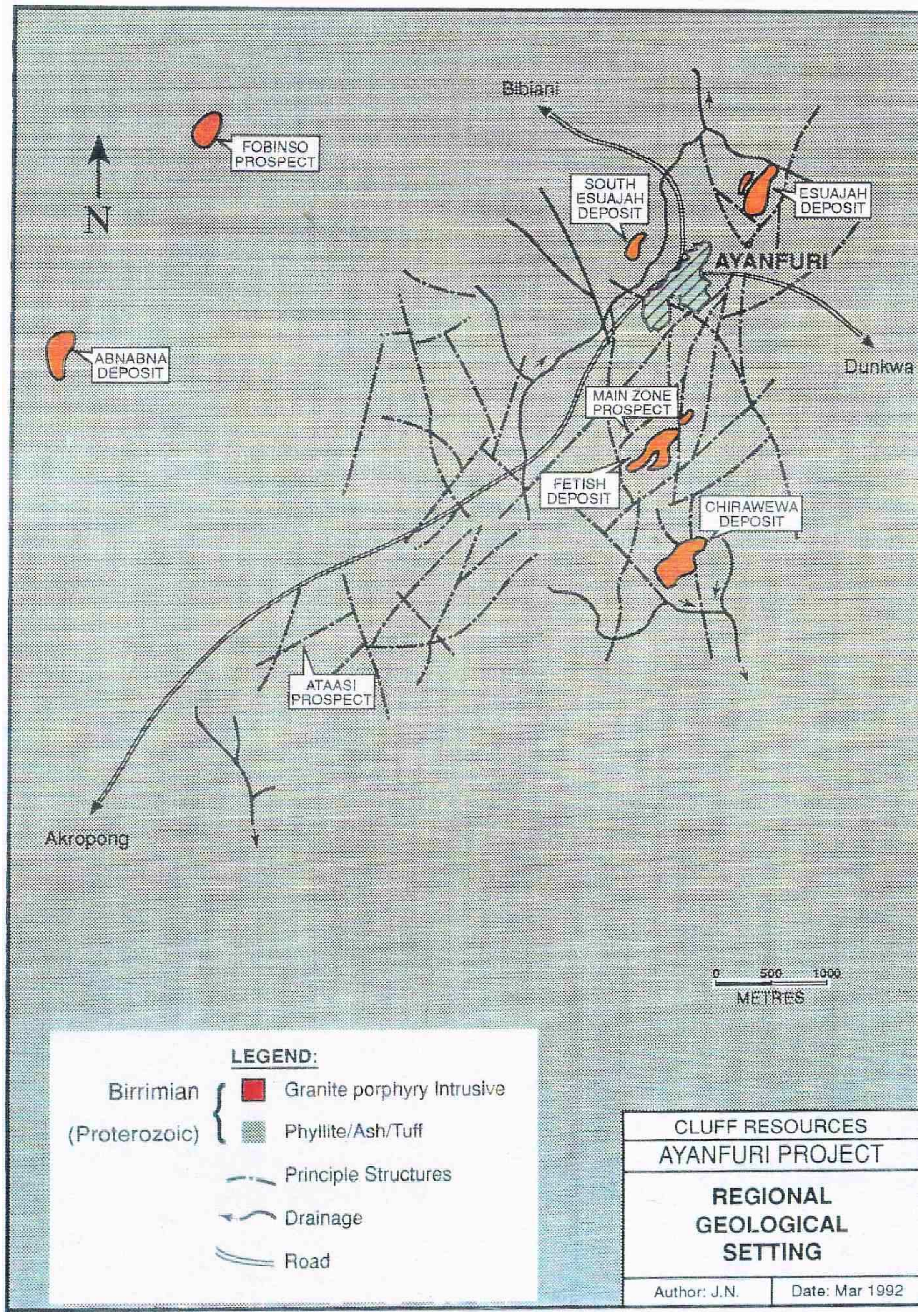

FIGURE 4 GEOLOGICAL STRUCTURES

The Esuajah deposit located 1km northeast of Esuajah South, occupied a ridge comprising a 400m long granitoid intrusive which averaged about 100m in width. Cluff delineated and mined oxide resources of 1.9Mt.

4.3.3 Fetish North and South

The Fetish pits are located about 2km south of South Esuaja.

The combined perimeter along the vehicular access for the pits is approximately 2000m and covers an area of 18.6 hectares. The volume of material mined out of these two pits is estimated to be 4.4 million m^3.

The two pits have water accumulated up to 135m MSL (a depth > 40m) with high pit walls ranging between 10m and 40m. The accumulated water in Fetish North is undisturbed and fairly clear. The Fetish South pit water has high suspended solids resulting in high turbidity. This is partly due to the type of material pushed into it in an attempt to backfill it and to limit the activities of illegal miners (galamsey operators) that existed in the area. The overflow water from the Fetish South pit is controlled by means of a spillway constructed towards the haul road and is directed to the Danyami stream, which joins the Subin stream. Partial backfilling has been undertaken and the west walls re-contoured.

4.3.4 Fobinso North and South

At the Fobinso mine site the two pits developed are adjacent to each other and share a common boundary. They have been named Fobinso North and Fobinso South pits. They are located in a farming area about 2km south of the heap leach pad and are surrounded by crop farms.

Together, they run in the northeast southwest direction.

The parameters on the north pit are as follows:

> Major axis: 450m; Minor axis: 200m; Perimeter: 1.4km; Maximum depth: 65m; Volume of material mined out: 1,907,326 m^3

The parameters on the south pit are as follows:

> Major axis: 300m; Minor axis: 200m; Perimeter: 1km; Maximum depth: 45m; Volume of material mined out: 280,905 m^3

Erosion has created small gullies on the wall faces. Remnants of a hedge planted around the north and south pits only remain with some grass and weeds with a background vegetation of secondary forest. Occasionally illegal mining (‘galamsey’) operators come to work around both pits. The north and south pits, which were mined to below the water table, are filled with water leaving about 20m of the pit walls above the water. The water in the north pit is slightly more turbid than that in the south pit. The north pit appears to be able to overflow to the north, but the location of any overflow of the south pit has not been identified by Coffey.

The results from the samples taken indicate fresh water with low metals.

4.3.5 Abnabna

The pit has an oval shape elongated in the northeast–southwest direction. The major axis is about 400m and the minor axis is 150m with a depth of 65m, which is below the water table. The total coverage area is 8.2 hectares. The volume of material mined out has been estimated to be 689,652 m^3.

The pit is filled with water to a depth of 40m with 25m height of the NW pit walls above the water level, while the SE wall, in contact with the access road, has been reduced to about 7m above the water level. The clear water shows evidence of aquatic life. Results of samples from the pit water indicate that it is slightly alkaline but fresh with low metals content. The slope faces have developed small gullies as a result of erosion. Vegetation has developed around the pit perimeter in addition to the secondary forest at the background of the NW wall.

Abnabna appears to overflow to the east into the Asuofa Stream system over a crest elevation of about 134m MSL (standing water level before the dewatering was about 133m MSL).

Pit Name	**Mined Volume (m3)**	**Current Pit Floor (m MSL)**	**Standing Water Elev.(m MSL)**
Abnabna	690,000	115	133
Fobinso North	1,900,000	105	131
Fobinso South	480,000	102	131
Esuajah S	2,000,000	104	133
Fetish S	4,400,000	112	152

TABLE 3 CURRENT PIT DIMENSIONS

5 MINING PROPOSALS

Perseus Gold Limited propose a major expansion of existing pits, extending well into adjoining unmined areas. In particular, the Abnabna Pit will extend into the Abnabna-Fobinso Gap (AF Gap).

