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

APPENDIX
Volume 2
Coal 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

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

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APPENDIX

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Report on Alpha Anthracite Site Visit

1 - 2 November 1993

1. GENERAL INFORMATION

Name of mine	Alpha Anthracite
Name of person(s) interviewed	Tammy Marshall Andre Erasmus Nick du Plessis
Position of person(s) interviewed	T Marshall - Mine Manager A Erasmus - Technical Manager N du Plessis - Engineering Manager
Nearest town	Vryheid
Name of catchment	Mfolozi, Mkuze, Tshoba
Monthly coal throughput (rom)	Alpha Central - 7 000 tons Open cast - 20 000 tons Dixon & Blesbok - 3 000 tons
Monthly saleable product	20 000 tons
Monthly discard production	8 500 tons coarse discard 1 500 tons slurry
Main product and market	Export market - 70 % Inland market - 30 %
Current age of mine	Alpha Central - 40 years Others - 20 years
Expected remaining life of mine	Alpha Central - 4 years Others - 8 years
Type of mining carried out	Open cast, underground (bord & pillar, stooping at Central)
Transport mode- mine to plant	Road
Has the mine already produced an EMPR	Still in progress

2. SITE VISIT PROGRAMME

2.1 Day 1 - 1 November 1993

- Arrival
- Short discussion of project background and objectives with Mr T Marshall
- Detailed site visits with Mr T Marshall

2.2 Day 2 - 2 November 1993

- Complete site visits with Mr N du Plessis
- Completion of questionnaire

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

3.1 DESCRIPTION OF WATER CIRCUITS

The mine operations can be divided into four different geographical areas as follows:

- Plant and main dump area;
- Nyembe area (Alfred open cast, Dixon and Blesbok shafts);
- Alpha Central; and
- East Shaft.

Detailed plans of the different areas were not available and schematic sketches, showing the pH and conductivity sampling points, were made on site. These sketches are attached as Figures1, 2 and 3.

It should also be pointed out that the area had received extensive rainfall during October, and as a consequence, evaporation facilities were full and seepage points could be readily identified.

3.2 DESCRIPTION OF WATER TREATMENT/MANAGEMENT SYSTEMS

3.2.1 Sewage treatment systems

The plant area and East shaft hostel complex use septic tanks and French drains for sewage disposal. The French drains at the main plant area appear to be overloaded, with seepage having direct access into the "clean" water drains.

Alpha Central has a simple sewage treatment plant as shown in Figure 4 below. Raw sewage passes through grit traps and is then mixed with return sludge from the final clarifier before entering an aerated reactor. Overflow from the reactor discharges into the final clarifier, which discharges into evaporation ponds situated adjacent to a water course. Clarifier discharge is passed over HTH tablets. At the time of the site visit, it was noted that the reactor had almost no biomass / sludge and it was ascertained that this situation had been in existence for some time.

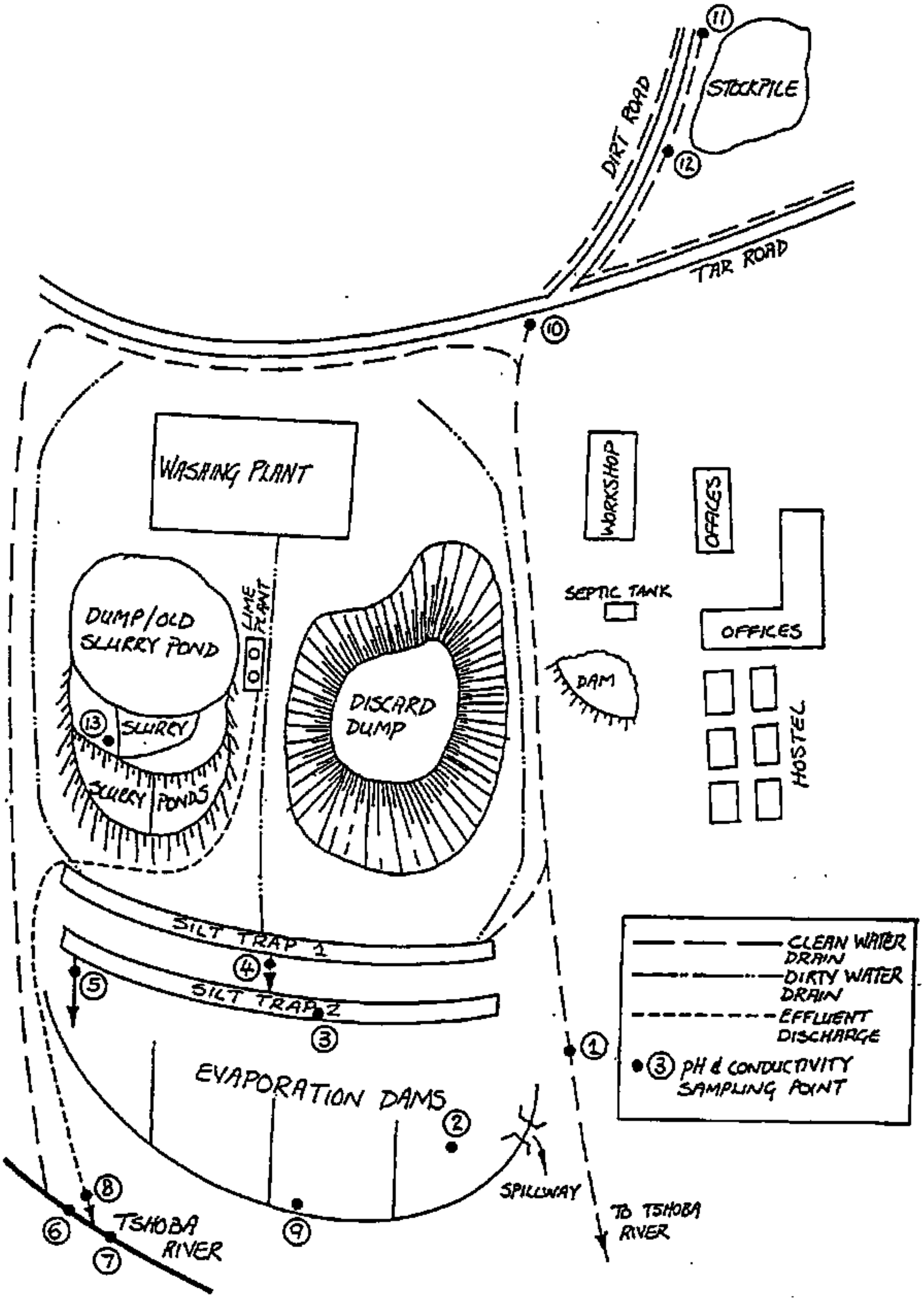


Figure 1 : Schematic Representation of Main Plant Area

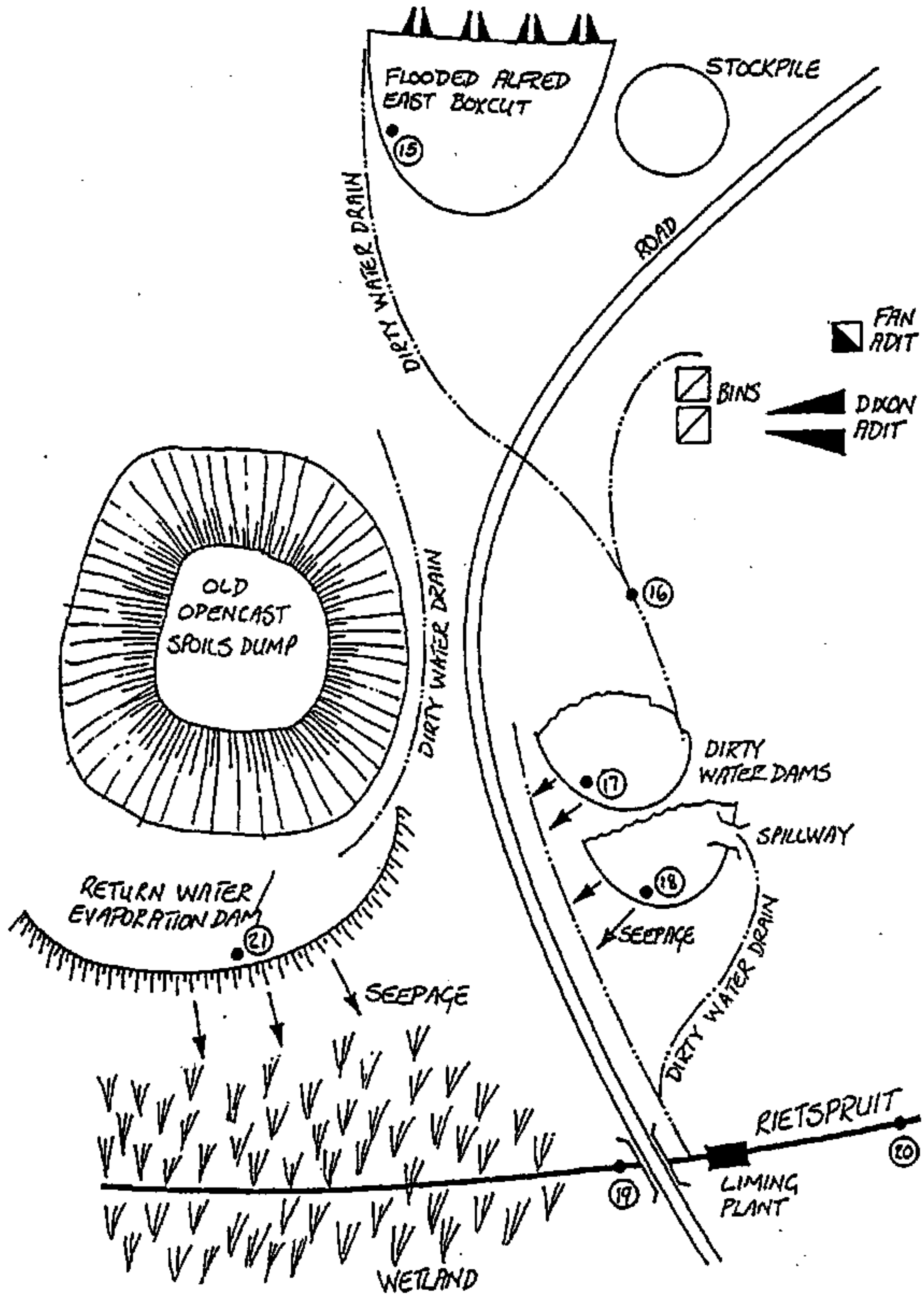


Figure 2 : Schematic Representation of Dixon Shaft & Alfred Area

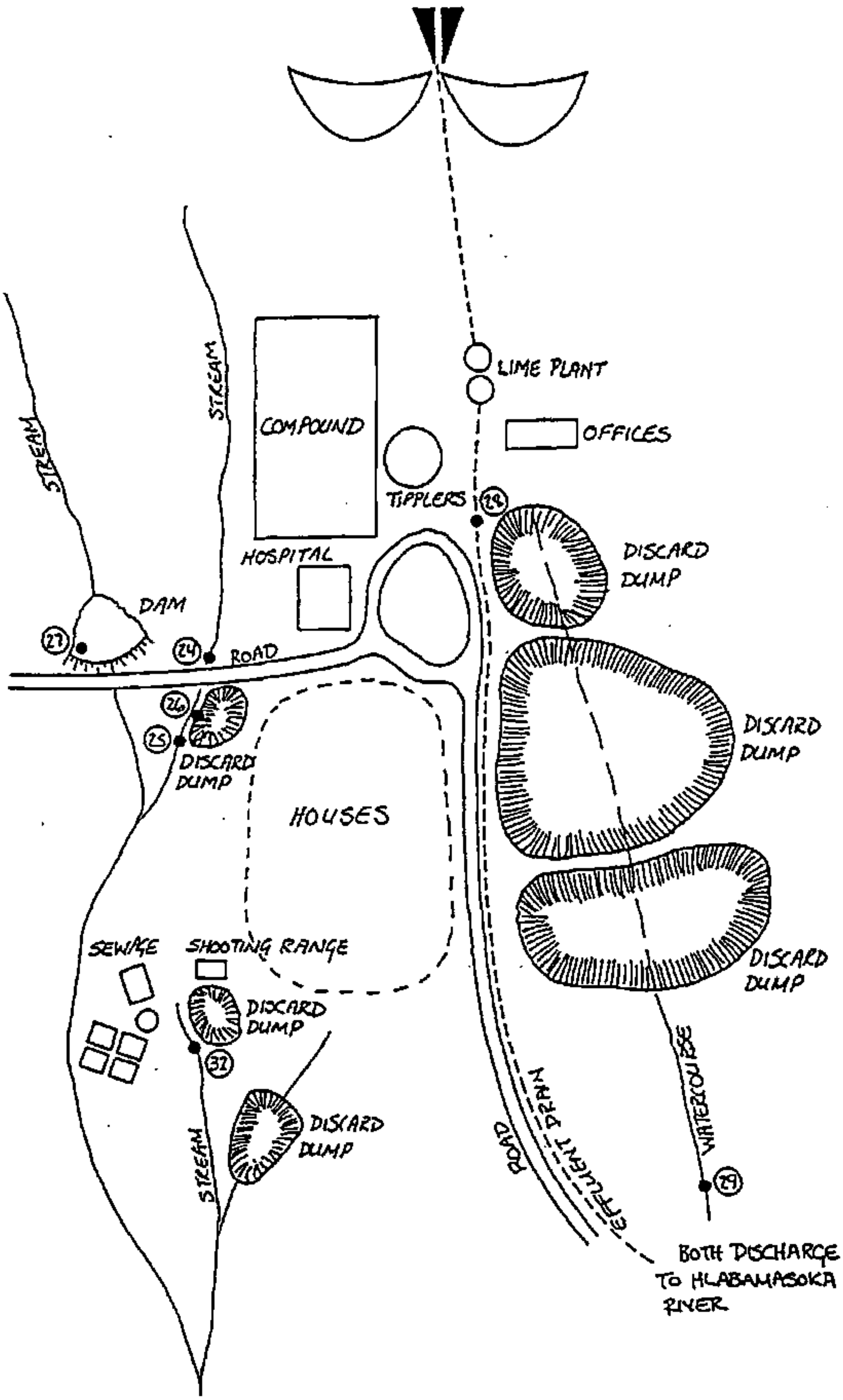


Figure 3 : Schematic Representation of Alpha Central Area

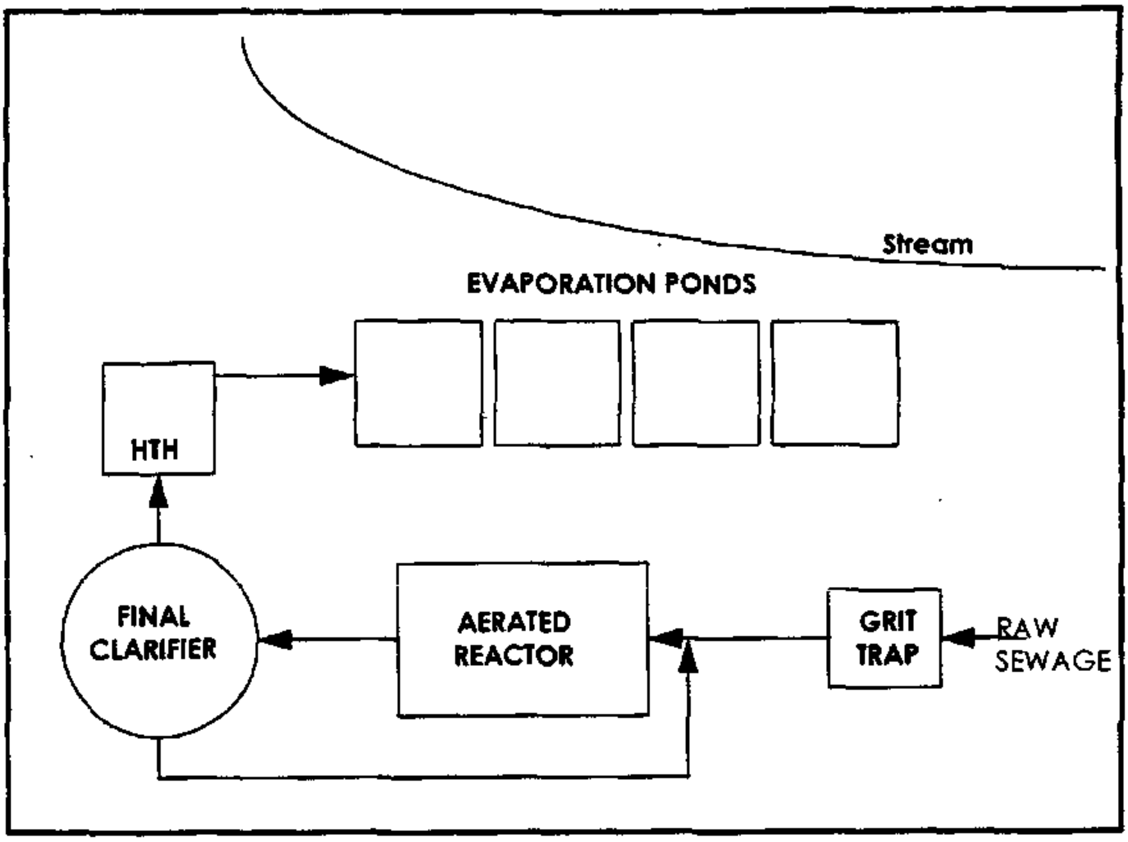


Figure 4 : Schematic Diagram of Alpha Central Sewage Treatment Plant

3.2.2 Potable water systems

The mine uses approximately 80 m³/day of potable water for domestic purposes (offices, workshops, hostels, houses, etc.) which is sourced from different areas as shown below.

