A Manual on Mine Water Treatment and Management Practices in South Africa

APPENDIX
Volume 3
Gold Mine Site Visit Reports

W Pulles • D Howie • D Otto • J Easton

Report to the Water Research Commission

by the

Chamber of Mines of SA

WRC Report No 527/3/96

APPENDIX TO WRC REPORT TT 80/96 :

A MANUAL ON MINE WATER TREATMENT AND MANAGEMENT PRACTICES IN SOUTH AFRICA

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APPENDIX

Volume 3

Gold Mine Site Visit Reports

WRC Report No 527/3/96

ISBN 1 86845 260 3
ISBN Set No 1 86845 263 8

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Report on Deelkraal Gold Mining Company Ltd Site Visit.

13 - 14 July 1994

1. GENERAL INFORMATION

Name of mine	Deelkraal Gold Mining Company Limited.
Name and position of person(s) interviewed	Messrs S de Kok - Acting Chief Engineer A F Lane - Ventilation Engineer P P Stander - Plant Superintendent N Rademeyer - Engineering Supervisor H Schreuder - Engineering Foreman R Botha - Plant Supervisor
Nearest town	Oberholzer
Name of catchment	Loopspruit running south to the Klipdrift dam Mooiriver to the north
Monthly tonnes mined	135 000 tonnes per month
Monthly waste rock dumped	20 000 tonnes per month
Monthly tonnes milled	115 000 tonnes per month
Monthly gold production	600 kg/month
Current age of mine	18 years
Expected remaining life of mine	22 years
Reef being mined/Stope width	Ventersdorp Contact Reef - 1,6m Deelkraal Reef - 2,0m
Mining method	Conventional underground long wall
Has an EMPR already been produced by the mine ?	Yes, draft report

2. SITE VISIT PROGRAMME

2.1 Day 1 - 13 July 1994

- Arrival at mine's main offices

- Short discussion on project background, objectives and site visit programme
- Present:
  S de Kok - Acting Chief Engineer
  H Schreuder - Engineering Foreman
  W Pulles - PHD
  J Laas - PHD
  D Howie - PHD
- Guided tour of the Metallurgical Plant, slimes dam area and sewage plant with Messrs Schreuder and Botha in the morning.
- Completion of mine surface area by visiting Waste Rock Dump area, Village dam and runoff area towards Mooiriver

2.2 Day 2 - 14 July 1994

- Arrival at mining offices
- Underground visit to a working stope at 31 level and the settlers at 33 level, guided by Messrs N Rademeyer and J M van Wyk
- Discussion on water management systems and completion of questionnaire with the following parties:

  N Rademeyer - Settling Operations
  A F Lane - Disinfection of underground water
  P P Stander - Metallurgical Plant
  S de Kok - General water management on mine

3. DISCUSSION OF THE MINE'S CURRENT WATER MANAGEMENT AND TREATMENT PRACTICES.

3.1 DESCRIPTION OF WATER CIRCUITS

Mine operations in terms of water management can be divided into the following geographical areas:

- Slimes dam area
- Waste rock rump area
- Sewage plant area
- Metallurgical plant, shaft, offices, village and compound area. Spillage and runoff from all these areas eventually runs into the Village Dam.
- The underground water reticulation system

Figure 1 shows the Deelkraal Mine water balance diagram.

The total inflow of water into the mine area is 13,8 Mℓ/day consisting of the following:

- Rand Water 9,8 Mℓ/day (71,5%)

- Runoff and stormwater into the Village dam 2,4 Mℓ/day (17,5%)
- Fissure water into the underground service water system 1,1 Mℓ/day (8,0%)
- Borehole water 0,4 Mℓ/day (2,9%)

These figures demonstrate that Deelkraal is a fairly dry mine with very little inflow of fissure water. The bulk of the water consumption (71,5%) is purchased from Rand Water at considerable cost to the mine. Water Usage Permit No. 726N allows the mine to use 18,4 Mℓ/day .

The mine water tank, which has a holding capacity of 2 x 1,4 Mℓ is the most important section in the whole mine service water system. This tank is used to balance the entire industrial water system. Supply from Rand Water, at a rate of 2,6 Mℓ/day, is used for makeup into the mine water tank.

The tank supplies water to the fridge plant at 22 Mℓ/day and to the metallurgical plant at 2,4 Mℓ/day.

The total outflow or water loss from Deelkraal Mine is 13,8 Mℓ/day and consists of:

- Treated sewage effluent to the Loopspruit 1,7 Mℓ/day (12,3%). Water Disposal Permit No. 1011B allows the mine to dispose of 5,6 Mℓ/day of purified sewage effluent to the gardens, hostel complex and the Loopspruit.
- Evaporation, seepage and interstitial water at slimes dam area 5,9 Mℓ/day (42,8%)
- Water loss to sports ground irrigation 0,3 Mℓ/day (2,1%)
- General evaporative losses 5,9 Mℓ/day (42,8%)

3.2 DESCRIPTION OF WATER TREATMENT/MANAGEMENT SYSTEMS

3.2.1 Slimes Dam

Deelkraal Gold Mine produces 135 000 tpm of which 20 000t is dumped on the waste rock dump and the rest treated in the metallurgical plant. A portion of the plant residue is treated in the backfill plant to produce 18 000 tpm for backfilling underground. The rest of the plant residue is deposited on the slimes dam as a slurry at a relative density of 1,48.

The solids settle on top of the slimes dam and water is drawn through the pen stock to the two silt dams from where part of the water is pumped back to the met plant as return water. Excess water overflows into the return water dam.

The water balance for the slimes dam, based on the residue tonnes and density placed, and the volume of return water pumped back to the plant, is reflected in Figure 2. Water loss, primarily due to evaporation and seepage, is 5,9 Mℓ/d. Only 1,8 Mℓ/d is returned to the metallurgical plant.

A system of catchment paddocks around the entire base of the slimes dam retains storm water runoff from the sides and slime, caused by erosion products. Water evaporates from the paddocks and solids are removed and used for building up the side walls, which maintains the required freeboard.

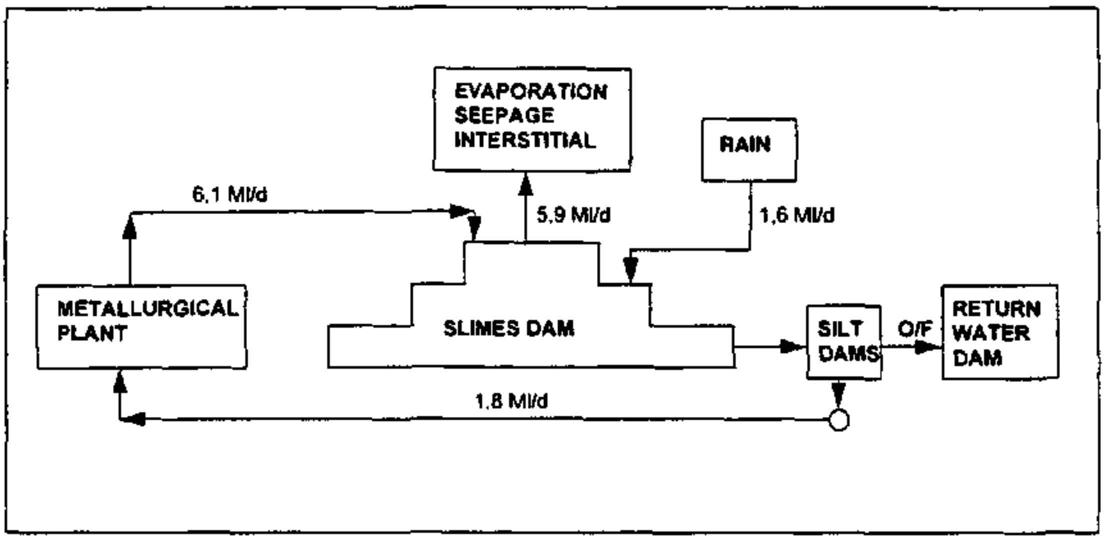


Figure 2 : Water balance around the slimes dam

The slimes dam also has a cutoff trench around the paddocks which captures the seepage from the slimes dam area. The seepage water from this trench flows into the two 35m³ silt dams, from where it can be pumped back to the plant as return water. This cutoff trench also prevents lateral movement of contaminated seepage into the area surrounding the slimes dam.

To the northeast of the slimes dam, a big stormwater cutoff trench diverts stormwater around the return water dam and back into the original water course. A total of eighteen under drains around the slimes dam discharge seepage into the cutoff trench, which feeds the return water dam.

3.2.2 Waste Rock Area

Approximately 20 000 tpm, with an average moisture content of 5%, is deposited on the waste rock dump. This indicates that 1 Mℓ of water is deposited on the dump on a monthly basis, part of which evaporates or seeps through the dump, with the balance kept in place as inherent moisture.

The rock dump area has no paddocks, evaporation or seepage trenches. All stormwater runoff and seepage from the rock dump flows from the rock dump in a northeasterly direction where it is discharged into a water course which eventually feeds into the small dam overflowing into the Village dam.

3.2.3 Sewage Treatment Plant

A single treatment plant makes use of the activated sludge process to treat 3,5 Mℓ/d. Figure 3 gives a schematic diagram of the sewage plant layout. Raw sewage passes through a macerator before entering an aerated reactor. Overflow from the reactor discharges into two settlers; the combined clarified overflow is disinfected with chlorine gas before it flows into a maturation pond. 0,4 Mℓ/d is pumped from the pond back to the met plant and 1,3 Mℓ/d is used in the continuous toilet flushing system for the hostels. The balance of 1,7 Mℓ/d is released into the Loopspruit catchment.

The under flow from the settlers is pumped into a system of drying beds; the dried solids from these beds are buried at the waste rock dump. Chlorine gas is dosed for disinfection of the clarified sewage at a rate of 0,8 g/m^3 or 154 g/h.

3.2.4 Metallurgical Plant, Shaft, Offices, Village and Hostel Areas

All spillages and runoff from the plant area are prevented from leaving the plant area by means of a concrete retaining wall at the lower end of the plant. Water from this catchment system is pumped back into the plant for reuse in the metallurgical process. Contaminated stormwater runoff within the plant is pumped back for use in the process water circuit. Clean stormwater runoff is diverted away from the plant into the Village dam.

Clean stormwater runoff from the shaft, offices, village and hostel areas flows via stormwater trenches to the Village dam, which is maintained as a recreational area. Contaminated water within these areas is pumped to the sewage plant for treatment.

3.2.5 Underground Water Reticulation System

3.2.5.1 *General Layout*

Figure 4 shows the basic underground water reticulation system. A total of 21 Mℓ/d chilled water is pumped from the surface fridge plant into a chilled water dam at 9 level from where it is distributed to the different sections as service water.

Dirty water from the sections gravitates to the two settler installations on 33 level, together with 1,1 Mℓ/d of fissure water and water from the backfill sections. The combined clear water from the settlers is pumped into a clear water dam before being pumped up to the mine water tank on surface. It again supplies the fridge plant with 22 Mℓ/d of clear water. Rand Water supply and water from the Village dam is pumped to the mine water tanks as makeup for the service water system.

Potable water is supplied by Rand Water to various underground locations.

3.2.5.2 *Stope Area*

During the underground visit to panel 31/21 7 West, the pH and conductivity of the service water to the stope, water coming out of the drill hole and dirty water from the section to the settlers was measured.

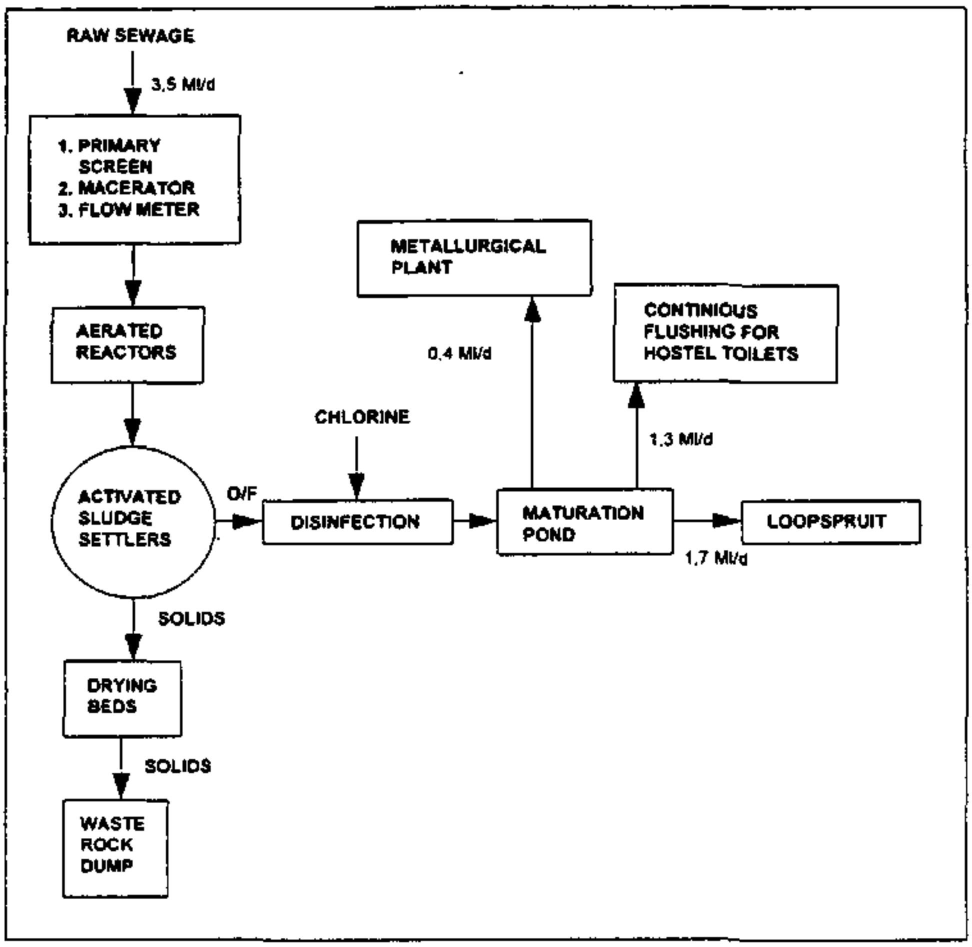


Figure 3 : Schematic of the sewage treatment plant

Figure 5 shows the schematic layout of the location of the various pH and conductivity readings taken during the underground visit and Table 1 gives the values recorded.

The service water to the stope during the site visit recorded a pH of 5,1, an electrical conductivity of 408 mS/m and a temperature of 20°C. Water running from the stope along the strike gully footwall into the dip gully measured a pH of 2,9 electrical conductivity of 546 and a temperature of 29° C. This shows a major increase in salinity and the effect of acid mine drainage from the stope.

Table 1: Location and readings for underground sampling points.

Sample Position	pH	Conductivity/(mS/m)	Temp/°C
1. Service water to stope	5,1	408	20
2. Water from drill hole	6,1	408	24
3. Footwall water in dip gully	2,9	546	29
4. Stagnant pond in dip gully	5,2	408	28
5. Water from borehole	5,1	478	28
6. Water into drain hole	3,5	489	29
7. Acid Mine Drainage at the top of chair lift	2,9	530	29
8. Water in drain of return air way on 33L	5,2	467	25

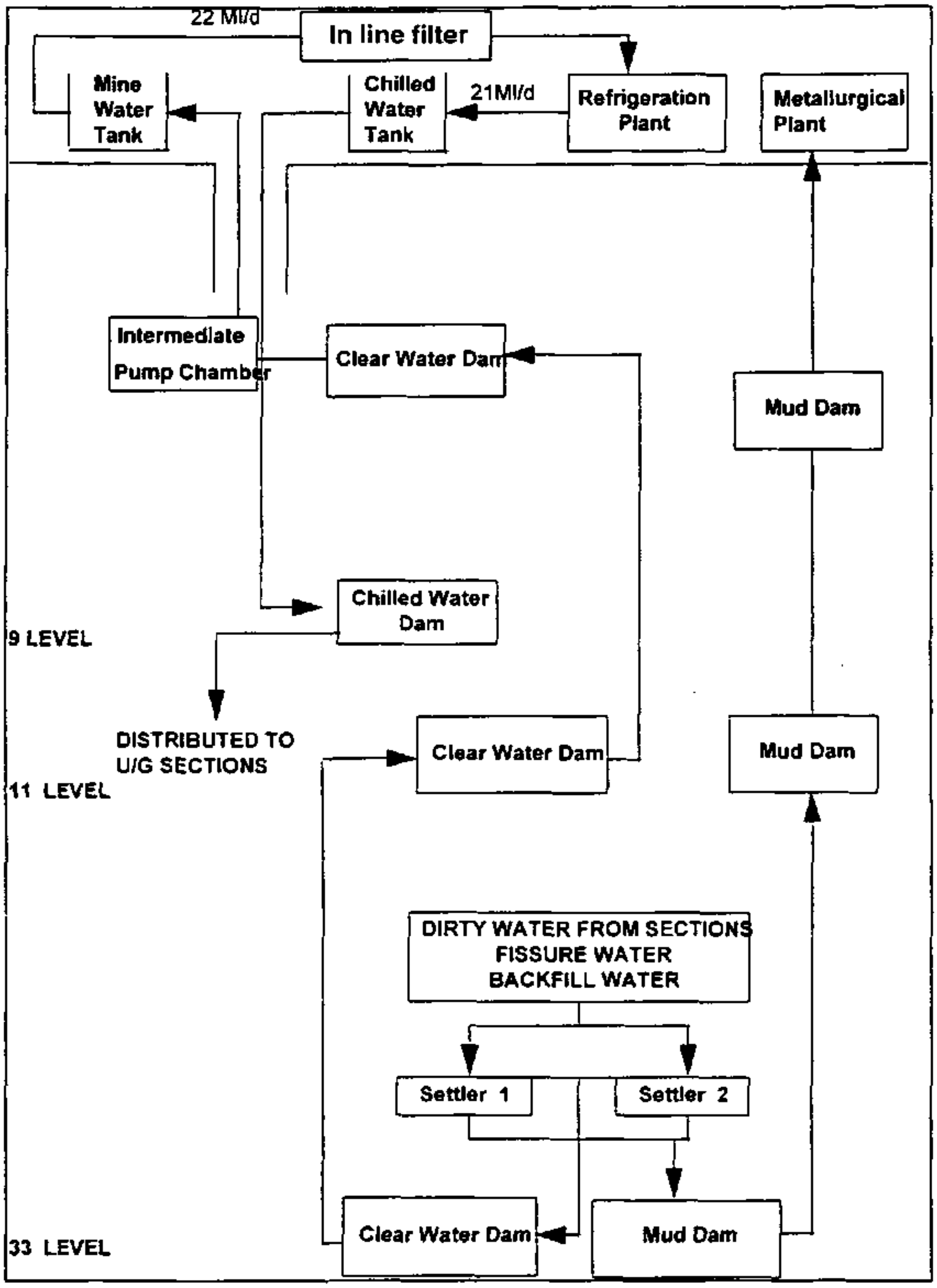


Figure 4 : Underground water reticulation system.

Acid mine drainage seeping from the sidewall at the top of the chair lift measured a pH of 2,9 and an electrical conductivity of 530 mS/m. This water, together with the runoff from the stopes causes an increase in dissolved salts in the service water to the settlers. The conductivity of the service water is 408 mS/m. The conductivity of the water increases by roughly 10% (from 408 to 450 mS/m) on a single pass through the underground mining operations.

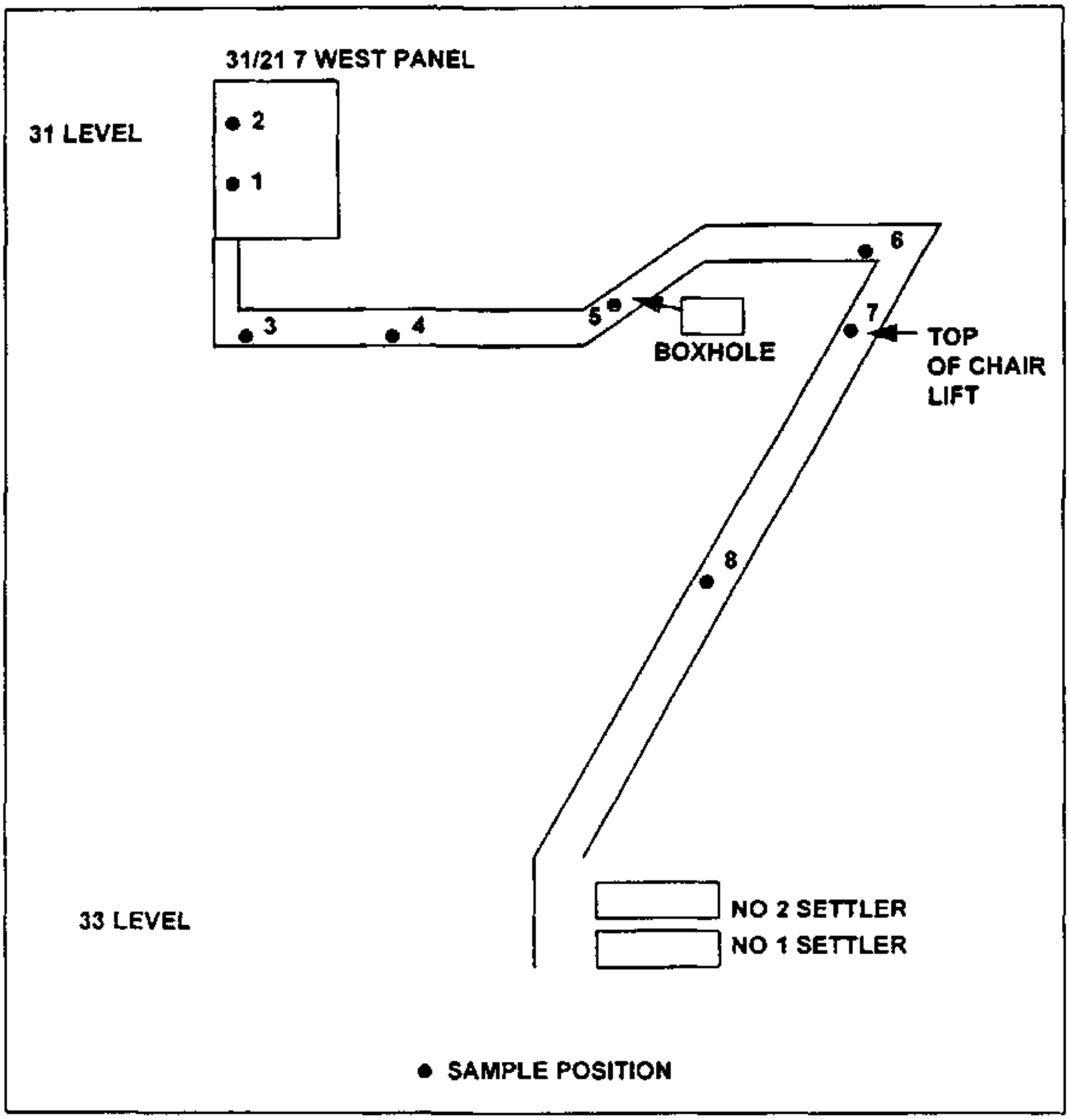


Figure 5 : Sampling points measured during the underground visit.

3.2.5.3 Underground Settlers

The two settler installations, each consisting of 6 rectangular cells, treat 25 - 26 Mℓ/d during the week and 14 - 15 Mℓ/d during weekends. The dirty water flow gravitates down from the sections directly into the settlers as there is no dirty water dam to handle any surge in the flow. This does not create any problems as the flow to settlers is very evenly spread over a 24 hour working day due to continuous mining and development operations.

Dirty water enters the settlers and is immediately neutralised to a pH of approximately 8 with the addition of soda ash.

There are two tanks available for the makeup of soda ash. A fresh soda ash solution is made up in one of the tanks whilst the dirty water is neutralised from

the second tank until emptied. Soda ash is supplied in 50 kg bags and the treatment cost is 19,4 c/m³ of dirty water treated.
Immediately after soda ash is added in the dirty water launder, a flocculant solution is added from a makeup tank. It is then rapidly mixed in the launder by a series of baffle plates. The flocculant treatment cost is 4,3 c/m³ treated dirty water.

The flocculated water is distributed by means of a splitter box and dirty water launders to the six cells per settler, where the flocculated solids settle to the bottom. The clear water then overflows into a clear water launder and into a vertical clear water dam before eventually being pumped to the surface.

Very little secondary settling of solids occurs in the vertical clear water dam, due to the good performance of the settlers. The small volume of sludge that is collected at the bottom of the clear water dam is removed weekly by opening the bottom drain valve. This is a self cleaning system and there is no need to drain the whole dam in order to remove the sludge.

Desludging of the cells is done hourly. The operator opens each of the 4 desludging valves per settler for 6 seconds. This time has been calculated to maintain a constant mud level. Thickened sludge is pumped with mud pumps via a mud dam on 11 level to the metallurgical plant.

The two settlers are manned by an operator and two assistants per shift. The mud pumping system is manned by an operator and four assistants.

The clear water pumps run for approximately 6000 - 9000 hours before requiring an overhaul. The cost of an overhaul is R120 000/pump.

It is also standard practice at Deelkraal to dose lime instead of soda ash for a period of 8 hours on a Friday for uranium precipitation.
The settler performance is monitored by taking samples of the clear overflow from the launder, every shift and analysing for pH and suspended solids.

A surface area of 74,25m² is occupied by each settler, which means that in order to treat 21 Mℓ/day, a rising velocity of 5,9 m/hr should be maintained when both settlers are in operation and 11,8 m/hr when only one is in use to treat the total flow.

3.2.5.4 *Disinfection of mine service water*

Disinfection of the mine service water is done by treating the water on surface at the following two points as shown in Table 2.

Table 2 : Water disinfection points on the mine

Dosing point	Chlorine gas	Bromine Liquid
East Pre cooling Tower	1,8 kg/h	0,6 ℓ/d
Mine Water Tank	1,6 kg/h	1,4 ℓ/d

The water disinfection efficiency is monitored by taking drinking and service water samples at different levels, once a fortnight and analysing for plate count, total and faecal coliforms.

3.2.6 Potable water supply

All potable water is supplied by Rand Water at a rate of 9,8 Mℓ/d.

3.2.7 Water Monitoring Programme

Table 3 shows the water monitoring and sampling programme for Deelkraal Gold Mining Company:

Various flow meter readings are recorded at different points on either a daily or monthly basis in order to compile a water balance.

3.2.8 Water Management Structure

The people responsible for water management are also shown in Table 3 together with the specific area or section of the mine under their control.

3.3 NOVEL OR UNIQUE WATER TREATMENT AND MANAGEMENT SYSTEMS

3.3.1 Treated sewage water reuse

Treated sewage is recycled in a continuous toilet flushing system in the hostel at a rate of 1,4 Mℓ/day.

3.3.2 Flocculant Supply Package

The flocculant powder is supplied in small plastic bags containing 1 kg flocculant powder each. This package format makes the flocculant makeup and control of concentration in the batch makeup system far more manageable. This also makes the handling of the flocculant easier and prevents spillage of flocculant powder as opposed to using 50 kg bags.

The use of two flocculant tanks, one as a dosing tank and the other as a makeup tank, ensures that the flocculant solution strength and required dosage are maintained. This is done by adding a precalculated amount of 1 kg bags into the makeup tank and dosing the solution at the required rate.

By using this system the operator is able to control the flocculant makeup and dosing for effective settling of the solids content in the dirty water flow to the settlers.

3.3.3 Erosion monitoring of slimes dam sides and the reuse of old filter cloths

A series of mild steel pens were hammered into the ground around the sides of the slimes dams. Each pen is numbered and has a small steel plate, about

200 mm from the top. Any erosion is then monitored in relation to the position of the plate.

Old filter cloths from the met plant filter section are used around the pen stock area to increase the stability of the walls around this area, as only the very fine solid particles are available in these areas for building the walls.

3.3.4 Settler Operation

The underground settlers exhibit excellent performance which is seldom seen in the mining industry. Probable reasons for the excellent performance include the following:

- good settler design
- fairly uniform incoming flow
- excellent settler housekeeping
- well trained and motivated operators and supervisor
- effective settler operation and desludging
- good pre treatment in terms of neutralisation and flocculation
- use of soda ash instead of lime for neutralisation
- use of prepackaged flocculant to give a consistent floc strength
- good mixing at floc dosing point

Table 3 : Water monitoring program

Samples Taken	Responsible person	Frequency of sampling	Parameters analysed for:	Results returned to:	Persons responsible for taking action
Underground samples of settled water	Shift Supervisors	Daily samples 3 per day/settler	pH and SS	Eng. Manager Chief Eng. Engineers	Engineer Supervisor
Surface - swimming pools, village dam, sewage, bottom dam	Plumbers and fitters on surface	Three days per week	Standard plate count, total Coli and Faecal Coli, pH, EC, SS, NO_3 and NO_2, Ammonia, PO_4	Eng. Manager Chief Engineer	Engineering Supervisor Foreman
Underground service and drinking water/RWB kitchen and final effluent	Trained Ventilation Department staff	Once every two weeks	Standard plate count, total Coli and Faecal Coli, pH, EC, SS, NO_3 and NO_2, Ammonia, PO_4	Ventilation Engineering/ Ventilation HOD	Vent. Engineer Ventilation HOD
Slimes dams, catchment dams, waste dump	Cyanide Plant Supervisor	Once a month	pH, TDS, Free CN	Metallurgical Manager, Assistant Plant Superintendent	Metallurgical Manager, Cyanide Plant Supervisor

3.4 POTENTIAL WATER TREATMENT/MANAGEMENT PROBLEMS AND NEEDS

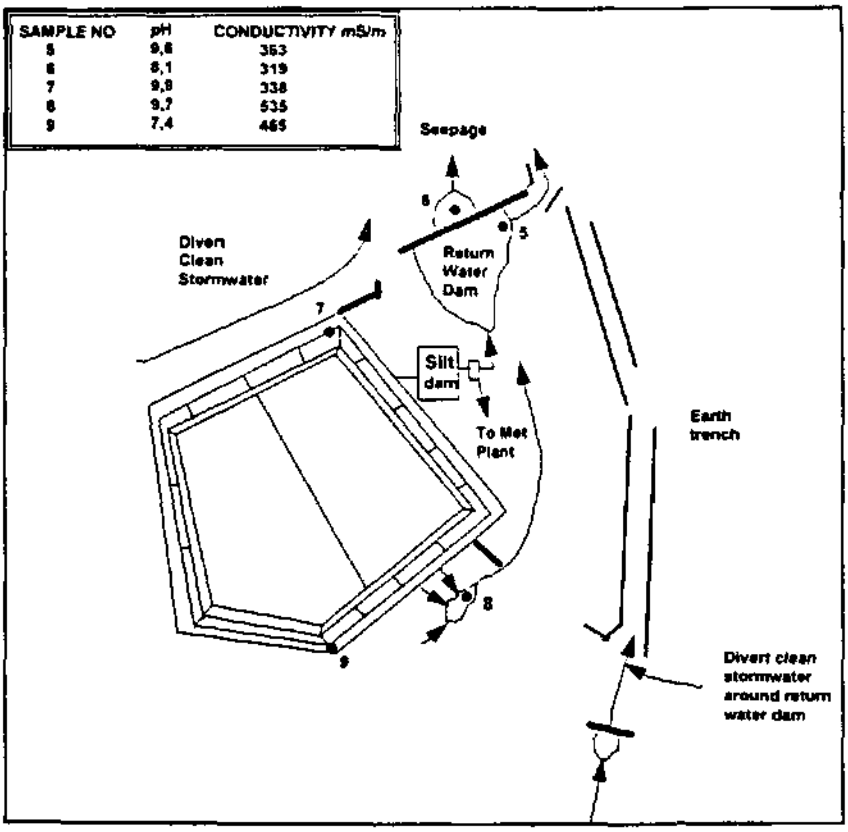
As a result of the discussions and site visits, the following potential problems were identified:

3.4.1 Management of the slimes dam and surrounding area as a pollution source

Figure 6 shows the basic layout of the slimes dam area and the position of the sampling points monitored during the site visit.

Seepage is occurring through the return water dam wall and may cause contamination of downstream water systems.

Seepage to the lower vlei area on the eastern side of the slimes dam was measured with a pH of 9,7 and a conductivity at 535 mS/m. This high salt content could contaminate the groundwater or the precipitated salts could be mobilised with stormwater runoff.



SAMPLE NO	pH	CONDUCTIVITY mS/m
5	9,6	353
6	8,1	319
7	9,8	338
8	9,7	535
9	7,4	465

Figure 6 : Schematic outlay of the slimes dam and return water with the points sampled during the site visit.

The slimes dam is situated on an eye in the southeastern corner and during the site visit, seepage caused by flow from the eye was visible on the eastern side of the dam. At this point pH was measured at 7,4 with a conductivity of 465 mS/m. The eye could continue to be the driving force for pollution and acid mine drainage in the area long after closure of the mining operation.

3.4.2 The waste rock dump as a pollution source

Figure 7 shows the location of the sampling points monitored during the site visit.

During the site visit, the seepage to the eastern side of the waste rock dump was measured at a pH of 3,5 with a conductivity of 990 mS/m. Surface runoff and seepage from the area pollutes the water and surrounding land. After closure this acidic seepage may continue to cause a deterioration in the water quality if released into the environment.

3.4.3 Treated sewage water reuse

The discharge of 1,7 Mℓ/day of treated effluent into the Loopspruit is unnecessary wastage of a potentially valuable and useful water resource. Reuse of this water could significantly reduce the consumption of the Rand Water supply.

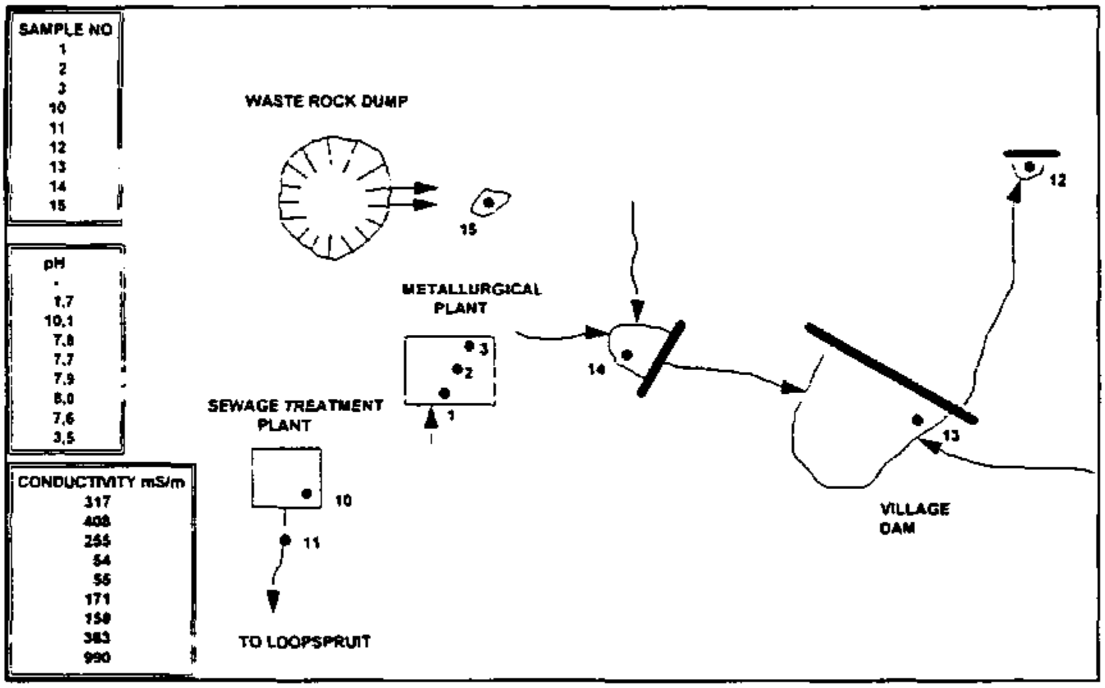


Figure 7 : The location of the sampling points measured around the waste rock dump, plant and Village dam.

3.4.4 Metallurgical plant area

All stormwater runoff and spillages in the plant area flow into an area at the lower end of the plant and is prevented from leaving the plant by means of a concrete retaining wall. Possible contamination of the groundwater could take place in the lower area. This is due to the fact that the area surrounding the thickener and the mill return tank lacks a concrete slab and sump which would help prevent contaminants seeping into the soil.

Another problem encountered with the sump is the amount of slurry silting up the sump which reduces the holding capacity, leading to an unnecessary overflow in the event of a big storm.

The overflow launder of the operating thickener in the plant is silted up and is not perfectly level, leading to short circuiting, as only a portion of the launder is used.

3.4.5 Settler operation

The dirty water reaching the settlers had a pH of 5,2 and a conductivity of 449 mS/m. After the addition of soda ash and flocculant the pH and conductivity increased to 8,3 and 482 mS/m respectively. The combined clear water overflow measured a pH of 8,4 and a conductivity of 486 mS/m.

The settlers are operated and controlled very well, producing good results. Suspended solids in the clear water launder varies from 8 - 30 mg/ℓ
The following aspects could be improved upon in the settling process:

- Overflow launders are not used equally over the entire length. This causes certain areas to record a higher flow into the launder and can result in solids short circuiting, when the flowrate is increased. This problem has been recognised and V- notch plates are being installed.

- The distribution of the flocculated dirty water in the launder feeding the cells can be improved upon and spread more evenly. The last cell tends to treat less than the previous ones as by the time the water reaches the last cell almost all the suspended solids have settled out.

Despite these shortcomings, the settlers operate very well and produce exceptionally good quality overflow water.

Appendix A - List of pH and conductivity readings taken during the Site Visit

During the site visit, a number of pH, conductivity and temperature readings were taken at various locations on the mine.

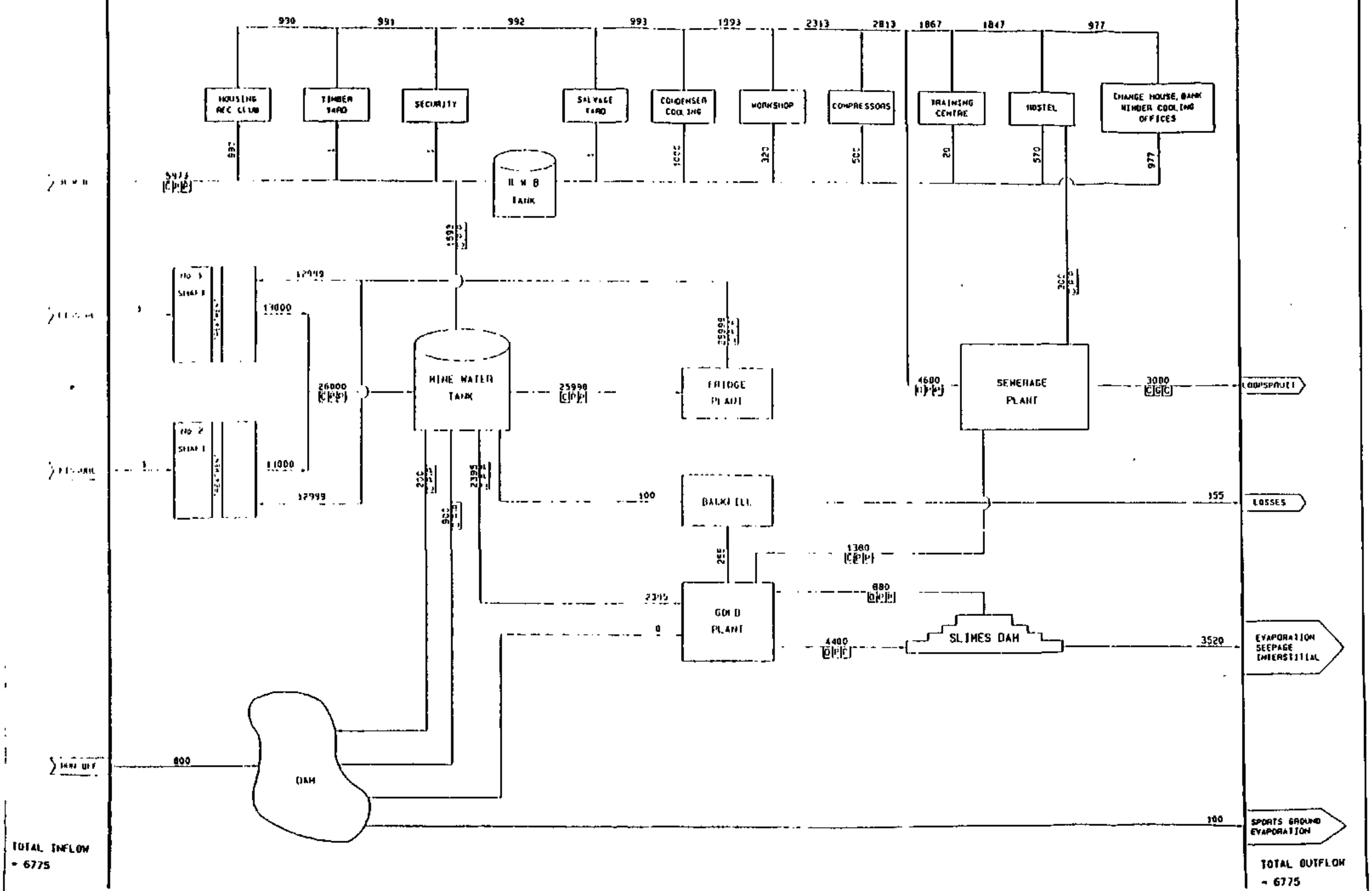
No	Monitoring Point Description	pH	Cond. (mS/m)	Temp °C
S1	Dam Return Water Tank in plant		317	17,8
S2	Thickener overflow to mill return tank	10,7	408	23,6
S3	Plant drainage sump	10,1	255	10
S4	Mill return tank	10,8	412	22
S5	Return water tank	9,6	363	11
S6	Seepage through return water dam	8,1	319	12
S7	Penstock drainage	9,9	338	13
S8	Seepage on east side of slimes dam	9,7	535	-
S9	Water from eye on dam	7,4	465	-
S10	Purified sewage	7,8	54	-
S11	Purified sewage to Loopspruit	7,7	55	-
S12	Recreation club seepage	7,9	171	-
S13	Recreation club dam	8,0	158	-
S14	Catchment dam - No, 2 above rec. club dam	7,6	363	-
S15	Seepage below waste rock dump	3,5	990	-
Underground Visit				
S18	Service water to stope	5,1	408	20
S19	Water from drill hole	6,1	408	24
S20	Footwall water in dip gully	2,9	546	29
S21	Stagnant pond in dip gully	5,2	408	28
S22	Water from borehole	5,1	478	28
S23	Water into drain hole	3,5	489	29
S24	Acid mine drainage at top of chair lift	2,9	530	29
S25	Water in drain of return airway on 33 level	5,2	467	25
Underground Settlers				
S28	Dirty water from sections	5,2	449	25
S29	Dirty water after soda ash dosing	8,1	477	25
S30	No. 2 settler clear water overflow	8,3	482	25
S31	Combined clear water overflow	8,4	486	26

Appendix B - List of Photographs

During the site visit, a number of photographs were taken at various locations on the mine.

Photograph No	Photo Subject Description
1	Milling Plant
2	Empty thickener
3	Mill return and small mill return tank
4	Cyclones on backfill plant
5	Plant spillage drain
6	Thickener overflow
7	Plant spillage sump
8	Slimes dam
9	Return water dam
10	Seepage through rainwater dam
11	Pen stock drainage from slimes dam
12	Silt dams pumping return water to plant
13	Seepage on eastern side of slimes dam
14	Eye in slimes dam paddock
15	Flow meter after macerator on sewage outlet
16	Sewage sludge drying beds
17	Aerated activated sludge tanks
18	Final clarifiers
19	Chlorination plant
20	Sewage overflow to Loopspruit being sampled
21	Seepage from Recreation Club dam
22	Recreation club/dam
23	Seepage below waste rock dump
24	Stope 31/21 West Panel 31 level
25	Drilling at stope
26	Water from borehole
27	Drain hole from 31 level to settlers
28	Acid mine drainage at top of chair lift
29	Soda Ash dosing at No. 2 settler
30	Flocculant dosing at No. 2 settler
31	Splitter box of dirty water launder
32	Clean water overflow launder
33	No. 2 settler
34	No. 1 settler soda ash dosing
35	No. 1 settler flocculant dosing
36	Flocculant packets

FIGURE 1



JOB No. 196369

PIPED/CHANNEL
PUMPED/GRAVITY
ALL VALUES m³/day

DEELKRAAL MINE WATER RETICULATION BALANCE

FIG No. G.4.1

Report on East Rand Gold and Uranium Company Ltd(ERGO) Site Visit.

25 - 26 August 1994

1. GENERAL INFORMATION

Name of mine	East Rand Gold and Uranium Company Limited.
Name and position of person(s) interviewed	Messrs R de Zoeten - Plant Production Superintendent, Environmental Services A Lategan - Environmental Metallurgist
Nearest town	The company has working areas spread throughout the entire East Rand region in Germiston, Benoni, Boksburg, Nigel, Springs and Brakpan
Name of catchment	The reclamation sites exist within several river catchments, namely , Blesbokspruit, Elsburgspruit, Rietspruit and Withokspruit. The Rietspruit is the main catchment.
Monthly tonnes treated	Brakpan Division : Approx 3 000 000 tonnes per month Daggafontein Division : 1 200 000 tonnes per month
Monthly gold production	Approximately 1 200 kg/month
Current age of mine	22 years
Expected remaining life of mine	8 years
Type of mining carried out	Removal of old gold mine slimes/sand dumps situated throughout the East Rand for re-processing
Transport mode, reclamation site to plant	Reclamation is either by mechanical loading with front-end loader onto conveyors on trucks, or by monitoring with high pressure water sprays and the slurry pumped to the metallurgical plants
Has an EMPR already been produced by the mine ?	Yes

2. SITE VISIT PROGRAMME

2.1 Day 1 - 25 August 1994

- Arrival at ERGO plant
- Short discussion on project background and objectives with Mr R de Zoeten
- Present at meeting:
- R de Zoeten - Plant Production Superintendent (Environmental Services)
- J Laas - PHD
- D Howie - PHD
- Guided tour of the ERGO metallurgical plant and water circuits related to the metallurgical process
- Guided tour of the SA Lands 1 (5L31) slimes dam reclamation site and surrounding area under rehabilitation
- Guided tour of the ERGO slimes dam and the Withok and Rietspruit in the vicinity of the slimes dam
- pH and electrical conductivity readings were taken at various points during the day

2.2 Day 2 - 26 August 1994

- Arrival at ERGO plant
- Guided tour of the Daggafontein slimes dam and surrounding areas including the Blesbokspruit
- Visit to the Geduld slimes dam, the Cowles Dam and inspection of the later management system surrounding the two sites
- pH and electrical conductivity readings were taken at various points during the day

3. DISCUSSION OF THE MINE'S CURRENT WATER MANAGEMENT AND TREATMENT PRACTICES.

3.1 DESCRIPTION OF WATER CIRCUITS

3.1.1 General Location

ERGO's mining operation consists of reprocessing old gold mine slimes dumps situated throughout the East Rand, for the production of gold and sulphuric acid. The tailings are deposited on two operational slimes dams, i.e. the ERGO tailings dam, south of Brakpan and Daggafontein tailings dam, east of Springs.

The reclamation operations are spread throughout the East Rand and activities cover the following towns and cities: Germiston, Boksburg, Benoni, Brakpan, Springs and Nigel.

The complex forms part of the following river catchments: Blesbokspruit, Elsburgspruit, Rietspruit and Withokspruit.

Water is primarily used in the reclamation operation and the slurry transported along hundreds of kilometres of pipeline to the two metallurgical plants and via pipelines pumped out to the two tailings dams.

3.1.2 Reclamation sites

Twenty two slimes or sand dumps are in the process of, or will be reclaimed in the near future. During normal operations a number of different slimes dams are reclaimed at any time. Each individual slimes dam, together with its associated pump station operates as an independent section and is operated in accordance with the relevant sections of the Water Act.

The monitoring process, whereby the slime is slurried with the use of high pressure water guns, requires large amounts of water. The slurry, together with any stormwater falling within the operational area, is laundered into specially constructed, unlined channels close to the pump stations. The pump stations are built, wherever possible, at the lowest point of the reclamation site to facilitate the free gravity flow of the slurry towards the pump stations.

These monitoring catchments have been designed to hold stormwater emanating from a 1 in 50 year storm event and to contain all the slurry produced during periods of pump station failure or any other downstream constraints. Once an area has been cleared of all the slime, it is paddocked to prevent any further stormwater runoff from the area.

3.1.3 Metallurgical plants

ERGO operates two process plants, one at Vulcania in Brakpan and the other at Daggafontein in Springs. The production rates at the two divisions of ERGO are as follows: Brakpan - 2.5 million tonnes/month and Daggafontein - 1.2 million tonnes/month.

3.1.3.1 Brakpan division

The plant operations include various monitoring stations to recover slime from slimes dams, which are then pumped to the main complex. An average of 88 000 tonnes of slime is recovered per day. In addition approximately 7 000 tonnes/day of sand is mechanically loaded into the sand milling plant before it is blended with the slime pumped to the main plant. The flotation plant treats the slime to recover pyrite concentrate. This concentrate is burnt in an acid plant to produce sulphuric acid. The calcine product is passed into a gold leach plant for further gold recovery. The flotation residue passes through the carbon in leach (CIL) section, after cyanidation, for the recovery of gold. The gold is cast in a gold plant smelt house. All the plant residue is pumped to the ERGO tailings dam.

3.1.3.2 *Daggafontein Division*

This plant also treats slime recovered by the monitoring of old slimes dams. The CIL process is used to recover gold and the extracted metal is sent to Brakpan Division for final smelting. All the plant residue is pumped to the Daggafontein tailings dam.

These dams are similarly constructed and the operations are monitored by outside contractors, Anglo American Civils Department for the Daggafontein dam and Knight Piesold for the Brakpan dam. The dams are fitted with underdrains along the sidewalls which discharge into toe trenches. Water is reclaimed from both dams and recycled to the main process plant.

The Blesbokspruit flows from north to south past the Daggafontein tailings dam on its western side with the Marievale bird sanctuary in close proximity. The return water dams are situated on the northern side of the dam, from where the water is pumped back to the Daggafontein process plant.

The Rietspruit flows from north to south, past the ERGO tailings dam. On the western side, the Withokspruit flows from east to west on the northern side of the tailings dam and then joins the Rietspruit. The return water dam is situated on the northern side of the tailings dam and water can be pumped back to the Brakpan processing plant from these return water dams. In the process this water is also passed through carbon columns for gold recovery. Seepage, via the underdrains, can flow either to the return water dams, or to an evaporation pond situated on the northwestern side of the tailings dam next to the Withokspruit.

3.2 DESCRIPTION OF WATER MANAGEMENT SYSTEMS

3.2.1 Reclamation sites

Process water is supplied to the reclamation sites from the clear water reservoir at the ERGO plant area, from where it is pumped via pipelines to each individual reclamation site. The reclamation of slimes from old mine tailings is effected by monitoring with high pressure water spray guns. The generated slurry is channelled via unlined earth launders to a pump station and then pumped to a central plant for processing.

All water spillages are captured in constructed paddocks and the slurry is channelled into the launders for pumping to the process plant. The paddock walls are maintained and checked regularly to ensure no leakage or spillage through the walls. Erosion of old slimes dams, which are in the process of being reclaimed, has occurred in the past due to the absence of adequate runoff control in the form of terraces and paddocks. Where possible, during a reclamation operation paddocks are built so as to prevent this from occurring.

Any stormwater from the reclaimed area is channelled to an emergency catchment which is constructed on each site. The dammed up water is then released under controlled conditions to the pump station where it is then pumped to the thickeners situated at the process plants. The decanted water is either returned to the reclamation site for monitoring or is pumped to the tailings dam where it is stored for later use or recycling.

As previously mentioned, hundred of kilometres of pipeline are used in this type of mining operation. All new pipes used by ERGO are maintained and inspected regularly. Once a new pipeline has been installed it is pressure tested and inspected before commissioning. All pipelines are maintained by a comprehensively planned maintenance system which includes:

- regular pipe wall thickness testing
- pipe rotation
- pipe replacement where required

In the event of a pipeline failure, the impact is minimised by taking the following steps:

- The affected pipeline is immediately isolated and a bypass line installed
- The area is bunded, or in areas where it is not practically possible, diverted into a bunded area.
- The water is allowed to evaporate. When the spill has dried sufficiently the remaining slime is mechanically removed

3.2.2 Rehabilitated areas

Where an old slimes dam has already been reclaimed, a rehabilitation programme is instituted. Similar to pre mining conditions, the surface water quality on the reclaimed areas is initially very poor. This situation is controlled by paddocking the reclaimed sites and ripping the ground to facilitate the leaching of salts into the subsoil. These sites are paddocked to contain any stormwater and precipitation arising from a 1 in 100 year event with the required freeboard of 0,5m.

Slimes dams which are totally reclaimed are managed according to the following programme. The perimeter wall and outside drain surrounding the boundary of the reclaimed slimes dam is designed and constructed to ensure that external stormwater or other waters cannot enter the site, preventing possible discharge of polluted water from the site. The area within the old slimes dam boundary is subdivided by earthwalls into smaller areas and paddocks. The height of these walls are built so that they make provision for a freeboard of at least 0,5m after a 24 hour precipitation with an average frequency of reoccurrence of 1 in 100 years. The ground within the paddocks is also mechanically ripped to a depth of ±0,5m and this has the following benefits.

- It promotes the leaching of acidic material into the ground and reduces the surface salt concentration
- It reduces dust pollution and erosion once vegetation has been established

Rehabilitation programmes are regularly monitored by periodic analysis of the soil and water samples collected in the area. During dam cleanup operations and rehabilitation a variety of earth moving equipment including front-end loaders, trucks and excavators are utilised to build the necessary walls and paddocks to manage water. The objective is to keep the unpolluted water outside these areas clean, and the polluted water inside the paddock separate from the outside water. The water in the paddocks is left to evaporate.

3.2.3 Metallurgical plants

3.2.3.1 Brakpan plant

The metallurgical complex is subdivided into separate plants, each with their own bunded areas to contain spillages. To recover any lost gold, spillages within the bunded areas are recycled to the same section. Around the acid, gold and pyrite handling plants, an intermediate system of stormwater drains divert all the highly acidic and caustic water to a central effluent sump within the plant area. This sump collects and recycles all immediate spillages to the acid plant calcine thickener and via this process back into the process water circuit. For the remainder of the plant all roads, stormwater drains and any spillages in these areas, which escape from the bunded area are directed to the primary settling ponds outside the metallurgical process area. These two unlined settling plants collect any spillages in the immediate vicinity of the plant and the solids are settled out.

The two ponds function as an operating and a standby unit in parallel. Any accumulated slime is reclaimed by monitoring the ponds on a daily basis. The solids are settled out and accumulated slimes are recycled to the flotation tailings thickeners and back into the process. The clarified water overflows back into the primary settling ponds within the plant area. These two ponds are also operated on a running and standby basis. Any slime still in suspension settles in these ponds.

The clear water is recycled to the main process reservoirs by a level activated pumping system. In the event of any water discharging into the Withokspruit, the flow is measured and the volume reported to the Department of Water Affairs on a monthly basis. A set of routine water analysis are taken and data collected on the water quality in the system. Any accumulated solids are removed periodically by mechanical means and eventually report to the tailings dams.

3.2.3.2 *Daggafontein plant*

This metallurgical complex is also subdivided into separate plants, each with their own bunded areas to contain local spillages. For the remainder of the plant all roads, stormwater drains and any spillages in these areas which escape from the primary bunded area are directed to the primary settling ponds inside the main plant area. These two unlined settling ponds thus collect any spillages in the immediate vicinity. The accumulated water in these ponds is pumped to the residue sump and then to the tailings dam for reuse.

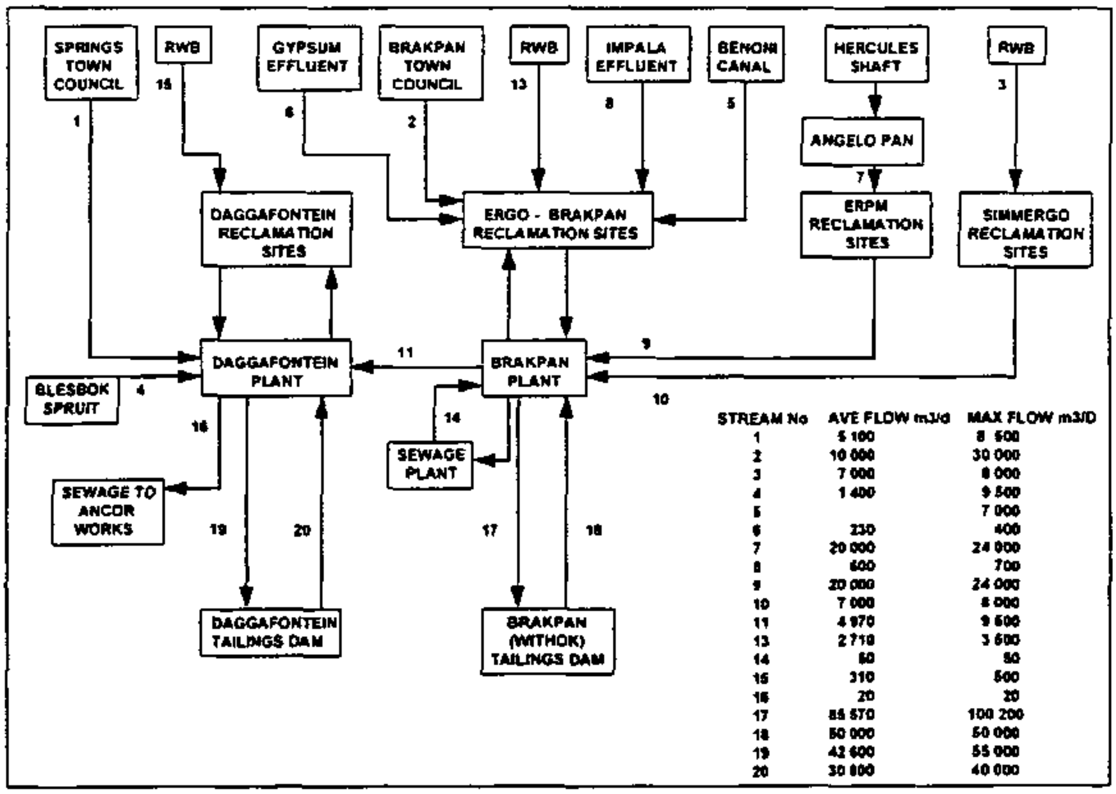
The solids in the settling ponds are removed by monitoring and pumped via the residue sump to the tailings dam for disposal. There are no existing facilities for the treatment of water as all water is recycled and reused as process water in both plants.

3.2.4 Potable water supply

Rand Water supplies potable water via the various municipalities to the operation as there are no potable water plants in the entire operation.

3.2.5 Process water supply

The flow of process water for the ERGO operation is given in the water balance diagram of Figure 1 below.



STREAM No	AVE FLOW m3/d	MAX FLOW m3/D
1	5 100	8 500
2	10 000	30 000
3	7 000	8 000
4	1 400	9 500
5		7 000
6	230	400
7	20 000	24 000
8	600	700
9	20 000	24 000
10	7 000	8 000
11	4 970	9 600
13	2 710	3 600
14	60	50
15	310	500
16	20	20
17	85 570	100 200
18	50 000	60 000
19	42 600	55 000
20	30 800	40 000

Figure 1 : Schematic diagram of the ERGO complex water balance

The shortfall in process water requirements is made up from Rand Water which is supplied by various municipalities and extracted from various points in the process.

3.2.6 Stormwater

Storm water outside the tailings dams and plant sites is diverted around the operation by means of diversion walls and trenches. A system of paddocking has been introduced to prevent any discharge of water from polluted sites. The objective is to keep the cleaner stormwater separate from any contaminated water, which is then reused.

3.2.7 Sewage plants

Only Brakpan has a self contained sewage plant, with a design capacity of $50m^3$/day. This unit operates automatically and is checked on a daily basis by the operating staff who in turn report to the Services Manager. Anglo American Civil Engineering Department inspects the plants on a monthly basis and their water chemist takes samples for analysis and reports back on any operational problems. The treated effluent is discharged from the plant into the stormwater system of the complex upstream of the settling ponds. All the effluent thus reports to the outside settling ponds which is then recycled via the process water stream to the metallurgical process. The small sewage plant treats the sewage effluent from the Brakpan metallurgical plant. Municipality sewerage works are used for treatment of the sewerage at all the other mining activities and the outside reclamation areas.

3.2.8 Operating slimes dams

The ERGO operation utilises two metallurgical process residue disposal sites, namely the Daggafontein tailings dam for the Daggafontein plant and the Brakpan tailings dam for the ERGO Brakpan based operation. The plant residue is pumped in a slurry form to these two tailings dams at a solids content of $\pm$ 50%. The solids settle on the beach area and the water is drawn off through a decanting tower to the return water dams. At Daggafontein, a floating pump station is used to pump the water from the tailings dam to the return water dam. At Ergo, a decant tower is used to decant the water to the return water dam.

The slimes dam construction is different to the conventional daywall and night pool deposition. The walls are constructed through the use of numerous cyclones around the perimeter wall, arranged at approximately 30m intervals. These may be moved periodically to build up the walls in other areas. Slime is delivered into the dam and the solid content settles along the beach area to allow the water to drain towards the centrally located floating penstock tower. The philosophy behind this method of slimes dam construction is not the rapid removal of water from the dam, but instead the dam acts more as a storage reservoir. The penstock drainage is delivered to an intermediate return water dam, which acts more as a pumping sump than storage dam. The flow into the return water transfer dam is monitored by a continuous level meter.

Stormwater is prevented from entering the tailings dams site by means of walls and trenches. Any stormwater runoff from the outside walls is contained within paddocks constructed around the perimeter. Erosion by stormwater on the wall is prevented by promoting vegetation on the walls. The cycloning method of wall construction has the disadvantage of slime spillage down the outside of the wall, if the operation is not managed correctly and an organised programme of cyclone movement needs to be strictly controlled. This problem can be controlled by maintaining adequate capacity in the paddocks. Several areas of slime spillage down the outside wall were evident during the site visit. This does not cause serious stability problems, but the slime flows down into the catchment paddocks and the required freeboard is then reduced. It also prevents any vegetation of the slopes and the grassing can only commence when the slime deposition is completed in that area. The short term operation has, however, been changed to enable ongoing establishment of vegetation in the long term.

The boreholes situated around the tailings dams are sampled every three months at both Withok and Daggafontein in order to monitor the possible deterioration in groundwater quality.

3.2.9 Surface Water

Defunct slimes dams, for which Ergo has an option to reclaim and treat, have a negative impact on both the surface and groundwater quality. Many of the older slimes dams are adjacent to natural water courses and in some cases the construction of the dams has diverted the natural water courses. Generally, little or no provision exists for containment of stormwater runoff on these defunct slimes dam which are administered by the State. Most of the original storm water facilities are no longer functional and any stormwater emanating from these sites flows directly into the various water courses.

Approximately 20 Mℓ/day of polluted underground water is routed from a location known as the Angelo Pan in Boksburg, which forms part of the ERPM mining operation. The water is pumped from underground at the ERPM South West Vertical shaft is then treated at their HDS plant. It is discharged to the Angelo Pan and overflow is to the Elsburgspruit. Some of the water is then used in the ERGO reclamation operations near Boksburg.

3.2.10 Water management structure

Figure 2 shows the Environmental Department's structure of responsibility for water and environmental management.

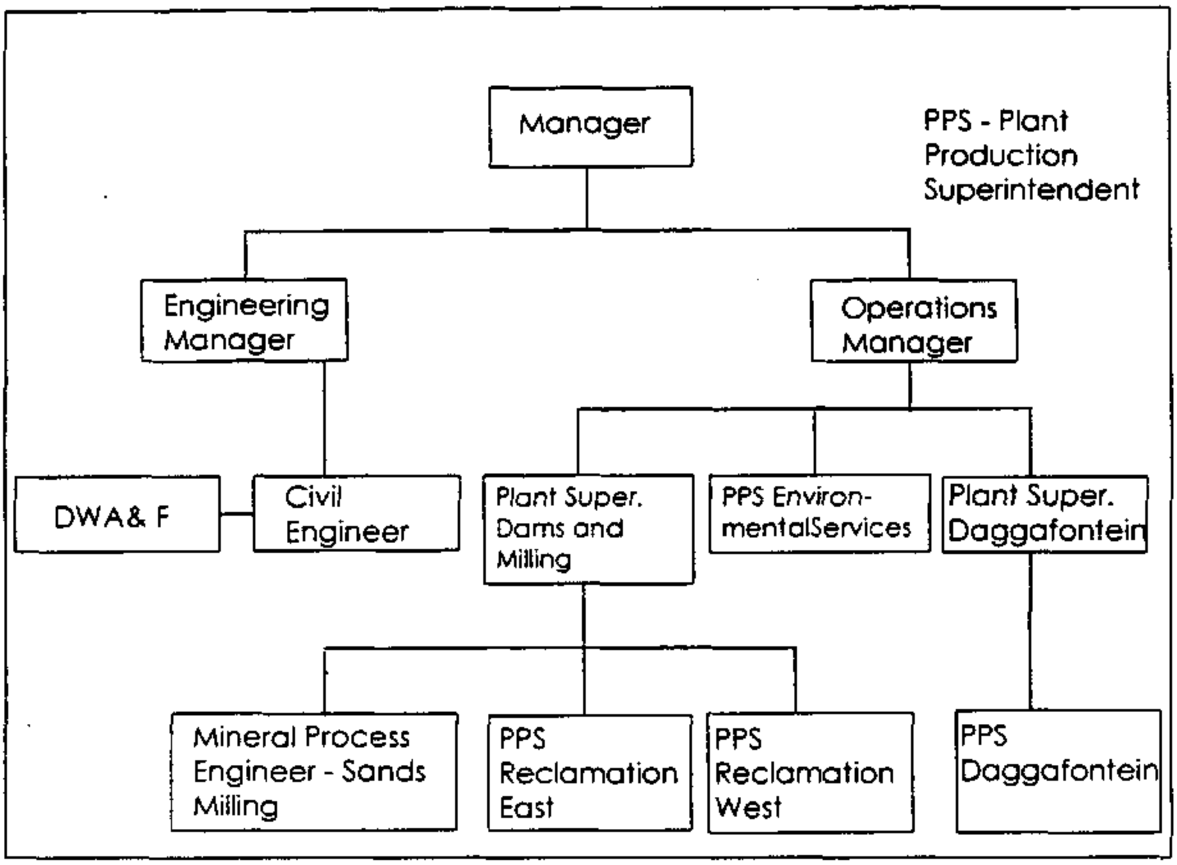


Figure 2 : The environmental management structure for Ergo

A high priority is given to radioactivity and radiation protection. All reclamation sites are surveyed in accordance with procedures outlined by the Council for Nuclear Safety (CNS). All parties are well trained in radiation protection and all the sites are supervised and controlled according to CNS requirements.

The following information is submitted regularly to the Departments mentioned below:

INFORMATION	DEPARTMENT	PERIOD
Water usage & quality	Water Affairs & Forestry	Monthly
Condition of acid plant stack	Brakpan Health Dept	Monthly
Review of radiological hazards	Council for Nuclear Safety	Quarterly
Review of reclamation and rehabilitation	Mineral & Energy Affairs	Quarterly
Review of water quality controls	Water Affairs & Forestry	Quarterly
Liaison meetings	Brakpan	Quarterly
Liaison meetings	Benoni, Springs, Nigel & Germiston Town Councils	As required

3.2.11 Water sampling and environmental monitoring programme

Various samples around the reclamation sites and metallurgical process plants are taken on a weekly basis and reported to the Reclamation Plant Superintendent. These samples are analysed in a well equipped chemical laboratory at the ERGO plant complex. These sampling points include the Gypsum industrial effluent, Impala effluent, Sallies water, Rand Water, Sewage plant final effluent, Sallies Pond overflow, tailings dam reservoir, and evaporation dam overflow.

Groundwater is monitored by sampling various boreholes around the two operating tailings dams. The groundwater around the Geduld East (6L13) slimes dam, near Cowles Dam, is the subject of an intense study. Seepage from the slimes dam is polluting the neighbouring Cowles Dam and a series of boreholes have been sunk in the area between the two. This water is pumped out and returned to the slimes dam in an attempt to intercept it before reaching the Cowles Dam.

3.3 POTENTIAL WATER TREATMENT/MANAGEMENT PROBLEMS AND NEEDS

Due to the vastness of ERGO's operations only a few areas could be covered during the site visit. These included ERGO's metallurgical plant, S.A. Lands 1 dump and reclamation site, the ERGO tailings dam and surrounding Withok and Rietspruit, the Daggafontein tailings dam and Blesbokspruit, the Cowles Dam and Geduld East slimes dam.

3.3.1 ERGO metallurgical process plant area

The runoff and stormwater control in this area is well established. This site is situated on a steep slope near the external spillage catchment ponds and a large portion of the area is concreted. It is essential that these two spillage catchment ponds remain empty to ensure that all runoff and stormwater is captured in the event of a heavy rainstorm.

On the day of the site visit, readings were taken of the clear, process water reservoirs and a pH 8,2 and conductivity of 272 mS/m was recorded. These combined internal spillages from the gold, float and acid plants measured a pH of 2,1 and a conductivity of 650 mS/m. These spillages are however, well contained and are pumped back into the process circuits.

