CHAPTER 2 - Area of Study

2.1 Overview of the Area

This study was conducted at the West Rand Region, part of South African-based Anglogold's operations, to assess the impacts of mine waste disposal at a typical South African deep-level gold mine. The West Rand Region is made up of four shafts- Mponeng, Savuka, Tautona and West Wits 2 shaft at Elandsrand (The mine at Elandsrand was sold to Harmony in 2001). The first three shafts are situated 75 km west of Johannesburg and 12 km south of Carltonville. West Wits 2 plant is situated in the Far West Rand region, approximately 80-km southwest of Johannesburg.

Mponeng produces gold from a depth of 2,800 metres below the surface and employs 5,164 people, including 712 contractors, in 2004 (AngloGold Ashanti, 2005). The shaft system at Savuka mine reaches a depth of 3,777 metres. Three thousand and one, including 228 contractors, are employed at Savuka. At Tautona mining takes place between 1,800 and 3,500 metres below the surface. Tautona employs 5,673 people, including 825 contractors. In 2004, production at Mponeng, Savuka and Tautona was 438,000, 158,000 and 568,000 oz respectively. A total of 14, 603 people were employed at the West Wits operation in 2004 (AngloGold Ashanti, 2005).

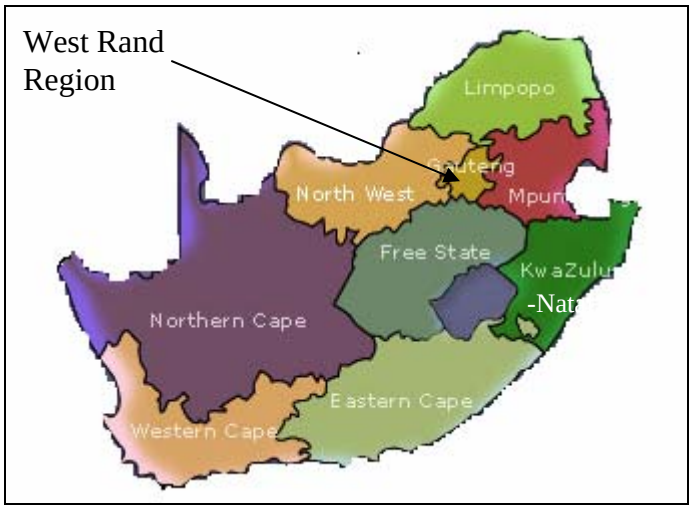


Figure 2.1 Map of South Africa showing the location of the study area

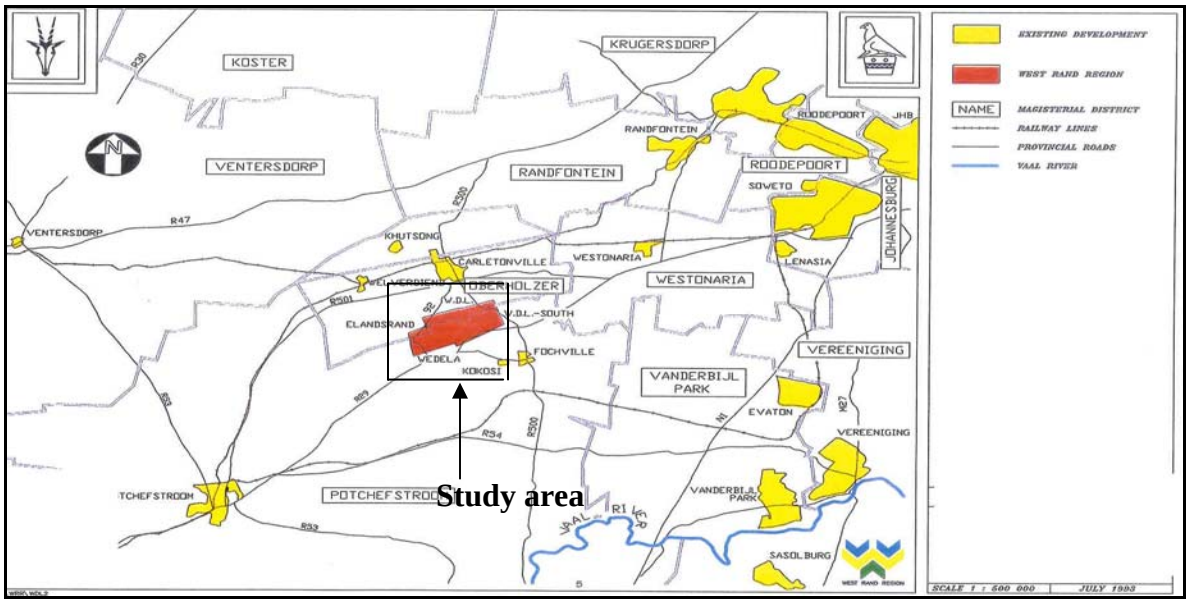


Figure 2.2 Locality plan (Anglo American Corporation, 1995).

