Mine Work Programme

for the mining of the heavy mineral sand

resource at Walviskop, Port Nolloth

1. Introduction

Whale Head Minerals (Pty) Ltd has identified a mineral sand deposit some 30 km North of Port Nolloth, Northern Cape Province, South Africa, with the aim of developing this resource to produce a saleable heavy mineral concentrate product from the wet concentrator plant (WCP), which would include garnet, ilmenite, monazite, zircon and rutile. The resource was originally prospected by Alexkor in the 1980's and 1990's while exploring for diamonds. Whale Head Minerals (Pty) Ltd conducted a Feasibility Study based on the findings by Alexkor, which considered the viability of the overall project, allowing for a mining operation, with a WCP.

The operation is required to produce a garnet, ilmenite, monazite, rutile and zircon rich concentrate. The proposed project site is characterized by coastal environmental sensitivity, as well as the relative remoteness of the site. Fresh water is not readily available, in addition the nearest electrical power source is some kilometres from the site.

2. Scope of work

2.1. Beach mining

2.1.1. Introduction

The Whale Head Minerals (Pty) Ltd heavy mineral sands project is located on the West Coast of South Africa some 30 km north of Port Nolloth at a small pocket beach. Here the mineral sands are located on a narrow corridor of beach between the tidal zone and a rocky cliff line. It is estimated that approximately 622 700t of ore will be mined from the beach over a 5-year period, producing high grade heavy minerals concentrates. This timeline may be extended due to the possibility of unrealized potential in the resource through the replenishment of the resource. The replenishment takes place by heavy minerals resupply from beyond the breaker zone in the seaward part of the nearshore-midwater area as well as replenishment of heavy minerals by the longshore drift and counter current flow feeding sediment from neighbouring areas into the Walviskop bay area. Log spiral flow in the bay entrains light sand (quartz, shell fragments) and selectively deposits heavy minerals in the bay. The resource would be exploited through the use of pumping techniques whereby the ore would be pumped from the mining blocks to a wet concentrator plant.

The West Coast of South Africa is synonymous with rough and unpredictable seas which may present a risk to the project. The mining method proposed will require heavy piping and equipment on the beach. Local miners who have mined diamonds for many years in the same area are of the opinion that mobility of equipment on the beach is essential so that the equipment can be removed relatively quickly and easily in the event of the sea turning. Mining at Walviskop is done by means of a high-performance suction pump which is fitted to an excavator and receives the sediment from the suction head (mining tool fitted on the end of the excavator boom) and delivers the sediment mined from the sea bed to a ~220t per hour wet concentrator plant located on the beach for heavy mineral processing.

2.1.2 Setting

2.1.2.1 Climate

An arid climate prevails along the Southern African West Coast region. The Alexander Bay – Port Nolloth area experiences winter rainfall, albeit extremely low. From September to April, the prevailing south-westerly winds reach gale force velocities at times in excess of 70km/h, producing swells up to a maximum height of 10m.

2.1.2.2 Topography

The coastal topography just south of the Orange River mouth is generally flat across a ~5 to 10km wide stretch of sandy coastal lowland, which terminates to the east against the mountain land of the Namaqualand Metamorphic Complex. The rugged quartzite and sandstone coastline exhibit sandy pocket beaches within embayment's flanked by rocky stretches that can be continuous for several kilometres. Walviskop is a south-west facing pocket beach in one of the embayment's south of the Orange River mouth.

2.1.2.3 Water Depth

Water depth at Walviskop ranges between ~1m low tide and ~4.5m low tide in the surf zone. Seabed slope averages at 0.01.

2.1.2.4 Sea State

Average shallow marine wave height along the West Coast of South Africa is ~2.5 metres (breaking wave height exceeds 2.5 metres ~50% of the time). This is taking into account some degree of wave crest elevation (8-10%) during shoaling of the wave. Wave height is below 3 metres ~85% of the time, and below 4 metres ~95% of the time. Thus, extreme conditions (wave heights of 4 metres or more) occur less than 5% of time.

2.1.2.5 Wave Regime of the West Coast

Since the South Atlantic Anticyclone became established during Tertiary times as the dominant weather pattern impacting upon the West Coast of Southern Africa, prevailing wind and wave direction ranged between south and west, mainly south-southwest to west-southwest.

Wave currents therefore move sediment primarily in a north-eastward direction, upslope upon the West Coast shoreface, while gravity backwash pulls sediment back downslope in a westward direction. The resultant zigzag motion progresses steadily northward. In the nearshore environment, wave-induced bottom-currents are powerful enough to regularly move entire bodies of coarse sediment, and sand-sized sediment during winter storms. Storm winds from the northwest during winter also sometimes move gravel in a southerly direction. The overall effect of these weather forces is to supply the driving force behind migration of large sediment populations along the coastline, predominantly northward. The interaction of wind, waves, and currents in beach and nearshore environments is the main driving forces influencing sedimentation in the beach and nearshore environment. Wave power, size and availability of sediment, beach slope, and backwash velocity are important factors. Wave height is considered to be the most important factor controlling beach morphology (Figure 1). The surf zone is subject to a variation in wave-energy which determines the spectrum of sedimentation regimes in the various areas. Low wave-energy reflective beaches, such as Walviskop in the summer months, contain medium-scale landward-dipping cross-lamination produced by asymmetrical oscillation ripples.

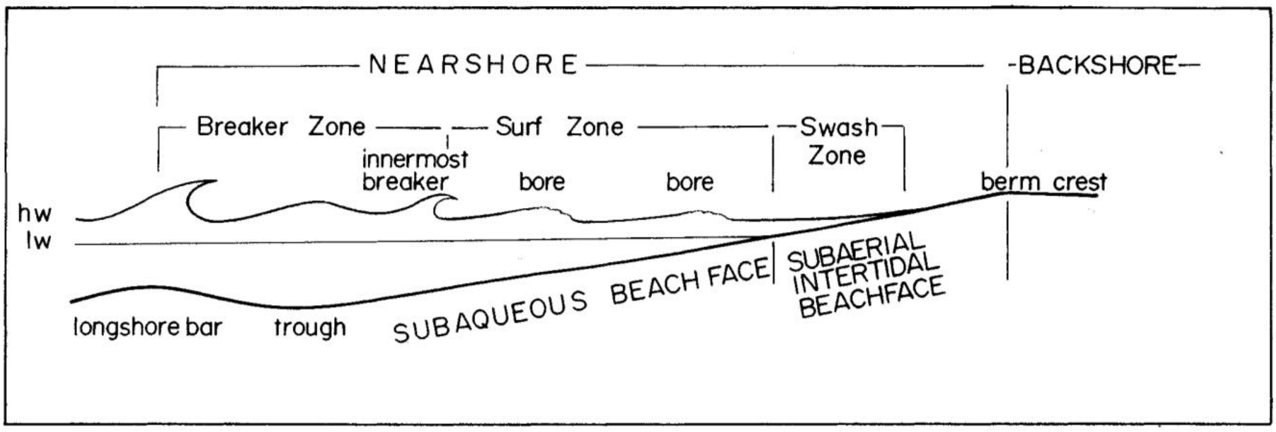


Figure 1: Diagram showing terminology used in this report (after Illgner, 2008). This is a typical beach profile for the Walviskop area which is characterized by a semi-permanent longshore bar and trough (hw = high water line; lw = low water line).