Table 4 identifies proposed sequence of mining, and depths to base of mining for each stage of mining.

Pits	Period		End of Period Elevation (mRL)
	Start	Finish	
AF Gap Stage 1	Year 0, Mth 1	Year 2, Mth 8	15
AF Gap Stage 2	Year 1, Mth 16	Year 4 Qtr 4	-45
AF Gap Stage 3	Year 2, Mth 8	Year 7 Qtr 2	-105
Abnabna Stage 1	Year 0, Mth 4	Year 2, Mth 10	15
Abnabna Stage 2	Year 1, Mth 8	Year 3 Qtr 3	-15
Abnabna Stage 3	Year 3 Qtr 2	Year 6 Qtr 3	-70
Fobinso Stage 1	Year 1, Mth 4	Year 3 Qtr 3	0
Fobinso Stage 2	Year 4 Qtr 2	Year 5 Qtr 2	50
Esuajah North	Year 3 Qtr 2	Year 8 Qtr 4	-30
Fetish Stage 1	Year 5 Qtr 2	Year 8 Qtr 2	10
Fetish Stage 2	Year 7 Qtr 1	Year 10 Qtr 1	-55

TABLE 4 PROPOSED PIT DEVELOPMENT SCHEDULE

Figures sighted during the course of preparation of this report shows the combined volume of rock (soil, ore and waste rock) to be recovered from Abnabna and the Abnabna-Fobinso Gap pit area is some $34.8 \times 10^6 m^3$, with a pit envelope of almost $400{,}000 m^2$. The volume of rock from the Fobinso Pit is some $9.2 \times 10^6 m^3$ with a pit envelope of almost $150{,}000 m^2$. We have not sighted figures for Esuajah or Fetish.

The proposed works will require a diversion of the Asuafa Stream from its current alignment east of the pit to a new alignment west of the expanded pit. Appendix E presents a copy of the proposed drainage plan from Coffey Mining (2009), illustrating the extent of the Abnabna/Fobinso/Gap pit envelopes, and the realigned stream.

6 RESOURCE DRILLING PIT DEWATERING

6.1 Pit Water Balance

Dewatering of the Fobinso North and Abnabna pits commenced on 22 July 2008, with base of pits substantially achieved about 16 November (about 115 days of pumping) and 13 September (about 53 days of pumping) respectively. During this period, pit volume data indicates the water removed from storage had been 532ML for Fobinso North (21m drawdown from standing water level) and 382ML from Abnabna (18m drawdown from standing water level). Pumping rates for each pit averaged about 8500kL/d during the primary period of dewatering, reducing due to operational reasons as the dewatering proceeded. When the pits had been substantially drained, dewatering continued at a much reduced rate with smaller pumps in both pits to remove groundwater and rainfall inflows, until 19

November 2008 and 1 December 2008 (respectively) when pumping ceased and water levels in the pits commenced a steady recovery.

The data is sufficient to allow a water balance for the dewatering to be prepared. The water balance has five elements, as discussed below:

i. Pumped Quantities: Recorded on a weekly basis until water levels had been drawn down to the base of the pit, and the large “dewatering” pump was substituted with smaller pumps to maintain the pit floor in a drained condition.

ii. Change in pit storage: Pit horizontal surface areas were supplied by Perseus for this analysis. The areas were produced at 1m vertical intervals. A 3 order polynomial was applied to the level versus surface area data, to allow rapid interpolation of surface areas for elevations between the 1m vertical spacings. Whilst this is an approximation, a reasonable fit was achieved using the polynomial.

iii. Open water evaporation: As measurements of open water evaporation were not recorded, an estimate has been made based on 100% average monthly pan evaporation figures for Dunkwa, applied to the surface area exposed at any pit water level. The volumes involved are little more than 1% of the volumes pumped, and therefore the water balance is not particularly sensitive to this evaporation figure.

iv. Rain water runoff: Rain water runoff can be a combination of direct rainfall on the exposed pit envelope, together with some runoff from any catchment feeding into the pit (and not excluded from doing so by earth bunds). At the very least (a lower bound figure) rainfall runoff will be 100% of the area of the exposed pit envelope, but depending on size of catchment, magnitude of rainfall event, antecedent conditions, and capacity for the surrounding vegetated areas to “hold” water, the actual runoff may be several times larger.

v. Leakage into the pit from the groundwater table: The remaining element of the water balance will be leakage through the walls and floor of the pit. Leakage can not be measured, and has to be inferred from the water balance. It should be noted that falling water levels in Fobinso South pit at a time in which other pit levels were rising or stable, indicates leakage of that pit into Fobinso North Pit.

Water balance assessments were undertaken for both Fobinso North and Abnabna pits, using data collected during the lowering of water levels once pumping was underway, and also data collected during the subsequent dry season when water levels were recovering, and no pumping was taken place.

Table 5 summarises the results of the water balance analyses. Appendix B presents the data used in these analyses.

The water balance figures adopted, assume that only direct rainfall runs into the pit (i.e. areas outside the pit envelope did not contribute runoff into the pit). This is unlikely and would lead to an over estimate of groundwater leakage rate. We also assumed evaporation from the open water body only. Evaporation will also occur from the walls of the pit, and therefore leakage through the walls would tend to be underestimated for this factor.

“Recovery” data is likely to be more accurate than drawdown data, because it is not subject to the accuracy of recording of pumped volumes, and because the recovery took place over a dry period –

and is not strongly affected by rainfall. It is nevertheless worthy of note that the interpretation of leakage rate based on pumping data and the recovery data provide reasonably consistent results.

Based on judgement, and reporting to the nearest significant figure only, average leakage rates over the test drawdown ranges were about 700kL/d (Fobinso North) and 500kL/d (Abnabna).

PIT	CONDITION	PUMPED	STORAGE	EVAP	RAIN	LEAKAGE	COMMENT
Fob Nth	Pumping	8503	7554	107	251	804	30 July to 17 Sept
	Recovery	0	-685	32	8	709	20 Dec to 28 Feb
Abnabna	Pumping	8015	7495	69	191	398	30 July to 10 Sept
	Recovery	0	-507	24	21	509	9 Dec to 28 Feb

TABLE 5 WATER BALANCE (DAILY RATES – ML)

6.2 Impact on Bore Water Levels

6.2.1 Abnabna

Water levels were monitored in a number of inclined bores which were located adjacent each pit and which were cased with HDPE tubing to allow for the monitoring probe. The data files show some anomalies. For example ABRDD324 is shown as ground surface elevation of 154.4m MSL, whereas its location is illustrated where ground surface contours suggest a ground surface elevation of less than 135m MSL. ABRDD308 also appears to have an anomalous reduced level (about 4m lower than contours might suggest). In addition, the exploration bore locations form a linear zone extending from an elevated ridge to the north east of the pit, and across a low lying surface water drainage path to the south west of the pit. The data collected therefore does not provide a view of groundwater responses for areas surrounding the pit and outside this zone.

Hydrographs of selected bores are presented in Appendix C. Figure 2 illustrates the locations of these bores.