User	Source	Flow
Washing plant/offices	Borehole	±10 m³/d
Central Shaft	Borehole & mountain spring	±20 m³/d
East mine hostel	Mountain spring (sample point 31)	±40 m³/d
Dixon & Blesbok shafts	Old open cast dam (rainwater)	±10 m³/d

The mountain spring waters at Central and East Shafts are of an exceptionally high quality, with measured conductivities of 8 and 2 mS/m respectively. Both springs had a measured pH of 6.3. Borehole water was not sampled.

During the recent drought period in the area (up till October 1993), approximately 6 m³/day were trucked in to supplement the potable water supply.

3.2.3 Plant water circuits

The coal washing plant area essentially operates on a closed water circuit. Water lost to the discards, slurry and products is made up by rainfall runoff in the wet season and water pumped from Hlobane mine in the dry season. Make-up demand is estimated to be 35 m^3/day. A schematic representation of the plant water circuits is shown in Figure 5 below.

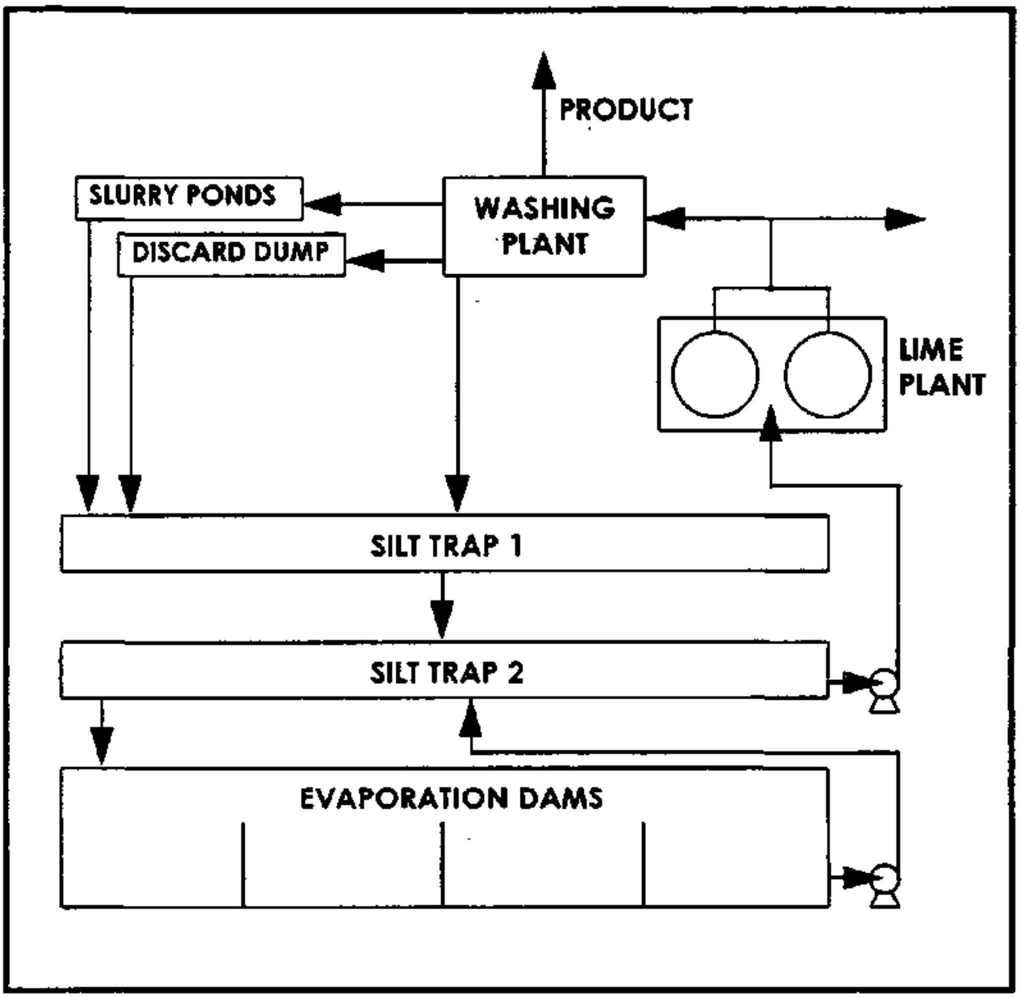


Figure 5 : Schematic Diagram of Plant Water Circuits

When the evaporation dams are full (as was the case during the site visit), the lime plant, with a throughput of approximately 1 000 m^3/day, is operated 24 hours a day. For 8 hours the limed water is sent to the washing plant, while for 16 hours the limed water is pumped to the Tshoba River for discharge as effluent.

In addition to the lime addition at the lime plant, the washing plant water circuits are also treated using soda ash and flocculant as shown schematically in Figure 6 below. The treatment specification for water sent to *the washing plant is pH ± 7 and low suspended solids. Fine tuning of the plant* water pH is carried out with soda ash addition (manual control with litmus paper), while suspended solids are removed through flocculation and settling.

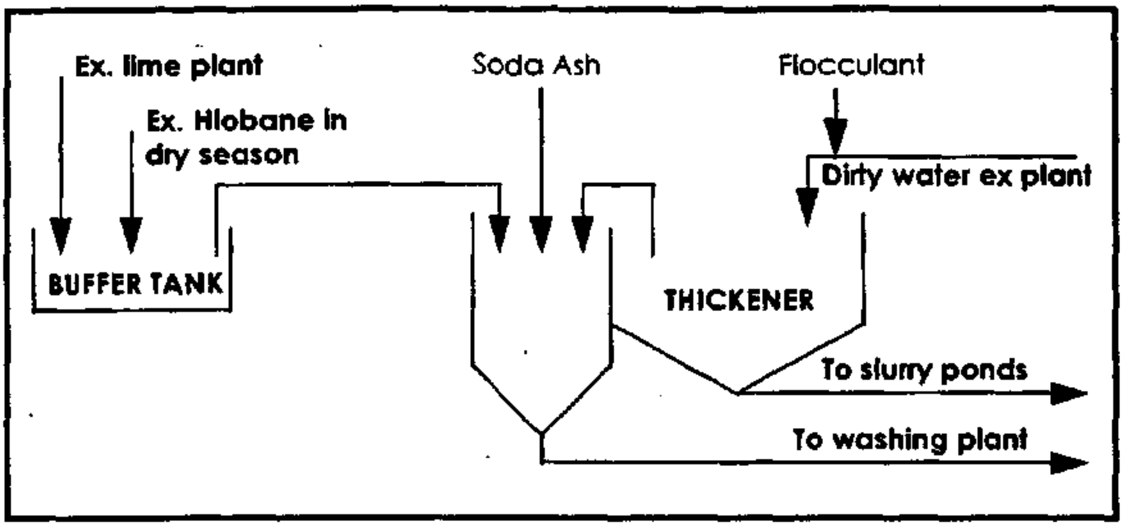


Figure 6 : Schematic Diagram of Plant Water Treatment

3.2.4 Discard dumps

All runoff and toe seepage from the washing plant discard dump and slurry dams is collected in the silt traps and newly constructed evaporation dams. The extent of seepage into the groundwater systems is unknown. The main plant discard dump, although largely burnt out, is still burning. Alpha Central mine has a number of discard dumps constructed within the natural water courses. Seepage from these dumps is uncontrolled and is discharged into the tributaries of the Mkuze River system.

3.2.5 Water monitoring systems

The mine has no regular water sampling or monitoring programme in place.

3.2.6 Water management structure

The water management structure is shown in Figure 7 below.

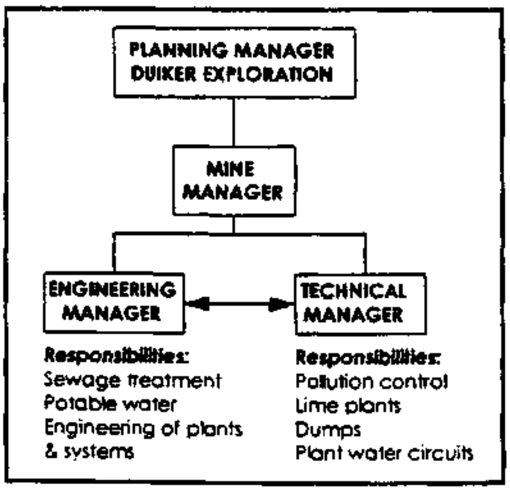


Figure 7 : Alpha Anthracite Water Management Structure

3.3 NOVEL OR UNIQUE WATER TREATMENT AND MANAGEMENT SYSTEMS

3.3.1 Dry lime feeders

The dry lime feeder system (referred to as a "donkey") used to dose lime directly into the river is a system which may find application elsewhere. The operating system is entirely mechanical and is driven by the energy of the water in the stream being treated. A schematic diagram of the lime feeder operating system is shown in Figure 8 below.

The operation of the dry lime feeder is discussed on the basis of four sketches detailing different components of the system.

A. A small weir is built in the stream, upstream of the lime feeder. The head of water behind the weir forms the driving force for the lime feeder. Water is fed down a pipe to fill the water buckets which drive the feeder.

B. The water discharges into a bucket which tips over to the right hand side when it is full. This tipping action activates a wiper blade which wipes the lime off the plate below the lime hopper, into the stream flowing underneath.

C. The water then discharges into the second bucket which tips to the left, thereby activating the wiper to the left.

D. The gap between the lime hopper and the flat plate is such that lime does not spill out over the edges until the wiper blade is activated by the tipping of the water buckets.

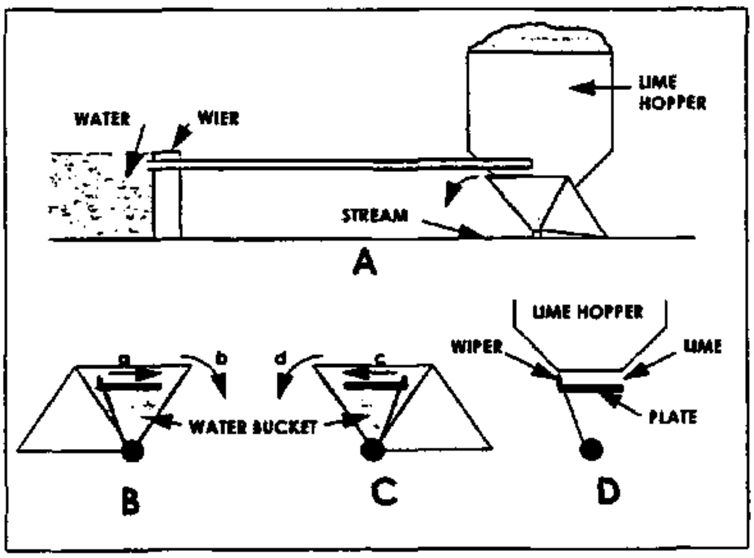


Figure 8 : Operation of Dry Lime Feeder

The only criticism of this lime dosing system is that it is not proportional to flow. If a study were undertaken to determine the relationship between flow and pH for the particular stream to be treated, then the lime feeder could be made to dispense lime in the appropriate manner by installing a flow proportional weir at the upstream weir which could convert flow to driving head in the correct proportion.

Such a system would have potential application in many situations where acid streams need to be treated and where electrical power and pH probe controlled systems are inappropriate.

3.4 POTENTIAL WATER TREATMENT/MANAGEMENT PROBLEMS AND NEEDS

As a result of the discussions and site visits, a number of issues were identified where knowledge gaps still exist. Due to time constraints, however, the old open cast operations could not be visited and any problems or needs relating to these operations are therefore excluded from the discussion below.

3.4.1 Management of diffuse pollution sources

The mining operations consist of small, discrete workings, spread out over a fairly wide area and, as a consequence, the management of diffuse pollution is assessed to be the major water related problem at Alpha Anthracite. In a number of instances, discards and other acid producing materials have been disposed of in natural watercourses, resulting in the formation of highly acidic and saline seeps. In another case, discard/spoils material has been used as the core of an evaporation dam which was constructed to retain runoff and seepage from an old spoils dam. The dam is leaking and the core of the dam wall is contributing to the additional contamination of the seepage.

In order to be able to address such a large number of diffuse pollution sources in a sensible manner, a fairly detailed salt balance is required which is capable of quantifying the contribution of the different sources and identifying and prioritising the appropriate management strategies.

3.4.2 Management of clean and dirty water

The current clean and dirty water management / separation systems are not performing their intended duty and appear to be incorrectly designed and placed. Samples 1, 10, 11 and 12 in Appendix B indicate that the clean stormwater drains are, in fact, draining dirty water. An additional problem identified during the site visit was that the "clean" water drain was discharging into the dirty water system, i.e. No 1 silt trap.

The mine area needs to be divided into clean and dirty water catchments and clean water drains need to be constructed accordingly. By adhering to the principle of separating clean and dirty water, the pollution load discharged by the mine and the volume load on the silt traps and evaporation dams can be significantly reduced.

3.4.3 Water and salt balance

The problems discussed in Sections 3.4.1 and 3.4.2 could be managed if the mine had access to a proper detailed water and salt balance. Such a balance must clearly identify all water and salt sources and users, together with all internal recycle systems. The balance must also accommodate hydrological and geohydrological aspects. The schematic water balance for the plant area is shown in Figure 9, indicating the extent of missing information. Similar water balances need to be prepared for all areas where coal mining activities impact on the water environment.

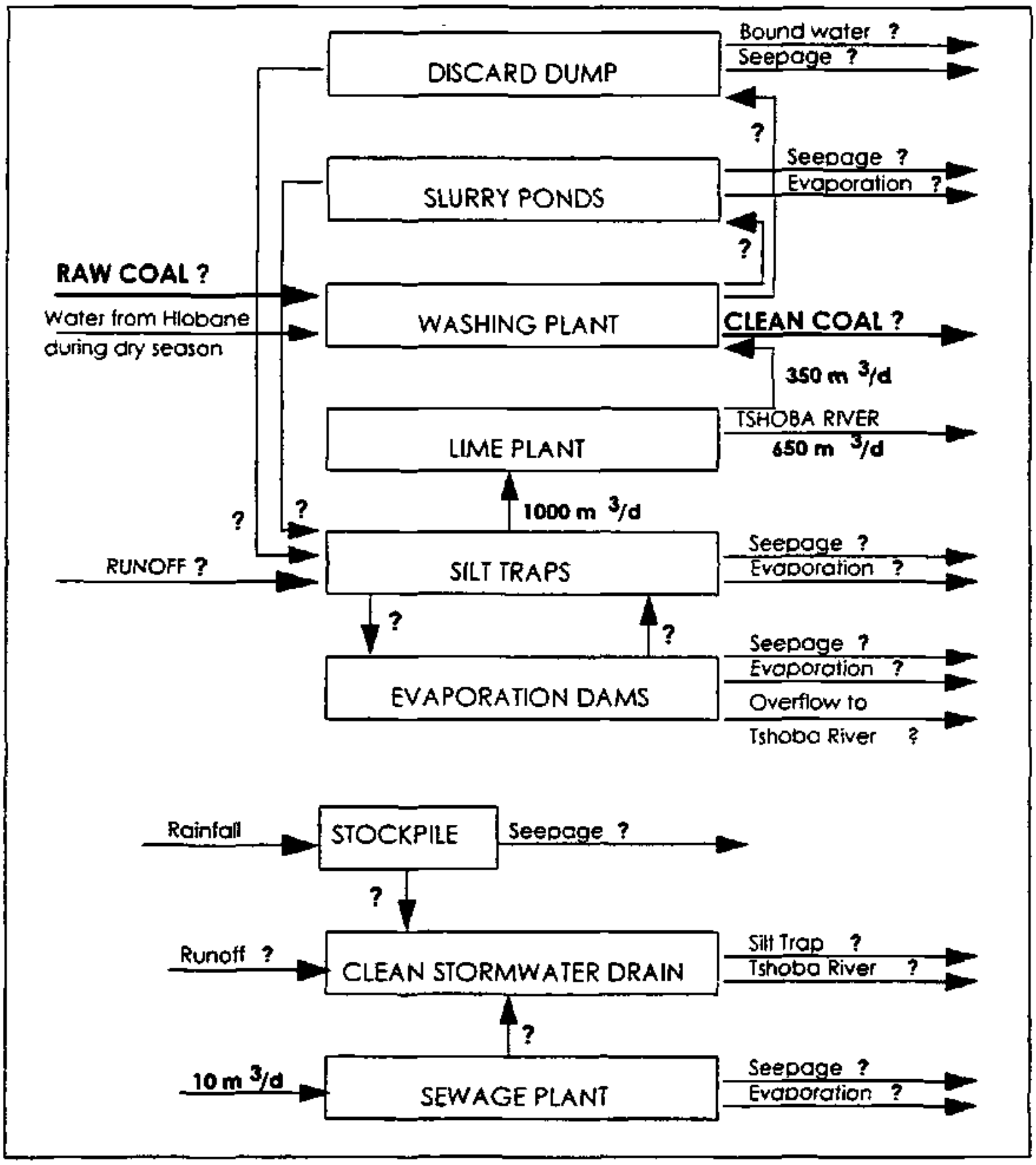


Figure 9 : Schematic Water Balance for Plant Area

The water and salt balance should be seen as the most important dynamic water management tool available to the mine and can assist in optimising internal recycle and treatment systems, minimising pollution discharges and fresh water requirements. The water and salt balance will need to be viewed as a dynamic tool which will require constant updating with physical, flow and water quality data.

3.4.4 Lime dosing systems

The mine has two lime dosing plants, each with its own problems. The lime dosing plant at the washing plant which treats water pumped up from the silt trap is undersized and has no lime dosing control mechanism. The quality of the raw water fed to the lime plant was sampled during the site visit and analysed as shown in Table 1 below.