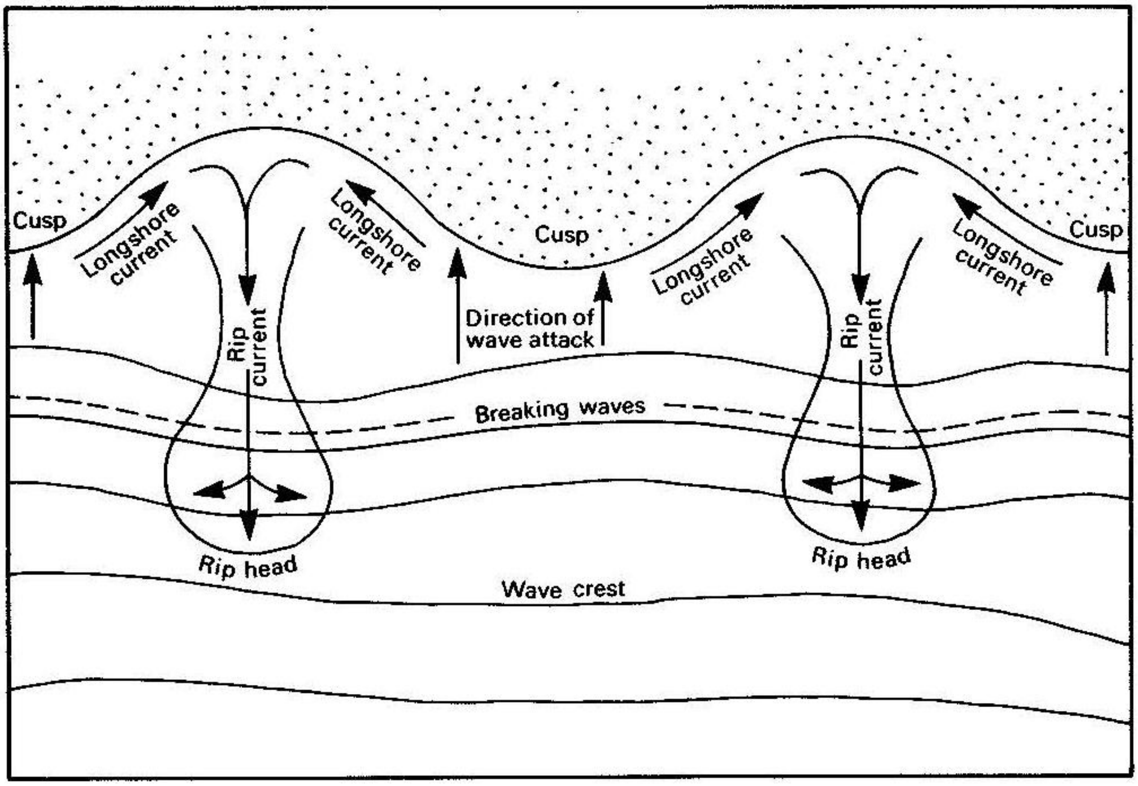


Figure 2: Cusp formation is caused by interactions between longshore and rip currents (after Illgner, 2008).

Cusps are crescentic accumulations of sand between the swash zone and just below the berm crest that vary in height from a few centimetres to as much as 3 m or even more. They are formed of crescentic ridges of coarse sand which surround depressions of finer grained sand. The width of a cusp is seldom more than a few metres. Cusps are ephemeral features, formed by wave action, that migrate along a beach in the direction of longshore drift. They owe their existence to edge waves. These are secondary waves that move at right angles to the primary on-shore waves of the coastal zone. The edge waves cause undulation in wave crests, thereby producing a rhythmic swash line. The uneven swash line, in turn, favours the development of rip currents, which return swash rapidly to the sea and scour-out the "bays" between cusp horns (Figure 2). Cusps occur on many beaches, but are especially prominent where beaches consist of a mixture of sediment sizes (gravel and sand).

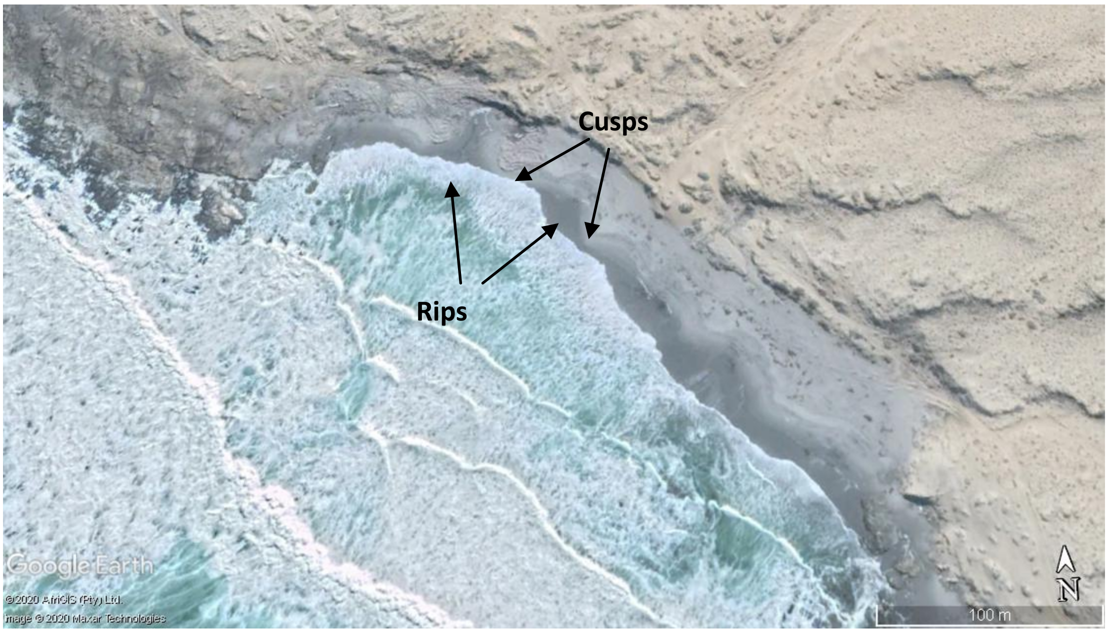


Figure 3: Winter satellite image taken in June 2003 during high tide.

Figure 4: Summer satellite image taken in November 2006 showing clear wave interference.

Figure 5: Winter satellite image taken in June 2010 during low tide.

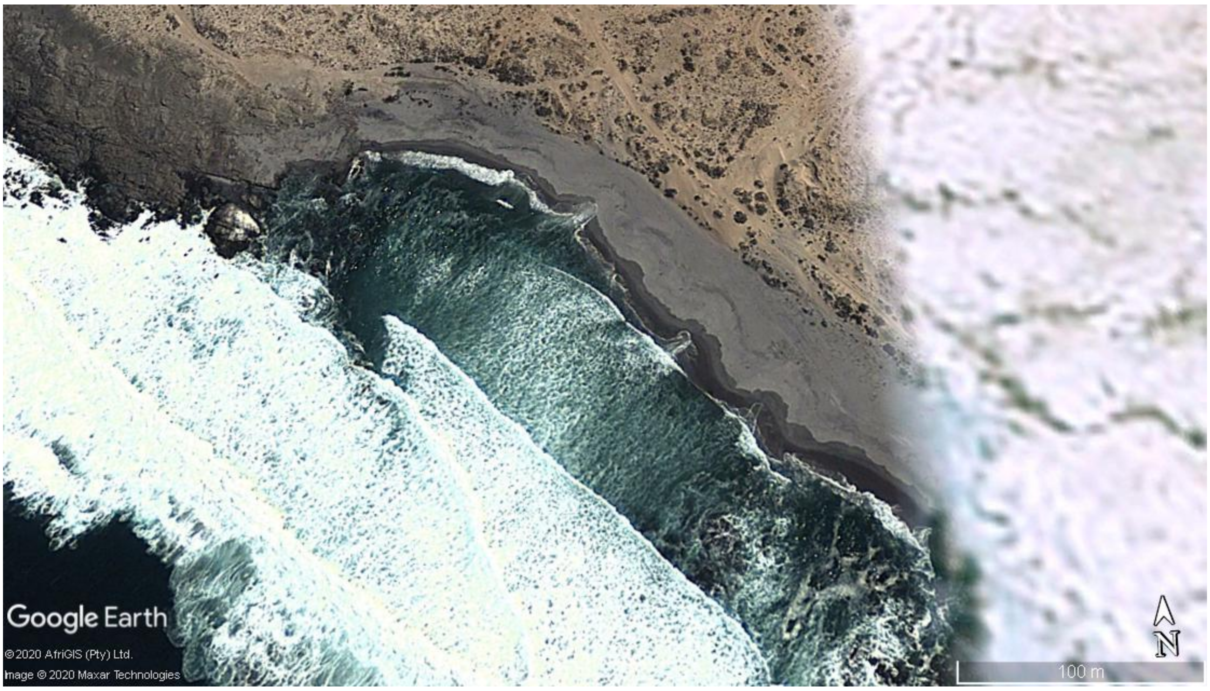


Figure 6: Cusps and rip currents in the nearshore area.

At Walviskop the presence of rip currents that plays a major role in transporting sediment from the swash zone to at least the breaker zone is revealed by the cusp formation on the beaches. This is probably the single most important force in transporting light sediment from the beach back into the bay leaving behind the high density heavy minerals that resists entrainment. This selective entrainment results in the enrichment of heavy minerals on the beach through this process of placer development.

One of the most distinctive features of shallow marine sedimentation, is the frequency of depositional and erosional cycles superimposed upon any given stretch of coast over relatively short periods of geological time. Another distinctive feature is the general tendency of marine sediments to remain unconsolidated for much longer periods than their subaerially exposed counterparts. This facilitates relatively high sediment mobility in an environment of continuous wave energy and enhances the opportunity for placer development providing a good source of heavy minerals is available. In the shallow-marine environment, hydrodynamic boundaries control sediment transport and deposition. Boundaries in turn are controlled by the interaction between homogenous deep wave fronts and coastal bathymetry, resulting in differentiation of wave energy.