2.2 Physical Characteristics

2.2.1 Vegetation

The area was covered with scattered indigenous trees and shrubs, largely of the Acacia, Celtis and Protea species. These are mostly found on the hilltops and slopes, but are also found near watercourses (Anglo American Corporation, 1995).

2.2.2 Soils

The rocks weather at varying rates with the quartzite forming prominent ridges and the diabase weathering to clay. The area is covered by transported soils that are characterised by the topography and source of the soils. These vary from thin sandy soils to thick clayey soils, depending on location (Anglo American Corporation, 1995).

2.2.3 Geology

Rocks of the Timeball Hill Formation, Transvaal Sequence, underlie the Western Deep Levels area. These are sedimentary rocks, generally quartzite and shales. Diabase dykes and sills intrude these rocks. Towards the south, igneous rocks of the Hekpoort Formation underlie the area, which is generally andesite (Anglo American Corporation, 1995). Ferruginous shale and quartzite are the dominant rock formations. Dolomite and chert underlie the northwest. Diabase and andesite make up a small portion of the region.

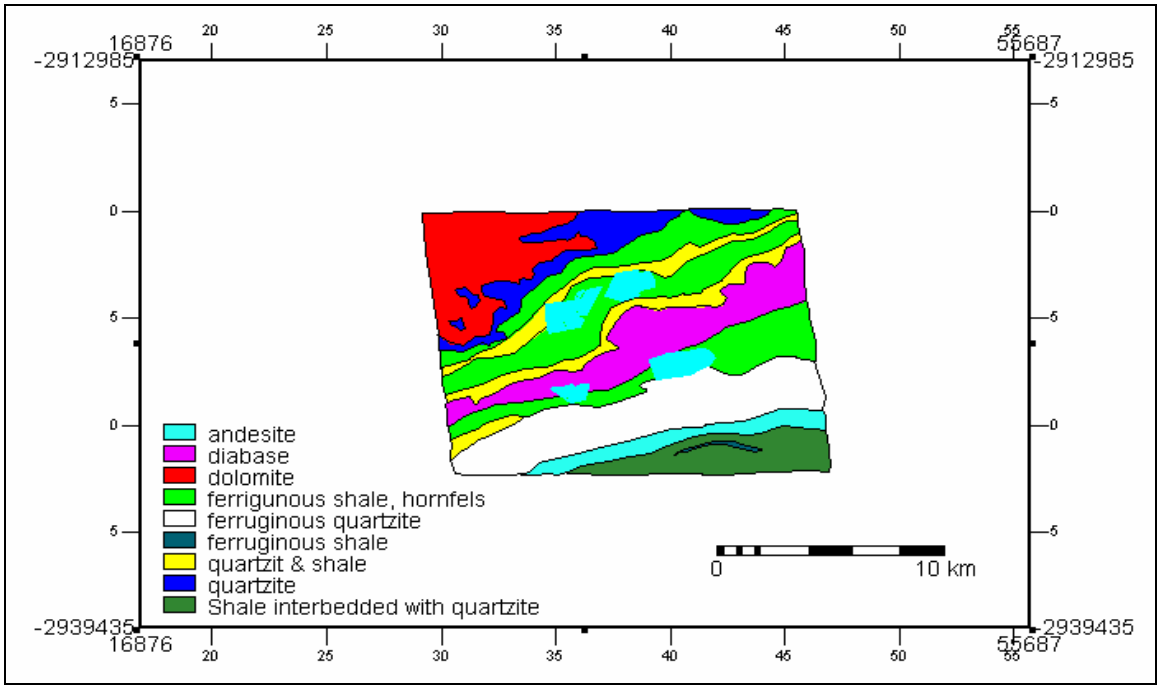


Figure 2.3 Geology of the West Rand Region & location of the tailings dams

2.2.4 Surface Water

Many of the streams that leave the West Rand Region rise on the region's property and their flow rates are very small. Refer to Figure 2.4.