Table 1 : Raw Water Quality to Lime Plant from Silt Trap

Determinant	Value
pH	2.9
Conductivity	479 mS/m
Total Dissolved Solids	5630 mg/l
Chloride	58 mg/l
Sulphate	3700 mg/l
Sodium	150 mg/l
Calcium	470 mg/l
Magnesium	240 mg/l
Acidity	1240 mg/l as $CaCO_3$

Addition of lime to this water will result in the formation of calcium sulphate and calcium carbonate precipitates and the existing reactors are inadequate for the task of settling out these precipitates which will then be settled out in the washing plant circuits. As the lime plant also has no pH control loop, the pH of the lime treated water will be erratic.

As discussed in Section 3.3.1 above, the dry lime feeders on the Rietspruit require modification in order to make them capable of dosing lime in correct proportion to flow. At the time of the site visit, the pH in the Rietspruit downstream of the lime feeder was measured as 11.9 which far exceeds the optimum pH of 6 - 8.

3.4.5 Evaporation and settling dams

The evaporation and settling dams at the main plant area below the discard dump have not been adequately designed. In particular, the problems observed during the site visit are as follows:

silt dams : the inflow and overflow arrangements are improperly designed and promote hydraulic short-circuiting rather than effective settling; and the desludging arrangements appear to be insufficient.

evap. dams : the capacity of the evaporation dams appears to be inadequate for the catchment which needs to be served, although this problem is linked to that discussed in Section 3.4.2 above - the dams were overflowing at the time of the visit.

3.4.6 Water quality

The mine suffers from very poor water quality and the conductivities listed in Appendix B are amongst the highest recorded at any coal mine. The water and salt balance must be used as a management tool to improve the water quality in circulation and discharged by the mine.

3.4.7 Management and monitoring systems

Although the mine has significant impacts on the water environment in a number of different catchments, none of the mine personnel have specialist knowledge on water systems. Although senior management on the mine exhibited both a keen interest in the site visit and a growing awareness of the impact of the mining activities on the water environment, the knowledge and tools (such as a water balance) are not available to enable management of these impacts. In particular the total lack of water quality or flow monitoring data makes it impossible to quantify and manage the mine's negative impacts.

3.4.8 Ground water systems

No information is available on the impact of mining activities on the ground water systems and this will need to be rectified in order to manage the mine's environmental impact.

4. GENERAL IMPRESSIONS

The general impression gained from the site visit is that the mine has significant impacts on the surface and ground water systems which are presently not understood, quantified or managed. However, discussions with mine management indicated a growing awareness and willingness to address these problems - many of the more significant problems are manageable and can be addressed once the mine has access to an accurate water and salt balance.

The mine personnel responsible for environmental management on the mine are not directly involved in the development and drafting of the mine's EMPR. A more direct involvement would assist in creating an awareness of the mine's negative environmental impact and would increase the chances of finding practical sustainable solutions to the current water management and treatment problems.

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. The following is a list of the readings taken:

No	Description	pH	Cond.
1	"Clean" stormwater drain	3.90	198
2	Evaporation dam contents	3.06	334
3	Silt trap 2 at pump to lime plant	3.08	407
4	Central drain from plant into silt trap 2	6.45	500
5	Water leaving silt trap 2 into evaporation dam	2.97	550
6	Tshoba River upstream of effluent discharge	7.45	205
7	Tshoba River downstream of effluent discharge	5.85	421
8	Lime plant discharge to Tshoba River	5.46	479
9	Contents of evaporation dam (middle)	2.82	488
10	"Clean" stormwater drain at tar road	2.78	404
11	"Clean" stormwater drain upstream of stockpile	3.15	102
12	"Clean" stormwater drain downstream of stockpile	2.85	330
13	Water on top of slurry dam	2.63	675
14	Water seeping out of footwall at Blesbok Shaft boxcut	5.30	145
15	Water in flooded Alfred boxcut	2.78	495
16	Water discharged from Dixon Shaft into pollution control dam	5.70	392
17	Water in Dixon upper pollution control dam	4.70	266
18	Water in Dixon lower pollution control dam	4.20	170
19	Rietspruit discharging from wetland upstream of lime feeder	3.02	510
20	Rietspruit downstream of lime feeder	11.90	960
21	Evaporation dam below old Alfred opencast spoils dump	3.02	335
22	Rietspruit at crossing with Nongoma road	7.35	98
23	Hlobamasoka River at crossing with Nongoma road	5.10	150
24	Central Shaft Hospital stream above dump in watercourse	4.70	62
25	Central Shaft Hospital stream 15m below dump in watercourse	3.40	100
26	Seepage from dump in Hospital stream watercourse	2.80	277
27	Uncontaminated stream next to Central Shaft	6.30	8
28	Limed discharge from Central Shaft	8.30	112
29	Seepage from Central dump in watercourse	2.70	620
30	Stream below East Shaft opencast	5.80	12
31	Mountain spring water to East Shaft hostel complex	6.30	2
32	Seepage from dump below shooting range at Central Shaft	2.20	1050
33	Tshoba River at crossing with road to Vryheid (next day)	6.10	205

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:

Photograph No	Description
1	Clean stormwater drain alongside plant dump
2,3,4	Evaporation ponds and slurry discard dump
5	No. 2 silt trap showing discharge from pump abstracting from evaporation dam
6	Central drain from plant into silt trap 2
7	Silt trap 2 overflow into evaporation dam
8	Tshoba River upstream of effluent discharge point
9	Tshoba River downstream of effluent discharge point
10	Lime plant discharge to Tshoba River
11	View downstream of evaporation dam
12	Coal stockpile next to stormwater drain
13	Lime plant treating silt trap return water
14	Slurry ponds
15	Blesbok shaft - showing seepage at footwall
16	Old Alfred adit at Dixon Shaft
17	Dixon Shaft pollution control dams (lower dam returns water to Shaft)
18	Seepage through pollution control dams
19	Lime feeder in Rietspruit at Dixon Shaft
20	Rietspruit downstream of lime feeder
21	Alpha Central Shaft from valley bottom
22	Alpha Central Shaft from loading bin below
23	Seepage from Central dump
24	East Shaft above opencast pits
25	Central sewage treatment plant
26	Discard in water course below shooting range
27	Workshops adjacent to clean storm water drain

Report on Durnacol Site Visit

22 - 23 March 1994

1. GENERAL INFORMATION

Name of mine	Durban Navigation Colliery
Name of person(s) interviewed	W Zietsman
Position of person(s) interviewed	Acting Head : Production
Nearest town	Dannhauser
Name of catchment	Kalabas - Chelmsford Dam
Monthly coal throughput (rom)	274 000 tons
Monthly saleable product	91 700 tons
Monthly discard production	157 600 tons
Monthly slurry production	24 700 tons
Main product and market	Coking coal to Iscor
Current age of mine	93 years
Expected remaining life of mine	10 years
Type of mining carried out	Underground (bord & pillar, longwall)
Transport mode- mine to plant	Conveyor
Has the mine already produced an EMPR	Yes

2. SITE VISIT PROGRAMME

2.1 Day 1 - 22 March 1994

- Short discussion of project background and objectives with Mr W Zietsman
- Detailed site visit with Mr Zietsman

2.2 Day 2 - 10 March 1994

- Complete site visits with Mr Zietsman
- Completion of questionnaire

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

3.1 DESCRIPTION OF WATER CIRCUITS

The mine operations can be divided into four different areas as follows:

- No 7 Plant and No 7 & 8 dump area;
- No 1 dump area;
- No 3 dump area; and
- Underground workings.

Detailed plans of the different areas were made available and simplified plans, showing the pH and conductivity sampling points are attached as Figures 1 and 2. A schematic water balance is attached as Figure 3. Exploded views of the site visit sampling strategy around No 1 and No 3 dumps are shown in Figures 4 and 5.

The Eastern side of the mine, which is no longer actively mined, borders on the town of Dannhauser. This eastern portion is drained by the Klipspruit. Details of this eastern portion of the mine can be seen in Figures 1 and 4. The main area of the mine is drained by the Kalabas river, which drains roughly from south to north, as shown in Figure 2. The southern tributaries of the Kalabas, with the exception of the south eastern tributary, can essentially be considered as clean water. The south eastern tributary receives treated sewage water from the No 3 sewage plant, and is also contaminated by saline seepage from the No 3 dump. The portion of the Kalabas river north of the road from the No 3 plant through to the No 7 plant is polluted, and receives drainage pumped up from underground, through No 4 and No 12 shafts. This northern portion of the Kalabas also receives overflow from the No 7 dam. The most western tributary of the Kalabas, as shown on Figure 2 drains into the No 4 dam. This water is clean and is used in the underground operations. No 4 dam overflows and joins up with the northern portion of the Kalabas river. The combined stream drains into the Chelmsford dam.

3.2 DESCRIPTION OF WATER TREATMENT/MANAGEMENT SYSTEMS

3.2.1 Sewage treatment systems

The mine operates two sewage treatment plants, being the No 3 and the No 5 sewage plants. The raw sewage is treated by primary screening and grit removal, thereafter being fed into a Pasveer ditch. The treated effluent from the Pasveer ditch is settled in two settling systems - the primary settlers and the secondary settlers. Sludge from these settlers is recycled to the Pasveer ditch, and excess sludge is disposed of. Clarified effluent from the secondary settler is dosed with chlorine gas, in a chlorine contacter. The chlorinated, treated sewage is then discharged to the Kalabas river. According to the mine personnel, no problems are experienced with the sewage treatment systems. The mine has also calculated that the cost of treating this sewage is 43c/m^3.

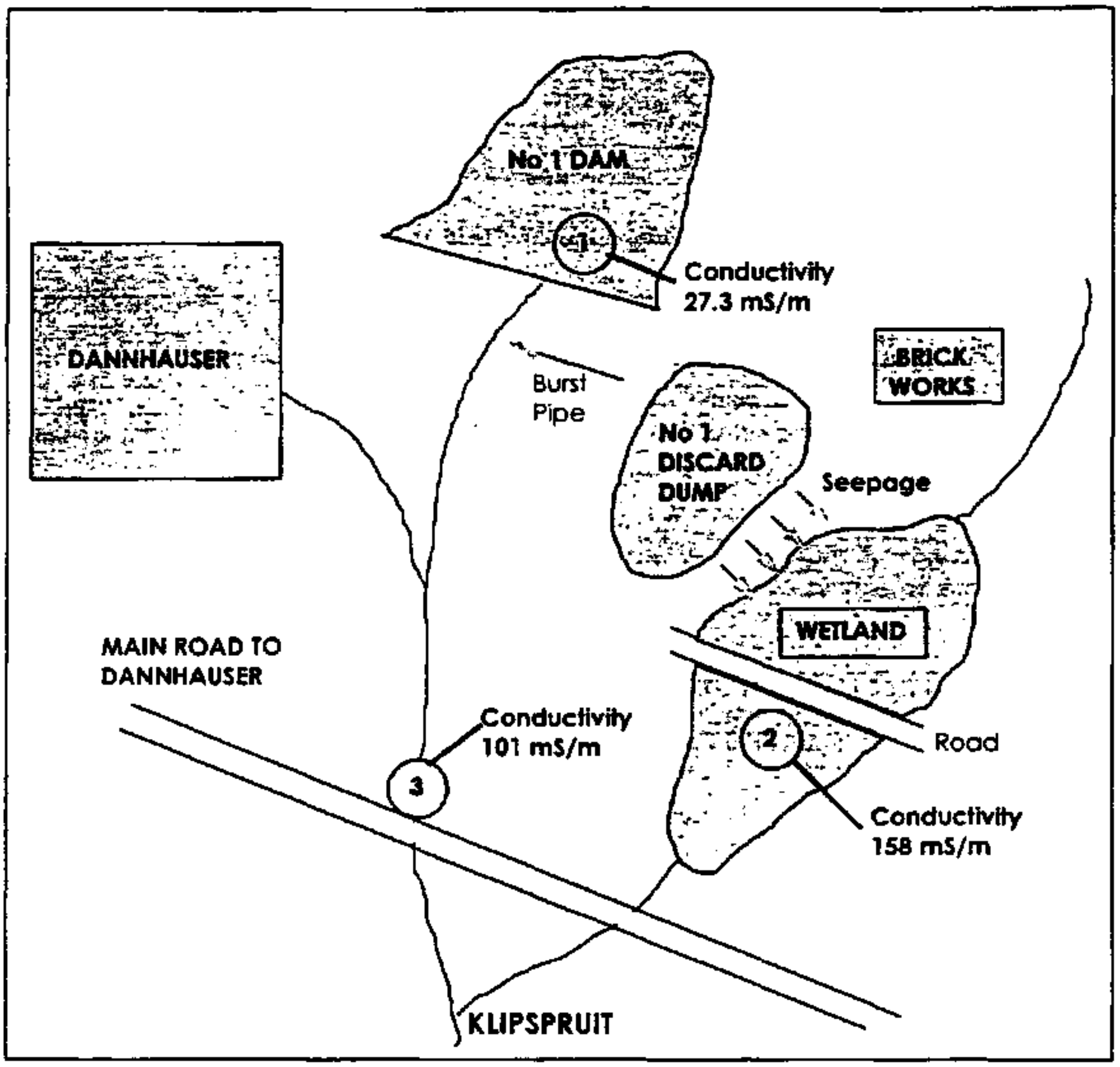
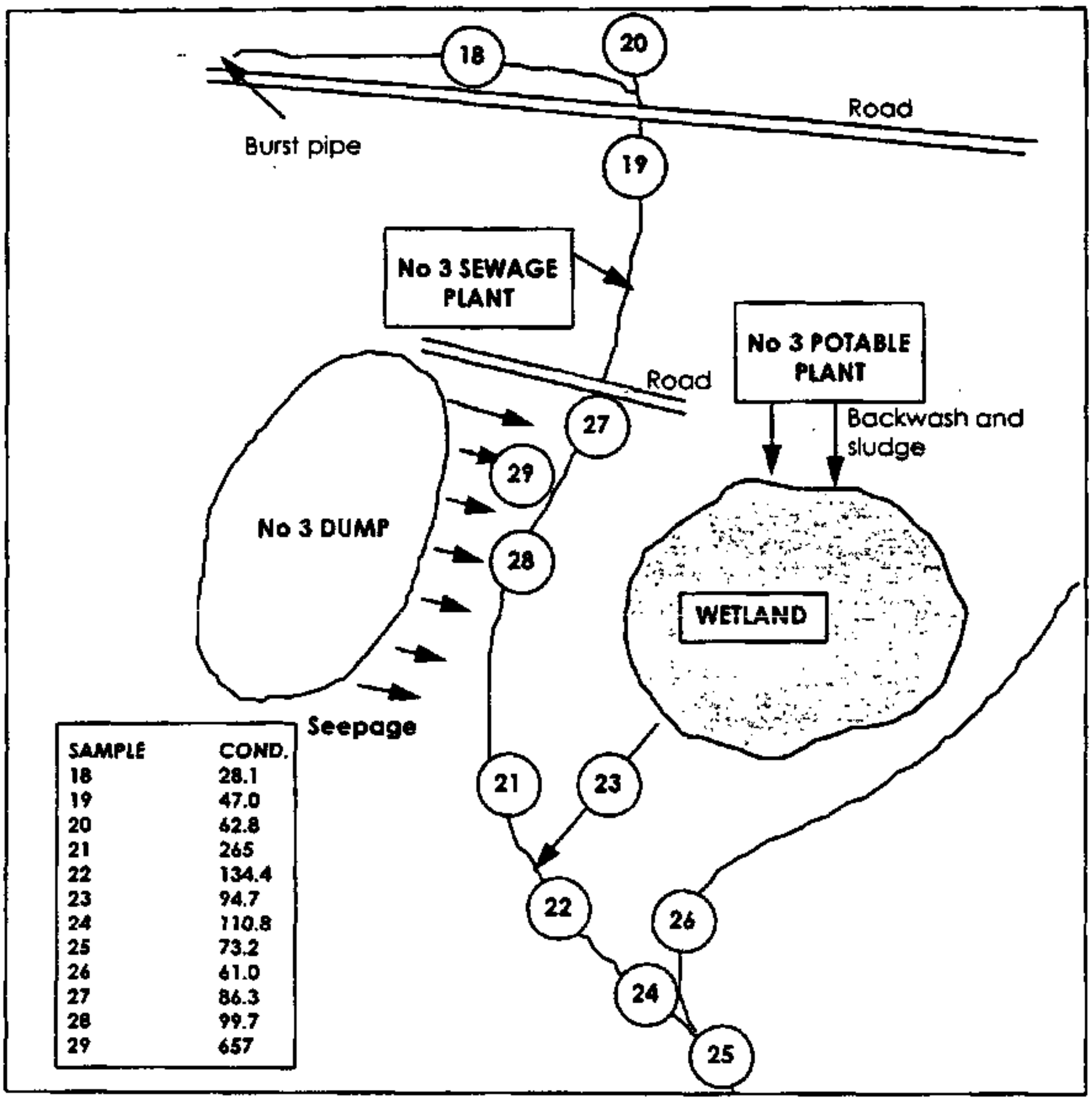


Figure 4 : Sampling Programme Around No 1 Discard Dump

3.2.2 Potable water systems

The mine operates two potable water treatment plants, being the No 2 and No 3 plants. The No 2 plant is the main potable water treatment plant, and can receive its raw water from two alternative sources - either the No 1 dam, or the Chelmsford dam. The raw water is pumped up into reservoirs, from where it flows by gravity to a radial inflow clarifier. Flocculant is dosed into the outflow from the raw water reservoir. Overflow from the radial inflow clarifier is treated in three parallel upflow sand filters. The filtered water is dosed with chlorine gas and pumped up to the potable reservoir from where it is distributed to the village, hostels and plant. The backwash water from the sand filters and the sludge removed from the clarifier is discharged to an open pit, where a portion of the water will evaporate, and excess water overflows into the veld.