These mechanisms are the driving forces behind sediment transport with heavy minerals and quartz sand that are washed into the bay during storm events and then through selective entrainment the quartz is washed back into deeper water further offshore causing enrichment of heavy minerals on the beach of the log spiral bay.

2.2 Beach Mining Operation

2.2.1 Walviskop Sediments

The near shore sediments at Walviskop comprise a marine gravel layer resting on a gently seaward sloping bedrock platform. Here the gravel layer in turn is overlain by a medium to coarse grained beach sand layer. Heavy mineral mineralization occurs predominantly in this beach sand unit and to a lesser extent in the gravel layer.

The bed rock floor on the platform is a very uneven surface with gullies, potholes and large boulders (> 400mm in diameter) in places.

The gravel layer rests on the bedrock floor and varies in thickness between 100 and 500mm. The gravel unit consists of gravel clasts and shell fragments and subordinate sand size material. Clast sizes ranges from > 100mm (8%) to 100 – 2mm (92%) and comprise almost entirely of vein quartz and quartzite.

The overlaying beach sand layer is 3 to 5 m thick on average but after a severe winter storm it can be very thin or even totally absent. The sand comprise a ~50 – 50 mix of coarse to medium grained quartz sand, broken shell material and heavy minerals as a compact well packed sand layer prone to continuous relocation by bottom currents particularly during storm events.

2.2.2 Mineralization

Mineralization of valuable heavy minerals developed predominantly in the sandy beach deposits where very high grade zircon-ilmenite- garnet-rutile-monazite resources formed at well developed south facing log spiral bays such as the bay at Walviskop. The main minerals of economic interest here are rutile and ilmenite (TiO_2), zircon ($ZrSiO_4$), by far the most common zirconium mineral (ZrO_2)

and monazite $(Ce,La,Nd,Th)(PO_4,SiO_4)$, a very good source of a variety of valuable rare earth elements and garnet.

At this part of the coast, heavy mineral suites are diverse and consist of various proportions of ilmenite and its related alteration products, leucoxene,haematite, magnetite as well as rutile, zircon, garnet, amphibole, pyroxene, epidote, aluminosilicates, titanite, monazite, staurolite, collophane and glauconite. The economically viable minerals, ilmenite, rutile, garnet, monazite and zircon constitute a very large portion of the total heavy mineral suite, often an order of magnitude greater than the gangue. Generally, the total heavy mineral suite in the area is dominated by ilmenite (50 – 73 wt%), with garnet (6 –12 wt%), zircon (5 -7 wt%), monazite (2 – 3 wt%), and rutile (1 wt%) constituting the rest of the economic fraction.

The titanium-bearing minerals comprise, in addition to pure ilmenite, a complex suite of Fe-Ti-oxides often intimately intergrown. Single grain analyses indicate that ilmenites contain on average 51% TiO_2 with only trace amounts of impurities. Only a small portion (~8%) of the ilmenite fraction is altered and in most cases alteration was insufficient to enhance the titanium content of the ilmenite fraction. These results are remarkably consistent with previous studies conducted on other west coast localities.

Zircon sand contains zirconium as silicate. Zircon populations were found to be heterogeneous, displaying contrasting physical, geochemical, cathodoluminescent and radiometric properties.

Heavy mineral grains vary in size between 75 and 180µm whereas the gangue minerals such as quartz occur predominantly in the 250 to 500 µm size range.

2.2.3 Process Description

The beach at Walviskop will be mined using an excavator fitted with a dredge pump (hydraulically driven submersible dredge pumps) onto the boom of an excavator feeding directly into a booster pump that will deliver the slurry into a main pipe spine along the beach. The mining rate has been estimated at rate of 260 tonnes per hour based on applying a non-conventional mining method to the project.

The mining operation proposed here will consist essentially of a land-based operation advancing from the beach into the surf zone by carrying a mining tool, the HY 300A hydraulic dredge pump, which will replace the bucket on an 80t excavator (Figure 7, 8, 9 & 10). The pump is equipped with a high-pressure water jet ring system that delivers $100m^3$ of water at 6 – 7 bar onto the pump suction area (Figure 10). This water jet system will cause the liquefaction of the sand layer to the extent that the sand in the immediate vicinity of the pump will be kept in suspension through a combination of the turbulence caused by the water jets and motion of the sea water. Dredging will then focus on the suspended sediment comprising mainly sand at a rate of 900 m^3 slurry (up to 50% solids). The mined sediment is pumped from the mining area on the beach, surf zone and breaker zone to the back beach via a 250mm diameter pipe line to the WCP.

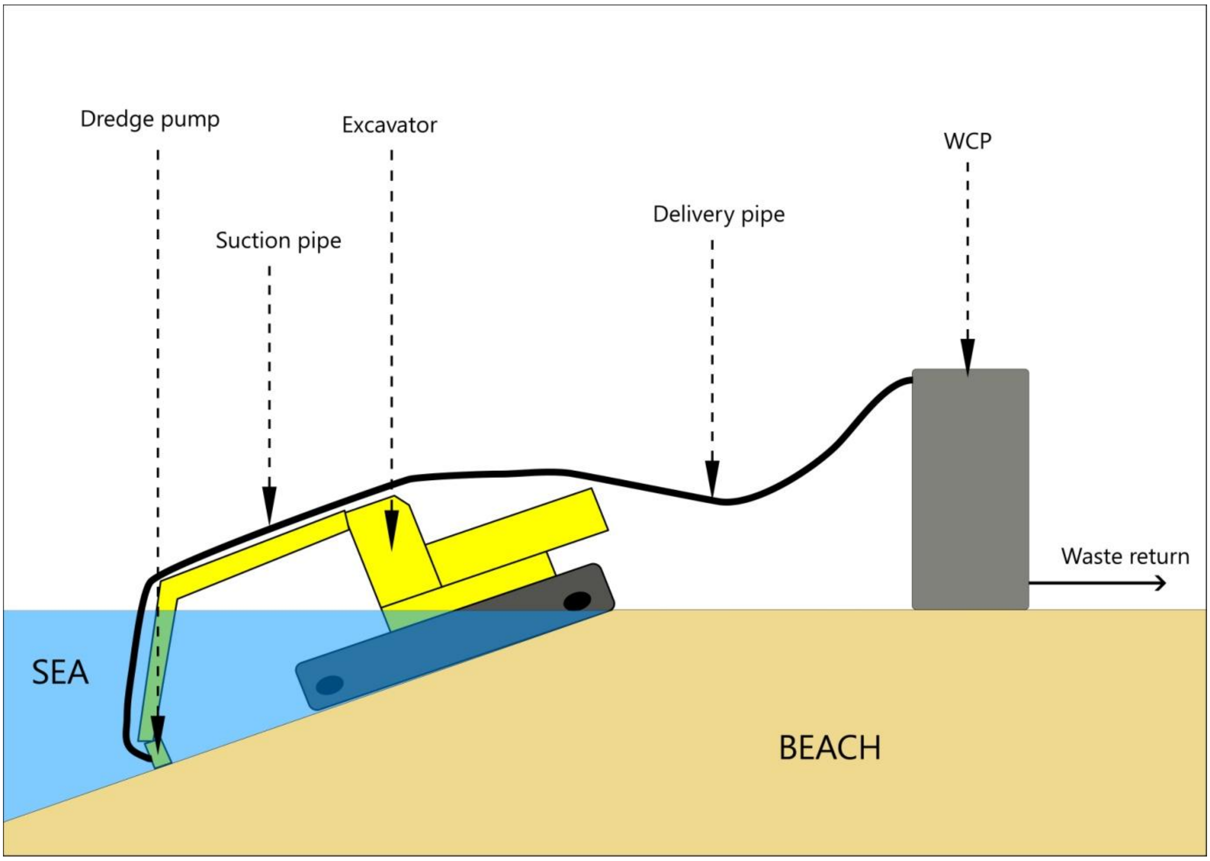


Figure 7: Mining operation on the beach

The sand-size gangue and oversize gravel fraction tailings from the WCP on is considered waste and gets returned to the surf zone by means of gravity flow and gets re distributed and deposited by the wave action on the beach. Mine planning will have to take the direction of longshore drift in to consideration by commencing mining at the down current end of the mining block. The mining will be done by means of a mining tool attached to a high flow rate suction pump. The Dragflow suction tool is attached to the boom of the excavator where it will perform the mining by means of a dredging action. The excavator is equipped with a GPS system to ensure that precise mining take place and that mined-out areas are avoided. Mining will take place at a nominal rate of 260 tonnes per hour at an average utilisation of 75% as a result of beach availability due to tidal events. The mining system is designed at an engineering availability of 85% equating to a mining design capacity of 350tph. The mine area will be divided into mine blocks some 100 x 100m in size and mined from south to north starting with the blocks on the seaward side (Figure 8).