2.2.5 Climate

The West Rand Region falls within the summer rainfall region and receives precipitation in the range 375 mm to 969 mm per annum. The rain occurs between October and April with January being the highest rainfall month (Anglo American Corporation, 1995).

2.2.6 Groundwater

One spring and a zone of seepage have been identified within the West Rand Region mine lease area. The spring is associated with an unusually fractured zone within quartzite of the Pretoria Group.

A zone of seepage is located east of Elandsrand slimes dam, upslope of the return water dam. It has developed as a result of accumulation of throughflow above impermeable horizons in the near surface zone, and water from this area has historically been collected in a trench. Groundwater recharge will take place from artificial sources such as tailings dams. Water percolates downwards, locally elevating groundwater levels and inducing flow away from these facilities. Seepage from nearby tailings and the seasonally wet conditions now sustains perennial seepage into the collection trench (Anglo American Corporation, 1995).

2.3 Landuse

In the pre-mining period the land was used primarily as grazing land with the rocky outcrops and wetlands remaining as wilderness areas. This use has been reduced substantially to cater for mine infrastructure. Arable land lost over the years is unlikely to be significant in an area that is basically undulating and rocky with the deeper agricultural soils confined to valley bottoms and small water courses. Arable land has always been scarce in the area and most of this is available for limited agricultural production.