Observations that can be made from the above data are as follows:

- Prior to commencement of pumping at the end of July 2008, the water table in the surface drainage line to the south of the pit was close to the pit water level (about 133m MSL to 134m MSL). Groundwater elevations under the ridge to the north were only slightly elevated (typically less than 140m MSL).
- ABRC051 is an inclined bore with hole orientation parallel and in close proximity to the pit wall. Water level drawdowns in this bore were very substantial, and reflect strong hydraulic contact with the pit. The reason for the rapid rise in water level in this bore in March 2009 is not known.
- Bores ABRDD306 and ABRD308 both recorded very significant drawdown (over 6m when pit dewatering drawdown was about 17m). ABRDD308 is shown as some 150m distance from the pit. The bores are north east and south west of the pit respectively. Note the uncertainty raised about ABRDD308 ground surface reduced level (see above).

- Bores ABRC146 and ABRC144 about 100m east of ABRDD306, recorded drawdowns of 1.2m and 0.5m respectively over the same period
- Bores south of the pit (ABDD088 and ABDD91) both recorded drawdowns of less than 1m. Whilst both bores are within the drainage line south of the pit, ABRDD308 and ABRC051 are also shown within this drainage line.
- Water levels in the bores generally continued to fall following cessation of pit dewatering, not withstanding that pit water levels have risen in excess of 5m above their dewatered minimum. Some bores in relatively close proximity to the pit have shown a rise in ground water levels (for example ABRDD324; ABRD302, ABRD286, ABRDD312, ABRC051).

In view of the variable groundwater responses, the water yielding zones are likely to be non-homogeneous and anisotropic and are likely to be dictated by structural discontinuities (note presence of faulting as discussed in Section 4.3.1). Recharge from surface water infiltrating into the rock mass along the drainage line to the south of the pit, did not maintain groundwater table elevations at the monitoring sites along the drainage line, and it is likely the shallow soils provided a low permeability perching layer in this area. A reasonable interpretation of aquifer conditions for those bores unaffected by the >5m rise in pit water levels, is that the water yielding zones for these bores may be predominantly above the recovering pit water level – i.e. a shallower higher yielding aquifer zone.

6.2.2 Fobinso North

Bores monitored for Fobinso North provided similar data irregularities to Abnabna.

Two groups of bores have been monitored: a group to the north east of Fobinso South pit which is north west of Fobinso North Pit; and a group north east of Fobinso North Pit.

Hydrographs of selected bores are presented in Appendix C. Figure 3 illustrates the locations of the exploration bores used.

Observations that can be made from the above data are as follows:

- Bore AFRC015 at the west end of Fobinso South, is largely unaffected by the dewatering of Fobinso North. It is noted that Fobinso South pit water levels dropped by little more than 1m during the dewatering of Fobinso North, and this water body acts as a groundwater recharge boundary for bores closer to Fobinso North;
- Bores to the north east of Fobinso North all showed drawdowns of 2m (FBDD032 some 150m north east of the pit) to 5m (closer bores to the pit). Bores to the north west of the Fobinso North pit also showed significant levels of drawdown (e.g. AFRDD082 some 3m) noting these bores also are influenced by the continuing high water levels in Fobinso South Pit.
- There has been no noticeable recovery of water levels in the observed bores since cessation of pumping from Fobinso North, notwithstanding the 6m recovery in pit water levels.

Whilst groundwater movement for Fobinso North would be expected to be influenced by structural discontinuities in the rock mass, the data does not demonstrate a predominant flow direction. This may be in part because bores used were not distributed around the full perimeter of the pit, and were generally grouped in two areas only. The continuing drawdown of bores despite the recovery in water levels in the pit provides some evidence that the water yielding zones for these bores may be predominantly above the recovering pit water level – i.e. a shallower higher yielding aquifer zones.

7 HYDROGEOLOGICAL ASSESSMENT

7.1 Groundwater Occurrence and Hydraulic Gradients

Anglo Ashanti Gold (undated) notes that the Birimian formations are considered to be one of the most important water-bearing formations in Ghana and borehole success in the area has generally been one of the highest in the Central Region. Nevertheless, aquifers are characterised by low transmissivity, limited area extent and low storage capacity. Storage and flow of groundwater within aquifers occurs predominantly in the fractures and other discontinuities rather than as intersticial flow.

Water levels in exploration bores surrounding the Ayanfuri pits generally reflect the pit water levels. The exploration boreholes are not sufficiently well cased/constructed that water table elevations for individual bores can be considered highly reliable (noting these are inclined holes, with variable collar heights, and holes are likely to be blocked at varying depths) . They have been useful in assessing overall groundwater trends because of the numbers of bores, and consistency of trends observed from bore to bore.

Groundwater levels in the monitoring bores are typically within metres of ground surface for the low lying natural surface drainage features in the area, indicating the regional hydraulic gradient is strongly influenced by regional topography, and is therefore assumed to be towards the Ofin River to the North.

Pit water level in July 2008 for Abnanba and for Fobinso North was about 133m MSL and 131m MSL respectively, suggesting an overall fall in levels of 2m over about 1500m (<0.2% gradient). There is evidence of more localised groundwater regimes, with groundwater levels in bores north of Abnabna above this “regional” trend.

7.2 Pit Water Levels

Based on the rainfall and evaporation figures, presented in Section 4.1 of this report, rainfall slightly exceeds evaporation from the pit. Where the area of the catchment contributing rainfall runoff is significantly larger than the pit, there would be a reasonable expectation that, in a low permeability rock environment and following cessation of mining, the pits will fill up to an over-flow point to discharge to surrounding surface drainage features.

This is the case for Fetish South, and for Fobinso North, and is likely for Abnabna, based on our interpretation of contour plans. We have not confirmed whether this is also the case for Esuajah South, or Fobinso South. For Esuaja South and Fobinso South, the contributing catchment is not more than 10% larger than the pit. In addition, for Fobinso South, hydraulic contact with Fobinso North can be demonstrated noting water levels declining by about a metre whilst Fobinso North has been dewatered (pits remote from dewatering did not show a water table decline).

7.3 Pit Water Yielding Zones

Observation of exploration borehole records for the Abnabna and Fobinso North pits shows that soils in the area are comparatively thin. The volume of water likely to flow through the soils as pit inflow (or outflow) is expected to be small given their clayey nature, and limited thickness. Nevertheless, the contact between surficial soils and underlying rock represents a zone where groundwater must be expected to perch, and to seep into the pit across the pit walls.

Below this thin soil profile, groundwater movement will be through rock structural discontinuities rather than particle intersticies, and this implies an order of magnitude lower storativity than for a soil.

An examination of diamond core for Fetish (ADD038), Abdabna (ABDD-001), Esuaja North (ADD-010), Esuaja South (ADD-014) and Fobinso South (FDDD002), revealed little evidence of significant water yielding structure below the weathering profile zone of stress relief – generally less than about 40m depth (typically less than 30m below the water table – see also Base of Oxidation discussed in Section 4.3.2). Significant structural discontinuities when mapped, may be water yielding. However no major water yielding discontinuities have been identified from the diamond core observed, or in discussions with site geologists during our 2007 site visit.

Groundwater movement may therefore occur primarily at or above the base of weathering.

The monitoring of exploration boreholes does not provide sufficient data to show anisotropy within the water yielding conditions around these pits. It is frequently the case that permeabilities associated with the trend of mineralisation are higher than permeabilities normal to this direction. It is anticipated that with interconnection of water yielding rock jointing systems within the rock weathering profile, the differences in permeability are likely to be significantly less than an order of magnitude.

In section 6.2, the interpretation of bore water level data indicated water yielding conditions may be decreasing with depth. A rock stress release zone near the base of weathering may provide locally higher inflows to the pit, but to-date there is no evidence of the presence of a large high yield zone deeper than the current pit floors.