3.3.2 S.A. Lands 1 Dump reclamation site

The pH's and conductivities measured in this area varied from a pH of 6,6 to 8,0 and conductivities ranging from 325 to 406. All the paddocks and trenches were well maintained and there was no evidence of seepage and spillages through the earthwalls.

3.3.3 ERGO's tailings dam, Withok and Rietspruit

Figure 3 shows some of the pH and conductivities measured in these areas. Of significance is the changes in the water quality upstream and downstream of the tailings dam.

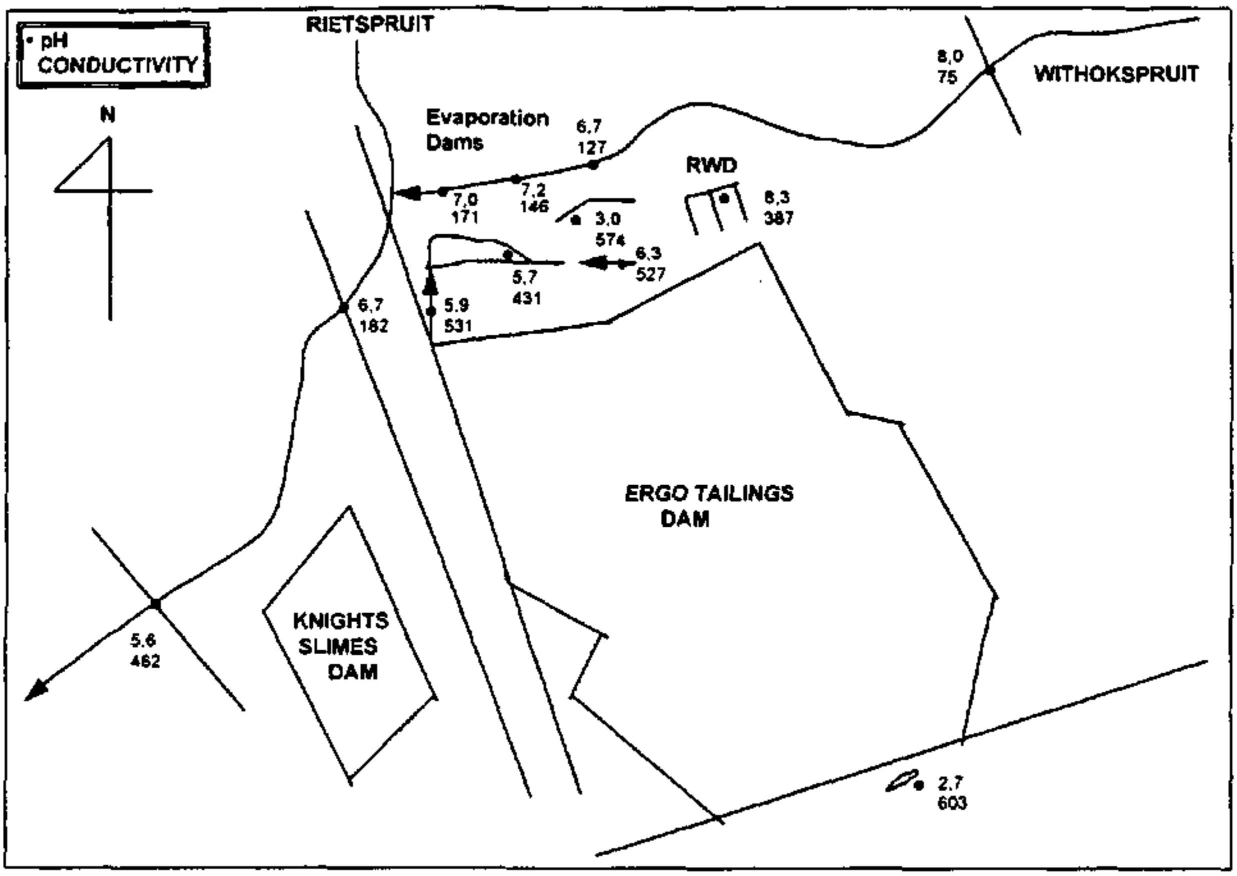


Figure 3 : pH and Conductivities measured

The Withokspruit flows from east to west past the ERGO tailings dam on the northern side. Upstream of the tailings dam, at the tar road, a pH of 8,0 and a conductivity of 75 mS/m was measured. The water quality, however, deteriorated and the pH changed to 7,0 and the conductivity increased to 171 mS/m closer to the confluence of the Withokspruit and Rietspruit. pH values as low as 3 and conductivities as high as 574 mS/m were measured in the area. The flow of underdrainage measured a pH of 5,9 and conductivity of 531. All seepage flow is collected in an evaporation pond and the wall of this dam showed signs of seepage. This evaporation facility is most likely causing a further deterioration in the Withokspruit water quality.

Due to the vlei nature of the area, it was only possible to measure the quality of the Rietspruit at selected points. Upstream of the Knights slimes dam a pH of 6,7 and a conductivity of 182 mS/m was recorded. Downstream of the Knights slimes dam, situated on the western side of the ERGO Tailings dam, the Rietspruit water quality deteriorated to a pH of 5,6 and conductivity of 462 mS/m. This represents a substantial deterioration in water quality and another contributing factor may be the large quarrying and crusher operation situated on the western side of the Rietspruit.

To minimise pollution of the Withokspruit, it is essential to manage the evaporation pond more efficiently. This evaporation pond is a collector dam which collects all the water rising from the cutoff trenches around the tailings dam. The water level in this dam is kept low by pumping back any excess to the return water dam. The area does however, require the construction of seepage cutoff trenches downstream of the dam wall. It is also essential to inspect and maintain the trenches directing the seepage from the tailings dam to the evaporation pond. During the site visit it was evident that some of these trenches could not handle the flow and actually overflowed directly into the Withokspruit before the water reached the evaporation pond. Although the trenches are long and tortuous, the lining of these channels would minimise seepage and assist in the regular cleaning thereof.

3.3.4 Daggafontein tailings dam and Blesbokspruit

During the site visit the Blesbokspruit water quality upstream of the tailings dam was measured and a pH of 8,1 and conductivity of 151 mS/m was recorded. A pH of 6,3 and conductivity of 164 was measured downstream of the tailings dam in the Marievale bird sanctuary. There is an abundance of poor quality water in some of the paddocks on the western side of Blesbokspruit at the partially rehabilitated sites. In some of the paddocks the water quality was measured at a pH of 3,4 and a conductivity of 162. Severe salt precipitation was also observed in the area which would mobilise during a storm event and wash into the Blesbokspruit.

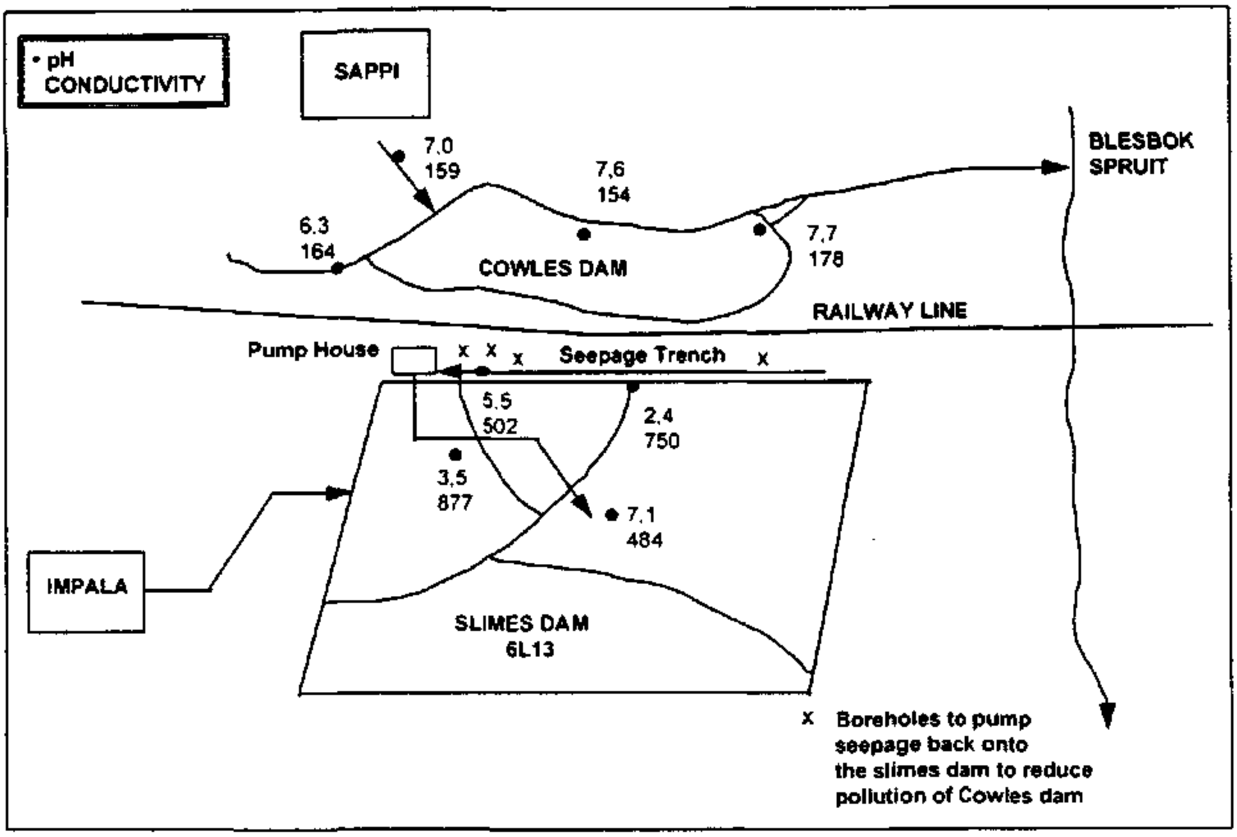
The underdrain seepage of the tailings dam measured a pH of 6,5 and conductivity of 404 mS/m. The seepage is channelled to an evaporation pond south of the dam and water in this pond measured pH of 6,3 and conductivity of 391 mS/m for the eastern compartment and pH of 5,9 and conductivity of 468 for the western compartment. Seepages through the earthwall of these evaporation ponds had a pH of 6,1 and conductivity of 247 mS/m.

3.3.5 Cowles Dam / 6L13 slimes dam area.

Impala Platinum is currently pumping effluent to the western compartment of this dam on a daily basis. During the site visit this effluent measured a pH of 3,5 and a conductivity of 877 mS/m. The top of this slimes dam is used as a storage and evaporation facility for several effluent and seepage sources. The eastern compartment receives the collected seepage from the northwestern corner of the slimes dam. This is the seepage which is intercepted before Cowles Dam and is collected in a central sump before delivery to the top of the slimes dam.

The boreholes on the northern side are dewatered and the water pumped up to the eastern compartment where a pH of 7,1 and a conductivity of 484 mS/m was measured. A pH of 2,4 and conductivity of 750 mS/m was recorded for the seepage in the trenches. Although the rationale behind this strategy is to prevent contamination of Cowles Dam, the measurements indicate that the slimes dam seepage is being diluted by better quality seepage from Cowles Dam.

The low flowrate inflow to Cowles Dam measured a pH of 6,3 and conductivity of 164 mS/m. Sappi also discharges effluent from their plant on the northwestern side directly into the Cowles Dam. This effluent stream measured a pH of 7,0 and a conductivity of 159 mS/m which would suggest a dilution effect of the discharge. A pH of 7,7 and a conductivity of 178 mS/m was measured at the Cowles Dam overflow. This would indicate that the seepage from the slimes dam is still impacting slightly on Cowles Dam.



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3.4 NOVEL OR UNIQUE WATER TREATMENT/MANAGEMENT SYSTEMS

The uniqueness of the ERGO operation lies in the fact that it is the largest dump reclamation operation in South Africa. The operations are spread over vast areas and there are more than 20 reclamation sites. The reclamation sites, processing plants and residue disposal dams are linked to one another with hundreds of kilometres of pipeline, often crossing land not under ERGO control. This has special significance for the monitoring and control of these areas. Pipe failures and spillages are more difficult to detect and the management strategy is thus geared towards the prevention of failure. This is achieved through a fairly strict pipe maintenance schedule.

The size and construction of the two tailings dams are also unique in South Africa. The strategy of using the top of the dam as a storage reservoir is in complete contrast to conventional slimes dam operation where the objective is to remove the water as soon as possible to maintain stability. Although, the return flow from these dams is measured, the volume of water stored on the dam makes a water balance around such a facility more difficult to estimate. The depth of water implies an increase in the driving head for downward seepage and coupled with the larger area exposed to evaporation, this suggests the relative water losses would be greater for this type of slimes dam. According to the water balance, however, the return flow is estimated at 58% for the Withok dam and 72 % for the Daggafontein dam. If these figures are accurate, then this type of facility needs further investigation, as the return water flow from conventional slimes dam construction is approximately 25 - 35%. The stability problems associated with the conventional daywall system of construction are also reduced.

Appendix A - List of pH and conductivity readings taken during the Site Visit

During the site visit, a number of pH and conductivity readings were taken at various locations on the mine.

No	Monitoring Point Description	pH	Cond (mS/m)
Ergo metallurgical process plant			
1	Clear water reservoir (Hot side)	8,2	272
2	Internal spillage trench for gold and float plant	2,2	604
3	Acid plant spillage trench	2,7	320
4	Combined internal spillage	2,1	650
5	Pyrite paddocks and gold plant spillages	4,3	413
6	Combined thickener overflow	6,8	360
7	Clear water reservoir (Cold side)	8,1	282
8	Plant spillage to external spillage catchment ponds	8,2	326
Sallies No1 dump reclamation site			
9	Streams on northern side of Sallies No 1 from farmers	7,2	406
10	Stream in outside trench on western side of Sallies No 1 dump	7,6	375
11	Sumps with pumps on western side of Sallies No 1 dump	8,0	325
12	Slurry trench for reclaimed material - West side of No 1 dump	6,3	329
13	Slurry flowing into pumping station	6,6	327
ERGO tailings dam, Withok and Rietspruit			
14	Stagnant water in paddock on eastern side of ERGO	7,5	516
15	Seepage from underdrain on NE side of tailings dam	6,5	400
16	Combined seepage and decanted water from decant tower	8,7	386
17	Seepage from underdrain on north side of ERGO tailings dam	6,4	464
18	Eastern compartment of RW Dam	8,3	387
19	Western compartment of RW Dam	8,2	391
20	Seepage through RW Dam wall	7,8	372
21	Spillage/seepage on northern side of NIMCIX-plant	7,5	215
22	Seepage in cut-off trench on northern side	6,3	527
23	Stagnant pond with wall and valves on NW side of dump	3,0	574
24	Withok spruit on northern side of evaporation pond	7,2	146
25	Seepage flowing to evap. pond on NW side of tailings dam	5,9	531
26	Withok spruit on northern side of evaporation pond	7,2	146
27	Seepage in cut-off trench on NW corner of tailings dam	5,3	516
28	Water in evaporation pond on northern side	5,7	431
29	Seepage in stagnant pond on south eastern side (Old RWD)	2,7	603
30	Rietspruit at tar road bridge west of Knights S/dam	5,6	462
31	Rietspruit at dirt road upstream of bridge	6,7	182
32	Withok at dirt road west of evaporation ponds	7,0	171
33	Withok at tar road north east of ERGO tailings dam	8,0	75

Appendix A - List of pH and conductivity readings taken during the Site Visit - continued

No	Monitoring Point Description	pH	Cond (mS/m)
Daggafontein tailings dam, Blesbokspruit			
34	Blesbokspruit south of D/fontein tailings dam at bird sanctuary	6,3	164
35	Stagnant water in paddock west of Blesbok at rehabed site	3,4	162
36	Seepage through underdrain at west corner of Daggafontein tailings dam	6,5	404
37	Evaporation pond on southern side of eastern compartment	6,3	391
38	Evaporation pond on southern side of western compartment	5,9	468
39	Seepage through wall in stagnant pool	6,1	247
40	Top of tailings dam pool water at catwalk	8,2	475
41	Water from floating pump station in toe trench	8,8	467
42	RW Dam on north western side of northern compartment	8,3	461
43	RW Dam on north western side of northern compartment	8,1	475
44	Blesbokspruit at pump station upstream of tailings dam	8,1	151
Cowles Dam area and Geduld East Mine s/dam			
45	Dewatering borehole water discharged into eastern compartment	7,1	484
46	Impala effluent discharge into western compartment	3,5	877
47	Seepage cutoff trench on north side of s/dam	2,4	750
48	Combined seepage and groundwater from boreholes at pump station	5,5	502
49	Stream flowing into Cowles dam	6,3	164
50	Sappi effluent into Cowles dam	7,0	159
51	Cowles dam northern bank	7,6	154
52	Cowles dam overflow	7,7	178

Appendix B - List of Photographs

During the site visit, a number of photographs were taken at various locations on the mine.

Photograph No	Description of Photograph
1	Clear water reservoir
2	Clear water reservoir
3	Acid plant stack
4	Acid plant stack spillage trench
5	Acid plant spillage trench
6	Gold and float plant spillage trench
7	Internal spillage sumps
8	Float bell
9	Combined thickener overflow
10	View from pyrite paddocks to thickeners and float plant
11	Pyrite spillages at paddocks
12	Inside pyrite paddocks
13	Plant spillage trench to external catchment ponds
14	Monitoring of solids from catchment ponds to wet plant
15	Monitoring of solids from catchment ponds to wet plant
16	High pressure water gem at Sallies No1 reclamation site
17	Paddocking of cleared site to control the flow of the reclaimed material
18	Part of Sallies No1 dump reclaimed
19	Trench directing slurry to pumping station
20	Trench directing slurry to pumping station
21	Paddocking of reclaimed site
22	Paddocking of reclaimed site
23	Water streams and trenches on western side of Sallies No1 dump
24	Water streams and trenches on western side of Sallies No1 dump
25	Water streams and trenches on western side of Sallies No1 dump
26	Water streams and trenches on western side of Sallies No1 dump
27	Accumulated water in earth dam on western side of Sallies No1 dump
28	Accumulated water in earth dam on western side of Sallies No1 dump
29	Reclaimed site under rehabilitation
30	Cyclone in operation for outside dam wall building
31	Cyclone in operation for outside dam wall building
32	Toe paddocks cleaning up operation to ensure enough holding capacity
33	North side of Ergo tailings dam wall
34	North side of Ergo tailings dam wall
35	Inside slope of tailings dam wall
36	Slope created from cyclone position
37	Building up of wall with a series of cyclones
38	RW Dams from top of tailings dam wall
39	Decantation tower
40	Decantation tower
41	Stagnant pool in cutoff trench
42	Seepage in cutoff trench
43	Underdrains discharge into combined seepage and decant water
44	Ultrasonic flow measuring installation for flow to RWD
45	RWD eastern compartment

Appendix B - List of Photographs - continued

Photograph No	Description of Photograph
Photograph No	Description of Photograph
46	NIMCIX Columns
47	Seepage through RWD wall
48	Evaporation pond on north western side of Ergo tailings dam
49	Evaporation pond on north western side of Ergo tailings dam
50	Old RWD at Withok tailings dam
51	Rietspruit at dirt road downstream of Ergo tailings dam
52	Rietspruit at tar road downstream of Knights tailings dam
53	Cycloning for building outside dam wall at Daggafontein tailings dam
54	Cycloning for building outside dam wall at Daggafontein tailings dam
55	Cleaning of toe paddock
56	Beach area on eastern side of top surface
57	Catwalk and floating pump station
58	Floating pump station
59	Underdrain
60	Canal system to control seepage to the two compartments of the evaporation pond
61	Eastern compartment of evaporation ponds
62	Western compartment of evaporation ponds
63	Pump station at evaporation pond
64	Seepage through dam wall collected in pond
65	Seepage through dam wall collected in pond
66	Seepage through dam wall collected in pond
67	Seepage through dam wall
68	?
69	Ultrasonic level central at RWD
70	Bird sanctuary on western side of Daggafontein tailings dam
71	Bird sanctuary on western side of Daggafontein tailings dam
72	Bird sanctuary on western side of Daggafontein tailings dam
73	Bird sanctuary on western side of Daggafontein tailings dam
74	Stagnant pool in paddock on western side of bird sanctuary
75	Paddocking of reclaimed area on western side of bird sanctuary
76	Paddocking of reclaimed area on western side of bird sanctuary
77	Slime left behind after reclamation
78	Slime left behind after reclamation
79	Precipitation of salts on outside wall of paddocks
80	Precipitation of salts on outside wall of paddocks
81	Pump station in Blesbokspruit upstream of D/fontein tailings dam
82	Pump station in Blesbokspruit upstream of D/fontein tailings dam
83	Sappi from top of 6L13 on NW side
84	Impala platinum from top of 6L13 on west side
85	Impala effluent discharge in western compartment
86	Impala effluent discharge in western compartment
87	Seepage and groundwater pumped from boreholes to eastern compartment
88	Lining of sides of western compartment
89	Sewage works on north eastern corner
90 to 93	Cowles dam
94	Cutoff seepage trench on northern side of 6L13

Report on East Rand Proprietary Mines Limited Site Visit.

26 - 28 July 1994

1. GENERAL INFORMATION

Name of mine	East Rand Proprietary Mines Limited (ERPM)
Name and position of person(s) in	Messrs S Hattingh - Technical Services Consultant R Dias - Metallurgical Manager R McIntyre - Chief Ventilation Officer J Moritz - Sectional Ventilation Officer
Nearest town	Boksburg
Name of catchment	Cinderella Dam to the east overflowing into the Dixiespruit which flows south Elsburg Dam to the west overflowing into the Elsburgspruit which flows south The Dixiespruit joins the Elsburgspruit south of the slimes dams.
Monthly tonnes mined	90 000 tonnes per month
Monthly waste rock dumped	No waste rock is dumped. All waste rock is removed and processed by Hippo Quarries
Monthly tonnes milled	90 000 tonnes per month - underground ore 185 000 tonnes per month - old sand dumps
Monthly gold production	650 kg/month
Current age of mine	101 years
Expected remaining life of mine	10 years
Reefs being mined	Main Reef Main Reef Leader Composite Reef
Stope Width	1.0m
Current Mining Methods	Longwall for underground operation Sand reclamation for surface operation
Has an EMPR already been produced by the mine?	No, still busy compiling the draft EMPR

2. SITE VISIT PROGRAMME

2.1 Day 1 - 26 July 1994

- Arrival at mine's main offices
- Short discussion on project background, objectives and site visit programme
- Present:
  S Hattingh - Technical Services Consultant
  W Pulles - PHD
  J Laas - PHD
  D Howie - PHD
- Guided tour of the Central Metallurgical Plant and slimes dam area with Messrs Hattingh, Dias and Otto.

2.2 Day 2 - 27 July 1994

- Arrival at SEV Shaft
- Underground visit to a working stope at 80 level and the underground settlers at 68 level K Shaft, guided by Mr J Moritz
- Visit the Ice Plant at FEV Shaft
- Visit the HDS plant

2.3 Day 3 - 28 July 1994

- Arrival at main offices
- Completion of mine surface area by visiting Boksburg Lake, Settling Dam area west of Central Metallurgical Plant and Elsburg Dam
- Completion of questionnaire with Mr Hattingh

3. DISCUSSION OF THE MINE'S CURRENT WATER MANAGEMENT AND TREATMENT PRACTICES.

3.1 DESCRIPTION OF WATER CIRCUITS

3.1.1 Surface water systems

The ERPM surface systems can be subdivided into three areas from a surface water point of view, namely:

- Elsburg Dam and catchment to the west
- Cinderella Dam and catchment to the east
- The area to the south, downstream of Elsburg and Cinderella dams, down to the confluence of the Elsburgspruit and Dixiespruit.

3.1.1.1 *Elsburg Catchment Area*

Various slimes tailings dams and sand dumps are scattered throughout the catchment area of the Elsburg Dam. This includes the Angelo slimes dam and sand dumps, the Ginsburg slimes dam and Witdeep Gold dump from where natural runoff and seepage drains via the Walschesspruit into Elsburg Dam.

The Elsburgspruit enters the ERPM mining lease area at the Delmore Dam and effluent from the HDS plant joins the stream upstream of Elsburg Dam.

The Angelo Pan collects natural runoff from the area and when it overflows it joins the Walschesspruit. Water is pumped from underground to surface at South West Vertical shaft and discharged into Angelo pan. Since mid 1993, a pumping scheme was introduced to pump excess mine water from Angelo pan to East Rand Gold and Uranium Company (ERGO). This is beneficial to the current operation of Angelo pan as it assists in establishing a zero discharge system.

The combined effects of the HDS plant effluent, Angelo pan overflow and diffuse seepage and drainage from the Driefontein dump area has a significant impact on the water quality and quantity of Elsburg Dam. This is discussed in Section 3.2.3.2 and shown in Figure 3.

The Elsburg Dam catchment area consists of approximately 50% residential suburbs, including industrial activity, which contributes to the effluent draining into the Elsburg Dam catchment area.

A large part of the remaining area has been disturbed by mining activity in the form of tailings dams and sand dumps. The South West Vertical (SWV) shaft and metallurgical plant are also part of the catchment.

Most of the slimes dams and sand dumps in the area are in the process of being reclaimed or will be in the near future and the influence on water quality, after proper rehabilitation of the area, will therefore be reduced.

The Driefontein slimes dam and Angelo slimes dam are currently being reclaimed by ERGO. The Angelo sand dump is treated by ERPM whilst all the other slimes dams and sand dumps have been sold to other companies.

3.1.1.2 *Cinderella Dam catchment*

In contrast to the Elsburg spruit, the water flowing through this area is relatively undisturbed by mining, compared with the Elsburg Dam area. The only significant mining related operations are that of the Cason dump and a number of smaller dumps in the vicinity of Hercules Shaft. The Cason dump and slimes are located in close proximity to the Boksburg Lake. The lake is used primarily for recreational purposes and an acceptable water quality is therefore essential.

The Boksburg Lake overflow joins runoff from the Hercules Shaft and Reigerpark residential area before entering the Cinderella Dam.

Parkrandspruit is another stream feeding Cinderella Dam on the eastern side. This spruit drains an area made up of open veld and residential areas. This spruit only flows during the rainy season when it drains runoff from these areas.

This layout is discussed in more detail in Section 3.2.4.1 and shown in Figure 3.

Cinderella Dam catchment includes Hercules, Central, South East Vertical, Angelo and Cason Shafts.

3.1.1.3 The confluence catchment

This section of ERPM's surface water consists of the area below the Elsburg and Cinderella Dams and includes the drainage area upstream of the confluence between Elsburgspruit and Dixiespruit. Figure 3 shows the layout and the sampling points for the site visit. It covers approximately 60% of residential development. It also includes Germiston Lake which overflows to the Elsburgspruit below Elsburg Dam.

The ERPM slimes dams are situated between Elsburg and Dixiespruits and have the most significant mining impact on the area. Return and runoff water from the toe paddocks of slime dams No's 1, 2, 2a, 3 and 4 is collected in a return water dam southeast of slimes dam No. 4 and the water pumped to the metallurgical plant for reuse. The FEV shaft is also included in this catchment area.

3.1.2 Metallurgical Plant and Operating Slimes Dams

ERPM operates one metallurgical plant, i.e. the Central Reduction Works (CRW) which treats two feed stocks viz. underground (90 000 tpm) and surface sand dumps (185 000 tpm).

The metallurgical plant residue is repulped with HDS water to a solids content of approximately 50% and then pumped with the HDS plant sludge to the slimes dam. Four slimes dams are situated between the Elsburg Dam and Cinderella dam. These slimes dams are called Elsburg Slimes dam No's 1 - 4. No. 2 is no longer in use.

Water is decanted from the slimes dams and returned to the metallurgical plant process.

3.1.3 Underground water circuits

Service water from the underground working stopes settle underground. The overflow is pumped to Hercules Shaft and then to surface where it is discharged into Angelo pan.

The Central Witwatersrand compartment is dewatered by pumping water via the SWV Shaft to the HDS plant for neutralisation.

3.2 DESCRIPTION OF WATER TREATMENT / MANAGEMENT SYSTEMS

3.2.1 Metallurgical plant

The main water sources for the metallurgical process plant are Angelo pan and return water from the slimes dam. The remainder is made up of Rand Water and moisture content in the ore.

After milling and leaching, the leach product is filtered with rotary drum filters. The filtrate is put through a conventional gold recovery process which discharges zinc precipitation and filter cake. This filter cake contains approximately 25% moisture by mass. It is then repulped with HDS water to approximately 50% solids content by mass (relative density of 1,45). This slurry is then deposited on the slimes dams.

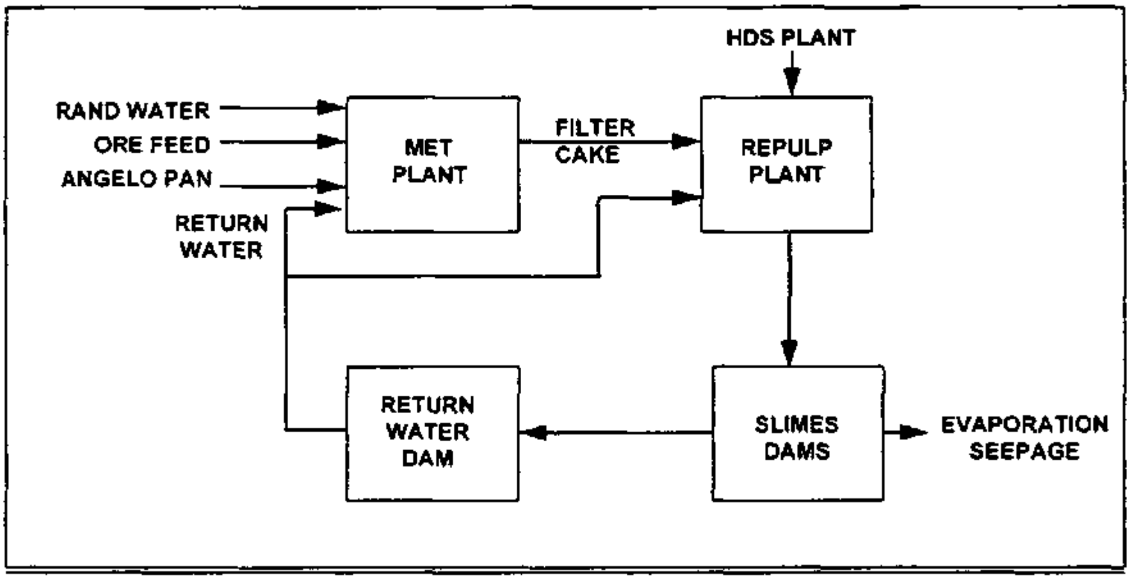

Figure 1 : Metallurgical plant and slimes dams water flow diagram

Plant spillages are collected in internal sumps and pumped back into the plant circuit to prevent gold loss and pollution. Runoff water from the plant is cut off in trenches and then pumped back into the plant if it is gold bearing, or redirected to the evaporation ponds on the southwestern side of the plant area. At the time of the site visit these evaporation ponds were dry.

No specific water treatment is currently applied for the metallurgical process water requirements. Where water quality can have a negative effect on the equipment or gold recovery process, the Rand Water supply is used, e.g., gland service water.

During the site visit to the plant the pH and conductivity of two points were measured.

Point Description	pH	Conductivity (mS/m)
Combined thickener overflow	13,3	804
Cutoff containment trench	12,8	340

3.2.2 Slimes Dams

As already mentioned, ERPM utilises four slimes dams for slimes depositing. No. 2 dam is, however, dormant and it is planned to vegetate the top surface in the near future.

The technique employed to operate and construct the other three dams is the ring dyke system. The rate of rise is maintained below the accepted norm of 1,5 m per annum. The outer perimeter dam walls are constructed during the day and at night the slime is deposited in the beach area of the slimes dam.

Water is decanted from the beach pool through the penstock to the return water dam. For stability purposes the water volume and pool area is kept as low as possible. This operational practice serves to control the phreatic surface and minimise the seepage into the groundwater systems underlying the deposit.

Inflows to the slimes dam water balances are as follows:

- Slime pumped from the processing plant is deposited on the impoundment area at a liquid to solids ratio of 1:1 by mass. The full capacity for slimes depositing is 12600 tonnes/day and 10 000 tonnes/day is currently deposited.
- rainwater during the rainy season falls onto the top, the sides of the dam and the toe paddocks
- irrigation water to establish the vegetation

Outflows are as follows:

- evaporation from the dam area
- interstitial retention
- seepage into the underlying soil and groundwater, depending on the geology and permeability of the underlying layers
- water decanted off the pool and berm areas via penstocks is conveyed to the return water dam via a network of seepage trenches, pipes and intermediate holding/settling dams

- water from the underdrains is also conveyed to the return water dam, from where all process water is pumped back to the metallurgical plant.

Runoff catchment paddocks at the toe of every dam serve to retain any eroded side slope silt and runoff. The water is either left to evaporate or is decanted off into the seepage trenches.

Seepage trenches are constructed around the outer paddock walls and are maintained on an ongoing basis to prevent blockages caused by silt or vegetation growth.

Stormwater cutoff and diversion trenches are constructed on the outer perimeter of the seepage trenches, to prevent stormwater from being contaminated with process water.

These trenches are usually only constructed where the topography slopes towards the slime deposits.

3.2.3 Underground Visit

An underground visit to SEV K Shaft to working stope 80 West No.1 and the settlers at 68 level K1 shaft was undertaken and Figure 2 shows the layout for the levels visited.

3.2.3.1 Working Stope

The following water samples were monitored in the stope:

Point Description	pH	Conductivity (mS/m)	Temp °C
Service Water	5,1	95	30
Water from drill hole	4,2	98	33
Water in strike gully	4,8	128	33

These readings indicate the deterioration of the water quality due to mining activities in the stope. The pH decreases due to the reaction of the water (usually with sulphide minerals such as pyrite), and conductivity increases simultaneously due to the dissolution of the minerals.

3.2.3.2 Settlers

The settling system at 68 level receives the dirty water from the stopes where it is delivered in a dirty water launder which then feeds the separate settlers. This very old system uses old technology and each settler is basically a horizontal dam (20 - 30m long), excavated into the rock.

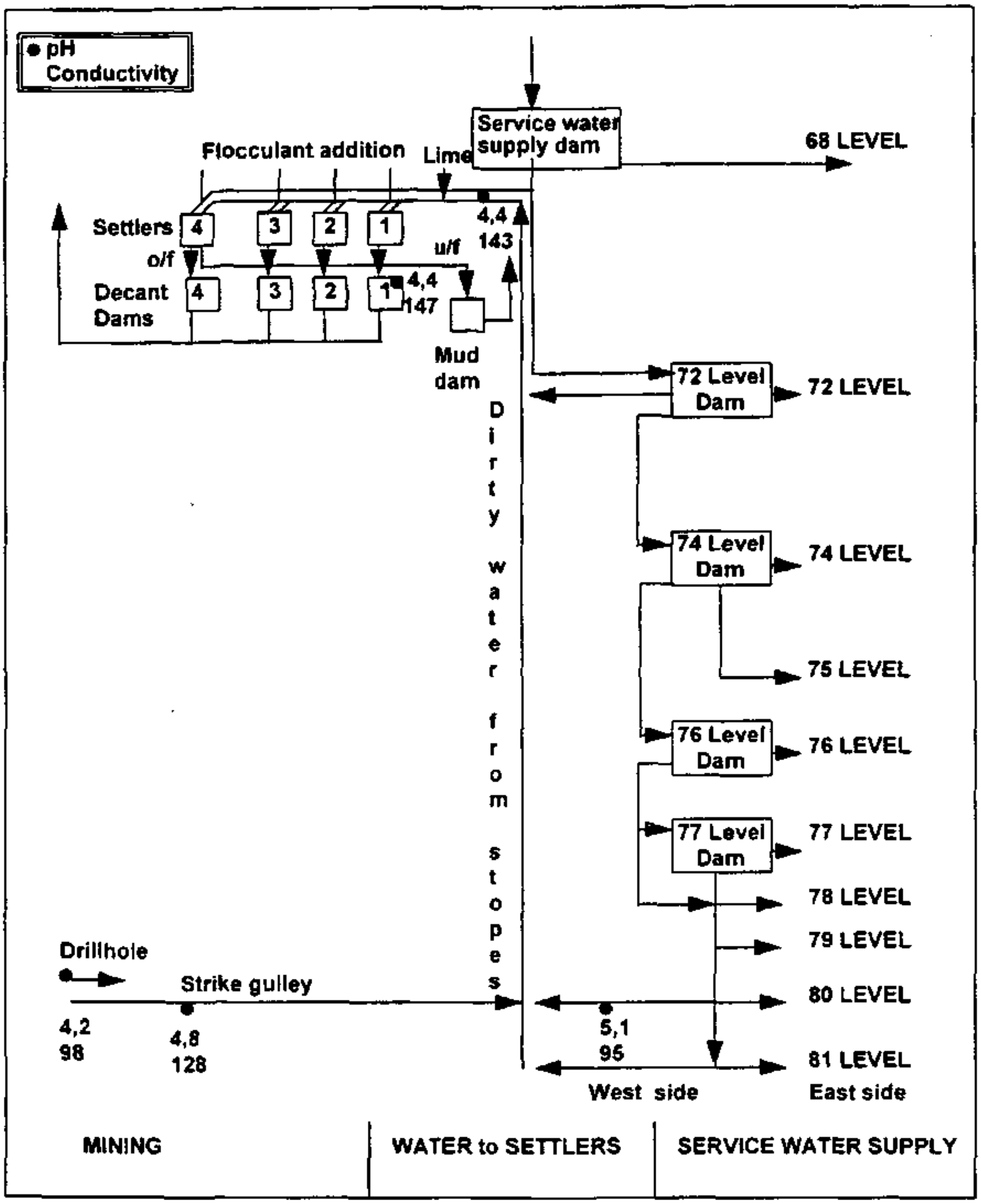

Figure 2 : Diagram showing the underground service water and settler systems for 68 to 81 level K1 Shaft

The following water samples were monitored at the settlers:

Point Description	pH	Conductivity (mS/m)
Dirty water in launder before lime addition	4,4	143
Overflow	4,4	147

The operating procedure is as follows:

- neutralisation with hydrated lime in the dirty water launder
- flocculation of dirty water in launder
- feeding dirty water into settler
- desludging of settler into mud dam
- overflow from settler system to decantation dams

3.2.3.3 Neutralisation

A 50 kg bag of lime/shift is added to the dirty water launder. The bag is cut open and put into a 50 ℓ drum where water is constantly added with a hose to flush the diluted lime slurry into the dirty water launder. The pH is checked by the operator by way of a portable pH meter. This gives him an indication whether to increase or decrease the addition of lime. A pH probe and meter was installed but due to the daily cleaning of the probe and the cost involved to replace the broken probe, it is no longer used.

3.2.3.4 Flocculation

A diluted flocculant solution is fed, always at a constant rate, to the dirty water launder at addition points, just before entering the settlers. This flocculant solution is made up on an hourly basis by adding 2 - 4 small containers (old coffee tin) of flocculant to the flocculant makeup tank, before topping up the tank with water. The tank is permanently agitated with compressed air.

3.2.3.5 Launder Distribution System

Starting at the main launder, every settler is fed via a T off launder which is fitted with a plate to control the flow or to close the settler off.

3.2.3.6 Desludging

Every settler is equipped with a desludging pipe and valve. The valves are opened every 10 minutes to drop the thickened sludge into the sludge launder feeding the mud dam. The relative density of the underflow is checked with a mass balance and the operator attempts to keep it at a value of 1.6.

3.2.3.7 Overflow from settlers

The overflow from the settlers gravitates into a decantation dam from where it is pumped to surface.

3.2.3.8 Chilled Water (SEV section)

Chilled water is provided to the underground workforce by cooling the water in underground fridge plants. Rand Water is used as makeup for the system and coil coolers are used close to the stopes for final cooling before it is used in the stopes. The chilled water is disinfected by adding four HTH booster tablets to the makeup tank every two and a half weeks. During the visit the chilled water measured at the cooling plant on 68 level had a pH of 9,1 and a conductivity of 28 mS/m at 10°C.

Samples to check the effectiveness of the disinfection treatment are sent to the South African Institute for Medical Research every six months.

3.2.4 Surface Water Systems

It should be noted that the site visit took place during July and the values and conditions which were observed were obviously applicable to winter conditions.

3.2.4.1 Slimes Dams and surrounding areas

Figure 3 shows the sampling points and results obtained during the site visit around the slimes dams, including Boksburg Lake, Cinderella Dam and Dixiespruit, on the eastern side of the slimes dams.

The base flow for the system is the water feeding the Boksburg Lake which measured a pH of 8,6 and conductivity of 63 mS/m. The water quality changed to a pH of 7,9 and a conductivity of 72 mS/m downstream of the lake. The water quality in Cinderella Dam before it overflows into the Dixiespruit was measured at a pH of 6,6 and conductivity of 61 mS/m. The water quality in the Dixiespruit changed to a pH of 5,7 and a conductivity of 383 mS/m at the N17 road bridge. Downstream of the return water sumps at the Heidelberg Road Bridge, the water in the Dixiespruit changed to a pH of 10,2 and conductivity of 222 mS/m.

These results indicate a deterioration in water quality in the Dixiespruit, downstream of Cinderella Dam. This is possibly due to the effect of diffuse seepage from slimes dams No. 2 and 4. Various points were measured between No. 2 dam and Cinderella dam / Dixiespruit, and the pH readings ranged from 3,4 to 6,0 and the conductivity from 364 to 596 mS/m, indicating the possible presence of acid mine drainage.

East of the No. 4 slimes dam the pH value measurements ranged from 8,3 to 11,3 and the conductivity from 412 to 434 mS/m. This quality has a major influence on the Dixiespruit water quality downstream of the return water dam, as a pH measurement of 10,2 indicated.

On the western side of the slimes dam the Elsburg spruit flows south and Dixie spruit joins it downstream of No. 4 slimes dam.

A pH of 6,2 and a conductivity of 326 mS/m was measured at the Elsburg Dam wall. The dam overflows into the Elsburgspruit. Downstream of the dam wall a stream flowing from the east joins the Elsburgspruit. This stream contains the overflow from the Victoria Lake and industrial effluent and measured a pH of 6,7 and a conductivity of 104 mS/m. The stream has a diluting effect on the Elsburg Dam overflow and thus a conductivity of 282 mS/m was measured downstream.

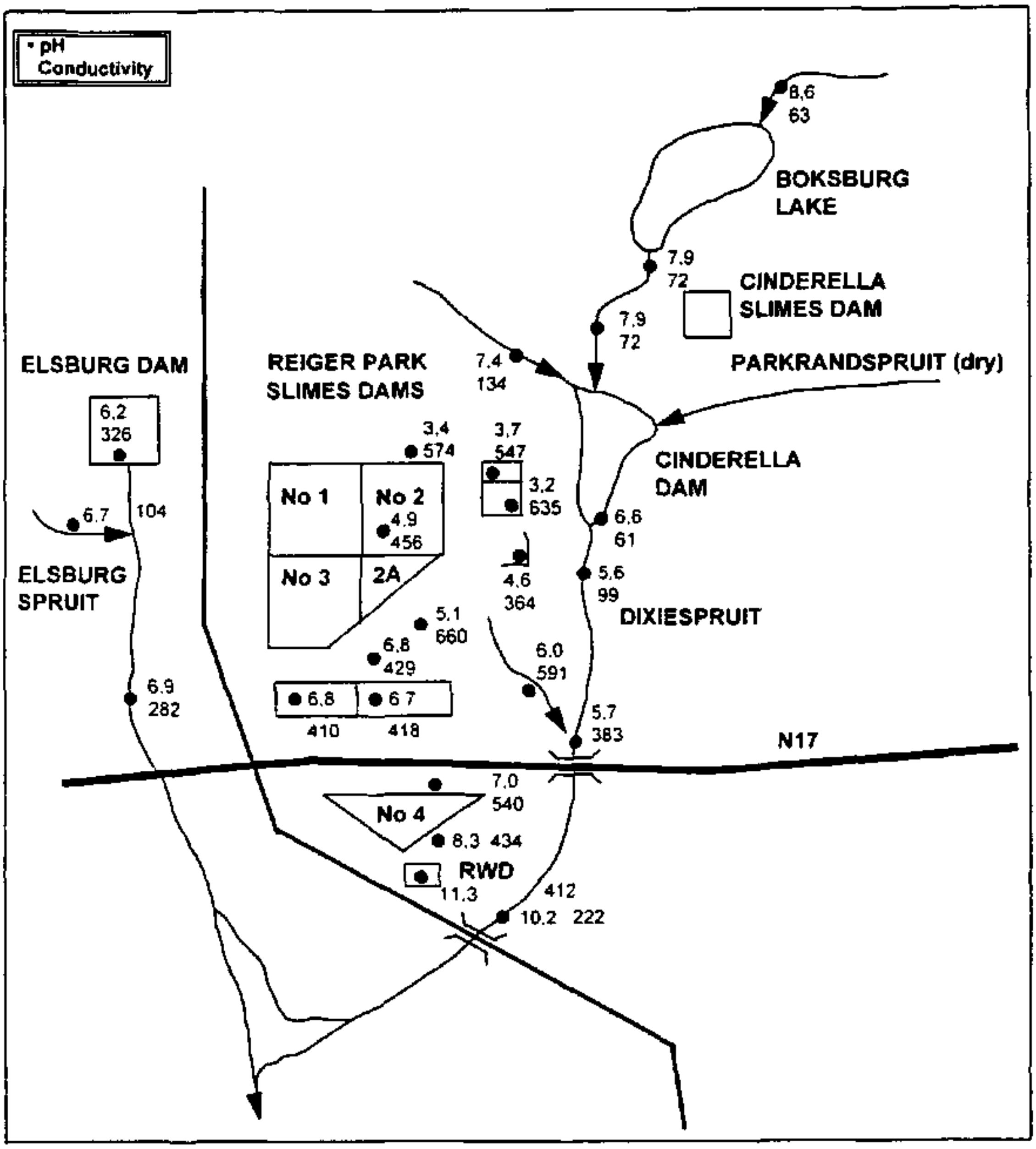

Figure 3 : Sampling points and readings obtained during the site visit around the slimes dam complex.

3.2.3.2 *Surface area north of slimes dam complex*

Figure 4 shows the layout of the surface water systems north of the slimes dam complex. On the western side a large wetland area collects stormwater runoff and seepage from the slimes dams situated to the west and east of the wetland.

During the site visit this area was dry. A stagnant pool, below the lower Boksburg Road bridge measured a pH of 5,9 and a conductivity of 300 mS/m.

Effluent from the HDS plant joins the outflow from the wetland and flows into Elsburg Dam.

In the centre of this area a settling or evaporation area is used to manage and accumulate seepage and runoff from the surrounding areas, which includes Wit Deep, Ginsburg slimes dams and the Angelo sand dump. A small volume of water had accumulated in this area. As indicated in Figure 4, industrial effluent from the Witfield area also flows towards this evaporation dam area with a measured pH of 6,9 and a conductivity of 107 mS/m.

Seepage and runoff from the Wit Deep Gold slimes dam measured a pH of 2,7 and a conductivity of 2150 mS/m and the stream from the Ginsburg slimes dam area had a pH of 5,3 and a conductivity of 225 mS/m.

The dam collects seepage and runoff from the Angelo Sand Dump and a pH of 2,9 and a conductivity of 752 mS/m was measured.

All these streams collect in the big settling/evaporation dam which also on occasion, accommodates the overflow from the Angelo pan. A pH of 3,6 and a conductivity of 420 mS/m was measured on the southern side of the dam, which held a small volume of water at the time of the site visit. The outflow from this area is called the Walschesspruit which flows into the Elsburg Dam. The Walschesspruit water quality was measured downstream of the lower Boksburg Road bridge at a pH of 4,8 and a conductivity of 245 mS/m.

The old slimes dam on the immediate western side of the settling/evaporation dam is currently being removed by road trucks for reprocessing. This results in part of the pollution source being removed from the area, as the outflow from this dam flows via the slimes dam, and at certain points, collects seepage from the slimes dam. All the slimes dams in the vicinity will eventually be removed.

Many of the pollution problems in the vicinity originate outside ERPM lease area but eventually run through ERPM property. The area would benefit from a pollution control plan which would need to be developed by the owners of all the slimes dams in the area, as well as representatives of the community.

3.3 WATER MANAGEMENT STRUCTURE

The water management structure is shown in Figure 5.

The General Manager is the overall responsible person and the following line personnel report to him:

- Resident Engineer, responsible for monitoring and maintaining the underground water reticulation systems for the different shafts.
- Technical Services Manager, responsible for compiling the EMPR.

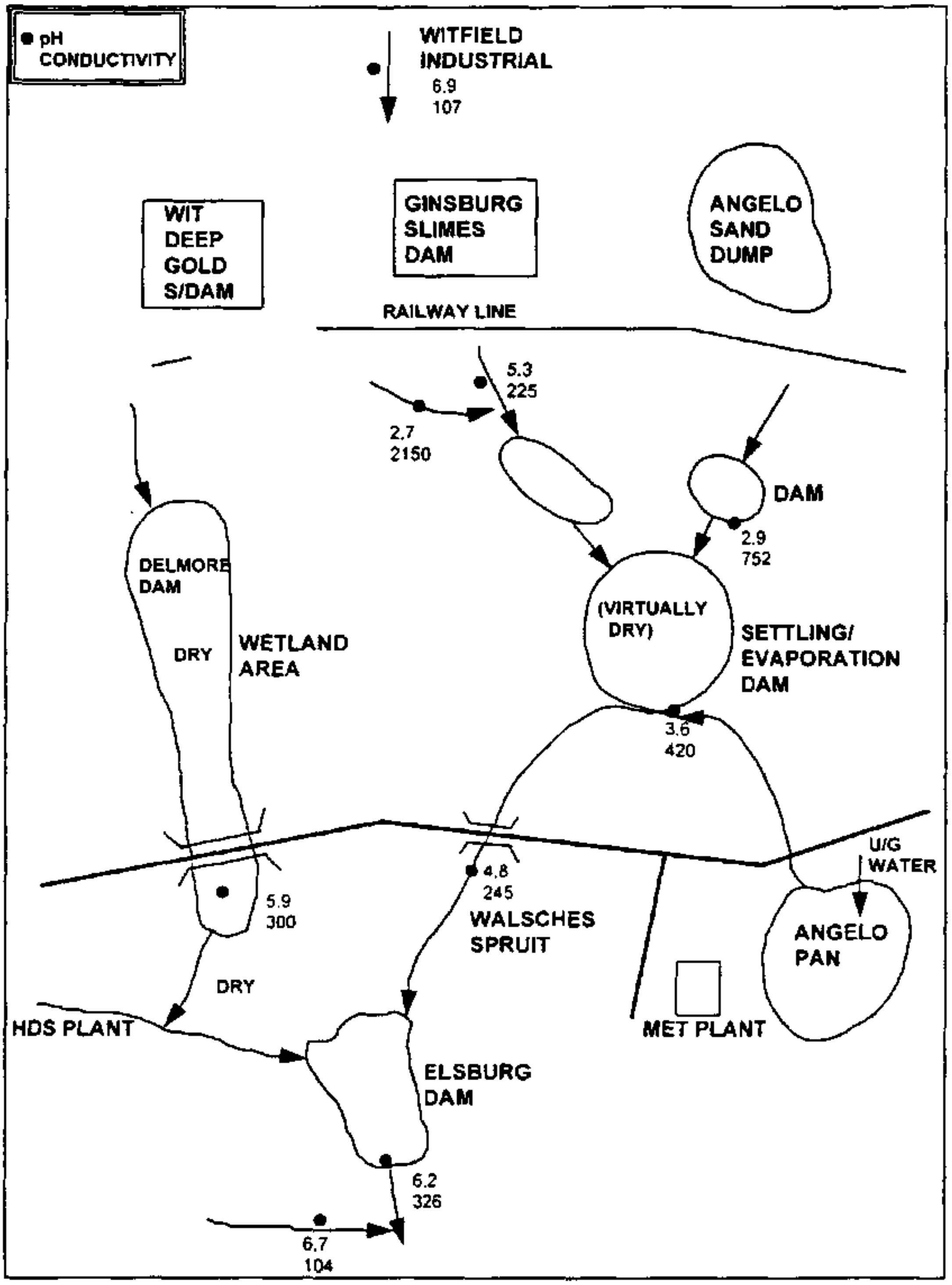

Figure 4 : Surface water systems north of the slimes dam complex.

- Environmental Consultants from Head Office, responsible for advice and interpretation of results.

3.4 NOVEL OR UNIQUE WATER TREATMENT AND MANAGEMENT SYSTEMS

3.4.1 Lime dosing system and high density sludge process

ERPM has to dewater approximately 30 Mℓ/day from the South West Vertical shaft to prevent flooding. The water has a low pH and a high iron content. In order to protect the dewatering pumps, slaked lime is delivered underground to be dosed before the water reports to the pumps. The lime slurry is prepared in a slaking plant on surface. Once on surface, the partially neutralised water is treated further in the high density sludge (HDS) process. This process is aimed at the removal of the iron content before discharge to the Elsburgspruit and Angelo Pan. The process consists of the following stages as shown in Figure 6.

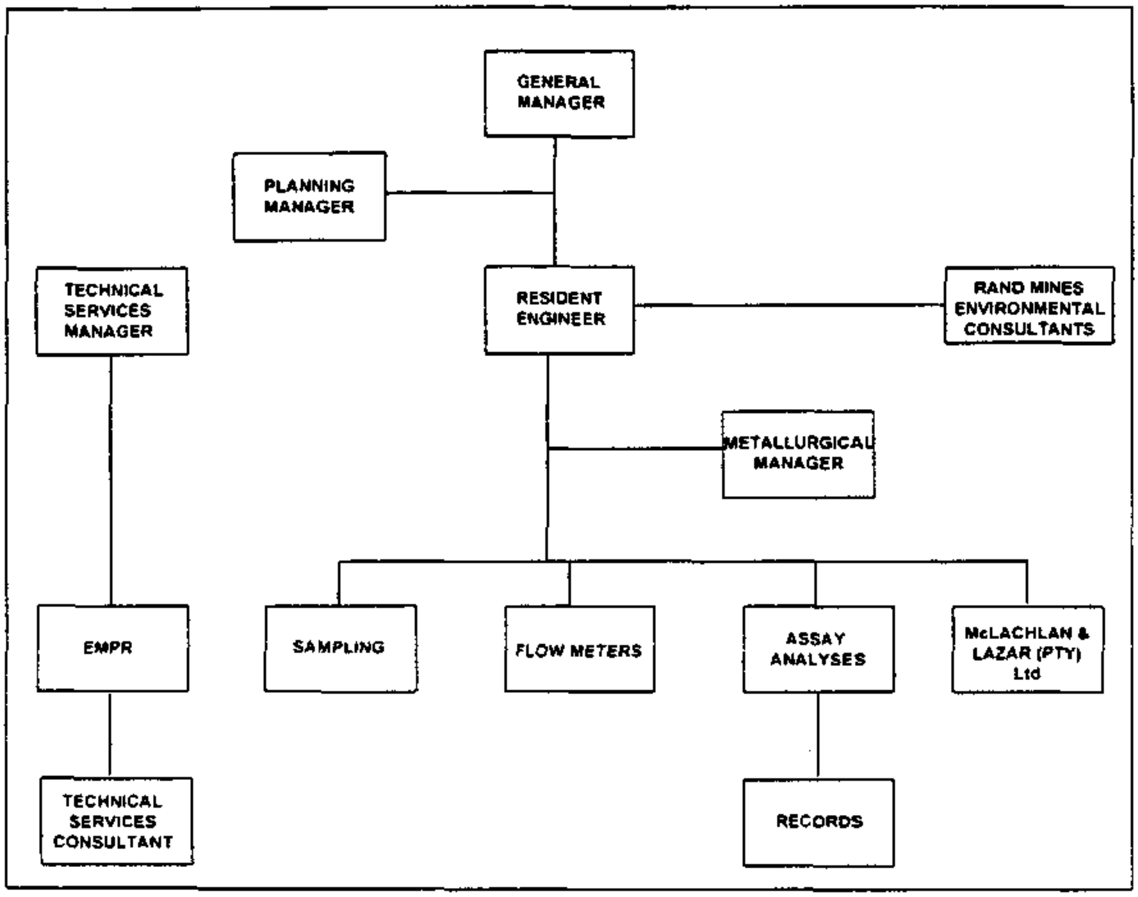

Figure 5 : Water management structure for ERPM

- further neutralisation with lime slurry to a pH of approximately 9,0
- aeration to oxidise Fe^{2+} to Fe^{3+}, which then precipitates as the metal hydroxide
- thickening and sludge recycle to increase the effective metal removal by the provision of precipitation nuclei.

The plant consists of the following components:

- Lime makeup tank
- Rapid mix tank for agitating the milk of lime with the untreated water
- Lime reactor for keeping the solids and precipitate in suspension, dispersing the air into the water, and contacting the air, water and solids.
- Flocculent mix tank
- Settler or clarifier system
- Sludge handling/disposal system

- Clear neutralised water pumping system

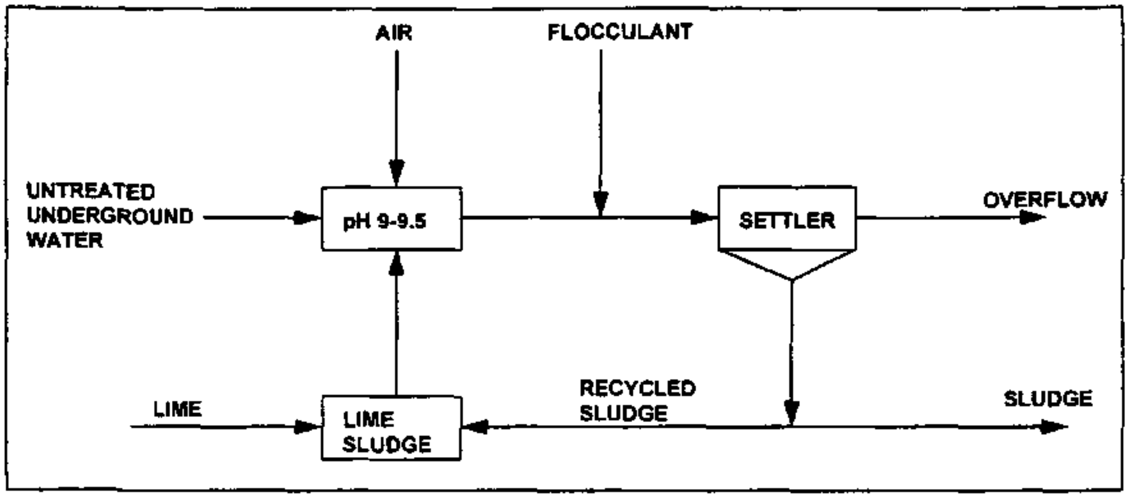

Figure 6 : Simplified High Density Sludge process flow sheet

At the time of the site visit the untreated water from underground measured a pH of 6,8 and the clear overflow from the settler a pH of 8,2. This is the only HDS plant in South Africa but the process is used successfully at various plants internationally.

3.4.2 Ice Plant

The depth of mining at the Far East Vertical shaft presents many challenges, particularly when it comes to cooling the underground environment. The necessary cooling medium is provided by a modular ice plant on surface. Each module has a capacity of 1000 t/day and four modules are operational.

The ice piped underground has five times the cooling capacity of chilled water. Each plant consists of 80 ice tubes which are divided into four modules. These modules freeze and defrost/harvest ice in sequence.

During the freeze mode, cold ammonia is circulated through the tubes and water cascades down and freezes on the outside of the tubes. Once sufficient ice has collected in the tubes, hot ammonia is circulated through the inside of the tubes, loosening the ice and causing it to drop into ice breakers. The crushed ice is then routed to the shaft area, via a system of screw conveyors, belt conveyor and a pipe to the shaft.

3.4.3 Size of the return water dam (RWD)

The size of the RWD south of No. 4 dam is very small for the surface area of the slimes dam being serviced. The use of an intermediate desilting dam in conjunction with the RWD is also unusual. This dam is used to remove some of the solids content of the penstock return water before the water is pumped from the RWD back to the metallurgical plant. The size of the RWD limits the holding capacity of the water and requires that the water be continuously pumped back to the plant.

3.5 POTENTIAL WATER TREATMENT/MANAGEMENT PROBLEMS AND NEEDS

3.5.1 Plant Area

Plant management is currently busy with the construction of containment walls around certain sections of the plant, to control and prevent spillages in these areas. These spillages are currently silting up the trenches which causes spillages to spread over larger plant areas. The cleaning up of spillage involves unnecessary time and labour.

3.5.2 Operating slimes dam

Diffuse seepage occurs along the eastern side of the slimes dam No. 2 and 2A. Figure 3 indicates the sampling points where seepage affects the Dixiespruit and Cinderella Dam. pH decreased from 6.6 to 5.6 and conductivity increased from 61 to 99 mS/m over a distance of 200m from the dam overflow.

Downstream the conductivity of the water in the Dixiespruit increased to 383 mS/m and seepage in the area measured a conductivity of 591 mS/m.

According to the plant personnel a water spring situated between No. 1 and 2 may be the reason for the continuous seepage in the area, as No. 2 has not been operational for a number of years.

If there is a spring in the area it will continue to pollute the surrounding water system as it would be the driving force for water flowing through oxidised slime, even after closure of the operation.

3.5.3 Settling/Evaporation Dam

The area north of the metallurgical plant accumulates seepage from the surrounding slimes dams and dumps. As indicated in Figure 4, seepage from the Wit Deep Gold slimes dam measured a pH of 2,7 and a conductivity of 2150 mS/m and a pH of 5,3 and a conductivity of 225 mS/m for the Ginsburg slimes dam. Industrial runoff from the Witfield area may be the driving force through the Ginsburg area and a pH of 6,9 and conductivity of 107 mS/m was measured. Seepage from the Angelo sand dump measured a pH of 2,9 and a conductivity of 752 mS/m.

All the water accumulates in the larger dam area which measured a pH of 3,6 and a conductivity of 420 mS/m. Water from this area may seep to the Walschesspruit which flows into the Elsburg dam. The Walschesspruit measured a pH of 4,8 and a conductivity of 245 mS/m downstream of the lower Boksburg Road.

Severe salt precipitation was observed around these settling/evaporation dams, which could mobilise during the rainy season and eventually report to the Walschesspruit.

The water balance around this area is important as it will give a better understanding of the inflow and quality into the area of the various streams and the outflow and quality from the area. The option of bypassing flow around the evaporation dam, to prevent the mobilisation of salts and collection of seepage, should be investigated. One such stream is the *industrial runoff from the Witfield area with a pH of 6,9 and conductivity of 107* mS/m.

3.5.4 Pollution caused by other mining activities

Various mining Groups have purchased almost all the old slimes dams and sand dumps on the ERPM lease area for reprocessing. In the interim these *poorly managed dumps pose a potential pollution problem.*

Pipe lines for pumping slurry through ERPM property to the ERGO plant also pose a potential pollution risk, should pipes leak or burst. This was observed during the site visit. It appears that spillages are detected fairly early and cleaning operations are well managed. Spillage paddocks were constructed on the eastern side of No. 2 slimes dam, to prevent spillage from entering Cinderella dam.

The large wetland area, Delmore Dam, on the western side, as shown in Figure 4, was dry during the site visit. Perhaps subsurface flows caused the stagnant pool to form underneath the road bridge which measured a pH of 5,9 and a conductivity of 300 mS/m.

Elsburg Dam is the receiving body for these existing and potential pollution problems. This is particularly problematic since Elsburg Dam is part of the public stream system. There are a variety of interested parties in the area and a management programme involving all these parties should be instituted. Responsibility for the pollution control of the old dumps needs to be defined and enforced.

3.5.5 Underground settling of dirty service water

The settler system visited at SEV shaft at 68 level K shaft is an old system and exhibits a number of problems :

- Lime addition: The current method of adding lime to the settler feed by flushing lime from a bag with running water in a 100 l drum, which overflows into the launder, is ineffective. The operator will also shake the bag to increase the lime addition a few times per shift. This means that the addition process is not continuous and that very little neutralisation is achieved. Another problem with this system is that the lime addition is not proportional to the flowrate and no extra lime is added during peak flow.

- pH control: The operator measures the pH with a portable pH meter which is not calibrated regularly. In addition, the point of pH measurement is too close to the dosing point which does not allow sufficient mixing and reaction time. The frequency of measurement is too low to allow adequate control.

- Flocculation system: Flocculant is made up every hour which is unnecessarily labour intensive. The flocculant dosage rate is not controlled with respect to the feed water flowrate and there is only one dosing point per settler. The sub launder to the settler is approximately 2 m long which is insufficient for initial mixing and floc formation.

- Flow distribution to settlers: The settlers are currently used in a semi batch manner, as all the flow is directed to only one or two settlers at a time, while the other two are emptied and cleaned. This situation implies that almost no flow distribution of the dirty water occurs and that the settler in operation must treat the full flow.

- Desludging: This is done every 10 minutes when a sludge with a relative density of 1,6 is drawn off into the mud dam for pumping to Hercules Shaft. This is time consuming and leaves the operator with little time to manage the lime and pH control.

- Operation and supervision: It appears that the system, although old, is poorly managed. There is insufficient control and supervision. The operators are badly trained and have no user friendly measures of the settling performance.

Appendix A - List Of pH And Conductivity Readings Taken During The Site Visit

During the site visit, a number of pH and conductivity readings were taken at various locations on the mine.

No	Monitoring Point Description	pH	Cond. (mS/m)
S1	Combined thickener overflow	13,3	804
S2	Cut off containment trench	12,8	340
S3	Return water dam	11,3	412
S4	Dixie spruit at Elsburg Road	10,2	222
S5	Seepage drain along SE side of No. 4 slimes dam	8,3	434
S6	Seepage drain along N side of No. 4 slimes dam	7,0	540
S7	Intermediate/settling dam at No. 3 slimes dam	6,8	410
S8	Seepage water into intermediate dam	6,7	418
S9	Seepage water into intermediate dam	6,8	429
S10	Seepage water ex gully between No. 2 and 3 slime dam	5,1	660
S11	Dixie spruit at N17 water stagnant	5,7	383
S12	Seepage to Dixie spruit from No. 2 slimes dam area	6,0	591
S13	Angelo Dam	6,3	367
S14	Cinderella Dam	6,6	61
S15	Steam below Cinderella Dam	5,6	99
S16	Seepage from No. 2 slimes dam to Cinderella Dam	3,4	596
S17	Little dam on E face of No. 2 slimes dam	4,6	364
S18	Return water sump on NE corner of No. 2 slimes dam	3,2	635
S19	2nd Return water sump on NE corner of No. 2 slimes dam	3,7	547
S20	Seepage from NE corner of No. 2 slimes dam	3,4	574
S21	Seepage from No. 2 slimes dam in gully between No. 1 & 2	4,9	456
S22	Water from u/g to HDS plant	6,8	355
S23	Thickener feed	8,8	343
S24	Thickener overflow	8,2	371
S25	Boksburg lake inflow NE side	8,6	63
S26	Downstream of overflow weir	7,9	72
S27	Water stream downstream of Cinderella slimes dam	7,9	72
S28	Runoff water from Reiger Park into Cinderella dam	7,4	134
S29	Evaporation/settling pan N of Commissioner Street	3,6	420
S30	Evaporation pan S of Angelo Dump and Railway line	2,9	752
S31	Stream from Ginsburg slimes dam direction to evaporation pan	5,3	225
S32	Stream from S/dam on W side to evaporation pan	2,7	2150
S33	Watschesspruit at Lower Boksburg Rd bridge from evaporation pan	4,8	245
S34	Wetland water pool area to W at next bridge (stagnant)	5,9	300
S35	Elsburg dam water measured on S side at dam wall	6,2	326
S36	Water stream from west joining Elsburg spruit (Victoria Lake)	6,7	104
S37	Elsburg spruit south of Elsburg	6,9	282
S38	Effluent stream south of Witfield Industrial Area	6,9	107
	Underground Stope Visit		
U1	Service Water	5,1	95
U2	Water from drill hole	4,2	98
U3	Water in strike gully	4,8	128
U4	Fridge plant on 68 level	9,1	28
	Underground Settlers on 68 level		
U5	Dirty water in launder before lime addition	4,4	143
U6	Overflow	4,4	147
U7	Decantation Dam No1	4,2	106

Appendix B - List of Photographs

During the site visit, a number of photographs were taken at various locations on the mine

Photograph No	Photo Subject Description
1	Central Plant Thickener
2	Return Water dams
3	Dixie spruit at Elsburg Road
4	Toe paddocks at No. 4 slimes dam
5	Vegetated side slope of No. 4 slimes dam
6	Seepage drain along SW side of No. 4 slimes dam
7	Vegetated step in at No. 4 slimes dam
8	Intermediate/Settling dams south of No. 3 slimes dam
9	Seepage/drain water ex gully between No. 2 and 3 slimes dams
10	Seepage from No. 2 slimes dam to Dixie spruit
11	Cinderella dam
12	Stream below Cinderella Dam
13	Seepage from No. 2 slimes dam to Cinderella Dam
14	Return water sumps on NE corner of No. 2 slimes dam
15	Seepage and precipitated salts at NE corner of No. 2 slimes dam
16	Gully between No. 2 and 1 slimes dams
17	Preparation of side slopes prior to vegetation
18	Seepage from No. 2 in gully
19	Seepage from No. 2 in gully
20	Agitation of u/g water after lime addition at HDS plant
21	HDS plant thickener
22	Spray water at top of ice forming tubes
23	Outside of ice tubes
24	Conveyor transporting ice product from plant
25	Conveyor transporting ice product from plant
26	Measuring water quality in stope
27	Measuring water quality in dirty water launder
28	Drop valve and launder for underflow sludge removal at settlers
29	Grid to remove coarse material from sludge
30	U/g cooling plant
31	Boksburg lake overflow water downstream of weir
32	Salt precipitation from Cinderella slimes dam
33	Downstream of Cinderella slimes dam
34	Evaporation/settling pan N of Commissioner Street
35	Salt precipitation on edges of pan
36	Smaller evaporation pan S of Angelo Dump and Railway Line
37	Two effluent streams upstream of evaporation pan
38	Closer picture of precipitate forming as two effluent streams blend
39	Effluent stream from Wit Deep Gold Dump direction
40	Watschesspruit upstream of Elsburg Dam
41	Elsburg Dam
42	Water stream joining Elsburg spruit from West (Victoria Lake)
43	Effluent stream south of Witfield Industrial Area

Report on Hartebeestfontein Gold Mine Co. Limited Site Visit.