The mining operation will have a main pipe spine that runs along the length of the beach 10m from the cliff bottom. This pipe spine consists of 3 lines: a water line transporting water from the process water dam to the mining operation, a tailings line returning WCP tailings to the beach running adjacent to the water line, and a line transporting ROM slurry to the WCP from the mining operation. There will be tie in points on the pipe spine every 50m along the beach to facilitate the relatively high advance rate along the beach estimated at around 27m per day. The excavators will be connected to the booster pumps using flexible hose that will allow the excavators to move as the mining operation advances.

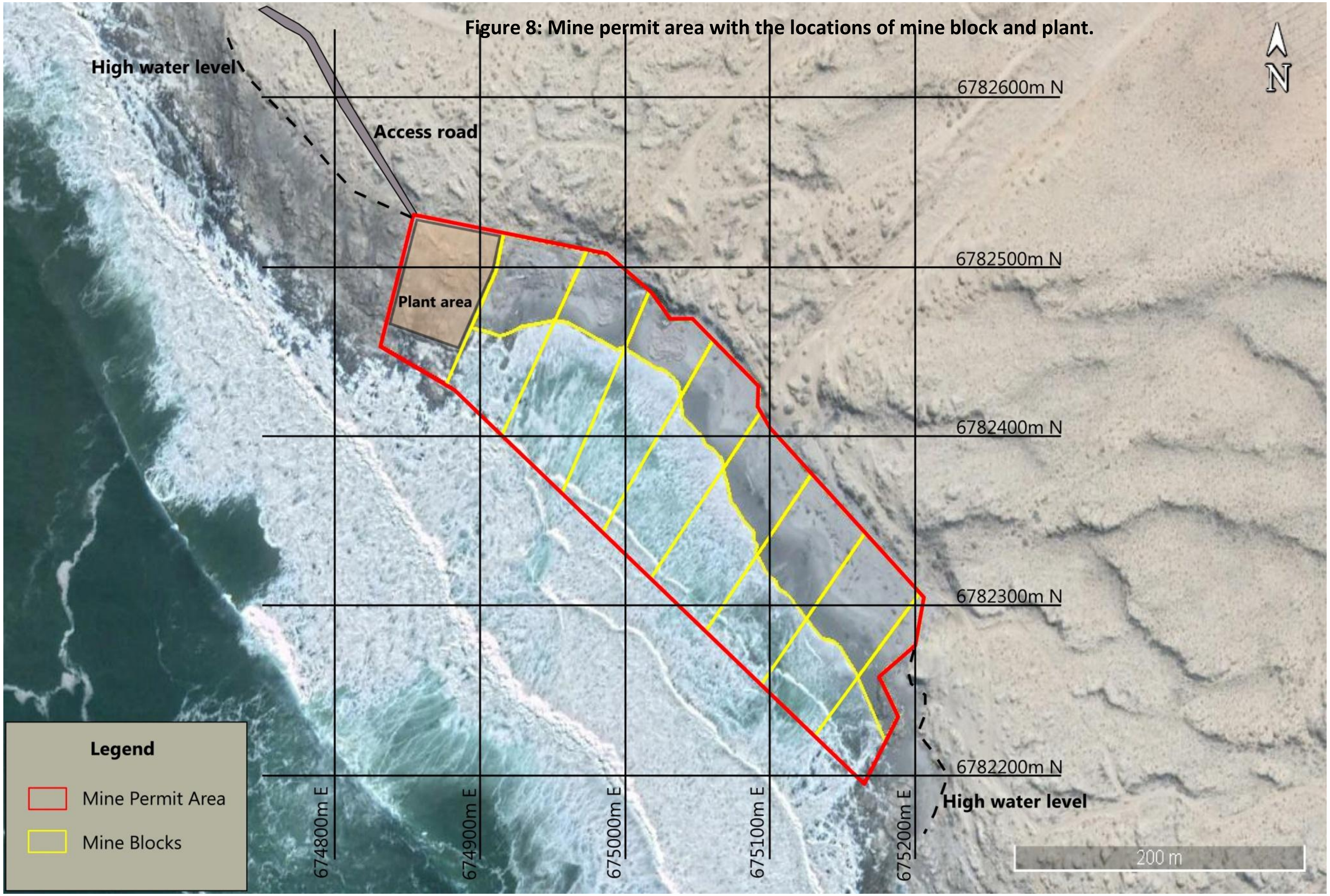


Figure 8: Mine permit area with the locations of mine block and plant.
N
High water level
Access road
Plant area
6782600m N
6782500m N
6782400m N
6782300m N
6782200m N
674800m E
674900m E
675000m E
675100m E
675200m E
High water level
200 m
Legend
Mine Permit Area
Mine Blocks

The mining operation will receive water from the process water dam as already mentioned, and it is foreseen that the water requirement would reduce as the amount of water in the feed increases with increasing depth of mining. Indications are that only the top 1.5m of sand will be dry and the remainder of the resource 1.5 to 5m deep will be waterlogged.

The process water dam will be fed from a single fixed sea water intake located close to the WCP. The sea water intake (SWI) will be in the form of a well field buried in this section of the beach. The SWI will supply water to the process water dam at a nominal rate of 360m^3/h. The water table at the beach is approximately 1.5m below the surface on average. This would also be a function of the distance from the shoreline and the tide.

2.2.4 Assumptions

The main assumptions used in this costing model were:

a) **Mining plans** were based on a mining sequence where mining started at the southern most end furthest from the plant and progressed northwards towards the plant.

b) **Mining** to only take place 10 metres from the toe of the cliff towards the sea.

c) Mining takes places 16 hours per day for 250 days per year with the assumption that 25% of this time will be lost mainly due to inclement sea conditions.

d) The average **bulk density** of 1.87t/m^3 was derived from the ore reserve estimate.

e) Mining equipment selection is based on Komatsu data.

f) Mining **fuel consumption** figures were estimated from the Komatsu handbook.

g) **Light vehicle** consumption was calculated from the AA Rates manual for Light Commercial Vehicles.

h) **Fuel prices** – as promulgated on 5 February 2020 and obtained from the Shell website.

i) **Pipe distances** were derived from the original haul road calculations and drawings.

j) The mining blocks in the Northern Areas were only mined once while the southern areas were mined at least twice producing some 4.9 million tons.

k) **Roadway maintenance** – will be done using a grader and water bowser with fresh water supply from Muisvlak plant.

l) Logistics – costs included for:

   1. LDV for supervision.

   2. One 25 000L fuel bowser.

m) **Piping and pumping costs** are calculated within the ore processing battery limits.

2.2.5 Mining Machine Selection

Machine capacities and types were selected based on discussions with local operators and OEM suppliers. Komatsu PC800 excavators were selected as the main mining tool as suggested by the suppliers (Figure 9). These machines would be equipped with an extra-long boom capacity which will be sufficient to support the mass of the hydraulic pump over the 18m mining radius. The hydraulic pump will replace the excavator bucket being fitted to the excavator arm and connected to the hydraulic system of the excavator (Figure 10). To support the PC800 excavators in moving the 250 mm (10 inch) pipes on the beach, one PC 300 excavator has been selected. The movement of piping on the beach is a cumbersome task and will require relatively heavy equipment to achieve. These machines will also play an important role in removing equipment from the beach should sea conditions so require. Komatsu have a strong presence in the area and are prepared to enter into repair and maintenance contracts. Therefore, for the purpose of this exercise, the Komatsu pricing and maintenance schedules were used.

Figure 9: An 80t excavator equipped with a long reach 4,6m arm and an 8,2 m boom and 1 010 mm double grouser shoes. The bucked gets replaced by a hydraulic pump fitted by means of a quick release attachment.

Figure 10

DRAGFLOW HYDRAULIC PUMP HY300A

- Solid concentration can vary from 5% to 70% by weight of pump capacity due to the kind of material to be pumped, the delivery distance, the working depth, static head and dredging operation
- They are suitable to handle high abrasive materials thanks to low rotation speed which decreases wear and tear to the parts subjected to abrasion.
- Solids passage: 120 mm

Technical specifications

- Weight: 3.500 kg (A model)
- Cross Section: 120 mm
- Impeller: 2 vanes closed / Diameter: 760 mm
- Delivery diameter: 250 mm (A model)

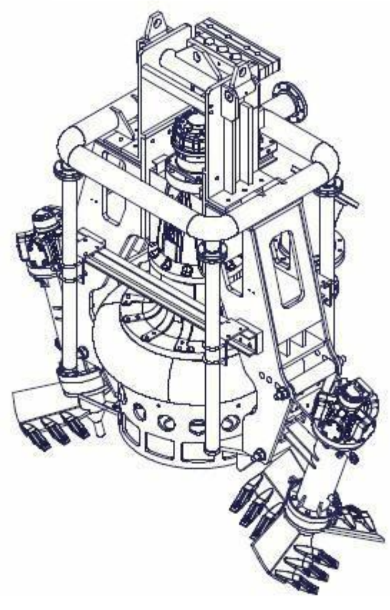
Motor

- Speed min-max: 600 - 750 R.P.M.
- Power min-max: 110 - 214 kW (150 - 292 HP)
- Need of oil min-max: 300 - 375 l/min
- Oil pressure min-max: 230 - 350 bar
- Motor displacement: 500 c.c.