Fresh bedrock is judged to be generally low yielding.

There is no evidence in documents sighted, that dewatering of pits had presented an operational problem for Anglo Ashanti Gold/ Cluff. Anglo Ashanti Gold (undated) refers to the general low permeability of the region. Based on the pit water balance estimates discussed in Section 5.1, the groundwater flows into the pits averaged 700kL/d (Fobinso North) and 500kL/d (Abnabna) for nominal depths of drawdown of about 15m over the periods for which the water balances apply.

The significance of these results as a “mine scale” test of dewatering requirements (undertaken during wet season months) is emphasized. If major structural features are water yielding, then it can be expected they will have contributed to these figures.

7.4 Permeability and Storativity

Coffey Geotechnics Pty Ltd (Perth) pre-feasibility report reference GEOTHERD08308AA-AA dated 22 August 2007 presented the results of analyses of pumping tests for a large number of village water supply bores associated primarily with the Perseus Gold Grumesa prospect, in similar geological conditions. The bores tested were “successful” bores, and therefore typical water yielding conditions can be expected to be lower than observed for these bores. The typical range in transmissivities was about $1m^2/d$ to $3m^2/d$ from these pumping tests, or permeability of the order of 0.1 to 0.3m/d for the nominal 10m depth of penetration of the water table in these bores.

Field testing to assess permeabilities of the shallow weathered phyllite underlying the proposed tailings disposal site concluded that for the depths tested, the typical permeability was $2x10^{-8}$ m/s (0.002m/d) illustrating a very low permeability near surface environment (C Lane, pers comm.).

There is no background information available on the potential range of specific yield.

Simple numerical analyses (using the finite difference seepage model MODFLOW) have been undertaken to back analyse pit drawdown versus time data to assess an overall permeability for the Abnabna and Fobinso North Pits based on the assumptions set out in Table 6. The analyses have been simplified because there is insufficient data to assess the impact of surface streams on recharge, and to assess both recharge and barrier hydraulic boundaries. Note that at the time of the testing Fobinso South would have acted as an hydraulic boundary for dewatering from Fobinso North – but Asuofa Stream system is also an effective "permanent" water body that may also provide constant head conditions. On the other hand changes in rock type may present barrier boundary conditions to groundwater flow. Asuofa Stream also is a likely constant head boundary for Abnabna.

In addition, the aquifer performance is a combination of both permeability and storativity, and therefore any interpretation must be based on some judgement as to the likely range in values for these parameters. Further, observations of rock core have suggested groundwater conditions below the base of oxidation are likely to be very low yielding. For the purposes of the analyses, we have assumed these conditions contributed little to groundwater flow regimes during the pit trial dewatering process.

CRITERION	**FOBINSO NORTH**	**ABNABNA**	**COMMENT**
Dewatering Trial (days)	250	250	Reflecting the period August 2008 to March 2009 inclusive
Drawdown (m)	15	15	Typical for this period
Pit Inflow (kL/d)	700	500	As assessed in Section 6.1
Pit Wetted Area (m2)	20,000	15,000	Based on 1m pit survey (nominally 15m below pre-pumping water table)
Equivalent Radius (m)	140	120	From wetted area
Saturated Aquifer Thickness (m)	30m	30m	Assumes permeabilities at greater depth at least an order of magnitude less than at shallower depths.
Specific Yield	0.02	0.02	As outlined above

TABLE 6 PARAMETERS ADOPTED IN BACK ANALYSIS OF PIT PERMEABILITIES

In undertaking the analyses, a range in specific yield from 0.005 to 0.05 was considered likely for these rock types. Based on the magnitudes of drawdowns observed in the monitoring bores around the pit and preliminary analysis with the model, a specific yield of 0.005 is likely to result in drawdowns in bores larger than those judged representative based on the borehole data, whereas a specific yield of 0.05 is judged to be a likely upper bound figure. A figure for specific yield of S_y=0.02 has been adopted.

Based on the results of the back analyses and using a figure for specific yield of 0.02, than, an overall equivalent permeability for the upper 30m of the water table was then assessed to be about k=0.1m/d. This is significantly higher than the values measured at the tailings dam site in the shallower weathering profile, and possibly reflect both a higher permeability environment in the areas that have been mineralised, and also higher permeabilities in the deeper weathering profile (and in particular the so-called “stress release” zone near the base of weathering).

Significant jointing systems, faults and other structural discontinuities will contribute locally “high” permeabilities. With the likely interconnection of jointing systems, and the lack of monitoring data confirming a particularly high permeability in a preferential direction, the assumption of an overall pit permeability provides a reasonable basis for assessing on-going pit dewatering requirements.

Permeabilities and storativity are anticipated to decrease significantly in the deeper fresh rock environment (see also Section 6.2). Average permeability is judged to be an order of magnitude lower over a 30m depth below base of oxidation than the 0.1m/d adopted above the base of oxidation; and storativity below the base of oxidation is judged to be closer to the lower bound value of 0.005 discussed in an earlier paragraph, and

The analyses are not sufficiently refined to show a significant difference in aquifer parameters between Fobinso North and Abnabna Pits. It is proposed the parameters derived by this assessment be used in assessing dewatering requirements for all pits.

Table 7 summarises the aquifer parameters arising from this analysis.

Relative to Base of Oxidation (BoO)	Permeability (m/d)	Specific Yield
Above (adopt a nominal 30m saturated aquifer thickness to BoO)	0.1	0.02
Below	0.01	0.005

TABLE 7 AQUIFER PARAMETERS

7.5 Recharge and Pit Flood Risk

The implication of the close proximity of the pits to natural drainage features which may flow for much of the year is that there is a ready source of recharge of water to maintain groundwater seepage as pit water levels drop. Permanent water will act as natural groundwater recharge barrier. The proximity of Asuaofo Stream to as it is diverted around Abnabna Pit and to a lesser extent to Fobinso South Pit, creates a close constant head boundary. The close proximity of Fobinso South means this pit will act as a constant head boundary for the dewatering of Fobinso North as it continues to recharge after rainfall events, if this pit also is not dewatered.

In addition the pits can be at risk from flooding of the natural drainage features whether permanent water courses or seasonal drainage paths. Adequate protection of the pits will require earth bunds around the low lying areas, with haul roads raised above the bund elevations and contoured embankments to divert surface runoff around the bunded pit areas. The design of earth bunds/ embankments is beyond the scope of this report. In order to manage the flood risk created by 232mm 100 year return event over 24 hours, and 600mm over a month, as much runoff from upslope areas of the pit should be diverted around the pit and as far from the edge of the pit as is practical.

Auafa Stream (main tributary – adjacent Abnabna pit) and Danjami-Subin drainage line (adjacent South Esuaja) are to be modified to ensure runoff from upgradient is controlled as it flows past these pits as they develop.

Direct rainfall on the pit envelope will also be significant. Direct rainfall for a 100 year return period 24 hour event is estimated at 232mm. In section 4.1.1 it has already been noted that monthly rainfalls of in excess of 520mm have been recorded on 2 occasions in the 46 years of records for Dankwa Meteorological Station, and a higher monthly figure (in excess of 600mm) would need to be allowed for in detailed design to represent a 100 year recurrence event. The sizing of pump will depend on factors such as management of ore stockpiles, and the duration of mining time permissible to be lost due to weather/ flooding (see Section 8.3).