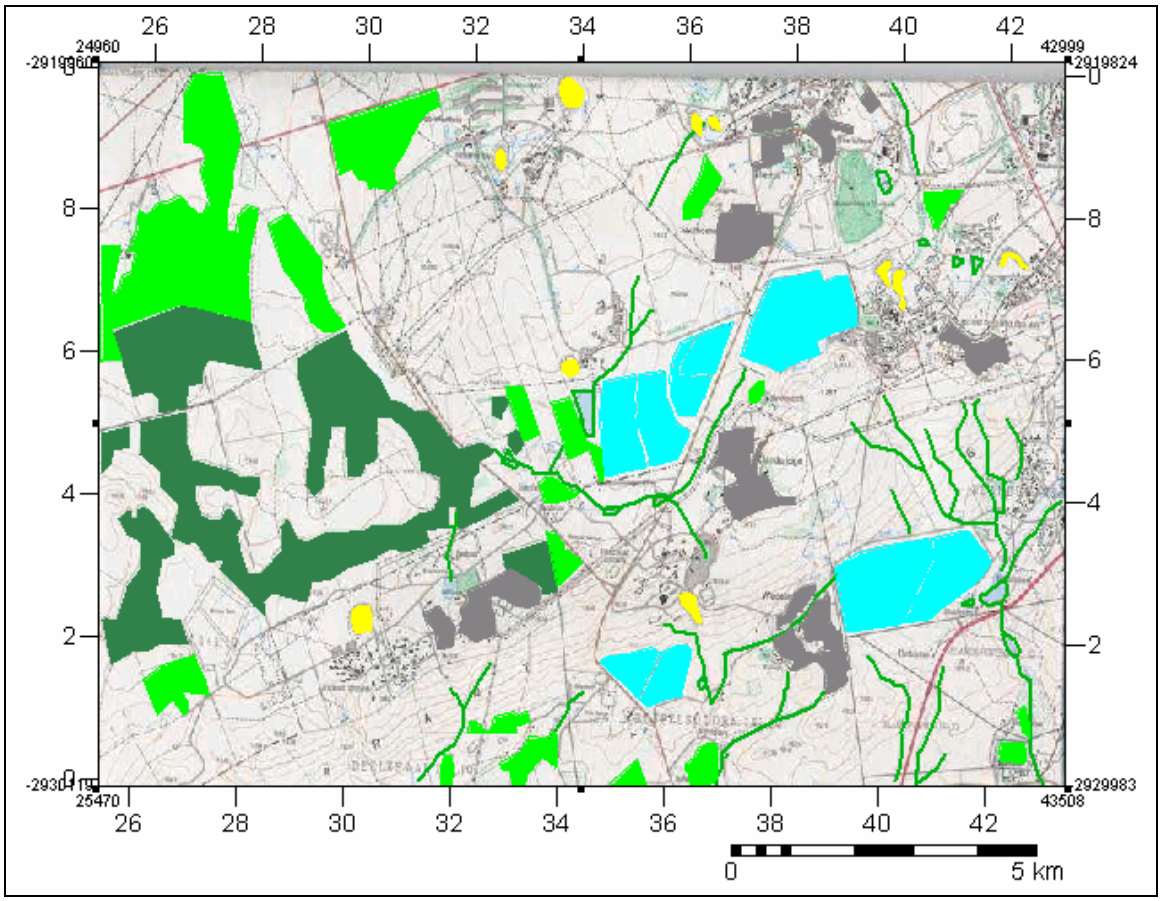


Figure 2.4 An overview of land uses in the study area

The different land uses were digitized from the 1:50 000 topographic map. The green represents cultivated land, forest green shows the location of the plantation and tailings dams (AngloGold's, including Elandsrand dams which now belongs to Harmony) are represented by the cyan colour. The yellow colour represents mine dumps and built-up area is grey. The rivers, most of which are non-perennial except the one running south east of the area are represented by the green segments. The rest of the area is bare except for other insignificant uses (in terms of the areal extent) such as recreational clubs and excavations.

2.4 System Overview

The West Wits Operation consists of four shafts. The number 1 shaft is called Mponeng (originally called South Mine), Number 2, Sazuka, (originally called West Mine),

Number 3, Tautona, (originally known as East Mine), and West Wits 2 shaft at Elandsrand. North mine dams contain treated pulp residue from number 2 & 3 gold plants. The residue is pumped to either number 4, 5, or 7 slimes dams depending on the maintenance and pumping schedule (see figure 1.3 for location of dams). North mine dam 3 has not been used since May 1997. South Mine dam receives final treated pulp residue from number 1 gold plant. Elandsrand slimes dam receives final treated pulp residue from the Elandsrand gold plant. The residue is pumped to either number 1 or 2 compartments depending on the maintenance/pumping schedule (refer to figure 2.5). Wastewater originates from Rand water, underground fissure water and circulating process water.