Materials

- Main body: Spheroidal Cast Iron GS500
- Motor housing: Cast Iron G25
- Wearing parts: High Chrome
- Main Shaft: Austempering NiCrMo4 Steel

High pressure water ring jet system with 4 x 25mm nozzles and a 150mm inlet.



DRAGFLOW HYDRAULIC PUMP HY300A fitted with

A high pressure water ring jet system and two

excavators (optional)

This pump is attached to the excavator by means of a quick coupling system.

Although construction and maintenance of the roadways has been reduced significantly from the baseline mining study, maintenance of these roads from a health and safety perspective is still a necessity and provision should be made for this in the processing estimate. The fuel bowser capacity has been increased from 20 000 - 25 000 litres to ensure sufficient availability of fuel for the additional booster pump stations.

2.3 Mechanical and Piping

2.3.1 Description

The design has been based on the following parameters:

Dry Solids Feed Rate = 260tph + 20% Design Factor.

Slurry Flow Rate = 907m³/h + 20% Design Factor.

Solids SG = 3.63t/ m³

Slurry SG = 1.27t/ m³

Pipe Length = 5,000m

Static Head = 46m

Cyclone Structure Height = 15m

Cyclone Feed Pressure = 7.5m

Total Static Head = 68.5m

Durand's Limiting Settling Velocity calculation was used and the Warman table on "solids for widely graded sizing" was used to determine Friction Loss. Due to Durand's formula being very conservative we used 80% of the calculated Settling Velocity to determine the minimum pipe sizes.

To calculate the Required Power the following calculation was used:

Required Power = (Absorbed Power X Drive Loss Factor X Friction Losses in Fitting or Transmission Factor) / Pump Efficiency

Drive Loss Factor or Safety Factor = 20%

Friction Losses in Fitting or Transmission Factor = 5%

The piping selected for the project was PE 100 HDPE PN 10 complete with galvanised flanges

drilled to SANS 1123 T1000/3 FF.

2.3.2 Scope

The beach mining operation consists of 2 ROM Transfer Pumps spaced along the pipe route. The first pump will be fed by the hydraulic dredge pump mounted on the excavator. Followed by a series of booster pumps feeding the ROM stacker cyclones.

ROM Feed

- 2 x Warman 10/8 AH Metal Pump c/w 275 kW Diesel Engine, all skid mounted.
- 1 x 250 NB x 1,000 mm long Rubber Hose to connect overland piping to the suction side of the pump.
- 1 x 200 NB x 1,000 mm long Rubber Hose to connect the overland piping to the discharge side of the pump.
- 250 x 12,000 mm lengths of 355 OD HDPE PN 10 pipe flanged both ends to SANS 1123 T1000/3 FF galvanised.
- 100 x 12,000 mm lengths of 355 OD HDPE PN 10 pipe flanged both ends to SANS 1123 T1000/3 FF galvanised, c/w 355 Dump T.
- 100 x Dump T's.
- Note that the flexible hose delivering ROM slurry to the first booster pump from the Hydraulic Dredge pumps has been included with the Hydraulic Dredge pump cost.

Sea Water Intake

The sea water intake (SWI) consists of an underground of perforated pipes routing water to a central well pipe. Water is pumped from the central well pipe to the WCP process water dam as required.

- 1 x Warman 6/4 AH Metal Pump c/w 110 kW Diesel Engine, skid mounted.
- 135 x 12,000 mm lengths of 250 OD HDPE PN 10 pipe flanged both ends to SANS 1123 T1000/3 FF galvanised.
- 14 m 450mm OD HDPE PN 10 piping cut to suit
- 1 x 8m length of 450 HDPE PN 10 pipe flanged both ends to SANS 1123 T1000/3 FF galvanised
- 1 x dump tees

2.4 Civil

The only civil work included in the beach mining section relates to the access roads to the platform above the beach, where provision has been made for a plastic lined culvert to hold the main pipe spine as well as run off diversion from the main road (Figure 11).

The culvert for the main pipe spine runs parallel to the access road and has an earth berm on either side to keep any spillage as a result of a bust pipe away from the dune vegetation and channel it down to the beach. Run off during rainstorms will also be drained from the road to the culvert where it would run down to the beach without eroding the access way.

The access way itself will be designed in such a way that water will not erode the surface and cause instability in the cliff adjacent to the access way.

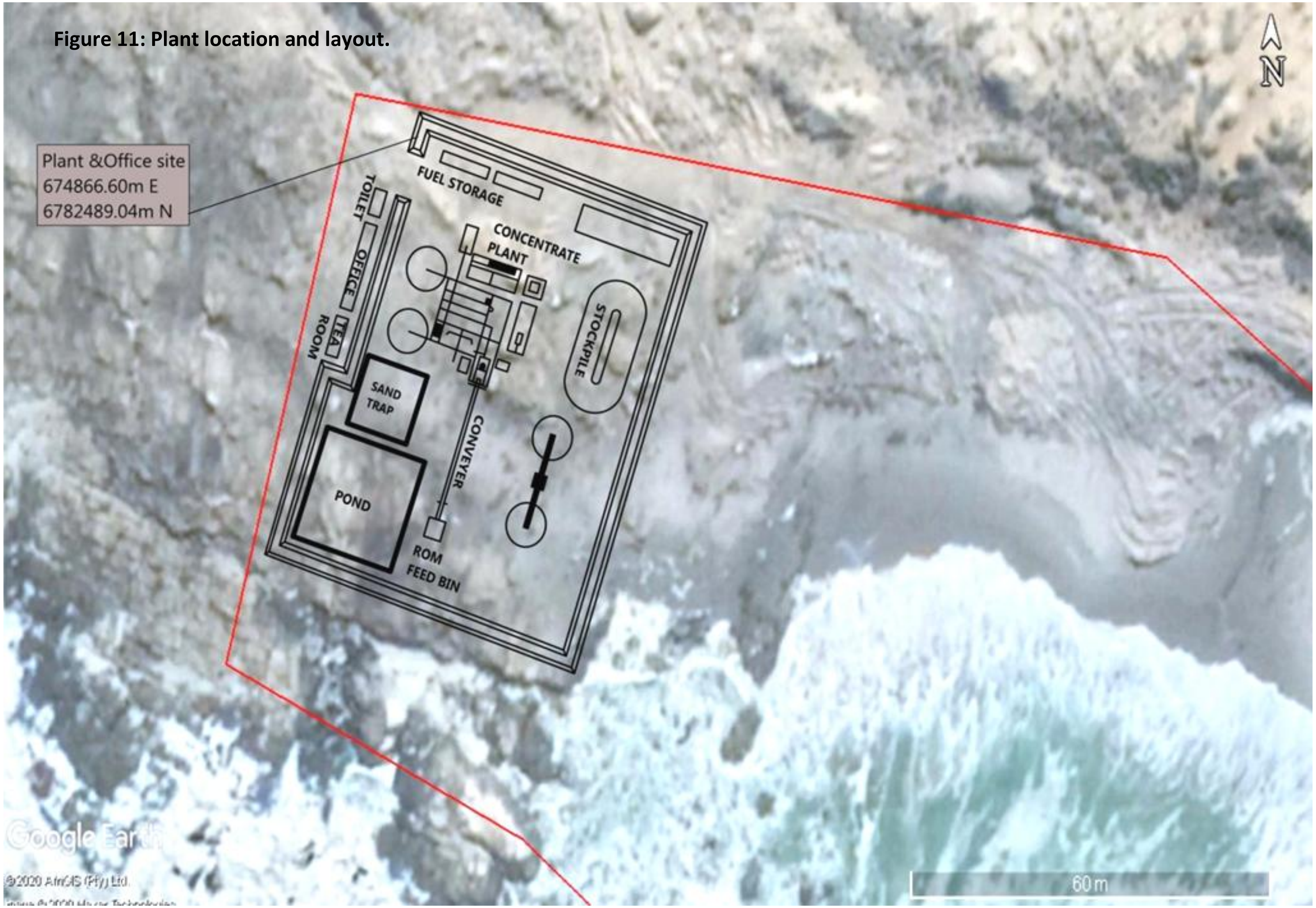


Figure 11: Plant location and layout.