7.6 Water Quality

7.6.1 Pre Resource Drilling Dewatering

Test results from the sampling and water analysis for the Ayanfuri pits, supplemented by sampling and analysis of nearby surface hydrological features prior to the resource drilling dewatering programme, are presented in Appendix A.

Broad features of this analysis are:

- The water is remarkably fresh, and in many test results could be considered to be only a factor of 2 or 3 times rainwater salinity. The salinity is typically an order of magnitude better (lower than) W.H.O. acceptable upper limit drinking water limits.
- Given the very low salinity, trace metals contents are also generally very low, despite being in a polymetallic environment.
- Iron content (and also manganese) is significant within the overall salinity, and reflects contact with the high organic content surficial soils and vegetation.
- Total suspended solids reflect erosion off mined slopes and former waste rock dumps, and in particular, the site disturbance taking place as a result of galamesi.
- Turbidity reflects the above disturbance, and also the impact of decomposition of organic matter.
- Acidity is generally within acceptable ranges, but shows considerable variability. pH values of less than 6 may require pre-treatment before release of waters to the streams and rivers of the area.

More specific assessment of the pH and electric conductivity or salinity data shows the following:

- The Ofin River samples were slightly acidic (generally pH 6 to 6.8) possibly reflecting acids generated by the breakdown of organic matter. Note also that Mireku-Gyimah (2005) shows a number of the soil types in the region as being acidic.
- The Ofin River samples showed an EC range of 90 to 320 uS/cm.
- Prior to the dewatering, the Abnanbna, Fetish and Fobinso pits all showed very low electric conductivity/ salinity (EC of about 80, 40 and 40 uS/cm respectively). The quality of this water suggests direct rainfall with runoff from the immediate catchment, and relatively little contribution in salt contents from groundwater inflow from the pits.

- Esuaja showed a significantly higher EC (up to 360uS/cm), and this may be attributable to a relatively greater contribution of the rock formations and groundwater inflow, than observed in the other pits.
- Despite the above, Esuaja had the more neutral pH (typically 6.3 and above).
- The range in pH values recorded over the 3 different monitoring phases for Abnabna, Fetish and Fobinso can not be readily explained.

A possible explanation for the variability in pH is the generation of acidity from decomposing organic matter (which may have more impact in the dry season than the wet season with more concentrated pH in smaller flows, and more decomposition in higher temperature periods); and also from acid topsoils. A contribution from acid sulphate is less likely given the pits had been filled with water.

7.6.2 Testing of Samples During Resource Drilling Dewatering

Appendix D presents the results of testing of pH and conductivity/ salinity during the course of the resource drilling dewatering operations for Abnabna and Fobinso North.

The results show a rise in salinity in Fobinso North and little change in pH during the course of the dewatering. Water quality remained very fresh. Salinity increased in Abnabna by a factor of 2 – but remained very fresh at less than 200mg/L TDS. pH remained comparatively stable. The salinity (electric conductivity) recorded for both pits at the end of data collection (September 08 – when Abnabna had been substantially dewatered) was well below the salinity (electric conductivity) range indicated for the Ofin River.

It is noted that lime dosing was applied discontinuously to water discharged from the two pits.

Review of the results of the comprehensive analyses undertaken in 2007 compared to those completed in 2009, shows for Abnabna a significant increase in the salinity of the pit water (whilst remaining very fresh). There was no increase in chloride or sulphate ions, but a very significant increase in alkalinity and in calcium ion. Lime dosing is likely to have been a significant factor to these changes in water quality, and would have been supporting the neutral pH observations for the water taken from the base of the pit, if it was taken from areas lime dosed, rather than as seepage from the wall. The results for Fobinso North also showed a very substantial increase in total alkalinity, no increase in chloride ion – with some uncertainty (when comparing the recent result with results in 2007 for a full pit water profile) of the impact on calcium ion.

Both Abnabna and Fobinso North pits had a level of alkalinity in the water in 2007 (i.e. prior to any lime dosing) that is significant within the context of the low salinity of the waters from those pits, suggesting the pits may have had some natural buffering.

By comparison, Fobinso South pit water analysis has negligible alkalinity, negligible calcium or magnesium, and therefore may have had negligible buffering capacity. It has a low pH reading. It is noted that the sampling undertaken in 2007 for Abnabna and Forbinso North pits through the vertical profile shows a lowering of pH with increasing depth. Salinities were very low, and at Abnabna at least, appeared to decrease (become even fresher) with depth.

In the 2007 data, water in the Esuaja South pit was similar pH to background environmental conditions represented by the Ofin River, at about 6.0 to 6.5. The pH in other pits Abnabna, Fetish S, and Fobinso N were up to one pH unit lower at about 5.0 to 6.0. There is some evidence of slight acidity associated with the pit operations. In the recent March 2009 analyses, Fobinso North, and Abnabna both showed pH in excess of 7, which as discussed above is possibly attributable to lime dosing. Fetish pit showed a pH of 8.6, some 3 pH units higher than the 2007 data (no lime dosing).

Within the same testing regime, Fobinso South pit records a pH of just 3.8.

The field pH measured at the time of sampling for Fetish and for Fobinso South was 6.7 and 5.3 respectively – i.e. closer to values anticipated from the 2007 testing. It is not clear what the causes are for this variability. Further testing of the site will be required to understand better the acidity regime.

The recent March 2009 testing included the results from tests undertaken for nutrients and for trace metals. Nitrate concentrations are high, with Fobinso South the highest at 6.15mg/L. It is noted however that Ofin River (the receiving water) also has high nitrate content at about 1.5mg/L. These values do not represent a significant environmental concern. Arsenic was the only trace metal with a concentration that might require management. At Fobinso North the arsenic concentration was 34ug/L and at Fobinso South 16ug/L (the lower acidity has not translated to higher trace metals). In the 2007 sampling, arsenic in the Ofin River was between 30 and 90ug/L – well above the levels in these pits. WHO drinking water guidelines suggest a limit of 10ug/L.

At Ayanfuri then, there is evidence of some acidification of the existing pit walls. The cause of the acidification has not been assessed, but could include surface effects (break down of vegetation, acidic surface soils, ferrolysis). Based on the salinities recorded, water quality at the base of pit remains very fresh. Discharge of such waters to the environment is likely to remain acceptable. Some lime dosing may be required to maintain acceptable pH.

Previous mining at this site has essentially been restricted in depth to the oxides. As the mine is deepened into the sulphides (and an examination of core samples does show significant pyrite), the risk of acid mine drainage becomes greater, and provision will need to be made to further manage that risk.

7.6.3 Impact on Regional Water Courses from Previous Mining Activities

Suspended solids and turbidity already exists in the major streams arising from previous mining activities in the area, and the current activities of galamsey (see Section 4.2 with respect to Asuafo Stream). Re-mining of the region will provide an opportunity to reduce the erosion from existing waste rock dumps and other mining affected areas, and reduce stream turbidity.

A clear objective for the renewed mining must be to manage site disturbance and water runoff to ensure turbidity where the Asuafo and Subin drainage systems enter Ofin River does not increase (and similarly turbidity is not increased in the Mansi River system), and commence rehabilitation of previous mine works to reduce turbidity arising from earlier mining operations.

Considerable further work will be required to assess what can be practically achieved.

8 DISCUSSION

8.1 Water Supply

The mine water balance for this site (Coffey Mining 2007) indicates a net water gain in the processing circuit, and therefore a long term water supply for processing will not be required. It is assumed that the existing pits will be managed to provide all required “start up” waters, and consideration may be given to the use of one or more selected pits as water storage dams (which can be topped up from adjacent stream flows if necessary).