SAMPLE	COND.
18	28.1
19	47.0
20	62.8
21	265
22	134.4
23	94.7
24	110.8
25	73.2
26	61.0
27	86.3
28	99.7
29	657

Figure 5 : Sampling Programme Around No 3 Discard Dump

No 3 potable plant draws its water from the No 3 dam. The No 3 dam is characterised as containing very turbid water, which can not be purified in the same manner as the water at the No 2 potable plant. The raw water to the No 3 potable plant is dosed with lime and alum, and then fed into a horizontal flow clarifier. The clarified water is then treated in three parallel upflow sand filters, with the filtered water being dosed with chlorine gas before being pumped into a potable reservoir from where it is then pumped to the end users. The backwash from the sand filters and the sludge from the horizontal flow clarifier are discharged into a wetland adjacent to the No 3 potable plant.

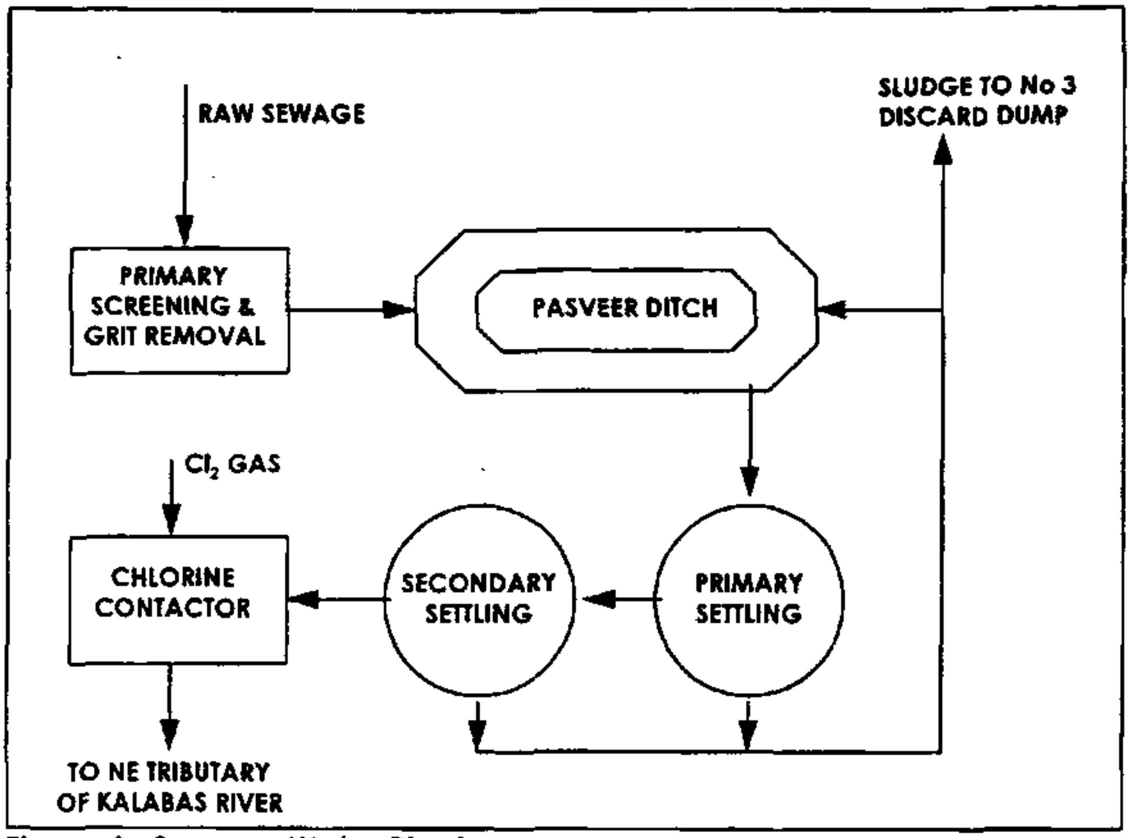


Figure 6 : Sewage Water Plants

The No 2 potable plant has a design capacity of 120m^3 / hour, while the No 3 plant has a design capacity of 45m^3 / hour. According to the mine, the cost of producing potable water is 37.5c /m^3. No serious problems are experienced at the potable water plants, although occasional problems are experienced at the No 3 plant, due to the very high turbidity of the water from No 3 dam. One of the associated problems with the potable water system is the potable distribution system, which is estimated to be in excess of 70 years old. Due to the age of this system, a number of problems are experienced with pipe failures, and this system has a fairly high maintenance requirement.

3.2.3 Plant water circuits

The only operational beneficiation plant at Durnacol is the No 7 plant. This plant obtains its raw water from a feed reservoir, which in turn receives water from the No 7 dam, as well as make up water from underground which is pumped up through the No 7 shaft. The No 7 plant discharges water through three streams being :

- surface moisture associated with the washed product
- surface moisture associated with the coarse discard material
- slurry

The bulk of the water discharged from the plant is contained in the slurry, which is discharged into slurry dams built within the new No 8 discard dump. The decant from these slurry ponds is returned, together with runoff from the

No 7 plant area, to the No 7 dam from where it is then pumped back to the reservoir feeding the No 7 plant.

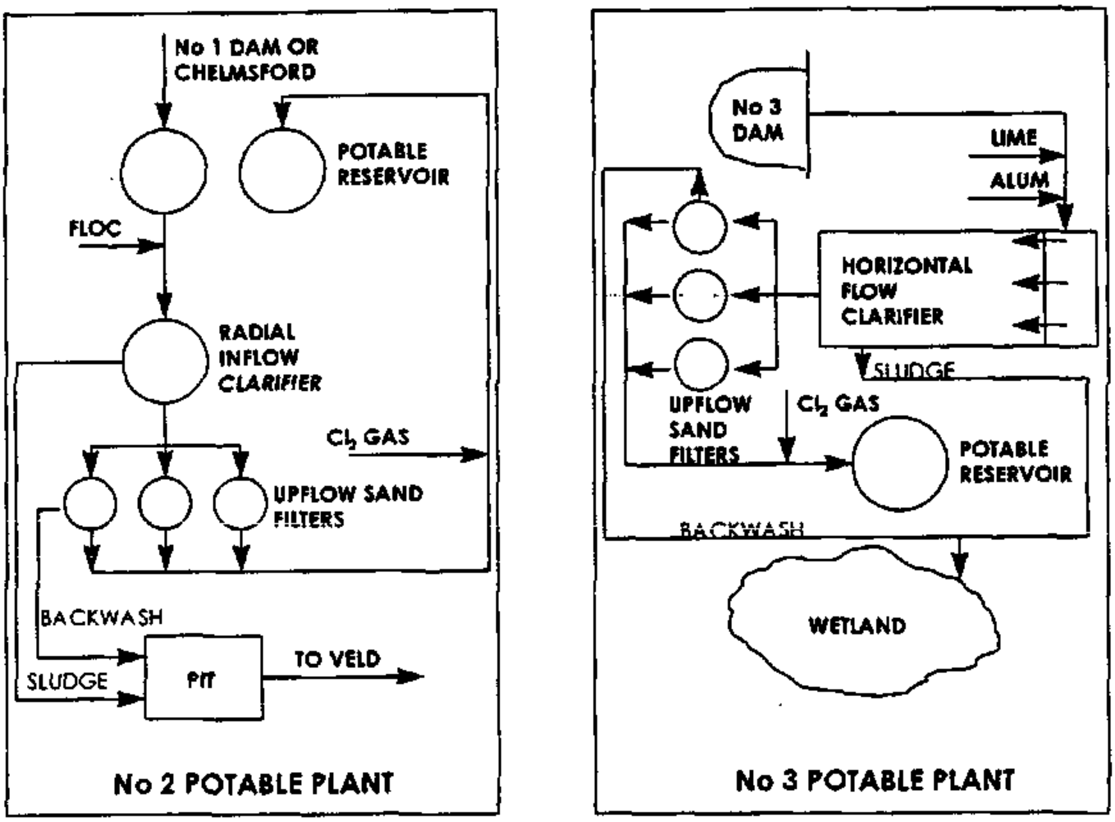


Figure 7 : Potable Water Plants

The No 7 dam overflows into the Kalabas river and at the time of the site visit, overflow was taking place. Due to problems, with siltation in the No 7 dam, it is proposed, in future, to pass the decant from the slurry dams through silt traps, before being allowed to overflow into the No 7 dam. These silt traps will then remove the silt ahead of the No 7 dam and can be easily cleaned, with the removed silt being deposited onto the No 8 discard dump.

3.2.4 Underground water circuits

The underground water circuits can be divided into two different systems. The one system receives clean water from the No 4 dam on surface. Water is pumped from the No 4 dam to header tanks close to the No 7 plant. These header tanks supply water underground to 5 shaft and 7 shaft. This water is very turbid and is filtered underground in a cartridge filter system, before being supplied to the hydraulic props used underground.

The main water supply used underground for mining purposes and for dust control receives ground water liberated by the mining activities. This groundwater is collected and reticulated underground for mining and dust control purposes, with the excess water being pumped up through 4 shaft, 7 shaft and 12 shaft. The water pumped up through 4 shaft and 12 shaft is discharged into settling dams which can overflow into a V-notch into the

Kalabas river. The water pumped up from No 7 shaft is discharged into the No 7 dam, from where it is then used in the No 7 beneficiation plant.

Potable water is also supplied underground at the shaft stations for drinking purposes.

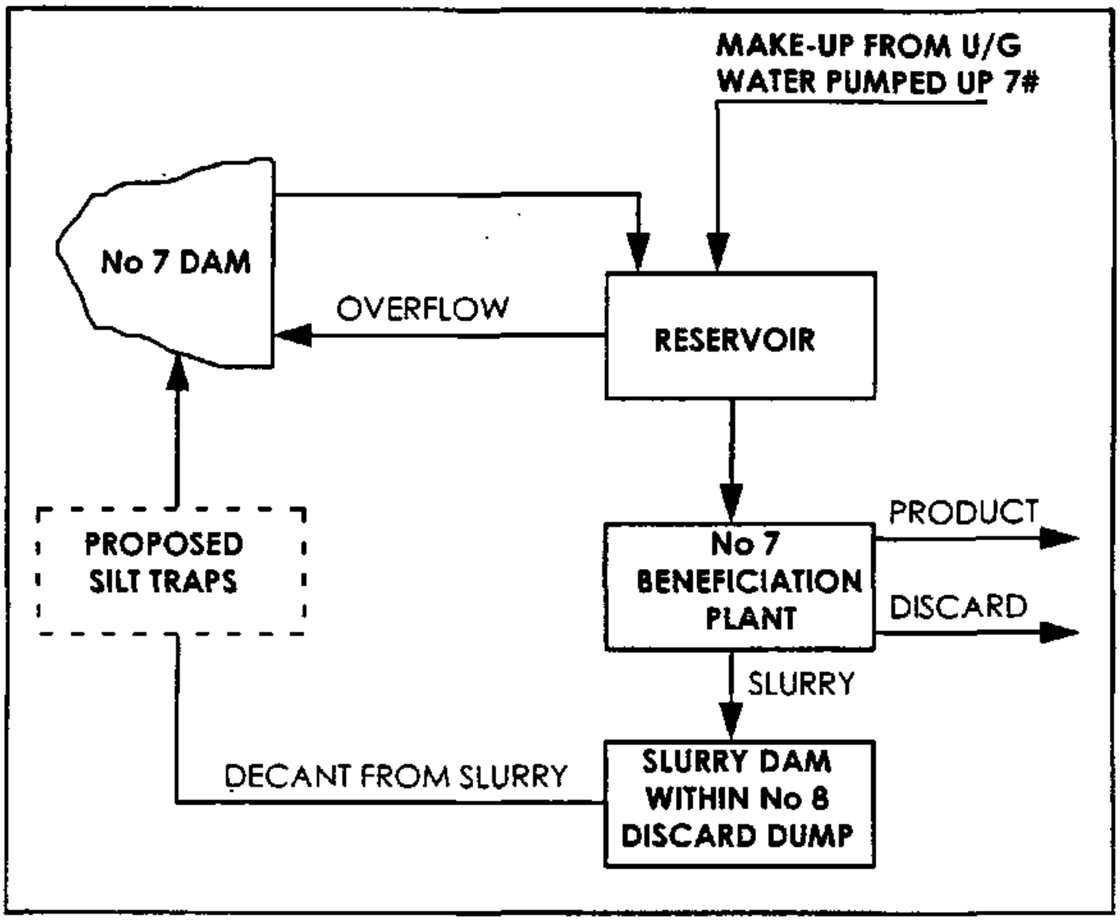


Figure 8 : Plant Water Circuits

3.2.5 Water monitoring systems

The mine does not have any continuous water flow or quality measurement or monitoring systems. The only flow measurement system in place is a V-notch, on the outflow of the settling dams receiving water from 4 shaft and 12 shaft, which is read on a weekly basis. Grab samples are taken at seven points on a monthly basis for a quality analysis. These seven points are:

- Outflow from the No 2 potable water plant
- Outflow from the No 3 sewage treatment plant
- Outflow from the No 5 sewage treatment plant
- Outflow from the No 3 potable water plant
- Potable water as supplied in Dannhauser
- Discharge at the V-notch below the settling dams.
- Water pumped up from underground through No 4 shaft.

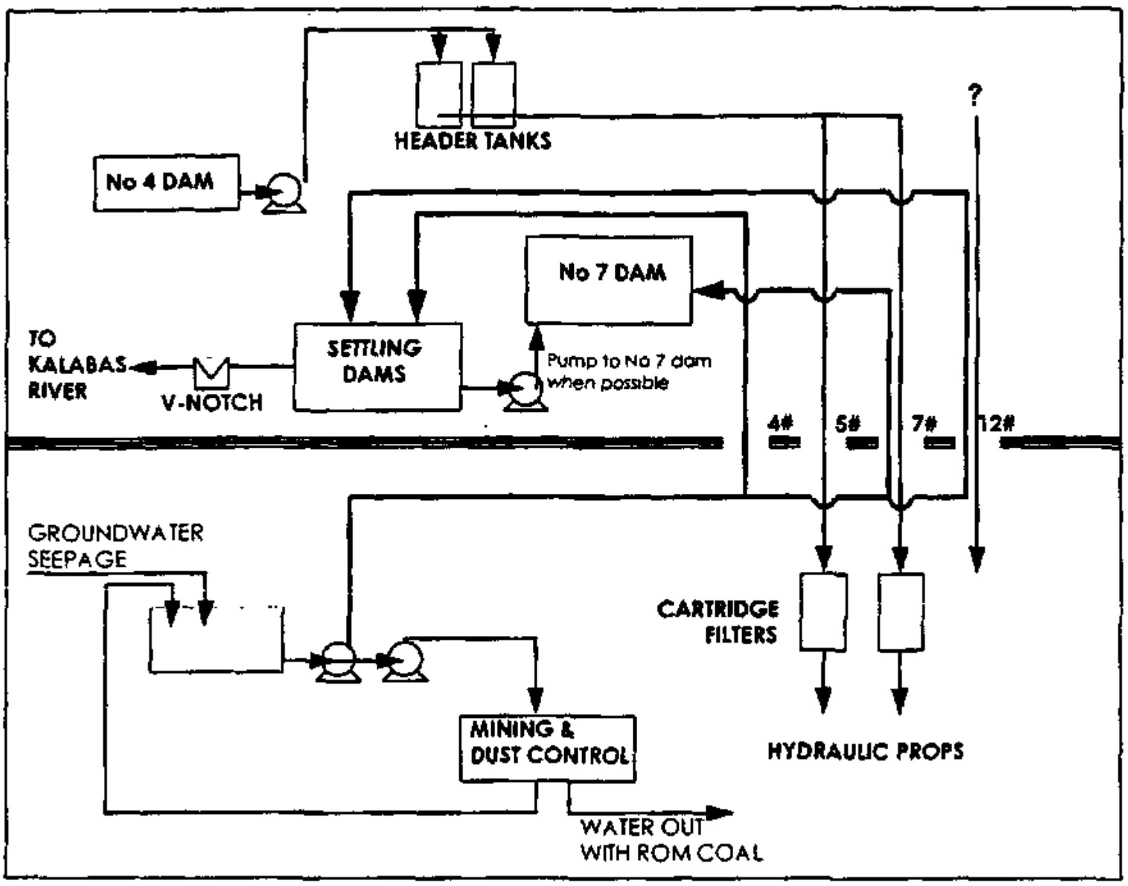


Figure 9 : Underground Water Circuits

3.2.6 Water management structure

The water management structure is shown in Figure 10 below.

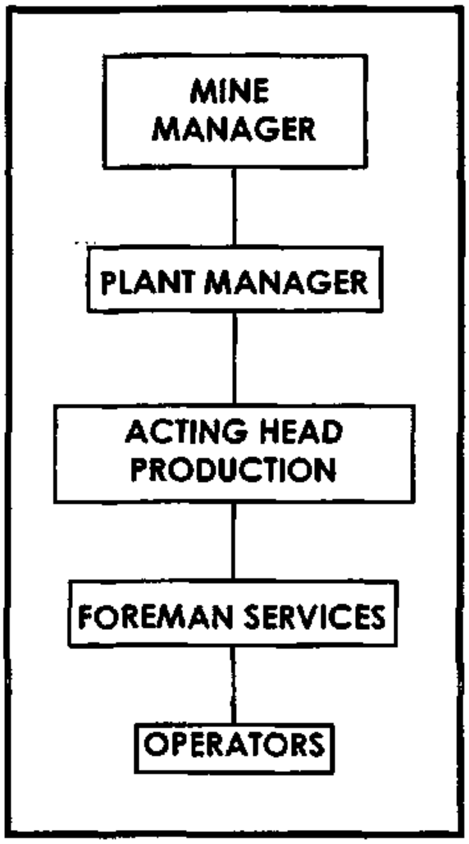


Figure 10 : Durnacol Water Management Structure

3.3 NOVEL OR UNIQUE WATER TREATMENT AND MANAGEMENT SYSTEMS

3.3.1 Brickworks

The No 1 discard dump is essentially burned out and consists largely of ash. Although the ash has a lower pollution potential than fresh discard, the conductivity readings taken in the wetland below the No 1 ash dump clearly indicate that this dump is still contributing polluted effluent to the surface water systems.