2.5 Electrical

The electrical scope on the beach will be limited to area lighting that will be mounted on the pieces of equipment on the beach i.e. the booster pumps. The electrical supply for the lighting will be run from an alternator on the equipment diesel engine.

2.5 Process Control and Automation

There are three main functional areas in the mining section: Water supply to the beach, ROM feed to the main pump spine and the main pipe spine that transports water and slurry along the length of the beach.

The ROM supply to the pipe spine is delivered by two excavators fitted with Hydraulic Dredge pumps. The excavators have on-board flow and density control, and work to a set point of 30% solids by mass to the main pipe spine by controlling the water addition, pump speed and pump position.

The main pipe spine receives the ROM in slurry form from hydraulic dredge pump at the first booster pump station. Water addition will also be supplied at this pump station of ; this water will maintain the flow in the pipeline at low flow conditions from the dredge pump.

The sea water intake (SWI) maintains the level in the process water dam. Water is supplied to beach mining operation through the mining water supply pump from the process water dam. Water addition to the ROM stream is controlled by a motorized valve and adds water when the flow meter on the discharge of pump measures a low flow condition.

The excavators will receive an alarm when the pressure in the discharge header exceeds normal operating parameters indicating that there is an obstruction in the main pipe spine and that the line should be flushed. The booster pumps on the main pump spine are interlocked with each other. All instrumentation in the beach mining section communicates with the main plant PLC via a radio link.

Each of 2 stations will be fitted typically with a 25IO MicroLogix 1000 PLC operated off 24VDC from the battery system of the Diesel engine. The latter will be mounted in a remote station radio panel. These systems will be able to monitor 6 digital inputs, 2 analogue inputs, 8 digital relay outputs and 1 analogue output. As a result of this the operator will have the ability to operate the diesel pumps from the control room and receive indication of the status of the units.

The radio signals are fed to a 105U gateway on the plant which supplies the data onto the Ethernet network connected to the PLC.

Communications to the plant personnel will be done by two-way radios that have been included in the estimate.

2.6 Wet Concentrator Plant

The wet concentrator plant (WCP) will be located well above the beach where it will receive sediment at a rate of approximately 260t per hour (Figure 11). The WCP receives ROM slurry from the beach mining operation and produces tailings that is sent back to the beach mining operation and concentrate which is bagged and dispatched from the concentrator plant. Provision has also been made for a five-day ROM stockpile and a Low Grade concentrate stockpile. The plant will use water from the process water dam.

2.7.1 Process Description

WCP Feed Reception

The rate of production at the mine excavation is estimated to be 260t/h solids and the WCP has a capacity of between 208 and 210t/h (+/- 20%) solids. The 260t/h mining rate is considered an average rate and depending on the water content in the beach sand, the ratio water to sediment could vary and supply from the water supply pump will decease while working high up on the beach as opposed to down below water level. This will result in the slurry density increasing and decreasing depending on the working area resulting in the 260t/h figure being a minimum number that could increase as much as 5-6%.

At the WCP the slurry flow into the plant will be carefully controlled not to overfeed the plant with the excess feed being diverted to a dewatering/stacker cyclone system that will stock pile the dewatered sand on a stock pile pad for use in the plant should the mining unit not being able to supply slurry directly to the plant due to unavailability during routine maintenance, refuelling, unexpected breakdowns of the excavator-pump unit or high sea stand on the beach area. Enough material will be collected on the stockpile pad to cover 5 days allowing for a serious mechanical failure at the excavator/pump or rough seas during severe storm conditions.

Slurry from the mining operation will report to the ROM stockpile(s) via the stacker cyclones which will dewater the material. The ROM stockpiles will be reclaimed by means of a front-end loader and placed on an adjacent stockpile. The ROM stockpiles will have a collective capacity of 5 days plant capacity.

Water run-off from the ROM stockpiles will be channelled to the process water dam. ROM ore will be fed into the WCP directly from the dredge via the pipe line that will discharge the material into a trommel screen acting as a tramp removal screen with a cut point of 2mm. The oversize will be stockpiled while the undersize is discharged into a densifying cyclone and from the cyclone to the primary sluices (spiral banks) (figure 12).

The ROM feed will be controlled by the density meter on the rougher feed discharge in order to feed the pulp into the rougher circuit at a constant density. The level of the rougher feed bin will be maintained by an actuated valve linked to a level sensor in the rougher feed bin.

Water will be stored at the plant site in a lined earth dam (process water dam, PWD). The water supply will consist of the cyclone overflows from the stacker cyclone on the ROM stockpile as well as make up water from sea water intake (SWI) and return water from the plant. The water level in the process water dam will be maintained by the SWI that will be linked to a level instrument on the PWD.

The PWD will include a self-cleaning sand trap that will overflow into the main PWD with streams carrying solids reporting to the said sand trap. Silt will be removed from the PWD by a submersible pump that will be permanently mounted in the sand trap, the silt will be pumped into the PWD overflow where it will be allowed to return to the beach.

There will be an overflow which will return water to the beach when the mining operation is producing water in excess of the losses to tailings.

Gravity Concentration Area

Material from the densifying cyclone will be fed to the primary sluices (rougher spirals) via a 4-way pressure distributor.

Four banks of 12 triple start rougher spirals are required. The rougher concentrate will report to the LIMS feed bin in the magnetic concentration area of the plant. The rougher middlings will report to the Midds Scavenger Feed Bin and the rougher tails will proceed directly to the Final Tails Bin.

The Midds Scavenger Spirals receive its feed from the Midds Scavenger Feed Bin. The Midds Scavenger Spirals consists of two banks of 10 triple start spirals. The concentrate from the Midds Scavenger Spirals reports to the Cleaner Feed Bin and the tails to the Final Tailings Bin. Make up water for the Midds scavenger bin is received from the tailing's densifier cyclone.

The Midds Scavenger concentrate, and the scavenger concentrate are fed to the cleaner spirals. The cleaner feed is pumped from the Cleaner Feed Bin to a single bank of 8 triple start spirals. The concentrate from this stage joins the rougher concentrate in the LIMS feed bin with the tailings being further treated in the scavenger spirals.

The Scavenger Spirals consist of a single bank of 4 triple start spirals. The concentrate reports to the Cleaner Feed Bin and the tailings proceed to the Final Tails Bin.

In general, there is a water shortage in spiral concentrate bins that requires water to be added to reach the desired density for pumping. Water is thus transferred between bins to limit the total amount of water that needs to be pumped into the plant.

A common sump is located below the process equipment for the containment of spillage; hosing points have also been provided in the area.

There will be no product collection launders feeding into the sumps and all spiral products will be piped directly to the said sumps.

Concentrate Handling Section

The concentrate handling section is fed directly from the Concentrate Bin. The high-grade concentrate is dewatered by either one of two stacker cyclones, one located at the bagging plant and another at the emergency stockpile.

The low-grade concentrate reports to a dedicated LG concentrate stacker cyclone that discharges on the LG stockpile.

The combined cyclone overflows are re-circulated to the rougher feed bin.