8.2 Dewatering and Disposal of Excess Water

8.2.1 Water Volumes at Start Up of Mining

There are two components to the dewatering. The first component is the removal of stored water in the pits. During dewatering for the resource drilling, the EPA guidelines did not need to be breached (it is noted there was minor lime dosing to maintain pH above 6) and overall pumped quantity was less than 30% of the licence allocation. The licence required that the discharge meet EPA standards which had not been set out. The quality of the receiving waters for any mine release (the Ofin River) is very fresh, but with measurable trace levels of arsenic. An overall criterion that should be considered is that overall salinity and arsenic concentrations discharged should be no worse than the salinity and arsenic content of water that is observed in the Ofin River. Quality requirements will need to be clarified with EPA for further licencing. The licence expired in December 2008 and a new licence will be required for further mining activities.

Water levels have been recovering within the pits since the cessation of pumping late in 2008, and therefore a further exercise in removing stored waters (as well as for on-going dewatering – see below) will be required when the pits are re-entered to be mined.

An estimate has been made of the time required to dewater each pit based on similar pumping regimes and similar pumps to those used during the resource drilling dewatering programme – see Table 7. The estimate makes an allowance for normal seasonal rain (but not extreme events) and groundwater inflow. The estimate assumes that water levels in Fobinso North and Abnabna will have recovered to the levels that existed prior to the resource drilling dewatering programme.

Pit Name	Pit Water Volume (m^3)	Dewatering Rate (m^3/d)	Time to Dewater Pit (days)	Continuing Groundwater Inflow Rate (m^3/d)
Abnabna	340,000	8000	50	500
Fobinso N	910,000	8000	130	700[1]
Fobinso S	300,000	8000	45	500[1]
Esuajah	500,000	8000	75	900
Fetish	1,400,000	8000	210	1000

Note: [1] - Combined quantities expected to be less if both pits dewatered concurrently.

TABLE 7 DEWATERING TIMES – REMOVAL OF STORED WATERS AND DEWATERING AT START UP OF MINING

At the start up of mining, groundwater inflows are likely to be of the order experienced during the recent trial dewatering for Abnabna and Fobinso North pits. Inflow figures have been interpolated for the remaining pits based on pit sizes, but with a higher flow allowed for Esuajah noting pit salinity considerations discussed earlier. Direct rainfall and runoff from areas encompassed by the pit envelope (areas where runoff is not diverted around the pit) add to the dewatering requirements, however an allowance for a nominal area of inflow has been allowed in the above figures.

The rate at which water levels are lowered in the pit can result in a specific pit wall 'loading' condition referred to as a 'rapid drawdown' condition. The major implication of this condition is significantly higher potentiometric pressures in the walls than would normally be assumed in stability analyses. Similarly, as the pits are expanded across current stream alignments, the water within the streams during periods of flow will both increase recharge to the pits and possible dewatering volumes, and also will result in higher potentiometric pressures in pit walls reducing their stability. The advice of a pit geotechnical specialist should be sought concerning risks brought about by this condition.

We understand it is intended that water removed from the pits be managed through the FTSF. Licence approval should be sought from the EPA for any disposal of stored pit waters into the Ofin River via its tributaries, (noting the success of the earlier resource drilling dewatering programme, where water quality discharged was superior to water quality in the Ofin River).

Given the expected low magnitude of groundwater inflows for the sizes of these pits, and the low permeability assumed below the base of oxidation, dewatering bores located outside the pit will generally not be practical, and dewatering will need to be achieved using in-pit sumps and collector systems around the toe of pit walls. It is probable however that some significant water yielding structural discontinuities will be identified as mining proceeds. These should be targeted by boreholes drilled to intersect them outside the pit and pumped to provide a means of lowering water levels below the pit floor (the discontinuity acts as a "drain" collecting water for the bore pump to remove) and supplement the in pit dewatering.

8.2.2 Dewatering Requirements During Pit Expansion

The second component is the on-going removal of groundwater inflows.

The hydrogeological model developed for Ayanfuri assumes that permeabilities are very low below the base of oxidation. By implication then, deepening of the pits (which for the pits discussed in this report has already penetrated through the significant water yielding zone) by itself does not lead to a significant increase in groundwater flow. Increasing the perimeter of the pit above the base of oxidation will increase groundwater flow. However the major driver for groundwater flow for these sites is likely to be the proximity to a constant source of groundwater recharge – and more specifically the length of pit adjacent a recharge zone and the separation of the pit from the recharge zone.

The overall Abnabna/Fobinso/ Gap operations will result in a series of pit lobes in excess of 2km in length. Current combined lengths of Abnabna and Fobinso North and South pits, is nominally 900m (almost half the final pit length) – noting also these pits are at either end of the 2km zone. The combined inflows for Abnabna and Fobinso North pits based on the test programme were assessed to average a combined 1200kL/d (which included seasonal rainfall). The impact of "joining" and widening the pits, of diversion of Asuafa Stream and of long term pumping will be to increase groundwater flow and also increase the area of catchment immediately encompassing the pits from the current area of about 170,000m^2 to about 743,000m^2 (email B Marwood to M Hillman 18 May 2009)

With rainfall at 1505mm/year, and evaporation almost the same magnitude at 1469mm/year, then negligible surface water runoff would be anticipated for many months of the year. The rainfall excess over evaporation for the wet months of the year from March to October is 346mm – which based on catchment areas increasing from 170,000m^2 to about 743,000m^2 is equivalent to a rainfall inflow from about 160kL/d to about 700kL/d (averaged over the full year).

On dewatering of Abnabna, Fobinso North and Fobinso South, the expected dewatering rate will be less than 1700kL/d (see Table 7), which includes normal seasonal rainfall (estimated at about 160kL/d). The groundwater inflow component is therefore estimated at less than 1540kL/d. This is not a steady state flow, as it relates to an initial pumping condition wherein the rocks immediately encompassing the pits are being rapidly drained. Steady state flows (years of pumping rather than months) would be expected to be less.

A simple steady state model of groundwater inflow to the combined pits, assuming the diverted Asuafa Stream acts as a constant head boundary (i.e.constant recharge), based on permeability and equivalent saturated aquifer thickness back analysed in this report (see Section 7.4), an average separation of Asuafa Stream (to the west) from base of main water yielding zone of 150m to 200m, and inflow from the east at about 60% of inflows from the constant head boundary of Asuafa Stream, provides an ultimate pit groundwater inflow of about 2400kL/d. Groundwater plus surface runoff could achieve a flow by the end of mining of 3100kL/d. for average seasonal conditions.

These figures will need to be reviewed based on operational experience. For water budgeting purposes, we have assumed inflows will increase progressively over the 6 years required to mine the combined pits, noting that all three existing pits will not be dewatered simultaneously (see Table 4), and the area of catchment encompassing mine cut back areas that can’t be diverted off site will be managed to maintain as little rainfall inflow off catchments as is practical. Over the intial 3 years of mining, water removed for disposal through the tailings circuit (following initial disposal of currently stored water) is anticipated to be about 75% of the final pit inflows calculated above, or about 2350kL/d..

A similar assessment can be undertaken for Esuajah and Fetish pits, based on primarily a consideration of the final pit envelopes. This has not been done at this feasibility stage noting these pits are not mined until well into year 3 of the mining schedule.