The pollution problem of the No 1 ash dump is being addressed in a fairly novel manner. An independent contractor has set up an operation adjacent to the ash dump to produce building bricks. The ash is removed from the dump, is screened manually, is then mixed with water and cement and is converted into building blocks. These building blocks are supplied to the mine for construction purposes, and also to the local community for the purpose of building houses. This is seen as a particularly useful and novel approach to addressing the long term problems associated with a discard or ash dump.

3.4 POTENTIAL WATER TREATMENT/MANAGEMENT PROBLEMS AND NEEDS

As a result of the discussions and site visits, a number of issues were identified where knowledge gaps still exist.

3.4.1 Management of diffuse pollution sources

Being an underground operation, Durnacol has relatively few sources of diffuse pollution, in addition to the No 7 plant area, where a large amount of coal is spread around on the surface and a potential diffuse pollution source exists, the main diffuse pollution sources are the discard dumps. The No 7 discard dump has drainage systems and surface runoff systems which feed the polluted water into the No 7 dam. The No 2 discard dump is in the process of being finally rehabilitated, and is located some distance away from any surface water courses. The No 1 discard dump is being recovered at the brickworks, as discussed earlier in the report. The main source of diffuse pollution is the No 3 discard dump.

The extent of the diffuse pollution from the No 3 discard dump is quite clearly shown in Figure 5. An extensive sampling programme was undertaken during the site visit along the tributary of the Kalabas river which runs adjacent to the No 3 dump. The results of this sampling programme, which are shown in Figure 5 and in Appendix A clearly indicate that the quality of the water deteriorates from a conductivity of 47 mS/m upstream of the No 3 dump, to a level of 265 mS/m downstream of the No 3 dump. The pollution control systems in place at the No 3 dump are clearly not succeeding in preventing diffuse pollution from this dump entering into the surface water systems.

The mine does not have any monitoring programme which would enable it to quantify the contribution of diffuse pollution from No 3 dump to the total salt load being discharged by the mine. This information will only become available once the mine has the ability to put together a fairly detailed water and salt balance, as is discussed in section 3.4.4 of this report.

3.4.2 Management of point source discharges

At the time of the site visit, a number of substantial point source discharges of effluent to the Kalabas river were noted, in particular, these include the following:

- Water pumped up from underground through No 4 shaft
- Water pumped up from underground through No 12 shaft
- Overflow from the No 7 dam
- Treated sewage from the No 3 sewage plant
- Treated sewage from the No 5 sewage plant
- Backwash water and sludge from the No 3 potable water plant.

Although the mine has a permit from the Department of Water Affairs which specifies a given volume of water at a given quality, the mine does not have any systems in place which enable it to determine whether or not these permit conditions are being met. Furthermore, although the approved EMPR includes an undertaking to eliminate the point source discharges of effluent to the Kalabas river, at the time of the site visit, substantial volumes of point source effluents were being discharged. in order to reduce these point source discharges in a structured, practical and cost-effective manner, the mine will have to have access to a detailed water and salt balance as discussed in section 3.4.4 of this report.

This water and salt balance could then be used to design a water reclamation system. Such a water reclamation system should aim at ensuring that the only point source discharge of salts from the mine would be with the surface moisture attached to the coal product and the coarse discard. All other water streams should be reused as far as possible within the plant and the underground mining systems. Surplus water which needs to be discharged from the mine should be of as high a quality as possible.

3.4.3 High salinity - corrosion

According to mine personnel, the No 7 beneficiation plant has experienced quite severe problems with corrosion, due to the high salinity of water contained within the No 7 dam. As a result of these corrosion problems, the No 7 plant is in the process of replacing many of its carbon steel components with stainless steel components. In addition, the hydraulic props used underground, which used to use water from the No 7 dam, have had to convert from No 7 dam water to No 4 dam water as a result of corrosion problems. Again, the solution to the high salinity problems and the resultant corrosion problems experienced by the mine lies in the development of a detailed water and salt balance which can then be used to manage the quality of the mine water systems.

3.4.4 Water and salt balance

A detailed water and salt balance should be viewed by the mine as the most fundamental and important water management tool which is available to it. Although Durnacol has prepared a water balance, as shown in Figure 3, this balance only takes account of those flows which are contained within various pipelines. The mine does not have access to a proper water balance which integrates the mine operations with the surface environment, in particular, the influence of hydrology in terms of flows within the surface water courses, rainfall, runoff within plant areas, seepages, evaporation effects and discharges into the groundwater are all aspects which the mine is unable to quantify, in addition to a proper water balance, the mine also requires access to sufficient water quality data to enable it to prepare a detailed salt balance. This water and salt balance can then be used by the mine to develop water reclamation systems, to design pollution control strategies, and to generally reduce the environmental impact which the mine has on both the ground and surface water systems. Without access to such a water and salt balance, it will be very difficult to properly direct the pollution control efforts of the mine.

3.4.5 Potable water plant impact on wetlands

No 3 potable water treatment plant discharges both backwash water and sludge from the horizontal flow clarifiers into the adjacent wetland. Although this practice has probably contributed to the establishment of the wetlands, it should be noted that the discharge of high levels of suspended solids such as is contained in backwash water and clarifier sludge, will have a long term negative impact on the wetlands, and this practice can be expected to result in the siltation and clogging of the wetland.

3.4.6 Management and monitoring systems

As discussed elsewhere in the report, the mine does not have appropriate flow or water quality monitoring systems. The monitoring systems are inadequate in terms of enabling the mine to prepare a water and salt balance, and in addition, the existing monitoring systems do not enable the mine to determine whether or not it is complying with the requirements of its water discharge permit. At the same time, without access to these monitoring systems, the mine will not be capable of monitoring the compliance with the approved EMPR.

3.4.7 Ground water systems

No information is available on the impact of mining activities on the ground water systems and this will need to be rectified in order to manage the mine's environmental impact.

3.4.8 Burning dumps

Although the burning dumps have their primary impact on air pollution, the fact that these dumps are burning prevents them from being properly rehabilitated, thereby increasing the negative impacts of these dumps on both the surface and groundwater systems. Appropriate water pollution control measures can only be properly implemented once the burning dumps have been brought under control and have been properly rehabilitated.

4. GENERAL IMPRESSIONS

The general impression gained from the site visit is that the mine has significant impacts on the surface and groundwater systems, which are presently not being adequately managed. Many of the current environmental impacts of the mine are avoidable, and can be addressed and rectified once the mine has access to an accurate water and salt balance.

The mine's potable and sewage treatment plants appear to be well operated and well managed, and mine personnel in charge of these plants have the appropriate qualifications and expertise to ensure that these plants continue to be properly operated.

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. The following is a list of the readings taken:

No	Description	pH	Cond.
1	No 1 dam	6.79	27.3
2	Wetland below No 1 discard dump	3.70	158
3	Klipspruit under Dannhauser road	7.82	101
4	Chelmsford dam water in storage reservoir	7.83	29.8
5	Inflow to No 2 dam	6.94	87.6
6	NE tributary of Kalabas on road from No 3 plant to No 3 dam	8.25	82
7	Inflow to No 3 dam	8.45	46
8	Seepage from settling ponds / toe paddocks of No 3 dump	7.34	701
9	Underground pumpage ex No 4 shaft	8.54	510
10	Discharge from No 12 shaft	8.61	711
11	NE tributary of Kalabas at No 5 shaft hostel	8.55	40.8
12	SW tributary of Kalabas at tar road to No 7 shaft	6.75	393
13	Slurry decant from No 8 dump	7.66	772
14	No 7 dam	8.41	621
15	No 4 dam	8.32	24.8
16	Kalabas upstream of mixing point with No 4 dam overflow	8.11	345
17	Kalabas downstream of mixing point with No 4 dam overflow - at DWA&F weir	8.04	232
18	Flow along road from burst pipe into NE tributary of Kalabas	8.07	28.1
19	NE trib. of Kalabas on road from No 3 plant to No 3 dam	8.19	47.0
20	NE trib. of Kalabas upstream of join with sample 18	8.27	62.8
21	NE trib. of Kalabas upstream of join with wetland inflow	7.69	265
22	NE trib. of Kalabas downstream of join with wetland outflow	8.07	134.4
23	Outflow from wetland into NE tributary of Kalabas	8.30	94.7
24	NE trib. of Kalabas downstream of sample 22 but upstream of join with No 3 dam overflow tributary	7.84	110.8
25	NE trib. of Kalabas downstream of join with No 3 dam overflow tributary	8.07	73.2
26	No 3 dam overflow tributary	8.72	61.0
27	NE trib. of Kalabas at bridge below No 3 sewage plant	7.52	86.3
28	NE trib. of Kalabas 50 m below sample 27	7.72	99.7
29	Seepage between samples 27 and 28 from No 3 dump	7.87	657

All conductivity measurements are in mS/m

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:

Photograph No	Description
1	No 1 dam
2	Klipspruit under Dannhauser road
3	No 1 discard / ash dump
4	Wetlands below No 1 discard / ash dump
5	Brickworks at No 1 discard / ash dump
6	Top of No 1 discard dump
7	No 2 dam
8	No 3 discard dump (SE section / face)
9	Inflow to No 3 dam
10	Settlers at No 3 potable plant
11	Filters at No 3 potable plant
12	No 3 sewage treatment plant
13	No 1 settling dam
14	V-notch on outflow of mine water to Kalabas river
15	Seepage from No 3 dump settling ponds / toe paddocks
16	Discharge from No 12 shaft
17	NE tributary of Kalabas river at 5 # hostel
18	Slurry decant from No 8 dump
19	View across No 7 dam to plant
20	No 4 dam
21	Mixing point of Kalabas and No 4 dam overflow
22	DWA&F weir on Kalabas below mixing point with No 4 dam overflow

THE DURBAN NAVIGATION COLLIERIES (PTY) LIMITED

FIGURE 1

INFRASTRUCTURE

EAST AREA

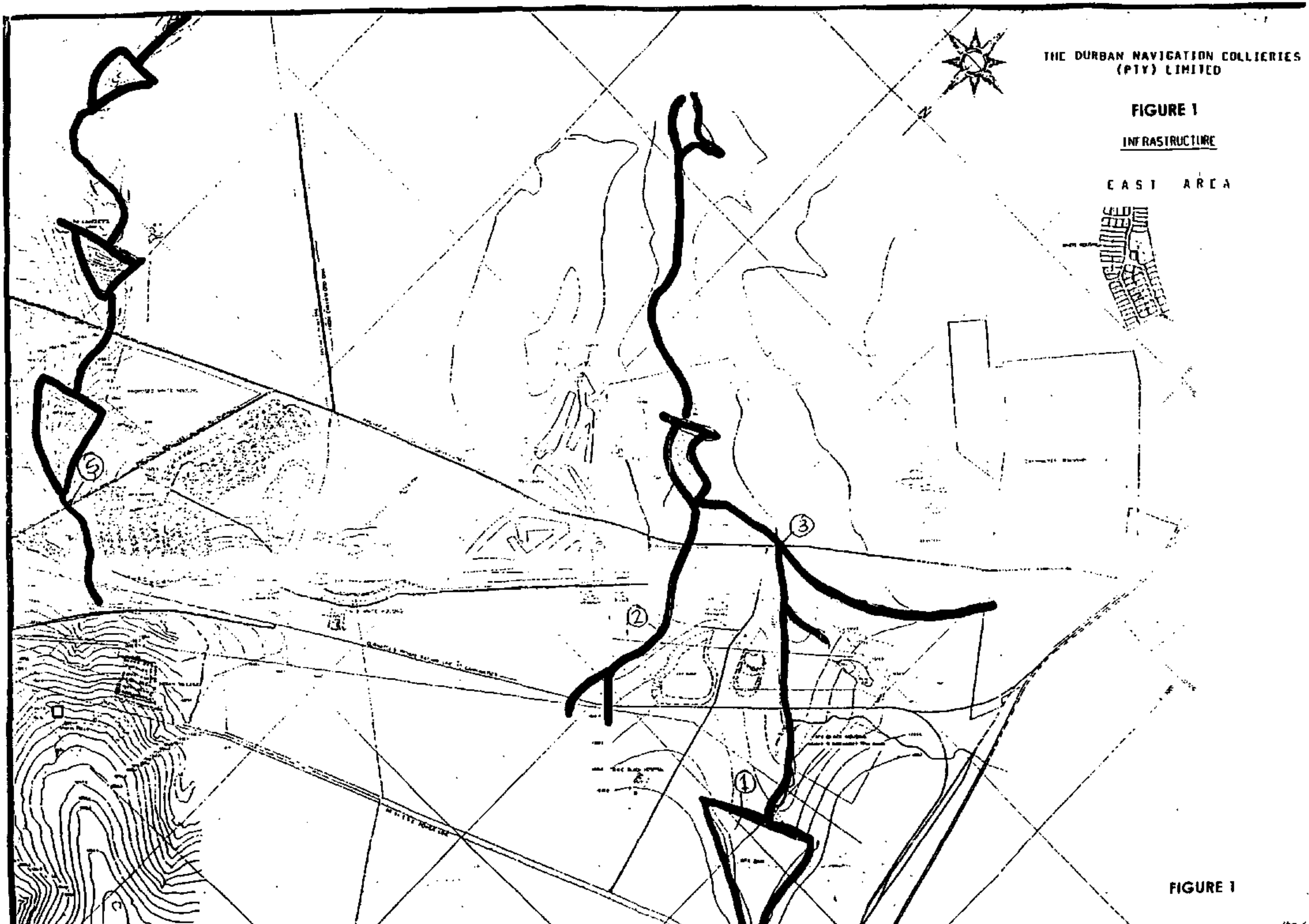
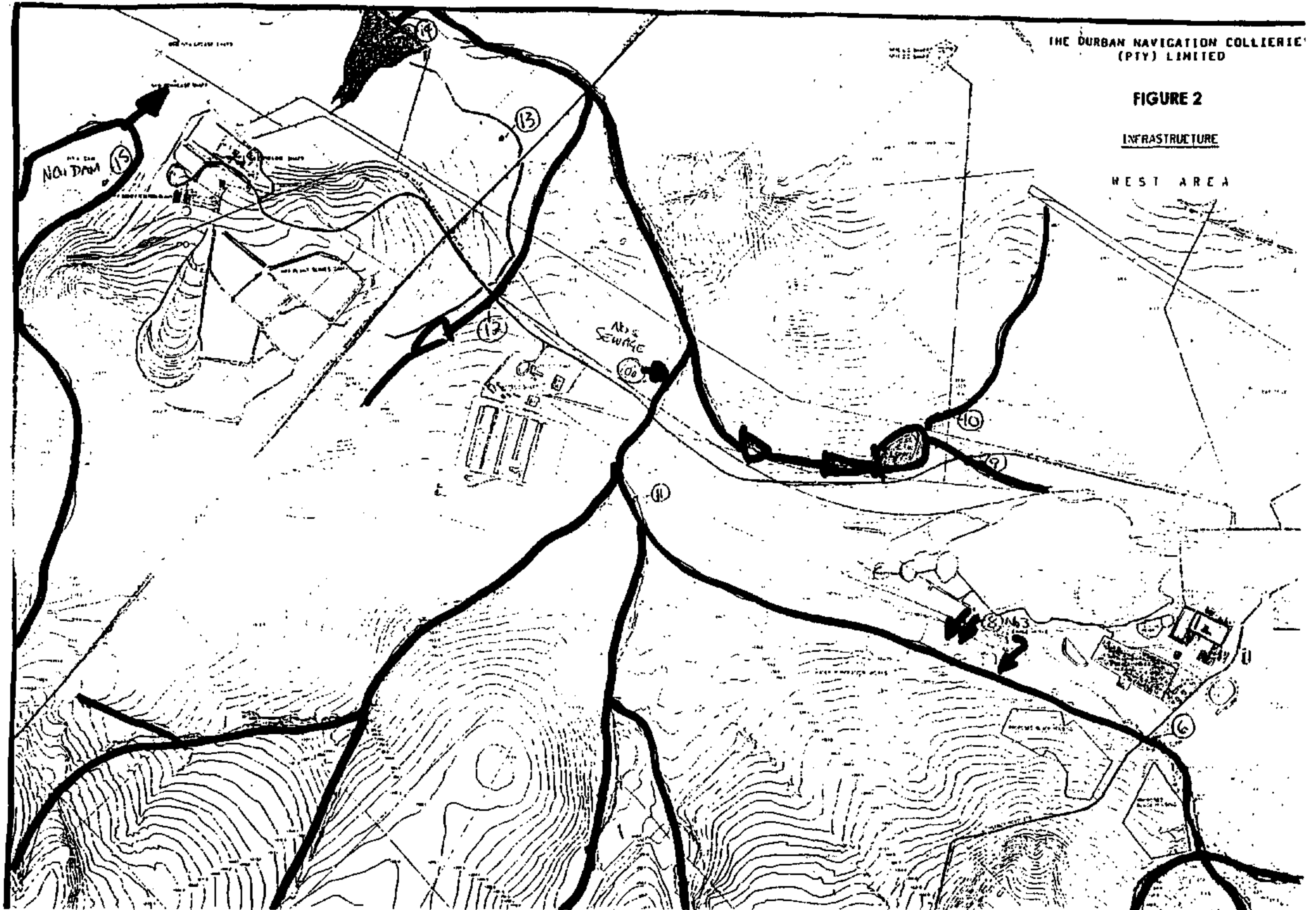