11 - 13 October 1994

1. GENERAL INFORMATION

Name of mine	Hartebeestfontein Gold Mine Co. Limited
Name and position of person(s) interviewed	Messrs F Smit - Plant Manager G Wendell - Radiation Superintendent R du Preez - Relieving Environmental Engineer H Rust - Sectional Environmental Officer K Jefferies - Sectional Engineer (Technical Services) P Volschenk - Mechanical Engineering Foreman (6 Shaft)
Nearest town	Stilfontein
Name of catchment	Middle Vaal River
Monthly tonnes mined	380 000 tonnes per month
Monthly waste rock dumped	20 000 tonnes per month
Monthly tonnes milled	260 000 tonnes per month from underground sources 160 000 tonnes per month from reprocessing waste rock dumps
Main product - Gold monthly production:	
Gold	2 500 kg/month
Uranium	22 - 25 tonnes per month
Sulphuric acid	12 000 tonnes per month
Current age of mine	45 years
Expected remaining life of mine	10 - 16 years
Reef being mined and stope width	Vaal Reef - 1,24m
Current Mining Methods	Cave Mining
Has an EMPR already been produced by the mine?	Yes, draft EMPR has been submitted

2. SITE VISIT PROGRAMME

2.1 Day 1 - 11 October 1994

- Arrival at mine's main offices
- Short discussion on project background, objectives and site visit programme
- Present:
- R Du Preez - Relieving Environmental Engineer
- H Rust - Sectional Environmental Officer
- G Wendell - Radiation Superintendent
- J Laas - PHD
- A discussion and orientation of surface water pollution control systems covering the entire Hartebeestfontein Gold Mine with the aid of a surface plan, including all shafts, tailings dams, metallurgical plants and hostels.
- Guided tour of the surface water systems by Mr K Jefferies, Sectional Engineer (Technical Services), which included the following: surface filter plant for the treatment of underground water for dewatering purposes and blending with regional water (domestic water) which is distributed throughout the entire mining area as potable water; 7-Shaft sewage plant; and the Margaret Shaft dewatering pump station for dewatering of the closed Stilfontein Gold Mine.

2.2 Day 2 - 12 October 1994

- Arrival at mine's main offices
- *Underground visit to a working stope at 77 level and the settler system at 78* level, guided by Messrs H Rust, P Volschenk and E Halgryn
- Guided tour of the metallurgical plant complex at 2 Shaft covering the gold, uranium and acid plants.
- Discussion on water management systems around the plant area and completion of the relevant sections of the questionnaire with the following parties: Messrs F Smit and G Wendell.

2.3 Day 3 - 13 October 1994

- Arrival at mine's main offices
- *A guided tour of the mine's tailings dam complex by Mr L Gilbert,* Metallurgical Supervisor (Acid Plant).
- Discussion on water management and water related problems at the acid plant complex with Mr G Muller.
- Visit to the uranium plant chemical laboratory to obtain the necessary water analyses
- Discussion on surface water sampling with Mr T Ferreira from the Industrial Engineering Department.
- Completion of questionnaire and collection of outstanding information with Mr R du Preez, Relieving Environmental Engineer.

3. DISCUSSION OF THE MINE'S CURRENT WATER MANAGEMENT AND TREATMENT PRACTICES.

3.1 DESCRIPTION OF WATER CIRCUITS

3.1.1 Water Reticulation Systems

Figure 1 is attached and shows the overall mine water balance and distribution systems as obtained from the mine's EMPR document.

The mine uses three sources of water, namely regional water, underground water from Stilfontein mine and Stilfontein municipal treated sewage effluent. The regional supply is pumped to three main reservoirs and distributed for potable water use and also plant operations which require a better quality water. Stilfontein underground water is pumped to surface to prevent flooding of the underground mining operations.

The underground water is pumped to surface at Margaret Shaft to the north east of Hartebeestfontein Gold Mine. 40 Mℓ/day is currently being pumped to surface, of which 20 Mℓ/day is either used for irrigation at the golf course or discharged into the Koekemoerspruit, which flows from north to south on the eastern side of the mine. The remaining 20 Mℓ/day is used in the mine water reticulation system mainly as process water in the low grade gold and uranium plants.

A portion of the underground water is also sent through a sand filtration plant situated north of the No. 2 Shaft metallurgical plant complex. Thereafter, the clarified water is disinfected with chlorine and pumped to the main reservoir, where it is blended with the regional water intake and used as potable water for domestic purposes throughout the mine complex.

Stilfontein treated sewage effluent is used in both the uranium and acid plants but the intake is reduced as a result of the Stilfontein underground water which is used as a more cost effective replacement.

3.2 DESCRIPTION OF WATER TREATMENT/MANAGEMENT SYSTEMS

3.2.1 7-Shaft sewage plant

The raw sewage from No. 2, 4, 5, 6, 7 & 8 shaft hostels is treated at the 7-Shaft sewage plant. This is the only sewage plant operated by the mine. The treated sewage effluent is pumped to a system of maturation ponds as the final stage, from where the water is sent to the 7-Shaft gold plant and for irrigation of the sports fields.

Raw sewage from the mine hostels is received at the sewage works. The larger solid material is removed by a coarse screen. The second stage in the process is the activated sludge aerators or the pasveer system. These two systems can either be used in series or parallel, depending on the flow to the

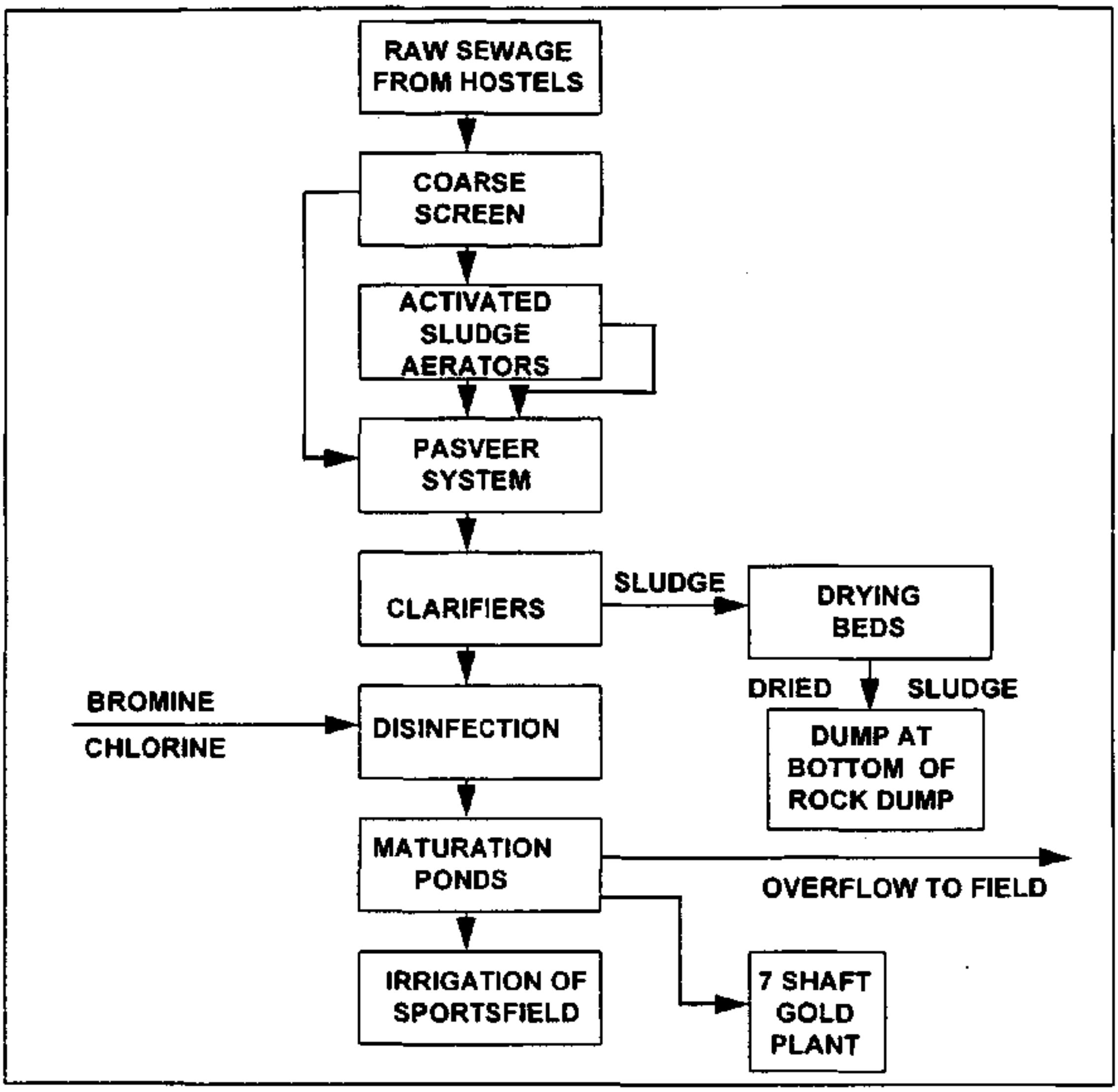

Figure 2 : 7 Shaft Sewage Plant Layout

plant. After aeration, the water goes to the clarifiers where the thickened sludge underflow is sent to drying beds. The dried sludge is dumped at the bottom of a rock dump and covered with waste rock. The overflow is disinfected by the addition of bromine and chlorine. Thereafter, the treated sewage is pumped to a series of six maturation ponds, in a cascade setup. Water is pumped from the final maturation pond to the 7-Shaft gold plant for use in the gold recovery process. This water is also used for irrigation of the sports fields. Spillage from the maturation ponds, which seldom occurs, runs into the open veld and is left to evaporate or seep away.

3.2.2 Plant residue depositing and return water system

The monthly production of plant residue is approximately 380 000 tonnes. The residue is deposited on the slimes dam complex which consists of six dams. Most of the plant residue is currently deposited on No.'s 5 & 6 dams. There are no cutoff or seepage trenches around the slimes dam complex, but evaporation paddocks are placed to control the runoff from the sides. The slimes dam complex is situated at the highest point of the mining area and consequently does not lie in any natural water course.

All the runoff and stormwater from the sides of the slimes dam is contained within the toe paddocks from where it evaporates. The penstock return water from No.'s 5 & 6 dams is piped around the southern side to the return water dams. These return water dams consist of four main dams of which No. 4 is an emergency dam. This is kept empty to ensure sufficient holding capacity in the event of a spillage. The penstock return water is received in No. 1 dam and overflows either to No. 2, but usually to No. 3 dam. The pump station is situated on the northern side and water is pumped back to the No. 2 Shaft metallurgical complex as return water for use in the process.

A portion of the northern side and the entire western side of No. 1 to 4 slimes dams have already been vegetated. All the slimes dams and evaporation dams are situated above the dolomite aquifer and are unlined. Drainage from these wet features occurs through the upper permeable soils and into the unconfined fractured network of the dolomite aquifer below. Spillage from the metallurgical plants and runoff from the watering of rock dumps also contributes to the overall artificial recharge and contamination of the dolomite aquifer.

The development of sinkholes on the surface are mainly the result of increased infiltration at surface features such as slimes dams, return water dams, spillages and leaking service pipelines. The occurrence of sinkholes has increased as a result of a dropping water table, which in turn is due to increased dewatering operations. Sink holes are usually small to medium in size. A contractor is employed to fill the sink holes. The entire area is first checked by drilling holes to gauge the extent of cavitation and each drill hole is then filled with cement.

Figure 3 shows the surface water features of the Hartebeestfontein Gold Mine and the sampling points measured during the site visits.

The return water from No. 5 & 6 slimes dams which is piped to the evaporation dams, measured a pH of 7,8 and a conductivity of 500 mS/m. The penstock return water from Nos. 1 to 4 dams measured a pH of 7,7 and a conductivity of 595 mS/m.

During the site visit it was observed that these two penstock return streams had a high content of suspended solids which resulted in the silting up of the trenches, especially the evaporation dams, thus reducing the holding capacity.

The penstock return water received in No. 1 dam overflows into No. 3 dam. The overflow into No. 3 dam measured a pH of 7,6 and a conductivity of 553 mS/m. A pump station to the north of No. 3 dam pumps water from No. 3 dam back into the No. 2 shaft metallurgical plant complex. No. 3 dam overflows into No. 4 dam and this overflow measured a pH of 7,4 and a conductivity of

618 mS/m. No. 2 dam is used as an emergency dam to control or prevent No. 4 dam from overflowing. When No. 3 & 4 dams are full, No. 1 dam overflows directly into No. 2 dam.

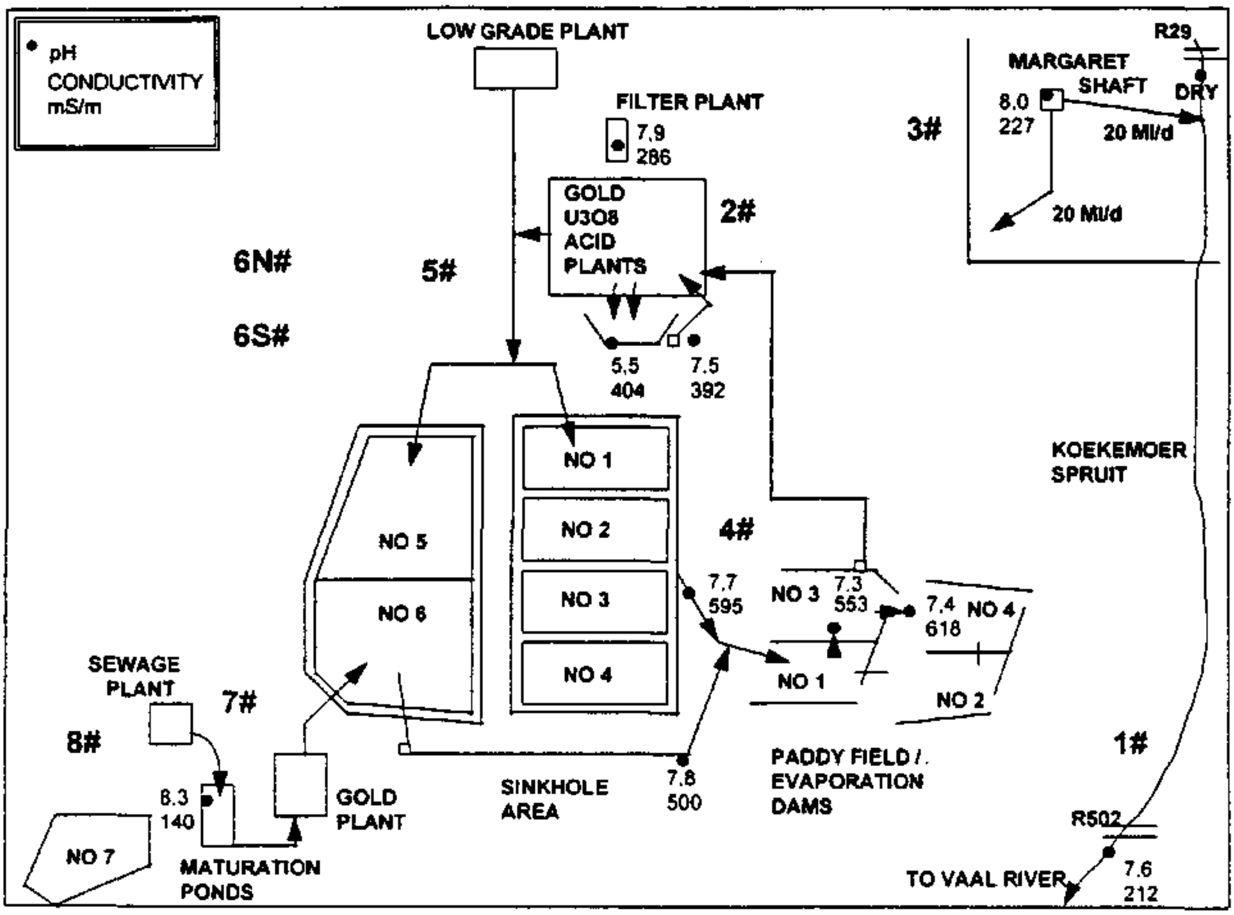

Figure 3 : Surface water layout and points sampled during the site visit.

It was observed that due to the evaporation of water from these dams, an increase in the dissolved solids content is reflected in the increased conductivity at No. 1 and No. 3 dams. The high suspended solids content in the feed water to No. 1 had silted up the dam significantly, reducing its holding capacity.

3.2.3 2-Shaft metallurgical plant complex

This complex consists of gold, acid and uranium plants and the plant residue is pumped out to the slimes dam complex, as discussed in Section 3.2.2. It was interesting to note that the pH of the outgoing slime is controlled at 8,5 which is lower than the normal gold plant residue. Gold extraction occurs at a pH of 11,5. This results from the mixing of the low pH barren water from the uranium plant with the gold plant residue. The pH of the outgoing plant residue is controlled at 8,5 which ensures a return water pH of approximately 7, as measured during the site visit. The return water pumped from the No. 3 evaporation dam measured a pH of 7,6.

All plant spillages from the gold, acid and uranium plants accumulate in internal sumps. When the sumps overflow or trenches are silted up, the spillages flow outside the plant border into a catchment dam situated to the south of the plant, from where the water is pumped back into the plant circuits.

The catchment dam is lined and the pH in the dam was measured at 5,5 and the conductivity at 404 mS/m. The previous day the water pumped back into the plant circuit measured a pH of 7,5 and a conductivity of 392 mS/m. This indicates that the pH and the water quality depends on which of the three plants discharged/spilled water into the catchment dam, before being pumped into the plant circuit. When spillages from the gold plant occur, the pH will be higher. Where spillages from the acid or uranium plant occur, the pH tends to be lower.

The low grade gold plant has its own spillage dams and plant spillages are recirculated back into the plant circuit, in much the same way as at No. 7 Shaft gold plant.

3.2.4 Surface Filter Plant

As indicated in Figure 1, Stilfontein underground water is pumped to surface. A portion of the underground water is used in the acid and uranium plants. The remainder of the water is treated through the surface filter plant north of the 2-Shaft metallurgical complex. This filter plant is a 2-stage upflow sand filtration process with an up flow direction. The filtered water is chlorinated for disinfection and then pumped to the 2 main reservoirs where it is mixed with Western Transvaal regional water and distributed throughout the mining complex as potable water for domestic use.

The filter plant operator checks the residual chlorine of the disinfected water on a daily basis with a portable test kit to ensure that the process is operating efficiently. The residual chlorine ranges between 0,1 and 0,4 mg/ℓ.

3.2.5 Margaret Shaft dewatering operation

Hartebeestfontein Gold Mine dewaters the Stilfontein Mine, which has stopped its mining operations, through Margaret Shaft. This is to prevent flooding of the Hartebeestfontein Mine's underground operations. The water is pumped to surface at approximately 40 Mℓ/day of which 20 Mℓ/day is pumped to the golf course for irrigation or discharged into the Koekemoerspruit, which flows into the Vaal River. The remaining 20 Mℓ/day is split between the uranium and acid plants and the balance treated through the surface filtration plant. After chlorination, this underground water is blended with regional water and, distributed throughout the mining system as potable water for domestic use.

3.2.6 Penstock return water

Hartebeestfontein Gold Mine operates a system of 6 slimes dams. Most of the plant residue is deposited on No. 6. All penstock return water from this complex is discharged in a system of evaporation dams situated on the eastern side of the slimes dam complex.

The evaporation dams consist of 4 separate interlinked dams. No. 1 overflows into No. 2 or 3 and eventually ends up in No. 4. Water from these evaporation dams or paddy fields can be pumped back to the 2 Shaft metallurgical plant complex for reuse in the process. Due to sink hole formation at the southern side of No. 6 slimes dam, the water is piped to the paddy fields, to prevent water spillages from causing sink holes in the dolomitic area.

3.2.7 Metallurgical plants

The mine operates 3 metallurgical plants. The main plant complex at No. 2 Shaft consists of a gold, acid and uranium plant. A gold plant is also operated at No. 7 Shaft. To the north of the mine a low grade plant treats old rock dumps for gold recovery. The main plant complex has its own spillage dam, situated to the south of the 3 plants. All spillages from these plants gravitate to a system of spillage sumps and catchment dams from where it can be pumped back into the operation for reuse in the extraction process.

3.2.8 Production shafts

Hartebeestfontein Gold Mine operates 6 production shafts, i.e. No. 2, 4, 5, 6, 7 & 8. Underground service water is utilised for these shafts and recirculated continuously. Regional water is supplied from the main reservoirs and used as makeup water to reduce the dissolved solids content or salt load in the overall water circulation.

The service water is cooled in the refrigeration plant and sent to the working stopes. The dirty water accumulates and gravitates to the settler systems where the solids content is separated and the sludge pumped to surface to the gold plants. The clear overflow is circulated back to the refrigeration plants for cooling and fresh makeup water added to control the water quality in the system.

3.2.9 Underground Water Reticulation System

3.2.9.1 *General layout*

The underground visit was conducted at No. 6 Shaft which consists of 2 vertical shafts, i.e. the southern and northern shaft. Figure 4 shows the underground water reticulation layout, the settling system at 78 level and the stope on 74 level.

Approximately 5 Mℓ/day is recirculated throughout this shaft water system. Water is cooled at the fridge plant at 74 level and is then distributed to the different working stopes from where the dirty water gravitates to the 4 Hudson Conical Settlers at 78 level. The solids content is then separated and the sludge pumped to surface. The clear overflow in the settlers is treated via 14 sand filters before the water is returned to the fridge plant and cooled for reuse.

Water is cooled at the fridge plant at 71 level. There are no service water fridge plant facilities at No. 7 Shaft. Some of the settler overflow water from No. 7 Shaft is pumped to the underground fridge plant at No. 6 Shaft for chilling and use at No. 6 shaft.

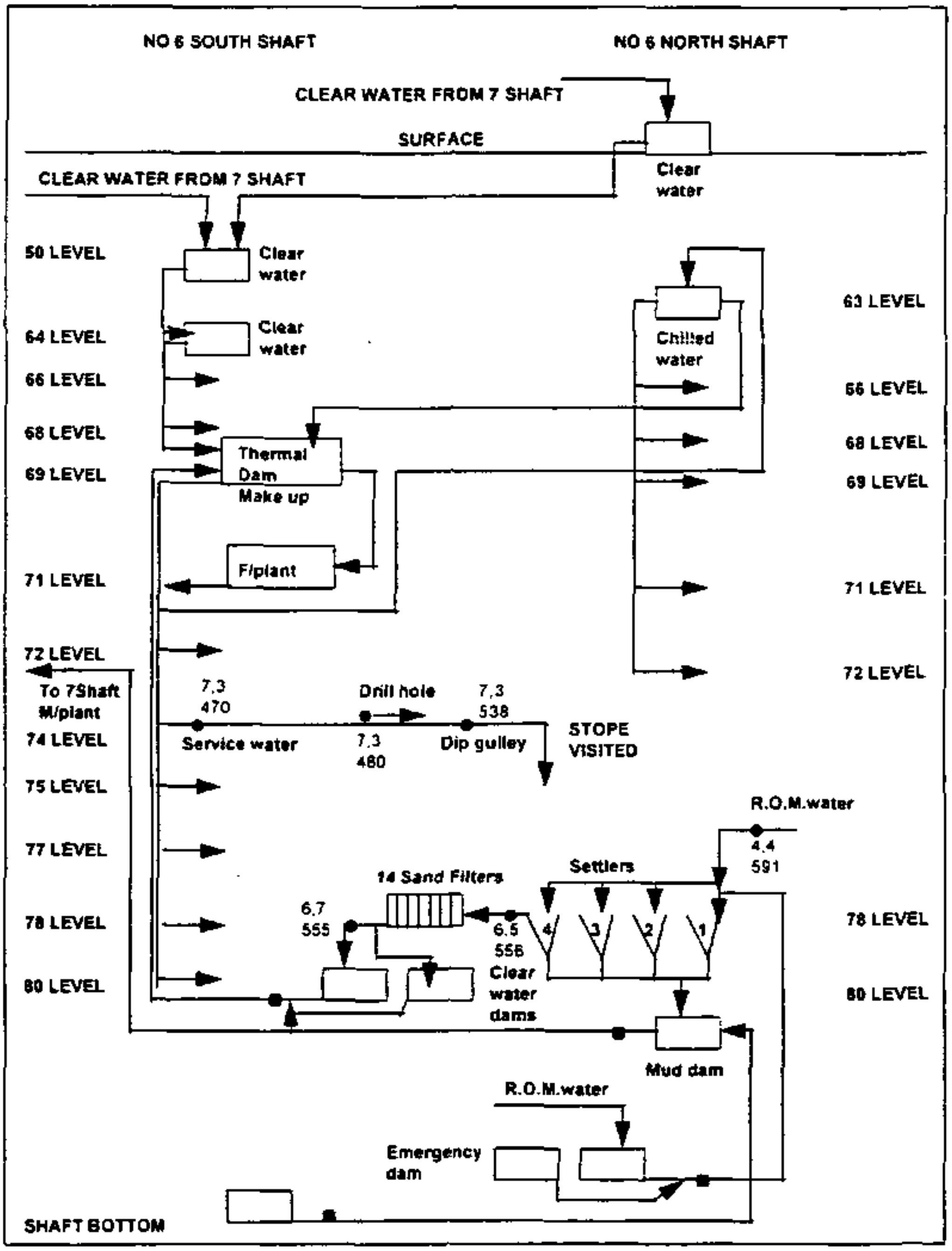

Figure 4 : No. 6 Shaft underground water reticulation system

The four Hudson conical settlers are used at 78 level to treat approximately 5 Mℓ/day. Each settler has a diameter of 6,7 meters and a rise velocity of < 2 m/h which falls in the category of conventional thickeners. Dirty water from the sections gravitates down to the settler system where it is neutralised. Neutralisation is done with the addition of soda ash made up in a holding tank. Approximately 100 bags/month are used at a cost of R47/bag. During the site visit dirty water, prior to neutralisation, measured a pH of 4,4, a conductivity of 591 mS/m and a temperature of 26,4 °C. After neutralisation, the dirty water measured a pH of 6,7 and a conductivity of 572 mS/m. Gel blocks are used for flocculation. These gel blocks are kept in wire baskets in the dirty launders and have proved very effective at this particular installation as indicated by the clear water overflow from the settlers.

The gel block consumption/month is approximately 370 kg at a cost of R500. The performance of the settlers was impressive, as evidenced by the overflow from the settlers which had a very low suspended solids content. The combined clear overflow from the settlers measured a pH of 6,9 and a conductivity of 562 mS/m. Disinfection of the clarified water is effected immediately after settling with the addition of BCH (containing both bromine and chlorine). Bromine consumption is 88 kg/month at a total cost of R2 100. Chlorine is added at 100 kg/month at a total cost of R800.

BCH is also added to the clear water after the water is clarified in the filter plant. The 5 Mℓ/day settler overflow is treated through 14 down flow sand filters which have an average flowrate of 200 m^3/hour. Thereafter the clear water is disinfected at the second dosing point upstream of the clear water dam before it is pumped back to the fridge plant at 74 level.

The settlers are desludged on a daily basis. The underflow valve is opened and the sludge flows down to the mud dam until it is clean. This is done on a daily basis for every settler in use.

3.2.9.2 *Underground stope visit*

A stope on 74 level was visited and the points measured and water quality are shown in the following table:

Monitoring Point Description	pH	Cond. (mS/m)	Temp (°C)
Service water to stope	7,3	470	14,3
Water from drill hole	7,3	480	19,6
Footwall water in dip gully	7,3	538	24,3

These measurements show the change in water quality caused by the mining operations, the pH was unchanged at 7,3 but the conductivity increased from 470 mS/m in the service water to 538 mS/m in the dip gully. This is due to the dissolution of cations and anions in the water increasing the dissolved solids and the electrical conductivity of the water.

3.2.9.3 Potable and process water supply

Personnel make use of the chilled refrigeration water system. The following process is followed in the supply of service water:

- Water is recirculated on a continuous basis;
- The cycles of concentrations are monitored and where necessary, fresh makeup water is added to prevent scaling or corrosion of the underground fridge plant systems.

3.2.10 Underground water monitoring programme

The settler and underground filter operations are monitored by sending samples twice a week for suspended solids analysis. Results vary between 10 and 15 ppm suspended solids. Water samples are also sent to the Duff Scott Hospital for microbiological analysis. Water samples are taken at the following points for this purpose at 6 shaft:

- 80 level clear water dam
- 80 level clear water pumps
- 78 level launder

These samples are analysed twice a week for E. Coli and total plate count. The environmental control department takes mine water samples on a quarterly basis and at No. 6 Shaft the following points are sampled:

- 50 level dam
- 50 level water from 7-Shaft
- 50 level main supply
- 68 level main supply
- 69 level main supply
- 71 level dam
- 71 level main supply
- 72 level main supply
- 74 level main supply
- 75 level main supply
- 77 level main supply
- 78 level main supply
- 78 level settlers
- 80 level dam
- 80 level main supply

The following analysis is done in duplicate:

- dust count
- pH

- total bacterial count
- E. Coli

Whenever persons from the environmental or ventilation department visit any of the mining work stations, water samples are taken for similar analysis, although not on a routine basis.

3.2.11 Surface water monitoring and sampling

The following water samples are analysed at the uranium laboratory on a monthly basis:

- Raw water from underground (Stilfontein dewatering)
- Regional water
- Domestic water from the reservoir

These three samples are analysed for pH, TDS, suspended solids, sulphates, chlorides, total hardness and manganese. This sampling program is not adequate to manage the surface water. The current samples only represent some of the water sources for the water balance. No effluent streams are monitored.

The industrial engineering department is responsible for surface water sampling, particularly at the reservoirs. The following samples are taken on a weekly basis and analysed for E. Coli. and total organisms:

- 2-Shaft East reservoir No 1,
- 2-Shaft West reservoir,
- water at the main offices canteen and
- 7-Shaft main reservoir.

No other surface water samples are taken as only the Koekemoerspruit passes through the mining area on the eastern side and the only water discharged into the Koekemoerspruit, is Stilfontein mine water pumped from underground. When this water is not used at the golf course for irrigation, it is discharged into the Koekemoerspruit. All other surface water systems are considered as a closed circuit and the water is recirculated continuously. The only way of polluting the water systems is via seepage to the ground water. All the boreholes in the area are currently being investigated and mine management will determine whether to monitor water samples from these boreholes or to drill more holes to monitor the ground water.

3.3 WATER MANAGEMENT STRUCTURE

Figure 5 shows the water management structure for Hartebeestfontein Gold Mine.

The General Manager is the overall responsible person and the following line personnel report to him: the Manager-Mining; the Engineering Manager; and the Metallurgical Manager.

The Technical Services Manager, the Production Manager-North and the Production Manager-South report to the Manager-Mining.

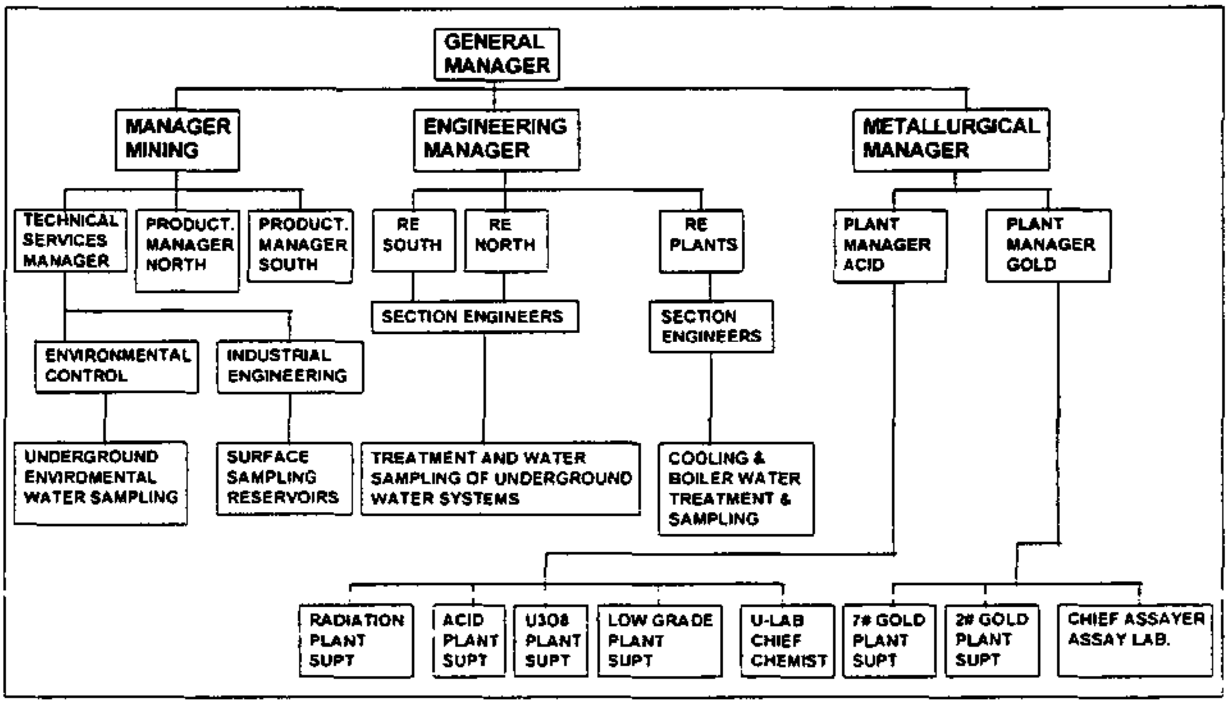

Figure 5 : Water Management Structure for Hartebeestfontein Gold Mine

The environmental control department and the industrial engineering department report to the Technical Services Manager.

The environmental control department is responsible for underground water sampling at all shafts and checking the water quality in terms of domestic use. These samples are taken on a quarterly basis at various points throughout each shaft.

The industrial engineering department is responsible for surface water sampling at the reservoirs which is done on a weekly basis. The Engineering Manager is assisted by the Resident Engineer South, the Resident Engineer North and the Resident Engineer for the Metallurgical Plants.

The Resident Engineers, through their engineering teams, are responsible for managing, water sampling and chemical treatment of the underground water systems, mainly at the underground settlers and fridge plants. The Sectional Engineers assist the Resident Engineers and are also responsible for cooling and boiler water treatment.

The Metallurgical Manager is assisted by 2 Plant Managers, 1 from the Acid Plant and the other from the Gold Plant. The latter are assisted by various plant Superintendents, responsible for the metallurgical processes which include water management.

3.4 POTENTIAL WATER TREATMENT/MANAGEMENT PROBLEMS & NEEDS

3.4.1 Slimes dams

At the time of the site visit it was observed that the penstock return water had a very high suspended solids content, causing problems in the trenches and paddy fields, silting up these systems and thereby reducing the holding capacity. This could cause problems during the rainy season. When contaminated rainwater ends up in these systems, it could cause the paddy fields to overflow and pollute public streams.

3.4.2 Metallurgical plants

The high salt load content as indicated by the high conductivity readings may influence the metallurgical processes and affect equipment like heat exchangers, causing scale formation or corrosion. This high concentration is caused by a high degree of recirculation. More fresh makeup water such as regional water or a another good quality water should be blended into the system, to replace the bleed off water and control the salt load. The return water from the paddy fields also has a high salt content because of the evaporation that takes place before the water is pumped to the plant. By pumping the penstock return directly from a small dam upstream of the paddy fields to the plant, and allowing the dam to overflow into the paddy fields, this concentration through evaporation of the return water can be minimised.

3.4.3 Filter plant

The surface filter plant is used to filter the water pumped from underground from Margaret Shaft. These filters are very old. Some of the sections are currently being renovated at a cost of R80 000/filter. It is essential that these systems are renovated to improve the filtration operation. For example, the sand bed in the empty standby filter was very badly disturbed and uneven which could cause short circuiting during the filtration and backwash steps. The sand also contained a high quantity of dirt showing that the backwash step is not effective. This results in a poor filtration rate.

Another problem is the fact that no samples are taken to monitor the filter plant's performance in terms of suspended solids removal. The filter plant product water quality is important as it is blended with regional water before it is distributed throughout the mining areas as potable water for domestic use.

3.4.4 Underground potable water supply

Personnel either make use of the chilled refrigeration water system or supply their own water for use underground.

3.4.5 Ground water pollution

Mine management is currently determining the possible use of existing boreholes to monitor ground water pollution. It may be necessary to drill more holes in order to monitor the groundwater quality effectively.

3.4.6 Monitoring of surface water systems

The few samples currently taken as the surface water program are inadequate and will have to be expanded to establish a system that covers all water sources and potential pollution sources.

3.5 NOVEL OR UNIQUE WATER TREATMENT & MANAGEMENT SYSTEMS

3.5.1 Disinfection of 7-Shaft sewage works effluent

A combination of bromine and chlorine are used to disinfect the clarified sewage effluent. The use of bromine is not common in the mining industry but the disinfection results are satisfactory.

3.5.2 Filling of sinkholes

The formation of small to medium size sinkholes to the south of No. 6 slimes dams was mainly due to penstock return water which sometimes overflowed the trench. Most of the sinkholes formed either alongside or inside the trench itself. Mine management uses a contractor to fill these sinkholes and to check the cavitation caused by the sinkholes in the entire area. When the sinkhole is formed, the hole is first filled with waste rock and then covered with topsoil. A whole matrix of drill holes are sunk around the sinkhole to check subsurface cavitation around the sinkholes. These drill holes are filled with cement, pressure tested and covered. This is done to stabilise the entire area and to prevent any new sinkhole formation.

3.5.3 Checklist for slimes dam and evaporation dams

Once a month the Acid Plant Superintendent, together with a representative from the slimes dam contracting company, visit the entire slimes dam complex and evaporation dams to check, with the aid of a checklist, the following items:

- the outer dam wall/daywall
- condition of walkways
- condition of penstocks
- condition of toe dams
- condition of catchment paddocks
- fences, access routes, etc.
- stormwater drains and trenches
- condition of vegetation
- condition of monitoring equipment

This information is utilised to identify problem areas and to ensure that the entire operation is managed according to the set standards. It also ensures active mine involvement although the daily operation is managed by the contractors.

3.5.4 Metallurgical plant and residue pH control

During the production of uranium a solution called the barren solution is produced at the uranium plant. This barren solution is not recirculated throughout the process but blended with the plant residue and deposited on the slimes dam complex. The pH of the outgoing plant residue is controlled at a pH of 8,5 by mixing the barren solution with the residue. Gold extraction occurs at a high pH of approximately 11. By controlling the pH at 8,5 the return water from the slimes has a pH of 7,0 which is ideal for the water reuse. The blending of the barren solution may cause the dissolution of other metals and compounds from the solids content in the plant residue which may in turn increase the dissolved solids content in the return water.

3.5.5 PLC System for underground water management

A PLC System has been installed at No. 6 Shaft for recording of flow and pH on a 24 hour basis. This makes the operation of the settlers and fridge plant and the overall water reticulation system much easier as the Mechanical Foreman can access the flow rates on the graphs produced by the PLC System over a 24 hour period. This serves as an early warning system as it highlights problem areas. Another interesting feature of this system is that it monitors the pump oil temperatures and thereby gives an early indication whether or not a pump overhaul is required.

3.5.6 Underground filters

After the solids are removed from the dirty water by the settlers, the clear overflow is treated through a set of sand filters. These sand filters remove all the excess suspended solids remaining in the settler overflow. This is a very unique situation and the first time in the survey that underground filter were used to reduce the suspended solids after settling. This serves to give extra pump protection.

Appendix A - List of pH and conductivity readings taken during the site visit

During the site visit, a number of pH, conductivity and temperature readings were taken at various locations on the mine:

No.	Monitoring Point Description	pH	Cond (mS/m)	Temp (°C)
1	Surface filter plant backwash water	7,9	286	-
2	Maturation ponds	8,3	140	-
3	Stilfontein mine water pumped to surface at Margaret shaft	8,0	227	-
4	Combined Gold, Uranium and acid plants spillage water			
	return to circuit from catchment dam	7,5	392	-
5	Koekemoerspruit downstream of HGM at R502 road	7,6	212	-
6	Koekemoerspruit upstream of HGM at R29 road	dry	dry	-
7	Combined penstock return water from No. 5 and 6 slimes dam	7,8	500	-
8	Combined penstock return water from No. 1-4 dam complex	7,7	595	-
9	Paddy field dam No. 1 at spillway	7,6	553	-
10	Paddy field No. 3 dam at spillway	7,4	618	-
11	Plant spillage catchment dam	5,5	404	-
	Underground Visit			
12	Service water to stope	7,3	470	14,3
13	Water from drill hole	7,3	480	19,6
14	Footwall water in dip gully	7,3	538	24,3
	Underground Settlers			
15	Dirty water in main launder before soda ash addition	4,4	591	26,4
16	Dirty water to No. 1 settler	6,7	572	26,9
17	Clear water from No. 1 settler	6,1	483	26,4
18	Clear water from No. 1, 2 and 3 settlers	6,9	562	-
19	Combined clear water after disinfection	6,5	556	26,5
20	Clear water after filtration to clear water dam	6,7	555	26,5

Appendix B - List of Photographs

During the site visit, a number of photographs were taken at various locations on the mine.

Slide No	Slide Subject Description
1	Clarified water from filter plant
2	Holding dam for filter plant backwash
3	Sand bed for filter section not in use at the time
4	Pasveer section of 7# sewage plant
5	Coarse screening of raw sewage
6, 7	Pasveer section
8, 9, 10	Disinfection of clarified sewage
11	Drying bed
12	Maturation ponds
13, 14, 15	Water pumped from underground at Margaret shaft
16	Soda ash makeup tank at 78 level 6#
17	Gel block basket in main launder
18	Main launder to settler system
19	Launder feeding No. 1 settler
20, 21	Overflow launder of No. 1 settler
22	Flash mixing through gel block basket
23	Combined clear water launder
24	Vortex formed in down pipe to feed settler
25	Cat walk to centre of settler
26	Main launder to settler No. 2
27	Clear water launder from No. 2 settler
28	BCH addition point of combined clear water
29	BCH makeup system
30	pH recording installation for PLC system
31	Flow reading installation for PLC system
32	Sand filtration system for treating combined settler overflow
33	Pipe for conveying settler underflow sludge
34	Shaft bottom
35	Pump chamber for pumping mud and clear water
36	Drilling underground to install strata control
37	Drilling at a slope face
38	Internal spillage sump and pump station at 2# gold plant
39	Water return from outside catchment dam to plant circuit
40	Koekemoerspruit downstream of HGM at R502
41	Koekemoerspruit upstream of HGM at R29 (dry.)
42	Air pollution taking place when dumping waste rock
43	Penstock return water piped and pumped to paddy fields from No. 5 and 6 slimes dam
44	Daywall building on southern side of No. 6 slimes dam
45	Cracks forming in dried out day wall top surface
46	Discharging plant residue on daywall paddock
47	Toe paddocks on south of No. 6 slimes dam
48	Rat hole damage repaired on No. 6 dam southern side wall
49	Return water trench from No. 6 dam not in use due to sinkhole formation

Appendix B - List of Photographs - continued

Slide No	Slide Subject Description
50	Sinkhole next to return water trench
51	Sinkhole from the top
52	Drill hole after cementation
53	Pressure testing of drill hole
54, 55	Waste rock dumped in sinkhole
56	Mixing of cement to fill drill holes
57	Cracks formed in soil due to underground cavitation
58	Drill machine in operation
59	Vegetation on western side of No. 1-4 dam complex
60	Vegetation on northern side of No. 1-4 dam complex
61	Preparation of side wall erosion trenches by labourers
62	Waste rock berm at dam toe removed to be treated through low grade met plant
63	Return water trench from No. 1-4 slimes dams
64	Return water from No. 5 and 6 slimes dams showing high SS content
65, 66, 67	Paddy field/Evaporation dams
68	Paddy field No. 3 dam overflowing to No. 4
69	Spillage catchment dam south of No. 2# metallurgical complex

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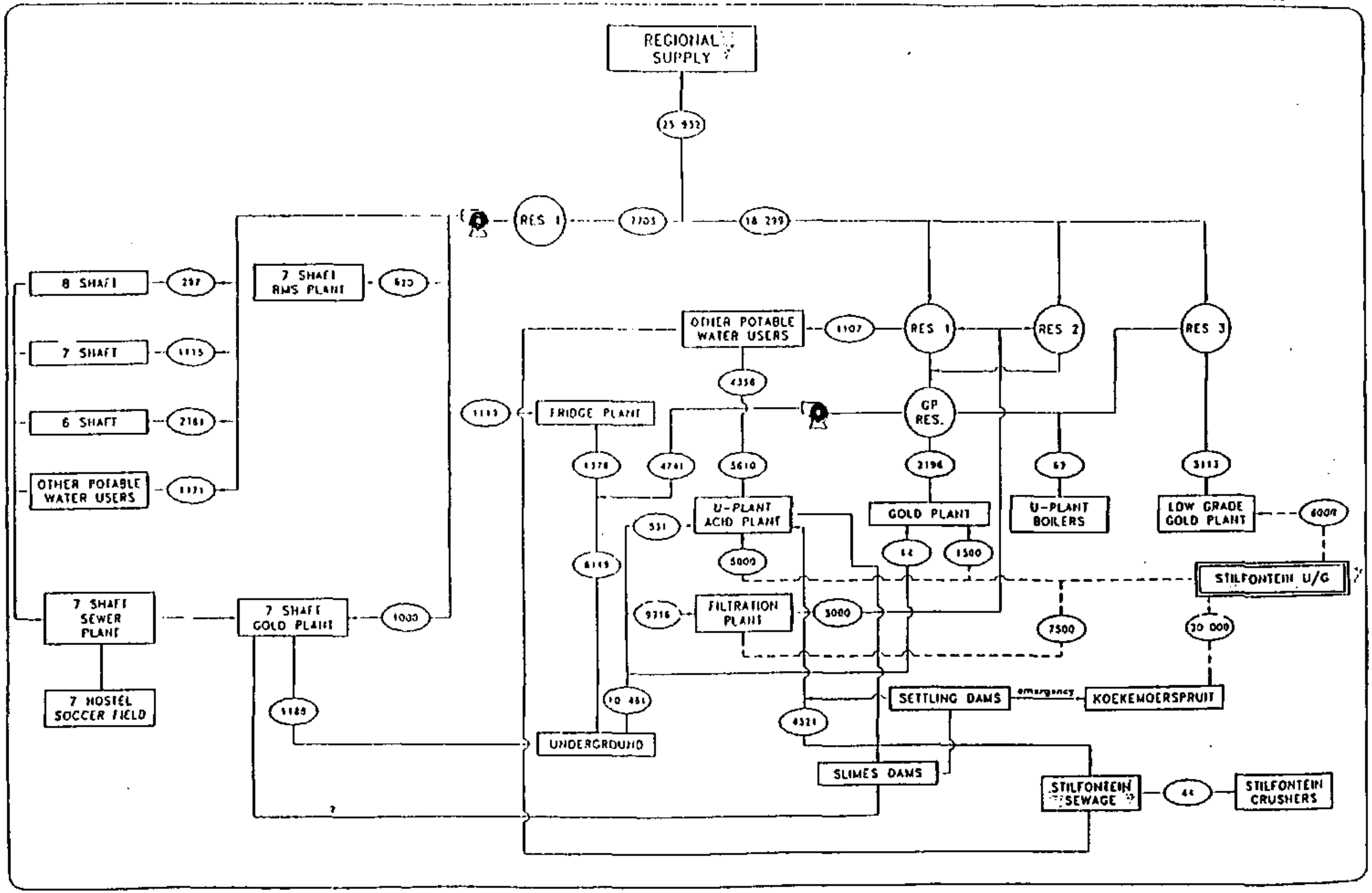


FIGURE1 WATER BALANCE DIAGRAM (figures in m3/day)

Report on Kloof - A Division of Kloof Gold Mine Company Ltd Site Visit.

4 - 6 October 1994

1. GENERAL INFORMATION

Name of mine	Kloof - A Division of Kloof Gold Mine Company Limited.
Name and position of person(s) who completed the questionnaire	Messrs T Kegel - Chief Engineer
Nearest town	Westonaria
Name of catchment	Leeuspruit & Loopspruit
Monthly tonnes treated	240 0000 tonnes per month
Monthly waste rock dumped	50 000 tonnes/month at Main Shaft Rock Dump 10 000 tonnes/month at 4 Shaft Rock Dump
Monthly tonnes milled	180 000 tonnes/month
Reef being mined and ore body width	VCR - 1,57 metres Kloof Reef - 1,89 metres Combined Reef - 1,58 metres
Monthly gold production	2 300 kg/month
Current age of the mine	30 years
Expected remaining life of the mine	27 years
Current mining methods	Longwall
Has an EMPR already been produced by the mine ?	Yes, awaiting approval

2. SITE VISIT PROGRAMME

2.1 Day 1 - 4 October 1994

- Arrival at Mine planning office
- Short discussion on project background, objectives and site visit programme
- Present at meeting:
- T Kegel - Chief Engineer
- C de Jager - Sewage Plant Supervisor
- J Laas - PHD
- D Howie - PHD
- Guided tour of Kloof Mine effluent monitoring sampling points starting at 3 Shaft, which also covered No. 1 Shaft waste rock dump, Rheeders Dam, 4 Shaft sewage plant, the Rheeders Dam pump station, runoff from hostel

and Main Shaft bank areas, No. 1 tailings dam (no longer in use) and No. 2 tailings dam currently in use for depositing plant tailings.
- Completion of the mine surface area by visiting No. 1 Shaft sewage plant and the maturation ponds for excess mine water and treated sewage water which overflows into the Loopspruit.

2.2 Day 2 - 5 October 1994

- Arrival at Engineering planning offices
- Underground visit to the water reticulation system at 23 Level which included the dirty water collection dam and chilled water dam, the 2 settlers and underground fridge plant at 23 - 60 Level guided by Mr T Kegel and B Gosmer, Section Engineer.
- Guided tour of the metallurgical plant, clean and contaminated stormwater runoff control systems for the plant area
- Guided tour of the filter plant at Main Shaft used to filter all clear water from the underground settlers on surface before being pumped to the fridge plant at 3 Shaft
- Visit to fridge plant at 3 Shaft

2.3 Day 3 - 6 October 1994

- Arrival at Engineering planning offices
- Discussion on water management systems and completion of questionnaire with Mr T Kegel, Chief Engineer, responsible for water management. All other supporting documents, including water analysis sampling points, graphs and water related reports were supplied during the discussions.

3. DISCUSSION OF THE MINE'S CURRENT WATER MANAGEMENT AND TREATMENT PRACTICES.

3.1 DESCRIPTION OF MINE WATER CIRCUITS

A steep rocky ridge known as Gatsrand runs along the mine's northern and northwestern boundaries. The majority of the mine's surface infrastructure is situated along this ridge. The mine's main offices, residential areas and No. 3 Shaft complex are situated along the north facing slope of the ridge whilst the Main Shaft and plant area, hostel and No. 1 waste rock dump are situated on the southwestern side of the ridge. No. 1 tailings dam is to the east of the No. 1 Shaft complex. This tailings dam is, however, no longer in use.

No. 4 Shaft and waste rock dump lies along the southeastern boundary of the mine. This shaft is in the development and is not a production shaft as yet. No. 2 tailings is an active tailings stage used to deposit the total plant residue from the metallurgical plant and is situated at the mine's southern boundary.

The low flow runoff from the plant, hostels and main shaft area is collected in a series of stormwater cutoff drains and diverted into brick dams where it is recycled back into the system. Any spillage's from the brick dam are diverted into the mine water holding ponds, which are adjacent to the sewage maturation ponds. These ponds are situated to the south of the mine next to the R671 road.

Excess runoff during storm conditions is diverted into the Rheeders dam, which is on a tributary of the Leeuspruit. The sewage works which serves the Kloof mining complex is located approximately 1 km to the south of the plant on the western side of the R671. Treated effluent from this plant is discharged into a series of maturation ponds adjacent to the sewage works. Excess mine water, which includes service water and fissure water is pumped from underground and is diverted into the mine holding ponds where it is then discharged with the overflow from the sewage maturation ponds into the tributary of the Loopspruit, southwest of the mine via a 4 km long gravity pipeline.

The southern section of the mine where the metallurgical plant, tailings dams, rock dumps and sewage treatment works are situated, is in the Leeuspruit catchment. The northern section of the mine which is on the northern side of Gatsrand drains to the Wonderfonteinspruit, which is to the northwest of Kloof Mine.

There is no significant dry weather flow in the water course upstream of the Rheeders Dam, except for a natural spring which originates underneath No. 1 Rock dump and is piped through the rock dump and discharges into Rheeders dam. The Loopspruit's tributary to which the excess mine water is piped, also has a seasonal flow and this water flow is increased by approximately 18,4 Mℓ/day of mine discharge water.

The water reticulation balance for Kloof Mine is given in Figure 1.

The total inflow of water into the mine area is 35,3 Mℓ/day and is made up as follows:

Source	Volume and percentage
Rand Water	7,8 Mℓ/day (22%)
Main Shaft Fissure Water	4,8 Mℓ/day (14%)
Harvie Watt Shaft Dewatering to Kloof Mine	14 Mℓ/day (40%)
3 Shaft Fissure Water	3,9 Mℓ/day (11%)
Leeudoring Division Fissure Water	2,9 Mℓ/day (8%)
4 Shaft Fissure Water	1,9 Mℓ/day (5%)

These figures demonstrate that Kloof Division is a very wet mine, with 38% of the total inflow due to fissure water. The bulk of the water consumed in the mine operations is supplied by fissure water (38%) and Harvie Watt Shaft dewatering water (40%). Only 22% is purchased from Rand Water.

The total outflow of water from Kloof Division is 35,3 Mℓ/day made up as follows:

Outflow	**Volume and percentage**
Discharge to Loopspruit from the mine water ponds & sewage plant maturation ponds	18,4 Mℓ/day (52 %)
Treated sewage to Leeuspruit from the 4 Shaft sewage plant	0,5 Mℓ/day (1,5 %)
Evaporation and seepage from the mine water ponds	0,5 Mℓ/day (1,5 %)
Evaporation and seepage from the No.1 Shaft sewage treatment plant maturation ponds	0,2 Mℓ/day (0,5 %)
Evaporation and seepage from the No.1 crushers	0,7 Mℓ/day (0,2 %)
Evaporation from the No.2 Tailings Dam	4,5 Mℓ/day (13%)
Water losses from the Timber treatment plant	1 Mℓ/day (3%)
Fan moisture evaporation from 3 Shaft surface fridge plant	2,3 Mℓ/day (7 %)
Water loss due to pre cool and condenser tower evaporation	1,5 Mℓ/day (4 %)

The major component of water loss is the discharge of 18,4 Mℓ/day into the Loopspruit from the sewage plant maturation pond as well as the mine water evaporation ponds. This water is vital to downstream users, such as the farmers who use the water for their livestock watering. The Loopspruit eventually discharges downstream of the Vaal Barrage.

In terms of the total mine operation for water management, the entire operation can be divided into the following:

- Plant tailings dams:

There are two slimes dams on the mine property. The No. 1 slimes dam is no longer in use and this area is rehabilitated with side wall vegetation. The No. 2 slimes dam currently receives the total metallurgical plant residue of 180 000 *tonnes/month.*

- Waste rock dump areas

These include the main rock dump at No. 1 Shaft which currently receives 50 000 tonnes/month and No. 4 Shaft rock dump where approximately 10 000 tonnes/month is deposited. This shaft is still in the development phase and not in full production yet.

- Sewage plant areas

There are two sewage plants. The main sewage plant is situated south of the main shaft and treats approximately 6 Mℓ/day. The second, a much smaller sewage plant at No. 4 Shaft, treats 0,5 Mℓ/day.

- Metallurgical plant area
- Shaft areas, mine office, hostel and sport fields
- Underground water reticulation system

Access to underground workings is via 5 vertical shafts, the Main Shaft with a No. 1 sub-vertical and No. 2 sub-vertical; No. 3 Shaft with a No. 3 sub-vertical and 3A; and No. 4 Shaft with No. 4 sub-vertical.

- Surface effluent sampling program

A total of 28 water samples are taken throughout the entire mine water reticulation system to monitor and manage all effluent and potential pollution sources. These samples are taken fortnightly and form part of the EMPR programme. This sampling program is discussed in more detail in Section 3.4.1.

3.2 DESCRIPTION OF WATER TREATMENT/MANAGEMENT SYSTEMS

3.2.1 Slimes Dams

The Kloof Division produces an average of 240 000 tonnes/month of which 60 000 is dumped on the two waste rock dumps and the remainder is treated at the metallurgical plant for gold recovery. A portion of the metallurgical plant residue is treated in the backfill plant to produce 12000 tonnes/month of backfill material for underground. The remainder of the metallurgical plant residue is deposited on support slimes dam No. 2. The water is decanted through the pen stock to two return water dams from where the water is pumped back to the metallurgical plant for use in the process.

The excess water from the return water dams which is not required by the plant, is stored in the seepage dam, situated at the lowest point in the area, next to the return water dams. This water can also be returned to the plant as process water, if required.

3.2.1.1 No. 1 tailings dam

This tailings dam is no longer in use and is currently being rehabilitated. It is built on gently sloping terrain and is approximately 20m high on the southern side, sloping to ground level at the northern side. A waste rock buttress with a height of approximately 6m has been constructed around most of the perimeter of the tailings dam. Catchment paddocks have been constructed where there are no waste rock buttresses. Stormwater is decanted from the top of the dam via a pen stock system. There is no under drain system for this particular tailings dam. A seepage trench around the perimeter of the dam conveys seepage water together with decanted water to a small return water dam. This water can be pumped back to the metallurgical plant or left to evaporate. A stormwater cutoff trench has been constructed to divert stormwater around the dam.

When seepage escapes from the cutoff trenches it can flow in a westerly direction towards the Rheeders Dam outflow and the combined flow reports to Smiths dam and eventually flows down into the Leeuspruit catchment. However, due to the low flows of the seepage and high outflow from Rheeders dam, significant dilution occurs.

3.2.1.2 *No. 2 Tailings Dam*

Plant residue is pumped to the No. 2 tailings dam. This dam has two independent paddocks located on the side of a gently sloping hill. The paddocks are equipped with under drains and starter walls. Tailings are delivered via an inwall delivery system into a daywall operation. Process water is decanted off the paddocks via a pen stock system into a perimeter solution trench which flows into a series of return water dams.

The return water dams consist of 2 pumping dams which are always kept full and spills over to storm water dams, which are kept as low as possible to ensure enough holding capacity, in the event of a rain storm. Water is pumped from the return water dams back to the plant. Catchment paddocks have been constructed around the dam perimeter to collect any eroded material from the side wall of the slimes dam. This area is fenced and except for a provincial road close to the dam, there are no other structures in the area.

3.2.2 Waste rock dumps

3.2.2.1 *No. 1 Rock Dump*

Waste rock is hauled by truck from the main shaft across a large, 30m high waste rock causeway. The causeway crosses a water course. Pipe culverts were constructed before the causeway was built to direct the water flow to the side of the rock dump. The rock dump has been developed in a series of terraces at different levels. There are, however, some slopes which exceed 60m in height which do not have terraces. The rock dump is very close to watercourses on the east and west side. There are no stormwater controls on or around the dump.

The dump has been developed on gently sloping terrain which directs the spring water originating somewhere below the dump towards the Rheeders Dam on the southern side of the rock dump. A private contractor produces various sizes of crushed rock from the dump. Runoff and spillage from these crushers also flows down into Rheeder Dam, situated in the Leeuspruit catchment area.

3.2.2.2 *No. 4 Rock Dump*

The waste rock is hauled with trucks from the shaft to the dump where it is used to build the terraces. The dump has been developed on generally flat terrain and is not near any water courses. There is no storm water control on or around the dump.

3.2.3 Metallurgical plant - Main Shaft, offices and hostel areas

Figure 2 is a schematic layout of the hostel, metallurgical plant and shaft areas and indicates the storm water trenches, different dams and pump stations in relation to one another for controlling runoff and spillage's.

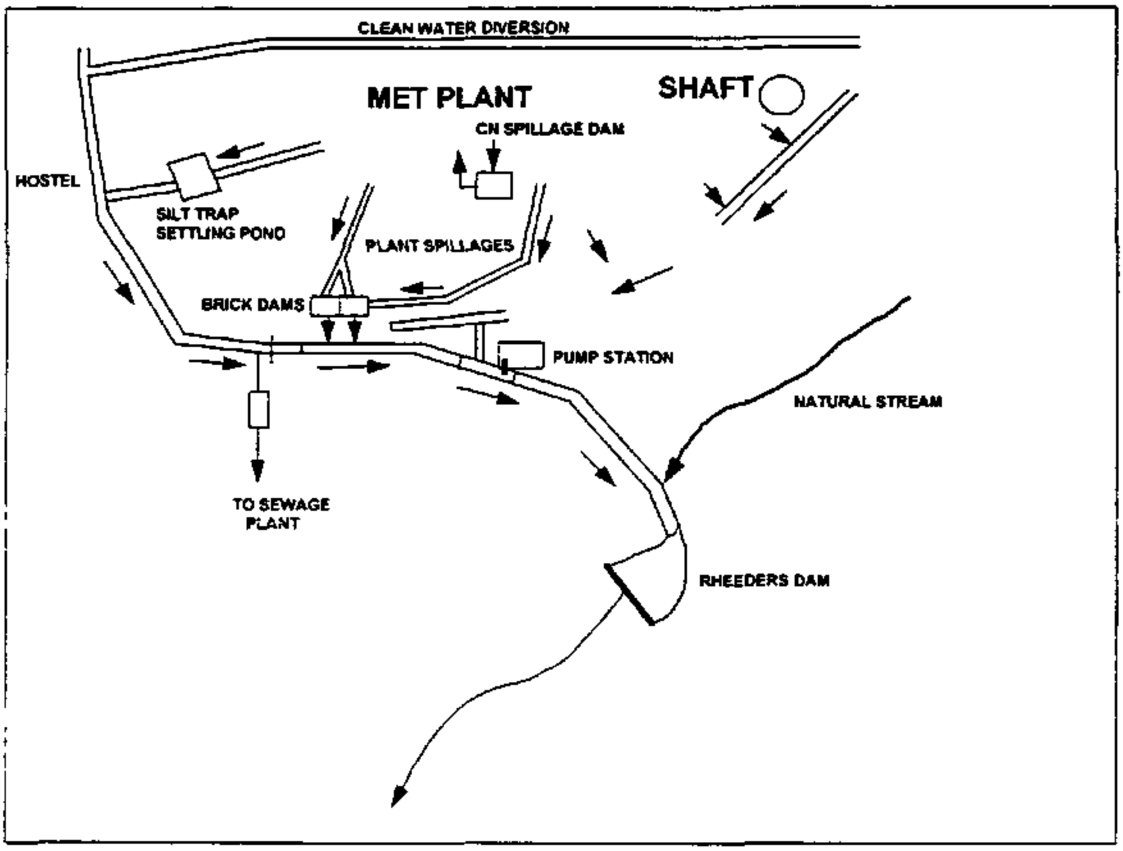


Figure 2 : Schematic layout of the metallurgical plant, shaft and hostel areas with the trenches used to control runoff and spillage's.

This area is situated on the southern slope of Gatsrand and the relevant catchment dams and pump stations are situated on the southern and western side. The natural slope of the area is used to direct spillage's and runoff towards the dams and pump stations.

Clean storm water is diverted around the plant area towards the hostel. Runoff from the hostel area flows via a trench into a water trap which leads to a sewer from where the water is pumped to the main sewage plant. On the eastern and southern side on the outside of the plant area a cement trench diverts runoff from the shaft area towards a pump station, which is situated next to the main launder. The main launder directs all excess spillage's from the hostel and metallurgical plant, combined with the shaft runoff towards the Rheeders Dam. The excess water flows down to the Rheeders Dam.

The plant area is divided into different sections and the two brick dams are used to collect spillage's from most of these sections. These two dams are situated at the lowest point of the plant to control most of the internal spillage's from the plant area. Water is decanted from these dams back into the process.

All spillage's containing cyanide from the gold leach section are collected in a separate dam, which is operated as a closed system within the gold leaching circuit. Cyanide spillage's from the cyanide section are collected in a separate spillage sump where the solids are settled first. The water from this sump is decanted and pumped back to the leach process of the gold plant.

Storm water from within the plant area runs in a westerly direction through a settling pond and meets the trench from the hostel area which leads to the sewer system and main launder outside the plant area. The solids from the settling pond can also be washed back into the metallurgical process.

On the eastern side of the metallurgical plant there is also a spillage trench. All spillage's and storm water from this section flow in to the main launder outside the plant area, where it combines with the excess water from the hostel area. The water in the main launder flows towards the Rheeders pump station, from where the water is pumped to the mine settling ponds, next to the sewage plant and maturation ponds. Mine management plans to use Rheeders Dam as an emergency dam to collect all the excess water from the plant, hostel and shaft area.

3.2.4 Sewage treatment plants

The main sewage plant is situated on the western side of the No. 1 Shaft complex and has a design capacity of 6,2 Mℓ/day. The sewage plant process is anaerobic and makes use of biofilters and digestors. Figure 3 shows a schematic diagram of the plant process.

Approximately 6 - 7 Mℓ/day of raw sewage is treated by the entire operation which consists of a primary screen for solids removal. These are then burnt in an incinerator with a capacity of 50 kg/run. The raw sewage then flows through biosocks which assists with the removal of fat and grease. The sewage is then clarified to prevent the blocking of the biofilter sprays which is the next stage of treatment.

The under flow sludge from the clarifiers is pumped to the digestors. The treated sludge from the digestors is then dewatered in drying beds. The dried sludge is stockpiled and mine personnel collect it for use in their gardens.

The overflow from the clarifiers is sent through biofilters and a second clarifier. The supernatant is then disinfected with chlorine. Chlorine is dosed at 280 g/hr to ensure a free chlorine level of 0,3 mg/ℓ and a residual level at the last maturation pond of 0,1 mg/ℓ.

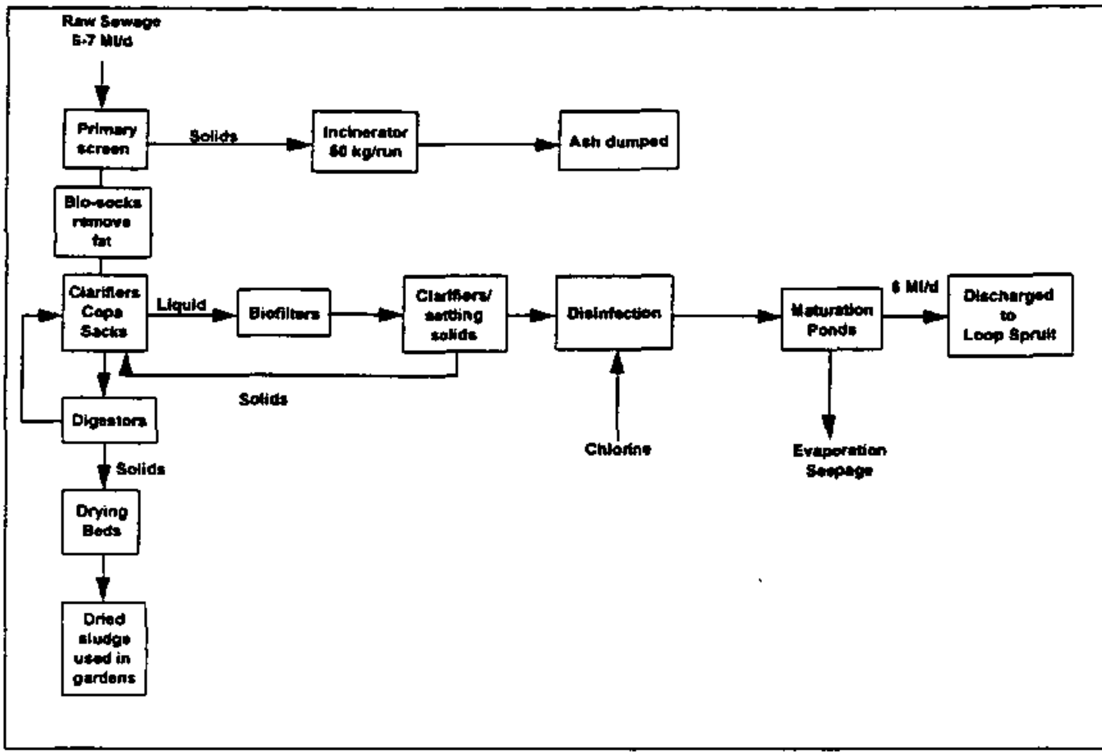


Figure 3 : Layout of the main sewage treatment plant and process at Main Shaft

The disinfected liquid is pumped to a series of maturation ponds from where approximately 6 Mℓ/day is discharged to Loopspruit. This treated sewage pumped to the Loopspruit combines with the excess mine water which amounts to approximately 12,4 Mℓ/day. This forms the total discharge to the stream.