The above assessments do not consider the inflow that will occur in response to more extreme rainfall events (see Section 8.3).

8.2.3 Water Quality Issues

Groundwater quality during the resource drilling dewatering programme remained adequate for disposal to the environment with only limited lime dosing. However there is evidence of acidity in the mine waters, and as the pits are deepened and extend into the sulphides there is a risk of acid sulphate generation and higher trace metals (in particular arsenic) within the recovered groundwaters. At present, salinity of dewatering waters and trace metals contents are less than the magnitude of these parameters in the Ofin River – the receiving waters for pit dewatering. This is likely to be an over-riding criterion for the release of pumped waters – that the release does not result in significant deterioration of Ofin River waters.

It is of considerable significance, that for the current depths of mining, Anglo Ashanti Ghana reported the water quality they tested to have been excellent.

It is understood that mine planning has allowed for dewatering water under normal operational conditions to be managed through the mines process system under normal seasonal conditions. A backup system should beconsidered should the mines process water system become overloaded and the water not be proven fit for disposal, to enable dewatering water to be pumped from operational pit area to non operational pit area. Lime dosing facilities should be on hand to maintain pH>6 in any discharge water.

Significant flooding occurring during a low recurrence interval rainfall event could overwhelm the mines capacity (both the process circuit and the ability to pump into and store within an alternative pit). The quality of water arising from such inundation is likely to be very good, and discharging to the nearby water courses will be taking place when these water courses are running at a significant rate due to run off from the rest of the catchment – i.e. dilution will occur (see comments in Section 8.3). Agreed criteria for the release of excess mine water will need to be negotiated with the EPA based on agreed sampling points, sampling criteria, limiting values to parameters following dilution, and dilution rates.

It should be noted that turbidity in existing water courses arising from erosion off waste rock dumps associated with previous mining activities and from the activities of galamsey are not issues associated with dewatering, but do represent issues that may prove difficult to separate from the dewatering. Whilst there would be an environmental obligation to manage future mining activities such that erosion from haul roads, dumps etc is managed, and water quality is protected, Perseus will also need to give consideration to controlling runoff from areas disturbed prior to their recommencement of mining work.

8.3 Sizing of Dewatering Infrastructure

The dewatering requirements (sizing of pumps, discharge lines and disposal areas) for pits is likely to be dictated primarily by the amount of direct rainfall within the pit envelope (i.e not excluded by contour banks and pit bunds) that occurs in a design rainfall event plus expected groundwater inflow for that pit – see Section 7.5. The influence of pit depth is comparatively small.

Table 8 provides an estimate of dewatering requirements under a 1 year and also a 100 year recurrence interval rainfall event, for an overall Abnabna/Fobinso/ Gap pit envelope of 743,000m^2 area, with dewatering within 10 days, 20 days or 30 days. The estimate allows for groundwater inflow throughout the rainfall event.

In calculating the pump rates illustrated in the Table, it has been assumed that evaporation during the rainfall extremes would be negligible.

	Instantaneous Pump Rate (kL/hour)	
DEWATERING TIME (days)	**5 Year Return Event**	**100 Year Return Event**
10	850	1340
20	630	940
30	540	790

TABLE 8 PIT DEWATERING REQUIREMENTS 5 YEAR AND 100 YEAR RETURN RAINFALL EVENT – ABNABNA/FOBINSO/GAP PITS

The instantaneous rates set out in Table 8 need to be considered in the context of the normal seasonal rates anticipated under Section 8.2.2, of 2,350kL/d or 98kL/hour. We assume normal seasonal water inflow will be removed by a series of pumps operating in deepened “lobes” in the pit. The overall pit envelope illustrated in the figure at Appendix E indicates possibly 5 such “lobes”. As mining develops towards the ultimate pit dimensions, the overall capacity of the pumps and piping systems for these lobes should be based on a nominal wet season operational condition of some 250kL/hour, (based on catchments to the current pits Abnabna, Fobinso North and Fobinso South of 170,000m^2) with capacity capable of upgrading to at least 850kL/hour as the area of catchment encompassed by the growing pit envelopes increases, to deal with the 5 year return rainfall event within 10 days. This combined pumping capacity will be adequate to deal with the 100 year return event over 30 days, which we understand is acceptable to Perseus (email B Marwood to M Hillman 19 May 2009).

The mine will need to give consideration to pit operational strategies that will allow mining to proceed in possibly more elevated areas of the pit following a rainfall event, whilst dewatering removes the runoff drained to lower areas.

The percentage of groundwater inflow to total pit inflow, during a 5 year return interval 10 day rainfall event, will be close to 25% at the start of mining, (25% of 250kL/hour when the capacity of the mines tailings circuit is most likely to be able to cope with such a deluge), decreasing to less than 15% at the completion of mining (850kL/hour). It is probable that under the neutralising impact of such large rainfall volumes, water pumped from the pits at the end of the trial would not have required any pre-treatment.

For the purposes of the initial site water balance modelling under *“average operating conditions”* (after the initial pit dewatering is competed and mining has commences) average pit dewatering rates are anticipated be approximately 2,350kL/d, with inflows from groundwater comprising approximately 75% of the inflow with the balance being from rainfall runoff under storm events.

An assessment of requirements for Esuajah and Fetish pits has not been undertaken. It is noted that Esuajah North does not commence mining until the second quarter of year 3, and Fetish pits do not commence until year 5. Overall dewatering requirements will need to be reviewed based on operational experience for Abnabna/Fobinso/Gap pits, and the results of that review taken into account when designing dewatering capacity for Esuajah and Fetish pits.

The design of pump sets, pipeline systems, and ancillary plant is beyond the scope of this report.

9 MONITORING

Considerable base line hydrological and hydrogeological data has already been collected by mine site personnel. Most of the data sighted to data was collected in the dry season (February 2007) or was specific to the Resource Drilling dewatering programme for Abnabna and Fobinso North. In order to adequately capture the likely range of annual conditions, it is recommended a sampling regime commence with nominally four sets of samples to be taken and tested in the first year, and including samples taken during a prolonged dry season dry period, and also following major rainfall runoff in a wet season. Samples should be collected as follows:

- Sampling points in the Ofin River a short distance upstream from their intersection with Akesoa and Subin Stream systems; of the Asuafo Stream a short distance upstream from Abnabna Pit and again downstream from Fobinso Pits; from Danyami upstream and downstream of South Esuaja. River levels from the nearest monitoring station should be recorded.
- Sampling of all pit waters. Pit water levels should be recorded.

Samples collected should be subject to comprehensive analyses, including: pH, electric conductivity, Total Dissolved Salts, Total Suspended Solids, alkalinity, acidity, turbidity, hardness, iron, manganese, major anions, major cations, nutrients and selected metals (including mercury, cadmium, lead, arsenic).

We note the collection of site specific rainfall records commenced in 2006 is to continue. Access should also be sought to obtaining copies of river level monitoring records for the Ofin and Mansi rivers, and if these are not available in close proximity to the sampling areas, establishing continuous monitoring sites adjacent the rivers to collect this data. It is also recommended water level monitoring stations be established for Asuafa adjacent Abnabna and Danyami adjacent South Esuaja.

It is recommended a network of groundwater monitoring bores be designed and installed adjacent each operating mine pit, with bore locations selected by a hydrogeologist taking into account site surface hydrological features (such as water course locations) as well as geological and hydrogeological conditions. Monitoring of the bores should comprise water level, pH and conductivity on a weekly basis, and “comprehensive” analyses on a quarterly basis.