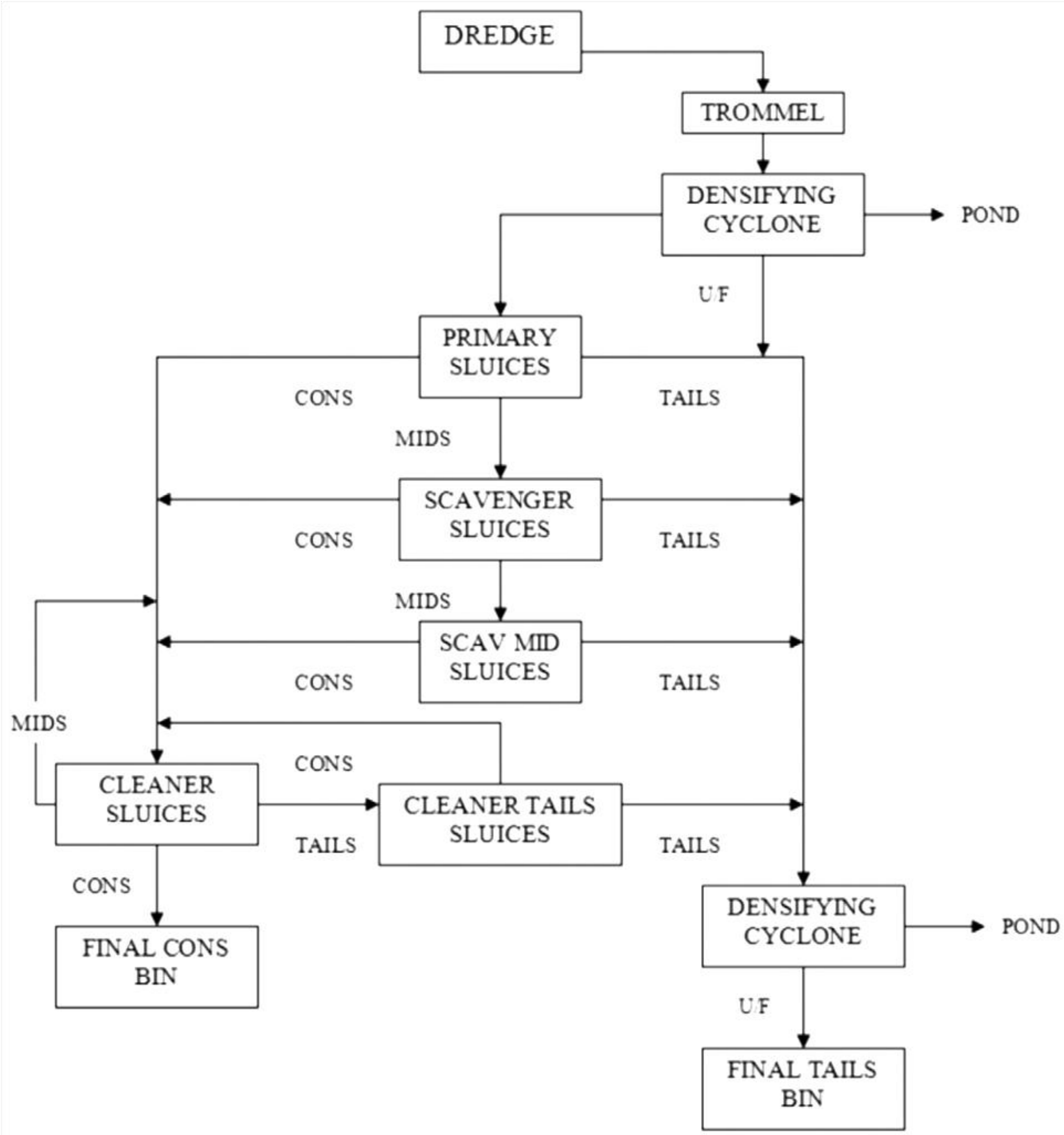


Figure 12: *WCP Feed Reception and Gravity Concentration Area*

2.7.2 Mechanical and Piping

The Wet Concentrator Plant was designed on the following parameters:

Material Handling

Dry Solids Feed Rate = 210tph +20% Design Factor

Slurry Handling

Dry Solids Feed Rate = 208tph +20% Design Factor

Solids SG Range = 2.70 to 4.44t/ m^3

Slurry SG Range = 1.03 to 1.34t/ m^3

Durand's Limiting Settling Velocity calculation was used and the Warman table on "solids for widely graded sizing" was used to determine Friction Loss. Due to Durand's formula being very conservative we used 80% of the calculated Settling Velocity to determine the minimum pipe sizes.

To calculate the Require Power the following calculation was used:

Required Power = (Absorbed Power X Drive Loss Factor X Friction Losses in Fitting or Transmission Factor) / Pump Efficiency

Drive Loss Factor or Safety Factor = 20%

Friction Losses in Fitting or Transmission Factor = 5%

The piping selected for the plant is PE 100 HDPE PN 10 complete with galvanised flanges drilled to SANS 1123 T1000/3 FF.

Galvanised mild steel is selected for small bore piping (50 NB) required for the screen spray and hosing down points.

The High-Pressure Water circuit was designed for 6 bar discharge pressure at the pump for flushing of lines, supply to hose down points and Fire Water supply providing to strategic points around the WCP modules, e.g. each spiral bank.

The WCP Water Supply circuit was designed for 4 bar discharge pressure at the pump for screen sprays as well as make up water for the plant.

Warman AH rubber lined pumps are selected for the plant and these range from a 10/8 down to a 4/3 model. The pumps feeding the spiral banks are fitted with Variable Speed Drives (VSD) which give the plant some flexibility if one of the spiral banks is down due to blockage or maintenance, then two or three spiral banks can still be operated.

All tanks are designed on a rise rate of 0.5 m/minute. The tanks are fabricated from mild steel, rubber lined, and corrosion protected for the harsh marine environment. A freshwater wash has been included using a hydro-sizer that is provided with desalinated sea water from a reverse osmosis plant.

2.7.3 Tailings discharge

Some 40 - 50% of the mined sediment will be retained as concentrate and the remaining 50 to 60% will be discarded as tailings. The tailings will be discharged into a steel bin (sump) from where it will be pumped back to the mined-out areas in the surf zone. Here the tailings will be discharged back to the mined-out areas in the surf zone via a 250mm diameter flexi hose.

Should prevailing conditions allow, the tailings will be piped back (gravity flow) to the surf zone just south of the plant from where the released sediment will move southward and will be washed back onto the beach south of the plant. This would take place by the southwards flowing counter current eddy driven by the northward moving longshore drift that will take the sediment dispersed at the outlet in the surf zone and will get re-deposited onto the beach and thereby re-establishing the beach in the same manner as normal sediment accumulation on the beach takes place.

Should this sediment dispersal not follow the processes anticipated above then it will have to be pumped to the surf zone at the excavation for redeposition.

Gravel particles will settle upon discharge in the excavated depressions at the mined out areas where as the sand will stay in suspension for some time before settling. Tailings discharge will take place by constantly moving the discharge pipe outlet along with the excavator by placing the outlet on the mined outside of the excavator in order to make use of the longshore drift and rip currents to back fill the mined out areas and not to dump tailings in the areas that still needs to be mined. Tailings should under no circumstances be discharged onto rocky outcrop areas.

2.8 Civil and Earthworks

2.8.1 Earthworks

The entire plant area will have a plastic lining to be in line with the environmental management plan. The intention of the plastic lining is to contain all possible sea water drainage. The plant will also have a berm around it to contain spillage run off.

I. The whole of the WCP area will be excavated to a depth of 500mm and the ground will then be scarified and compacted to 90% modified AASHTO density.

II. All excavated sand will be stockpiled for re-filling of area.

III. The areas for the sand trap dam and the process water dam will be excavated to the correct dimensions.

IV. Suitable plastic sheeting will be laid over the whole area including that of the dams. The stockpiled sand will be backfilled to NGL, compacted to 90% modified AASHTO density in 150mm layers. Ground slopes are directed towards the sand trap dam.

V. Berms will be constructed around the periphery of the site and around the dams using imported material.

VI. A weir arrangement will be incorporated from the sand trap dam to the process water dam.

VII. A diamond mesh fence will be erected around the site periphery making an allowance for a 4m wide gate at the entrance.

VIII. A diamond mesh fence will be erected around the dams with a 4m wide gate at the entrance and a pedestrian gate on the opposite side for emergency exit.

IX. Trenching and preparation for the overflow pipe from the process water dam to the beach will be completed.

2.8.2 Roadworks

I. The area between the existing road and the WCP area will be excavated and layer works constructed for an access roadway for a distance of some 200m north of the WCP.

2.8.3 Civils

Concrete bases will be constructed for the WCP, the ROM gantry, plant buildings and product storage areas.

I. A base will be constructed for the ROM Stockpile Gantry.

II. Bases and surface beds provided for the workshop and storage buildings.

III. The following appropriate surface beds will be constructed:

- Fuel storage area – allowance for oils and spillage bund.
- Bag storage area.
- Laboratory.
- Ablution block c/w sewage and waste disposal facilities.
- Office block.
- Tea room.

IV. A trench will be prepared, and concrete lined for a spoon drain from the WCP to the sand trap dam.

V. All stockpile areas will be compacted to 93% modified ASHTO. The G5 imported material levels will be to falls draining towards the sand trap dam. Appropriate surface beds will be provided for the generator, MCC and Control Room.

VI. A bunded area will be provided for the 'day fuel tank' for the generator

VII. Bases for the ROM Feed Conveyor will be constructed.

VIII. The concrete beam arrangement, surface bed and sump area under the WCP will be constructed.

2.9 Structural

Structural design works comprise the following:

I. ROM Stockpile Gantry incorporating 2 cyclone discharges.

II. WCP modular construction inclusive of stair modules and screen and rougher bin modules.

III. Cyclones mounted on jib arms for the high grade, low grade and bagging shed.

IV. ROM feed bin and feed conveyor.

V. Bagging plant.

VI. MCC support platform.

VII. Workshop.

VIII. Storage shed.

The WCP modules have been designed to be abnormal loads that will not clash with power lines while being transported to site.

2.10 Electrical and Instrumentation

2.10.1 Plant Operation

The plant will be operated via a SCADA system in the control room. The control room will be container based and mounted on top of the MCC container. The SCADA system will be RSView and was chosen as it interfaces well with the Allen Bradley PLC.