The entire process is monitored by taking samples, fortnightly, which are sent to AL Abbot & Associates (Pty) Ltd in Cape Town for analysis and interpretation.

Figure 4 shows the schematic diagram for the sewage treatment plant at 4 Shaft. This shaft is still in the development phase and is not in production yet. The raw sewage volume from this shaft area is very small in comparison with the Main sewage treatment plant at No. 1 Shaft complex.

This plant treats approximately 0,5 Mℓ/day of raw sewage. The process consist of a septic tank, followed by a biodisc filter and settler system. The clear overflow is disinfected with chlorine and the bulk of the treated sewage is used for garden irrigation around the 4 Shaft area. Any excess treated sewage is discharged into a small wetland area below the shaft area, which is situated in the Leeuspruit catchment. The sludge from the settling tank is returned to the septic tank. When this tank is approximately 33% full, it is desludged.

Chlorine is dosed at a rate of 20 g/hour, to produce a residue level of 0,3 mg/ℓ. Ferric chloride is also sometimes dosed at the sewage plant flow after the biodisc filters in order to reduce the phosphate content of the flow, but this dosing system was not operational during the site visit.

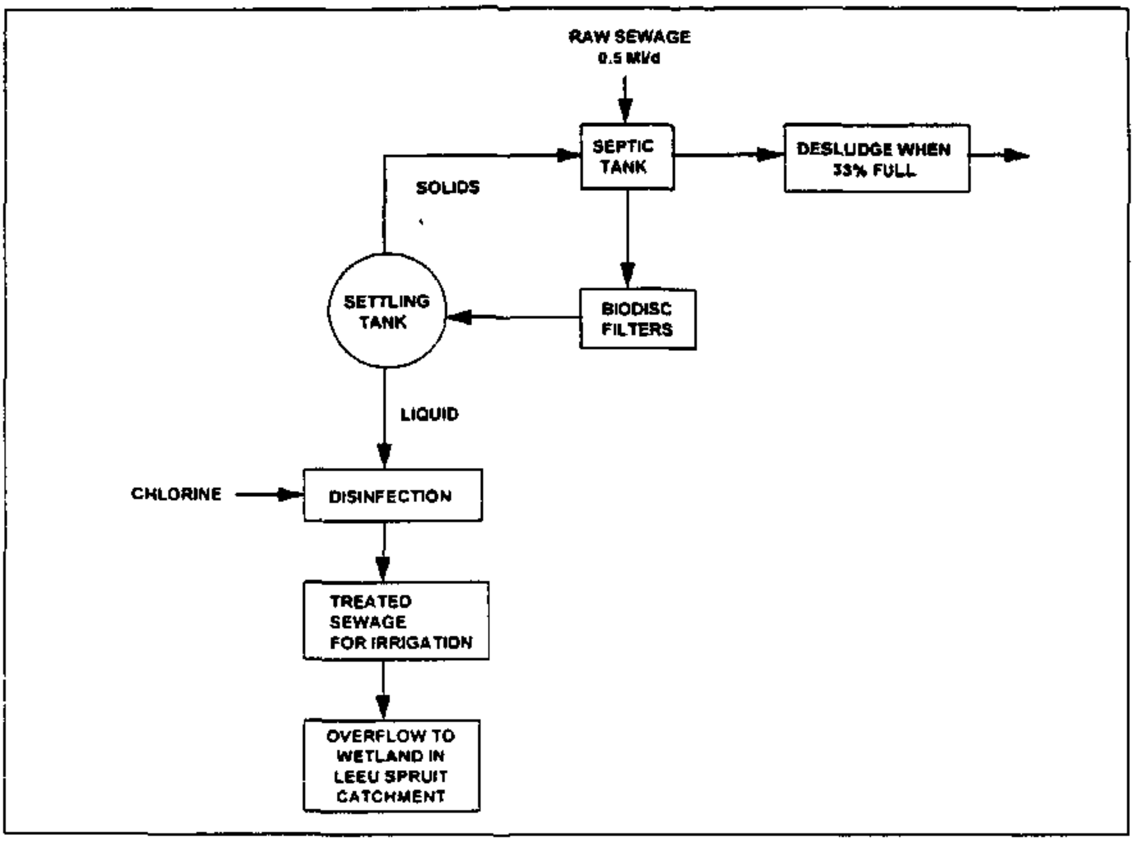


Figure 4 : The sewage plant layout at 4 Shaft.

3.2.5 Underground Water Reticulation System

3.2.5.1 *General Layout*

Figure 5 shows the basic underground water reticulation system for the entire Kloof Division which consists of the Main Shaft or No. 1 Shaft, No. 3 Shaft and No. 4 shaft, currently under development.

All clarified process water from the settlers, fissure water and dewatering water pumped from Harvie Watt shaft, are pumped to surface via 1 Shaft and all chilled water produced at the surface fridge plant at 3 Shaft is delivered via 3 Shaft.

No. 1 Shaft which is the Main Shaft consists of No.1 sub-vertical with its own settler system on 31 Level and No. 2 sub-vertical Shaft with its settlers at 40 Level. All clarified water from these two settlers is pumped up to a 33 - 60 Level clear water pump chamber in the main shaft from where it is pumped to surface. The Main Shaft has its own settler system at 23 - 60 Level and the clear water from this settler also joins the settler and the clear water overflow from the other settler installations of the mine, before it is pumped to surface.

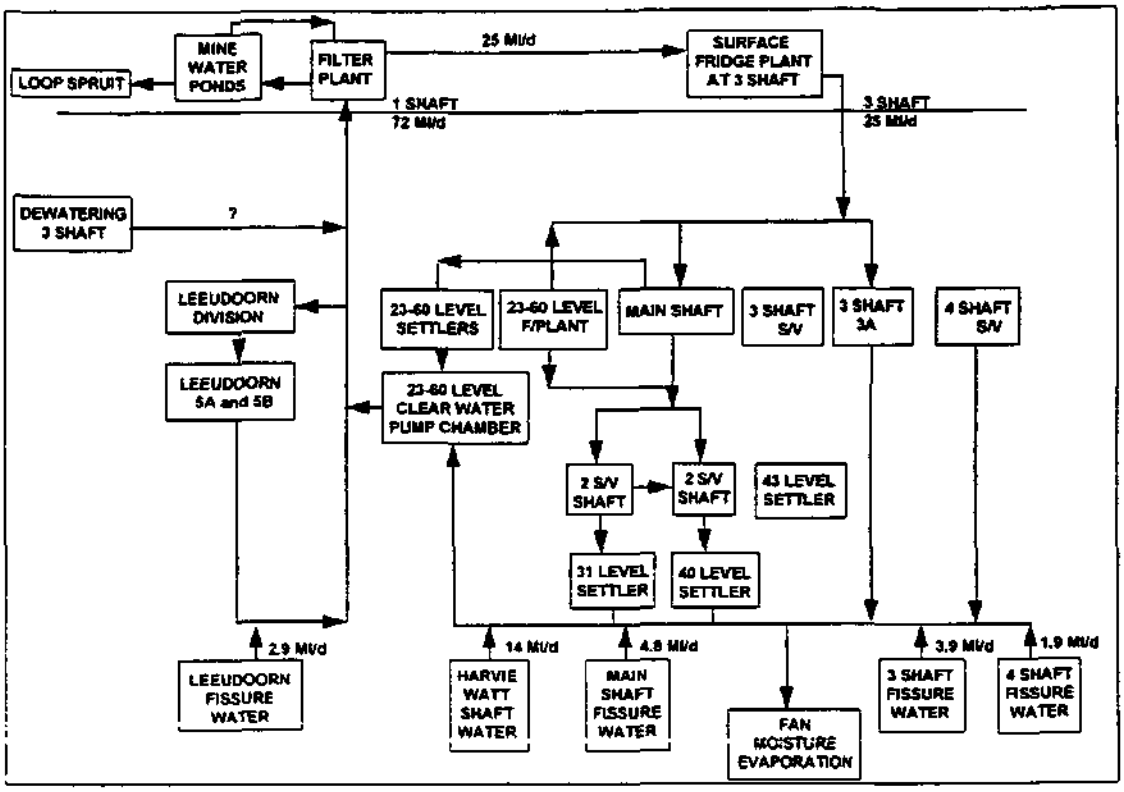


Figure 5 : The underground water reticulation system for Kloof Division

The settler system at 3 Shaft on 43 Level is currently flooded due to a shaft accident 3 years ago. This shaft is in full production for all levels higher than 43 Level. At this stage this section of the mine is still being dewatered and water is pumped to surface via No. 1 Shaft. No Rand Water supply is used as makeup water in the entire process. Fissure water provides the makeup water as follows: 1,9 Mℓ/day at 4 Shaft, 3,9 Mℓ/day at 3 Shaft and the Main Shaft fissure water totals 4,8 Mℓ/day.

Harvie Watt water which is pumped to Main Shaft amounts to 14 Mℓ/day. Leeudoring Division also produces 2,9 Mℓ/day of fissure water which is blended with the water reticulation system of Kloof Division. A total volume of approximately 72 Mℓ/day is pumped to surface via No. 1 Shaft.

3.2.6 Surface filter plant

The filter plant situated at No. 1 Shaft complex is very important to the entire water reticulation system. Of the 72 Mℓ/day dewatered from underground, approximately 30 Mℓ/day is treated through the filter plant. The excess underground water not treated through the filter plant is pumped to the mine water ponds situated at the sewage plant. The overflow from the mine water ponds is discharged into the Loopspruit. If the filter plant experiences a water shortage, water can be recycled from the ponds back to the filter plant. Approximately 6 Mℓ/day is used for backwashing of the filters. The backwash water is clarified in a small thickener at the filter plant and the sludge is pumped to the gold plant.

The filter plant consists of 16 upflow sand filters. The clarified water is disinfected at the filter plant with brominator systems and chlorine dioxide. The total costs for disinfection is approximately R120 000/month for a volume of 30 Mℓ/day. This includes the disinfection cost for the underground fridge plant water at 23 - 60 level at Main Shaft, which treats approximately 10 Mℓ /day.

3.2.7 Surface fridge plant at No. 3 Shaft

The clarified water from the filter plant is pumped from No. 1 Shaft complex via a pipeline to No. 3 Shaft complex where 25 Mℓ/day is chilled and supplied underground as service and drinking water.

The fridge plant at 3 Shaft consists of two 5 Mℓ storage tanks for storing the water supplied from the filter plant and six 1 Mℓ storage tanks which are insulated for the storage of the chilled water, before delivery underground.

At 23 - 60 level a fridge plant treats 10 Mℓ/day which is then also supplied as chilled water underground.

3.2.8 Underground Settlers

During the site visit the underground settler system at Main Shaft 23 - 60 Level was visited. The Main Shaft has settler systems at 1 sub-vertical Shaft, 31 Level and at 2 sub-vertical at 40 Level. The settler system at 3 Shaft on 43 Level is currently under water and although 3 Shaft is in full production, all the dirty water from 3 Shaft is distributed to the settlers at 1 and 2 sub-vertical shafts at the Main Shaft. The settler system at 23 - 60 level is currently treating 8,6 Mℓ /day, the settler system at 1 sub-vertical shaft 31 level treats 45,5 Mℓ/day and the settler system at 2 sub-vertical shaft 40 level treats 17,9 Mℓ/day.

The clear water settler overflow from No. 2 sub-vertical shafts is pumped to 23 - 60 level at the Main Shaft to the clear water dam where it joins the clear water overflow from the settler at 23 - 60 level. It is then pumped to surface via 1 Shaft. A portion thereof is pumped to the Leeudoring Division.

During the site visit the 2 settlers at 23 - 60 level were visited. Each settler consists of rectangular cells and treats a total volume of 8,6 Mℓ/day. The operational procedure is to direct the maximum flow through No. 1 Settler and the excess dirty water through No. 2 settler. The reason for this is the desludging process at No. 1 settler, which utilises an overhead sludge pumping system. This pumps the sludge from the settler bottom directly into a desludging launder.

Although the No.2 settler should be used to accommodate superfluous flow, this is often not done as the use of No. 2 settler implies a manual desludging operation. This is problematic in that the clear water overflow from No. 1 settler sometimes has high suspended solid values which causes secondary settling in the clear water system and higher maintenance costs for the clear water pumps.

3.2.9 Neutralisation of dirty water

No pH adjustment is required for the dirty water as the natural pH is sufficient high enough for the flocculant performance. During the site visit the pH of the dirty water was measured at 7,5 with a conductivity of 177 mS/m at a temperature of 29°C.

3.2.10 Flocculation

The No. 1 Setter has two flocculant makeup tanks. The flocculant solution is made up by adding small amounts of flocculant to a tank, which has a capacity of 1000 litres. It is then agitated while flocculant is dosed from the ready made up flocculant tank. Approximately 5 tanks per shift are used. The flocculant dosing control is manual and the operator merely opens and closes the flocculant dosing valve according to the dirty water flow level in the launder. By checking the overflow clarity of the settlers the decision is made as to whether to add more or less flocculant.

No. 2 settler is currently using gel blocks and coagulants on a trial basis. The coagulant is also supplied in 1 kg bags which allows easier and more accurate control of the makeup procedure.

The total flocculant cost is R62 000/month for a treated volume of 72 Mℓ/day. Based on 26 production days per month, the cost is 3,3 cents/m^3 treated.

3.2.11 Clear Water Pumps

All clear water from the settler accumulates at 23 - 60 level where it is pumped to surface via No.1 shaft. At this stage an average of approximately 10 000 hours per pump is obtained before an overhaul is needed. The cost of an overhaul is R250 000 per pump.

3.2.12 Potable water supply to underground

There is no separate potable water supply system for the underground workforce. The service and mine water which is chilled is sent underground and used as potable water for the underground workforce. The mine monitors the water by taking weekly samples at various points and having it analysed at the CSIR laboratory for the following:

Total coliforms and faecal coliforms. The bromine cost for disinfection month is R80 000/month.

3.3 WATER MANAGEMENT STRUCTURE

Figure 6 shows the mine's water management structure. The overall responsible person is the Mine Manager supported by the Engineering Manager and the Metallurgical Manager. The Chief Engineer is responsible for the total water reticulation system of the mine and he reports directly to the Engineering Manager. The Chief Engineer utilises external services and various water treatment companies for the supply of chemicals and for technical support.

All effluent samples are sent to AL Abbot & Associates, Consulting & Analytical Services in Cape Town. The water treatment companies providing technical support are Chemserve and Floccutan who also supply all the water treatment chemicals for the various mine processes.

An analyst, reporting to the Chief Engineer, is responsible for certain daily analyses. Important and urgent analyses such as suspended solids are carried out at the laboratory which is use to operate and check the performance of the settlers and the filter plant.

The Metallurgical Plant Superintendent reports to the Metallurgical Manager who is responsible for the Metallurgical Process Water Management. The plant residue is pumped to the No. 2 slimes dam and water management around the slimes dam is done by an outside contracting company, Fraser Alexander.

3.4 WATER MONITORING PROGRAMME

3.4.1 Surface Water & Effluent Sampling Programme

Kloof Division has a very comprehensive effluent sampling programme consisting of 28 sampling points at various places. These samples are taken on a fortnightly basis by the Sewage Plant Supervisor. These samples are then analysed for pH, conductivity, ammonia, nitrate, or the phosphate, sulphate, sodium, cyanide and fluoride by AL Abbott & Associates, Consulting & Analytical Services in Cape Town. The following sampling points are sampled.

These sampling points do not always have water flowing at a particular point. At the last sampling exercise, 4 of the sampling points were dry and 2 points were discontinued for a specific reason. This is a very comprehensive sampling programme, covering important effluent streams which could leave the mine surface area and cause pollution, due to mining activity in the area.

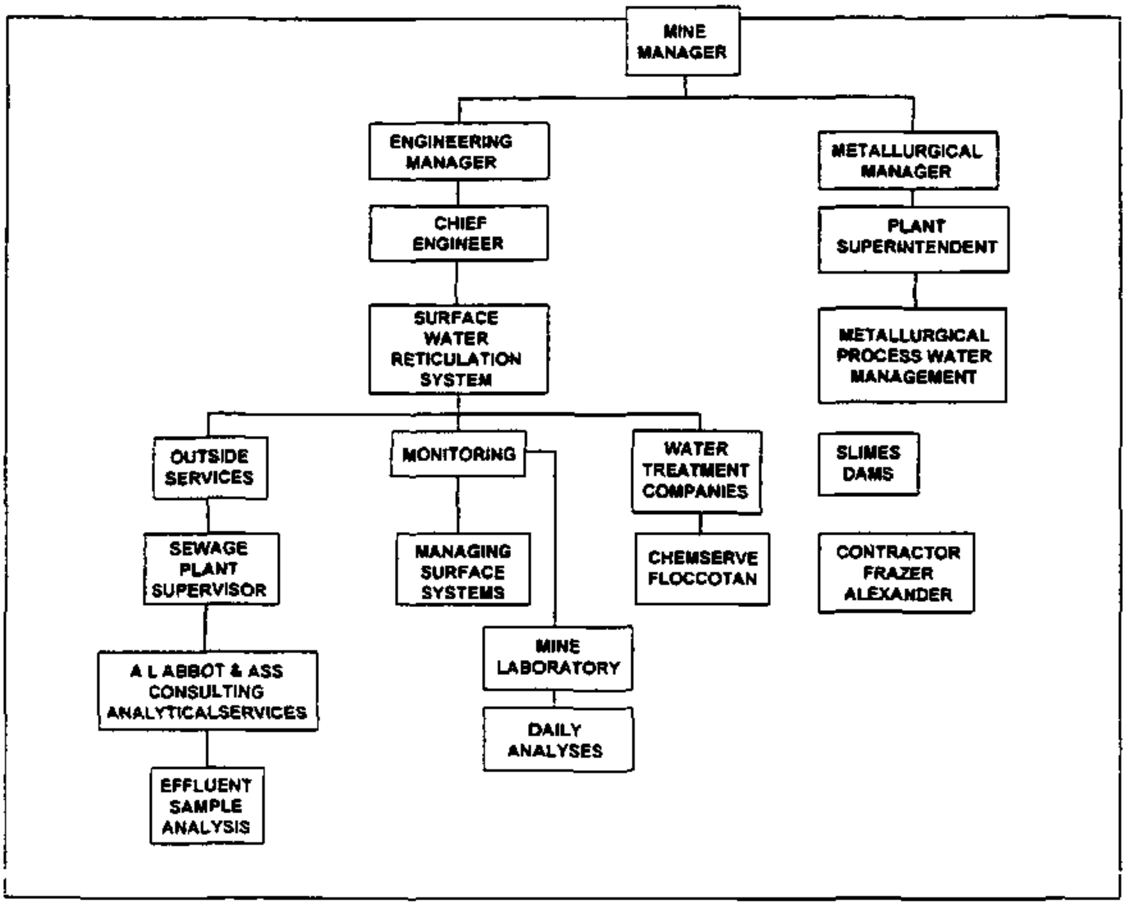


Figure 6 : Mine water management structure

3.4.2 Daily Main Shaft Water Analysis

As already mentioned, the Chief Engineer employs a Water Analyst at the Mine Laboratory at Main Shaft who analyses water samples on a daily basis. Each of the 16 filters of the filter plant is sampled daily to control the suspended load removed daily in the filter operation.

Due to the fluctuation in the suspended solids content of the underground clear water, it is possible for the filter plant to have a build up of suspended solids load of up to 2,5 tonnes/day. By monitoring the suspended solids content in the feed water and also the suspended solids content in the outlet water from the filter plant this loading process can be monitored, as well as the underground settler performance.

All these samples are analysed for pH, conductivity, total alkalinity, solids in suspension, chlorides and total dissolved solids. The main objective for this sample analysis is to control and assist the performance of the filters and to control the solids in suspension which will reduce maintenance costs, increase running hours of the different pumps and the different process units.

An example of the graphic presentation of the results, particularly solids in suspension, is attached. The graph indicates the filter performance in terms of solids in suspension transfer to 3 Shaft, with an average value of approximately 5 ppm. This is extremely important to prevent any operational problems.

SAMPLING POINT	
1	Main Shaft & Rock Dump runoff
2	Compound & Gold Plant runoff
3	West side of Slimes dam runoff
4	4 Shaft effluent runoff
5	Combined effluent to Leeu spruit
6	No. 1 slimes dam overflow runoff
7	Mine excess water to Loop spruit
8	Combined effluent to Loop spruit
9	Groundwater Main Shaft
10	Natural spring above magazine
11	No. 1 Slimes dam cutoff trench
12	No. 1 Slimes dam return dams
13	Groundwater at Hermina School
14	3 Shaft surface water
15	3 Shaft runoff
16	3 Shaft groundwater
17	No. 2 Slimes dam return
18	No. 2 Slimes dam seepage
19	Groundwater below No. 2 Slimes dam
20	Netto's farm on the eastern side of No. 1 Slimes dam
21	Harvie Watt water to Main Shaft
22	Stables
23	Johan de Lange borehole
24	Weir south of rock dump
25	Weir bypass
26	Rheeders dam outlet
27	Smit Special at 4 Shaft
28	Mine inlet at Kloof maturation plant

As already mentioned, a weekly sampling procedure is in place for checking the mine water disinfection programme. Water samples are taken at various places and then analysed by the CSIR for total coliforms and faecal coliforms. The potable standards limits which are used are the following:

- Total coliforms per 100 mℓ
- Faecal coliforms per 100 mℓ

The disinfection sampling points are the following:

1 Pumps to 3 Shaft
2 Halfway to 3 Shaft
3 3 Shaft Refrigeration
4 23 Level 3 Shaft pipeline
5 23 - 60 Level Refrigeration plant
6 23 Level 5 Mℓ dam
7 17 Level service water
8 23 Level service water

The daily Main Shaft water analysis consist of the following:

1	3 Shaft
2	Harvie Watt
3	2-5 to surface No. 1
4	2-5 to surface No. 2
5	2-5 to surface No. 3
6	Minus to 2-5 No. 1
7	Minus to 2-5 No. 2
8	17 Level to 2-5 Level
9	Minus to 17 Level
10	32 to minus No.1
11	32 to minus No. 2
12	32 to minus No. 3
13	3 Shaft to 32 Level
14	40 to 32 Level No. 1
15	40 to 32 Level No. 2
16	3 Shaft 44 level
17	3 Sub-vertical Shaft 43½ Level
18	Settler 3 Shaft
19	2-5 Low lift
20	23 minus 60 Fridge Plant feed
21	23 minus 60 Fridge Plant chilled water
22	23 minus 60 Condenser water

3.5 NOVEL OR UNIQUE WATER TREATMENT AND MANAGEMENT SYSTEMS

3.5.1 Sewage Treatment Plant

At the main sewage treatment plant at 1 Shaft complex, a few interesting water treatment aspects were observed.
One is the biosocks that are used to remove and break down the fat in the raw sewage. This will decrease the extra load and floating of the fat at the clarifiers.

At the clarifier inlet system the water is channelled through biofilters which is then producing a sewage product which has a reduced floating material content that can cause the blockage of the sprays at the biofilter section.

Another feature is the incinerator that has been installed recently for burning all the coarse material screened off at the primary screens.

Another advantage at this sewage plant is the fact that the sewage plant supervisor works for an outside company, but is permanently based at this particular sewage plant. He is an expert and is a qualified sewage plant operator and his expertise is used to run the whole operation within the prescribed criteria.

3.5.2 Potable Water Supply Underground

No Rand Water is supplied underground. The drinking water supplied underground is the chilled service water. This water is tested weekly for biological quality by the CSIR and is a very sensitive issue to ensure that the prescribed limit is not exceeded.

3.5.3 Dewatering at the Shaft Banks

At both 1 and 3 Shaft there are dewatering boreholes around the shaft bank from where water is pumped to fishponds and also back into the mine service water systems. This is done to keep the shaft dry as this is a very wet mine, and many problems can arise in terms of ventilation, corrosion and general working conditions, if water very close to the surface runs down into the shaft all the time.

3.5.4 Unique Desludging System

A unique desludging system in the form of dorcho pumps runs above the settler No. 1 settler cells. This pump system has two suction lines which run on the bottom of the cells and sucks up the thickened sludge. The sludge is then discharged into the sludge launder which is gravitating into the sludge dam. *There is no specific operational procedure for the desludging process.* The operator checks the clarity of the overflow and uses a stick to feel the sludge bed and then decides whether to desludge the settler.

3.6 POTENTIAL WATER TREATMENT/MANAGEMENT PROBLEMS AND NEEDS

3.6.1 Decanted Water from No. 2 Tailings Dam

During the site visit it was observed that the decanted water from the pen stock of No. 2 Tailings Dam had a very high suspended solids content. This can cause a few problems in the return water dams; where these solids are settle and reduce the holding capacities of these dams. If this happens regularly, it will also cause the return water dams to overflow into the storm water dams more often, *in the event of a thunder storm, it will then have to* accommodate all runoff water form the slimes dam area into the storm water dams. *When the storm water dams is already filled with pen stock water*, the holding capacity will not be sufficient, these dams will then overflow which can cause pollution of the surrounding areas.

3.6.2 Spillage's from the Rheeders Dam Pump Station

Spillage's from the metallurgical plant, hostel and shaft area flows to a pump station from where it is pumped to the mine ponds. The excess water from the pump station flows down towards the Rheeders Dam. During the site visit the combined overflow at the pump station measured a pH of 10,7 and a conductivity of 187 mS/m. This water then joins the natural spring water originating underneath the No. 1 Shaft Rock Dump which was measured at a pH of 8,4 and a conductivity of 97 mS/m. This combined water then ends up in the Rheeders dam which is then overflowing into the next downstream dam called the Smits dam which is a farmers dam which can then get contaminated in the process. The mine management is planning to keep the Rheeders dam empty and use it as an emergency catchment dam in the event of their pump station overflowing or out of order. In the process the natural spring water will then be bypassed around the Rheeders dam and continuously flowing into the Smits dam. This process will help solve this pollution potential.

3.6.3 Settler operation on 23 -60 level and Main Shaft

The main problem for this settler system is the effort to treat the total flow through No. 1 settler with its easy desludging, Dorco pump system. The result of this is that No. 2 is at most time getting zero or very little flow for most of the day as was observed during the site visit. The dirty feed flow launder system will have to be changed to alter the current operational procedure. This will have a positive affect on the suspended solids content of the combined settler overflow.

Appendix A - List of pH and conductivity monitoring readings taken during the Site Visit

During the site visit, a number of pH, conductivity and temperature readings were taken at various locations on the mine

No	Monitoring Point Description	pH	Cond (mS/m)	Temp °C
1	No 3 Shaft runoff and dewatering bore hole	11,0	163	-
2	Netto's farm dam	8,2	261	-
3	Rheeders dam outflow	9,1	170	-
4	Rheeders pump station overflow to Rheeders dam	10,7	181	-
5	Natural spring originates underneath No 1 Rock dump	8,4	97	-
6	Plant spillage overflow to Rheeders	11,0	212	-
7	Main shaft runoff to pump station	9,6	85	-
8	*Combined overflow at pump station*	10,7	187	-
9	Outflow of Smith's dam	8,6	144	-
10	Outflow at tar road to Leeu spruit	8,5	142	-
11	Seepage trench upstream of return water dam	8,2	358	-
12	Decantation water from penstock to RWD	10,1	276	-
13	Combined flow to RWD at No1 slimes dam	10,2	279	-
14	No 2 slimes dam seepage from RWD	7,0	226	-
15	Groundwater in borehole below No 2 slimes dam	7,2	176	-
16	Combined effluent to Loopspruit	8,4	131	
17	Excess mine water from filter plant	7,6	164	
18	Supernatant of CN-plant spillage dam	10,4	243	
Underground Visit 23-60 Level settlers at Main Shaft				
19	Chilled water dam 23 level	7,2	163	9,4
20	Dirty water dam 23 level	7,5	137	22,1
21	Stagnant pool in haulage from Harvie Watt shaft	2,9	424	29,7
22	Combined clear water from settlers of main and S/V Shafts	6,4	177	30,8
23	Dirty water to No 2 settler 23-60 level	7,5	177	29,0

Appendix B - List of Photographs

During the site visit, a number of photographs were taken at various locations on the mine

Slides No.	Slide Subject Description
1	Sump for collecting runoff water from No 3 Shaft area.
2	Solid waste disposal site with No 1 slimes dam in background.
3	Solid waste disposal site with No 1 slimes dam in background.
4	Solid waste disposal site with Main Shaft and Rock Dump in the background
5	Toe paddocks on eastern side of No 1 slimes dam which is not in use anymore.
6	Irrigation systems on southern side of No 1 slimes dam for the establishing of vegetation.
7	Netto's farm dam.
8	Rheeders dam outflow and seepage through the dam wall.
9	Rheeders dam outflow and seepage through the dam wall.
10	Rheeders Dam
11	Overflow from pump station channelled to Rheeders dam
12	Second inflow stream into Rheeders dam
13	Crusher sand storage site on western side of Rheeders Dam with the metallurgical plant in the background.
14	Cement channel for runoff water from the Main Shaft Hostel area.
15	Plant spillage catchment dam overflowing into the main cement trench on the eastern side of the plant area.
16	Runoff water from the Main Shaft area flowing along a cement launder towards Rheeders Dam.
17	Weir system and flow meter installations in the main launder leading towards Rheeders Dam.
18	Weir system and flow meter installations in the main launder leading towards Rheeders Dam.
19	No 4 Shaft sewage plant
20	No 4 Shaft sewage plant
21	No 4 Shaft sewage plant
22	Smit dam outflow at tar road
23	Most eastern sampling point in Leeu spruit
24	Return water channels leading to the return water dams
25	Return water channels leading to the return water dams
26	Storm water dam next to return water dams
27	Seepage through storm water dam wall
28	Groundwater sampling borehole below No 2 slimes dam. The water level in the borehole is at surface level.
29	Coarse screens at main sewage plant
30	Incinerator for burning coarse material
31	Raw sewage after coarse screening
32	Digestors for treating sludge from the clarifiers
33	Burning of coarse material in incinerator
34	Maturation ponds from the top of the digestors
35	Drying beds for drying the sludge from the digestors
36	Biofilters
37	Clear liquid outflow from Biofilters

Appendix B - List of Photographs - continued

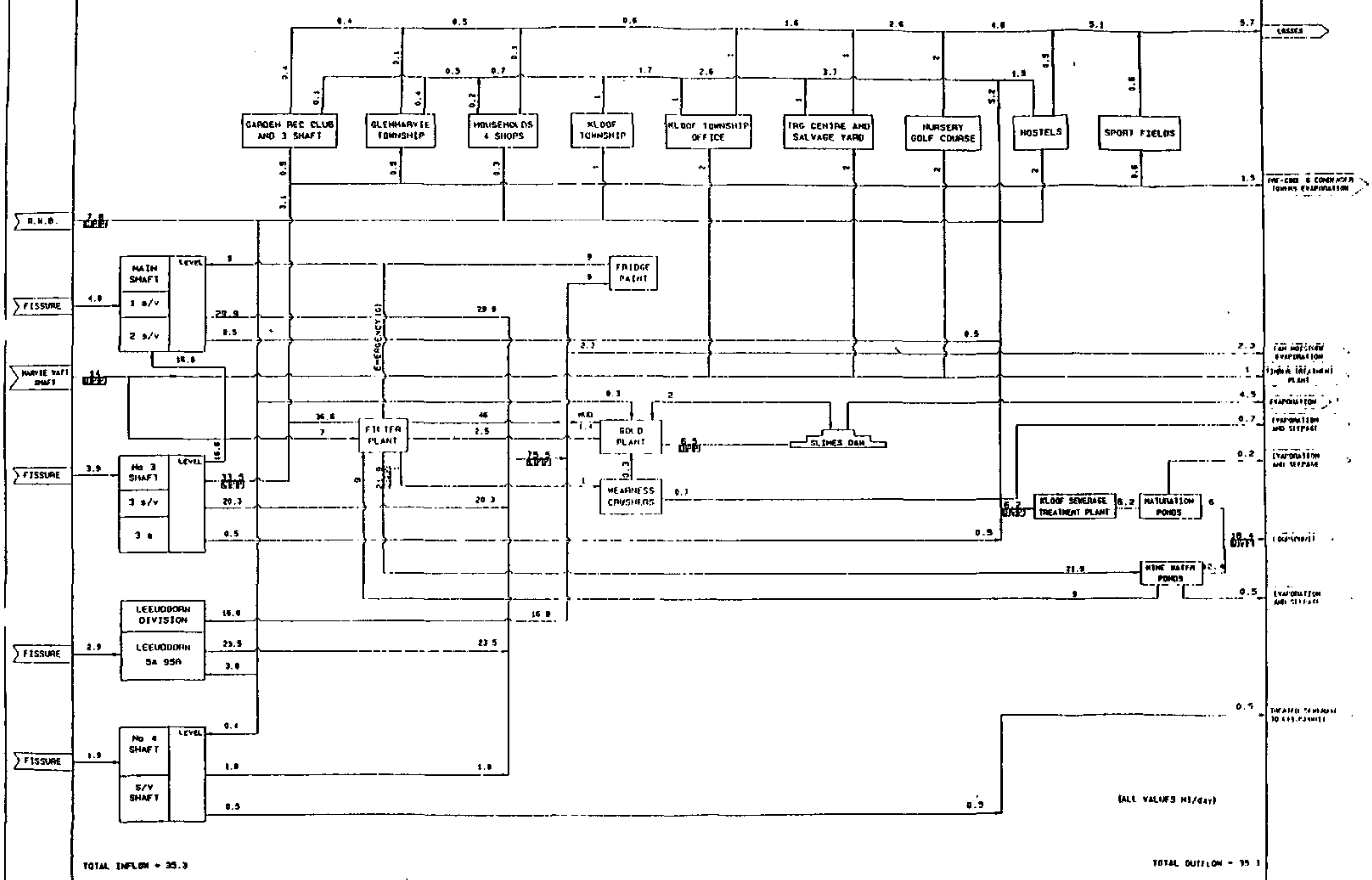
38	Spraying systems at the top of the Biofilters
39	Closeup of biofilter rock material for biological organism growth.
40	Spraywater system for distribution of sewage water evenly over biofilter surface area.
41	Side of biofilters
42	Clarifiers before the biofilter section
43	Clarifiers after the biofilter section
44	Chlorine cylinders for disinfection
45	Overflow from the last maturation pond
46	Discharge from the maturation pond system to the hoop spruit.
47	Maturation ponds
48	Maturation ponds
49	Discharge of excess mine water to the maturation ponds
	Underground Visit
50	Chilled water dam on 23 level
51	Dirty water dam on 23 level
52	Dirty water dam on 23 level
53	Clear water pumps
54	Clear water pumps
55	Clear water discharge into dam after settling
56	Dorco sludge pumping system at settler No 1
57	Dorco sludge pumping system at settler No 1
58	Top of No 1 settler 23 - 60 level
59	Top of No 1 settler 23 - 60 level
60	Dorco pumping system at No 1 settler
61	Flocculant and coagulant bags and makeup system
62	Dirty water launders to settler No 1 and 2
63	Screen for coarse material removal
64	Baskets for gel blocks
65	Gel block basket in dirty water launder
66	Flocculant makeup tanks
67	Top of settler No 2
68	Dirty water launder empty at last cell
69	Top of Settler No 2
70	Disinfection system for underground water
71	Underground fridge plant
72	Removal of wood chips etc. from dirty water before pumping to settlers
73	Old ozone generating pilot plant for disinfection of mine water. Not in use anymore.
74	Storage tanks for chemicals used for disinfection of mine water before filtration
75	Soda ash dosing system
76	Floccutan chemical holding tank
77	Top of sand filters
78	Top of sand filters

Appendix B - List of Photographs - continued

79	Sand filter being backwash
80	Clear water in filter
81	Filter sand
82	Disinfection system
83	Inside of flowmeter
84	Inside of empty filter
85	Disinfection installation at 3 shaft fridge plant
86	Flow diagram of surface fridge plant at no 3 shaft
87	Condenser open for maintenance and cleaning
88	Scale formation on inside of water pipe
89	Good housekeeping of fridge plant section
90	Scale formation on inside of condenser pipes
91	Chilled water holding tanks
92	3 Shaft surface Winder
93	3 Shaft surface Winder
94	3 Shaft surface Winder
95	Size of Winder tools
96	Trucks for transporting underground sewage to surface

STEFFEN, ROBERTSON & KIRSTEN

FIGURE 1



JOB No. 196369

KLOOF MINE WATER RETICULATION BALANCE

FIG No D.4.1.1

Report on Libanon Gold Mine Site Visit.

16 - 18 August 1994

1. GENERAL INFORMATION

Name of mine	Libanon Gold Mine - A division of Kloof Gold Mining Company Ltd
Name and position of person(s) interviewed	Messrs L v.d. Walt - Pupil Engineer L du Plessis - Plant Superintendent J D le Roux - Shift Boss 4 Shaft
Nearest town	Westonaria
Name of catchment	The northern section of the Wonderfonteinspruit flowing from east to west
Monthly tonnes mined	Southern Section of Libanon shafts : 130 000 tonnes per month Northern Section or Venterspost : 30 000 tonnes per month
Monthly tonnages milled	Southern Section of Libanon shafts : 130 000 tonnes per month Northern Section of Venterspost : 90 000 tonnes per month consisting of 30 000 tonnes from underground and 60 000 tonnes reprocessing old rock dumps
Monthly gold production	Approximately 625 kg per month for the southern section and ± 300 kg per month for the northern section
Current age of mine	Northern Section : 50 years Southern Section : 48 years
Expected remaining life of mine	Approximately 8 years
Reef being mined and stope width	Main reef 1,4m VCR 1,45m Kloof reef 2,2m Libanon reef 1, 9m
Has an EMPR already been produced by the mine ?	Yes, draft report

2. SITE VISIT PROGRAMME

2.1 Day 1 - 16 August 1994

- Arrival at mine's main planning office

- Short discussion on project background and site visit programme
- Present at meeting:
  Mr Donaldson - Chief Engineer
  Mr v.d. Walt - Pupil Engineer
  Mr Laas - PHD
  Mr Howie - PHD
- Guided tour of the Northern section and the No. 1 slimes dam at 5 Shaft
- Guided tour of the Donaldson Dam and the pipeline from east to west conveying the water across the sinkhole area.
- Guided tour of the tailings dam on the southern section at No. 1 shaft
- The Metallurgical process plant of the Southern section at No. 1 shaft
- A visit to Harvie Watt shaft runoff and the Mine Managers' water reservoir
- A visit to the hostel runoff at No 1 shaft

2.2 Day 2 - 17 August 1994

- Arrival at Engineering Planning Offices
- The underground visit to No. 4 shaft was cancelled due to shaft maintenance. Instead the project team visited the fridge plant and compressor systems at No. 1 shaft
- The remainder of the day's programme was cancelled as Mr v.d. Walt was summoned to Head Office for an urgent appointment

2.3 Day 3 - 18 August 1994

- Arrival at Engineering Planning Offices
- Underground visit to No. 4 subvertical shaft
- The visit to panel 28 North 13 was guided by the Shift Boss, Mr J D le Roux
- The visit to the underground settlers at 42½level was conducted by Mr L v.d. Walt
- Discussion on water management systems and completion of questionnaire with Mr L v.d. Walt.

3. DISCUSSION OF MINE'S CURRENT WATER MANAGEMENT AND TREATMENT PRACTICES

3.1 DESCRIPTION OF MINE WATER CIRCUITS

3.1.1 Surface Water

The Libanon Mine catchment area can be divided into two main areas, i.e. the area previously falling within the Venterspost area (the northern section) and the Libanon area (the southern section of Libanon mine). There is a well defined water course within the northern section, the Wonderfonteinspruit, which flows from east to west through this section.

A small tributary, the Middelvlei, has its confluence with the Wonderfonteinspruit approximately 1 km east of the No. 5 shaft complex but this tributary was dry during the site visit and generally only flows during the rainy season. The general flow of surface water in the Libanon catchment area is from east to west and north to south towards Wonderfonteinspruit. There are no well defined water courses in the southern section. The surface water flow is interrupted in areas of dolomite outcrops. In general, surface water runoff has been channelled over the dolomitic areas or has been diverted around them to prevent infiltration of water into the mine workings.

3.1.2 Southern section

The Southern section consists of the Harvie Watt shaft in the south and the No. 1 & 4 Shafts. The metallurgical plant is situated on the eastern side of No. 1 site and processes all the ore from the southern section. The tailings dam is situated on the northern side of the metallurgical plant. The town of Westonaria is situated to the northeast of the southern section of the Old Libanon mine.

Stormwater runoff in the vicinity of the Harvie Watt shaft is diverted to an evaporation area to the north of the Potchefstroom/Johannesburg road. Runoff from the area around the No. 1 shaft drains to the settling dams, nortnwest of the mine boundary, where the water is used to irrigate vegetables on an adjacent farm. Stormwater which drains towards the No. 1 Shaft tailings dam is diverted around the tailings dams by means of open channels to a series of settling dams from where it is evaporated. Runoff from the sides of the No. 1 tailings dam is contained in evaporation paddocks located around the perimeter of the dam, where it is evaporated. Storm water falling on the top of the dam is decanted to a sump located on the western side of the tailings dam from where it is returned to the plant. Excess water in the sump spills to the settling dams located on the western side of the railway line where it is evaporated. Spillages from these settling dams enter the Wonderfonteinspruit after passing over 3 km of farmland.

3.1.3 Northern Section

The Northern Section includes the No. 5, No. 2 Shaft complexes and the town of Westonaria. The Wonderfonteinspruit flows through the middle of the northern section. The Donaldson Dam is situated northeast of the Wonderfonteinspruit. The overflow from the Wonderfonteinspruit, approximately 1200m downstream of the Donaldson Dam, is collected at the weir. So as to reduce the potential for sinkhole formation and recharge to the mine underground workings, the overflow is diverted into a 1m diameter pipeline and discharged at a point 29 km downstream in the Wonderfonteinspruit course.

Excess flow during storm conditions passes over the weir and flows into the existing Wonderfonteinspruit course. The Middelvlei water course, a tributary of the Wonderfonteinspruit, situated to the east of the No. 5 shaft complex, is not affected by mining operations and no flow was observed during the site visit. Flow is only apparent during the rainy season. Stormwater from the Westonaria township is collected in an earthlined storm water canal, located to the north of the railway line, and is diverted directly into the Wonderfonteinspruit at a point to the west of the mine boundary. Stormwater runoff from the Westonaria golf course and surrounding areas is carried over the dolomitic areas by a network of open, lined channels, which prevents excessive infiltration into dolomitic areas, and is then discharged into the Wonderfonteinspruit.

Fissure water from the No. 2 and 5 shafts is pumped to surface from the No. 5 shaft. Fissure water from Harvie Watt shaft is pumped to surface via the Kloof Mine Main Shaft. The water pumped to the surface at No. 5 shaft and not used by the mine, is pumped to a canal near the old town of Bank from where it is channelled to a small dam, in the Wonderfonteinspruit, to the northwest of Carletonville.

The Venterspost metallurgical plant lies to the northwest of the No. 5 shaft complex. Tailings dam No.1 of 5 shaft lies to the north of the metallurgical processing plant. Runoff from the sides of this tailings dam is contained in evaporation paddocks located around the perimeter of the dam from where it is evaporated. Stormwater falling on the top of the dam is decanted to a sump situated on the western side of the tailings dam from where it is returned to the plant.

3.1.4 River diversions

The only river diversion on the mine is the 1m diameter pipeline which conveys the Donaldson Dam overflow across the dolomitic section. This reduces infiltration into underground workings, and the risk of sinkhole formation is reduced.

3.1.5 Fissure water

Fissure water pumped to surface is an important component in the overall quality of water discharged from the mine property.

3.1.5.1 Fissure water from Libanon southern section

Fissure water from the Harvie Watt shaft section is pumped to Kloof Gold Mine and discharged or recycled within the Kloof Mine water circuit.

3.1.5.2 Fissure water from Libanon northern section

Fissure water blended with mine process water from Libanon northern section is pumped to surface at No. 2 shaft and then pumped 18 km to a transfer point near the Bank road where it flows via the 1m diameter pipeline. This arrangement can, however, be substituted by pumping the water into a canal system. The water can be pumped into a canal near the old town of Bank and flow via a series of canals to a dam northwest of Carletonville, situated on the Wonderfonteinspruit. This dam is used for recreational purposes. The main surface water, immediately downstream of the mine is used by farmers for agricultural purposes.

3.1.6 Groundwater

Dewatering of the dolomites has led to a progressive depletion of groundwater stored in the dolomites. This has resulted in the drying up of numerous springs and boreholes in the area. No boreholes are currently being utilised for groundwater supplies on the mine property.

3.1.7 Sewage treatment plants

There are no sewage works at Libanon's southern section. The sewage works at Libanon's northern section are controlled by Westonaria municipality.

3.1.8 Water treatment facilities

Water treatment facilities, namely caustic for neutralisation and chlorine for disinfection is carried out for utilisation underground. Surplus fissure water is pumped to Bank and Carletonville and treated by the municipalities before utilisation by these towns. There are no other surface water treatment facilities on the mine.

3.1.9 Potable water plant

Potable water is provided by Rand Water. Disinfected chilled water from the fridge plant is sent underground. Rand Water supplies 4,5 Mℓ/day to Libanon's southern section and 1,5 Mℓ/day to Libanon's northern section.

3.1.10 Process water supply

Process water used by the mine is sourced from fissure water, Rand Water and water returned from the tailings dam. The underground water is treated with caustic soda for neutralisation and chlorine for disinfection.

3.1.11 Metallurgical processing plants

The two processing plants at Libanon can be subdivided as follows:

Crushing, milling, slime thickening, leaching, filtration, clarification, precipitation, smelting, chemical storage and tailings disposal.

3.1.12 Mine water balance

The Libanon mine water reticulation balance is shown in Figure 1. It also indicates the linkage of the different water systems to and from the different facilities on the northern and southern sections. The total inflow of water into the Libanon northern section amounts to 756 Mℓ/month and consists of:

Rand Water	46	Mℓ/month (6%)
Fissure Water	647	Mℓ/month (86%)
Rain	63	Mℓ/month (8%)

There is also a transfer of 148 Mℓ/month of raw sewage water from the southern section which is discharged to the Westonaria sewage works.

The total outflow or water loss from the Libanon Northern Section amounts to 756 Mℓ/month, of which 129 Mℓ/month (17%) is raw sewage. Pumping of fissure water or dewatering to Bank amounts to 386 Mℓ/month (51%). Around the slimes dams water loss due to evaporation, seepage and interstitial water amounts to 226 Mℓ/month (30%). A volume of 15 Mℓ/month (2%) is lost due to irrigation and evaporation from gardening and sports fields.

The total inflow of water into the Libanon southern section is 1182 Mℓ/month and consists of:

Rand Water	137 Mℓ/month (12%)
Fissure water to No. 1 Shaft	273 Mℓ/month (23%)
Fissure water to No. 4 Shaft	683 Mℓ/month (58%)
Rainfall	89 Mℓ/month (8%)

The total outflow of water or water loss from Libanon southern section is 1182 Mℓ/month and consists of 420 Mℓ/month (36%) dewatering to Kloof Gold Mine. Around the slimes dam water loss is due to evaporation, seepage and interstitial water, amounting to 561 Mℓ/month (47%). Water loss of 43 Mℓ/month (4%) is due to irrigation and gardening at the village and 10 Mℓ/month (1%) used by the hostel and small vegetable plots. The release of sewage to the Westonaria sewage works, via the northern section amounts to 148 Mℓ/month (13%).

3.2 DESCRIPTION OF WATER TREATMENT/MANAGEMENT SYSTEMS

3.2.1 Slimes Dams

Libanon southern section has two tailings dams, one very small and defunct for many years, and the other currently in use at No. 1 shaft.

Libanon northern section has two tailings dams, of which only one is currently in use.

3.2.1.1 No. 1 Shaft Tailings dam.

Plant tailings are pumped from the metallurgical process plant on the southern side of the dam to the No. 1 Shaft tailings dam. This is the largest tailings dam with three operating compartments, situated on a gently sloping terrain to the northwest, to the Wonderfonteinspruit. There is a rock buttress, approximately 35m high around the western half of the dam. Tailings are delivered via an inwall system to the daywall paddocks during day time, and on the beach area during night deposition. There are no under drainage systems. Surface water is decanted off the paddocks in the following manner.

Water from compartment one is decanted to the top surface of compartment two. Water from compartment two and three is decanted via two floating penstocks into a solution trench at the base of the tailings dam on the northern side. Seepage water and decanted surface water flows down the solution trench into a pumping sump on the north western side of the dam, where the water is returned to the metallurgical plant.

Excess storm and decanted penstock water from the solution trench spills over a weir and is conveyed to a series of stormwater retention ponds where the water is left to evaporate on the northwestern side of the dam. Catchment paddocks are in place at the toe of the eastern half of the dam. There are no paddock catchments at the toe of the rock buttress on the western side. The eastern slope of the dam rises at a steep overall angle and has no stepins.

3.2.1.2 Tailings dam No. 2 at 5 Shaft

This large tailings dam, which has only one compartment, is the only operational slimes dam on the northern section. Tailings are delivered via an inwall system into a daywall operation. Surface water is decanted off the top surface of the dam via a floating penstock and gravitates directly to the plant in a pipeline. There is no penstock return water dam between the tailings dam and the metallurgical plant. There is also no under drainage system or solution trenches around the perimeter of the dam. Storage capacity at the plant holds storm water flows from the tailings dam as well and the excess water gravitates to No. 5 Shaft retention dams, where the water is left to evaporate.

The top surface of the tailings dam is in a very dry condition due to the low tonnages deposited on this dam in relation to the total surface area of the dam. Very large catchment paddocks, much wider than the norm, have been constructed around the toe of the dam. This makes provision for any seepage and runoff from the side walls as there is no return water dam to collect and manage this water. The pollution control dam, paddocks and evaporation dams for both the northern and southern sections are unlined which could result in seepage entering groundwater systems.

The following management principles are applicable to both operating slimes dams. All stormwater management measures have been designed to cater for a 1 in 100 year storm event. Rainfall runoff upstream of the tailings dams is diverted around the dams by means of earth trenches. The toe paddocks provided to capture precipitated salts and runoff from the sides of the slopes are regularly inspected and maintained to ensure that they retain adequate holding capacity. The dam will be revegetated during construction as and when suitable areas become available so as to minimise erosion and maintenance of the runoff control measures. All runoff control works are inspected annually and repaired when necessary.

3.2.2 Waste Rock Areas

Several waste rock dumps are dispersed over the mining area.

The following rock dumps are situated in the southern section:

- Harvie Watt Shaft rock dump
- No. 4 Shaft rock dump (no longer in use)
- No. 1 rock dump
- No. 2 Vent Shaft rock dump (no longer in use)

The following rock dumps are situated in the northern section:

- No. 5 Shaft rock rump
- No. 6 Shaft rock dump (no longer in use)

The objective of the water management strategy for rock dumps is to prevent contamination of clean storm water runoff from coming into contact with the rock dump. Storm water drains have been constructed to divert storm water away from the rock dumps and to discharge it into the nearest water course or other suitable disposal sites. There is no capture of runoff water in toe paddocks or evaporation dams as all the rock dumps have been constructed on dolomitic areas or very close to such areas. The risk of sinkhole formation is considered to be more serious than the risk of surface water pollution.

3.2.3 Water management and stormwater control at plant, hostel and shaft complex areas

The main objective is to prevent clean stormwater runoff from coming into contact with contaminated areas and to prevent the runoff from contaminated areas from reaching surface water resources.

The following strategies are applied:

- Stormwater diversion canals have been constructed to divert clean stormwater from the plant, hostel and shaft complex areas.

- Stormwater drains within the plant have been constructed to direct washdown and cleaning water to the return water dam from where it is pumped back for reuse in the process water circuits.

The Harvie Watt Shaft washdown water goes to a settling facility where it is recycled for use in the shaft water circuits. Surplus water from Harvie Watt Shaft goes via lined drains to evaporation ponds situated north of the Johannesburg/Potchefstroom road area.

Runoff from No. 1 Shaft complex goes via a sump into the mine circuit. Surplus water discharged from the Shaft is used by a farmer to irrigate vegetables.

Contaminated washdown water from the hostel is screened and pumped to the municipal sewage works. The sewer inlet is designed to deal with the volumes associated with the washing water. Any storm water runoff, bypasses the sump and flows to the nearest water course. All storm water control measures are inspected regularly and maintenance carried out on a regular basis.

3.2.4 Underground water reticulation systems

3.2.4.1 *General Layout*

A total volume of 435 Mℓ/month of chilled water is pumped from the surface fridge plant at No. 1 Shaft to the underground dams at 3 level and 11 level and then to 14 level from where it is distributed to lower levels in 1 Shaft and down to the subvertical No. 4 Shaft.

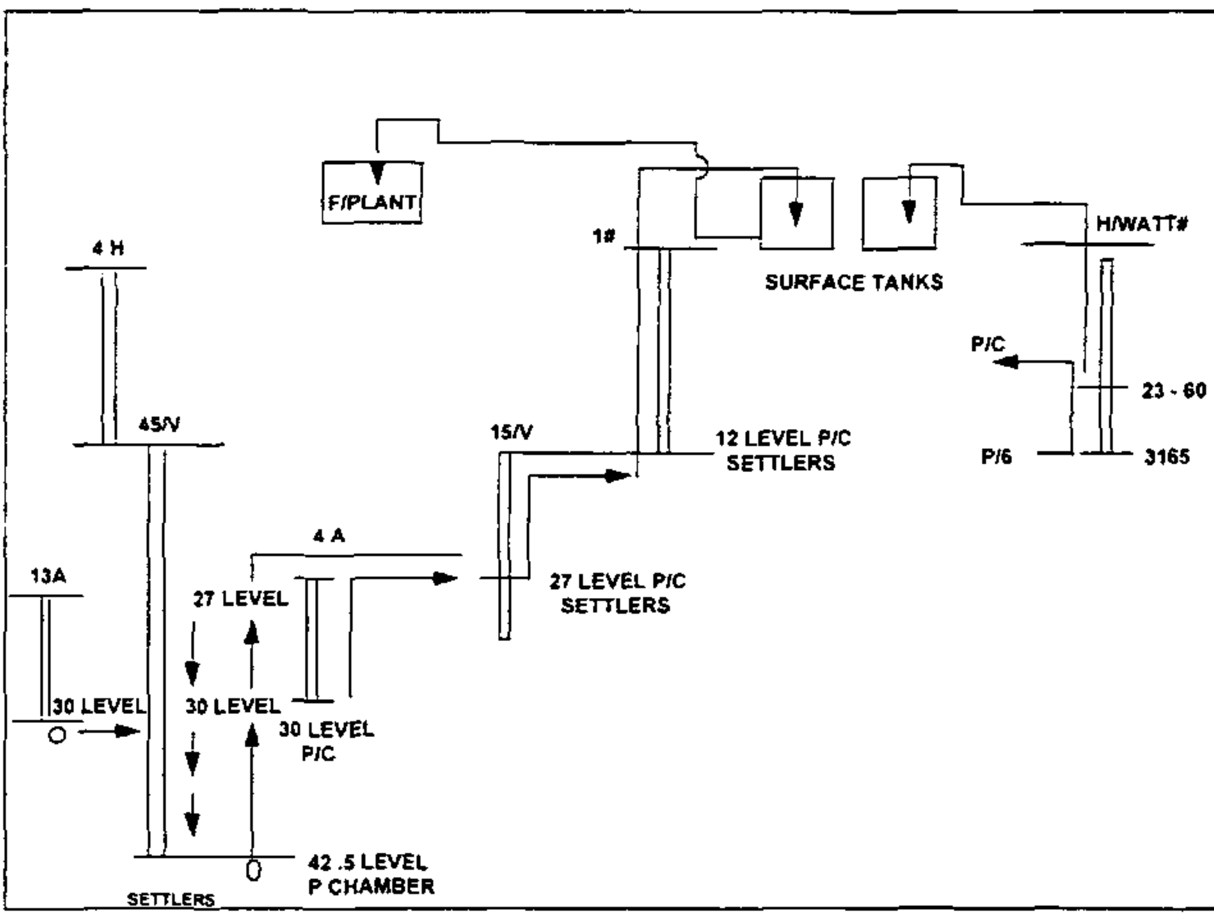


Figure 2 : Dewatering and water pumping systems

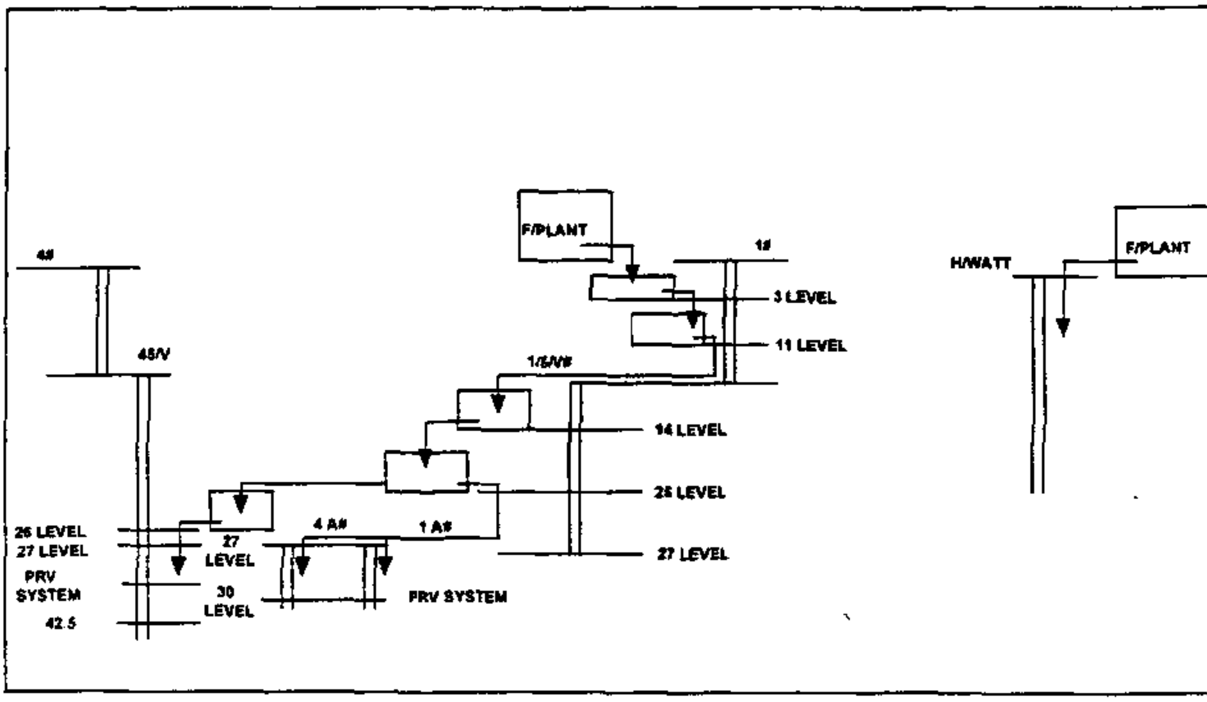


Figure 3 : Chilled water distribution to underground levels from surface fridge plant

Dirty water from the mining sections gravitates to two settler installations, one on 42½ level at the No. 4 subvertical Shaft and the other at No.1 Shaft settler installation at 27 level.

The clear water from the settlers and fissure water from underground water sources is pumped to the surface tanks at No. 1 Shaft from where the fridge plant is supplied and the excess water discharged via the 1m diameter pipeline to the Wonderfonteinspruit.

Potable water for underground use is supplied by Rand Water to various underground locations.

3.2.4.2 *Underground settlers*

The underground settler installation on 42½ level at No. 4 Shaft was visited. It consists of two settler installations, one with six rectangular cells and the other with ten cells. The dirty water flow gravitates to the settlers at 42½ level. Of significance, is that a degritting plant has been installed to remove all coarse material from the dirty water before the water is clarified in the settlers. The benefit of the degritting plant can be clearly seen in the extended operation time before maintenance of the equipment is required, especially the mud pumps and clear water pumps. During the site visit only the 6 celled settler was operational. The larger 10 cell settler was not required as the smaller settler was adequate to handle the total flow at that stage.

An additional advantage is the natural pH of the dirty water. The dirty water to the settlers measured a pH of 7,7 and a conductivity of 151 mS/m. No neutralisation is considered necessary before flocculation and settling. The flocculant solution is added from a makeup tank and then rapidly mixed in the launder by a series of baffle plates. The monthly cost of flocculant is approximately R10 000. The flow rate to the settlers is not measured and it unclear what the cost per volume treated is.

The flocculated dirty water is distributed across the 6 cells where the flocculated solids settle to the bottom. The clear water then overflows into a clear water launder and into a vertical clear water dam before it is eventually pumped to surface. No secondary settling of solids occurs in the vertical clear water dam due to the good performance of the settlers. These settlers are actually over designed for the current flowrate.

Desludging of the cells is done on an hourly basis. The operator opens each of the 4 desludging valves per settler for a few seconds in order to maintain a constant mud level. The thickened sludge is pumped from the mud dam with mud pumps to the metallurgical plant. The settler installations are manned by only 1 operator who is responsible for the whole operation, i.e. checking flocculant make up, desludging and the clear water overflow to the clear water dam.

Pumping hours were considerably reduced with the installation of the degritting plant. Prior to the installation of the degritting plant on 42 level, pumping hours for a major overhaul were as follows. For the clear water pumps ±3 months and for the mud pumps ±4 months. After installation of the degritting plant, clear water pumps needed an overhaul every ±6 months and the mud pumps every ±7 months.

3.2.4.3 *Disinfection of mine surface water*

Mine surface water is disinfected by treatment on surface. This is done at the fridge plant at No. 1 Shaft where the chilled water is treated with chlorine before it is sent underground to the working areas. The water disinfection efficiency is monitored fortnightly by taking samples of the drinking and the service water at different levels and then analysed for standard plate count, total E. Coli and Faecal coliforms. The mine ventilation department is responsible for taking these samples.

3.2.5 Water and environmental monitoring programme

Various water samples are taken at underground mining operations and activities. These samples are analysed for pH, solids in suspension and chlorides. These samples are taken on a daily basis and sent to the mine assay laboratory for analysis and the results are then forwarded to the Chief Engineer for the necessary action.

Another set of samples are taken at various places on the mine and underground. These samples are taken on demand and sent to Goldfields Laboratory and involves general analysis, i.e. pH, electrical conductivity, Langelier Saturation Index, the Ryzner Index, major cations, major anions, nitrogen and its compounds, organic constituents, minor constituents and suspended solids.

In the metallurgical process plant a few environmental monitoring samples for cyanide and lime content are also taken daily and sent in for analysis. Samples are taken from plant tailings or residue, slimes dam return, penstock return water, evaporation dam feed and evaporation dam overflow.

3.3 NOVEL OR UNIQUE WATER TREATMENT AND MANAGEMENT SYSTEMS

3.3.1 The installation of the degritting plant

The installation of a degritting plant before the settling of the dirty water underground has had major implications in terms of cost savings on maintenance and labour for the settling operation and pumping systems.

3.3.2 Area geology

Due to the dolomitic geology of the area and the possibility of sinkhole formation, the strategy of water distribution is geared towards conveyance of water in lined channels or pipelines. The distribution and storage of water in unlined trenches is avoided where possible.

3.4 POTENTIAL WATER TREATMENT/MANAGEMENT PROBLEMS AND NEEDS

3.4.1 Metallurgical process plant and No. 1 Shaft runoff

Surface runoff is channelled via concrete canals and trenches to the return water sumps and excess water overflows into the settling/evaporation dams on the western side of the tailings dam. When the settling/evaporation dams overflow, the water runs into the Wonderfonteinspruit catchment area.

At No.1 Shaft hostel, runoff is via an earth trench to an evaporation pond on the western side of the hostel. Water in the trench measured a pH of 7,7 and a conductivity of 151 mS/m and a pH of 8,5 and a conductivity of 135 mS/m was measured in the evaporation pond. Seepage and overflow from this evaporation pond would pollute the area below the evaporation pond, which is presently used for vegetable farming.

3.4.2 Rock dumps

There are no measures in place aimed at the contaiment of potential pollution from the many scattered rock dumps in the area. Presently, runoff is left to contaminate other surface water streams or left to infiltrate the groundwater.

3.4.3 Discharge of fissure water to Bank/Carletonville area

The large volume of fissure water discharged to Bank/Carletonville increases the flow in the systems and changes the hydrological state of the area. Discontinuation of the water will lead to a loss in water resources for downstream users. The amount of water discharged is approximately 459 Mℓ /month. Subsidence due to the watering of the dolomite, infiltration of storm water and fissure and mine water spillage into dolomitic areas cause sinkholes and surface instability. The 1m diameter pipe conveys the water from the Donaldson Dam downstream across the dolomitic area. During the site visit the pH in the Donaldson Dam was measured at 8,4 with a conductivity of 106 mS/m.

An earthlined stormwater canal conveys Westonaria runoff away from the neighbouring township. Various other lined canals and pipelines divert water away from the more sensitive sinkhole areas.

3.4.4 Contamination of groundwater

The most likely sources of contamination of the groundwater systems are the tailings dams and rock dumps. The seepage from tailings dams and rock dumps at Libanon is inclined to be acidic, containing high salt loads, particularly high loads of sulphates and may contain high concentrations of heavy metals. There are no conditions or measures which significantly reduce the impact of seepage from tailings dams and rock dumps on groundwater quality. Neither are there any well designed underground drainage systems in these operations and the underlying geology does not limit the spread of pollution in the area. Fissure water pumped from underground workings is made available to farmers and other water users through the discharge into natural water courses so that the value of the dolomitic aquifer as a water resource is not lost.

Figure 4 shows some of the water quality measures taken during the site visits in terms of pH and conductivity readings.

The general dewatering of the dolomitic aquifer by the mines on the West Wits line has rendered large tracts of land in the Westonaria and the Carletonville districts unsuitable for agricultural, industrial and urban development. The impact is predominantly the result of the development of sinkholes in the area.

3.5 WATER MANAGEMENT STRUCTURE

Figure 5 shows the water management structure for the mine. Firstly the Mine Manager has the overall responsibility for water management and subdivided into the Engineering Manager and Metallurgical Manager, the Engineering Foreman and Metallurgist are responsible for sampling and maintenance of the different systems used to control the water.

Daily samples are assayed on the mine premises at its own chemical laboratory which allows for a much shorter turnover time. Other samples are also sent away to Goldfields laboratory.

4. GENERAL IMPRESSION

Libanon Gold Mining's Northern & Southern section have well established water management systems. There is a general awareness of the danger of sinkhole formation and excess water is controlled via channels and pipelines to prevent spillages to the environment which could result in sinkholes.

Due to the high volumes of water pumped from underground for dewatering purposes, chemical and pollution loads are diluted in the process, which reduces its impact significantly. The EMPR has changed the attitude of the people responsible for water management. They are all aware of their responsibilities and the necessity for continuous maintenance, and where necessary, problems are reported for maintenance and for the required attention.