When mining commences, monitoring is to include quantities pumped, from where they are pumped and to where they are disposed, pH and electric conductivity (daily), and groundwater elevations at the pumping sites.

This monitoring regime does not consider monitoring requirements arising from the disposal of tailings for this project.

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Figures

Appendix A

Pre-Feasibility Monitoring Data

Appendix B

Water Balance Assessment

Appendix C

Monitoring Bore Hydrographs

Appendix D

Resource Dewatering – Water Quality Testing

Appendix E

Mine Site Drainage Plan

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

1) The relevant Ghana Acts, Regulations, Guidelines and Standards appropriate to the Project

2) Australian Standards and International Guidelines appropriate to the Project, including, but not necessarily limited to the following:

Document No.	Document Title
AS/NZS 1020:1995:	The control of undesirable static electricity
AS/NZS 1596:2002:	The storage and handling of LP gas
AS/NZS 1716:2003	Respiratory protective devices
AS/NZS 1768:2007:	Lightning protection
AS/NZS 1850:1997:	Portable fire extinguishers - classification, rating and performance testing
AS/NZS 2243.10:2004	Safety in laboratories - Storage of chemicals
AS/NZS 2243.2:2006	Safety in laboratories -Chemical aspects
AS/NZS 2430.3.1:2004:	Classification of hazardous areas - examples of area classification general
AS/NZS 2906:2001:	Fuel containers - portable-plastic and metal
AS/NZS 3678	Structural Steel - hot rolled plates, floor plates and slabs
AS/NZS 3679.2	Structural Steel - Welded Sections
AS/NZS 3816:1998	Management of clinical and related wastes
AS/NZS 3833	The Storage and Handling of Mixed Classes of Dangerous Goods in Packages and Intermediate Bulk Containers.
AS/NZS 3833:2007	The storage and handling of mixed classes of dangerous goods, in packages and intermediate bulk container
AS/NZS 4360 SET	Risk Management Set
AS/NZS 4360/3806 Set	Risk PLUS compliance Set
AS/NZS 4452:1997	The storage and handling of toxic substances
AS/NZS 4494:1998	Discharge of commercial and industrial liquid waste to sewer - General performance requirements.
AS/NZS 4581:1999	Management system integration - Guidance to business, government and community organizations
AS/NZS 4681:2000:	The storage and handling of class 9 (miscellaneous) dangerous goods and articles
AS/NZS 4745:2004:	Code of practice for handling combustible dusts
AS/NZS 4804:2001	Occupational health and safety management systems - General guidelines on principles, systems and supporting techniques
AS/NZS ISO 14001:1996	Environmental management systems - Specification with guidance for use
AS/NZS ISO 14001:2004	Environmental management systems Requirements with guidance for use
AS/NZS ISO 14031:2000	Environmental management- Environmental performance evaluation - Guidlines
AS/NZS ISO 19011:2003	Guidelines for quality and/or environmental management systems auditing
AS/NZS ISO 9001:2008	Quality management systems - Requirements
AS/NZS3500	Plumbing and Drainage
AS/NZS4261:1994	Reusable containers for the collection of sharp items used in human and animal medical applications.
AS1100.101	Technical Drawing General Principles
AS1100.201	Mechanical Engineering Drawings
AS1100.301	Architectural Drawings
AS1100.401	Engineering Survey Drawing
AS1100.501	Structural Engineering Drawing

AS1159	Polyethylene Pipe
AS1210	Pressure Vessels
AS1243	Voltage Transformers for measurement and Protection
AS1319-1994	Safety signs for the occupational environment
AS1345-1995:	Identification of the contents of pipes, conduits and ducts
AS1418	Cranes Hoists & Winches
AS1530.4-2005:	Methods for fire tests on building materials, components and structures - fire-resistance test of elements of construction
AS1554	Welding of Steel Structures
AS1657-1992	Fixed platforms, walkways, stairways and ladders - Design, construction and installation
AS1692-2006	Steel Tanks for Flammable and Combustible Liquids
AS1692-2006:	Steel tanks for flammable and combustible liquids
AS1755-2000	Conveyors - Safety Requirements
AS1851 -2005	Maintenance of fire protection systems and equipment
AS1885.1-1990	Measurement of occupational health and safety performance
AS1939 Supp 1-1990:	Degrees of protection provided by enclosures for electrical equipment (IP Code)
AS1940-2004:	The storage and handling of flammable and combustible liquids
AS2033	Installations of Polyethylene Pipe Systems
AS2118.1-1999:	Automatic fire sprinkler systems - general requirements
AS2129	Flanges for Pipes, Valves and Fittings
AS2187.1-1998	Explosives - Storage, transport and use
AS2337-2004:	Gas cylinder test stations - general requirements, inspection and tests - gas cylinders
AS2359.1 -1995	Powered industrial trucks - general requirements
AS2400	Packaging - Handling of Goods in Freight Containers
AS2441 -2005:	Installation of fire hose reels
AS2832.1-2004:	Cathodic protection of metals - pipes and cables
AS2865-1995	Safe Working in a Confined Space
AS3000	Electrical Installation Wiring Rules
AS3008	Electrical Installation Selection of Cables
AS3012	Electrical Installation Construction and Demolition
AS3600	Concrete Structures
AS3760	In-service safety inspeciton and testing of electrical equipment
AS3780-1994:	The storage and handling of corrosive substances
AS3798-2007	Guidelines on Earthworks for commercial and residential developments
AS3806-2006	Compliance Programmes
AS3873-2001:	Pressure equipment - operation and maintenance
AS3890	Rolling Bearings
AS3894	Site Testing of Protective Coatings
AS3961-2005:	The storage and handling of liquefied natural gas
AS4024	Safeguarding of Machinery
AS4041-2006:	Pressure piping
AS4089	Priming Paint for Steel
AS4324	Mobile Equipment for Continuous Handling of Bulk Material
AS4326-1995:	The storage and handling of oxidizing agents
AS4332-2004:	The storage and handling of gases in cylinders
AS4433.5	Guide to the Sampling of Particulate Minerals/Sampling of slurries
AS5062-2006	Fire protection for mobile and transportable equipment
AS60034.1-2009	Rotating Electrical Machines - Rating and Performance
AS60034.7-2010	Rotating Electrical Machines - classification of types of construction, mounting arrangements and terminal box position
AS60034.8-2009	Rotating Electrical Machines - Terminal Markings and direction of rotation
ISO 4065	Thermoplastic Pipes - Universal Wall Thickness Table
NOHSC: 1016 (2005)	National Standard for Construction Work
AS/NZS 5911 (Int): 2005	General guidelines on the verification, validation and assurance of environmental and sustainability reports
AS1678.6.0.009-1998	Emergency Procedure guide - Transport - Cyanides,
AS1725-2003	Chain-link fabric security fencing and gates
AS/NZS 2430.3.7:2004	Examples of area classification - Landfill gas, sewage treatment and sewage pumping plants

ANCOLD	Guidelines on Tailings Dam Design, Construction and Operations (dated October 1999) [Australian National Committee on Large Dams]
DoIR	Guidelines on the Safe Design and Operating Standards for Tailings Storage (May 1999) [Western Australian Department of Industry and Resources]
ICOLD	Static Analysis of Embankment Dams, Bulletin 53, 1986 [International Committee of Large Dams]
ICOLD	Tailings Dams – Design of Drainage – Review and Recommendations, Bulletin 97, 1994. [International Committee of Large Dams]
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