FIGURE 1



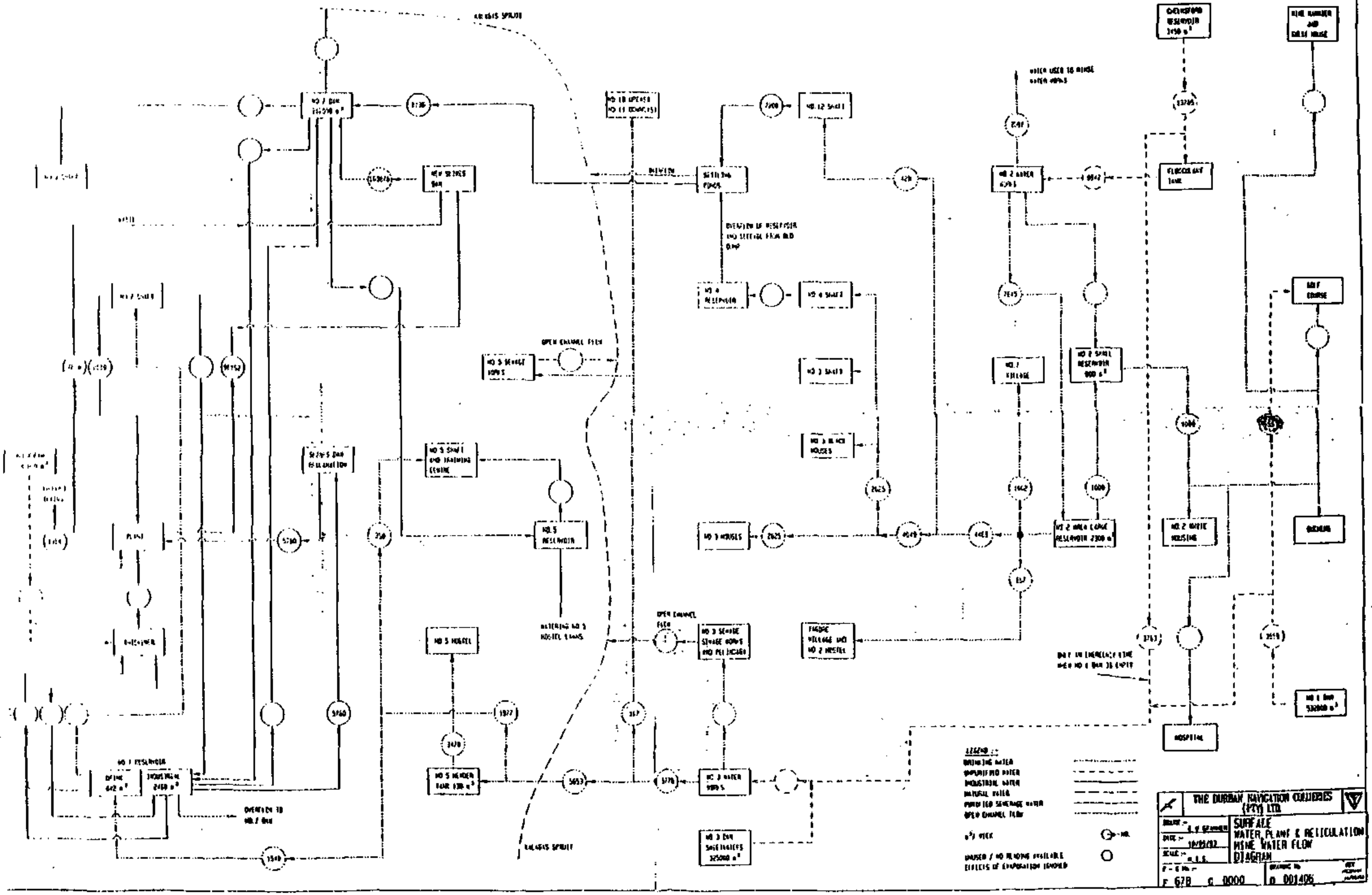
THE DURBAN NAVIGATION COLLIERIES (PTY) LIMITED

FIGURE 2

INFRASTRUCTURE

WEST AREA

FIGURE 3


THE DURBAN NAVIGATION COLLIERIES (PTY) LTD
SURFACE
WATER, PLANT & RETICULATION
MINE WATER FLOW
DIAGRAM
LEGEND :-
NO 1 DAM
HOSPITAL
F 67B C 0000
D 001406

Report on Duvha Opencast Services Site Visit.

16 - 17 September 1993.

1. GENERAL INFORMATION

Name of mine	Duvha Opencast Services
Name of person(s) completing questionnaire	Chris Theart Donald Winn
Position of person(s) completing questionnaire	Planning Officers
Nearest town	Witbank
Name of catchment	Boschmanskrans (Subcatchment of Witbank Dam)
Monthly coal throughput (rom)	800 000 tons per month
Monthly saleable product	Approximately 800 000 tons per month
Monthly discard production	Very little discard (2-3 %) - no washing plant
Main product and market	Duvha Power Station
Current age of mine	ca. 13 years
Expected remaining life of mine	ca. 30 years
Type of mining carried out	Opencast with draglines
Transport mode from pit to plant	135 ton road haulers
Has the mine already produced an Environmental Management Programme Report	First draft report has been completed and discussed with DWA. A number of changes to be implemented.

2. SITE VISIT PROGRAMME

2.1 Day 1- 16 September 1993

- Arrival
- Short discussion of project background and objectives
- Short introductory presentation of environmental activities on Duvha mine by Mr A J Pretorius
- Present at meetings:

Marshall	- Planning Manager, Duvha
A J Pretorius	- Geologist
G Trussler	- Env. Officer, Randgold
C Theart	- Planning Officer, Duvha
D Winn	- Planning Officer, Duvha
L de Lange	- PHD
W Pulles	- PHD

- Guided tour of the mine premises
- Completion of questionnaire

2.2 Day 2 - 17 September 1993

- Arrival
- Discussion of various problems experienced by mine personnel responsible for the completion of the mine's EMPR and water management.
- Visit sewage treatment plant
- Completion of questionnaire
- Present: D Winn
  C Theart
  L de Lange
  W Pulles

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

3.1 DESCRIPTION OF WATER CIRCUITS

The following diagrams are presented as a schematic summary of the major water circuit components as identified during the site visit. Unfortunately, a detailed water balance was not available at the time of the site visit and the flow diagrams presented here have been developed from personal observations and, therefore, do not include flowrates.

Figure 1 is an overview of the main components of the surface and groundwater systems of the mine. No information was obtained with regard to surface runoff and infiltration rates. Some of the more important features such as the reedbeds and continuous monitoring station, are also indicated.

Figure 2 shows the different users of potable water that were identified during discussions. Where possible, the effluents generated are also indicated e.g. the sewage treated at the sewage treatment plant. The sewage treatment plant is shown diagrammatically in more detail.

Figure 4 shows the basic elements of the "dirty water" system where water pumped from the pitfloor is limed, stored in a settling/ evaporation dam and used for dust suppression on the haul roads.

3.2 DESCRIPTION OF WATER TREATMENT/MANAGEMENT SYSTEMS

3.2.1 Sewage treatment plant.

The general impression formed about the sewage treatment plant is that it is well maintained and characterised by good housekeeping. As far as could be determined, all equipment was kept in a state of good repair.

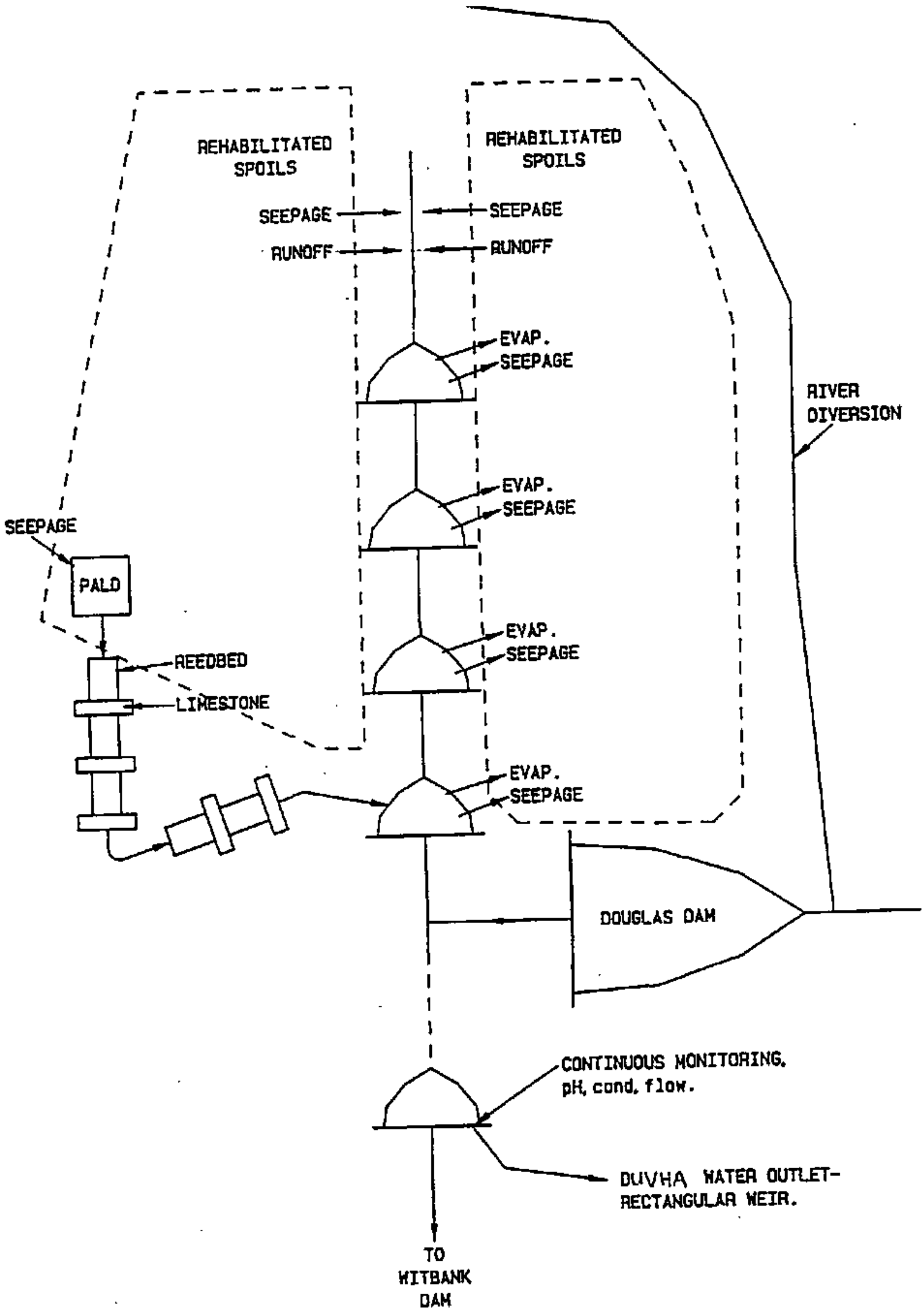


Figure 1 : Main components of the Duvha surface water system

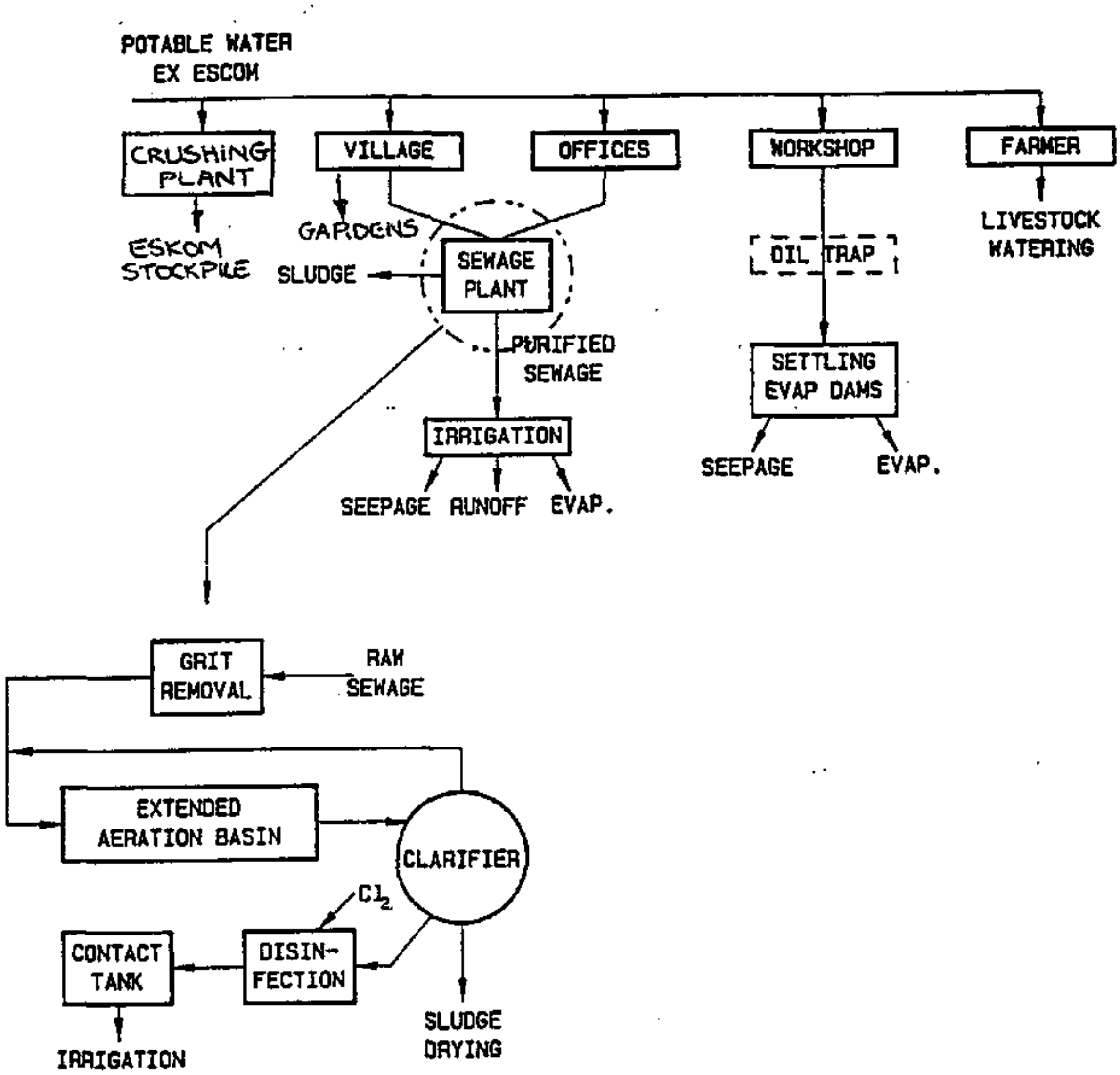


Figure 2 : Potable water and sewage circuits

Inspection of the chemical analysis of the effluent stream, indicated a high phosphate concentration (4 - 16 mg/l as P). The amount of duckweed in the dam below the plant would tend to indicate that the dam receives a high nutrient load.

It was pointed out that the mine intends terminating the practice of discharging treated sewage effluent into the dam. The treated effluent is currently being used for irrigation of kikuyu grass to be used in the rehabilitation programme. It was observed, however, that the irrigation takes place in close proximity to the dam mentioned earlier and the danger still exists that nutrients could find their way into the dam via seepage or runoff.

An unusual characteristic of the chemical analysis of the effluent, is the general absence of nitrates and ammonia in the effluent, despite the very small anoxic zone present in the treatment plant. No explanation could be offered for this phenomenon.

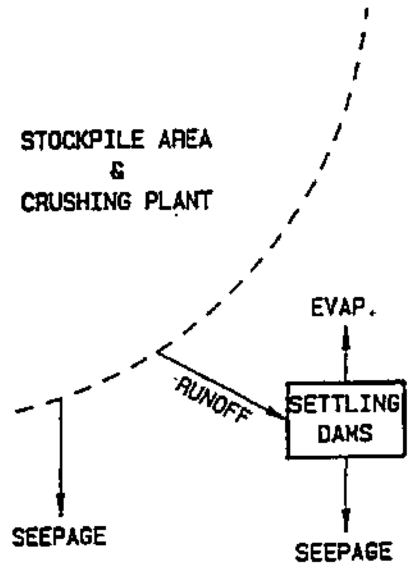


Figure 3 : Runoff from crushing plant and stockpile area

At the time of the site visit, no technical information with regard to the design and operating parameters was available. No information regarding the capital and operating costs were available. This data will be forwarded to PHD as soon as possible.

3.2.2 pH adjustment of the water pumped from the pitfloors.

The pH of the water pumped from the pitfloors is adjusted by manually adding dry hydrated lime to the water before it is discharged into a settling/ evaporation dam. The water in the dam is used for dust suppression on the haul roads. This water circuit is referred to as the dirty water system.

The lime feeder is manually operated. The person responsible for operating the system takes pH readings of the water being pumped to the settling dam from the pit on a daily basis. The amount of lime added is determined on the basis of previous experience, rather than on a calculated result.

In general terms, where the quality of the inflow is variable, some form of automated pH control is required. However, at Duvha, the pH of the inflow is generally neutral or slightly acidic with little demand for lime addition and the present system therefore functions quite adequately. If the inflow was to become more acidic with increased pH variability, then the manually operated dry lime feeder would not be appropriate for two reasons. Firstly, variable pH of inflow water will require equivalent variation in lime dosage which could only be provided by an interactive pH control loop and, secondly, dry lime reacts too slowly to allow for automated control of lime addition.