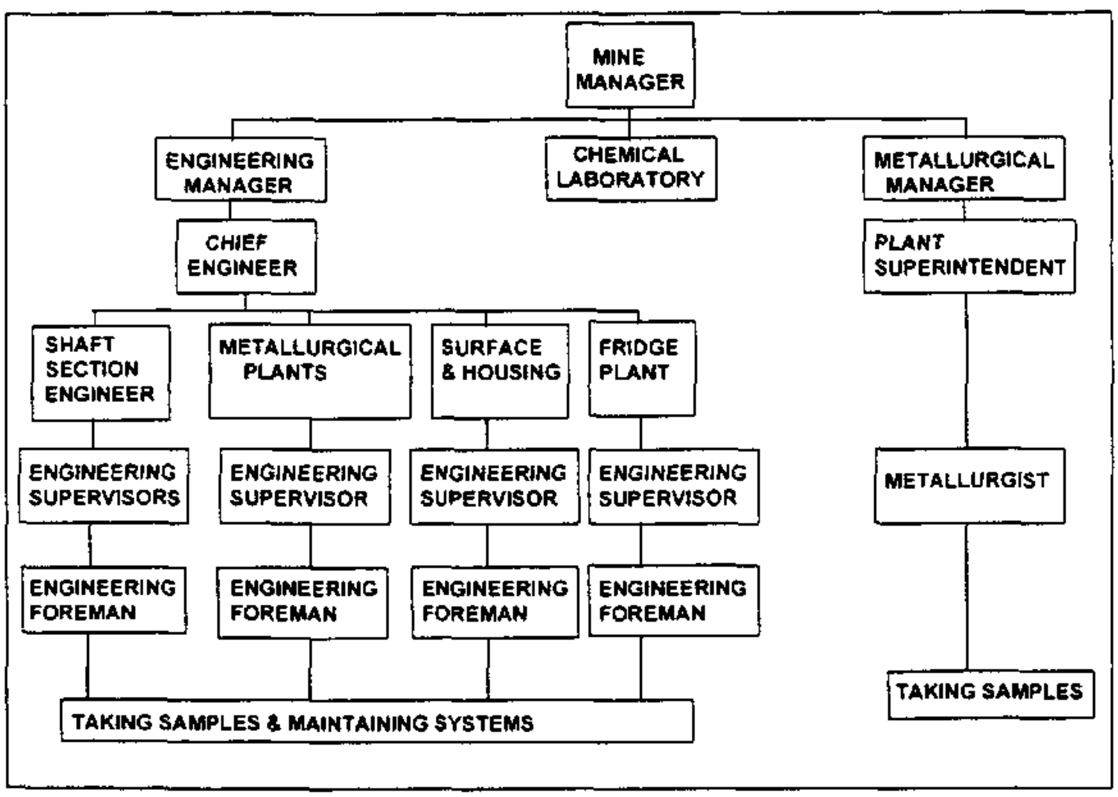


Figure 5 : Mine water management structure

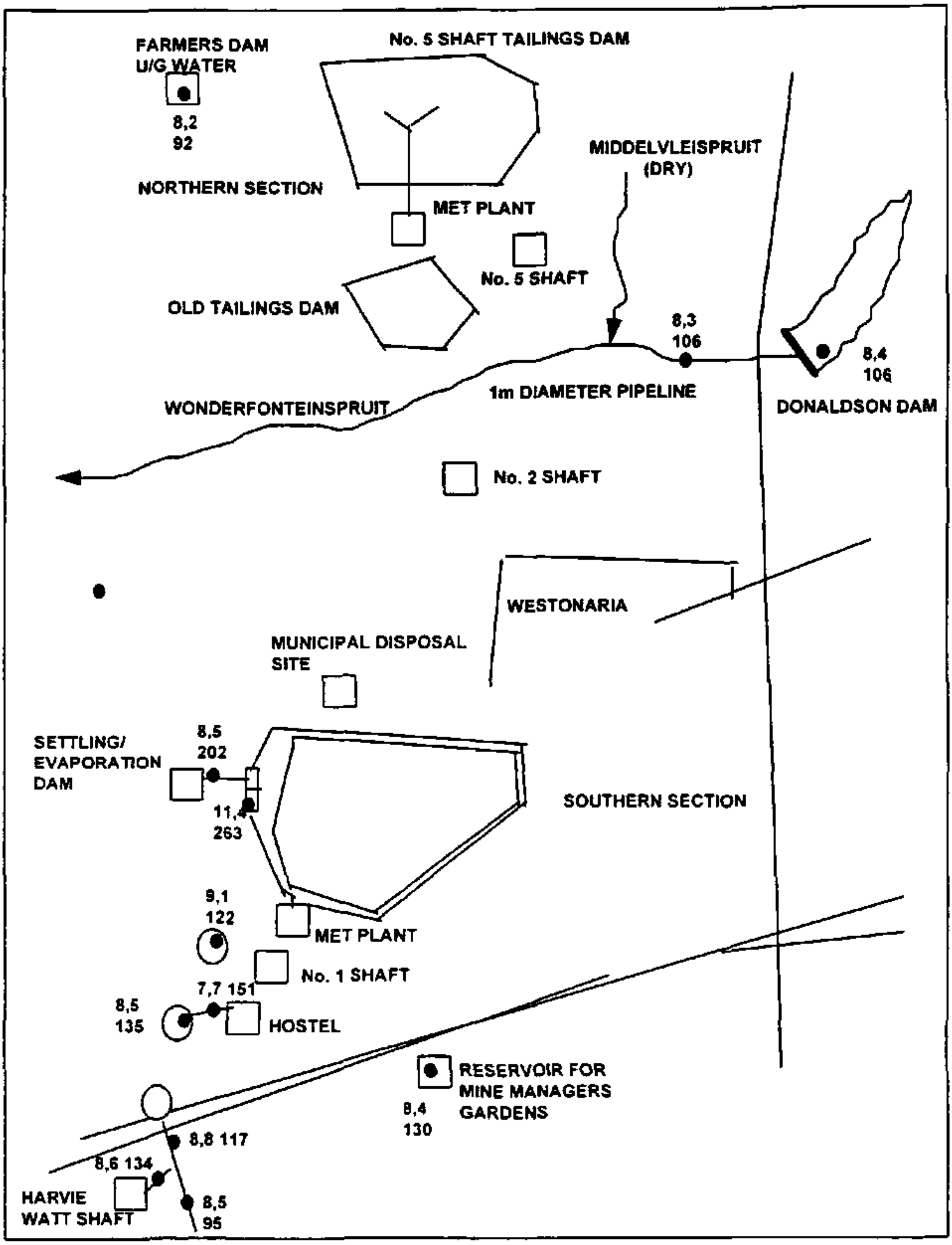


Figure 4 : Surface layout and sampling points measured during site visit

Appendix A - List of pH and conductivity monitoring readings taken during the Site Visit

During the site visit, a number of pH, conductivity and temperature readings were taken at various locations on the mine

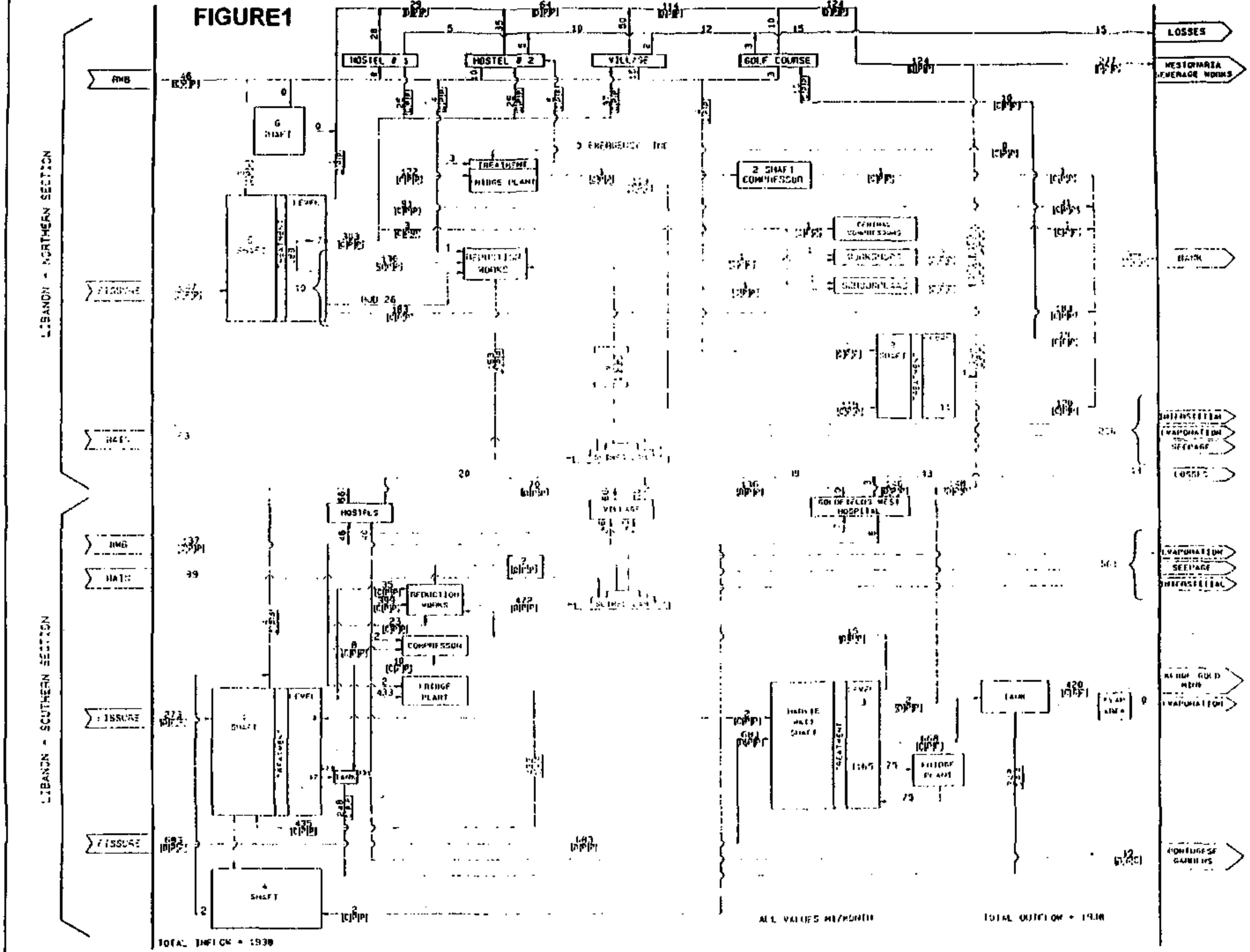
No	Monitoring Point Description	pH	Cond (mS/m)	Temp °C
1	Donaldson Dam overflow	8,4	96	-
2	Donaldson Dam overflow entering the 1m *diameter pipeline*	8,3	140	-
3	Water in Donaldson Dam	8,4	106	-
4	Downstream of dam water in pipeline	8,3	106	-
5	Farmers dam south of Venterspost	8,2	92	-
6	Excess water from return water sump to settling dam at No1 shaft tailings dam	8,5	202	-
7	Return water sump for water decanted of tailings dam	11,4	263	-
8	*Mine water tank at No1 shaft*	9,1	122	-
9	Harvie Watt shaft water tank	8,6	134	-
10	Harvie Watt shaft runoff water in cement trench	8,5	95	-
11	Harvie Watt shaft runoff water in cement trench	8,8	117	-
12	Mine managers water reservoir	8,4	130	-
13	Spillage from hostel at No 1 shaft	7,7	151	-
14	Evaporation dam below hostel	8,5	135	
Underground Visit at 4 SV Shaft Panel 28 North 13				
15	Water from drill hole	7,4	126	22
16	Service water to workplace	7,7	126	17,5
17	Water from strike gulley	7,3	146	26.0
18	Combined runoff from section	7,9	152	26.3
Underground Settlers				
19	Dirty water to settlers	7,7	151	28.0
20	Clarified overflow	7,6	151	-

Appendix B - List of Photographs

During the site visit, a number of photographs were taken at various locations on the mine

Photograph No	Photo Subject Description
1	Donaldson Dam weir
2	Daywall paddock on south side of No 2 tailings dam at 5 shaft
3	Daywall paddock on south side of No 2 tailings dam at 5 shaft
4	First and second line paddocks on south side of No 2 tailings dam 5 shaft
5	Farmers dam south of Venterspost Township
6	Northern sections setting/evaporation dam (decommissioned)
7	Trench to settling dams west of No1 shaft tailings dam
8	Municipal disposal site on northern side of tailings dam causes solid waste to end up in cutoff trench
9	Sump for collecting internal plant spillages
10	Cement lined trench for collection of plant spillages
11	Cement lined trench for collection of plant spillages
12	Mine water holding tank for dewatering water from 1 and 4 shaft
13	Earth trenches and evaporation dam for hostel effluent
14	Earth trenches and evaporation dam for hostel effluent
15	Earth trenches and evaporation dam for hostel effluent
16	Mine manages water reservoir for gardening
17	Mine manages water reservoir overflowing
18	Cement channel for Harvie Watt shaft runoff to evaporation dam
19	Backfill tanks at 4 shaft
20	*4 Shaft SV panel 28 north 13, marked and drilled*
21	*Foot and roof wall support in panel*
22	Backfill canvas
23	Backfill canvas
24	Backfill canvas
25	Water jetting
26	Water runoff from crosscut
27	Degritting plant before settlers
28	Degritting plant before settlers
29	pH and Ec measurement taken in haulage
30	Dirty water from degrit plant to settlers
31	Flocculant addition point
32	Degritting plant before settlers
33	Degritting plant before settlers
34	Cooling towers for fridge plant at 1 shaft
35	Inside cooling towers
36	Cooling system for compressors
37	Disinfection section for chilled water
38	Sand filters
39	Sand filters
40	Condensers
41	Condensers
42	Turbine opened for maintenance and repair

FIGURE1



JOB No. 196369

PIPED/CHANNEL
PUMPED/GRAVITY
DIRTY/CLEAN

LIBANON MINE WATER RETICULATION BALANCE

Report on President Brand Gold Mine Site Visit.

9 - 11 November 1994

1. GENERAL INFORMATION

Name of mine	President Brand Gold Mine, one of the six mines which forms part of Free State Consolidated Gold Mines (Operations) Ltd (Freegold)
Name and position of person(s) interviewed	Messrs DT Bell - Metallurgical Superintendent (Technical Services) J Mostert - Section Engineer, Environmental Affairs APS Howard - Plant Superintendent (Projects) T Pieterse - Regional Water Technologist F Smith - Mechanical Engineering Foreman
Nearest town	Welkom
Name of catchment	Sand River
Monthly tonnes treated for Freegold	1,6 million tonnes per month u/g ore 400 000 tonnes per month old rock dumps 900 000 tonnes per month slimes dam of which Pres Brand Gold Mine treats: 300 000 tonnes per month u/g ore
Reef being mined and ore body width	Includes "A" Reef, "B" Reef, Elsburg, Basal, Leader and Pyrite reefs. Average 1,6m width
Monthly gold production of Pres Brand	1,7 tonnes
Current age of mine	39 years. The consolidation of various mines to form Freegold took place in 1986
Expected remaining life of mine	6 years
Current mining methods	Standard open stoping layout for extraction of narrow, generally flat, dipping gold reefs
Has an EMPR already been produced by the mine	Yes, busy updating a draft copy of second version.

2. SITE VISIT PROGRAMME

2.1 Day 1 (as for Pres Steyn visit)

- Arrival at Pres Brand 2 Shaft Engineering Workshop Offices
- Short discussion on project background, objectives and site visit programme with Mr T Pieterse, Regional Water Technologist
- Collected surface plan of Pres Brand Gold Mine from main offices
- Short discussion on project background, objectives and site visit programme with Mr J Vorster, Sectional Manager Environmental Affairs, responsible for compiling the Freegold EMPR
- Obtained a draft copy of the EMPR from Mr J Vorster for use during site visit and a surface plan showing the entire Free State Consolidated Gold Mines (Operations) Ltd, indicating 54 environmental surface water sampling sites.
- Short discussion on project background, objectives and the site visit programme with Mr D Bell, Metallurgical Superintendent Technical Services, who arranged a combined visit to Pres Brand and Steyn slimes dam complex, including the dam arrangement for the return water system for distribution throughout the entire Free State Consolidated Gold Mine.

2.2 Day 2 (as for Pres Steyn visit)

- Arrival at Metallurgical Training Centre for appointment with Mr J Fourie, Slimes Dam Metallurgical Foreman. Visit to Pres Brand and Steyn Slimes Dam complex, which included a total of nine slimes dams (PS 1E; PS 2E; PS 2W; PS 3; PS 4; PS 5; PS 6; PB 1, 2, 3 and PB Old final dam); as well as the Sand River Canal and the seepage and penstock return water catchment dam system which included a total of nine dams (i.e. 12A, 12B, 12C, 13, Stuurmanspan, Jurgenshof Dam, return water dam, Wesselspan and local farmers dam).

2.3 Day 3

- Arrival at Pres Brand 5 Shaft offices
- Short discussion on project background, objectives and underground visit with Mr F Smith, Mechanical Engineering Foreman
- Guided tour of the 68 level settler system with Mr F Smith
- Visited Mr A Howard, Plant Superintendent (Projects and Information Systems) for Surface Waters. Collected water balances for Pres Brand Gold Mine as well as the Southern area which includes Pres Brand; the water management structure and environmental surface water sampling sites and programme for Freegold.
- Obtained underground water analysis reports for scale and biological control from Mr T Pieterse, Regional Water Technologist.

3. DISCUSSION OF MINE'S CURRENT WATER MANAGEMENT AND TREATMENT PRACTICES

The activities of the various mines within Freegold, and particularly the water distribution, are interlinked. For this reason, certain discussions regarding water circuits and management strategies will refer to the Freegold operation, in general. Where relevant, the distinction between Pres Steyn and Brand has been made.

3.1 DESCRIPTION OF MINE WATER CIRCUITS

The interests of Anglo American Corporation in the Free State Gold Fields was consolidated into one operating company to form Free State Consolidated Gold Mines (Operations) Ltd (Freegold).

Freegold covers an area of 30 000 hectares. A total of 29 operating shaft systems have been sunk throughout the Freegold mining area. Twenty six of these systems produce ore which is processed in 7 metallurgical plants. The Metallurgical Scheme treats slimes dam material in 4 separate metallurgical plants.

A total of 24 slimes dams and 29 waste rock dumps have been formed for residue deposition.

Currently mining operations occur at 18 shafts, of which 4 are Pres Brand Shafts (1, 2, 4 and 5). Mining is scheduled to stop by the year 2000 for the Pres Brand Shafts.

Freegold is divided into a northern and southern area. The southern area comprises the following 3 gold mines:

- Pres Steyn Gold Mine
- Pres Brand Gold Mine
- Free State Saaiplaas Gold Mine

Figure 1 shows the water balance for the period April '93 to March '94 for the entire southern area which includes Pres Brand.

This figure indicates that the following water sources are used in the southern area:

• Goudveld Water regional supply	40,1 Mℓ/day
• Municipal sewage effluent ex Welkom,	
• Theronia & Thabong sewage works	5,7 Mℓ/day
• Imported underground water	18,7 Mℓ/day
• Fissure water	4,6 Mℓ/day
• Boreholes	2,8 Mℓ/day

3.1.1 Water Sources for Pres Brand Gold Mine

Figure 2 shows the water balance for the same period, April 93 to March 94 for Pres Brand Gold Mine. It should be noted that the individual balances for Pres Brand and Steyn are slightly misleading due to the transfer of water between Dams 12A, 12B, 12C and 13.

The total inflow of water into the mine area is 69,2 Mℓ/day and consists of the following:

- Imported fissure water — 18,6 Mℓ/day
- Fissure water — 1,9 Mℓ/day
- Goudveld Water regional supply — 15,0 Mℓ/day
- Municipal sewage effluent ex Welkom and
- Theronia — 31,2 Mℓ/day
- From Pres Steyn Float Plant — 0,4 Mℓ/day
- Boreholes — 2,1 Mℓ/day

These figures demonstrate that Pres Brand is a relatively dry mine which produces very little fissure water. There is a heavy reliance on fissure water which is imported from mines such as Beatrix and H.J. Joel, further south. The bulk of the inflow water is obtained from the municipality as sewage effluent.

3.1.2 Goudveld Water Distribution

The Goudveld Water supply to Pres Brand is distributed as follows:

- Hostels, offices, workshops, surface
- and other infrastructures — 5,5 Mℓ/day
- Shaft and ancillary equipment — 4,5 Mℓ/day
- Metallurgical scheme — 3,9 Mℓ/day
- Gold plants — 1,0 Mℓ/day
- Outside concerns — 0,07 Mℓ/day
- Irrigation for sports fields and gardens — 0,09 Mℓ/day

As for Pres Steyn, the main users are the hostels and offices where water is used for domestic purposes. The second major user are the various shafts where potable water is supplied underground for satisfying workforce drinking requirements. The regional water is also blended with underground service water as a dilution factor to control the water quality for the cooling systems at the fridge plant and condensers.

3.1.3 Municipal sewage effluent

Municipal sewage effluent consists of water from the Welkom and Theronia works and is used mainly by the acid plant of the Pres Brand Metallurgical Scheme. A volume of 4,1 Mℓ/day flows into Witpan to supplement the volume of 2,2 Mℓ/day from the Thabong works.

3.1.4 Metallurgical process water return systems

Residue from the various metallurgical plants is deposited on the slimes dam complex. The penstock return water and underdrainage from these dams is channelled via a network of trenches to the various storage dams situated to the south-west of the slimes dam complex. Water from the 12A, 12B and 12C Dam complex is used in the Pres Brand gold plants. There is also a transfer of approximately 13 Mℓ/day to Dam 13, from where 9,3 Mℓ/day is pumped to the gold plant of Pres Steyn.

3.1.5 Other external sources

The Beatrix and H.J. Joel mines to the south of Virginia supply their excess fissure water to Freegold. Some of this water is evaporated but a large portion of it is required for use in the metallurgical plants. The water is supplied to the 12A, 12B and 12C Dams from where it is distributed as required.

3.2 DESCRIPTION OF WATER TREATMENT/MANAGEMENT SYSTEMS

3.2.1 General surface water layout

Figure 3 shows the general surface water layout for the Pres Steyn and Pres Brand mines. Pres Brand is situated to the west of Pres Steyn.

The figure shows the position of the newer slimes dams East and West of Pres Brand as well as the Old Final Dam which is not in use anymore. The sampling points at which pH and conductivity readings were taken during the site visit are also shown.

The Sand River to the south of Freegold property, flows from east to west where it eventually joins the Vet River at Hoopstad.

Witpan, which lies to the south of Welkom, receives stormwater from the industrial area of Welkom. Contaminated runoff from the Stone and Allied Crusher operation enters the trench which carries Thabong sewage effluent to Witpan.

The Unisel mining operation lies to the south of the 12A, 12B and 12C Dam complex which also includes the Jurgenshof, Stuurmans and Wessels Pans.

3.2.2 Operating slimes dams of Pres Brand

Pres Brand currently operates a total of 4 slimes dams numbered as PB East and West as well as A and D, to the west of the RWD. These slimes dams are situated to the north of Pres Brand 5 Shaft and they lie on the western border of the Freegold property. The defunct Old Final Dam is centrally located between the 12A, 12B, 12C and 13 Dams

Plant residue from the float and gold plants is deposited on these slimes dams.

Penstock return water from A and D dams, collected seepage and underdrainage is channelled via trenches to Dam 13 which acts as a return water storage dam before distribution back to the process water circuits in the metallurgical plants. The East and west dams return water is channelled to 12A dam.

All the slimes dams have properly constructed toe paddocks and seepage trenches. There is, however, very little vegetation of the slopes.

3.2.3 Municipal sewage effluent

Pres Brand makes extensive use of the treated sewage effluent (± 27 Mℓ/day) from the Welkom and Theronia works. The Metallurgical Scheme is due to close down in April 1995 and the demand for this effluent will then decrease. A portion of the treated effluent from the Thabong works is also channelled into Witpan when required. The facility exists for this effluent to be channelled to the Sand River via the Sand River Canal. This is described in more detail in the Pres Steyn report.

3.2.4 Metallurgical plants

Runoff and local plant spillages are prevented from leaving the plant area by means of internal spillage dams. The collected water is pumped back into the plant for reuse in the metallurgical process. Contaminated stormwater runoff within the plant is collected and pumped back for reuse in the process water circuit. Clean stormwater runoff is diverted away from the plant.

The gold plants treat underground ore and rock dumps, and the float plant treats old slimes dams as part of the Metallurgical Scheme. The metallurgical plant utilises the following water sources:

- Goudveld Water regional supply for plant processes requiring good quality water.
- Witpan, which receives sewage effluent and supplies mainly to the float plant.
- Process return water from Dams 12A, 12B, 12C and 13.

The pH of the return water, particularly that from Dam 13 is monitored twice a week. The dam levels are recorded and flowrates are then estimated. The aim of plant personnel is a return water pH of not less than 6,5.

At certain of the acid plant sections, boiler circuits and cooling towers, chemical water treatment, in the form of softening, is required.

3.2.5 Underground water reticulation system

The working stopes and settler installations of Pres Brand 5 Shaft were visited during the site visit.

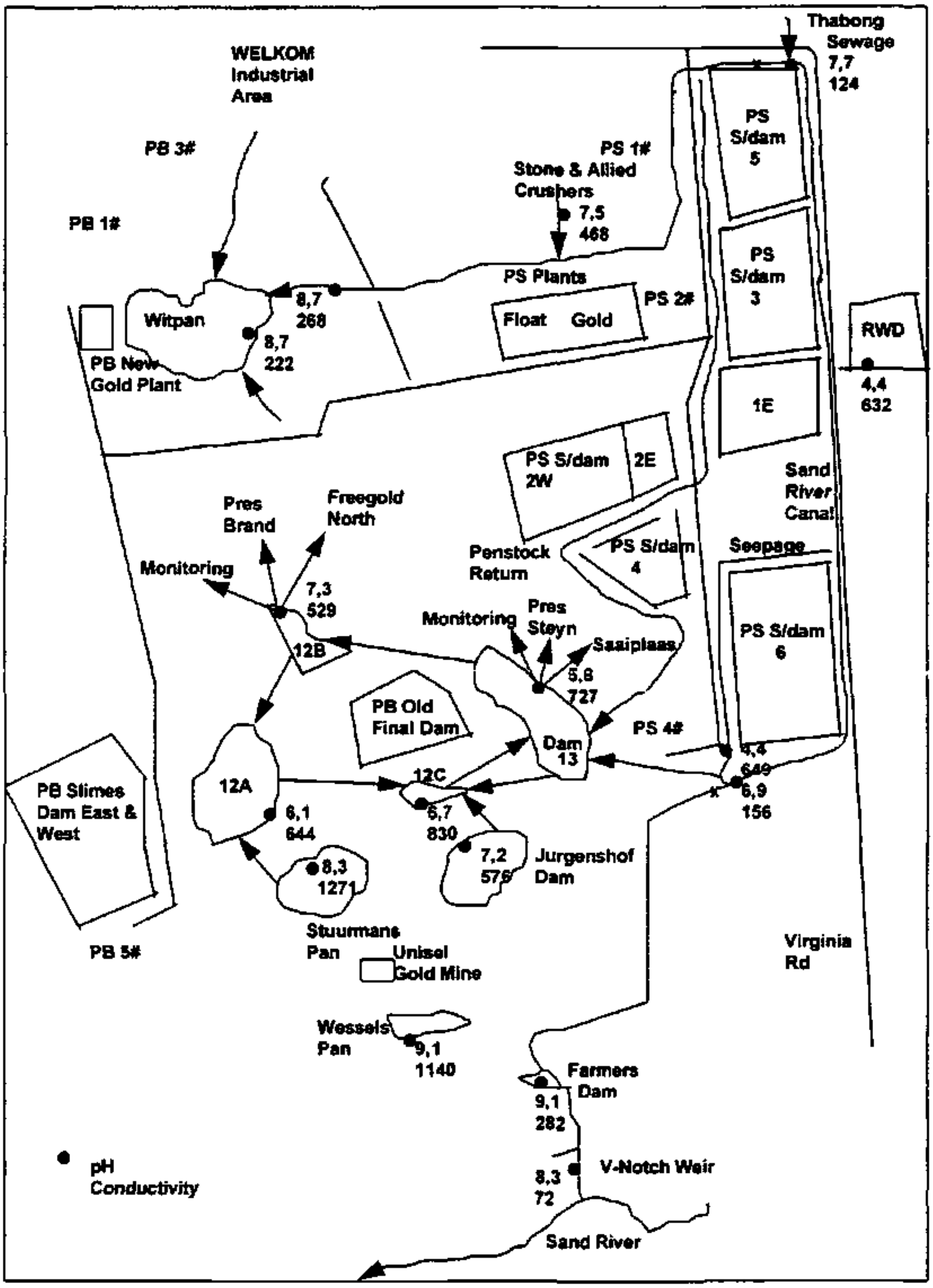


Figure 3 : Surface water systems, slimes dams layout and the various points measured during Pres. Brand and Steyn site visit.

3.2.5.1 General layout of Pres Brand 5 Shaft

Figure 4 shows the general layout of the underground water reticulation systems for Pres Brand No. 5 Shaft.

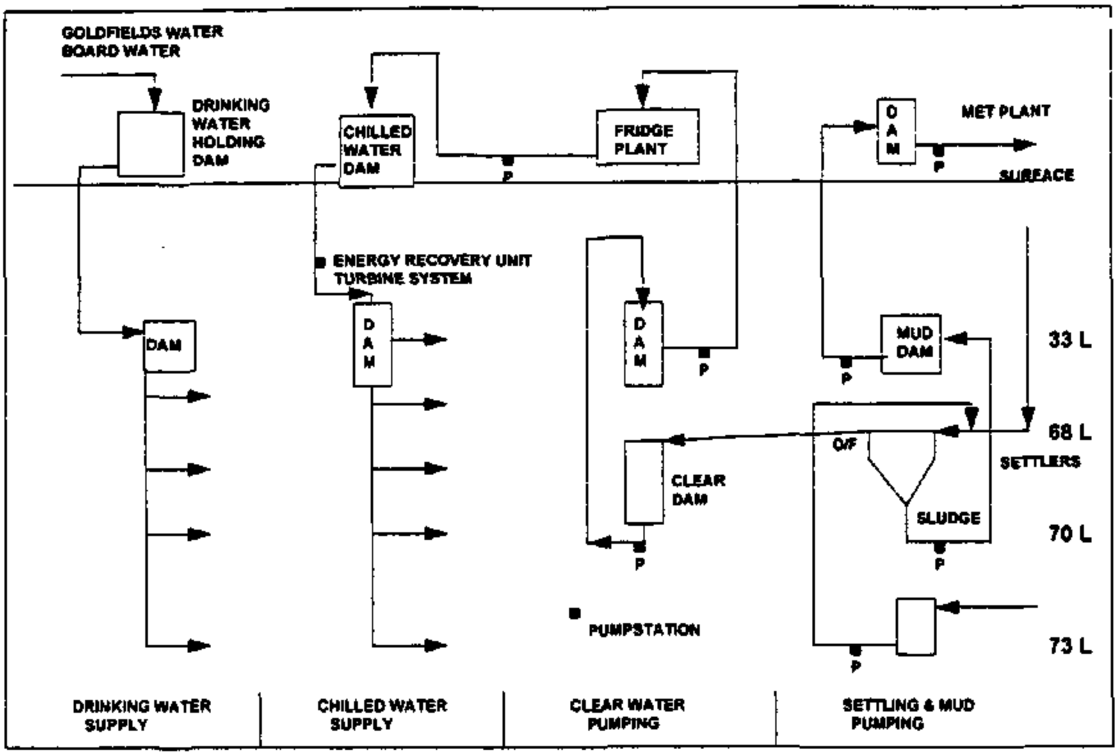


Figure 4 : Flow diagram of Pres. Brand 5 Shaft underground water reticulation system

A total of 15 Mℓ/day is circulated through the underground circuits which include a settler installation on 68 level and a surface fridge plant for chilling of the clear water overflow.

3.2.5.2 Underground settlers at 103 Level

Pres Brand 5 Shaft is served by a single settling installation at 68 level. This system consists of three conventional settlers and two Delkor high rate settlers of 9,5 m diameter. A portion of the dirty water flow gravitates down from the working sections directly into the settlers and a portion is pumped from 73 level to 68 level. Fissure water is pumped to the settlers at certain times of the day and there is some degree of dirty and clean water separation. The flow to the settlers is controlled to some degree by flood gates in the feed launders and coarse material is removed from the water with the use of vibrating screens. This coarse material is then sent to surface with the ore. There are intermediate clean water dams at 70 and 33 level. The settlers are desludged to a $200m^3$ storage dam from where the mud is delivered to the metallurgical plant on surface.

The cost of the lime dosing is approximately R6000 per month and the flocculant costs average R14 000 per month.

3.3 ENVIRONMENTAL SURFACE WATER SAMPLING SITES

The Freegold operation as a whole is well monitored with 54 surface water sampling sites included in a regular programme. The following sites are particularly relevant to the Pres Brand section.

- Leachate from the solids waste disposal site (Old PB "B" slimes dam)
- Pipeline outlet from Harmony into concrete trench near PS No 4 at Virginia Rd intersection, delivering to Dam 13.
- Jurgenshof Dam overflow
- Pipeline outlet from Beatrix line at 12B pump house
- Pipeline outlet from H.J. Joel line at 12B pump house
- Trench from PB No 2# draining to Witpan
- Trench past PB new gold plant draining to Witpan
- Drain from Concor Technicrete (near PB 1#) into Witpan
- Municipal drain from Industrial area into Witpan
- Municipal drain (ex Oppenheimer trench) into Witpan

The analyses include the following parameters: pH, conductivity, total alkalinity, total hardness, total dissolved solids, calcium hardness, chlorides, sodium, sulphates, cyanide, copper, lead, zinc and mercury. Monitoring of the Sand River Canal at the farmers dam and at the V notch weir upstream of the discharge into the Sand River is also important in terms of possible pollution from the storage dams situated in the southern area of Freegold. This has been identified as a potential problem area and consulting studies have been commissioned to investigate the area.

In addition, the qualities of the various sources of water entering Witpan are monitored as the dam serves as an important water source and storage facility.

3.4 WATER MANAGEMENT STRUCTURE

The water management structure is centralised and coordinated within Freegold. This structure and the personnel thereof are shown in Figure 5.

The Sectional Manager, Environmental Affairs, who reports to the Manager-Services, is responsible for compiling the EMPR as well as liaison with the Department of Water Affairs & Forestry.

The Plant Superintendent-Projects and Information Systems, is responsible for collecting all the information concerning surface water quality, dam levels, flow rates and also the sampling of the environmental surface water sampling programme. He reports to the Metallurgical Superintendent-Technical Services who in turn reports to the Metallurgy Manager.

The Section Engineer of every Shaft is supported by the General Engineering Supervisor and the Engineering Foreman who are both responsible for the underground water management systems and the maintenance of these systems. They are supported by the Regional Water Technologist who liaises with the water treatment companies and who also assist the shaft personnel in general interpretation of the water analyses.

The coordination between underground water management, surface water and EMPR matters occurs at a relatively high management level.

The Mine Water Laboratory does the routine analyses and reporting of the results to General Engineering Supervisor and the Regional Water Technologist.

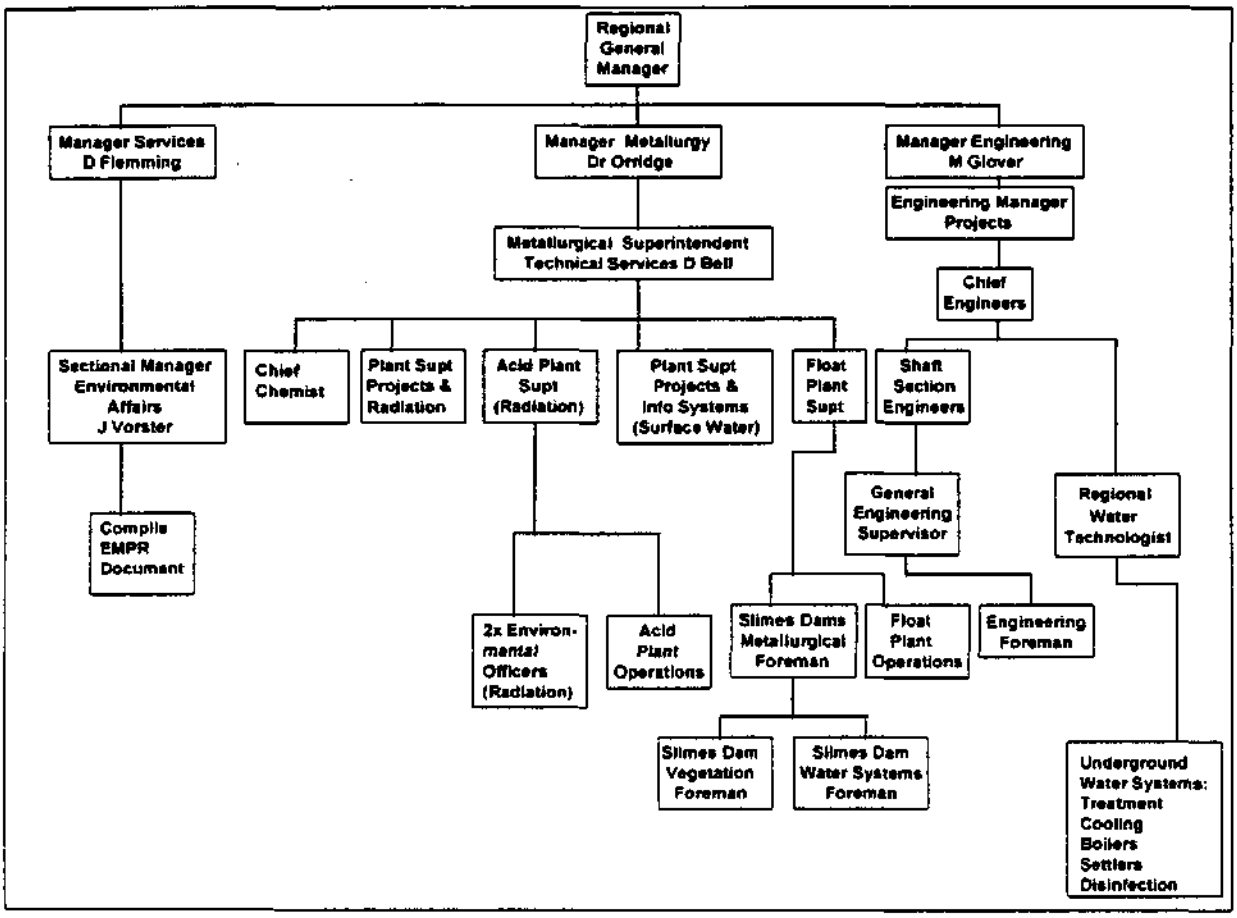


Figure 5 : Water Management Structure for Freegold

3.5 POTENTIAL WATER TREATMENT/MANAGEMENT PROBLEMS AND NEEDS

3.5.1 Pollution of the Sand River Canal

It is clear from the data supplied by the mine that the water flowing down the Sand River Canal is influenced by poor quality seepage from the various slimes dams which lie adjacent to the canal. This canal is collecting seepage en route to the Sand River. The purpose of the canal is to channel stormwater and treated sewage effluent from the works to the north of Pres Steyn and Brand to the Sand River in the south and ideally, the canal should have been lined to prevent contamination of the relatively good quality effluent with slimes dam seepage. A cheaper option would be the construction of a seepage cutoff trench between the slimes dams and the canal. This would aim to intercept the seepage before it reached the canal. This option may, however, be limited by the space limitations in this area. Since it is the slimes dams of Pres Steyn which are largely responsible for the seepage, this aspect is discussed in more detail in the Pres Steyn site visit report.

3.5.2 Witpan

Witpan serves as an important source for some of the Freegold metallurgical plants including the Pres Steyn float plant. The pan receives water from various sources and as such it is difficult to monitor and control the quality thereof. As with the Sand River Canal, trenches draining into Witpan are contaminated by slimes dam seepage as well as runoff from a local stone crushing plant. Industrial area runoff and residential stormwater drain into Witpan and contribute to the deterioration in water quality. The clean water sources such as the purified sewage effluent need to be diverted and isolated such that they remain clean before feeding Witpan.

3.5.3 Evaporation facilities

Of the total volume of water imported by Freegold from other mining concerns, only a portion is utilised and ultimately consumed in the process. Significant quantities of excess water are piped to evaporation pans for disposal. Water in these pans evaporates, leading to an increase in the salt concentrations. The seepage from these facilities is consequently of a very poor quality and contamination of the ground water occurs. The volumes of water involved make the alternative of lining such facilities impractical but at such a scale the possible treatment of the water for use as underground service water, for example, deserves further consideration.

3.6 NOVEL AND UNIQUE WATER TREATMENT AND MANAGEMENT SYSTEMS

3.6.1 Inter mine water transfer

The Free State Goldfields contains several mines in relative close proximity to one another. In this setup, Freegold is in the fortunate position of having fairly dry shafts but being able to utilise the excess water of a neighbouring wet mine. Although these neighbouring mines are approximately 25 km away the delivery of excess fissure water via pipeline is cheap when compared to the cost of purchasing from the regional water supplier, Goudveld Water. It also implies better utility of the regions limited water supply.

3.6.2 Coarse material removal prior to settling

The removal of coarse material from the dirty water flow to underground settlers, is not unique in itself although the practice is fairly uncommon. The uniqueness of the Pres Brand method is in the simplicity of the process. Dirty water is passed over a simple vibrating screen upstream of the settlers. Removed grit is taken to surface with the mined ore. The absence of coarse particles in the settled sludge implies less abrasion and longer life of the mud pumps. Settler operating staff also report improved settling operation and reduced flocculant consumption, although this may be due to other factors.

Appendix A - List of pH and conductivity readings taken during the site visit. (Points 1-17 are as for Pres Steyn visit)

No.	Monitoring Point Description	pH	Cond. (mS/m)	Temp (°C)
1	Witpan next to golf course	8.7	222	-
2	Inflow to Witpan	8.7	268	-
3	Water ex Stone and Allied Crusher site	7.5	468	-
4	Discharge of treated sewage from Thabong Sewage Works into Sand River Canal,	7.7	124	-
5	Return water Dam east of Virginia Rd	4.4	632	-
6	Thabong treated sewage before entering seepage and return water trench south east of President Steyn 4 shaft	6.9	156	-
7	Seepage trench before blended with Thabong treated sewage flowing to Dam 13	4.4	649	-
8	Dam 13 at pump-station suction	5.8	727	-
9	Penstock return water to Dam 13 from slimes dam No. 2, 3, 5	7.6	755	-
10	Dam 12B pump-station	7.3	529	-
11	Dam 12A pump-station	6.1	644	-
12	Dam 12C pump-station	6.7	830	-
13	Jurgenshof Dam	7.2	576	-
14	Stuurmanspan	8.3	1271	-
15	Wesselspan	9.1	1140	-
16	Farmers dam	9.1	282	-
17	V notch weir in Sand River Canal	8.3	71	-
	Underground visit			
18	Neutralised water to No 4 settler	8.3	783	28.6
19	Clear water ex No 4 settler	7.7	802	27.3
20	Dirty water to No 5 settler	8.5	797	28.4
21	Clear water ex No 5 settler	8.0	803	27.6
22	Dirty water to No 1 settler	7.8	800	28.0
23	Clear water ex No 1 settler	7.2	806	27.5
24	Water from stopes prior to lime addition	5.0	832	26.3

Appendix B - List of Photographs

During the site visit, a number of photographs were taken at various locations on the mine

Slide No	Slide Subject Description
1	Witpan under Welkom municipal control
2	Discharge of Thabong treated sewage in the Sand River Canal
3	Return water dam west of Saaiplaas slimes dam complex
4	Dam 13 pumpstation
5	Trench from Dam 12B to pump station
6	Dam 12A
7	Dam 12C
8	Jurgenshof Dam
9	Stuurmanspan
10	V notch in Sand River Canal
11	V notch in Sand River Canal
12	Sand River Canal entering Sand River

The following photographs were taken during the underground visit at President Brand 5 shaft.

13	Top of No. 4 Delkor settler at 68 level
14	Clear water launder inside No. 4 settler
15,16	Top of No. 5 Delkor settler
17	Top of No. 1 settler
18	Haulage showing clear water launder
19	Discharge into clear water dam
20,21	Flood gates for flow control in launders
22	Ultrasonic flow/level installation
23	Lime storage and make up dam
24	Lime dosing into main launder
25	Lime make up with compressed air agitation
26	Dirty water from stopes to vibrating screens
27	Coarse material removal from screens
28	Decommissioned flocculant dosing and make up
29	Flood gates in feed launders

FIGURE 1 WATER BALANCE - APRIL 1993 to MARCH 1994 SOUTHERN AREA

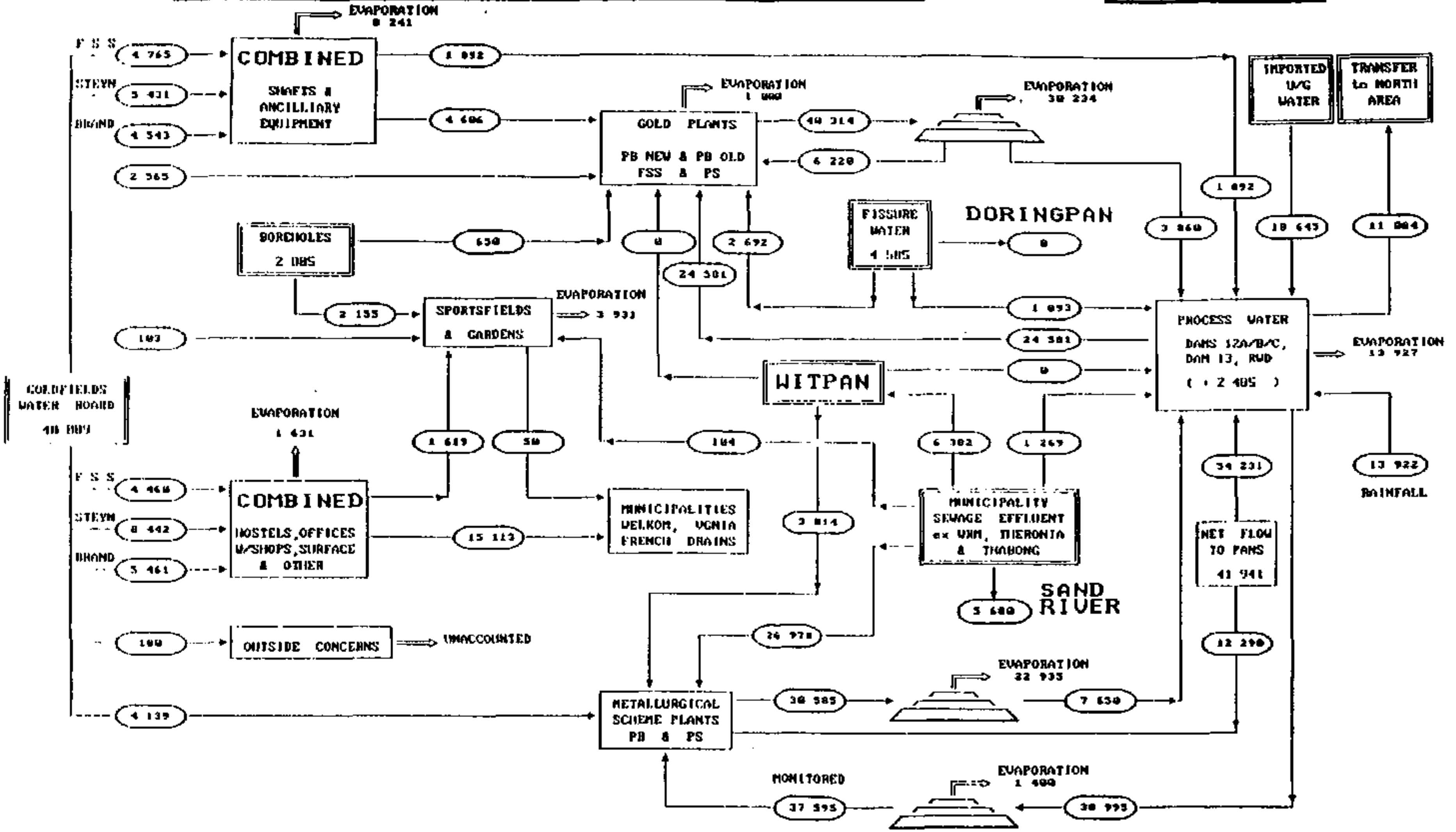
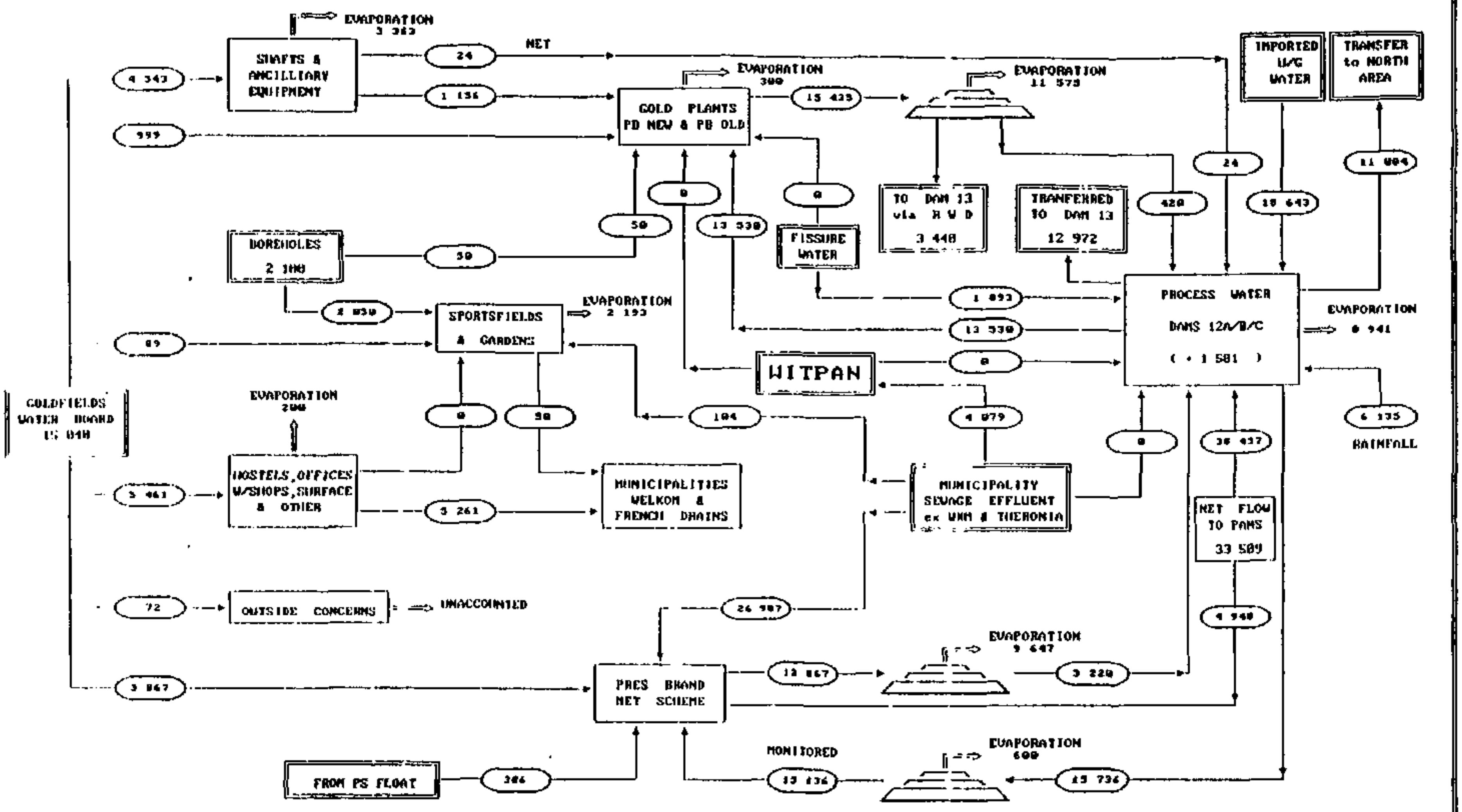


FIGURE 2 WATER BALANCE - APRIL 1993 to MARCH 1994 PRESIDENT BRAND



Report on President Steyn Gold Mine Site Visit.

7 - 9 November 1994

1. GENERAL INFORMATION

Name of mine	President Steyn Gold Mine, one of the 6 mines which forms part of Free State Consolidated Gold Mines (Operations) Ltd (Freegold)
Name and position of person(s) interviewed	Messrs DT Bell - Metallurgical Superintendent (Technical Services) J Vorster - Section Engineer, Environmental Affairs APS Howard - Plant Superintendent (Projects) T Pieterse - Regional Water Technologist J van Drunick - GES Refrigeration, Pres Steyn 4 Shaft M Paul - Mechanical Foreman (Pumping), Pres Steyn 4 Shaft
Nearest town	Welkom
Name of catchment	Sand River
Monthly tonnes treated for Freegold	1,6 million tonnes per month u/g ore, 400 000 tonnes per month old rock dumps and 900 000 tonnes per month slimes dam for Freegold of which Pres Steyn Gold Mine treats: 350 000 tonnes per month u/g ore; and 35 000 tonnes per month old rock dump
Reef being mined and ore body width	Includes "A" Reef, "B" Reef, Elsburg, Basal, Leader and Pyrite reefs. Average 1,6m width
Monthly gold production of Pres Steyn	2,3 tonnes
Current age of Pres Steyn Gold Mine	39 years. The consolidation of various mines to form Freegold took place in 1986
Expected remaining life of mine	13 years
Current mining methods	Standard open stoping layout for extraction of narrow, generally flat, dipping gold reefs
Has an EMPR already been produced by the mine	Yes, busy updating a draft copy of second version.

2. SITE VISIT PROGRAMME

2.1 Day 1 - 7 November 1994

- Arrival at Pres Brand 2 Shaft Engineering Workshop Offices
- Short discussion on project background, objectives and site visit programme with Mr T Pieterse, Regional Water Technologist
- Collected a surface plan of Pres Brand Gold Mine from main offices
- Short discussion on project background, objectives and site visit programme with Mr J Vorster, Sectional Engineer Environmental Affairs, also responsible for compiling the Freegold EMPR
- Obtained a draft copy of the EMPR from Mr J Vorster for use during site visit and a surface plan showing the entire Free State Consolidated Gold Mines (Operations) Ltd, indicating 54 environmental surface water sampling sites.
- Short discussion on project background, objectives and the site visit programme with Mr D Bell, Metallurgical Superintendent Technical Services, who arranged a combined visit to Pres Brand and Steyn slimes dam complex, including the surface water dam arrangement for the penstock return water, slimes dam seepage and rainwater collection system.

2.2 Day 2 - 8 November 1994

- Arrival at Metallurgical Training Centre for appointment with Mr J Fourie, Slimes Dam Metallurgical Foreman. Visit to Pres Brand and Steyn slimes dam complex, which included a total of nine slimes dams (PS 1E; PS 2E; PS 2W; PS 3; PS 4; PS 5; PS 6; PB 1, 2, 3 and PB Old final dam); as well as the Sand River Canal and the seepage and penstock return water catchment dam system which included a total of nine dams (i.e. 12A, 12B, 12C, 13, Stuurmanspan, Jurgenshof Dam, return water dam, Wesselspan and local farmer's dam).

2.3 Day 3 - 9 November 1994

- Arrival at Pres Steyn 4 Shaft offices
- Short discussion on project background, objectives and underground visit with Mr J van Drunick, GES Refrigeration
- Guided tour of the 103 level settler system with Messrs W Roode and J du Plessis, both Mechanical Fitters
- Short discussion on project background and objectives with Mr M Paul, Mechanical Foreman (Pumping) for Pres Steyn 4 Shaft and gathering of information on underground settling, water and mud pumping systems.
- Visited Mr A Howard, Plant Superintendent (Projects and Information Systems) for Surface Waters. Collected water balances for Pres Steyn Gold Mine as well as the Southern area which includes Pres Steyn, compiled a water management structure and discussed the environmental surface water sampling sites and monitoring programme.

3. DISCUSSION OF MINE'S CURRENT WATER MANAGEMENT AND TREATMENT PRACTICES

The activities of the various mines within Freegold, and particularly the water distribution, are closely interlinked. For this reason, certain discussions regarding water circuits and management strategies will refer to the Freegold operation, in general. Where relevant, the distinction between Pres Steyn and Brand has been made.

3.1 DESCRIPTION OF MINE WATER CIRCUITS

The interest of Anglo American Corporation in the Free State Gold Fields was consolidated into one operating company to form Free State Consolidated Gold Mines (Operations) Ltd (Freegold).

Freegold covers an area of 30 000 hectares around Welkom and a total of 29 operating shaft systems have been sunk throughout the Freegold mining area. These systems produce ore which is processed in 7 metallurgical plants. A total of 24 slimes dams and 29 waste rock dumps have been established through the years for plant residue and waste rock deposition.

The Metallurgical Scheme is a project which involves the treatment of slimes dams in another 4 metallurgical plants.

Freegold is divided into a northern and southern area. The southern area comprises the following 3 gold mines:

- Pres Steyn Gold Mine
- Pres Brand Gold Mine
- Free State Saaiplaas Gold Mine

Pres Steyn has 3 production shafts, namely No. 1, 2 & 4 Shaft. The two metallurgical plants currently in operation are the Pres Steyn Gold Plant and Pres Steyn Float Plant, which is part of the Metallurgical Scheme.

Figure 1 shows the water balance for the period April 93 to March 94 for the entire southern area which includes the Pres Steyn circuits.

This figure indicates that the following water sources are used in the southern area:

• Goudveld Water regional supply	40,1 Mℓ/day
• Municipal sewage effluent ex Welkom,	
• Theronia and Thabong sewage works	5,7 Mℓ/day
• Imported underground water	18,6 Mℓ/day
• Fissure water	4,6 Mℓ/day
• Boreholes	2,8 Mℓ/day

3.1.1 Water sources for Pres Steyn Gold Mine

Figure 2 shows the water balance for the same period, April 93 to March 94 for Pres Steyn Gold Mine. In terms of water supplied from Dam 13, this figure indicates the source of water as transfer from Dams 12A, 12B and 12C.

The total inflow of water into the mine area is 20,7 Mℓ/day and consists of the following:

- Goudveld Water regional supply 14,9 Mℓ/day
- Thabong sewage effluent 1,3 Mℓ/day
- Witpan (predominantly sewage effluent from
- Thabong sewage works) 3,8 Mℓ/day
- Boreholes 0,7 Mℓ/day

These figures demonstrate that Pres Steyn is a dry mine with no inflow of fissure water. A major portion of the water requirement is purchased from Goudveld Water, at considerable cost to the mine.

3.1.2 Goudveld Water distribution

The Goudveld Water regional supply is distributed throughout President Steyn as follows:

- Hostels, offices, workshops, surface
- and other infrastructures 8,4 Mℓ/day
- Shaft and ancillary equipment 5,4 Mℓ/day
- Gold plant 0,6 Mℓ/day
- Float plant 0,26 Mℓ/day
- Outside concerns 0,08 Mℓ/day
- Irrigation of sports fields and gardens 0,01 Mℓ/day

These figures show that the main users are the hostels, offices, workshops and other surface infrastructures where water is used for domestic purposes. The second major group of users are the shafts where potable water is supplied to the underground workforce. This potable supply is also blended with underground service water.

3.1.3 Thabong sewage effluent

Thabong is a township situated to the north of Pres Steyn Gold Mine. The sewage effluent from this township is treated at the Thabong municipal sewage works and the treated sewage effluent is distributed as follows:

- Discharge into the Sand River via
- Sand River Canal 5,7 Mℓ/day
- Discharge into Witpan 2,2 Mℓ/day
- Discharge into Dam 13 via Sand
- River Canal 1,2 Mℓ/day

A total of approximately 9,1 Mℓ/day is discharged from the Thabong sewage works. Witpan also receives approximately 4,1 Mℓ/day from the Welkom sewage works. These figures are supplied in the Pres Brand water balance.

3.1.4 Metallurgical process water return systems

Plant residue from the float and gold plants is deposited on the various slimes dams. Penstock return water and seepage from these dams gravitates via a network of trenches to various dams situated to the southwest of the slimes dam complex. The transfer and distribution between the various storage dams can be summarised as follows:

- 12B gravitates to 12A via overflow
- 12A gravitates to 12C via overflow
- 13 gravitates to 12B at northern end via adjustable overflow
- 13 gravitates to 12C at southern end via overflow
- Stuurmanspan pumped to 12C
- Jurgenshof pumped to 12A

Pumps at 12B can deliver water either to the Freegold North area or as monitoring water in the Metallurgical Scheme. Monitoring water can also be supplied from Dam 13 which has the facility to supply process water either to the Pres Steyn or Saaiplaas plants.

There is only one return water dam situated to the east of Pres Steyn slimes dam No. 1E. It should be noted that the water balance of Pres Steyn does not indicate the flow of fissure water imported from other mines. This omission is slightly misleading as the fissure water is pumped to the 12A, 12B and 12C Dam complex.

3.2 DESCRIPTION OF WATER TREATMENT/MANAGEMENT SYSTEMS

3.2.1 General surface water layout

Figure 3 shows the general surface water layout for Pres Steyn and Pres Brand Gold Mines. Pres Brand Gold Mine is situated to the west of Pres Steyn.

This figure shows the location of the 6 Pres Steyn slimes dams, Dam 13, the return water dam and the Sand River Canal System. The figure also indicates the sites at which pH and conductivity measurements were taken.

3.2.2 Operating slimes dams for Pres Steyn Gold Mine

Pres Steyn Gold Mine currently operates a total of 7 slimes dams which are numbered as PS 1-6. Slimes dam No. 2 has an east and west component.

All these slimes dams are situated on the western side of the Virginia Road and they form the eastern border of the Pres Steyn Gold Mine.

The residue from the float and gold plant processes is deposited separately on these slimes dams. Penstock return water and seepage are channelled via trenches to Dam 13 which is used as a return water dam, from where water is returned as process water back to the plants.

To the east of Pres Steyn No 1 slimes dam, on the eastern side of the Virginia road, is a return water dam which is used as a collection dam for the penstock drainage and seepage from the Saaiplaas slimes dams. Return water from this dam is also channelled to Dam 13.

3.2.3 Thabong treated sewage effluent

The Thabong sewage treatment plant is situated to the north of President Steyn slimes dam No. 5. The treated effluent is discharged into the Sand River canal which runs in a southerly direction along the eastern side of the slimes dams. Two options are available at the discharge points. The treated sewage can either be discharged directly into Witpan, via a canal, or into the Sand River Canal which runs south. To the south of President Steyn slimes dam No. 6 the flow in the Sand River Canal can either be directed into Dam 13, or follows the canal further south to the farmer's dam and eventually into the Sand River.

At the time of the site visit the total sewage discharge was taken into Dam 13 as shown in Figure 3. A few points were measured for pH and conductivity as indicated along the canal and at the dam pump stations.

The first was measured at the point of sewage discharge into the Sand River canal north of slimes dam No. 5 where a pH of 7,7 and a conductivity of 124 mS/m was recorded. To the south of President Steyn slimes dam No. 6 the treated sewage measured a pH of 6,9 and a conductivity of 156 mS/m in the canal. This deterioration of the water quality may be due to the effect of seepage from the adjacent slimes dams.

At the time of the site visit a small volume of sewage effluent seeped through the earthwall which is used to direct the flow to Dam 13.

A pH of 9,1 and a conductivity of 282 mS/m was measured at the farmer's dam further south. This is possibly due to the accumulation of seepage from the slimes dam complex.

The Thabong sewage effluent can also be directed to the west, past slimes dam No. 5 and the Stones & Allied Crushers site, into Witpan. The seepage from Stone & Allied Crusher's site area measured a pH of 7,5 and a conductivity of 468 mS/m. The trench arises at Pres Steyn No. 1 shaft and passes through to Stone & Allied operations site and reports to the same trench into Witpan. Upstream of Witpan, a very small flow was observed which measured a pH of 8,7 and a conductivity of 268 mS/m. This suggests that the seepage from the crusher site is diluted with a better quality water, possibly rainwater. Witpan itself measured a pH of 8,7 and a conductivity of 222 mS/m.

All penstock return water and seepage from the slimes dams eventually ends up in Dam 13. The water is then pumped back to the metallurgical plants for reuse in the extraction process.

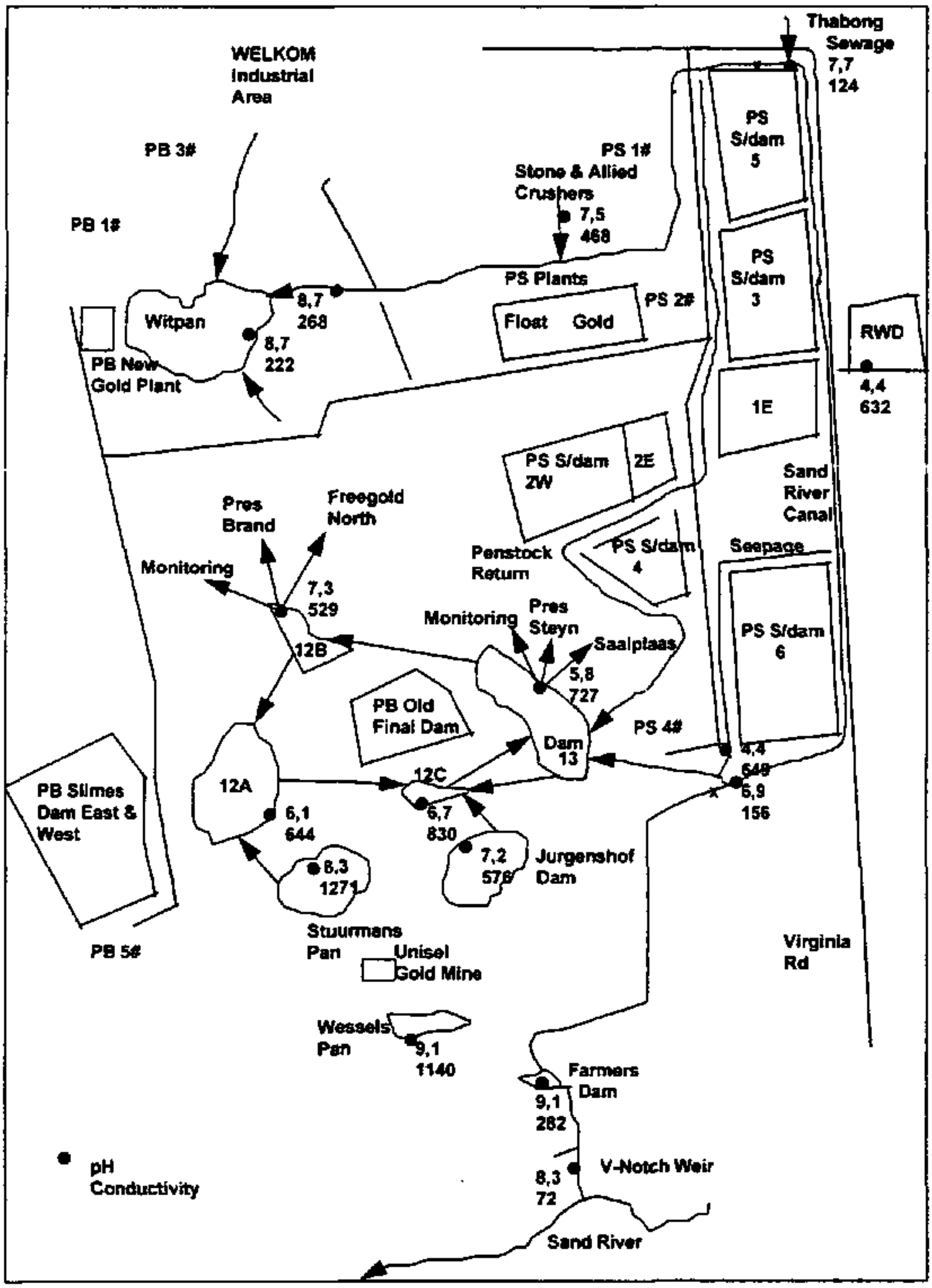


Figure 3 : Surface water systems, slimes dams layout and the various points measured during President Brand and Steyn site visit.

3.2.4 Dam 13 and return water dam

The return water dam situated east of the Virginia Road contains the seepage and penstock return water from the Saaiplaas slimes dam complex. Water from this dam is also directed into Dam 13. The pH in the return water dam measured 4,4 and a conductivity of 632 mS/m. Seepage from slimes dam No. 6 measured a pH of 4,4 and a conductivity of 649 mS/m. Return water from this dam reports to Dam 13 via a constructed trench. Both these measurements indicate the contamination load and pollution potential of these seepage flows.

Dam 13 measured a pH of 5,8 and a conductivity of 727 mS/m. Dam 13 is a very important dam in the Freegold water distribution system.

When the level in this dam is low, the Thabong sewage effluent intake may be increased. Excess water from Harmony can also be directed into Dam 13 as can water from the return water reservoir adjacent to the Virginia road.

3.2.5 Metallurgical plants

All runoff and spills are prevented from leaving the plant areas by means of internal spillage catchment dams. Water from these spillage dams is pumped back into the plant for reuse in the metallurgical process. Contaminated stormwater runoff within the plant is contained and pumped back for reuse in the process water circuit. Clean stormwater runoff is diverted away from the plant into natural water courses.

The gold plant treats underground ore and rock dumps while the float plant treats old slimes dams. The metallurgical plant utilises the following water sources for the extraction process:

- Goudveld Water supply for plant processes requiring good quality water.
- Witpan, which supplies water to the float plant.
- Process return water from Dam 13.

Return water levels and quality at various points in the return water system are checked twice a week by measuring the pH and taking level readings. The plant residue is neutralised to ensure a return water pH which is not lower than 6,5.

3.2.6 Underground water reticulation system

3.2.6.1 *General layout of Pres Steyn 4 Shaft*

Figure 4 shows the flow diagram of Pres Steyn No. 4 Shaft, which was visited.

A total of 64 Mℓ/day is recirculated through the system which consists of 2 settler installations, one at 72 level and the other at 103 level. Two fridge plant installations are also utilised on 58 and 75 level. Fresh make up water for the fridge plants and condenser systems is supplied underground via the potable, Goudveld Water regional supply system.

3.2.6.2 Underground Settlers at 103 Level

Two settler installations serve President Steyn 4 Shaft at 72 and 103 level. The 103 level installation, which was visited during the site visit, consists of 5 cone settlers which treat a total of 64 Mℓ/day. The dirty water flow gravitates down from the working sections directly towards the settlers. There is only a very small surge dam which is mainly used to remove the coarser material from the dirty water flow, before the settling of the solids content is done.

The overflow from this dam enters the main dirty water launder which supplies the individual settlers. The coarse material and grit is removed from the dam, over the quieter weekend periods, with a winch and scraper system, and hoisted to surface together with the reef.

No. 1 and 2 cone settlers are the skirt type, which discharge the flocculated dirty water on the outside of the skirt allowing the clear water to overflow towards the centre of the surface area. The design flow rate for these two installations is approximately 100 ℓ/s.

No. 3, 4 and 5 cone settlers have been modified to centre discharge systems, during which dirty water is discharged into a centre well and the clear water overflows towards the outside of the surface area into the overflow launders. The design flow rate for these installations is approximately 160 - 180 ℓ/s.

No 1 and No 2 settlers will also be modified to centre discharge installations which will increase the total flowrate capacity for the system. One of the problems experienced with the skirt system is the fact that these skirts, during peak flow periods, are pressed towards the centre.

Neutralisation of the dirty water from the mining sections occurs at 71, 73, and 91 levels by adding a lime slurry to the dirty water. No neutralisation occurs at 103 level. When the water reaches this level it has already been mixed with the lime slurry added at the above mentioned levels. Approximately 54 bags, of 25 kg each, are added per month, at a lime consumption cost of approximately R20 000 per month.