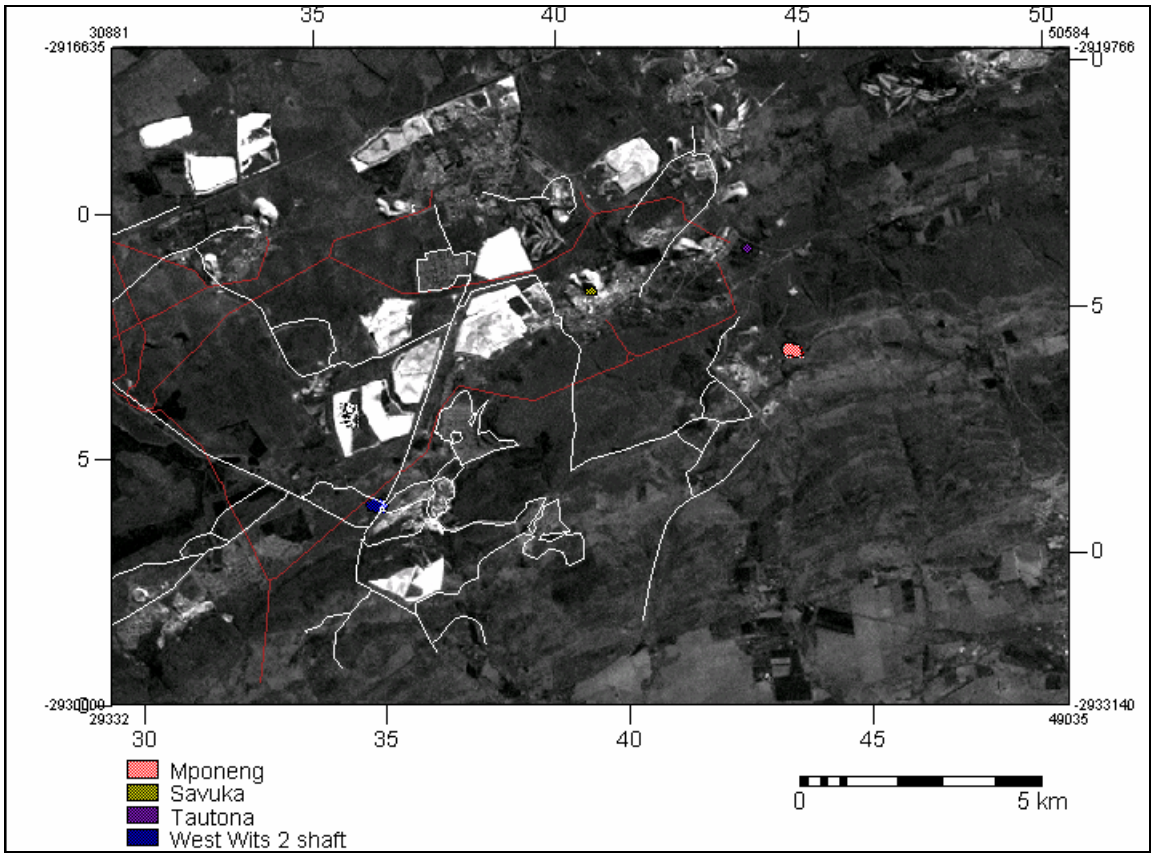


Figure 2.5 Location of the shafts and road (white lines) and power lines (black lines) overlain on TM band 1

North Boundary dam

Water from the sewage plant, West Driefontein and mine service water pumped to surface is contained in three dams adjacent to the mine nursery. Water from these dams can overflow into the North boundary dam, which acts as a buffer dam. Stormwater and runoff from the number 2 & 3 gold shafts flows directly into the North boundary dam. Water from the North boundary dam is pumped into the nursery dams for distribution and also to make certain that a minimum amount of water leaves the dam as overflow. The dam also receives water from underground, sewage effluent from the North Sewage Works and runoff from the slimes dams.

South Boundary dam

This dam is sampled from a pipe that discharges continuously. Water recovered from the slimes dam is collected in the return water dams and pumped directly to the metallurgical plant as process water. The dam on the South Mine boundary is used for recreation but also acts as a buffer dam. This dam can provide a dilution effect in the event of a spill or problem on the slimes dam. The dam contains water overflowing from pollution control dams during rainy periods.

Elandsrand West Boundary dam

The dam collects stormwater runoff and excess sewage effluent that is not used to irrigate the Elandsrand village and golf course.

Elandsrand & Wedela Loopspruit boundary (Loopspruit)

It receives treated effluent from the Wedela Sewage Works, storm water runoff from the Elandsrand south boundary dam and excess water from the Elandsrand gold plant after it has passed through carbon columns to remove the gold as well as contaminants.