Based on the results of the monitoring programme showing the pH of the water in the settling dam, the present system works quite effectively and a more complex control system would not be warranted. The existing system is simple with minimal capital and operating costs.

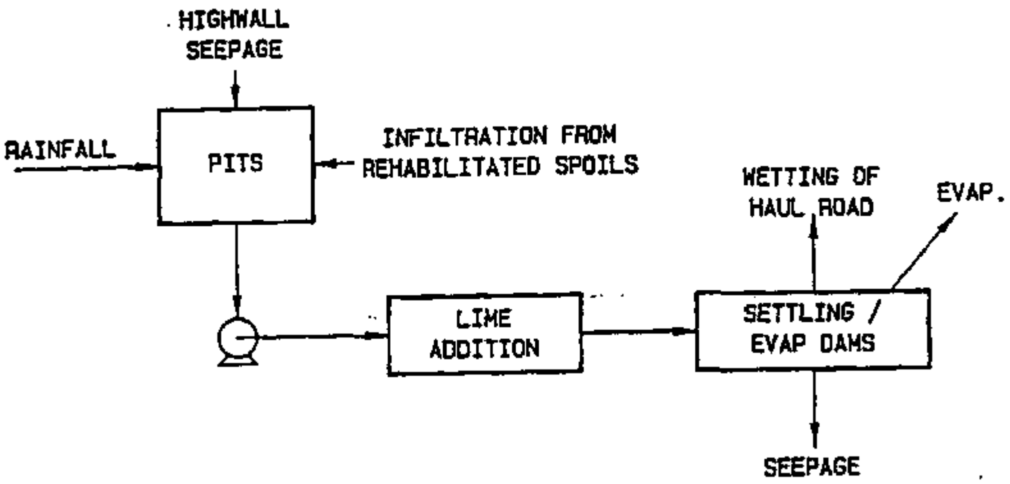


Figure 4 : Dirty water system

3.2.3 PALD and reedbeds.

The system comprises a PALD with five reedbeds in series, separated by limestone berms. The system was designed for a sub-surface flow of approximately 1 000 l/h. The system is largely experimental and does not occupy a large area.

The system was designed to treat an acidic seep. The objective of the system is to increase the pH of the inflow to an acceptable level and to reduce the salinity (SO_4, Mn and Fe) of the seep. Initial problems were experienced with blinding of the limestone chips in the PALD. In an effort to address this problem, the system was modified by increasing the size of the limestone chips in the PALD from 6mm to 25 - 30mm. In addition, modifications are to be made to create anoxic conditions at the inlet to the PALD. The mine believes that this system is very good for heavy metal removal, especially iron.

The results of the monitoring programme indicate that the PALD and reedbeds are reasonably successful in adjusting the pH of the seep but have little effect on reducing the salinity of the seep.

Full details of the capital costs associated with the construction of the system were not available. The operating costs of the experimental system are estimated to be fairly low, and are mainly associated with replacement of the limestone chips, and cutting of the reeds.

Some of the problems cited are blinding of the PALD and the destructive efforts of birds in the reeds during the drier periods.

The effluent from the reedbeds, is discharged to the surface water system.

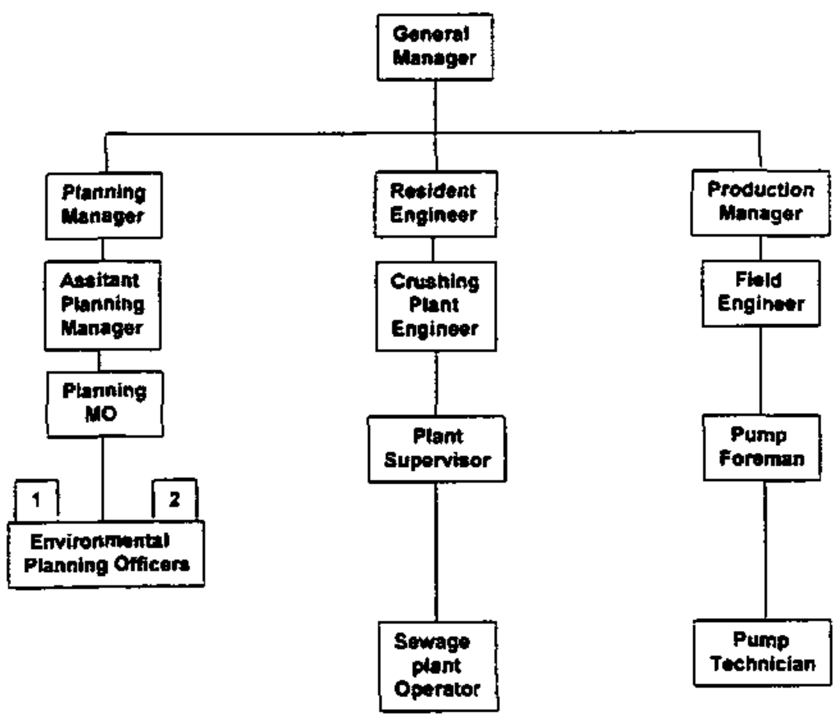
3.2.4 Settling dams and evaporation dams

A number of evaporation and settling dams were constructed at various locations. The following were identified as being the more important settling/evaporation dams on the mine premises:

- A dam receiving the neutralised water pumped from the pitfloors (the "dirty water circuit"). The details of this system are more fully described in section 3.2.2 above.
- A dam receiving surface runoff from the crushing plant area and coal stockpile area. The water is collected in an unlined earthen trench running along the periphery of the stockpile area and discharges into two parallel settling dams. The water from this dam is currently not reused and is allowed to evaporate.
- A dam receiving surface runoff from the workshop area. The water from the workshop area is mainly contaminated with oil, detergents and suspended matter. The mine is currently in the process of designing and installing an oil trap to intercept oil before it enters this dam. The water from this dam is currently not reused and is allowed to evaporate.

3.2.5 Water management structure

The following diagram showing the water management structure at Duvha was produced during the meeting on 17 September 1993.



3.3 NOVEL OR UNIQUE WATER TREATMENT AND MANAGEMENT SYSTEMS

3.3.1 PALD/reedbeds system

This system, although on an experimental scale, can be considered to be a reasonably unique mine water treatment system. This system is discussed in more detail in Section 3.2.3 above.

3.3.2 Possible GIS system

The mine is seriously investigating the option of installing a GIS system to form part of the planning and management systems. The potential application of this system for environmental management is recognised. The mine is optimistic about the possibility of transferring all environmentally related data onto the system. It is expected that their extensive surface and groundwater monitoring programme will produce the data that will enable them to use a GIS system as a practical and effective water management tool in future. If this system is installed at the mine, and used to the full extent of its capabilities for water management, then the mine will certainly be one of the forerunners as far as modern water management in the South African mining industry is concerned.

3.3.3 Staff approach to water management

A striking feature of the Duvha water management system, is the obvious enthusiasm with which the staff involved approach their task. During the meetings and interviews, it was observed, in more than one way, that the desire to tackle the water management problems that still exists is strong. It also appears that the operational staff enjoy strong support from top management.

3.4 POTENTIAL WATER TREATMENT/MANAGEMENT PROBLEMS AND NEEDS

During the discussions, a number of issues were identified where knowledge gaps still exist.

3.4.1 Sulphate load discharged to the surface water environment

Release of sulphate to the surface water bodies was identified as the major water quality problem experienced by the mine. At present, the mine is undertaking a number of studies with the aim of establishing the extent and source of the problem. In order to achieve this objective, a number of boreholes were drilled and specially lined to enable monitoring of groundwater quality. At present the mine has not yet identified a solution to the sulphate problem and no sulphate balance has been attempted.

3.4.2 Use of shale for construction purposes

Shale, due to its low cost and availability, is widely used for construction purposes throughout the mine. A number of roads, berms, dam walls, spillways etc. constructed from shale were observed during the site visit. The potential of this material to act as a non-point source of pollution and subsequent deterioration of water quality, has not been fully investigated by the mine.

3.4.3 Alteration of surface hydrology

The potential implications and impacts of actions that influence the catchment hydrology are not understood and have not been investigated in detail. For example, a series of dams have been constructed on the major watercourse flowing through the mine, supposedly for aesthetic reasons, without having defined the impact on catchment hydrology and downstream receiving body water quality.

Investigations carried out by PHD on a different catchment, indicated that such interference with surface hydrology can inhibit the flushing effect of a rainstorm and can negate the potential benefits for the water quality of a downstream waterbody such as the Witbank Dam. Interference with catchment hydrology can also enhance the negative effects of evaporation on water quality. Although the uniqueness of each catchment is recognised, such an investigation for the catchment in which Duvha is situated, could make an input into addressing the sulphate problem. The mine believes that the dams serve a useful purpose for recreation, providing a focal point for the mine personnel - thereby heightening awareness of the quality of water in the dam.

3.4.4 Haul roads as a potential source of pollution

The potential for the haul roads to act as a non-point source of pollution, should be investigated. The contribution of salts distributed on the road surfaces during wetting of the haul roads to catchment water pollution is not known. The potential for leachate and runoff from fine coal wastage along the haul roads to catchment water quality is also not known. The volume of water spread onto the roads is not monitored and the amount of salts that could ultimately report to the surface water due to this practice can, therefore, not be estimated.

3.4.5 Water management system

According to the diagrammatic representation of the water management system shown in Section 3.2.5, the Engineering and Planning Departments are the two main players involved. It appears that the Engineering Department is more involved with the issues relating to the day to day use and treatment of water, and the Planning department with the environmental issues such as EMPR related requirements e.g. monitoring programmes and investigations.

On the basis of information obtained from the mine, it would appear that the two functions are not integrated into a single middle management function as each Department reports directly to the General Manager. As water resource planning, water use, water reclamation, water treatment, effluent disposal and environmental impact are all interrelated, an effective water management system requires the integration of these responsibilities at an operational rather than senior management level.

3.4.6 Training and expertise of personnel responsible for water management

It would appear as if environmental management at the mine has historically focused largely on land rehabilitation. Water management appears to only recently have become a major issue and the mine does not have staff with specialist water management knowledge. This has potential negative impacts on the success of water management strategies at the mine and could also make it difficult for the mine to counter arguments presented by trained and experienced staff from the Department of Water Affairs.

Additional training in water treatment and management practices was identified by the mine personnel as an important need. It was indicated that the mine is presently very reliant on Head Office personnel and outside expertise to guide them in their water management efforts.

3.4.7 Water resource planning

The observation was made that apart from discussions on water usage with Escom, no formal regional water resource planning is undertaken. For example, the mine does not know how its water systems are influenced by activities on neighbouring mines, or how it influences neighbouring mines, now or in the future - an adjacent mine would quite easily construct a minor dam or river diversion without discussion with Duvha or investigating the impacts on Duvha's water systems.

3.4.8 Water monitoring at the continuous monitoring station

The water quality monitoring station at the mine's main discharge point, the rectangular weir, is based on instruments which apparently do not function reliably. In addition, it was observed that the instruments are placed in a stagnant zone and recorded data would therefore not be representative of water passing over the weir with regard to pH and conductivity.

The Olifants river catchment study has indicated to the DWA that the mine discharges approximately 16 tons of sulphate daily. The mine disputes this estimate and it should therefore be a high priority to ensure that the monitoring station is operating effectively. This estimate of sulphate load has a significant impact on the mine's negotiations with the DWA on a waste load allocation and the chances of obtaining an approved EMPR.

3.4.9 Water quality data reported to the mine

The mine sends collected water samples for analysis at the Escom laboratory, although samples were previously analysed by the Douglas laboratory. The change was made for financial reasons - Escom provides the analytical service free of charge while Douglas laboratory was charging approximately R11 000 per month.

Inspection of the laboratory results, however, indicated some serious shortcomings and inconsistencies. Neither the alkalinity of the water, nor the carbonate speciation of the water is indicated in the results. This is regarded as a serious omission, since it would be impossible to perform certain manipulations of the data, e.g. water characteristics such as the potential for $CaCO_3$ and $CaSO_4$ precipitation or chemical dosing requirements for softening or neutralisation cannot be determined from this data.

It was further observed that some of the reported data was clearly erroneous with regard to the relationship between conductivity and total dissolved solids. In addition, a cursory examination of the data indicated that serious ionic imbalances were present.

3.4.10 Water quality - "fitness-for-use" criteria

Duvha has a fairly simple water reticulation system and practically all end users of water are supplied with water of a potable quality - including the water used in the workshops as wash water. Although the present mine operations would not obtain any significant benefit from the implementation of internal water reclamation circuits, future operations relating to the installation of a coal washing plant, would.

From the discussions it became clear that the mine does not have a knowledge of fitness-for-use requirements for the different end users and consequently would have difficulty in specifying a water reclamation strategy. Fitness-for-use criteria for coal washing plant applications therefore need to be obtained.

3.4.11 River diversion

The correct procedures and placement of the river diversion over the rehabilitated spoils after closure of the open cast operations is unknown. This is a common problem within the industry and requires a general research project to find the appropriate answers.

4. GENERAL IMPRESSIONS

4.1 ROLE OF THE EMPR

From the discussions, it was concluded that the EMPR is the single most important factor that has guided the mine in identifying and addressing its water management issues.

4.2 INVOLVEMENT OF MINE PERSONNEL IN REGIONAL ISSUES

Mine personnel are involved in the creation of the Olifant's River Forum and this exposure to broader water related issues, together with the enthusiasm and desire to learn which is evident at the mine, are expected to have positive impacts on the mine's water management philosophy and practice.

4.3 OPENNESS ABOUT WATER AND ENVIRONMENTAL MANAGEMENT ISSUES

The mine has a very positive attitude towards water and environmental issues, and is very open and approachable. It was observed that a substantial amount of staff appears to be involved, although some of them may only have superficial input. The desire to address water related problems on the mine, appears to be a genuine concern and is demonstrated by the fact that the mine exhibited a pre-EMPR interest in water treatment issues as evidenced by experimental PALD and reedbeds.

4.4 WATER BALANCE FOR THE ENTIRE MINE

As discussed elsewhere, the mine has a fairly simple water reticulation system as far as water usage is concerned. However, if the definition of the system is expanded to include surface water and groundwater systems, it becomes a lot more complex.

One of the more important observations that was made during the visit, is the absence of an accurate and detailed water balance, which must be regarded as one of the most basic water management tools available to the mine. It would not be possible for the mine to address issues such as water reclamation or strategic water resource planning without an accurate water balance.

Although no water balance information was available at the time of the site visit, it was pointed out by mine personnel that the required study was underway.

4.5 REHABILITATION

Due to the tendency of the spoils to burn quite rapidly, Duvha rehabilitate the open cast areas fairly quickly - thereby reducing the contribution of direct rainfall to in-pit water. The effect of recharge from seepage through the rehabilitated spoils is unknown.

4.6 WATER QUALITY SAMPLING

The mine has a very comprehensive water sampling and analysis programme - more so than most mines visited.

Appendix A - List of photographs taken during the site visit.

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

Photograph No	Description
1	The river diversion running parallel to the tar road.
2 - 4	Open cast operation - view of pits and draglines
5	In-pit pumping - dirty water circuit
6	Marshallsvlei Dams East and West
7 - 8	Liming plant on dirty water circuit
9	View of the dirty water dam in relation to neighbouring surface water dam
10	Braithwaite tanks at dirty water loading station - dust suppression on haul roads
11	N1,N2 open pits - water accumulated on pitfloor
12	Limestone box (PALD)
13	Reedbeds downstream of limestone box
14	Exit point of reedbed system
15	Canal transporting dirty water from stockpile and tipping area
16 - 17	Continuous monitoring station at rectangular weir

Report on Goedehoop Colliery Site Visit.

29 - 30 November 1993

1. GENERAL INFORMATION

Name of mine	Goedehoop Colliery
Name of person(s) interviewed	Mr R Berry - Asst Manager Mr M Pryor - Cons. Mining Eng. Mr D Salmon - Geohydrologist, EMS Mr D Power - Plant Supt. Mr M Du Plooy - Sect. Man. Planning Mr D van Zyl - Acting Mine Surveyor
Nearest town	Witbank
Name of catchment	Olifants river 210
Monthly production (ROM)	330 000 t/m
Monthly saleable product	264 000 t/m
Monthly discard production	66 000 t/m
Main product and market	Steam coal and low ash coal for export market
Current age of mine	Springbok, Hope areas - since 1945 Goedehoop - 10 years
Expected remaining life of mine	22 yrs
Type of mining carried out	Underground
Transport mode from mine to plant	Overland conveyors
Has the mine already produced an EMPR	Final draft to be submitted

2. SITE VISIT PROGRAMME

2.1 Day 1 - 22 November 1993

- Arrival
- Short discussion on site visit objectives
- Short overview of mining activities
- Guided tour of the mine, Goedehoop, Hope areas

2.2 Day 2 - 23 November 1993

- Visit Springbok area
- Completion of questionnaire

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

3.1 DESCRIPTION OF WATER CIRCUITS

A number of plans were supplied by the mine and contain useful information regarding important components of the mine's water reticulation system. These plans are attached as Figures 1 to 4.

- Figure 1 is a plan showing the various surface and groundwater sampling points on the Goedehoop, Hope and Springbok areas. (Plan 14 of EMPR)
- Figure 2 shows the polluted water reticulation system around the main plant area and discard dumps in the Goedehoop area. (Plan 10 of EMPR)
- Figure 3 shows the outlay of the Springbok affected area (Plan 9 of EMPR)
- Figure 4 is a plan of the affected area around the Hope dump (Plan 11 of EMPR)

A water balance or diagrammatic representation thereof is currently the topic of ongoing investigation and at the time of the site visit, this information was not yet available.