Flocculation for No. 1 and No. 2 settlers is done by adding a diluted flocculant solution at various dosing points to the dirty water launder. Flocculation for No. 3, 4 and 5 settlers is done with the use of gel blocks. The flocculant consumption costs for the powder is approximately R25 000 per month and for the gel blocks approximately R18 000 per month.

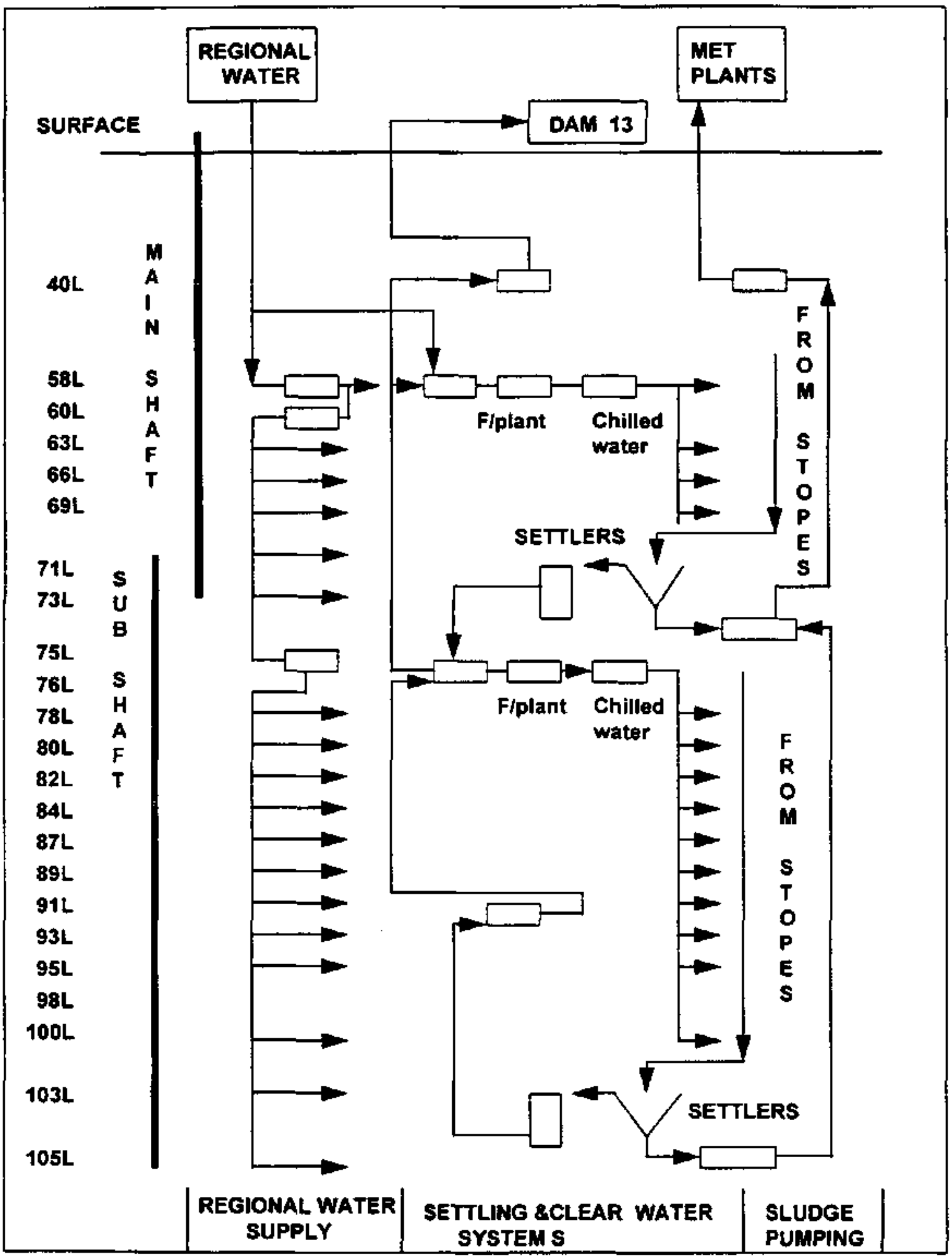


Figure 4 : Flow diagram of Pres. Steyn No. 4 Shaft underground water reticulation system

No flocculation is done in the main launder except for a few gel blocks before No. 5 Settler. Each settler is supplied with dirty water via a sub launder which leaves the main launder at an angle in a well designed system. The flow to the sub launder is controlled by a flood gate, a coarse screen is installed directly after the flood gate to remove any floating material like wood chips and grit. Directly after this, the flocculant is added to the dirty water in the sub launder. The length of the sub launder between dosing point and settler is approximately 10m. The feed launder system is well designed and the flow to each individual settler is controlled by the flood gate.

Very little secondary settling of solids occurs in the clear water dams due to the good performance of the settlers. The small volume of sludge which is collected at the bottom of the clear water dam is removed daily by opening the bottom discharge valve. This is a self cleaning system and there is thus no requirement to drain the whole dam in order to remove the sludge.

The clear water dam system consists of 4 elongated dams and 5 shorter dams. These dams have a sloping bottom section which forces solids to settle at the bottom. The suction pipes of the clear water pumps are situated above the settled solids level to minimise the chances of solids being pumped through the clear water pumps. This is discussed in more detail in Section 3.6.4.

Desludging of the settlers is done on a manual basis. The operator opens the desludging valve at the cone of each settler which then discharges the thickened sludge into the mud dam.

The thickened sludge is pumped with the mud pumps, from the mud dam on 105 level to the mud dam on 73 level, from where it is then pumped to 40 level and then to surface for processing in the metallurgical plant. The settling operation at 103 level is manned by one operator and an assistant per shift.

During the day shift a mechanical fitter is also available to maintain and manage the system. The mud pumps run between 3000 and 4000 hours per pump before the pump is overhauled. The cost of a pump overhaul is approximately R35 000. Each settler has a diameter of 8 m which means a surface area of approximately 50m^2/settler is available.

3.2.6.3 *Disinfection*

Disinfection of the mine service water is done by treating the water with BCH at a dosing rate of 55 kg per month. HTH is also used for occasional shock treatment. The total cost of disinfection is approximately R48 000 per month.

The water disinfection efficiency is monitored by taking drinking and service water samples at different levels once a month by the Environmental Control Department. The following samples are taken:

- Surface drinking water
- Hot water
- Raw service water
- Drinking water 37 level
- Drinking water 60 level
- Chilled service water 60 level
- Drinking water 75 level
- Water dam 75 level
- Chilled water 75 level

These samples are analysed at the mine laboratory for total organisms, E.coli. and faecal coliforms.

The water treatment company which supplies the disinfection chemicals also takes water samples on a weekly basis to check the treatment efficiency of the chemicals and the efficiency of the dosing program.

3.2.6.4 Monitoring of the service water quality

The service water quality at 4 Shaft is also monitored by taking water samples on a weekly basis at the following points:

- 40 Level Main Water Dam
- 73 Level Main Water Dam
- 91 Level Main Water Dam
- 105 Level Main Water Dam

The following analyses are done: Langelier Index, pH, conductivity, total alkalinity, total hardness, calcium hardness, chlorides, sulphates, nitrates and suspended solids.

The results are reported to the General Engineering Supervisor who then informs both the Mechanical Foreman and the Refrigeration Plant Foreman as to when to bleed off some of the service water. The regional water technologist also receives a copy of the results and assists the engineering staff with interpretation of the results.

3.2.6.5 Potable water supply

All potable water is obtained from Goudveld Water and is supplied at an average rate of 4,32 Mℓ/day. This water is then distributed throughout the main and the sub shaft and is available for drinking at various points.

This potable source also serves as make up to control the water quality and to reduce the salt concentration in the surface water systems.

3.3 ENVIRONMENTAL SURFACE WATER SAMPLING SITES

Currently the programme is based on quarterly sampling and analysis which is carried out at Freegold laboratories. There is also 6-monthly sampling at selected sites with analysis, by Anglo American Research Laboratories, for heavy metals. The person responsible for the sampling programme is the Metallurgical Superintendent, Technical Services. A total of 54 sites are sampled throughout the whole of Freegold with the following 9 sampling points relevant to the President Steyn area in particular:

- Start of Sand River Canal at Virginia Road President Steyn East
- Purified sewage effluent ex Thabong municipal works at inflow into Sand River Canal

- Stone and Allied trench. This arises at President Steyn 1 Shaft and passes through the Stone and Allied workings
- Trench draining from President Steyn 2 Shaft to Witpan, taken near shaft, just downstream of hostel trench link up
- Combined trenches (ex Sand River diversion/Stone and Allied/President Steyn No. 2 shaft trenches) just upstream of Witpan
- Mid section of Sand River Canal after crossing PS No 4#/FSS road
- Lower part of Sand River Canal at or below Harmony evaporation area
- Dam 13 overflow
- Purified sewage effluent from the Witpan works.

These samples are analysed for the following parameters: pH, conductivity, total alkalinity, total hardness, total dissolved solids, calcium hardness, chlorides, sodium, sulphates, cyanide, copper, lead, zinc and mercury.

The programme allows the Freegold management to establish whether there is a serious threat of contamination from the mining area. Areas of particular concern are:

- Seepage into the Sand River canal to the Sand River and via the diversion trench to Witpan
- Seepage from the President Brand and President Steyn area through Unisel to the Sand River.

Both these areas are being investigated by consultants who have been commissioned to identify possible management strategies for the areas.

3.4 WATER MANAGEMENT STRUCTURE

The structure and personnel of the water management for Freegold is given in Figure 5.

Some of the key personnel in this structure include the Sectional Manager, Environmental Affairs who reports to the Manager-Services who is responsible for compiling the EMPR and for liaison with the Department of Water Affairs & Forestry.

The Plant Superintendent-Projects and Information systems, who is responsible for collecting all the information concerning surface water quality, dam levels, flow rates and also the sampling of the environmental surface water sampling programme. He reports to the Metallurgical Superintendent-Technical Services.

The Section Engineer of every Shaft is supported by the General Engineering Supervisor and the Engineering Foreman who are both responsible for the underground water management systems and the maintenance of these systems. They are supported by the Regional Water Technologist who liaises with the water treatment companies and who also assist the shaft personnel in general interpretation of the water analyses.

The Mine Water Laboratory does the routine analyses and reporting of the results to General Engineering Supervisor and the Regional Water Technologist.

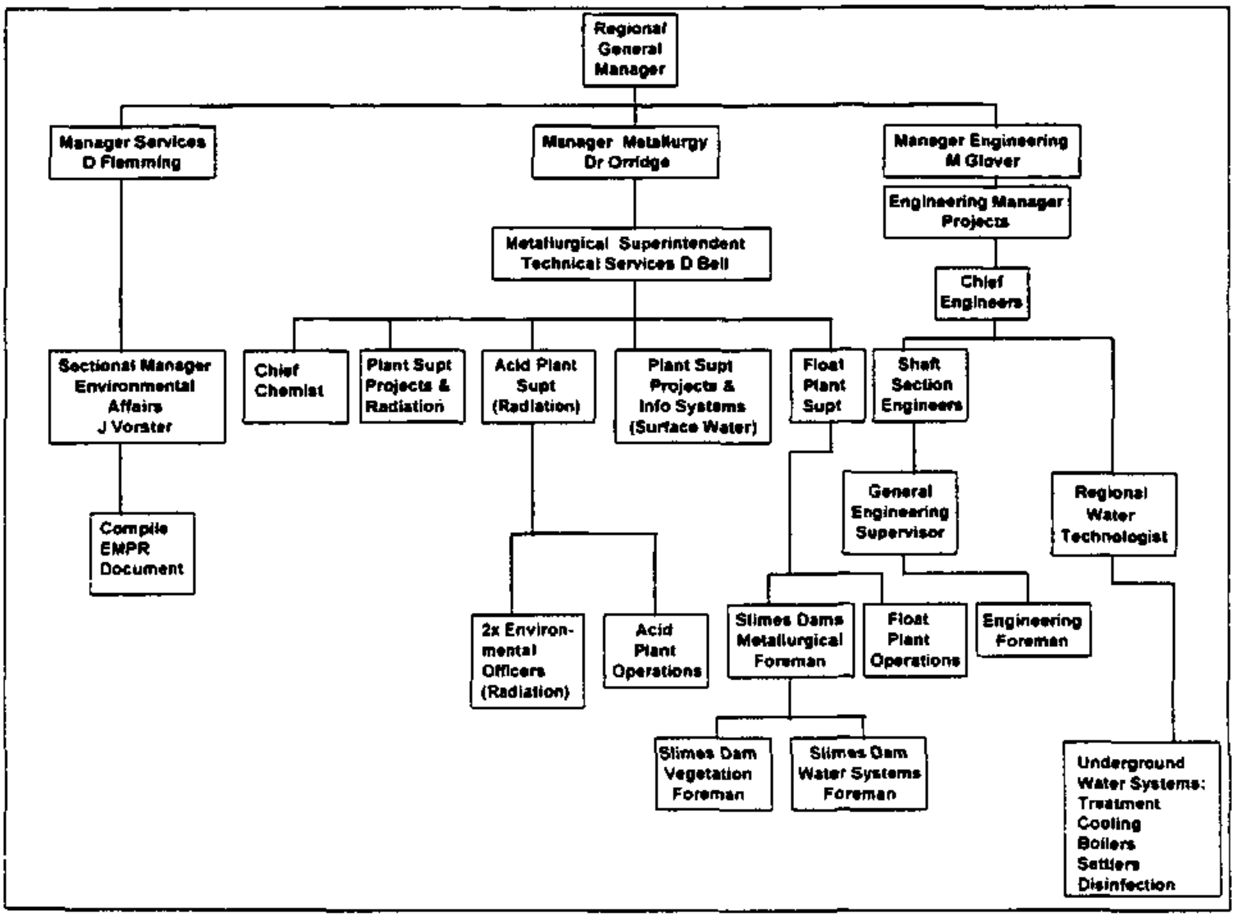


Figure 5 : Water management structure for Freegold

3.5 POTENTIAL WATER TREATMENT/MANAGEMENT PROBLEMS AND NEEDS

As a result of the discussions and site visits the following potential problems were identified:

3.5.1 Pollution of the Sand River Canal

As indicated in Figure 3 the start of the Sand River Canal is at the northeastern corner of President Steyn Slimes Dam No. 5. At this point the purified sewage effluent is discharged into the canal from where it can either be directed towards Witpan, or it can flow down the Sand River Canal where it can be diverted into Dam 13 at the south of President Steyn Slimes Dam No. 6, or flow further south towards the Sand River. During the site visit the Thabong sewage water was flowing down the Sand River Canal and into Dam 13. The water quality at the discharge point was measured at a pH of 7,7 and a conductivity of 124 mS/m.

South of President Steyn Slimes Dam No. 6 the quality was measured at pH 6,9 and a conductivity of 156 mS/m. These results indicate that the sewage effluent is being polluted by the seepage from the slimes dams. The actual seepage from the slimes dam was measured to the south of President Steyn Slimes Dam No. 6 at a pH of 4,4 and a conductivity of 649 mS/m.

The Sand River Canal was constructed by the Welkom City Council, and due to the depth of the canal it collects a substantial quantity of seepage from a number of slimes dams and dumps along its length. This pollution load eventually reports to the Sand River.

Studies of the pollution of the Sand River have confirmed this and suggest that the dry weather flows in the Sand River Canal have two sources, namely, seepage emanating from the President Steyn slimes dam complex and seepage from the Jurgenshof/Dam 13 complex.

3.5.2 Water quality of Dam 13

As discussed earlier Dam 13 serves as a return water storage dam prior to pumping back to the metallurgical plants.

During the site visit the pH at the pump station of Dam 13 was measured at 5,8 with a conductivity of 727 mS/m. The high salt content is probably a result of the high degree of recirculation which is practised.

3.5.3 Underground water jetting

At President Steyn No. 4 shaft water jetting was used to do the cleaning and sweeping of the underground areas to remove the fine material, which contains high gold values. It was discovered that this practice led to a reduction in gold recovery, possible due to loss of fine dust in rock cracks etc. When water jetting was stopped, the gold production reverted to normal.

3.6 NOVEL AND UNIQUE WATER TREATMENT AND MANAGEMENT SYSTEMS

3.6.1 Grit removal before settling

A small dirty water dam is used on 103 level as a grit trap to accumulate all the coarse material before the water overflows into the main launder towards the settlers. The coarse material is then removed from this dam by means of a winch and a scraper system and then hoisted to surface with the reef to the gold plant.

The frequent use of the winch and scraper is necessary, as the dam is very small for the high flow and the dam bottom is filled in a short period. This is, however, an extremely simple and cheap process which has yielded improved pump life.

3.6.2 Layout of settler system

In order to allow for the slow reaction and dissolution time of lime as a neutralising reagent, dosing occurs at 71, 73, and 91 level, from where it then gravitates down with the dirty water to 103 level. This allows for a longer reaction time for the lime.

In addition, as can be seen from Figure 6, the feed launder system has been designed, so as to minimise disturbance of the water after flocculation and thus reduce the floc breakage.

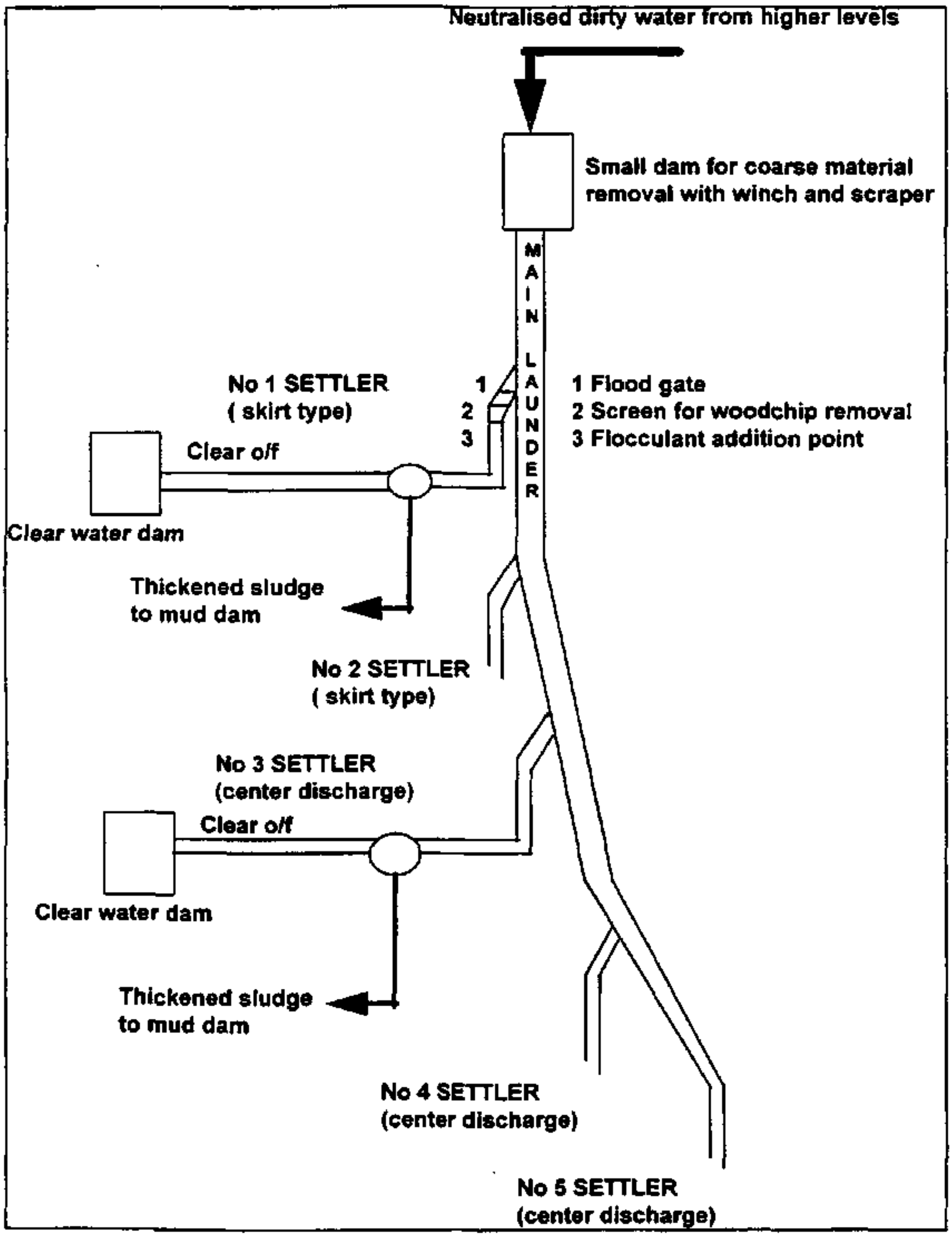


Figure 6 : Schematic of settler and launder system lay out on 103 Level

Appendix A - List of pH and conductivity readings taken during the site visit

During the site visit, a number of pH, conductivity and temperature readings were taken at various locations on the mine:

No.	Monitoring Point Description	pH	Cond. (mS/m)	Temp (° C)
1	Witpan next to golf course	8,7	222	-
2	Inflow to Witpan	8,7	268	-
3	Water ex Stone and Allied Crusher site	7,5	468	-
4	Discharge of treated sewage from Thabong Sewage Works into Sand River Canal.	7,7	124	-
5	Return water Dam east of Virginia Rd	4,4	632	-
6	Thabong treated sewage before entering seepage and return water trench south east of President Steyn 4-shaft	6,9	156	-
7	Seepage trench before blended with Thabong treated sewage flowing to Dam 13	4,4	649	-
8	Dam 13 at pump station suction	5,8	727	-
9	Penstock return water to Dam 13 from slimes dam No. 2, 3, 5	7,6	755	-
10	Dam 12B pump station	7,3	529	-
11	Dam 12A pump station	6,1	644	-
12	Dam 12C pump station	6,7	830	-
13	Jurgenshof Dam	7,2	576	
14	Stuurmanspan	8,3	1271	-
15	Wesselspan	9,1	1140	-
16	Farmers dam	9,1	282	-
17	V notch weir in Sand River Canal	8,3	71	-
	Underground Visit			
18	Neutralised dirty water to main launder	7,1	630	27,2
19	Water to cone settler No. 1	7,1	628	26,8
20	Clear water ex No. 1 settler	8,4	632	26,4
21	Water to settler No. 3	7,7	639	26,5
22	Clear water ex No. 3 settler	8,7	632	26,5

Appendix B - List of Photographs

During the site visit, a number of slides were taken at various locations on the mine

Slide No	Slide Subject Description
1	Witpan under Welkom municipal control
2	Discharge of Thabong treated sewage in the Sand River canal
3	Return Water Dam west of Saaiplaas slimes dam complex
4	Dam 13 pump station
5	Trench from Dam 12B to pump station
6	Dam 12A
7	Dam 12C
8	Jurgenshof Dam
9	Stuurmanspan
10	V notch weir in Sand River Canal
11	V notch weir in Sand River Canal
12	Sand River Canal entering the Sand River

<u>President Steyn Underground Visit</u>

13,14,15	President Steyn 4 Shaft headgear
16	Winch to remove coarse material from dirty water dam on 103 Level.
17	Launder splitting from main launder to feed dirty water to launders
18	Flood gate and screen to control flow to No. 1 settler and
	remove coarse material
19	Flocculant dosing point fed from make up tank
20	Flocculant make up tank
21, 22	Overflow launder system for settler overflow
23	Overflow water launder from No. 1 settler
24	Slide showing the distance between the settler side and the skirt installation
25	Clear overflow launder
26	Top of settler No. 3
27	Design of main launder bending smoothly with the separate launders feeding individual settlers, showing a gel block flocculant dosing point
28	Centre well feeding settler No. 3
29	Clarity of settler overflow making it possible to see the dirty water feed pipe below water surface
30	Lobster cage used to keep gel block submerged and causing flash mixing for flocculation
31	Combined clear water from No. 3 settler
32	Clear water launder to clear water dam No. 3

FIGURE 1 WATER BALANCE - APRIL 1993 to MARCH 1994 SOUTHERN AREA

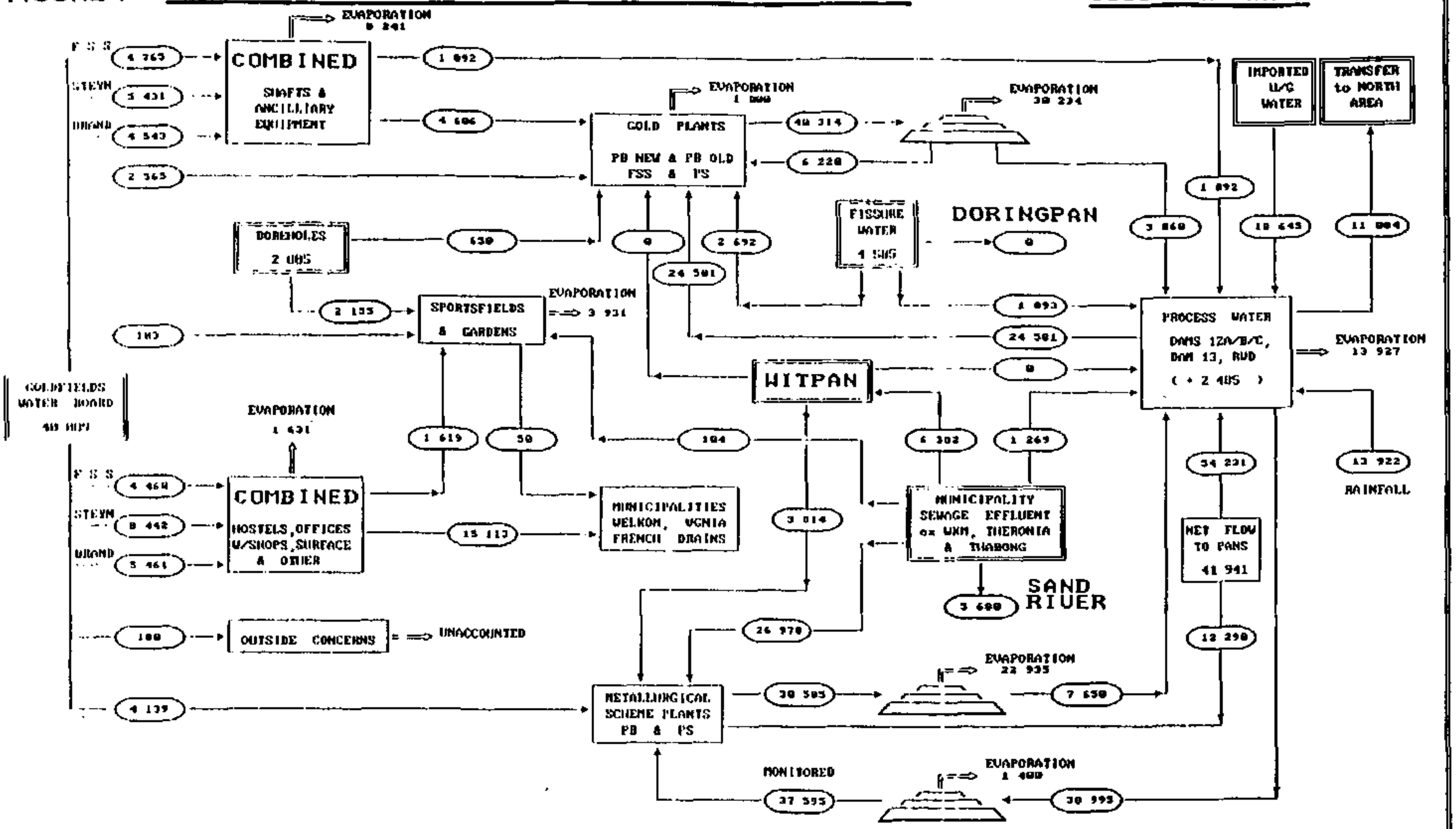
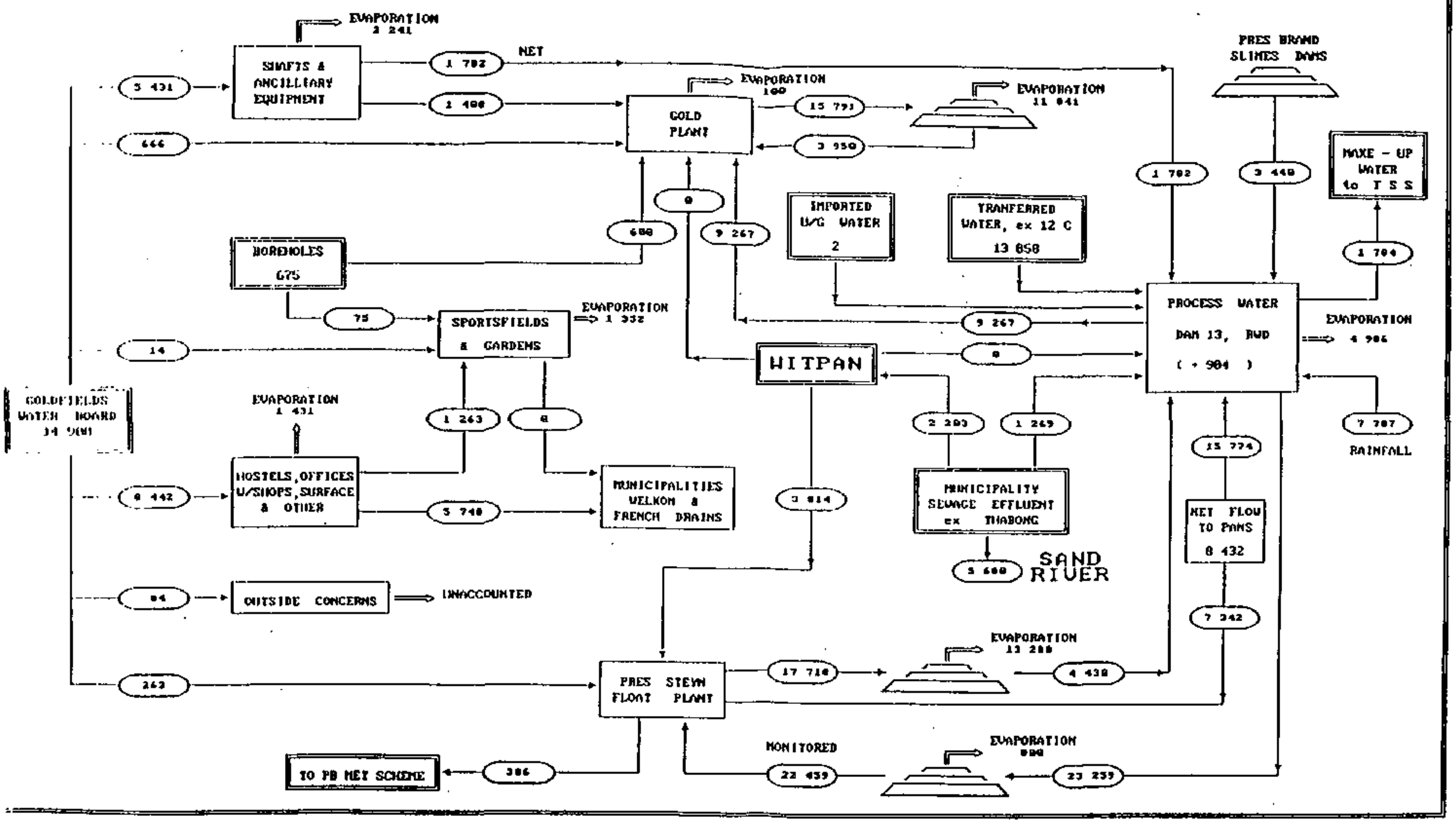


FIGURE 2 WATER BALANCE - APRIL 1993 to MARCH 1994 PRESIDENT STEYN



Report on Randfontein Estates Gold Mining Company Witwatersrand Ltd - Site Visit.

14 - 16 June 1994

1. GENERAL INFORMATION

Name of mine	Randfontein Estates Gold Mining Company (Witwatersrand) Limited, (REGM)
Name of person(s) Messrs interviewed	D Dorling - Chief Chemist L Duggan - Asst Chief Chemist B Thompson - Section Engineer Cooke 1 Shaft D Byleveldt - Snr Lab Technician K Youngman - Snr Plant Metallurgist B Appleton - Fitter Cooke 1 Shaft Water Treatment
Nearest town	Randfontein
Name of catchment	Klipriver on the east and Wonderfontein spruit on the west both flowing south along the boundaries of the property. Tweelopiesspruit on the north flowing north to the Crocodile River.
Monthly tonnes mined	420 000 tpm
Monthly tonnes treated	Millsite Gold Plant 196 000 tpm Cooke Gold Plant 220 000 tpm Doornkop Gold Plant 200 000 tpm
Monthly gold production	2 400 kg/month
Current age of mine	105 years
Expected remaining life of mine	25 years
Mining methods	Trackless and conventional underground
Reef being mined	Black reef quartzite, VCR, UEIA - Elsburg quartzite, K7 + K9 - Kimberley quartzite
Ore body width	If more than 2,2m, use trackless mining Where less, make use of conventional methods
Status of the mine's EMPR	Already submitted

2. SITE VISIT PROGRAMME

2.1 Day 1 - 14 June 1994

- Arrival at mine laboratory
- Short discussion of project background and objectives
- Present at meeting:
  D Dorling - Chief Chemist
  L Duggan - Assistant Chief Chemist
  D Byleveldt - Senior Laboratory Technician
  W Pulles - PHD
  J Laas - PHD
  D Howie - PHD
- Guided tour of the northern mine area from Vent Shaft towards Millsite and also the Cooke Gold Plant.

2.2 Day 2 - 15 June 1994

- Arrival at mine laboratory
- Underground visit at Cooke No. 1 Shaft, guided by Messrs B Thompson and B Appleton to 95 and 101 levels and the underground settlers on 106 level.
- Completion of the mine surface area along the Wonderfonteinspruit and Klipriver south from Vent Shaft.
- Visit to Cooke No. 2 Shaft sewage plant.

2.3 Day 3 - 16 June 1994

- Arrival at mine laboratory
- Completion of site visit questionnaire
- Present:
  D Dorling - Chief Chemist
  L Duggan - Assistant Chief Chemist
  B Appleton - Fitter Cooke 1 Shaft Water Treatment
  W Pulles - PHD
  J Laas - PHD
  D Howie - PHD
- Attended quarterly water management meeting at REGM main office boardroom, chaired by Mr SJR Allan, Acting Manager,Engineering.

3. DISCUSSION OF THE MINE'S CURRENT WATER MANAGEMENT AND TREATMENT PRACTICES

3.1 DESCRIPTION OF WATER CIRCUITS

3.1.1 Surface water systems

The surface water systems can be divided into three main sections or areas which are the following:

- Randfontein section in the north
- Doornkop section on the eastern side and
- Cooke section to south

Figure 1 shows the location of these three sections of REGM with respect to Randfontein.

The Randfontein section consists of the REGM offices, Vent Shaft dewatering operation, Millsite Plant and slimes dam complex and the Tweelopiesspruit.

The Tweelopiesspruit originates northwest of the Millsite plant and flows in a northerly direction which forms part of the Crocodile River catchment area. For the last few years no flow has been recorded in the Tweelopiesspruit within the REGM area.

The Doornkop section consists of the Doornkop plant and slimes dam No 1 and 2, Doornkop No 1 and 2 Shafts.

The Cooke section consists of the Cooke plant and slimes dam; and Cooke No 1, 2 and 3 Shafts.

The Doornkop and Cooke sections of the mine are situated in the Vaal River Catchment between the Wonderfonteinspruit Spruit on the western side and Klip River on the eastern side, both running from north to south, shown in Figure 2.

The contributors of surface water and seepage to these two streams are the following:

- Direct catchment which contributes both clean and contaminated runoff.
- Effluents from numerous operations and activities.
- Farming and irrigation operations within the area.
- Mining operations close to both streams within and before the REGM area.

A detailed surface plan was supplied by the mine which contained useful information regarding important components of the mine's water circuits and infrastructure. This plan is attached as Figures 3 and shows the whole REGM in relation to neighbouring mines, industries, urbanisation, farmland, smallholdings and townships.

3.1.1 Water Circuits For Underground Mining Operations.

Service water for underground drilling and mining activities is recirculated after collection, neutralisation, settling and disinfection. Fissure water and acid mine drainage are taken up in the underground water circuits. Rand Water Board water and borehole water are used as makeup to compensate for water losses.

3.2 DESCRIPTION OF WATER TREATMENT/MANAGEMENT SYSTEMS

3.2.1 Surface water systems

Water quality is monitored on a monthly basis for the Wonderfonteinspruit and at more irregular intervals for the Klipriver, by collecting samples at specific locations along the streams.

Samples are collected at specific points along the Wonderfonteinspruit from where the stream enters the REGM area up to the exit point. A major component of the base flow of the Wonderfonteinspruit is treated sewage from the Humans sewage treatment plant situated north of the Doornkop section.

Figure 4 shows the pH and conductivity readings measured along the Wonderfonteinspruit on the day of the site visit.

The potential impact of mining on this stream can be seen from these readings. Upstream at Main Reef road a pH reading of 8,4 and a conductivity of 56 mS/m were measured. Downstream of the Humans sewage treatment plant but still upstream of the Cooke slimes dam a pH of 7,3 and conductivity of 81 mS/m were measured. This means that some pollution from direct runoff and/or seepage is taking place already. Another source of pollution could be the squatter camp in the vicinity of the sewage works.

Downstream of the Cooke slimes dam return water dam a pH reading of 7,9 and a conductivity of 81 mS/m were measured. A significant volume of irrigation water runoff on the southern side of the slimes dam was observed running directly into the Wonderfonteinspruit at a pH of 6,6 and a conductivity of 357 mS/m. Downstream of the R559 road bridge this combined flow had a pH of 8,0 and a conductivity of 96 mS/m. This means that this irrigation water which is pumped from a nearby borehole, close to the Cooke slimes dam, can be already contaminated and a possible pollution source is the seepage from the up stream slimes dam area and the return water dam into the groundwater. The return water dam water had a pH of 7,5 and a conductivity of 403 mS/m which can have an effect on the quality of the groundwater.

Further downstream before the inflow into the Donaldson Dam the pH was still 8,0 and the conductivity 91 mS/m. At the Donaldson Dam a pH of 8,6 and conductivity of 99 mS/m at the mid section weir of the dam were measured. At the dam discharge weir and canal a pH of 8,7 and a conductivity of 104 mS/m. These figures at the dam indicate the effect of evaporation by which the dissolved salts in the water are concentrated due to water losses in the process.

These measurements show the perceived impact and problems caused by the mining operations and agricultural activities on the surface water quality of the of the Wonderfonteinspruit.

The Wonderfonteinspruit water is used by squatters communities in the area north of Cooke Plant and also by farmers in the area between Cooke 1 and 2 Shafts for irrigation and domestic purposes.

The Klip River flows adjacent to the mining area on the eastern side and samples are only collected at locations upstream and downstream of Doornkop Section. The major portion of the Klipriver base flow is mine effluent from Durban Roodepoort Deep Mine area which is situated to the northeast of the Doornkop Section. Water from this stream is mainly used for irrigation in the area south of Doornkop.

Figure 4 also shows the locations along the Klipriver where the pH and conductivity were measured during the site visit. In this area agricultural activities also exist and irrigation runoff from farmlands at conductivity's of 283, 496 and 268 mS/m in the direction of the Klip River was observed. Directly upstream of these activities a conductivity of 278 mS/m was measured in the Klip River and downstream of the irrigation activities the conductivity reading of 276 mS/m indicated for all practical reasons no change in the dissolved salts. These measurements shows that the dissolved salts in this stream is very high in comparison to the Wonderfonteinspruit.

3.2.2 Sewage treatment plant

There is only one sewage treatment facility operated by the mine, i.e., the sewage treatment works at Cooke 2 Shaft. This plant treats 2,3 Mℓ/d of raw sewage from Cooke 1, 2 and 3 shafts hostels. A flow of 1,3 Mℓ/d of treated sewage effluent is consumed by the next door farmer for irrigating instant lawn and the balance of approximately 1 Mℓ/d is pumped to the Wonderfonteinspruit.

The first section in the treatment process is the screens to remove all the coarse material from the raw sewage, followed by the activated sludge reactors. This is followed by the sludge thickener which produces a thickened sludge and a clear overflow. The overflow from the thickener is disinfected with chlorine gas before the treated effluent is discharged to the instant lawn farm and the Wonderfonteinspruit. The sludge from the thickener is dried in a series of drying beds before the dried solids are removed.

The rest of the mine's raw sewage is pumped either to Randfontein or Krugersdorp municipal sewage works.

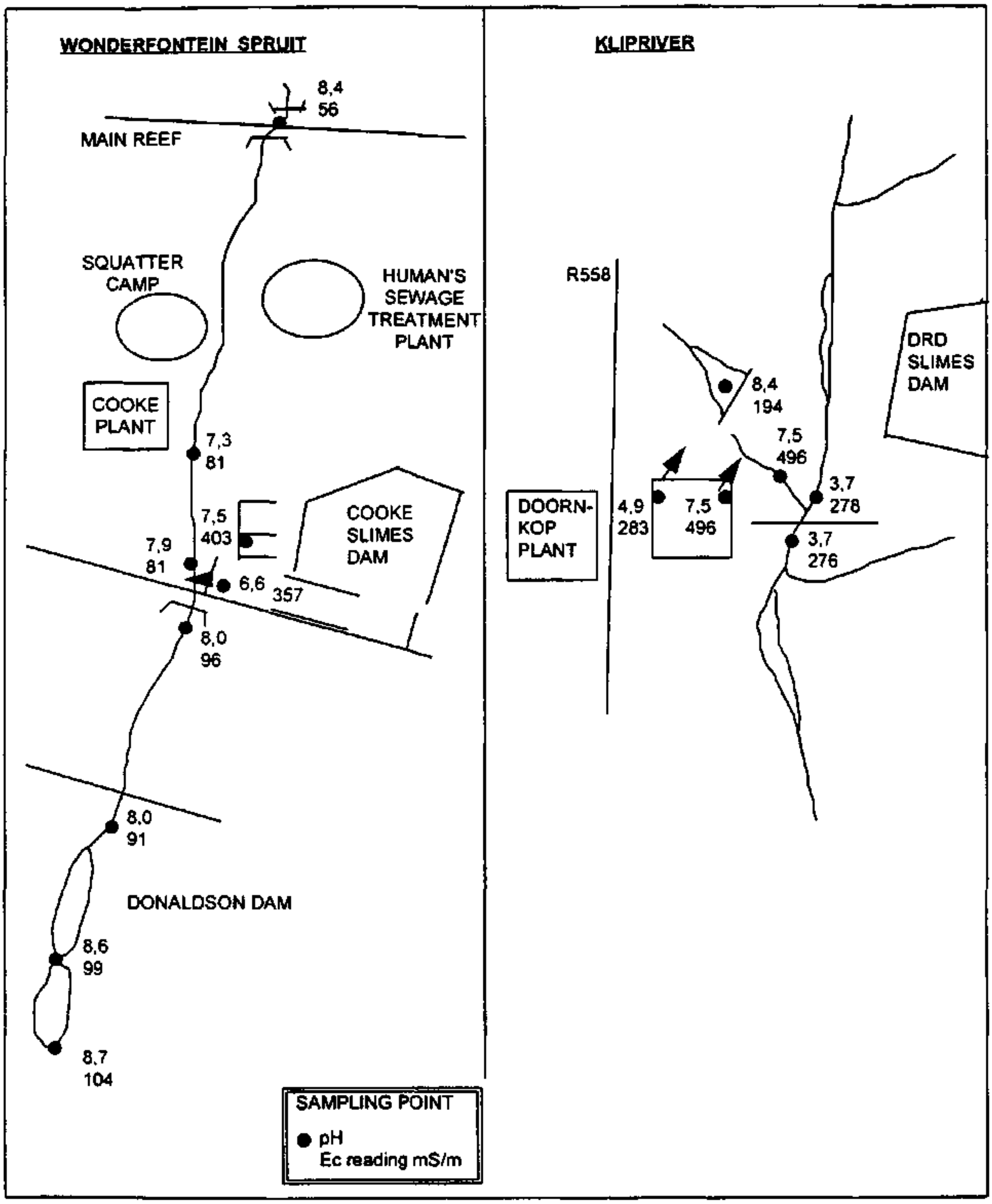


Figure 4 : Points measured along the Wonderfonteinspruit and Klip River

3.2.3 Potable water supply

There is no potable water treatment plant on REGM. All potable water requirements are supplied by Rand Water Board and local boreholes.

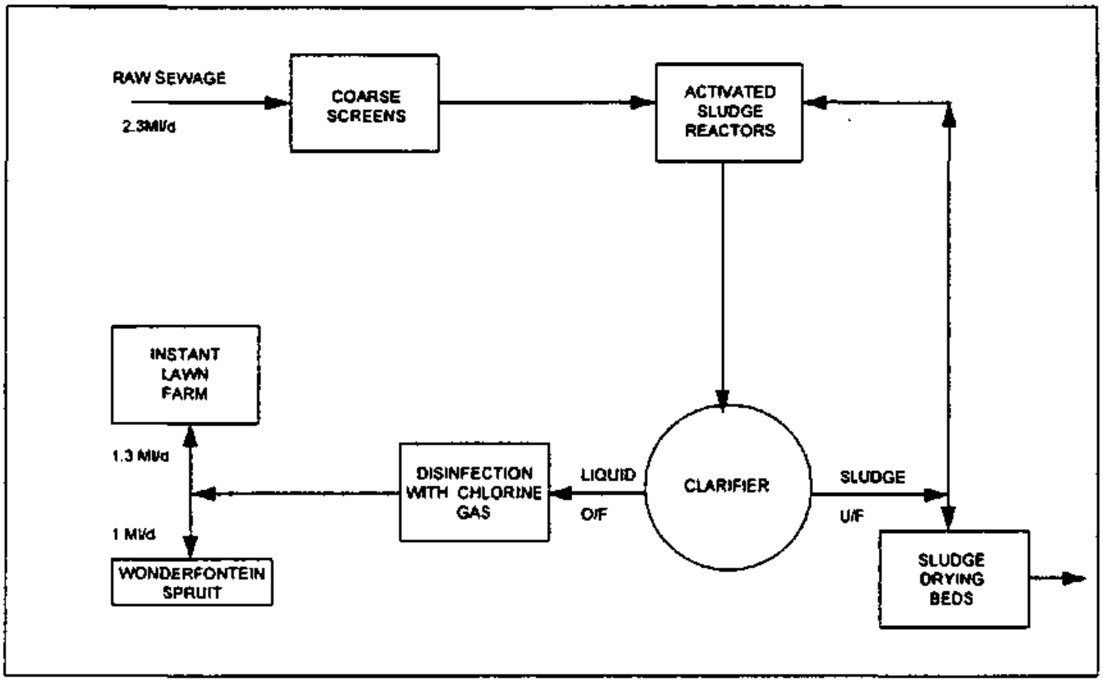


Figure 5 : The basic layout of the sewage plant sections at Cooke 2 Shaft.

3.2.4 Water for recreation

Two areas are used for recreation on the mine property, i.e., the Robinson Lake north of Randfontein mainly for angling (not full contact recreation) and the Donaldson Dam to the south situated north of Westonaria for angling and rowing. The Robinson Lake is supplied with neutralised underground water via the dewatering and neutralisation operation at Vent Shaft. On the day of the site visit a pH of 8,5 and conductivity of 280 mS/m was measured at the dam, compared to a pH of 7,3 and conductivity of 282 mS/m measured at the holding tank at Vent Shaft after lime addition. The Robinson Lake has an overflow weir to the Tweelopiesspruit, but no overflow has been recorded during the past four years according to the mine personnel.

Analyses of water from the Robinson Lake and Donaldson Dam sampled on 23 May 1994 are given in Table 1 below.

Table 1: Analyses of Robinson Lake and Donaldson Dam water

	pH	EC	NO_3	SS	Mn	Free CN	Tot CN	SO_4
Unit Control Standard	5.5-9.5	mS/m 250 max.	N mg/l 10 max.	mg/l 25 max.	mg/l 0,4 max.	mg/l nil max.	mg/l 0.5 max.	mg/l 700 max.
Robinson Lake	5.8	322	<0.2	15	19	<0.5	<0.5	2090
Donaldson Dam	8.3	118	<0.2	18	0.2	–	–	291

This situation is not likely to improve under the current operating conditions due to the quality of the Vent Shaft water flowing into the lake. Evaporation of water from the lake is taking place which is increasing the salt concentration in the lake. Without the lake overflowing, the salt load cannot be flushed out.

The runoff water entering the lake during the raining season does not seem to be sufficient to allow for any significant dilution of the water in the lake.

The Wonderfonteinspruit flows into the Donaldson Dam which then overflows into a 1m diameter pipeline taking the water across the sinkhole area to the south west of the dam. The water quality of the Donaldson Dam, according to the laboratory analysis, is always below the mine's control standards. Evaporation has a concentrating effect on the salt load, but because of constant inflow from the Wonderfonteinspruit with a conductivity of 90 mS/m just upstream of the dam, compared to 104 mS/m at the dam overflow weir, one can expect some dilution and flushing of salts to take place. The conductivity of Wonderfonteinspruit entering REGM property upstream is 56 mS/m and it flows into the Donaldson Dam at a conductivity of 90 mS/m. This appears to be due to contamination from irrigation runoff and possible seepage into the groundwater polluting the Wonderfonteinspruit.

3.3 UNDERGROUND OPERATIONS AND WATER MANAGEMENT

3.3.1 Underground water sources

Clear water is pumped to surface at the Central Ventilation Shaft, Cooke 1 Shaft, Cooke 2 Shaft, Doornkop and 17 Winze (old shaft not in use) for dewatering. The only water treatment that is currently taking place is neutralisation and settling of the water before it is recycled again as service water underground or pumped to the metallurgical plants and other surface consumers.

3.3.2 Underground water treatment

3.3.2.1 Central Ventilation Shaft

The main pumping shaft for underground water is the Central Ventilation Shaft which supplies water to:

• Cooke recovery plant	70 Mℓ/month
• Millsite recovery plant	87 Mℓ/month
• Lindum mine	52 Mℓ/month
• Robinson Lake/settling pond	75 Mℓ/month
• West Wits	15 Mℓ/month
• Slimes dam vegetation irrigation	6 Mℓ/month
• Water tankers	4 Mℓ/month
Total	309 Mℓ/month

At Central Ventilation Shaft, water is pumped to surface at 309Mℓ/month where it is neutralised with a lime slurry from Millsite Met Plant. The slaked lime slurry is transported with tankers to Vent Shaft where it is added to control the pH in the range 5,5 - 9,5. The mine management is currently considering feasible treatment options for removing the high iron and manganese content from this water, the presence of these two elements will increase the cyanide consumption in the gold extraction process when the process water contains high levels of dissolved iron and manganese.

Due to the fact that Vent Shaft water is distributed to various users it can be to the mine's advantage to treat the water at Vent Shaft, as close as possible to the source, in order to realise savings in treatment costs.

3.3.2.2 *Cooke 1 Shaft Water Distribution*

Cooke 1 Shaft is supplying neutralised underground water to the following consumers:

• Cooke metallurgical plant	125 Mℓ/month
• Cooke 1 Shaft underground	82 Mℓ/month
• Waste Washing	7 Mℓ/month
• Farm dam	11 Mℓ/month
• Lime Plant	12 Mℓ/month
Total	237 Mℓ/month

The 82 Mℓ/month which is returned underground as service water is treated, by additional neutralisation with unslaked lime and disinfected with chlorine before reused. This service water then mixes with fissure water before the total volume is treated again. Neutralisation and flocculation are done, before the underground settlers are used to remove the solids content from the dirty process water, to control the final water quality which is pumped to surface and supplied to the different consumers.

3.3.2.3 *Neutralisation at Cooke 1 Shaft*

A lime slurry is produced at the surface lime makeup plant by mixing 250 kg unslaked lime per hour with 2 000ℓ water. This lime slurry gravitates to 101 level where it is mixed with the dirty water and fissure water before settling takes place. The lime slurry is only pumped for 5 hours, that is from 04h00 to 09h00 during the main drilling period. From 09h00 to 11h00 the lime makeup tank is flushed, and from 11h00 to 14h00 the lime dosing pipeline to 101 level are flushed. The aim of this lime addition is to control the pH of the water pumped to surface to between 6,5 to 8,0 for control of corrosion as well as the removal of radioactivity at the settlers.

The fundamental problem with this lime dosing system is that there is no control. A fixed amount of lime is added every day from the lime makeup plant to 101 level, for the same period and at the same time everyday. The inflow of fissure water into the dirty water system may vary, as well as the dirty water flow from the working stopes. The lime slurry will mainly pass through the settlers as a batch, mixed with the dirty water accumulated at the settlers, which can cause a sharp increase in the pH of the water pumped to surface. This lime slurry can not be mixed with the dirty water received at a later stage.

During this stage the lime makeup system is flushed and one can than expect a decrease in the pH values.

The variation in flow to the settlers is one of the most important factors to consider during the neutralising step. It takes approximately three hours for the water to reach the settlers from the stopes. This means that the flow to the settlers will start to increase from about 07h00 and will last till about 12h00. At 7h00 approximately 60% of the lime slurry has already reached or passed through the settlers, only 40% of the lime slurry is dosed during the period of high flow to the settlers.

3.3.2.4 *Underground water monitoring during visit*

During the underground visit by the project team various pH, conductivity and temperature readings were taken on 95 and 101 levels. Results are shown in Appendix C.

The following schematic diagram indicates the sampling points.

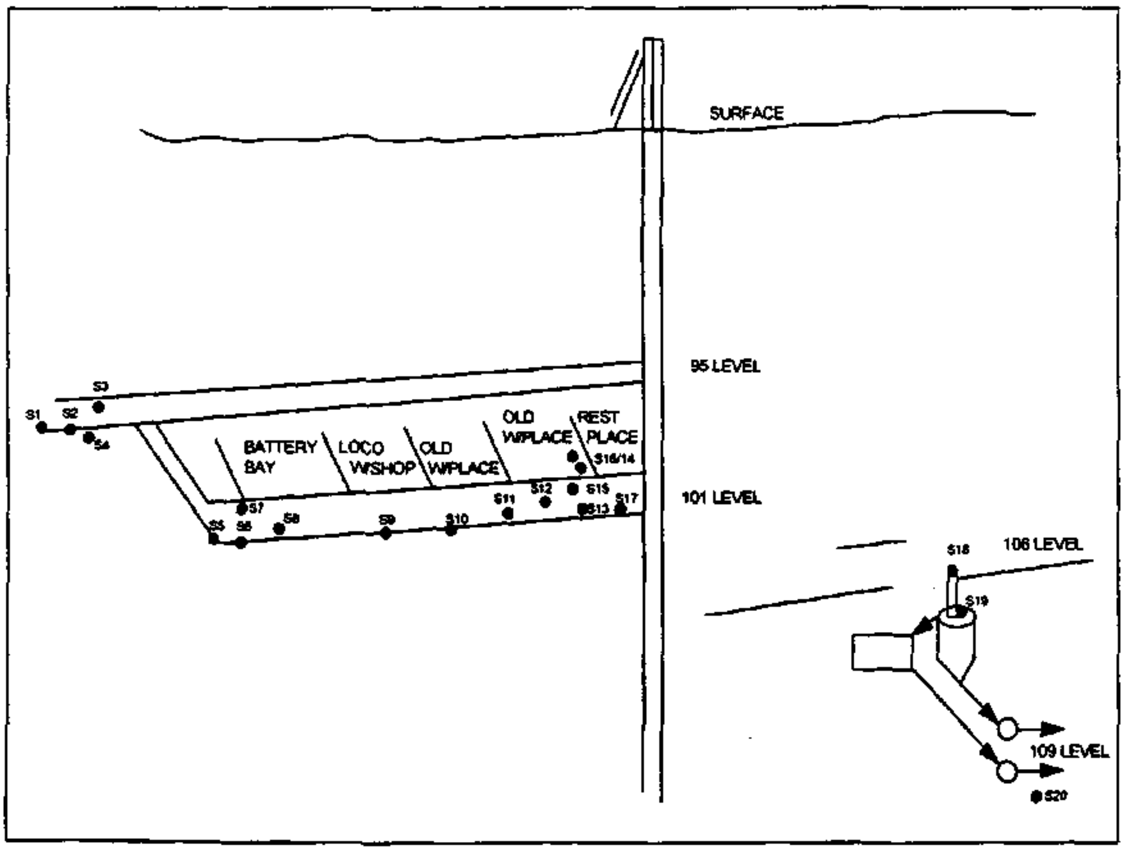


Figure 6 : Points measured during underground visit at Cooke 1 Shaft

These results show the variation in the quality of the different water streams from highly polluted water from old stopes and polluted fissure water, to better quality fissure water. All these different water streams flow combined in the main launder into the six settlers.

3.3.2.5 *Flocculant addition*

Every settler has its own flocculant makeup tank. Each 8 hourly shift fills the flocculant makeup tank and empties it. A liquid flocculant is used at No. 5 settlers while gel blocks are used at No. 1 settler. The flocculant addition takes place only in the sub launder to every settler.

3.3.2.6 *Settling System*

The settling system consists of six conical settlers (capacity 467 kℓ each) each with its own clear water dam (1 555 kℓ each).

From the main launder where all the dirty water and fissure water accumulates, flow is distributed to each of the six settlers. The flow distribution to the six individual settlers is controlled manually by moving a steel plate covering the entrance to the sub launder. No additional pH adjustment is done before settling to control the pH in the range required for optimal flocculation.

Flocculant addition takes place in the sub launder to each settler; floc formation only takes place in the following 5 - 7 m before entering the centre well of the settler.

Settling takes place and the overflow from each settler runs into its own clear water dam. The settler desludging is done by pumping the mud directly to surface. The top of the settler is visually inspected to check the height of the sludge level before the mud is pumped. All the clear water dams are interconnected and at every 8 hourly shift the clear water is pumped directly to surface to drop the level in all six dams, except where one is offline for cleaning.

3.3.2.7 *Desludging of settlers*

Every settler is desludged by the operator by opening the drop valve, this gets done when he observes carryover of sludge into the clear water launders. The desludging valve is shut when the mud dam level is to high or when water is flowing out.

Due to carryover of sludge from the settlers it is necessary to clean the six clear water dams on a continuous basis. It takes two weekends and a team of 10 workers to clean one. Meaning that each clear water dam gets cleaned once every three months.

3.4 METALLURGICAL PROCESS WATER AND MANAGEMENT

3.4.1 Process water

Three plants, Cooke, Doornkop and Millsite are operated for gold extraction.

Millsite plant uses mine water pumped from Vent Shaft and 17 Winze. Cooke plant uses mine water pumped from Cooke 1 Shaft, Vent Shaft, dolomitic boreholes and return water. Doornkop plant uses mine water pumped from South Roodepoort Mine.

All three plants use Rand Water Board water in the extraction process where good quality water is required, for example, in the elution section where the RWB water is passed through a cationic exchange column at Cooke plant.

Vent Shaft water is clarified through two Hopper clarifiers at Cooke plant to remove the iron hydroxide precipitate before it is utilised in the gold extraction process. At the time of the visit these two clarifiers were not performing very well as there was a high concentration of suspended solids carried over with the overflow. This means that settling of this solids will have to take place in the clear water holding tanks. If this iron ends up the cyanidation section it will increase the addition of cyanide as iron is a cyanide consumer, which can have a reduction in the gold leaching efficiency of the process and eventually higher gold residues.

Slaked lime is added before and after the milling section to control the pH of the process water at 11 to 11,5 for the cyanidation process.

3.4.2 Pollution control and storm water dams

Cooke plant storm water runoff is collected via storm water trenches around the plant to two surge ponds. Water is then pumped back into the plant for reuse as process water.

The Doornkop plant storm water runoff is collected via storm water trenches to the Doornkop slimes dam return water dam, from where the water is returned to the plant for reuse in the extraction process.

The Millsite plant storm water runoff makes its way to a water dam called the Klein Kariba from where it is pumped back to the plant.

There are no polluted water treatment facilities at any of the REGM plants, but facilities do exist for storm water to flow to adjacent streams in the event of abnormally high rainfall. This prevents the pollution control dams from overflowing, thereby preventing pollution of adjacent streams.

There is usually a negative water balance due to seepage and evaporation losses. For this reason it is unusual for any of these dams to overflow. These dams are not lined.

3.4.3 Mine/Plant residue deposit

There are three residue disposal sites:

- Cooke slimes dam for Cooke plant

- Doornkop slimes dam for Doornkop plant
- Millsite dams No's 38 (not in use), 39, 40 and 41. All three are used for the Millsite as well as West Wits.

The plant residue is pumped from the plants in the form of a slurry (ratio 1:1), discharged onto the slimes dam where the solids settle out and the water is decanted through the penstock. The water collects in return water dams. Water leaves these dams by being pumped back to Cooke and Doornkop plants, evaporation and seepage. These dams are not lined.

In Millsite the penstock return water is collected in a series of evaporation dams and only approximately 25% of the water is pumped to West Wits Mine which shares the slimes dam capacity on Dam No's 39, 40 and 41.

All the slimes dams are equipped with paddocks around their circumferences at their bases. These serve to contain any seepage and washdown from the dam walls. Water that collects in the paddocks evaporates. Solids that settle in the paddocks are mechanically removed when necessary so as to maintain the freeboard. These dams are also not lined.

3.5 WATER MONITORING SYSTEMS

The mine has a well established monitoring programme in place and a well managed laboratory facility.

The groundwater quality is monitored by means of a number of boreholes situated at various sites which were identified as the most crucial and appropriate. New boreholes are drilled on an ongoing basis, as and when required.

Various samples are taken on a daily, weekly and monthly basis for the mine water quality and environmental monitoring programme. Samples are taken and analysed for the following mine areas:

- mine service water after neutralisation and settling for all the shafts on different levels.
- shaft and metallurgical plant drinking water
- potential discharges from the mine property
- environmental pollution inspections from slimes dump areas
- other mine water sources

All the samples are analysed at the mine's own laboratory where the results are interpreted by laboratory staff. Should there be a problem, the responsible person is contacted with the information. Comments are made on a regular basis to assist the responsible persons with the operation of the systems according to control standards.

3.6 WATER MANAGEMENT STRUCTURE

The following diagram shows the water and environmental management structure for REGM. The main driving force responsible for water management is the water management committee, chaired by the manager engineering.

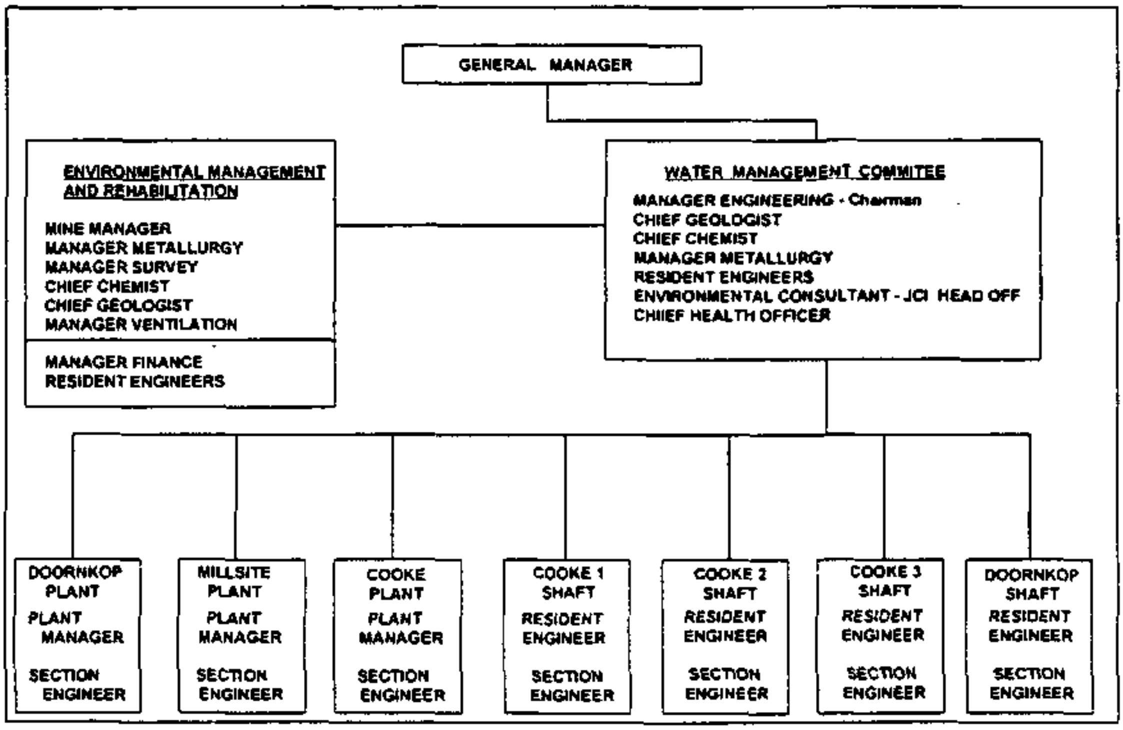


Figure 7 : Randfontein Estates Gold Mine Water Management Structure.

3.7 NOVEL OR UNIQUE WATER TREATMENT AND MANAGEMENT SYSTEMS

A novel feature at REGM is the Water Management Committee which ensures a multi-disciplinary approach to water management issues on the mine. The benefit of this quarterly meeting is the coordination of activities and discussion of various water related problems covering the following aspects:

- safety
- water supply and consumption
- treatment of mine service and cooling water
- groundwater condition monitoring

Another interesting environmental management tool used by REGM is the use of aerial and photographic surveys to identify environmental problems.

The mine receives a high standard of professional backup service from the mine laboratory, chief chemist and assistant chief chemist. The interpretation of environmental analysis and comments by the Chief Chemist provides valuable input to management strategy.

3.8 POTENTIAL WATER TREATMENT/MANAGEMENT PROBLEMS AND NEEDS

3.8.1 Vent Shaft water clarification

Vent Shaft water should be treated to remove precipitated iron before distributing to consumers. In the metallurgical plants this iron will act as a cyanide consumer in the gold leaching process. The mine is currently busy investigating different treatment options including aeration and clarification of the water.

3.8.2 Salt precipitation at slimes dams

Salt precipitation occurring on the western side of tailings dump No. 39 can cause environmental problems as a diffuse pollution source in that area. These salts could be mobilised by rainfall events.

3.8.3 Irrigation runoff

Various irrigation runoff takes place into the different streams together with salt precipitation in lower situated areas. This was specifically observed for the Klip river at agricultural lands to the east of the Doornkop Plant, also into the Wonderfonteinspruit spruit downstream of the Cooke slimes dam.

3.8.4 pH control system for underground water

A pH control system is needed to optimise/control the neutralisation and lime dosing system. Presently lime is not added in relation to the flow variation or any changes in the water quality what so ever. The same procedure is followed daily without considering the fluctuation in the flow or water quality. A pH control system will also benefit the settling performance as flocculants operate best at certain pH's, with a result that the suspended solids content will be lower and more pumping hours can be obtained before a pump needs an overhaul.

The current lime addition procedure is out of phase with the variation in flowrate of dirty water flow to the settlers.

The flowrate to the settlers, the lime addition and the resultant pH are presented on a graph over a 24 hour period. It is obvious from this presentation that the two activities are out of phase. A large portion of the lime dosing is taking place and passes through the settlers before the main/peak flow reaches the settlers.

3.8.5 Flocculation for settling

Flocculant addition is not proportional to the actual dirty water flow to the settlers. One flocculant makeup tank per settler is emptied every 8 hourly shift. This is done by manually opening the outlet valve and flocculant is dosed according to a declining head in the makeup tank which means there is no control of flocculant addition to match it to the actual requirement. When the makeup tank is full the dosage is at its highest but decreases as the tank is emptied.

Flocculant addition must be done at a point of high turbulence to get flash mixing, after which the flowrate must be reduce to such an extend to allow for flocculant formation to take place before reaching the central downpipe in the settler. This is not happening at the system that was visited.

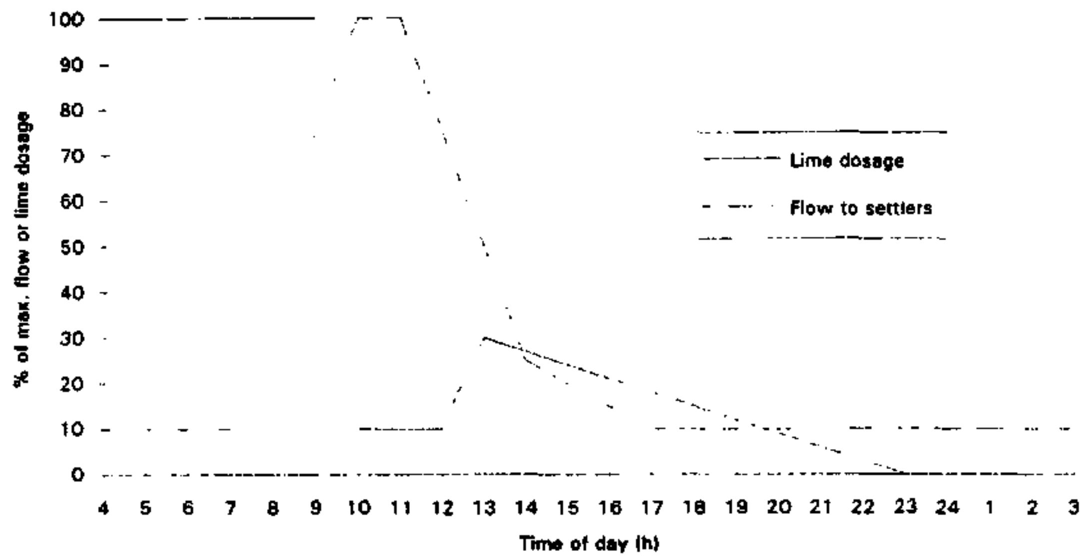


Figure 8 : The different phases during a 24h period for lime dosing and flow to the settlers.