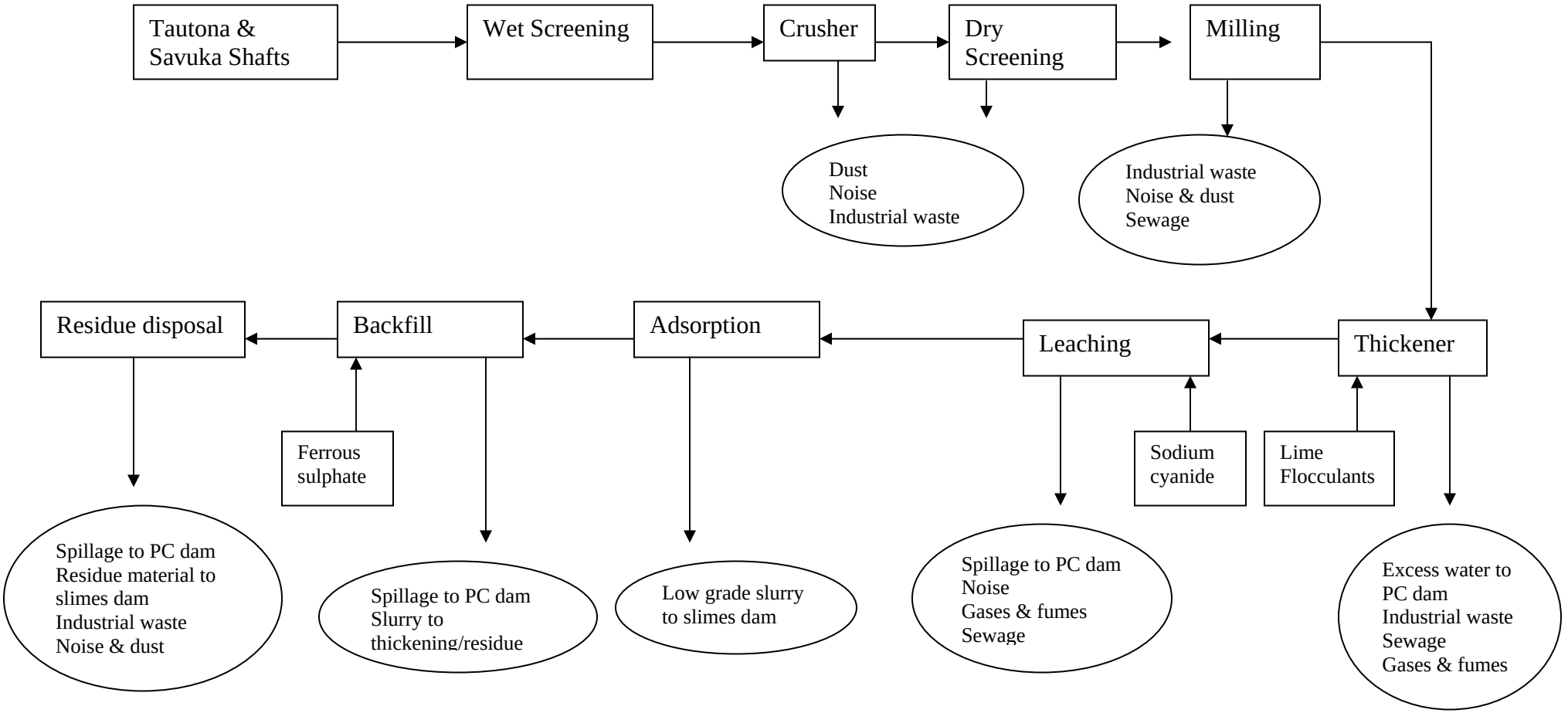
2.5 Process Flow

There are two metallurgical plants at AngloGold West Wits - Three Gold Plant and Mponeng Gold Plant. West Wits Three Gold Plant was commissioned in 1961. It receives its feed from Tautona and Savuka mines. The ore is transported from Savuka mine by conveyor belts while from Tautona mine the ore is transported by railway. The ore is fed into a screening plant for size distribution before it is crushed. From the crusher the ore is sent to a milling section where cyclones are used for classification into Carbon Leader, Ventersdorp Contact Reef (VCR) and VCR East. The milling product is gravitated to the thickener. Lime is added to help the milled ore to settle as well as to maintain alkalinity in the next step – leaching. A flocculant is also added to assist the ore to settle. The thickened underflow slurry is pumped to the leach section and the thickener overflow water is used in the milling circuit. In the leaching section sodium cyanide is added for gold dissolution purposes. Granulated carbon is used as an adsorption medium in the Pump-cell adsorption circuit. The low-grade slurry (residue) is then screened for fine carbon and transferred to the residue tanks where it is pumped either to the slimes dam or to the backfill plant.

The loaded carbon is screened from the pulp and taken to Mponeng Gold Plant by road. Gold is recovered from the carbon at Mponeng Gold Plant and the regenerated carbon is transported back to Three Gold Plant. At Mponeng Gold Plant the loaded carbon is stripped of gold using the AARL elution procedure. The gold is removed from the carbon by an acid wash, caustic/cyanide soak and elution strip. The stripped eluted carbon is regenerated by the use of rotary kilns at 750°C. The regenerated carbon is then transferred to the adsorption circuit at Mponeng Gold plant or is taken back to Three Gold plant. The gold is recovered using electrowinning cells with stainless steel cathodes. The gold is deposited onto the cathodes by electrolysis. The low grade solution is pumped to a carbon column to allow for further adsorption of gold from solution, thereafter is pumped to residue. The cathode gold sludge is filter pressed and calcined. The calcined material is then smelted into gold bars in the electric arc furnace

where borax and silica are used as a flux medium. The gold bullion is sent to Rand Refinery for further refining.