2.10.2 Management System

The project includes a management system that can be used by the plant manager as well as a 3 Com link that will allow for internet access and dumping data for access by a third party to data stored on the server. The office will communicate to the plant PLC via radio telemetry to facilitate moving the plant at a later stage.

2.10.3 Energy Supply

Power to the plant will be supplied via two generators, one rated at 1.8MW and the other at 160kW. The 160kW generator will only be used for construction power and on maintenance days when the main unit will be switched off. The standby generator is sized to run the 110kW fire pump (soft starter is incorporated on the pump) as well as the plant lighting and the welding plugs. The unit price included in the E&I tender is for a second-hand unit that has 2000h on the engine. This is deemed to be in order as the unit will only be needed on a standby basis.

The main generator will be sized according to the load, sized at 40% above the running current of the plant. The biggest motor to be started is a 160kW, however a soft starter should be included for all motors 100kW and above. The diversity factor on the motors was chosen at 10%. A design factor of 1.2 is included when specifying the motor powers. The chosen load of the motors is thus 72% of name plate current. As this is a plant with most of the pumps in line, a diversity of 10% is not deemed too high. There were no standby pumps allowed for or taken into account. The loading factor for the 6 welding plugs was chosen as 20%. If all the pumps are running, then the load on the generator increases to 1 431kVA and thus still within the maximum rating of the unit.

2.10.4 Voltage Drop

If the plant is running and the 160kW motor is started with the soft starter set at 300% of nominal current, then the voltage on the bus will drop to 92% which is well above the 85% minimum allowable. Low voltage cables will be to SANS 1507 600/1000V grade having steel wire armouring. Power cables in general will be 4 cores.

2.10.5 Energy Meter

An energy meter will be connected to the incoming section of the MCC and will be used to monitor the consumption of electricity as well as doing a routine check on fuel consumption of the generator. The meter will be connected via Ethernet for reporting purposes onto the server.

2.10.6 Earth Mat

Earthing will be done based on the final design by the appointed engineer and will result in a lightning protection resistance of less than 10Ω and a grounding resistance of less than 1Ω. The system will be designed and installed as specified and in accordance with the SANS Codes of Practice 10199 (2004) and 10313 (2008) in conjunction with SANS 62305-1-2-3-4:2007 and IEC 62305 -1-2-3-4:2006. The earthing system design is such as to provide a uni-potential system with all equipment being effectively earthed at a single earth potential. The interconnection of earth systems will be radial in nature to prevent the possibility of circulating currents, particularly in the vicinity of cable racks and pipelines.

2.10.7 Fault Current

The fault current is made up of two components, the generator and the effect of the motors to a direct short.

The panel ratings are 50kA and all 525VAC equipment will have fault ratings above 35kA. It is not possible to do fault current predictions for the future when an ESKOM supply is obtained, however the ratings are high enough that this should not pose a problem.

2.10.8 Welding Power

Allowance has been made for 3 feeds with two welding plugs per feed of 63A each. The welding plugs are supplied with 550VAC and this will have to be taken into account by the site contractors. Each welding plug is to be fitted with an earth leakage unit.

2.10.9 Construction Power

No allowance has been made for construction power as the units are modular, being built at the supplier’s premises, then transported to site and stacked in place. The standby generator will be available for the time the plant is being built as the unit is immediately available. The lead times on the MCC and all related equipment is 10 – 12 weeks and thus this can be ready long before the modules will be on site. The electrical container can also be made available to the module supplier for factory testing of his equipment.

2.10.10 Small Power

Small power was designed according to SABS0142:1993. The following areas will be supplied by small power:

Control room distribution board – 10kVA

UPS supply – 5kVA

Office supply – 50kVA

Plant lighting – 50kVA allowed, actual 22kVA

Maintenance workshop – 100kVA

The small power panel will be supplied by a 150kVA transformer.

2.10.11 Diesel Power

The 68,000l diesel tank will be supplied with 550VAC and this needs to be taken into account when the vendor for the supply of the tank is informed of his contract. The E&I contractor will supply the cable to the vendor distribution panel. As the lighting levels are low in the area, about 10 lux, (the assumption is made that all loading and pumping of diesel will occur in the day) if additional lighting is required then this is to be obtained from the 550VAC feed to the tank.

2.10.12 Plant Lighting

The plant lighting will be supplied via a three-phase supply to a DB where the individual single-phase lights will draw power. The DB will be fitted with a day/night switch.

There will be 5 different lighting DB box configurations as shown by the alpha numeric characters in red in the diagram below. The panels will be IP65 noncorrosive enclosures with exterior mounting facilities and tamper proof locking facility, similar to ABB GRP type enclosures. The plant lighting load will draw 82.27A single phase in total or 18kW. It is assumed that the control room and the offices will be supplied with lighting as they are container or modular based systems. Allowance will therefore not be made here for them.

Emergency lighting will be performed by standalone BEKA VLN 4x55w/EMG luminaries enclosed in an IP65 fitting with electronic control gear. The emergency control gear will operate the lamp for 1h at 50% light output. There will be an emergency light per module.

No high mast lighting has been allowed for. The conveyor lighting will be achieved form the 100W HPS lighting mounted on top of the modules.

2.10.13 Conveyor

Pull keys, single and double pole, will be installed every 80m on both sides of the conveyor belt for safety purposes (thus one set of pull keys for the conveyor). In case of the activation of a pull key (by human or other means), the design of the MCC (motor control centre) is such that the conveyor belt will be tripped. This is essential to comply with safety regulations and procedures.

The following Conveyor belt equipment will be covered under the Instrumentation Scope of Supply:

- Start-up sirens
- Belt alignment units
- Speed switches
- Electromechanical belt scales

2.10.14 Process Control System

The plant will be fully automated as far as is practically possible. All equipment will be stopped and started from the control room. Field start facilities are not provided. Sequential plant start-up and shutdown will be automated. Where operator input is required during the start-up sequence hold points will be provided. As equipment will be started remotely warning sirens shall be provided before any major equipment is started. Interlocking of all equipment will be via the PLC. Field stops and safety circuits directly affecting human safety are hardwired in line in the form of local isolators. The variable speed drive local isolator stations will have "early make late break" facility.

Extensive diagnostics will be incorporated into the system to allow fault finding quick analysis. Feedback to the PLC will be performed using Device Net communication. The PLC will communicate to the telemetry base station, bagging plant, RO filter and SCADA using an Ethernet platform. The SCADA System will gather the information from the PLC and analyse and distribute the information to the operator view nodes in the control room. The nodes in the control room will be capable of full control and access to all the information including all alarms and historical data. Certain functions will be password protected (i.e. loop tuning parameters) and will only be modified by authorised personnel.

The Functions of the SCADA system is to provide:

- An operator interface to the plant to monitor status of equipment.
- An interface to the plant to control and set-up equipment.
- Historical information to diagnose the circumstances leading to a malfunction.
- Historical information for process optimisation.
- Alarms and warnings to the operator.
- Data logging and event recording.

- Process data and print reports

The PLC will be powered through a 5kVA UPS. The UPS will also feed the plant SCADA computer.

3. SUPPORTING INFRASTRUCTURE

3.1. Offices

The offices that will be provided will consist of a single prefabricated unit that will house two offices and a meeting room.

Tee/Change Room and ablutions

3.2. Tea/Change Room and ablutions

Provision for rest and ablution facilities for the labourers have been made by means of a tea room, change room and ablution facilities. These facilities will be provided with potable water trucked in from Muisvlak (some 16km by road) once a week.

3.3. Laboratory and Sample Treatment

The laboratory is limited to sample preparation with sample analyses being done off site. Basic equipment for the drying splitting and weighing of samples will be provided. The laboratory and concentrate dispatch will be linked.

3.4. Workshop and Stores

The workshop will cater for repair of plant equipment with the exclusion of mobile and equipment with diesel engines that will be serviced at the dealership and contracted out respectively. The only mining equipment that will be serviced in the workshop will be the hydraulic dredge pumps. There will be an electrical, control and mechanical section in the workshop with basic maintenance equipment for repair of major pieces of equipment. The workshop will be set only to replace major components. The stores in the plant will cater for all consumables as well as major spares; all deliveries to the operation will be done through the stores. The workshop and stores will be located at the plant site.

3.5. Roads

Allowance has been made for the preparation of 900m of dirt road leading to the plant by replacing the sub layer with 900mm of calcrete material and resurfacing with compacted calcrete material.

3.6. Concentrate Transport

Provision has been allowed for the storage of 3 days of bagged or bulk concentrate production on concrete slabs. The concentrate bags will be stacked up to three high by means of an all-terrain forklift that has been included. Concentrate will be moved from the wet concentrator plant site by an outside contractor.