The pH reaching the settlers can vary anything between 3 to 10 which influences the performance of the specific flocculant which has a negative effect on the suspended solids content in the overflow.

3.8.6 Settler Design and Operation

Some settler design improvements and alterations are required to resolve the following problems:

- The bottom of the settler inflow launder is higher than the water level in the settler. This may cause air to be entrapped with the inflowing dirty water which may affect the settling of the solids. The turbulence generated by the influent dropping into the settler may also break up the flocs.

- The inlet downpipe goes down too far. In the process disturbing the solids in the settled zone.

- The dirty water distribution between the six settlers is out of balance with individual settlers receiving unequal flow.

- The settler overflow is still dirty with a high suspended solids content. Secondary settling takes place in the clear water dams.

- There is no mud holding tank underground.

- Due to secondary settling taking place in the clear water dams, labour intensive and costly cleaning of clear water dams is required on an ongoing basis.

Another problem with the settler operation is the desludging practise. The operator only desludges a settler when solids are carried over into the clear water launder which means that solids are carried over to the clear water dams. To clean these dams is labour intensive and the solids content have a increased wear on the clear water pumps, reducing the pumping hours before a overhaul is required.

3.8.7 Groundwater pollution

Groundwater pollution occurs around the Cooke slimes dam. This is evident in the high conductivity readings of the irrigation water which is converted by irrigation runoff to a surface water pollution problem.

3.8.8 Possible reuse of decanted slimes dam water

Slimes dam return water is decanted from the Millsite tailings dam no 39 and a large portion of this water is evaporated with the use of evaporation dams to the north west of these tailings dams. At the time of the site visit the pH and conductivity measured 11,8 and 147 mS/m. This water's quality is actually better than the quality used from other sources like Vent Shaft water in the metallurgical process. It may be viable to replace some of the Vent Shaft water with this penstock water and evaporate part of the Vent Shaft water instead.

Appendix A - List of pH and Conductivity readings taken during the site visit

During the site visit the following pH and conductivity readings were taken at various locations on the mine:

No	Sample ID	Description	pH	Cond.(mS/m)
1	S1	Vent Shaft water holding tank	7,3	282
2	S2	Vent Shaft water outlet to wetland next to Robinson dam	9,5	275
3	S3	Vent Shaft water passed from Robinson dam to Wes Wits dam	9,7	273
4	S4	Robinson dam recreation area	8,5	280
5	S5	Penstock return water from S/dump 39 Mill Site deposit	11,8	147
6	S6	Penstock return water from S/dump 40 + 41	12,4	312
7	S7	Part of penstock return water from Dump 39 to Wes Wits	12,0	194
8	S8	Vent Shaft water at inflow to surface settlers	9,3	265
9	S9	Clarified water from settlers to Wes Wits	8,6	177
10	S10	Water used for monitoring and dump reclaiming	8,6	283
11	S11	Cooke Plant No. 2 thickener overflow	12,3	520
12	S12	Surge Pond No. 1 return water to milling section	11,9	327
13	S13	Storm water trench on northern boundary of Cooke plant	10,2	193
14	S14	Wonderfonteinspruit at Main Reef Road	8,4	56
15	S15	Irrigation dam next to Klipriver	8,4	194
16	S16	Irrigation runoff water to Klipriver	4,9	283
17	S17	Irrigation runoff water to Klipriver	7,5	496
18	S18	Klipriver upstream of bridge on western side of DRD S/dump	3,7	278
19	S19	Trench from agriculture land before entering Klipriver	4,7	268
20	S20	Klipriver downstream of bridge (DRD)	3,7	276
21	S21	Wonderfonteinspruit upstream of Cooke S/dump	7,3	81
22	S22	Return water dams form Cooke S/dump	7,5	403
23	S23	Agricultural land runoff to Wonderfonteinspruit downstream of Cooke S/dump	6,6	357
24	S24	Upstream of bridge at the tar road to Cooke 1 shaft before agricultural runoff enters Wonderfonteinspruit	7,9	81
25	S25	Wonderfonteinspruit downstream of tar road crossing	8,0	96
26	S26	Wonderfonteinspruit upstream of Donaldson dam	8,0	91
27	S27	Donaldson dam at mid section weir	8,6	99
28	S28	Donaldson dam overflow	8,7	104

Appendix B - List of pH, Conductivity and temperature readings taken during the underground visit

During the underground visit the following pH, conductivity and temperature readings were taken at various locations:

No	Sample Description	pH	Cond. (mS/m)	Temp °C
S1	95L drill water	5,7	229	19,5
S2	95L foot wall	9,4	652	19,3
S3	95L service water	5,1	229	17,6
S4	95L runoff from stope	6,7	186	20,9
S5	95L standing water from side wall showing oxidation	2,1	2005	17,0
S6	101L water in trench	4,7	247	18,0
S7	101L water running from old bore hole	6,6	222	18,3
S8	101L trench downstream of battery bay	6,6	240	17,0
S9	101L trench downstream of loco workshop	6,6	234	17,1
S10	101L trench downstream of old workplace	6,6	270	17,2
S11	101L water from second workplace before mill in main trench	5,6	350	18,5
S12	101L water dripping from old box cut	7,1	171	21,1
S13	101L fissure water dripping from the roof at rest place	3,1	236	18,4
S14	101L trench from resting place	3,0	251	22,0
S15	101L water dripping from old box cut from rest place	3,9	197	20,5
S16	101L trench closer to resting place	2,9	245	22,0
S17	101L mined stream from rest place in main trench	3,3	241	20,7
S18	106L mine dirty from all levels in main launder to settlers	9,1	250	19,6
S19	106L launder to No. 4 settler	9,2	264	19,6
S20	106L fissure water from roof	8,2	163	20,0

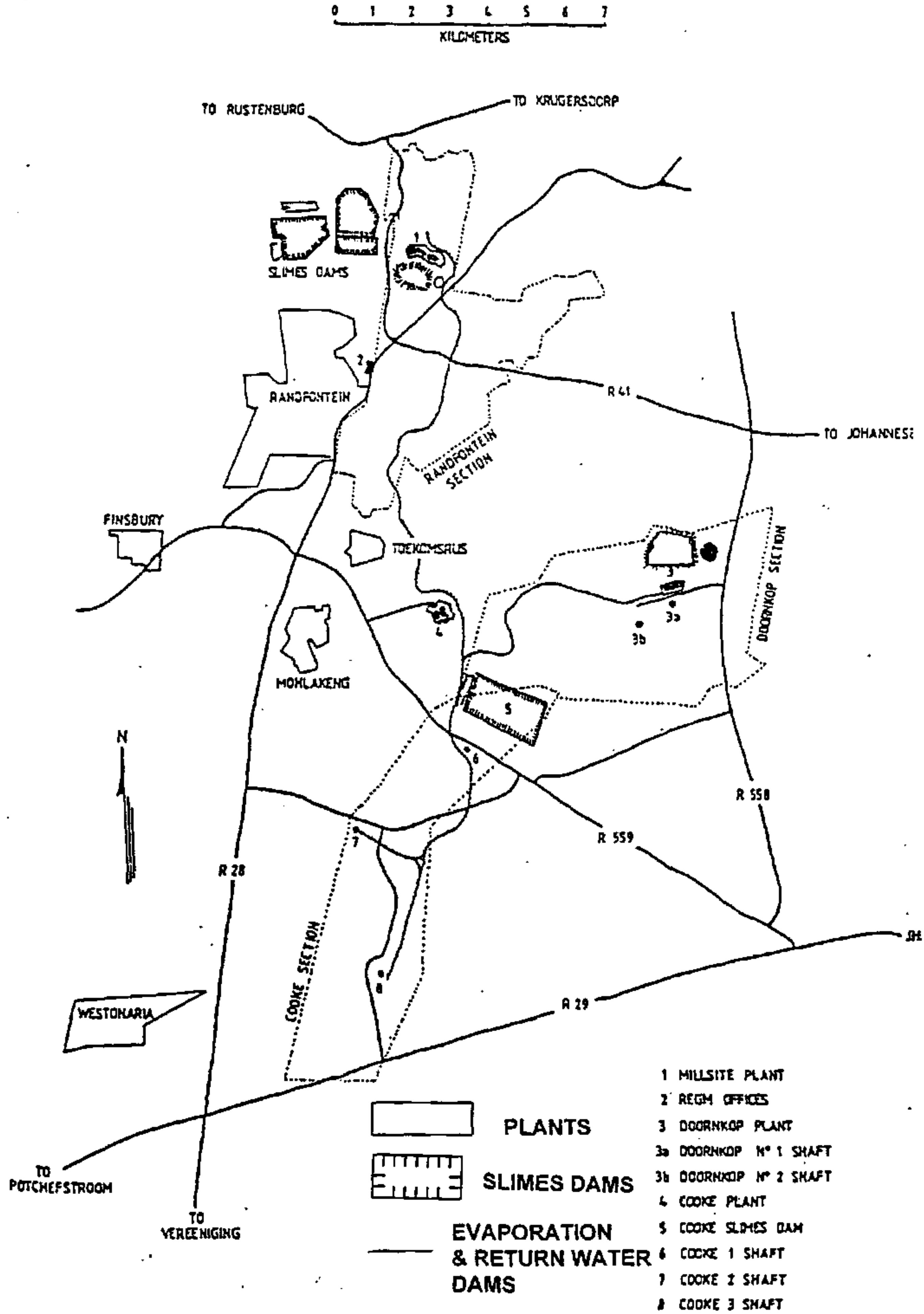
Appendix C - List of photographs taken during the site visit

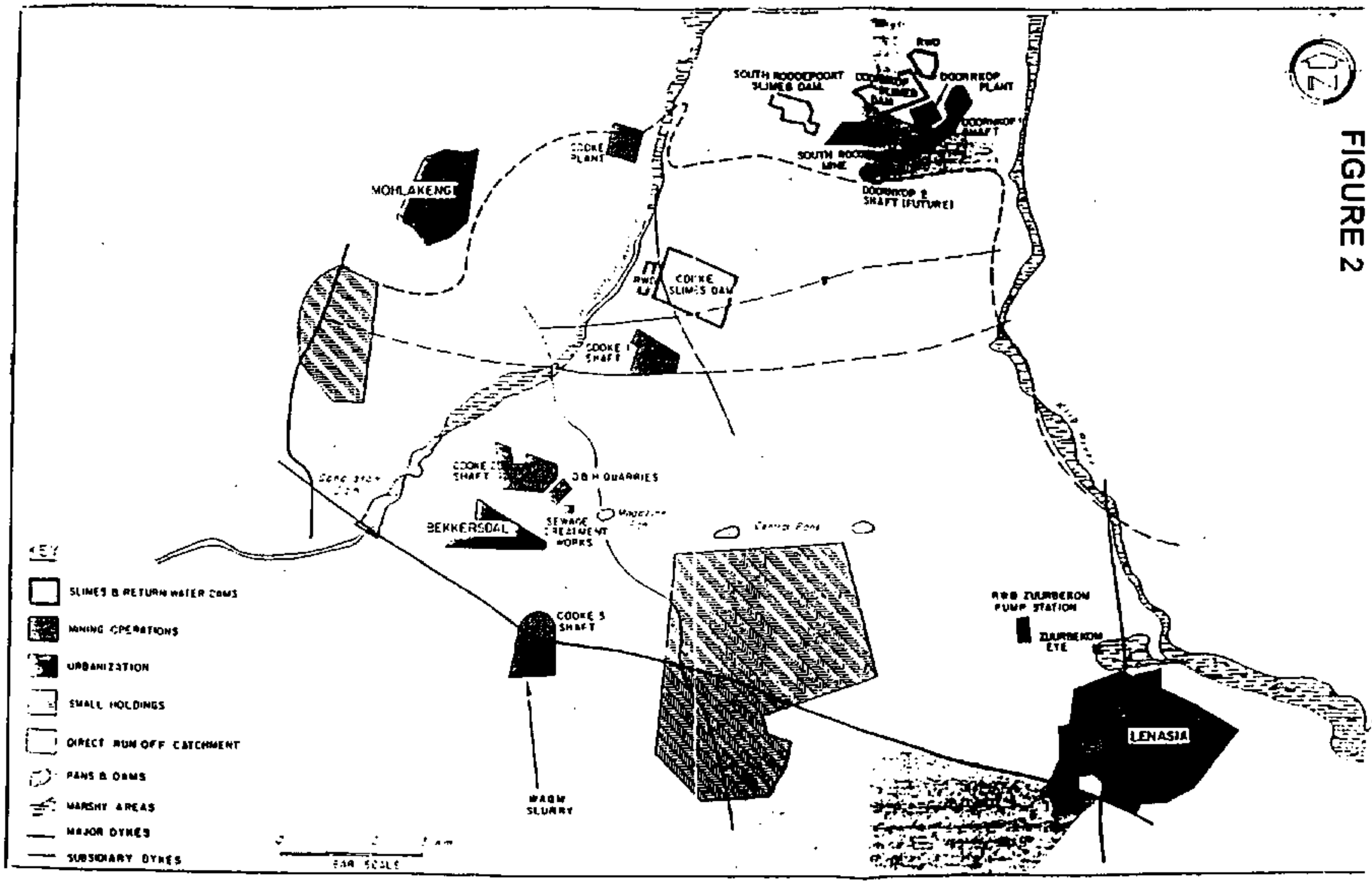
During the site visit the following photographs were taken at various locations on the mine:

Photograph No.	Description
1	Surface holding tank for Vent Shaft u/g water
2	Lime dosing point to Vent Shaft u/g water
3	Robinson dam recreation area
4,5	Earth dam next to origin of Tweelopiesspruit
6,7	Settling system of Vent Shaft for water for Wes Wits Heap Leach operation
8	Pump station for monitoring water supply at Dump 20 Mill site
9	Cooke plant process water holding tanks
10	Top of clarifier at Cooke Plant
11	Gland service water holding tank at Cooke Plant
12	Clarifier overflow launders, Cooke Plant
13	Thickener system at Cooke Plant
14	Storm and runoff water trench around the plant
15,16	Surge ponds at Cooke plant for collection of storm water
18	Wonderfonteinspruit at Main Reef Road
19	Salt precipitation and runoff at agricultural lands
20	Salt precipitation at agricultural land next to Klipriver
21	Wonderfonteinspruit - just upstream of Cooke slime dam
22	Cooke slime dam return water dams
23	Weir at Donaldson dam
24	Sewerage treatment works at Cooke 2 shaft, activated sludge reactor dams

MAP OF AREA OCCUPIED BY RANDFONTEIN ESTATES

FIGURE 1

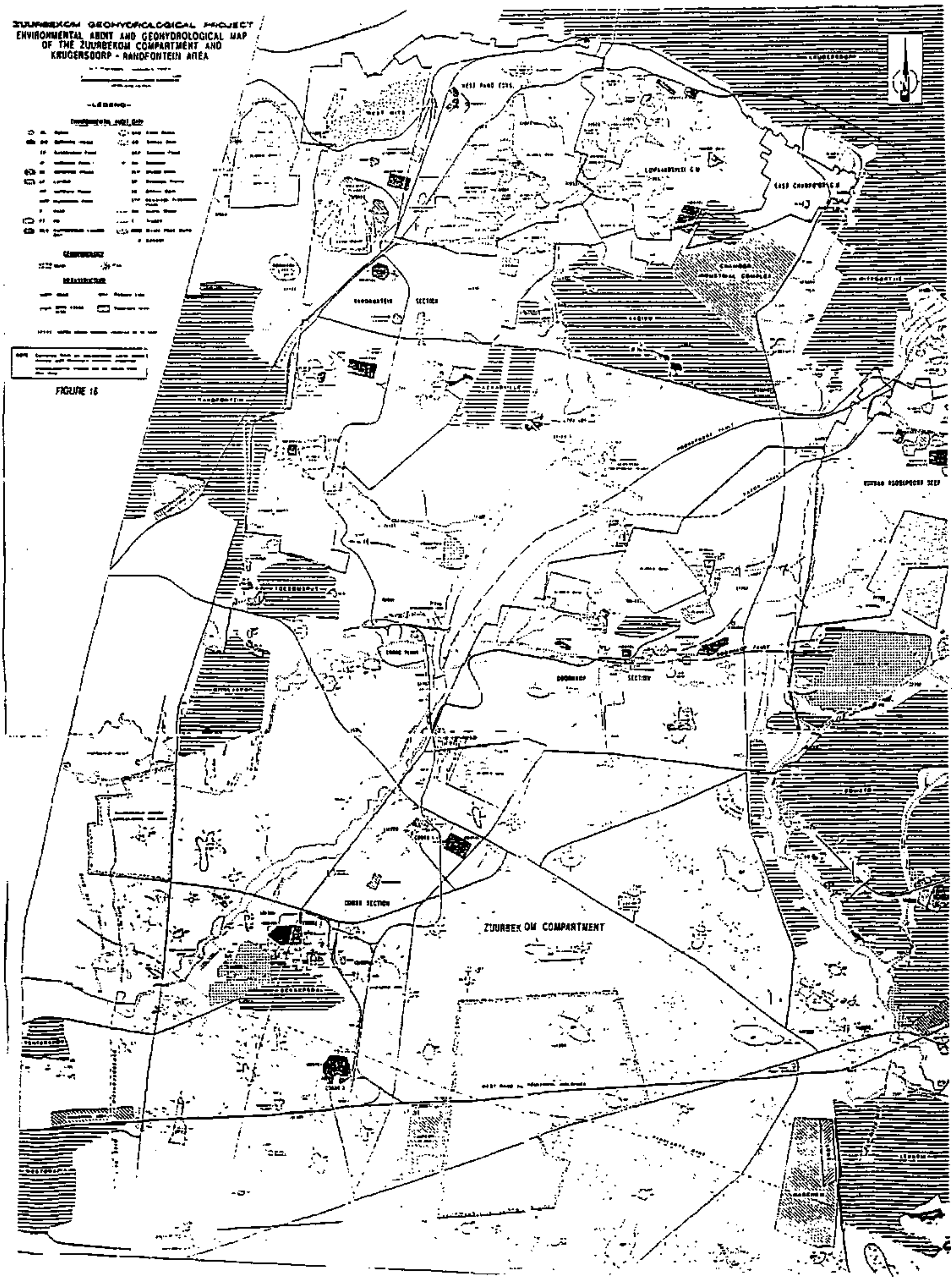




SOUTH ROODEPOORT SLIMES DAM
RWD
DOORNKOP PLANT
DOORNKOP SHAFT
SOUTH ROODEPOORT MINE
DOORNKOP 2 SHAFT (FUTURE)
COOKE PLANT
MOHLAKENG
COOKE SLIMES DAM
COOKE 1 SHAFT
COOKE 2 SHAFT
D B H QUARRIES
BEKKERSDAL
SEWAGE TREATMENT WORKS
COOKE 5 SHAFT
WAGM SLURRY
RWB ZUURBEKOM PUMP STATION
ZUURBEKOM EYE
LENASIA
KEY
SLIMES & RETURN WATER DAMS
MINING OPERATIONS
URBANIZATION
SMALL HOLDINGS
DIRECT RUN OFF CATCHMENT
PANS & DAMS
MARSHY AREAS
MAJOR DYKES
SUBSIDIARY DYKES

FIGURE 2

FIGURE 3


ZUURBEKOM GEOHYDROLOGICAL PROJECT
ENVIRONMENTAL AUDIT AND GEOHYDROLOGICAL MAP OF THE ZUURBEKOM COMPARTMENT AND KRUGERSDORP - RANDFONTEIN AREA
-LEGEND-
FIGURE 18
ZUURBEKOM COMPARTMENT
COOKE SECTION
DOORNKOP SECTION
WEST RAND CONS.
LUIPAARDSVLEI G M
EAST CHAMPDORE G M
CHAMDOR INDUSTRIAL COMPLEX

Report on Rand Mines Milling and Mining Company Ltd - Site Visit

5 - 6 July 1994

1. GENERAL INFORMATION

Name of mine	RMP Properties - Crown Plant previously Rand Mines Milling and Mining Company Ltd (RM3)
Name of person(s) interviewed	Messrs: Fred Diamond - Technical Service Manager Willem de Klerk - Asst Plant Manager
Nearest town	Johannesburg
Name of catchment	Klipspruit and Russell Stream for Crown Plant Area Natalspruit for City Plant Area
Monthly tonnes treated	Crown Plant 446 000 tpm City Plant 220 000 tpm
Monthly gold production	325 kg/month
Current age of mine	14 years
Expected remaining life of the mine	9 years
Type of mining carried out	Reprocessing of old sand dumps and slimes dams
Transport mode, reclamation site to plant	Monitoring slimes dam using high pressure water. Slurry is pumped to metallurgical plant. Mechanical loading of sand and screening on site before slurry is pumped to metallurgical plant.
Has the mine already produced an EMPR?	Yes, to be submitted

2. SITE VISIT PROGRAMME

2.1 Day 1 - 5 July 1994

- Arrival at Crown Plant
- Short discussion of project background and objectives with Mr Diamond
- Present at meeting:
  F Diamond - Technical Services Manager
  G Trusler - Rand Mines, Environmental Officer
  W Pulles - PHD
  J Laas - PHD
- Guided tour of the three slimes dams currently in use for depositing residue slime from both Crown and City Plants, accompanied by Mr Johnny Mooiman of Fraser Alexander.
- Guided tour of the following reclamation sites with Mr Stephen Eichstadt:

  B South Sand Dump - mechanical loading, screening and repulping operation
  B North Sand Dump - monitoring and slurry pumping operation 3L11 and 3L12 Slimes Dumps - monitoring and slurry pumping operations

- Measured pH and conductivity values for the Klipspruit and Russel stream at various points up and downstream of the sand dumps, slimes dams and reclamation operations.

2.2 Day 2 - 16 July 1994

- Arrival at Crown Plant
- Brief discussion of project background and objectives with Mr W de Klerk
- Present at meeting:
  W de Klerk - Asst Plant Superintendent
  W Pulles - PHD
  J Laas - PHD
- Guided tour of the Crown Metallurgical Plant and surrounding area with Mr de Klerk.
- Tracing the Russel stream origin to the Turfontein area down to the confluence of the north-eastern and south-eastern streams in Ophirton. pH and conductivity readings were measured at various points along the stream, past the Crown Plant area up to Crownwood road.
- Completion of the questionnaire:
  F Diamond - Technical Services Manager
  W Pulles and J Laas - PHD

3. DISCUSSION OF THE MINE'S CURRENT WATER MANAGEMENT AND TREATMENT PRACTICES

3.1 DESCRIPTION OF WATER CIRCUITS

3.1.1 General

The mine operations can be divided into the following areas:

- Slimes Dams areas (Diepkloof/Homestead, Mooifontein and GMTS) for depositing Crown and City Plant residue.
- Crown Plant area
- City Plant area (not visited)
- Present reclamation areas
- Future reclamation areas
- Cleared dump areas

A map was provided showing the location of all these areas.

Detailed plans of the different areas visited were not available and schematic diagrams showing the pH and conductivity sampling points were made. These diagrams are attached as Figures 2, 4 and 5.

3.1.2 Reclamation Operations

Two forms of feed material are recovered for treatment, one described as sand and the other as slime.

3.1.2.1 Slime

Slime is reclaimed by conventional hydraulic methods with high pressure monitors using processed water from the return water dams. The pulp flows by gravity to a sump from where it is pumped to a flat deck vibrating screen for the removal of swamp material such as oversized particles and vegetation. The under flow of the screen is pumped to the linear screens at the processing plant and the oversize is rejected as waste.

3.1.2.2 Sand

The material is reclaimed with front-end loaders and fed to movable hoppers fitted with grizzly bars and vibrating feeders which feed onto conveyor belt systems. The screened sand is then slurried and pumped to the plant.

Sand is also monitored at B North.

3.1.3 Plant Operations

3.1.3.1 *Sand Preparation, Leach and CIP*

A diagrammatic layout of the Crown Plant is shown in Figure 1.

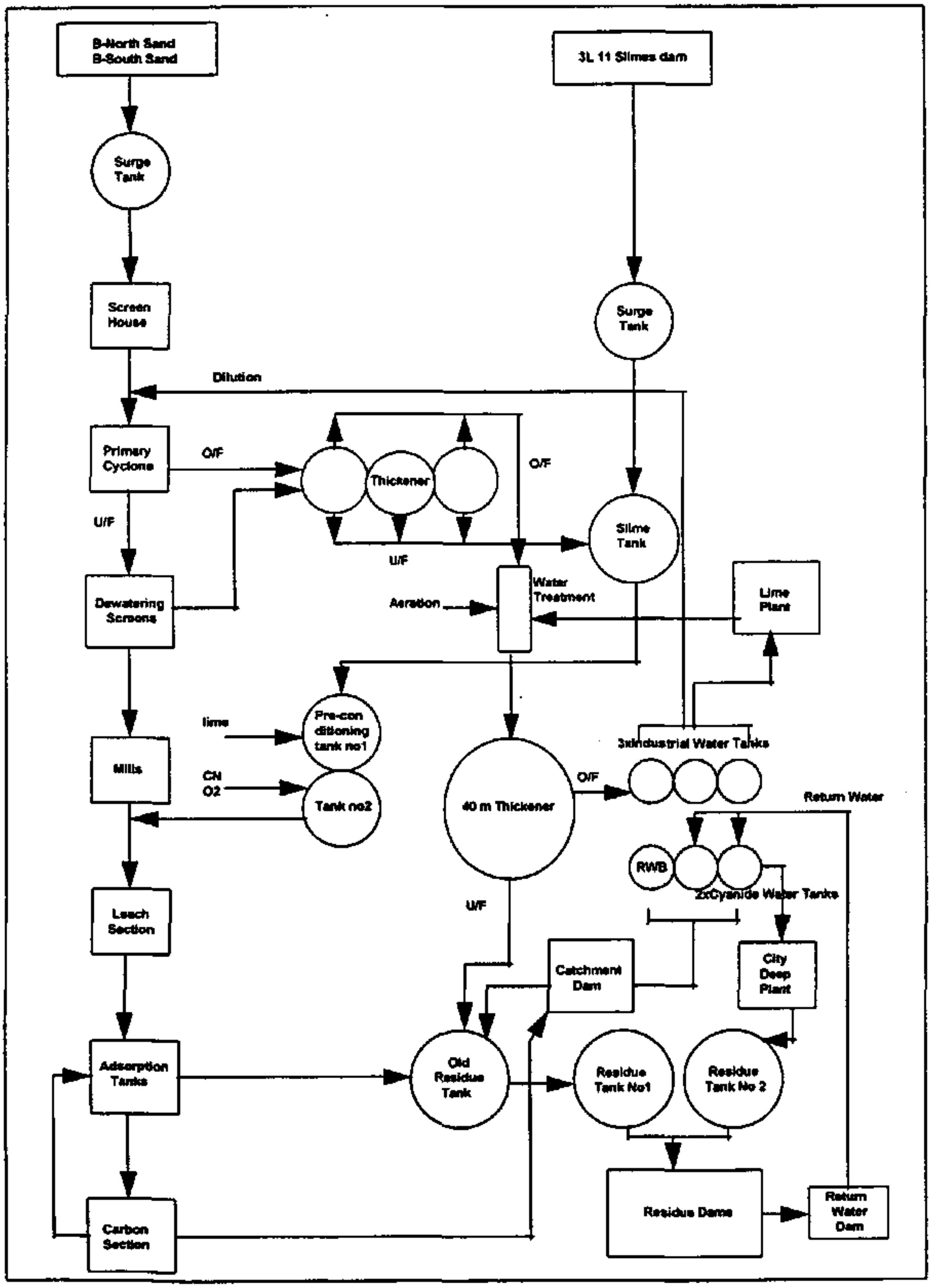


Figure 1: Diagrammatic layout of the Crown Plant Process

Reclaimed sand is fed by conveyor to a screen and washing sprays. The resulting pulp is pumped to the primary cyclones after the liquid : solid ratio is adjusted with process water from the plant tank farm. The overflow from the cyclones is fed to a thickener system. The underflow from the thickener is pumped into the slime surge tank where the pulp from the slimes reclamation process is received at the plant.

The primary cyclone underflow is dewatered to about 20% moisture on dewatering screens and is then treated through the milling section. The screen underflow is also pumped to the thickener system. A transfer pump then conveys the pulp from the lime surge tank to the preconditioning section, before it is treated in the leach and CIP sections.

The City Deep plant residue is also received at Crown Plant from where it is pumped to the three operating slimes dams.

3.1.4 Residue Deposition

The combined residue from Crown and City Deep plants is deposited onto three slimes dams, e.g. Homestead/Diepkloof, Mooifontein and GMTS. The plant residues can be deposited onto any of the three dams which are operated by Fraser Alexander. Deposition is carried out simultaneously on two slimes dams.

The surface area of each slimes dam as follows:

- Diepkloof 33,9 ha
- Homestead 38,1 ha
- Mooifontein 56,3 ha
- GMTS 94,4 ha

3.2 DESCRIPTION OF WATER TREATMENT / MANAGEMENT SYSTEMS

3.2.1 Slimes Dams and Return Water Dams

The three operating slimes dams were re commissioned when the reprocessing of the sand dumps and slimes dams began in the early 1980's. The fresh plant residues were deposited onto new dams on top of the old areas. Mooifontein and Homestead/Diepkloof were equipped with a plastic lining to control and prevent seepage into the groundwater systems through the old dams.

Figure 2 shows the location of the slimes dams and return water dams as well as the pH and conductivity sampling points. The residue from both Crown and City Deep plant can be pumped to either of the three slimes dams. Water is then decanted and flows down the solution trenches, to the return water dams. Both Homestead/Diepkloof and Mooifontein slimes dams have return water dams. Penstock return water from GMTS can be decanted to either of these return water dams. Toe paddock dams around the slimes dams are also in place to collect seepage and runoff water around the slimes dams.

All storm water runoff is also captured in the return water and toe paddock dam systems.

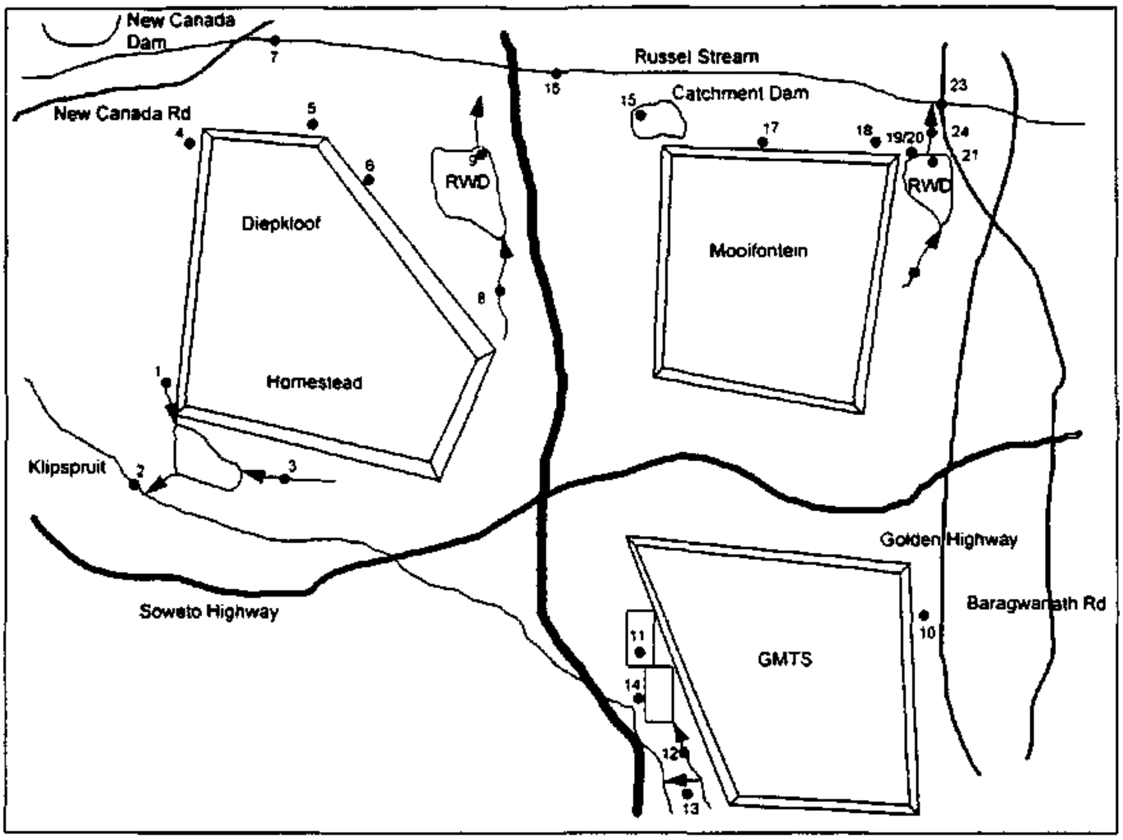


Figure 2 : Slimes dams and return water dams layout

3.2.2 Water management for reclamation process

Return water is used for high pressure monitoring of the slimes dams and sand dumps and is pumped via the plant tank farm to the site or directly from the return water dams. The slurry is pumped directly to the processing plant. Any runoff from the monitoring site is captured in a system of catchment paddocks for evaporation. Sediment erosion from the site is also controlled in this manner.

Rand Water supply water is used for gland service water in all these operations. Storm water runoff is also controlled with this system of catchment paddocks.

3.2.3 Water management in plant operations

Two sources of water are available to the plant:

- Return dam water for screen sprays, mill dilution and slimes reclamation monitors; and
- Rand Water supply for makeup, to feed the CIP processing section and for gland service.

The overflow from the thickener system is pumped to a water treatment section and then to a 40m water treatment thickener. In this water treatment system a lime slurry is added and the water well aerated to precipitate metal salt hydroxides. The precipitated metal salts are removed in the thickener underflow and then pumped to the residue tanks. The overflow from the 40m thickener is transferred to the plant via three industrial tanks and two cyanide water tanks. Return water from the slimes dams is pumped into the two cyanide water tanks. A Rand Water tank distributes water for use throughout the plant.

Internal water collection trenches are used to recycle storm water runoff and process water spillage in the plant circuits, prior to the gold recovery section. Carbon plant effluent containing fine carbon is collected in a catchment dam below the plant. Water from this dam is pumped back to the plant residue tanks and out to the slimes dams.

Overflow and seepage through the catchment dam is controlled by way of a series of evaporation ponds and berms downstream of the catchment dam.

3.3 WATER QUALITY AND FLOW MONITORING SYSTEMS

Water samples are regularly taken at the following points for analyses:

- RM3-CD1 Wemmerpan Weir
- RM3-CD2 Stream at 3/A/17
- RM3-1 From Russel stream south of 3/L/18
- RM3-2 From Russel stream at Crownwood Road bridge
- RM3-3 From Russel stream at Baragwanath Road
- RM3-4 Return water dam, east of Mooifontein slimes dam
- RM3-5 Water dam west of GMTS slimes dam
- RM3-6 Return water dam to the north of Diepkloof slimes dam
- RM3-7 Stream at 3/A/17 City

Samples were originally taken on a monthly basis, but since the results proved to be very similar and constant, it was decided to reduce the frequency.

Various flow meters are installed in the water reticulation system and flows are recorded daily.

3.4 POTENTIAL WATER MANAGEMENT PROBLEMS AND NEEDS

3.4.1 Slimes and Return Water Dams

The rise rate for the slime dams of 2,5m per year is very high and that may be a contributing factor for the seepage taking place around the dams. Local soil and geological conditions, together with silted up toe paddocks may also be contributing to the seepage. It should be highlighted that very active seepage is taking place at GMTS slimes dam and also through the return water dam. Homestead return water dam also shows signs of substantial seepage and overflow.

During the site visit at Mooifontein slimes dam, on the northern side, where the recent break away of the side wall had been stabilised, very active seepage through that section of the wall was observed. The pH and conductivity readings for that seepage were 3,0 and 881 mS/m respectively.

Due to the active seepage, precipitated salts could be seen at soil surfaces outside the cutoff trenches around the slimes dams. These precipitated salts are a pollution source and can be mobilised by storm water runoff from these areas to downstream watercourses.

Due to the lack of or poor vegetation of the lower slimes dam slopes, erosion takes place constantly, causing sediment to be captured in the catchment paddocks, solution trenches and the return/catchment water dams. All of these are badly silted up, reducing their holding capacity. As a result of this the return water dams regularly overflow into the Klipspruit and Russel stream.

Figure 2 shows the layout of the slimes dams and return water dams with the pH and conductivity sampling points. These results show that the overflow of the return water dams and seepage from the slimes dams contaminate the Russel stream. The base flow of the stream has a conductivity of 95 mS/m as measured at point 40 (Figure 4), compared with 127 mS/m at point 23, 170 mS/m at point 16 and 166 mS/m at point 7.

The use of a proper water balance for the slimes dams and return water dams as a water management tool must be emphasised. Such a water balance must be dynamic and capable of handling and reflecting any major changes in the mine's operations. At the moment the water imbalance around the slimes dams and return water dams is causing a lot of problems such as seepages through cutoff trenches and return water dam walls and especially the regular overflowing of these dams.

The following aspects need to be addressed:

- Slimes dam rise rate is too high. The use and development of additional slimes dams are required. The possible use of CMR slimes dams is being investigated by the mine.

- A proper water balance must be developed. The reuse of return water at City Deep will improve the control of the water balance. At present no water is returned to City Deep plant.

- Desilting of the catchment paddocks, solution trenches and return water dams are required.

- Vegetation of the slime dam slopes will reduce erosion and the resulting silting up of the system.

- The overflowing of the return water dams can be prevented if a level control system is used to activate the stopping and starting of the water pumps. At present this is performed manually by way of sending someone out to the pump station. The basic concept for such an installation is shown in the following diagram:

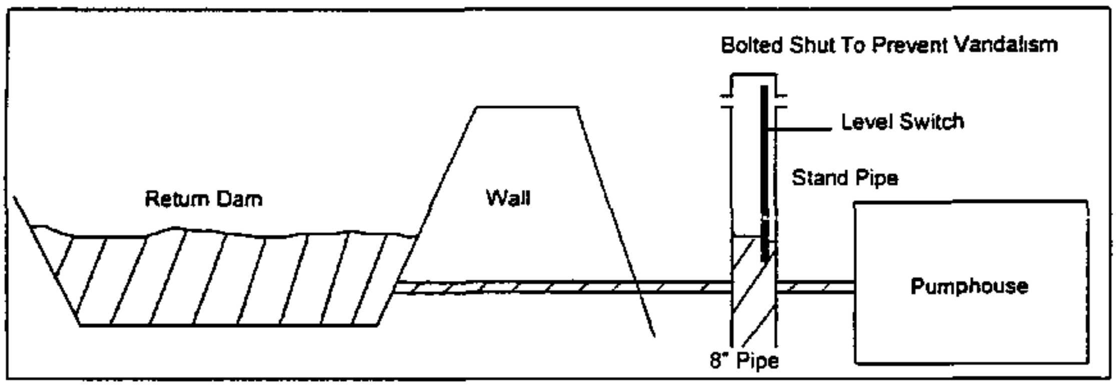


Figure 3 : Possible level control system to activate pumps to prevent overflowing of return water dams.

3.4.2 Reclamation Operations

The biggest water problem in this operation is seepage into the groundwater and the Russel stream. Figure 4 shows the layout of present reclamation areas feeding Crown Plant. The pH and conductivity sampling points are also indicated. The effect of seepage can be seen when comparing the conductivity reading of 155 mS/m at point 41 with a reading of 185 mS/m at point 28. The dilution effect of the urban runoff at point 27, with a conductivity of 62 mS/m, can be seen when compared to the conductivity of 127 mS/m at point 23.

It is also important to note that the whole Valley Silt Area is covered with a layer of slime of up to 5 m thick in some areas. The Russel stream flows through this area and in so doing is picking up pollutants from the slime, which increases the conductivity.

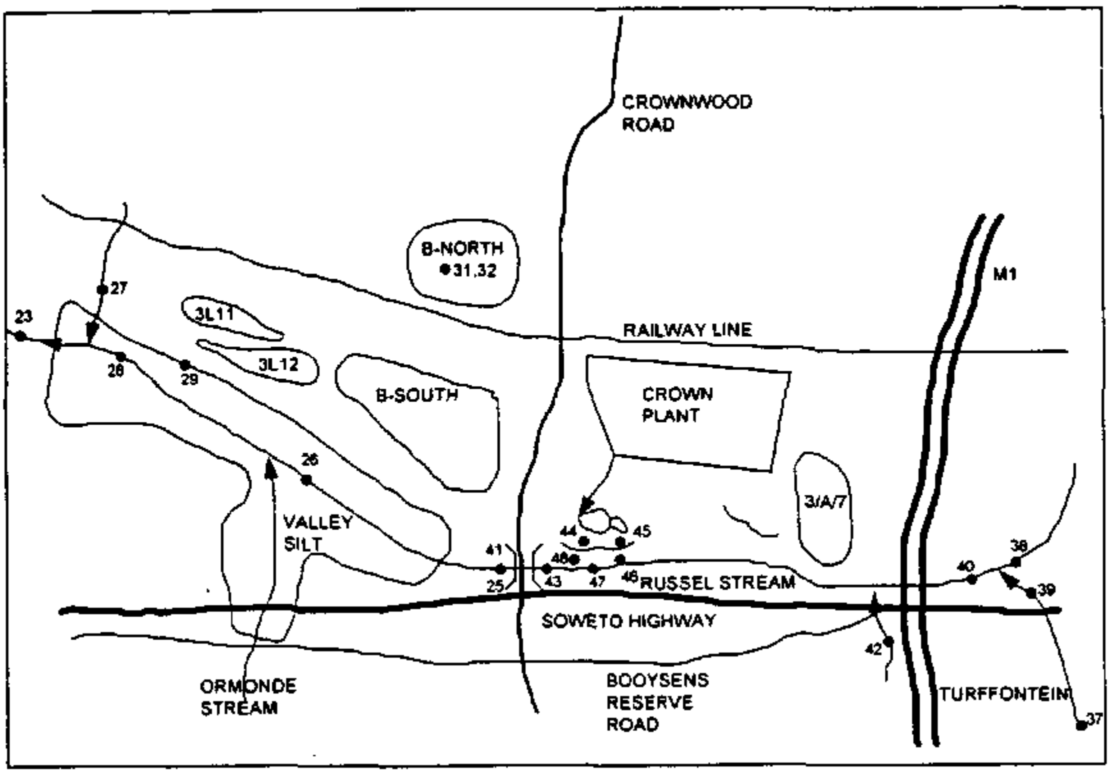


Figure 4 : Reclamation of sand dumps and slime dams sites in Crown plant area

Ponding of water within monitoring sites should be minimised to prevent the formation of groundwater recharge sites which will cause pollution thereof. Two such stagnant ponds on top of B North Sand Dump measured pH readings of 3,3 and 2,3 and conductivities of 467 and 1740 mS/m.

3.4.3 Crown Plant Catchment Dam Area

The carbon plant effluent containing fine carbon at pH 1 to 3 gravitates into the catchment dam, south of the Crown Plant. At night the water is pumped via the Old Residue Tank to the slimes dams. A system of evaporation ponds situated below the catchment dam, controls the storm water runoff from 3/A/7 dump area and seepage from the catchment dam.

Figure 5 shows the contamination of the Russel stream south of Crown Plant. The pH and conductivity sampling points and results are also shown. The Russel stream has a conductivity of 95 mS/m just after the confluence of the NE and SE tributaries. This is diluted to 92 mS/m downstream of the pedestrian bridge due to the inflow of urban runoff at 55 mS/m. At the cement channel south of the 3/A/7 dump, severe precipitation due to seepage into the Russel stream was observed. A conductivity reading downstream confirmed the occurrence of seepage, as the conductivity increased to 114 mS/m.

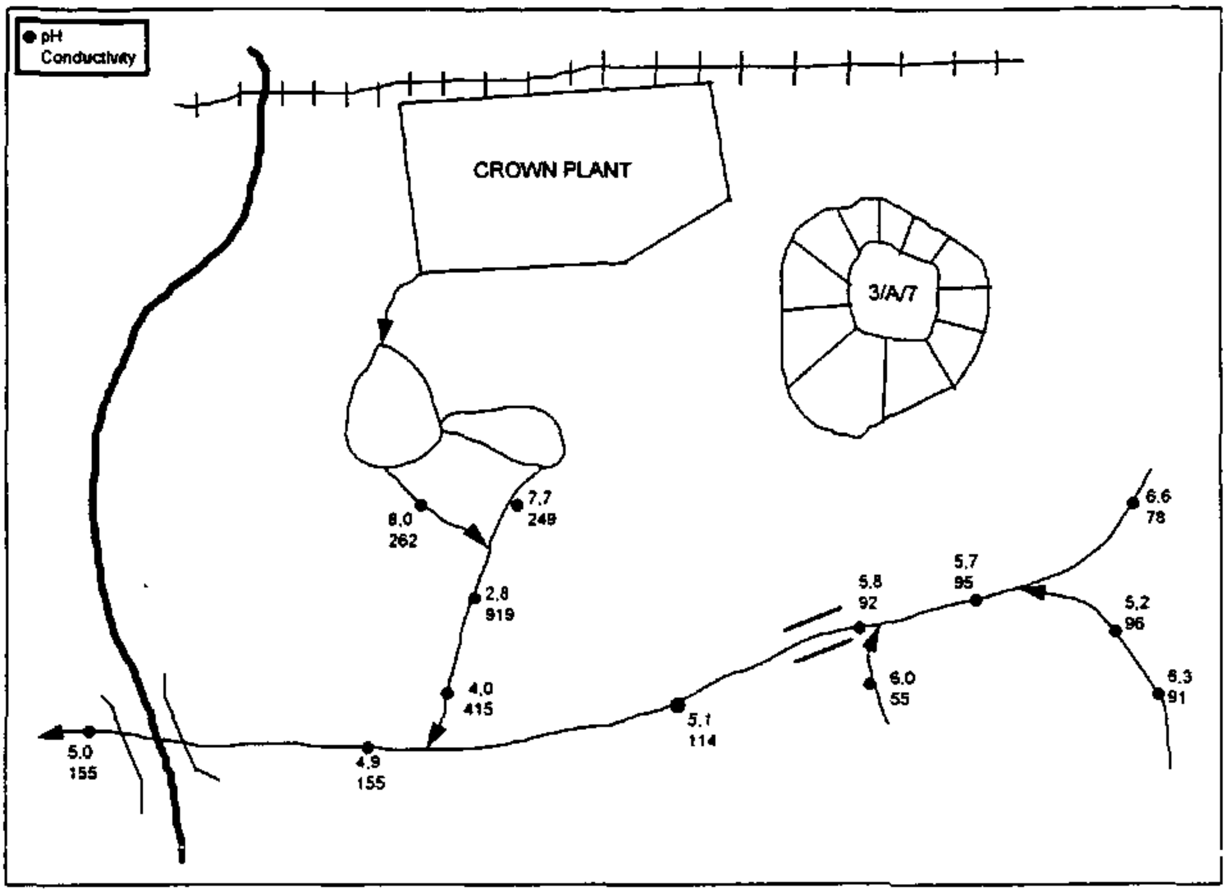


Figure 5 : pH and Conductivity measurements taken along the Russel spruit south of the Crown Plant

Two separate seeps from the catchment dam measured at 262 and 249 mS/m combined before flowing to the Russel stream. Closer to the Russel stream, a conductivity of 919 mS/m was measured following the course of the seepage to the stream. This may be possible due to subsurface seepage from the surrounding areas and 3/A/7 dump. The decrease in conductivity to 415 mS/m closer to the Russel stream is the dilution of the seepage with the water from the stream itself. Downstream of this seepage inflow the conductivity was 155 mS/m, similar to the reading at Crownwood bridge.

This is the current situation during winter when it is very dry and there is no stormwater runoff from this area. There is very little evaporation taking place from the evaporation ponds and berms downstream towards the Russel stream during this time of the year and a substantial amount of seepage is taking place.

The planned storm water trench from the eastern side of the plant area, around the southern side, down towards Crownwood road, should improve the seepage problem, as it will transfer clean storm water directly into the Russel stream, instead of over the slime/sand covering the area below the plant where contamination of the water then takes place.

In order to minimise the potential pollution of this area it will have to be reclaimed to such an extent that the slime and sand layers are removed from this area. Stormwater should then be routed around the area as the extent to which the soil layers below the reclaimed dump have become contaminated is unknown.

3.5 WATER MANAGEMENT STRUCTURES

A schematic line diagram of the mine water management structure is shown in Figure 6.

The responsibility of implementing the EMPR is shared by two Strategic Business Units (City Deep and Crown Plant) and the Technical Services Manager .

Water management in Crown Plant is integrated into plant functions and responsibilities. There is no separate structure or responsible person.

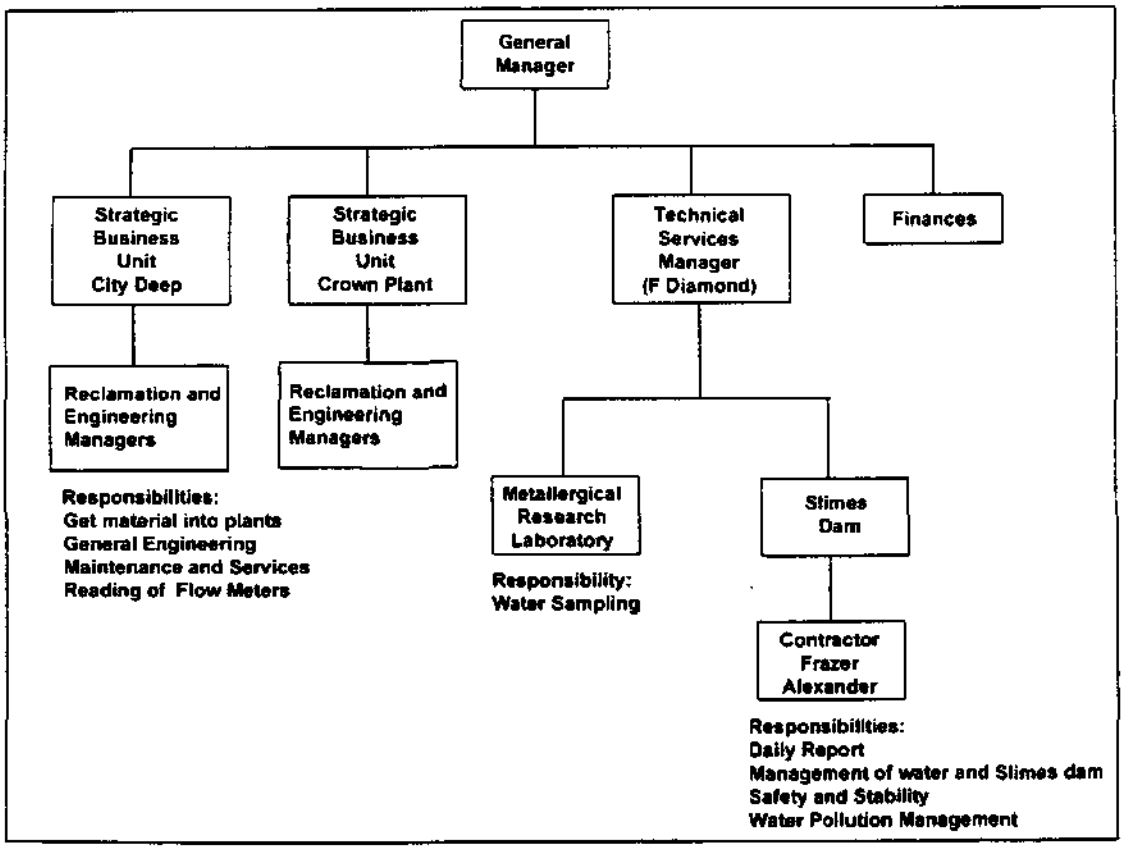


Figure 6 : Rand Mines Milling and Mining water management structure

4. GENERAL OBSERVATIONS

4.1 Slimes deposited in water courses/dams is a major long term problem. Due to contamination with organic detritus, this material is difficult to treat and has a high cyanide demand. Consideration should be given to developing regulatory/financial incentives for mines to reclaim this material as a priority.

4.2 The development of the EMPR has made the mine more aware of water management issues and has prompted the decision to commission the pipeline from the return water dams back to City Plant. This will have dual benefits in that the overflow/pollution to surface water systems will be reduced.

4.3 The rate of dump reclamation operations warrants special consideration in that these operations definitely have a long term beneficial impact by removing a pollution source. These operations must, however, be carefully managed to prevent a situation arising where their operations result in significant enhanced pollution in the short to medium term. In particular, consideration should be given to developing strategies to ensure that a dump is completely removed and rehabilitated in as short a time as possible, in order to prevent the seepage and pollution problems in the partially reclaimed site below Crown Plant.

Appendix A - List of pH and Conductivity readings taken during the site visit

During the site visit the following pH and conductivity readings were taken at various locations in the mine:

No	Sample Description	pH	Cond. (mS/m)
S1	Seepage into Homestead Return Water Dam	7,10	414
S2	Klipspruit below Homestead Return Water Dam	4,04	243
S3	Flow into Homestead Return Water Dam	4,80	478
S4	Seepage at NW corner of Homestead Slimes Dam	5,8	535
S5	Pumpage from Homestead RWD to Diepkloof Return Water Dam	5,08	461
S6	Seepage on N edge of Homestead Slimes Dam	3,7	605
S7	Russel stream at Commando Road	5,2	166
S8	Penstock return from GMTS and seepage from GMTS	7,42	306
S9	Contents of Diepkloof Return Water Dam at Spillway	8,40	310
S10	Return water at GMTS	7,11	336
S11	GMTS catchment dam	6,9	346
S12	Inflow into GMTS catch dam	6,7	353
S13	Drainage along SW side of GMTS Slimes Dam	5,4	243
S14	Seepage from GMTS catchment dam	6	382
S15	Mooifontein Slimes Dam catchment dam	3,8	474
S16	Russel stream below Mooifontein Slimes Dam	5,5	170
S17	Seepage along N edge of Mooifontein Slimes Dam	3	881
S18	Seepage at NE corner of Mooifontein Slimes Dam	4,8	583
S19	Inflow to Mooifontein Return Water Dam (green)	3,8	474
S20	Inflow to Mooifontein Return Water Dam (clear)	10	332
S21	Contents of Mooifontein Return Water Dam	5,5	422
S22	Mooifontein penstock drainage into Return Water Dam	9,5	296
S23	Russel stream at Crownwood Road	7,82	127
S24	Overflow from Mooifontein Return Water Dam into Russel stream	7,6	319
S25	Russel stream at Crownwood Road	5,7	141
S26	Russel stream downstream & adjacent to B South dump	5,1	163
S27	Tributary to Russel stream on west side of 3L11	5,82	62
S28	Russel stream below 3L11	4,9	185
S29	Seepage from 3L11 into Russel stream	5,6	475
S30	Return water used at 3L11	6,5	316
S31	Stagnant pond on top of B North	3,3	476
S32	Stagnant pond on top of B North	2,3	1740
S33	Russel stream next to 3A9 dump	6,5	72
S34	Water in 3A9 Pit	6,98	58
S35	Inflow to catchment dam	2,8	304
S36	Overflow from catchment dam	5,4	197
S37	Klipriver Rd Cnr - top end of storm water canal	6,3	91
S38	Stormwater drain from Ophirton, Selby, etc.	6,6	78

Appendix A - List of pH and Conductivity readings taken during the site visit (Cont.)

No	Sample Description	pH	Cond. (mS/m)
S39	Stormwater drain from Turfontein	5,2	96
S40	Combined drain	5,7	95
S41	Russel stream at Crownwood Bridge	5	155
S42	Stormwater drain from Ormonde	6	55
S43	Russel stream below plant	4.9	155
S44	Seepage from catchment dam	8	262
S45	Seepage from catchment dam	7,7	249
S46	Combined seepage to Russel stream	2,8	919
S47	Seepage stream at inlet to Russel stream	4	415
S48	Concrete sump below catchment dam	3	328

Appendix B - List of photographs taken during the site visit

During the site visit the following photographs were taken at various locations on the mine:

Photograph No.	Photo Subject Description
1	Seepage channel into Homestead Return Water Dam
2	Klipspruit below Homestead Return Water Dam
3	Icicles in Klipspruit below Homestead Return Water Dam
4	Inflow into Homestead Return Water Dam from Southern edge
5	Membrane in Homestead slimes dam
6	Discharge from pumped Homestead Return Water Dam to Diepkloof
7	Northern edge of Homestead Slimes Dam
8	Russel stream at "Commando Road"
9	GMTS penstock and seepage into Diepkloof RWD
10	Spillway from Diepkloof RWD
11	New filter drains on GMTS slimes dams
12	Connection between GMTS catchment dams
13	Drainage along SW side of GMTS Slimes Dam
14	Seepage from GMTS catchment dam
15	View to dumpsite along Russel stream from Mooifontein Slimes dam
16	Russel stream below Mooifontein Slimes Dam
17	Seepage along N edge of Mooifontein Slimes Dam
18	Breakaway on N edge of Mooifontein Slimes Dam - note fresh slime coming through
19	Mooifontein Return Water Dam
20	Russel stream upstream of Mooifontein Return Water Dam inflow
21	Outflow from Mooifontein Return Water Dam into Russel stream
22	Russel stream at Crownwood Road
23	B South Tank Farm
24	B South reclamation operations
25	Russel stream downstream of B South dump
26	Tributary to west of 3L11 to Russel stream
27	Aerial view of reclamation site from top of 3L11
28	Monitoring of B North sand dump
29	Monitoring of B North sand dump
30	Monitoring of B North sand dump
31	Screens on B North
32	Russel stream next to reclaimed 3A9 dump
33	Salts on side wall of 3A9 Pit
34	Water in 3A9 Pit
35	Discharge channel for water in 3A9 Pit

Appendix B - List of photographs taken during the site visit (cont.)

Photograph No.	Photo Subject Description
36	Screens on sand feed
37	Thickeners on cyclone O/F
38	Thickeners on cyclone O/F
39	RWB tank & CN tanks
40	Catchment dam for all water tanks
41	Water Treatment Plant
42	Empty Thickener
43	40m Thickener
44	Perimeter drains feeding to catchment dam
45	Inflow to catchment dam
46	Downstream of catchment dams
47	Stormwater tributary from Ophirton, Selby & Fordsburg
48	Stormwater tributary from Turfontein West & Booysens
49	Stormwater tributary from Ormonde
50	Channel from catchment area below plant into Russel stream
51	Seepage from dump/plant area into stormwater drain
52	Seepage through catchment dam
53	Seepage through catchment dam
54	Combined seepage to Russel stream
55	Concrete sump below catchment dam
56	Signboard below catchment dam

Report on Transvaal Gold Mining Estates Ltd Site Visit.

21 - 22 July 1994

1. GENERAL INFORMATION

Name of mine	Transvaal Gold Mining Estates Ltd (TGME)
Name and position of person(s) interviewed	Messrs J Steele - Mine Manager C van Jaarsveld - Engineer L Pohl - Laboratory Superintendent P Gillot - Metallurgist
Nearest town	Pilgrims Rest
Name of catchment	Blyde River flowing from south to north towards the Olifants River
Monthly tonnes milled	12 000 tonnes per month
Monthly waste rock dumped	30 000 tonnes per month
Monthly gold production	26 - 27 kg/month
Current age of mine	TGME was registered in 1895. Reprocessing of sand, slime and rock re-commenced in 1986 after a 14 year period of no mining activity.
Expected remaining life of mine	2 years for surface operations and 40 years for underground operations
Ore treated in metallurgical plant	Reclaiming and processing old rock and sand dumps. Investigating the possibility to commence underground operations.
Type of mining carried out and transport mode of ore to plant	Mechanical loading and screening of old sand and rock dumps on site, before the fine material is transported to the plant by road trucks.
Has an EMPR already been produced by the mine?	Yes, draft report

2. SITE VISIT PROGRAMME

2.1 Day 1 - 21 July 1994

- Arrival at TGME offices
- Short discussion on project background, objectives and site visit programme
- Present:
  J Steele - Mine Manager

P Gillot - Metallurgist
J Laas - PHD
D Howie - PHD

- Guided tour of the mine surface area which entailed a visit to the screening plant at the reclamation site, the slimes dam and return water dam areas and the various water monitoring points along the Blyde River, Peachtree and Clewer Creek streams.

2.2 Day 2 - 22 July 1994

- Completion of the mine surface area tour by visiting the metallurgical plant, sand dump reclamation area, east of the caravan park and the area south of the park, where rehabilitation is in progress.

- Discussion with the mine manager, Mr J Steele on water management systems and completion of questionnaire.

3. DISCUSSION OF THE MINE'S CURRENT WATER MANAGEMENT AND TREATMENT PRACTICES.

3.1 GENERAL DESCRIPTION AND BACKGROUND OF MINE'S OPERATIONS

TGME is situated approximately 2 km southwest of the historical small gold town called Pilgrim's Rest in the Eastern Transvaal. The present operation was designed to retreat waste rock dumps, sand dumps and slimes dams which arose from TGME's previous mining activities.

The site is situated in a historical mining area surrounded by scenic mountains. The Blyde River flows from south to north through the mining area and various mountain streams flow into the Blyde River. One of these streams, the Peachtree Creek stream, flows near to the Beta Dump Area before it reaches the Blyde River.

Approximately 80 people are employed in the whole operation. No housing or recreation facilities are provided on site due to a TPA decision not to allow mine workers to live in Pilgrim's Rest by not allowing the construction of new houses. Contractors have housed themselves next to the Beta Dump in temporary shacks. Skilled employees are housed in Graskop and semi skilled labourers own houses in the Dienkie Township, 40km north of Pilgrims Rest.

The mineral processing operation consists mainly of the following:

- Screening of the Beta rock dump on site by a contractor.
- The -8 mm (economically viable) size fraction is transported by road trucks to the plant.
- Reef picking is done on the -100 mm + 25 mm size fraction.

- The +100 mm and -25 + mm fractions are discarded on a new waste rock dump on site.
- The reduction plant consists primarily of a milling and a carbon in leach section whilst loaded carbon is treated at the City Deep Gold Plant in Johannesburg.
- Plant residue is deposited on the slimes dam, north of the reduction plant.

3.2 DESCRIPTION OF THE MINE'S WATER RETICULATION SYSTEM

The mine operations, in terms of water management, can be divided into the following areas:

- Metallurgical plant, mine offices and workshop area
- Slimes dam and return water/evaporation dams
- Screening plant and waste rock dump areas

Figure 1 shows the water reticulation system for the dump processing and metallurgical operation.

Two water sources supply these circuits, i.e., the Blyde River which is the main source at 800m^3/d and the Peachtree stream at 100m^3/d.

Water is pumped from the Blyde River up to the water reservoir which supplies the plant area, workshops and offices, toilets and change house with potable water. When required, water from the Blyde River is also pumped to the plant water tank and gland service tank, from where it is utilised in the metallurgical process. This water circuit also includes the plant residue which is pumped to the slimes dam at a relative slurry density of 1,45, which includes approximately 700m^3/d of water. Water is decanted from the slimes dam through the penstock to the return water dams and then pumped back to the plant.

Figure 1 also shows the water reticulation system for the screening plant. Water is pumped from the Peachtree Creek stream at a rate of 100m^3/d into a holding pond. This water is primarily used for spray water in the screening process. Runoff water from the screening sections is collected in a settling pond which can overflow into the holding pond.

No sewage plant is used on site as the number of people employed in the operation does not justify one. The toilets are served by a septic tank and the effluent runs off into a soak pit.

Water from the Blyde River is pumped to a closed reservoir and distributed for potable use, in the plant, offices and workshops.

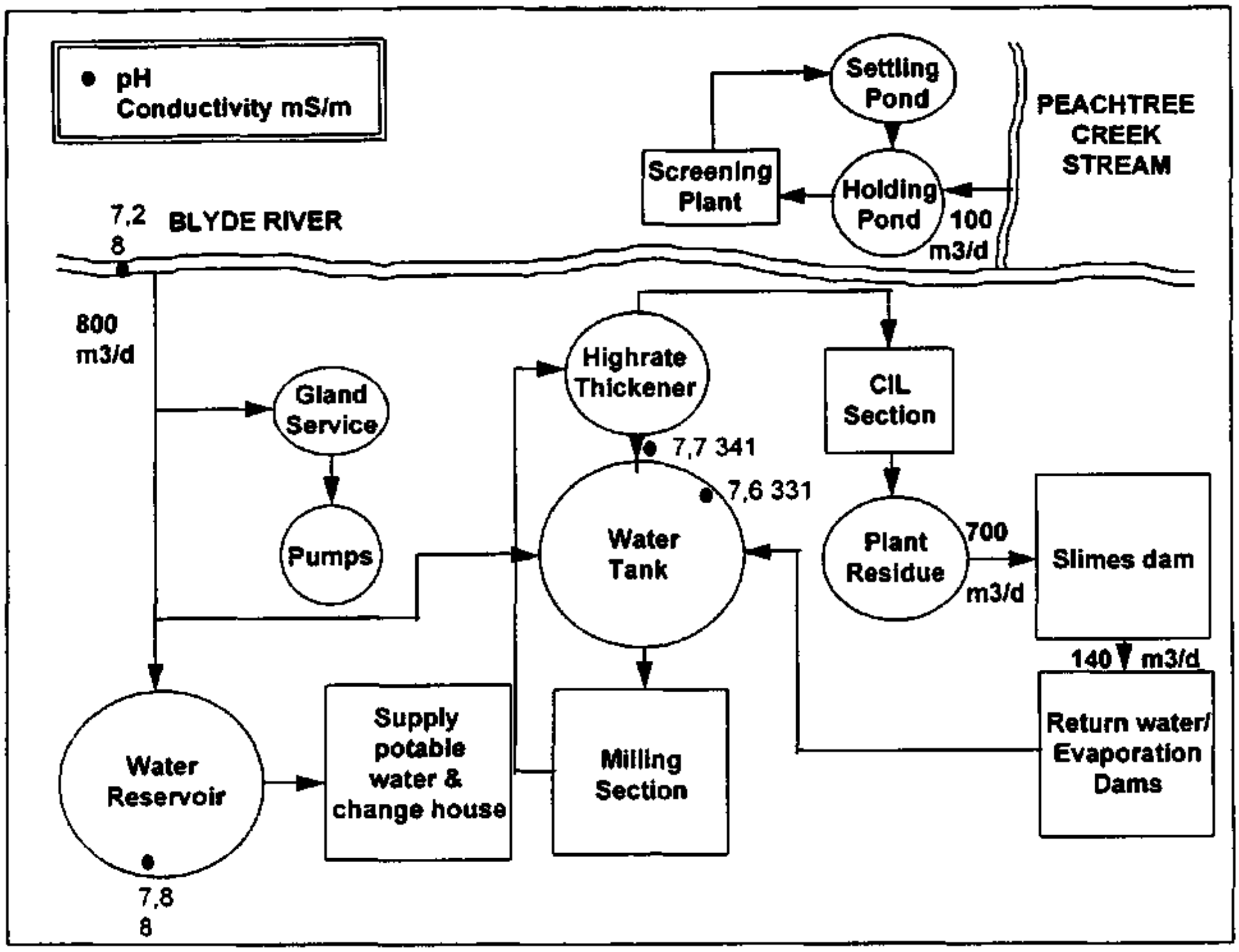


Figure 1 : Water reticulation system for the rock dump processing and metallurgical operation.

3.3 DESCRIPTION OF WATER MANAGEMENT

3.3.1 Plant, workshop and office area

Water from the Blyde River is pumped to the plant storage tank as makeup water for the metallurgical process. Overflow from the high rate thickener returns to the water storage tank for reuse in the process circuit. Water from the slimes dam return water dam can also be pumped backed to the plant storage tank.

All plant spillages and runoff flow to a spillage collection pond on the southwestern side of the plant. This pond consists of an earthwall berm with a spillway, in case of overtopping. The water may be pumped back to the plant or be left to evaporate. Below this spillage collection pond an extra earthwall is under construction to capture and control excess water overtopping the first pond.

Stormwater falling on the plant area can be contaminated and is contained within the plant spillage pond. Clean stormwater runoff is diverted around the plant area by means of two stormwater diversions. The main diversion is on the eastern side of the plant and diverts clean water around the plant into a southern direction. A smaller stormwater diversion serves the same purpose on the southern side of the plant area. All clean stormwater runoff eventually flows into the Blyde River on the western side of the plant.

3.3.2 Slimes and return water dams

Plant residue is deposited at a rate of approximately 13 000 tonnes/month onto a slimes dam situated on the northern side of the plant. An average dry density of 1450 kg/m^3 is currently deposited, i.e., 700 m^3/d of water. The slimes dam was designed for a deposition rate of 20 000 tonnes/month.

A cutoff trench located on the outer perimeter of the slimes dam intercepts seepage water from the under drainage system, decant penstocks and paddock drains. This trench in turn discharges water into a lined return water dam. All other effluent and storm water runoff from the slimes dam area are collected in the return water dam situated below the slimes dam on the north western corner. The return water dam is lined and has two compartments, each connected to a pump system to return the water to the plant for reuse.

Six boreholes to the north of the slimes dam have been drilled for groundwater monitoring, which have so far been mostly dry.