PROCESS FLOW DIAGRAM – WEST WITS THREE GOLD PLANT



NB: only outputs with potential negative impacts are shown on the flow diagram

Figure 2.6 Flow Diagram – West Wits Three Gold Plant (adapted from the Anglogold's EMPR, 2001)

PROCESS FLOW DIAGRAM – MPONENG GOLD PLANT

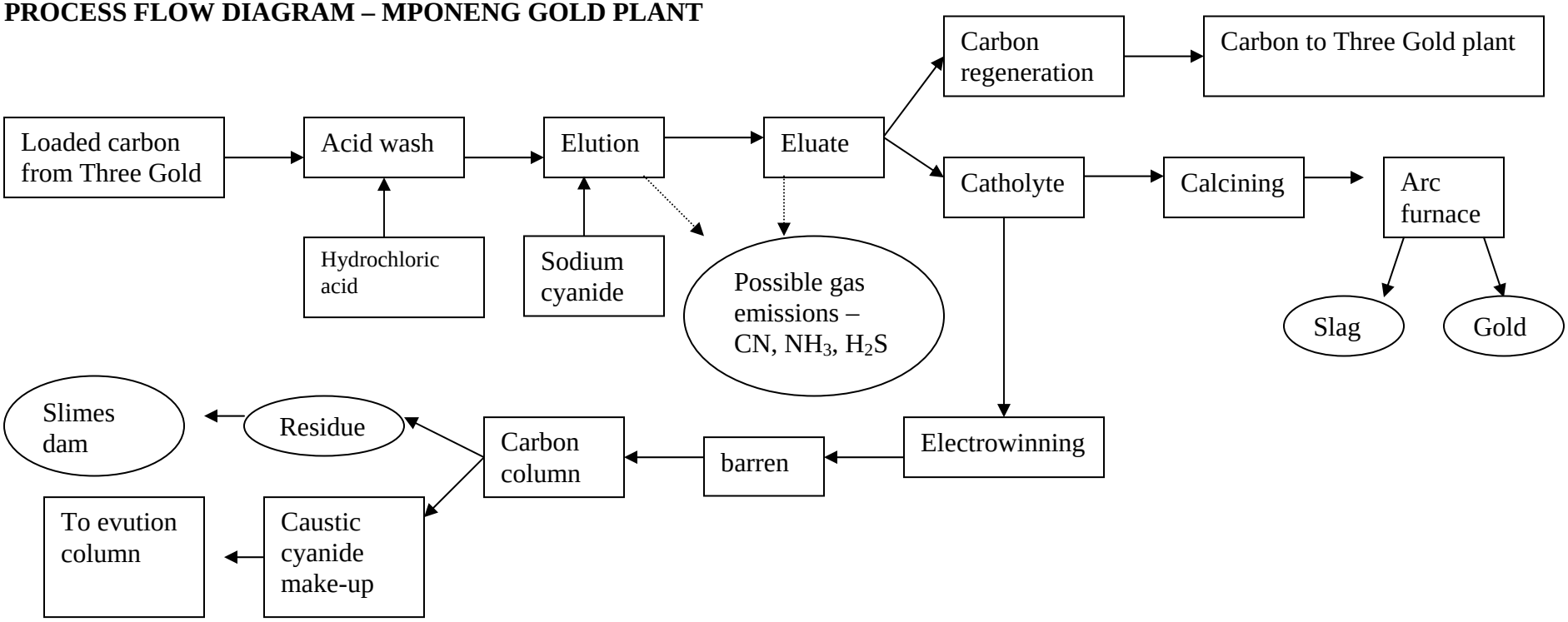


Figure 2.7 Process Flow Diagram – Mponeng Gold Plant (adapted from the Anglogold's EMPR, 2001)