It is estimated that approximately 20% of the water deposited with the plant residue on the slimes dam eventually ends up in the return water dam. Presently this means 140 m^3/d. The remainder of the water is lost due to evaporation, interstitial and seepage into groundwater. The return water dams have more than enough holding capacity for the current operation and no seepage through the dam wall was observed.

The return water dams are also used to retain rainwater from the top area and sides of the slimes dam, thus preventing it from reaching and polluting the Blyde River. Cutoff trenches, uphill of the slimes dam, have been provided to divert unpolluted storm water runoff from reaching the slimes dam. The return water dams have been sealed with bitumen.

3.3.3 Screening plant

Various old rock dumps on the western side of the Blyde River are currently being reprocessed, the Beta and Peachtree Dumps, in particular. These rock dumps are reprocessed by screening the coarse material on site. The waste rock, which is the oversize from the screening operation, forms one new dump on the old Beta dump site.

Clean stormwater runoff uphill of the new waste rock dump is diverted around the site by means of a trench, which ensures that the water does not pollute the Blyde River by running through the rock dump site before entering the Blyde River.

The fine material is transported with road trucks to the reduction plant.

Water for the screening plant is pumped from the Peachtree Creek stream into a holding pond on site at a rate of 100 m^3/d. The water is then used in the screening process, primarily for spray water. All excess water runs off into a settling dam where the fines settle out and all excess water flows into the holding pond for recirculation through the screening plant.

3.4 WATER MANAGEMENT STRUCTURE

The water management structure for the surface reclamation operation comprises the mine manager, responsible for the whole operation, supported by the laboratory superintendent, responsible for taking the appropriate water samples and sending them to the contracted laboratory for analyses. The plant metallurgist is responsible for the residue depositing operation on the slimes dam.

The Mine manager also utilises the expertise of environmental consultants from the Environmental Management Department at Head Office who assist in the interpretation of water results and advise on the management and solution of environmental problems.

Meetings between the mine manager and the Environmental Management Department are scheduled on a quarterly basis.

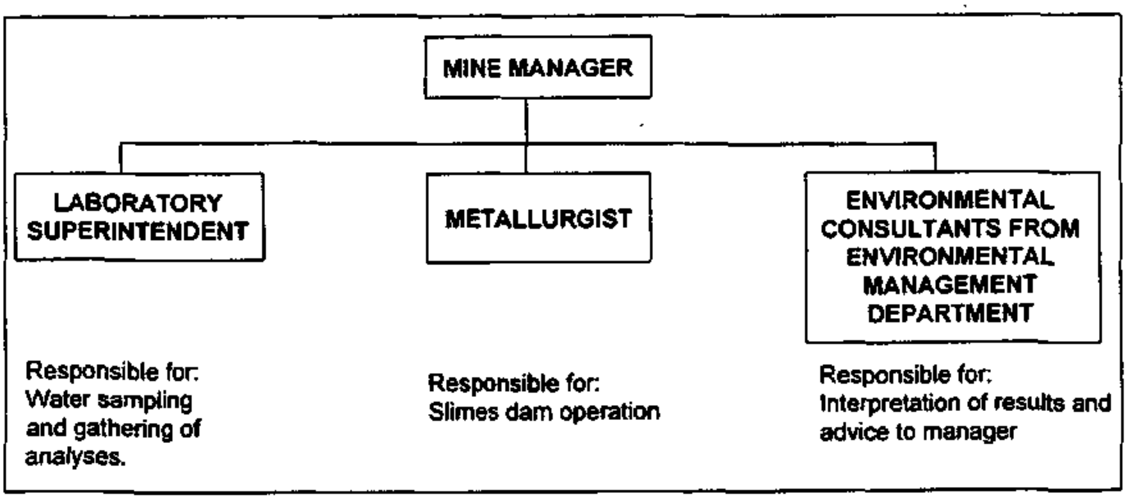


Figure 2 : The water and environmental management structure for TGME

3.5 NOVEL & UNIQUE WATER TREATMENT AND MANAGEMENT SYSTEMS

3.5.1 Slimes Dam

The slimes dam is situated against the eastern side of the valley which rises against a steep slope. The main access road to the plant and offices is along this high terrain which allows for easy monitoring of the top surface area and, consequently, easier management of the operation. Of benefit is that the pool size and general water courses on top of the slimes dam are easily observable.

Two small sinkholes were formed on dolomitic outcrops just after the slimes dam construction was started. These have been filled up with slimes and no further subsidence has been noted.

The reprocessing of different old waste rock and sand dumps makes the control of the relative density of the plant residue very difficult.

3.5.2 Water quality of Blyde River and downstream users

The water quality in the area is very good with the pH and electrical conductivity of the Blyde River measuring 7,2 and 8 mS/m on the day of the site visit.

The Parks Board's trout hatcheries are immediate downstream water users and the river is stocked every three months from the hatcheries. Downstream from the mine, trout fisherman make use of the whole Blyde River. Trout and other biological life in the river are very sensitive and thrive on a very good quality water.

3.5.3 General attitude towards environmental protection

In general an extremely positive attitude to conserve the environment was noted, particularly by mine management and the workforce. One of the mine's policies is to put money into a rehabilitation fund as part of it's working costs.

3.6 POTENTIAL WATER TREATMENT/MANAGEMENT PROBLEMS AND NEEDS

3.6.1 Metallurgical Plant

The biggest problem in terms of water management in the plant area is the use and condition of the plant spillage collection pond.

This pond is used on a daily basis for collection of all plant spillages, outside of bunded areas, including slurry. As a result thereof the pond is silted up and the holding capacity is very low. Part of the solids and water is monitored back into the plant on a daily basis but this cleaning procedure needs to be increased in preparation of the rainy season. A second precautionary step would be to minimise the spillages from the plant into the pond.

It is essential to empty the pond on a continuous basis to ensure 100% utility during the rainy season.

The plant storage tank water is very turbid which indicates that a high quantity of solids and suspended solids accumulate in the tank. The main contributor to the suspended solids content is the high rate thickener overflow.

Optimisation of the flocculant dosage and thickener performance could reduce the suspended solids concentration.

Old mill grease, discarded from maintaining the mills is currently being stored in 220 ℓ steel drums on site. Management are currently investigating possible reuse or disposal options. Their main concern is the prevention of pollution of the environment.

Potable water is pumped from the Blyde River and stored in a covered reservoir. During the site visit it was noted that the only treatment of the river water before usage was a disinfection by adding a few HTH pills in the reservoir on a fortnightly basis. The sand filter plant at the reservoir has not been in used for several months. This situation needs investigation and closer monitoring to ensure that the river water is always fit for human consumption.

pH and conductivity were measured at different points during the site visit and the base quality for the whole water circuit is that of the Blyde River water.

The following table shows the results obtained for the points measured in the plant area:

Point Measurement Taken	pH	Conductivity (mS/m)
Blyde River upstream of plant	7,2	8
Water Reservoir	7,8	8
High Rate Thickener overflow	7,7	341
Plant water tank	7,6	331
Plant Spillage pond	7,3	239

The results reflect a change in water quality due to the metallurgical process as the conductivity increases from 8 mS/m to 341 mS/m in the plant water circuit area.

3.6.2 Slimes Dam

The type of plant residue material changes from time to time due to the reprocessing of different types of old waste rock and sand dumps which makes the dam wall construction very difficult, especially where the relative pulp density is not constant.

A great deal of erosion occurs on the side slopes and a large amount of solids are washed down into the evaporation paddocks. The erosion can be controlled by establishing vegetation on the slopes.

During the site visit plant residue was deposited primarily on the southern and western sides in an attempt to improve the dam level and reduce the pool area respectively.

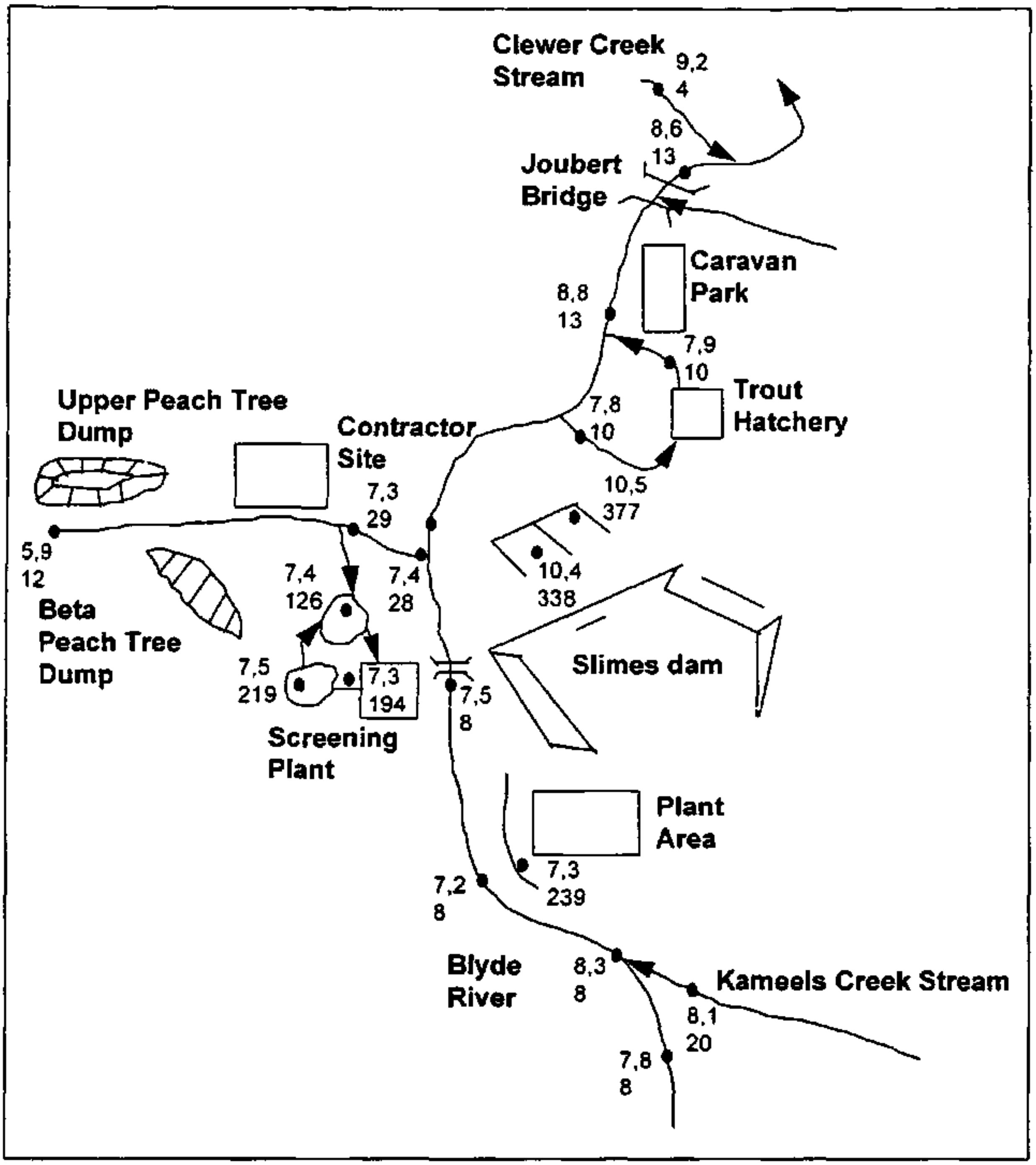


Figure 3 : Layout of the pH and conductivity readings taken during the site visit.

Although the slimes dam is designed to handle 20 000 tonnes per month, only 13 000 tonnes is currently being deposited and therefore the settling area is more than ample.

The slime was initially deposited behind the earthen starter wall whilst the dam was being constructed. At the time it was well vegetated including the evaporation toe paddocks. Currently, the grass is as high as 1.5m.

The pH and conductivity measured in the two return water dam compartments is reflected in the following table:

	pH	Conductivity (mS/m)
Eastern compartment	10,5	377
Western compartment	10,4	338

The above conductivity measurements are on par with the ranges measured in the plant but could increase if water is left in the dam to evaporate, which will result in increased salt concentration.

3.6.3 Screening plant at Beta rock dump

The screening plant has a potential pollution risk as water is pumped from the Peach Tree stream into the operation.

During the site visit a few points were monitored for pH and conductivity, the results of which are reflected in the following table as per the layout in Figure 3:

Point Measurement Taken	pH	Conductivity (mS/m)
Peach Tree Creek stream at upper dump	5,9	12
Peach Tree Creek stream below contractor site	7,3	29
Peach Tree Creek stream before entering Blyde River	7,4	28
Holding pond at Screening Plant	7,4	126
Return water launder from screens	7,3	194
Return/Settling Pond	7,5	219
Blyde River upstream of Met plant	7,3	8
Blyde River below screening plant upstream of Peach Creek stream	7,5	8
Blyde River downstream of Peach Tree Creek stream	7,5	9

These results indicate that virtually no surface water pollution occurs due to the screening operation. This is apparent by the quality of the water up and downstream of the screening plant site. The quality of the Peach Tree Creek stream causes the conductivity in the Blyde to increase from 8 to 9 mS/m. Although the conductivity of the stream is 28 mS/m before entering the river, this flowrate is very small in comparison with the river which causes an increase of 1 mS/m.

The pollution potential for the screening operation lays in the contamination of the groundwater through seepage from the two ponds into the ground. The water for the operation is supplied from the stream at a rate of 100 m^3/day of which a small portion is lost in moisture content in the fines transported to the plant. The remainder is lost through seepage into the groundwater and evaporation.

The conductivity of the water pumped from the stream is 29 mS/m. It increases to 126 mS/m in the holding pond and to 194 mS/m runoff from the screens. Once it reaches the settling pond it further increases to 219 mS/m.

Options on preventing the water loss into the groundwater need to be explored. Another factor to be considered is the gold content of the fines in the runoff from the screens which is left to settle in the pond and the possible recovery of gold in the metallurgical plant. Another possibility would be the lining of the two existing ponds.

The second potential source of environmental pollution could be attributed to the contractor's labourers who are accommodated at the site where no ablution facilities are available. Mechanised maintenance on site, loaders and trucks are all potential pollutants due to oil spillages on site.

The Peach Tree Creek stream has the poorest water quality in the whole mining area due to it flowing through all the old rock dams and mining sites in the valley. In some areas the stream flows into a cement channel to prevent contact with the old rock dumps and to control the direction of the flow. Measurement indicated that the conductivity increased from 12 mS/m to 29 mS/m before reaching the Blyde River by flowing through and making contact with the old rock dump.

3.6.4 Other Areas

3.6.4.1 Kameels Creek Area

Upstream of the TGME operation the Kameels Creek stream joins the Blyde River. The pH and conductivity of the Kameels Creek stream were measured as 8,1 and 20 mS/m. This stream has, due to the small flowrate, very little influence on the water quality of the Blyde River. The conductivity of the Blyde River measured 8 mS/m up and downstream of the confluence.

3.6.4.2 Parks Board's Fish Hatcheries

pH and conductivity measurements of the stream entering and leaving the trout hatcheries did not vary. Comparisons with the last readings taken upstream indicated no deviations.

3.6.4.3 Dump No. 3 - Surrounding Area

This dump had already been removed and the area is currently being filled and dressed with topsoil. During the site visit a white precipitate of salts could be observed around the area and these salts are a possible pollutant source to the river in the area. This could be the reason for the increase of conductivity of the Blyde River water from 9 to 13 mS/m between the Peach Tree Creek stream and downstream of No.3 dump area. The conductivity remained constant at 13 mS/m all the way downstream to Joubert Bridge.

Appendix A - List of pH and conductivity readings taken during the Site Visit

During the site visit, a number of pH and conductivity readings were taken at various locations on the mine.

No	Monitoring Point Description	pH	Cond. (mS/m)
S1	Blyde River upstream of met plant	7,2	8
S2	Plant spillage pond	7,3	239
S3	Blyde River below screening plant upstream of Peach Tree Creek	7,5	8
S4	Peach Tree Creek stream before entering Blyde River	7,4	28
S5	Blyde River downstream of Peach Tree Creek stream	7,5	9
S6	Holding pond at screening plant	7,4	126
S7	Return water and runoff from screening plant	7,3	194
S8	Return settling pond at screening plant	7,5	219
S9	Western compartment of Return water dam	10,4	338
S10	Western compartment of Return water dam	10,5	377
S11	Eastern compartment of Return water dam	7,9	10
S12	Blyde River at south of Caravan park	8,8	13
S13	Blyde River at Joubert Bridge	8,6	13
S14	Clewer Creek at golf course	9,2	4
S15	Water reservoir	7,8	8
S16	Plant water tank	7,6	331
S17	High rate thickener overflow	7,7	341
S18	Blyde River downstream of Clewer Creek	8,3	8
S19	Clewer Creek stream	8,1	20
S20	Blyde River upstream of Clewer Creek	7,8	8
S21	Blyde River water damming on NE side of old slimes dam	7,8	22
S22	Blyde River to Trout Hatcheries	7,8	10
S23	Water from pipe feeding Trout Hatcheries	7,8	10
S24	Peach Tree Creek stream at upper dump	5,9	12
S25	Peach Tree Creek before confluence with Peach Tree Creek	5,8	25
S26	Blyde River after confluence with Peach Tree Creek	6,0	9
S27	Peach Tree Creek stream below contractor site	7,3	29

Appendix B - List of Photographs

During the site visit, a number of photographs were taken at various locations on the mine.

Photograph No	Photo Subject Description
1	Blyde River point from where water is pumped to mine
2	Earth wall to contain overtopping of collection pond
3	Collection pond for plant spillages
4	Monitoring of slime from spillage pond back to plant
5	Met plant showing CIL section
6	Met plant area showing the slope of area for runoff
7	Plant water tank
8	High water thickener overflow
9	Flocculant make up
10	Old mill grease storage area
11	Manual press filter
12	Top of CIL tank
13	Linear screen removing wood chips
14	Fines dump onto belt at bottom of stock pile
15	Water reservoir for plant offices and workshop supply
16	Slimes dam as seen from plant
17	View of slimes dam from access road to plant
18	Slimes deposited in daywall paddock
19	Refuse disposal site at slimes dam
20	Shovel and packing of paddock walls
21	Water decantation from daywall paddock
22	Operating penstock and catwalk
23	Step in paddock penstock
24	Return water dam with two compartments
25	Return water dam
26	Stormwater from slimes dam area inlet to return water dam
27	Inside return water dam
28	Stepping of sides with daywall building, showing rat holes
29	Erosion of sides and salts precipitating
30	Stepin paddock silted up very small freeboard
31	Northern side of slimes dam wall
32	Established vegetation of original earthwall
33	Toe paddock inside covered with vegetation
34	Blyde River showing waste rock dump at screening plant
35	Beta dump seen from the slimes dam
36	Holding sand from Peach Tree Creek water at screening plant
37	Settling pond overflows into holding pond
38	Reef picking at waste rock dump
39	Runoff from screening plant
40	Course screening
41	Course screening
42	Fine screening
43	Screened product for plant ready for transportation
44	Access road to screen plant is sprayed regularly for dust suppression

Appendix B - List of Photographs - continued

45	Upper Peach Tree dump not open
46	Part of dump removed in Peach Tree Valley
47	Peach tree stream flowing in cement channel
48	Blyde River water in lower areas upstream of Trout Hatcheries
49	Salts precipitated in area south of Caravan park
50	Salts precipitated in area south of Caravan park
51	Sand and rock removal from area east of Caravan park
52	Joubert Bridge

Report on Western Areas Gold Mining Co. Ltd Site Visit.

2 - 4 August 1994

1. GENERAL INFORMATION

Name of mine	Western Areas Gold Mining Co. Ltd
Name and position of person(s) interviewed	Messrs P Gentz - Manager, Geology Dewatering M van Rooyen -Sectional Environmental Officer
Nearest town	Westonaria
Name of catchment	Leeuspruit flows from north to south through the mining area and Kleinwesrietspruit flows in an easterly direction. Both these streams originate on the northern section of the mine and the flow in these two streams is largely due to the dewatering flow which is pumped from underground and discharged into the streams.
Monthly tonnages milled	North Mine : 90 000 tonnes per month South Mine : 120 000 tonnes per month
Monthly gold production	North Mine : 400 kg/month South Mine : 1100 kg/month The North Mine also produces uranium in the form of ADU (Ammonium diuranate) and the monthly production is 24 tonnes per month
Current age of mine	34 years
Expected remaining life of mine	25 years
Reef being mined and stope width	VCR 1,42m Upper Elsburg from 2,7 to 3,5m Middle Elsburg 2,2m
Mining Method	Scattered and mechanised mining
Has an EMPR already been produced by the mine ?	Yes, draft report was submitted and approval is awaited

2. SITE VISIT PROGRAMME

2.1 Day 1 - 2 August 1994

- Arrival at North Mine Shaft at Geology Dewatering Department
- Short discussion on project background and site visit programme

- Present at meeting:
  Mr P Gentz - Manager, Geology Dewatering
  Mr van Rooyen - Sectional Environmental Officer
  Mr Laas - PHD
  Mr Howie - PHD
- Guided tour of the Metallurgical plant of North Shaft and discussion of Metallurgical Plant water circuits with Mr J Fisher, Plant Manager, and Miss M Pienaar, Plant Metallurgist.
- Guided tour of the Peter Wright Dam area, the discharge of underground water into *Kleinwesrietspruit and the artificial recharge* of the Gemsbokfontein eastern compartment.
- A visit to the North Shaft Tailings Dam and North Shaft Sewage Plant.

2.2 Day 2 - 3 August 1994

- Arrival at North Shaft Environmental and Health Department
- Underground visit to a working stope at 38 level and the settlers on 41 level guided by Mr M van Rooyen
- Discussion of mine water circuits and completion of the relevant sections of the questionnaire

2.3 Day 3 - 4 August 1994

- Arrival at North Shaft geology dewatering department
- Guided tour of Leeuspruit catchment area from the North Shaft to the South Shaft
- Visit to South Shaft tailings dams, cascades dams and the area where shaft sinking of South Deep Mine is in process
- The mine visit was completed with a visit to the South Mine sewage works
- Discussion on water management systems and completion of the questionnaire with the following parties:
- P Gentz - Manager, Geology Dewatering
- M van Rooyen - Sectional Environmental Officer

3. DISCUSSION OF MINE'S CURRENT WATER MANAGEMENT AND TREATMENT PRACTICES

3.1 DESCRIPTION OF MINE WATER CIRCUITS

The mine operations are divided into two main activities at the north and south mines, with the shaft sinking for the new South Deep Mine Shaft in progress. Each mine operation, in terms of the water management, is subdivided according to the following activity areas:

- Slimes dam area
- Waste rock dump area
- Sewage plant area
- Metallurgical plant

- Shaft offices
- Engineering workshops
- Hostels
- Underground water reticulation systems

3.1.1 Natural water courses and catchments

The Wonderfonteinspruit runs through the northern section of the mining lease area of the Gemsbokfontein western subcompartment. The Donaldson Dam in the same compartment forms part of the Wonderfonteinspruit. The area south of the Gatsrand range drains into the Kleinwesrietspruit and Leeuspruit and eventually discharges into the Groot Rietspruit which is a tributary of the Vaal River.

Very little natural water enters the mine surface freehold area. The flow in these streams is mainly due to the water which is discharged from underground. These are large volumes and the water is of fairly good quality in terms of the requirements of the downstream users.

The north mine, in terms of surface water, consists of the Peter Wright dam, situated northeast of the Shaft and metallurgical plant. The Peter Wright dam can overflow into the Kleinwesrietspruit. The source of the Kleinwesrietspruit lies at the Peter Wright dam and the stream flows in an easterly direction. Underground water is pumped to surface in order to dewater the mine and prevent the flooding of the mining areas.

Presently, 235 Mℓ/month is diverted around the Peter Wright Dam and discharged directly into the Kleinwesrietspruit.

Water is discharged into the Leeuspruit, via an artificial furrow, at a point south west of the hostels. It flows south, past South mines, shaft, gold plant and tailings dams. As with the Kleinwesrietspruit, the base flow of this stream, is the water pumped from underground.

The Leeuspruit also has two small tributaries on the south mine, one enters the Leeuspruit from a northwesterly direction, upstream of the south mine, and the other, also from a northwesterly direction, downstream of the tailings dams. Both the tributaries are dry during the winter season and will only flow after a rain event. There are no upstream users or operations that could affect the water quality of these streams .

Water from the Leeuspruit and Kleinwesrietspruit, is used primarily by farmers for livestock watering and crop irrigation downstream of WAGM property. The water authority for this region is the Department of Water Affairs and Forestry, Highveld Region.

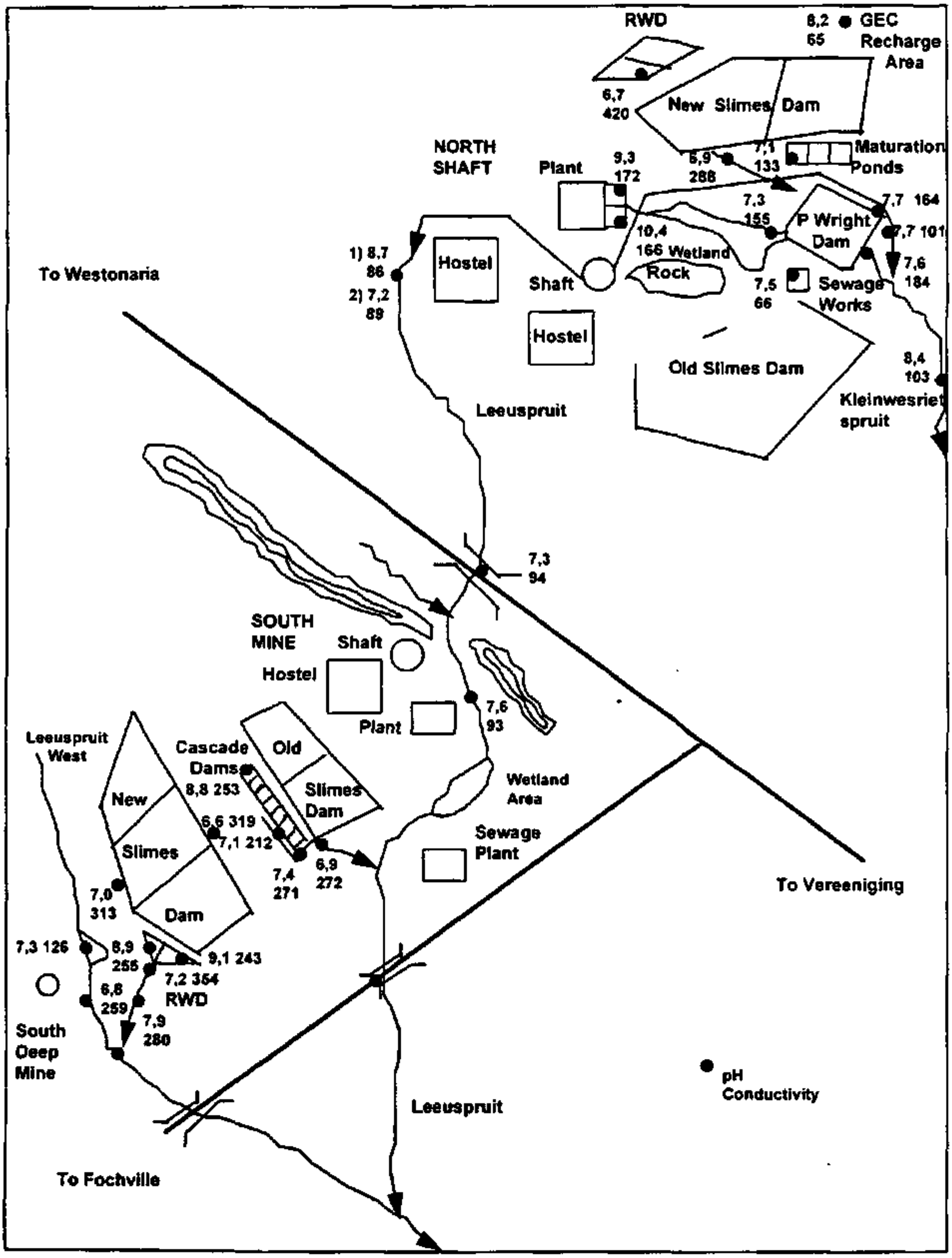


Figure 1 : WAGM surface layout showing the North and South Mines

The depth of the water table over the vast area of the WAGM property is assumed to vary significantly due to the dolomitic nature of the ground. The depth in the southern section indicates a water table varying from 17 to 60m, whilst at the north mine the water table could be between 35 and 65m. The groundwater zone underlying the freehold area includes Gemsbokfontein and a portion of the Zuurbekom compartments.

Surface water and pipeline systems are monitored closely in order to detect leaks and spillages early. These are repaired immediately as there is a danger of sinkhole formation.

3.2 DESCRIPTION OF WATER TREATMENT/MANAGEMENT SYSTEMS

3.2.1 North Shaft dewatering scheme

Dewatering of the Gemsbokfontein compartment via the north shaft is one of the major water management problems experienced at the north shaft. During July 1994, 66,1 Mℓ/day was pumped from underground. This is comprised of an underground water usage of 5,8 Mℓ/day (9%) and 49,3 Mℓ /day (75%) compartment dewatering. Artificial recharge of Gemsbokfontein eastern compartment amounts to 11,0 Mℓ/day or 16% of the total water volume pumped from underground.

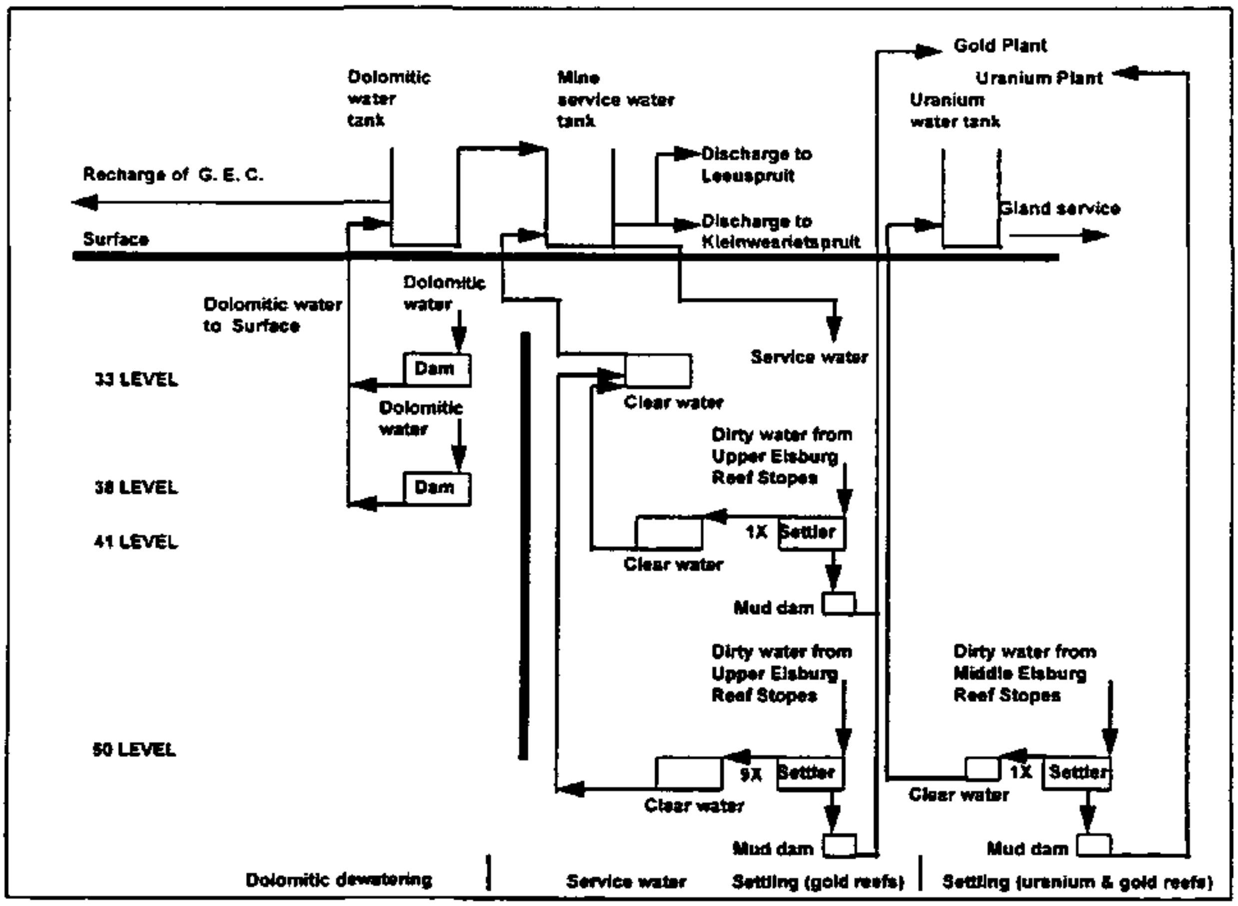


Figure 2 : North Shaft dewatering operation for dolomitic water, service water and settling systems.

The 49,3 Mℓ/day of water pumped out of the compartment is discharged to the Kleinwesrietspruit and the Leeuspruit as follows:

Kleinwesrietspruit - 7,9 Mℓ/day (16%)
Leeuspruit - 41,4 Mℓ/day (84 %).

Table 1 below gives the distribution of water in megalitres for north shaft for the period of July 1994.

Water Pumped	Water Usage - Metered							Water out of comp - Metered					
Type of water	To Surface	Plant	Cementation	PETER WRIGHT Dam	S/D	Tank	Tot Use	Kleinwes Rietspruit	Leeu spruit	Tot Out	Irrigation	Recharge G.E.C	Metered Grand Total
Uranium 50 Level	27.1	17.7		59.6			77						77.3
Dolomitic 41Level	623.9					12	12						12.2
Dolomitic 33 Level	301.6											329.4	329.4
Clear Water 41 Level Clear Water 33Level	212.3 796.6		50.0				50	235	1242	1478			1526
Sludge	35.8				35		35						
Total	1997	17.7	50.0	59.6	35	12		235	1242	1478		329.4	
Average per day (30 days)	66.6 100%	0.59 10%	1.67 28%	1.99 34%	1.1 20 %	0.4 7%	5.8 9%	7.86 16%	41.41 84%	49.27 75%	5.18	10.98 16%	
PETER WRIGHT Dam inflow				22.8									
Sewage											155		

Table 1 : North shaft water distribution for July 1994

The water usage of 5,84 Mℓ/day is divided as follows:

Plant Usage - 0,59 Mℓ/day (10,1%)
Sedimentation - 1,67 Mℓ/day (28,6%)
Peter Wright Dam - 1,99 Mℓ/day (34,1%)
Slimes Dam - 1,19 Mℓ/day (20,4%)
Ridge Tank - 0,41 Mℓ/day (7%)

The north shaft sewage plant also discharges 5,18 Mℓ/day to the maturation ponds on the southern side of the new slimes dam. This water is then used by the adjacent farmer, for irrigating of instant lawn crops. This is a substitute for the groundwater lost through shaft dewatering. All the sewage water is therefore used to irrigate the cultivated instant lawn.

In addition, 11 Mℓ/day is used to recharge the Gemsbokfontein eastern subcompartment.

3.2.2 Slimes dams / tailings dams

3.2.2.1 North Shaft

The north shaft operates one tailings dam which deposits the 120 000 tonnes/month of slurry processed by the gold and uranium plants. A portion of the plant residue is treated in the backfill plant to produce backfill material and is then pumped to Cooke 3 shaft (REGM) for backfilling underground. A second tailings dam is no longer in use.

A return water dam for the north shaft slimes dam collects the decanted water from the penstock. This is then pumped back to the metallurgical plant. The slimes dam seepage is collected in the cutoff trenches and a portion of this water is diverted to the return water dam. The remainder flows by gravity to the Peter Wright dam.

The tailings dam to the south of Peter Wright dam is no longer in use, but there is some runoff from rain which is directed towards evaporation ponds or to the Peter Wright Dam.

3.2.2.2 South Mine

The South Mine also operates one slimes dam complex, which consists of 3 different compartments. There is another slimes dam complex which is only used intermittently for surface wetting and dust suppression. Water from the slimes dam is directed towards a series of cascade dams, which are situated on the southwestern side of the old tailings dam. The new tailings dam also has a return water dam, situated on the southwestern corner of the tailings dam. This return water dam consists of two compartments. A small sump, below the return water dam wall, collects all seepage through the dam wall and this is then pumped back into return water dam. These return water dams collect any seepage and the remainder of the penstock return water.

The function of the cascade dams is to provide residence time in an attempt to lower the cyanide concentration levels of the penstock return water. The last one overflows into a trench which joins the treated sewage effluent from the south sewage plant. It then joins the water which is discharged into the Leeuspruit from the north shaft and the combined flow then leaves the mine lease area. It is planned to alter this arrangement and the return water will then be rerouted to the plant.

A system of catchment paddocks around the base of the slimes dams retains stormwater runoff as well as any slime spillages. Water evaporates from the paddocks and solids are removed for building up the side walls, in order to maintain the required freeboard.

The slimes dam has cutoff trenches around the paddocks which control seepage from the slimes dam area. The seepage from these trenches flows to the return water dams to be pumped to other evaporation areas. None of the slimes dams have any underdrains for phreatic surface control.

3.2.3 Waste rock areas

Both the south and north mines have their own waste rock dumps. At the north shaft, the waste rock dump is situated southeast of the metallurgical plants and all seepage and runoff from this area discharges into the Peter Wright Dam. Waste rock from the dump at the south mine, situated east of the metallurgical plant and shaft area, is reprocessed by Prop Crushers. These contractors are responsible for their own water management and EMPR. Both rock dump areas have no paddocks or seepage trenches. All stormwater runoff and seepage from the rock dumps flows from the rock dump areas at north shaft in the direction of the Peter Wright Dam at the south mine and ends up in the Leeuspruit.

3.2.4 Sewage treatment plants

Both the north and south mines operate their own sewage treatment plants. The design capacity of each plant allows for the treatment of 6,0 Mℓ of raw sewage per day.

The raw sewage is treated by the activated sludge process and the clarified effluent is disinfected and pumped from the plant, a few kilometres north to a series of maturation ponds, which are situated at the southeast corner of the operating new slimes dam. The overflow from the maturation ponds is then pumped to an instant lawn farm on the northern side of the new slimes dam. This arrangement serves to replace the suspected loss of ground water by the farmer due to the dewatering of the Gemsbokfontein compartment. Figure 3 shows the schematic outlay of the north mine sewage plant.

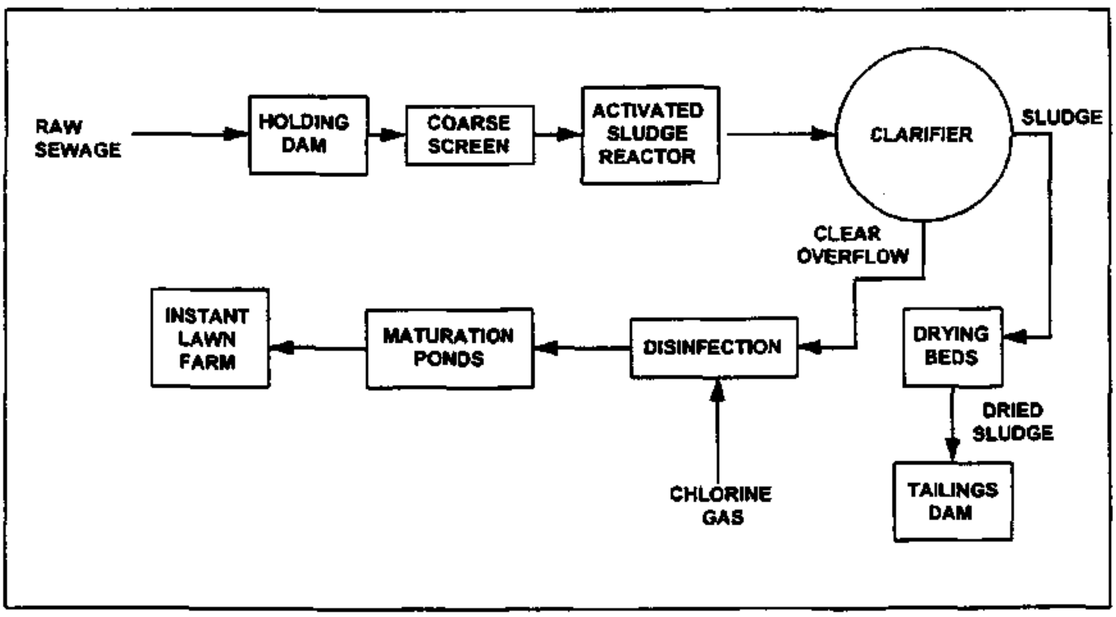


Figure 3 : North shaft sewage plant schematic layout.

The dried sludge from both sewage plants is deposited on the tailings dams. The final effluent from the south sewage plant is approximately 21 Mℓ/month compared to the flow from the north sewage plant which is approximately 193 Mℓ/month. Chlorine gas is dosed at the north plant for disinfection of the clarified sewage at a rate of 800 g/hour which translates to a cost of approximately R3/hour.

3.2.5 Metallurgical plant, shaft, offices and hostel areas

The north shaft metallurgical plant combines gold and uranium recovery sections. All internal spillages are isolated in containment structures and returned to the specific metallurgical process to recover any valuable content. Stormwater runoff from these areas is directed towards a settling pond at the eastern side, and lowest point, of the plant area. Water is returned from this pond as makeup for the gold extraction process. Occasionally the pond overflows and water is then released into the Peter Wright Dam.

All other spillages and stormwater runoff from the shaft area, offices and hostel areas are directed via stormwater drains and trenches to the Peter Wright Dam.

A large attenuation dam will be built shortly, to collect all the plant contaminated spillages and overflow from the "swimming pool" dam. This will reduce the pollution of the Peter Wright Dam. Plant management is currently undertaking desktop studies to determine the size and possible location of the attenuation dam.

3.2.6 Underground water reticulation system

During the site visit the north shaft underground workings were visited including the settlers on 41 level and a working stope on 38 level. Figure 2 shows the basic underground water reticulation system for North Shaft. As per the north shaft water distribution, the main components of this water system is the water pumped from underground for discharging into Leeuspruit and Kleinwesrietspruit and the artificial recharge of the Gemsbokfontein eastern compartment.

Fissure water, to be pumped to surface, is retained in two dams on 33 and 41 level. It is delivered to a holding dam on surface. Groundwater is then distributed for recharging. Two settler systems are operated in the water reticulation system, one on 41 level and a range of 10 settlers on 50 level.

The clarified water from the settler systems is pumped up to 33 level into a dam and pumped to a tank on surface from where water is discharged into the Leeuspruit and Kleinwesrietspruit. A uranium settler at 50 level settles dirty water containing uranium and gold runoff from the middle Elsburg reef. The overflow from this settler is pumped directly to a tank in the uranium plant, called the uranium or yellow tank, which is then used for gland service water in the plant. Dirty water from the upper Elsburg reef working stopes is treated in 8 settlers on 50 level and the clarified water is then pumped together with the clarified water from the settler on 41 level to the dam on 33 level.

Due to the low temperatures at north shaft, no fridge plant is required to cool the water before use in underground mining activities. Rand Water supply the potable water to various underground locations in a separate circuit.

3.2.7 Underground settlers

During the site visit the settler installation on 41 level was visited. This is a single settler installation consisting of various rectangular cells. All the dirty water is collected in a dirty launder. This is a well designed system with a very long dirty water launder, approximately 50 meters long and a depth of 1,2 meters with various gate valves to control the flow. Dirty water gravitates into the settlers and a flocculant solution is made up in two 1m³ tanks, one of which is always available for usage. The first flocculant addition point occurs at a high flowrate section of the main launder, where flash mixing can occur.

The dirty water launder splits and a second flocculant addition is done on either side of each individual launder for final flocculation before settling.

No pH adjustment of the dirty water is done for the settling operation. This is due to the natural pH of the water which is high enough (approximately 7,5), as evidenced during the site visit. A liquid flocculant is used and all the water treatment chemicals are supplied by BHT on a contractual basis. The technical representative from BHT spends between 2 - 3 days per week at WAGM and this time is split between the south and north shafts.

The following table shows the water quality measured at the settlers:

No.	Monitoring Point - Description	pH	Cond. (mS/m)	Temp (°C)
1	Dirty water from 38 level to settler on 41 level at start of launder	7,8	105	26
2	Combined dirty water to settler at end of launder	7,3	124	25
3	Clean overflow from settlers	7,4	114	25

Sludge from the settler underflow system is dropped from a specific cell when the overflow clarity becomes turbid. The drop valve is opened and the level dropped approximately 0,8 meters, when desludging is done. Each cell has 4 of these drop valves and each one is opened for a period of approximately 1 minute. Another important factor in the removal of sludge is the level of the mud dam that needs to be taken into consideration when sludge is dropped from the settler.

Flocculant consumption is approximately 100 kg/month for the treatment of a flowrate of 120 Mℓ/month. The flocculant concentration is made up to a 0,2%

solution and added at a rate of 2,5 mg/ℓ. The total flocculant costs, for both settler installations on the north mine, are between R6 300 to R7 000/month treating a total flow of approximately 300 Mℓ/month.

The clear water dam water seems clear and minimal secondary settling occurs in this dam. The clear water dam is cleaned annually. Clear water and mud pumps have a running time of between 8000 and 10 000 hours per pump before a pump overhaul is required. The settler performance is monitored by taking samples of the combined clear overflow in the launder, which is then analysed for pH, conductivity, suspended solids, total dissolved solids, calcium hardness, total hardness, manganese, sulphate and uranium. This is done to monitor the clear water quality which is pumped to surface and discharged into the Leeuspruit and Kleinwesrietspruit, both of which are public water courses.

3.2.8 Underground visit to a stope.

During the underground visit a stope on 38 level was visited, stope 2A East. The following water points were measured and the results are shown in the following table:

No	Measuring Point - Description	pH	Cond. (mS/m)	Temp (°C)
1	Dolomitic dam on 38 level	7,4	70	26
2	Water from drill hole of working stope 38 level 2A east	7,7	82	27
3	Service water to drill	7,7	81	25
4	Runoff from stope to dip gulley	10,6	89	26
5	Water from boxhole	9,8	61	27
6	Water in trench from crosscut loop	8,5	83	26
7	Water in main air return	8,2	74	26

Figure 4 shows the layout of the points measured during the underground visit to stope 2A East on 38 level. The dolomitic water measured a pH of 7,4 and a conductivity of 70 mS/m which is an indication of the water quality pumped to surface for recharging the G.E.C. The service water quality did not change due to the drilling activity, but the backfilling has a significant influence on the pH as it increased from 7,7 to 10,6, and the conductivity from 81 to 89. The effect of a better quality dolomitic water blending with the dirty water, can be seen in the decrease in the conductivity to 61 mS/m in the water from the boxhole. The deterioration in the water quality while flowing towards the shaft is seen in the combined dirty water flow from 38 level to 41 level. The conductivity increased significantly to 105 mS/m.

3.2.9 Potable water and service water supply

All potable water is obtained from Rand Water as there are no existing potable water plants on the premises. The possibility exists, however, that such a cost saving system will be commissioned in the near future to purify dolomitic water for use on the mining complex.

All the clear water from the underground settlers is pumped to surface and discharged, which is an open system. The underground service water is supplied from the dewatered dolomitic water and distributed throughout the underground workings.

3.2.10 Water monitoring programme

An extensive water sampling programme is in place for both the south and north mines. Samples are sent to Randfontein Estates Gold Mine (REGM) laboratory for analysis and the results are reported to the various responsible persons, i.e. the Plant Managers, Section Engineers and Chief Environmental Officers as well as the Geology Dewatering Department.

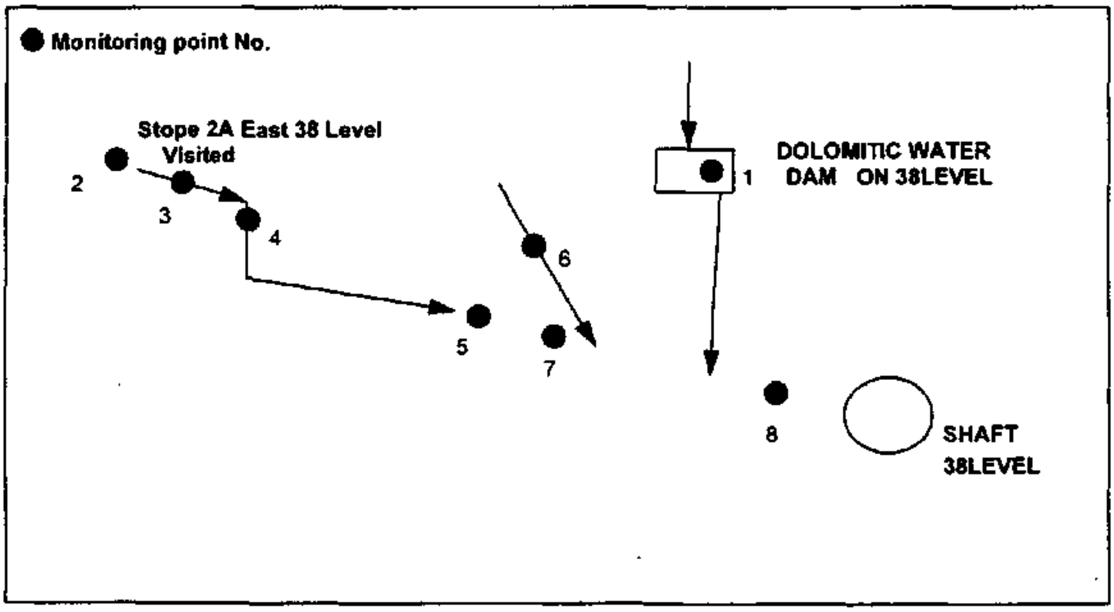


Figure 4 : Schematic layout of the points measured during the underground stope visit.

Tables 2 - 4 give the sample locations for the weekly water monitoring programme.

Table 2 and 3 give the location of the sampling sites for north and south respectively.

Table 4 reflects the weekly effluent samples taken at various points, particularly at public streams.

All these samples are analysed for the following:

- Total dissolved solids
- pH
- Suspended Solids
- Total Hardness

- Calcium Hardness
- Conductivity
- Free Cyanide
- Total Cyanide
- Uranium
- Sulphate
- Manganese

Various flow meter readings are recorded at different points on either a daily or monthly basis in order to compile the water balance which is crucial for the dewatering programme.

Table 2 : Weekly samples taken at North shaft

Sample ID	Description of Sampling Point
N1	Mine Water Settler at 50L
N1A	Mine Water Ex Settler 50L
N2	Uranium Water Settler at 50L
N2A	Uranium Water Ex Settler 50L
N3	Dolomite Water 41L
N3A	Mine Water Settler at 38L
N3B	Mine Water Ex Settler 41L
N4	Dolomite water 33L
N6	Donaldson Dam bypass Eye
N6A	Donaldson Dam Inflow
N8	Peter Wright Dam Inflow
N9A	Underground Water to N9
N10	Slimes Decant Return
N15	Peter Wright Underflow
N16	Peter Wright Dam
N17	Swimming Pool - Plant
N18	North Shaft Effluent
N25	Water Ex Cooke 3
N26	Sludge Decant Ex U/G
N27	Compressor Water (C/W)

3.2.11 Water management structure

The water management on WAGM forms part of the tasks of three subcommittees of the Environmental Management Central Committee. Figure 5 shows the different components of the environmental management structure as follows: A Central Committee with the following departments: Environmental Control; Engineering; Metallurgy; Mining; Geology; Geohydrology, Survey; Manpower and Water Chemist & Health Services. This again is subdivided into various subcommittees: Socio-economic structural functions, Health & Safety functions, Water Management Subcommittee for Mining, Water Management Sub-Committee for Metallurgy, Subcommittee for Dewatering and a Subcommittee for Internal Auditing. Each of these subcommittees has its own Chairman responsible for it's specific activities.

Table 3 : Weekly samples taken at South shaft

Sample ID	Description of Sampling Point
S1	Mine Water Ex SV1
S2	Mine Water Ex SV2 & SV3
S3	Dolomite Water 50L SV3
S4	Inlet 70L SV1 Settler
S4A	Outlet 70L SV1 Settler
S5	Refrigeration Backwash
S7	Slimes Decant Return
S7A	Cascade Dam Inflow
S8	Effluent Met Plant
S11	Leeu spruit Ex North
S15	Decant Tailing Onto Slimes
S16	Backfill Decant U/G
S17	Inlet 80L SV2 Settler
S18	Outlet 80L SV2 Settler
S19	Inlet 95L SV3 Settler
S20	Outlet 95L SV3 Settler
S21	80L Refr. Evap. Water
S22	80L Refr. Conden. Water
S23	Hot Water Dam Surface
S24	Compressor Water Cooling
S25	Surf F/Plant Condensate

Table 4 : Weekly effluent samples taken

Sample ID	Description of Sampling Point
N9	Discharge Kleinwesrietspruit
S6	Plant Bridge No 1
S7	Slimes Decant Return
S10	Plant Bridge No 2
S12	Chilled Water to u/g
S13	South Shaft Surface Effluent
S14	Leeuspruit Ex S6 & S10

The water management structure is shown in Figure 6, with the General and Mine Manager as the overall responsible parties which is then sub-divided into the Environmental Manager, the Metallurgical Manager, The Engineering Manager and the Geology Dewatering Manager and their supporting staff.

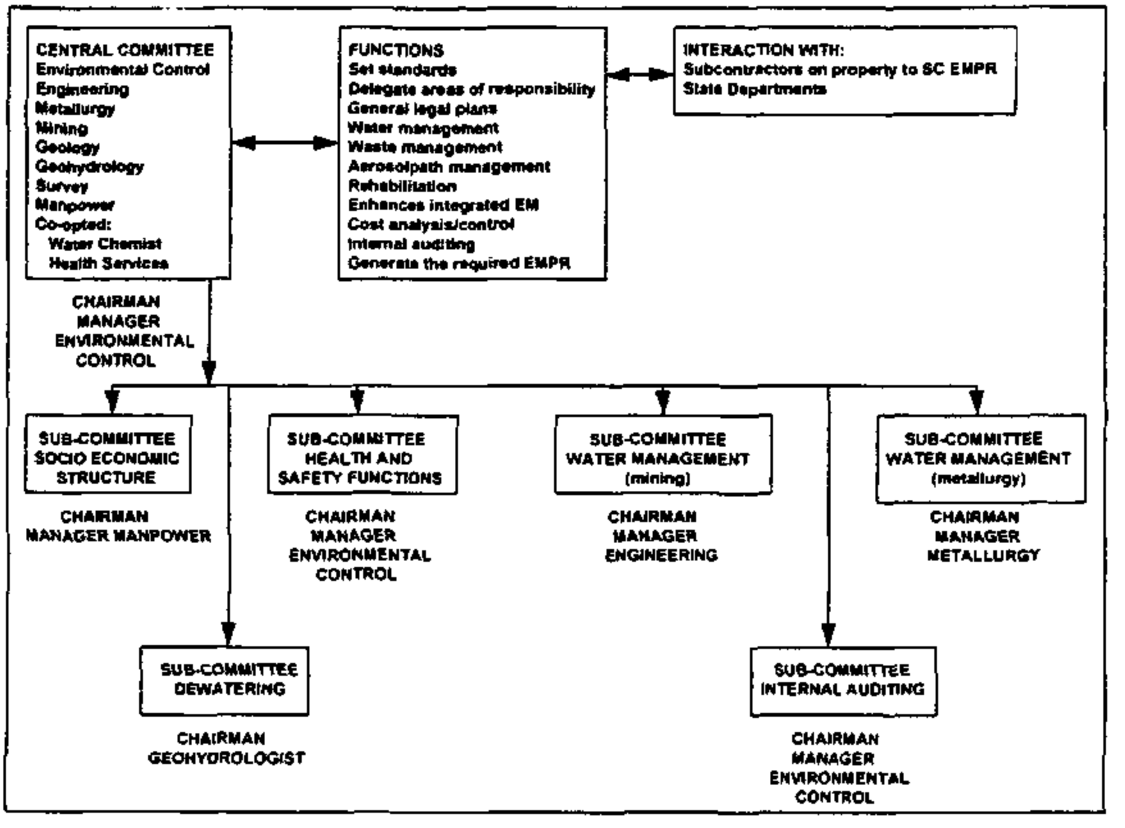


Figure 5 : The Environmental management structure for WAGM and its various subcommittees

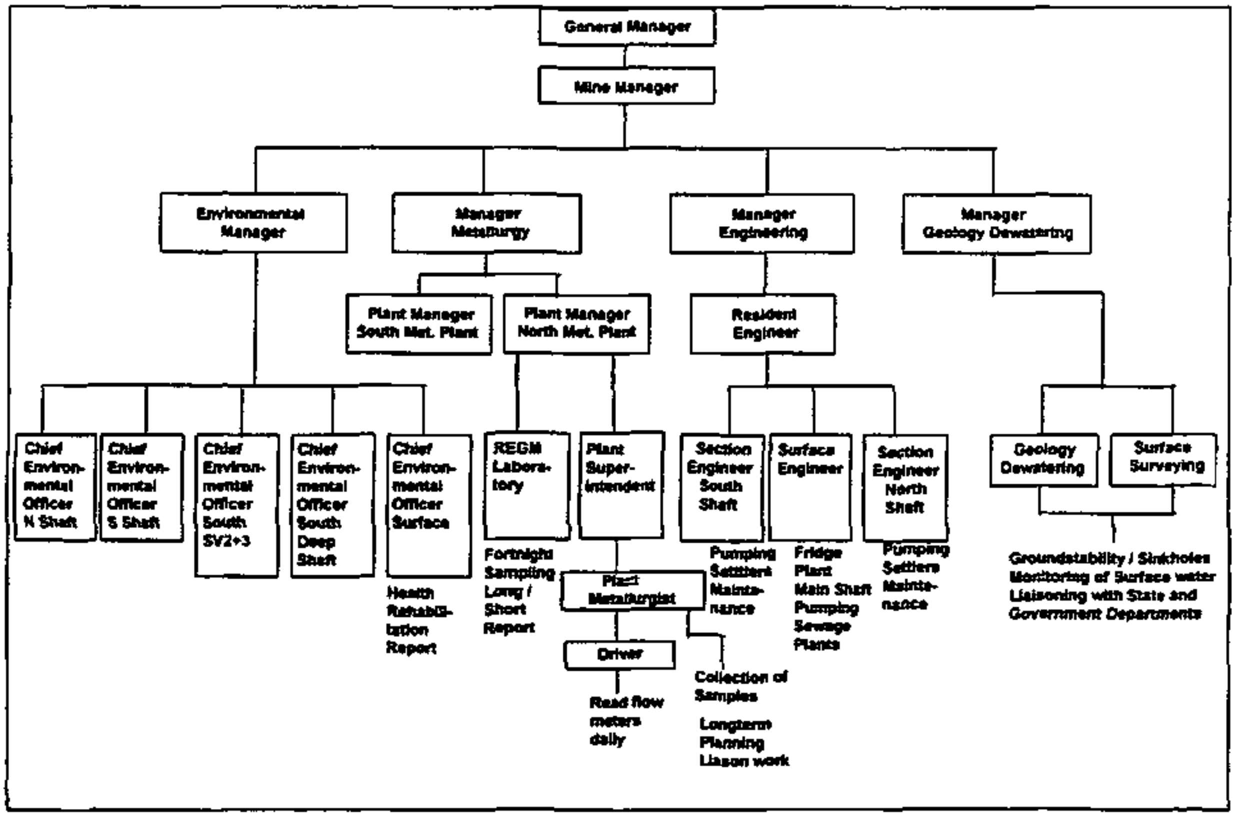


Figure 6 : Water Management Structure

3.3 NOVEL AND UNIQUE WATER TREATMENT AND MANAGEMENT SYSTEMS

3.3.1 Dewatering and artificial recharge of groundwater

The dewatering of the western portion of the Gemsbokfontein compartment and the recharge to the eastern portion is well managed and there appears to be a good understanding of the groundwater movement in the area. The dolomitic nature of the area leads to the development of sinkholes in water saturated areas. There is thus an extensive monitoring programme which aims at early detection of sinkholes in an attempt to limit possible damage.

3.3.2 Cascade Dams

A series of cascade dams are used at the south mine to reduce cyanide levels in the penstock return water from the operating slimes dams. This process destroys the cyanide content and ensures that it poses no danger for downstream users.

3.3.3 Supply of sewage effluent for irrigation

Although the use of purified sewage effluent for irrigation is not unique, the arrangement between the mine and the instant lawn farmer is unusual. The water supply is intended as compensation for the decrease in borehole yield which is experienced by the farmer, as a result of the mine's dewatering.

3.3.4 Mechanised slimes dam day wall construction

The mechanised construction of the slimes dam day wall is also not unique, but is still uncommon in the mining industry. This method has several advantages over manual labour packing. Apart from time and cost effectiveness, the use of a tractor requires drier conditions on the slimes dam surface and this in itself is a control measure for the correct management of disposal and distribution.

3.4 POTENTIAL WATER TREATMENT/MANAGEMENT PROBLEMS & NEEDS

3.4.1 Management of the Peter Wright Dam.

The Peter Wright Dam is presently receiving poor quality water from a number of sources including plant process water and spillages that overflow from the plant settling pond. Construction of a more efficient attenuation dam for the plant has already been planned and various management strategies for Peter Wright Dam and surrounding area are being considered. One considered option is the draining of the dam to allow dredging and eventual refill with a better quality water. Due to the volume and poor quality of water involved, this solution is unlikely to be permitted.

3.4.2 Return water control

A return water/evaporation earth dam, south of the old slimes dam was proposed and construction is to commence shortly. The main purpose of this evaporation dam will be to control part of the return water from the new tailings dam, the decanted water from the old tailings dam and the overflow from the cascade dams to this particular dam.

Most of the water will evaporate via different paddocks and overspill sections. The final emergency overspill will flow into the Leeuspruit. The proposed overflow dam will also serve to keep the clean unpolluted runoff water on the eastern side of the old slimes dam separate from the contaminated return and seepage water. This dam will ensure a better quality water flowing down the Leeuspruit.

4. GENERAL IMPRESSION

A very positive attitude towards environmental management was noted. This is evidenced by the well established environmental management structure which covers the whole spectrum of environment and mining. Everyone was aware of the requirements in terms of the EMPR and the necessity to preserve and conserve the environment in such a way that closure would be granted at the end of the mining life. There is a good water monitoring programme in place.

The sinking of the south deep mine, southwest of the south mine tailings dams will extend the life of WAGM by 10's of years which has a positive influence on the workforce attitude. The design and operation of this new mine will include environmental impact studies and environmental management programs to ensure that the necessary protection programmes are in place.

The natural pH of the fissure and underground service water is such that no neutralisation is required for flocculation conditioning or before discharge to the environment. In addition, the underground conditions are cool enough that there is no water cooling requirement. The abscence of neutralisation and refrigeration requirements represents a substantial cost saving.

The settler system on 41 level is well managed and shows good settling efficiencies. The staff have been well trained and there is a keen interest shown in the operation of the system. It is likely that the motivation behind such good performance, is the outside contractor who is employed on a half week basis to manage the operation. Such an arrangement ensures that the responsible person has a direct interest in the management of the settlers.

Appendix A - List of pH and conductivity monitoring readings taken during the site visit

During the site visit, a number of pH and conductivity readings were taken at various locations on the mine.

No	Monitoring Point - Description	pH	Cond. (mS/m)
1	Gland service water and hosing at North Plant (Peter Wright and Middle Elsburg water)	11.0	223
2	Mill return water tank at North Plant	11.4	229
3	Run off and spillages from thickener section	11.2	226
4	Settling dam south compartment (swimming pool)	10.4	166
5	Settling dam north compartment (swimming pool)	9.3	172
6	Uranium plant spillage to internal sump	9.4	173
7	Clear water from u/g settlers discharged in Leeuspruit (Origin of Leeuspruit southwest of north shaft hostel) 1st day reading	8.7	86
8	Kleinwesrietspruit below discharge point of u/g dolomitic water	8.4	103
9	Dolomitic water pumped into Gemsbokfontein East Compartment	8.2	65
10	Seepage through P. Wright dam wall	7.6	184
11	Dolomitic water discharge point at P. Wright dam overflow weir into Kleinwesrietspruit.	7.7	101
12	P. Wright dam water measured at overflow weir	7.7	164
13	Seepage in trench from tailings dam to P. Wright dam	6.9	288
14	Penstock return water at inlet of return water dam	6.7	420
15	First maturation pond of north sewage plant south of tailings dam	7.1	133
16	Settling dam overflow at inflow of P. Wright dam	7.3	155
17	Chlorinated treated sewage effluent	7.5	66
18	Leeuspruit at North Shaft (2nd day reading)	7.2	89
19	Leeuspruit at Vereeniging Rd	7.3	94
20	Leeuspruit at main entrance road to South Shaft	7.6	93
21	Leeuspruit at Fochville Rd Bridge south east of old tailings dam at south mine	7.3	123
22	Stagnant pool south of new tailings dam return water dams and Fochville road	7.2	354
23	Stagnant pool west of new tailings dam in Leeuspruit west No 2	7.3	126
24	Stagnant pool west of new tailings dam in Leeuspruit west No 2	6.8	259
25	Cascade dam inflow	8.8	253
26	Seepage in cutoff trench on western side of new tailings dam	7.0	313
27	Return water dam at new tailings dam west compartment	8.9	255
28	Return water dam at new tailings dam east compartment	9.1	243
29	Seepage below RWD wall in sump	7.9	280
30	Seepage from RWD into Leeu spruit west No 2	7.7	298
31	Seepage in cutoff trench on eastern side of new tailings dam	6.6	319
32	Cascade overflow	7.4	271
33	Trench downstream of cascade overflow	6.9	272
34	Cutoff trench on outside of cascade dam	7.1	212

Appendix A - List of pH and conductivity monitoring readings taken during the site visit (Cont.)

UNDERGROUND VISIT

No	Monitoring Point - Description	pH	Cond. (mS/m)	Temp (°C)
35	Dolomitic dam on 38 level	7,4	70	26
36	Water from drill hole of working stope 38 level 2 A east	7,7	82	27
37	Service water to drill	7,7	81	25
38	Runoff from stope to dip gulley	10,6	8,9	26
39	Water from borehole	9,8	61	27
40	Water in trench from cross cut loop	8,5	83	26
41	Water in main air return	8,2	74	26
	UNDERGROUND SETTLERS AT 41 LEVEL			
42	Dirty water from 38 level to settler on 41 level at the beginning of the main launder	7,8	105	26
43	Combined dirty water to settler at end of launder	7,3	124	25
44	Clean overflow from settlers	7,4	114	25

Appendix B - List of photographs taken during the site visit

During the site visit, a number of photographs were taken at various locations on the mine. The following is a list of the photographs taken:

Photo No	Photo Subject - Description
1	Uranium Plant Water holding tank
2	Gold plant thickeners
3	Lime makeup pachuca
4	Empty gold plant thickener
5	Raffinate launder
6	Raffinate holding tank
7	Manganese makeup tank
8	Stormwater trench around Uranium plant
9	Trench for Uranium plant spillages and slimes dam return water and sump for returning spillages to Uranium plant.
10	Settling pond for combined plant spillages (swimming pool)
11	Water discharged into Kleinwesrietspruit
12	Recharge point of dolomitic water to Gemsbokfontein Eastern Compartment
13	Pumping arrangement to return seepage through Peter Wright dam wall back to the dam
14	Pipe discharging dolomitic water into Peter Wright Dam overflow
15	Overflow west of Peter Wright Dam
16	Peter Wright Dam
17	Cement channel for dolomitic water discharge around the northern side of Peter Wright Dam
18	Seepage from north shaft tailings dam to Peter Wright Dam
19	Return water dam
20	Instant lawn farm using sewage water
21	Top of tailings dam showing pool and beach area
22	Maturation ponds on southern side of tailings dam (North shaft)
23	Chlorination system for disinfecting sewage water
24	Flowmeter installation measuring settling pond overflow from plant to Peter Wright Dam
25	Underground dolomitic water dam
26	Backfill pillar
27	Dirty water flowing from working places to pumps at 38 level
28	Pumping of dirty water at 38 level
29	Material handling at 38 level
30	Combined dirty water arriving at 41 level settler
31	Dirty water launder to settler
32	Basket installation for gel block flocculation
33	Grid for removing coarse material
34	Splitter arrangement in main launder
35	Flocculant makeup arrangement
36	Flocculant dosage
37	Top of settler cells
38	Clear water launder
39	Dirty water launder
40	Combined clear water flow after settling

Appendix B - List of photographs (cont.)

Photo No	Photo Subject - Description
41	Dolomitic water holding tank on surface for underground dewatering
42	Clear water holding tank on surface for settler overflow
43	Flow meter for underground clarified water discharge to Leeu spruit at north shaft
44	Leeu spruit at Vereeniging road (R29)
45	Leeu spruit at main entrance to south shaft
46	Leeu spruit south of old tailings dam at South Mine
47	Leeu spruit at Fochville road bridge
48	Ferrous sulphate bags in Leeu spruit
49	Stagnant pool south of new tailings dam South Mine
50	Piezometer marker
51	Stagnant pool west of new slimes dam South Mine
52	Sinking of South Deep Mine
53, 54	Cascade dams
55	Cascade dam overflow
56	Return water dams as South Mine new tailings dam
57, 58	Seepage below return water dam wall
59	Daywall building with tractor
60	Raw sewage to South Mine sewage plant
61	Aeration section
62	Clarification and settling
63, 64	Disinfection and retention time increase by channelling
65	Drying beds
66	Treated sewage