3.2 DESCRIPTION OF WATER TREATMENT/MANAGEMENT SYSTEMS

3.2.1 Sewage treatment plants.

There are a number of sewage treatment facilities on the mine. The following table summarises the details of these plants.

Plant	Area served	Design cap.	Process
A	Hope hostel and villages	625 m^3/d	Bio.filtration, digestion
B	HMS plant, workshops, stores, and main offices	30 m^3/d	Septic tank/Biodisk
C	Old Springbok mine, security, offices and village	410 m^3/d	Bio.filtration, digestion
D	Springbok village	125 m^3/d	Bio.filtration, digestion

Due to time constraints, it was not possible to visit the sewage treatment plants.

3.2.2 Potable water treatment plant.

There are two potable water plants. The Hope water treatment plant is situated at the HMS plant. The plant is designed to treat 190 m^3/d and the process consists of clarifier and pressure sand filters. The Springbok water works was designed to treat 75 m^3/d by clarification and rapid gravity sand filtration. Water is disinfected before distribution.

Due to time constraints, it was not possible to visit the potable treatment plants.

3.2.3 Surface water systems

Goedehoop Colliery is located within the upper Olifants river catchment upstream of the Witbank Dam. The main Goedehoop complex is situated in the Koringspruit sub-catchment, on the southern side and in the central portion of the Koringspruit drainage area. There are two small tributaries, locally known as the Goedehoopspruit and the Hopespruit that have their headwaters in the mine lease area.

The Hopespruit is a rather small stream flowing through a section of the mine where the Hope dump is situated. The Goedehoopspruit flows south of the operating Goedehoop discard dumps and flows into the Koringspruit upstream of the Koringspruit-Hopespruit confluence. The Goedehoopspruit is not indicated in Figure 1 but is shown in Figure 2.

The Springbok section of Goedehoop is located to the west and is separate from the main Goedehoop complex. This section is situated in the upper central region of a relatively short and small sub-catchment called the Springbokspruit (local name). Although the Springbokspruit is not named in Figure 1, it can be clearly identified as the only stream shown in the Springbok area.

The southernmost part of Goedehoop falls within the sub-catchment of the Leeufonteinspruit and the main Olifants river catchment. The receiving water bodies at Goedehoop Colliery are the Koringspruit, Springbokspruit, Leeufonteinspruit and the Kleinshaftspruit. These are all tributaries to the Olifants river. The Leeufonteinspruit is not affected by Goedehoop mining activities.

3.2.4 Evaporation dams

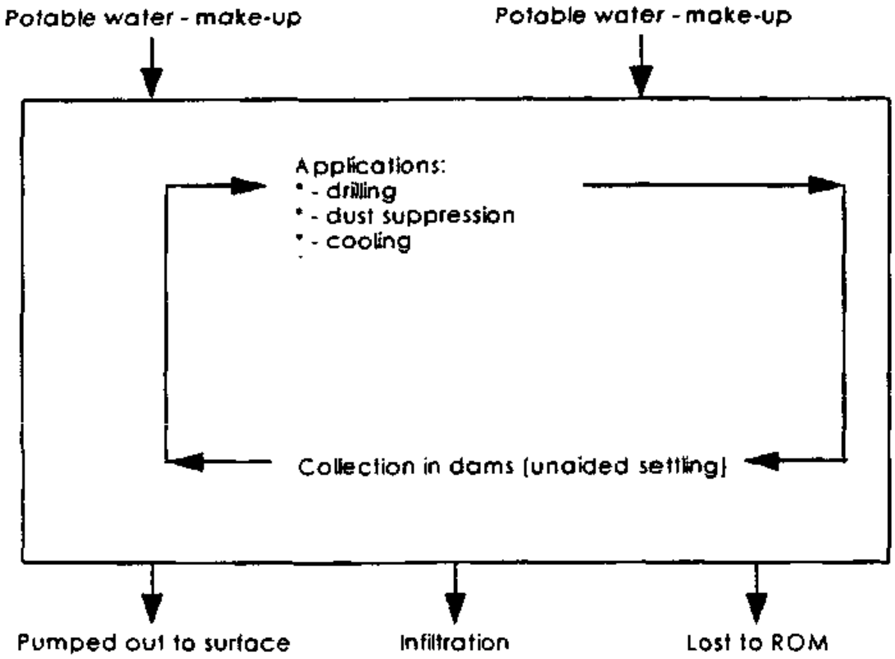
Although evaporation takes place as a natural process at all the surface reservoirs, they are operated without the intention of evaporating excess water.

3.2.5 Clear water or return water dams

The return water dam is situated close to the HMS plant and receives water from a number of sources as indicated in Figure 2. In addition to all the dirty runoff from the plant and Goedehoop discard dump areas, it also receives sewage effluent and contaminated water from the Hope maturation dam. Water from the return water dam is used in the HMS plant.

3.2.6 Underground operations.

The following diagram gives a simplified schematic representation of the way in which water is utilised in the underground operations.

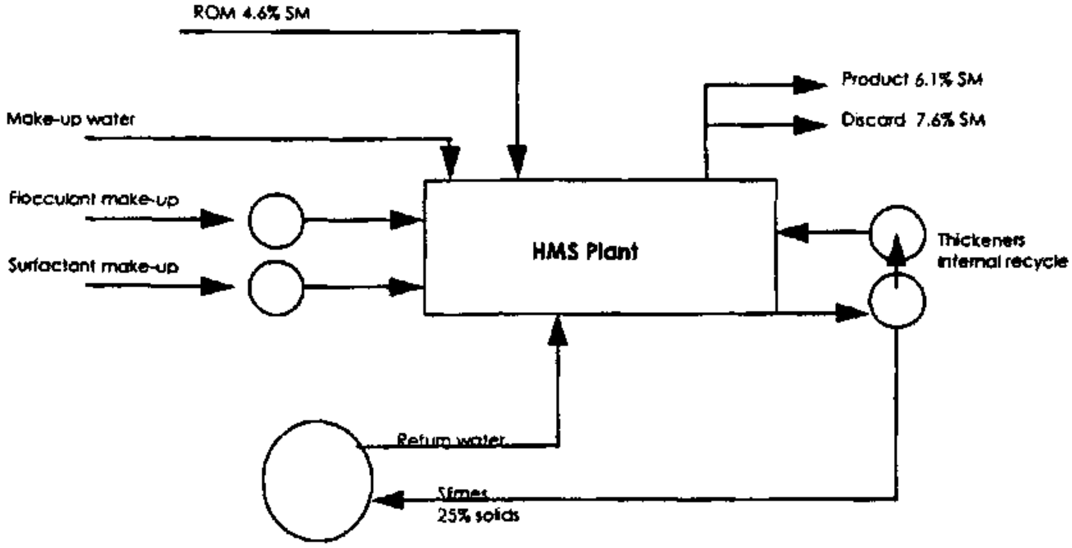


* - No flowrates measured

An interesting feature of the operation is the potable water used as make-up water for the underground operations. Unfortunately no flowrates are measured and the amount of potable water used is unknown.

3.2.7 Plant water circuits

The HMS plant is the major user of water on the mine and the following diagram is a simplified representation of the water flow around the HMS plant.



Note : Flowrates not measured

3.2.8 Discard dumps

Since the mine does not employ opencast mining techniques, the major sources of pollution of the surface and groundwater systems, are the discard dumps. There are essentially three main areas with discard dumps namely the Springbok area, Hope area and the Goedehoop area.

The Springbok area is currently the focus of a major project aimed at ameliorating the pollution impacts from this area. The measures taken in this area will be discussed more fully elsewhere. The main thrust of the project is removal of the new dump by reprocessing, proper rehabilitation of the old dump, cleaning the area by removing all unwanted material and the establishment of wetlands in the Springbokspruit.

The Hope dump is currently the area on the mine with the biggest potential for impact on the surface and ground water systems. The dump is old and has not been constructed properly. The aim is to remove the dump over the next three to five years by reprocessing. If this objective is achieved, a major source of pollution will be removed from the area. In the mean time, a series of toe paddocks, pollution control dams and a subsurface drain system has been installed to control the negative impacts from this dump. At the time of the site visit, the system was discharging contaminated water to a clean water dam due to the malfunctioning of a pump. Due to the malfunctioning of the pump, the level of the acid dam could not be controlled properly and water from the dam spilled into a channel flowing into the clean water dam.

The dumps in the Goedehoop area represent three phases of disposal:

i. the original Ove-ARUP designed discard dump
ii. the current combined slurry/discard disposal facility and
iii. the new combined slurry/discard facility, currently under construction,

which will ultimately encapsulate the two dumps in (i) and (ii) above.

A subsurface toe drain was installed to collect subsurface polluted water from the Ove-ARUP dump. A polluted water collection dam was constructed to contain the water emanating from this subsurface drain. A series of open drains were constructed to separate the clean and dirty water runoff from the dump area. The water from the polluted water collection dam is syphoned via the pollution control dam to the return water dam. When full, the return water dam overflows via the existing wetlands to the Koringspruit. A series of open trapezoidal drains was constructed around the dump site to divert clean and dirty water away from the dump area.

An interesting problem experienced by the Mine with the current co-disposal facility is that the distribution ratio of discard to slurry caused the sides of the dam to rise quicker than they should have. This caused the dump to reach the end of its useful life well before the anticipated date. Problems with improper beaching of slimes in the slimes dam caused water to infiltrate downwards thereby increasing the risk of contamination of the ground water and reducing the volume of water reclaimed from the facility.

At the time of the site visit, it was observed that contaminated water from the dump area was discharged to the Koringspruit. This was a temporary arrangement to allow the mine to complete the construction of silt traps in the dirty water drainage channels.

3.2.9 Water monitoring systems

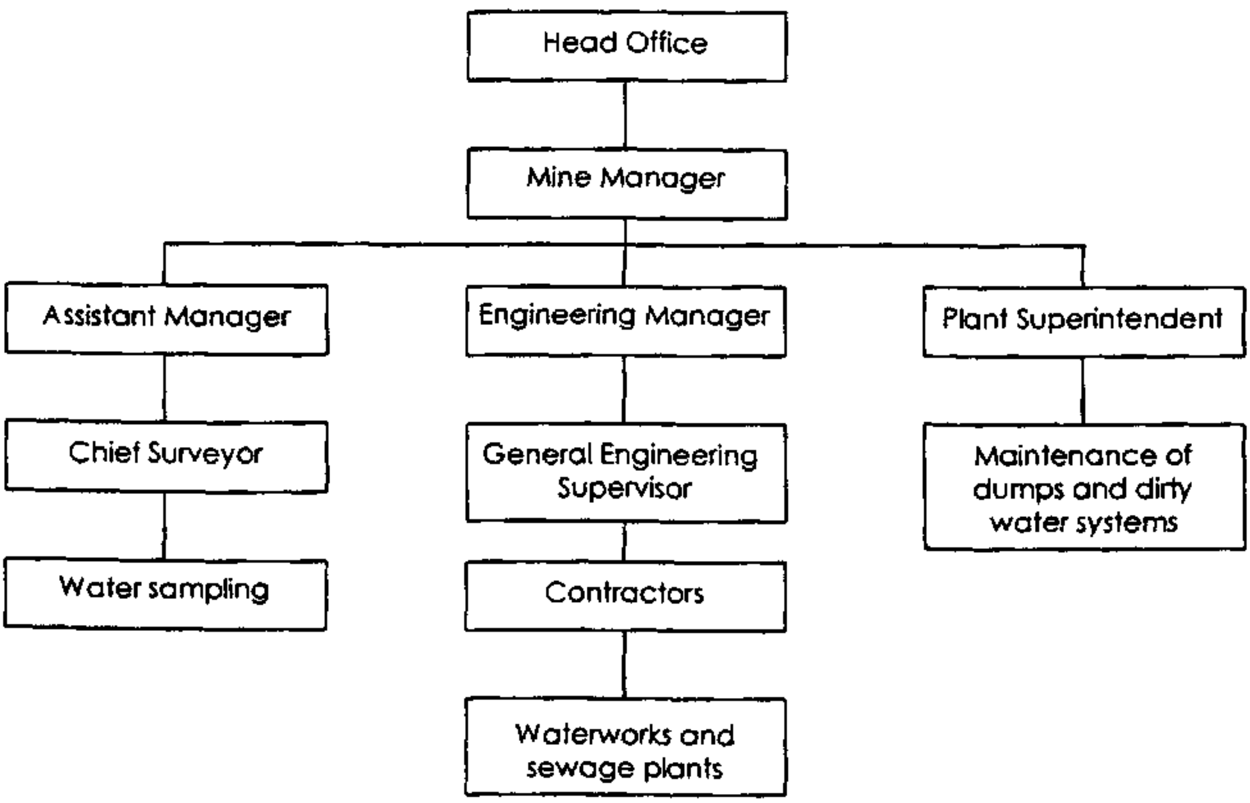
At present the mine is in the process of implementing measures aimed at improving the monitoring programme and facilities on the mine. *Figure 1* shows the various surface and groundwater sampling/ monitoring points.

The groundwater quality is monitored by means of a number of boreholes situated on various sites that were identified as the most crucial and appropriate.

Surface streams are presently monitored for quality parameters only. No flow rates are monitored. The mine is in the process of designing a continuous monitoring facility which will be installed in the Springbokspruit downstream of the rehabilitated Springbok area.

3.2.10 Water management structure

The following diagram, representing the water management structure with the various departments and personnel involved, was supplied by the mine.



A number of changes in the mine's management structure were implemented fairly recently and as a result, the management structure relevant to managing the water on the mine, has also been affected. A number of key personnel are currently finding their feet in terms of the water management situation on the mine.

3.3 NOVEL OR UNIQUE WATER TREATMENT AND MANAGEMENT SYSTEMS

3.3.1 Rehabilitation Of The Springbok Dump Area.

Previous reports dealing with the impacts of coal mining on the Olifants river, has implicated the Springbok-valley as a definite source of pollution. Since then, the mine has embarked on a major project aimed at ameliorating the impacts of this area on the surface water bodies. The project involved demolishing of the old infrastructure, cleaning up of the satellite dumps in the area, and the rehabilitation of the Springbok dump. A number of shallow dams were constructed in the riverbed with the aim of establishing a wetland area. (See Figure 3)

The old dump was rehabilitated by implementing the whale back design. In addition, it is believed that the runoff from the rehabilitated dump will be of a far better quality than the water previously generated in the area.

The new dump in the area is removed by reprocessing. As a result, the discard after reprocessing will be disposed of at the main Goedehoop discard dump. Removal of the new dump will remove a major contributor to pollution loads in the Springbok area.
A number of other measures were taken in conjunction with the cleaning up of discard material, rehabilitation of the old dump and reworking of the new dump. These measures include lining of the No 3 dam to prevent contamination by water seeping from the dump. A deep sump was excavated with associated deep cutoff drains to intercept affected seepage and surface water from the new dump. this water is presently pumped underground but this facility will be decommissioned after removal of the dump.

Although none of the procedures described above constitutes a novel or unique technique, the novel aspects are associated with the combination of the various steps that were taken and the relatively confined and defined area in which it has taken place. An opportunity exists to investigate the post-closure impacts associated with removal of discard and rehabilitation of dumps. This area could be used as a model with which these post-closure impacts can be studied, and parameters such as the rate with which pollution from a previously affected area decreases, could be defined.

3.4 POTENTIAL WATER TREATMENT/MANAGEMENT PROBLEMS AND NEEDS

As a result of the discussions and site visits, a number of issues were identified where knowledge gaps still exist.

3.4.1 Flow measurement

Accurate flow data is an essential component of a monitoring programme aimed at providing input into a water management strategy. In view of the waste load allocation policy advocated by the DWAF, it would not be possible to formulate an effective water management strategy if salt loads cannot be predicted or calculated.

With regard to surface water systems, pump curves and pumping hours are often used to calculate flow rates for some of the water transfer operations. The inherent inaccuracies of this method render it unsuitable in the long term and proper flow measurement methods should be employed. Considering the practical problems with monitoring flow in the mining environment, this is also considered to be a challenge for the personnel responsible for water management.

It is believed that the construction of a continuous monitoring station in the Springbokspruit, as envisaged by the mine, will go some way in addressing this need.

Presently the mine cannot characterise the groundwater system in terms of flow characteristics. Quality can be monitored with the various boreholes and piezometers but flowrates into different areas through aquifers and other features cannot be predicted or defined.

3.4.2 Prediction and simulation facilities

One of the gaps discussed was the absence of a definitive model for the mine's water systems. The data collected in the monitoring programmes should ideally be fed into a model or system that can be used to predict impacts, decant points and flows or qualities to be expected from certain sources or at specific points. Such a system will enable the mine to define more effective management strategies and will help with prioritising remedial or preventative actions.

Although potential impacts can be qualitatively described, they cannot be defined quantitatively. Prediction of long term and post closure impacts is not possible at present.

3.4.3 Modeling of discard dumps before and after rehabilitation.

At present the mine cannot define the impact of water seeping through the discard dumps on the environment. The volumes and quality of the water originating from this source cannot be quantified or estimated. The whole question of a water and salt balance around a discard dump is an issue which requires further investigation and can be considered to be an industry-wide issue.

3.4.4 Water management functions.

The water management structure on the mine has recently been changed. In addition, a number of people are currently taking responsibility for a number of issues with which they are not fully familiar. This problem is expected to be a very temporary problem as the people concerned are fully capable and qualified to take on the responsibility.

4. GENERAL IMPRESSIONS

4.1 ROLE OF THE EMPR

It is believed that the EMPR has played a significant role in focusing attention on water management aspects. The personnel interviewed, held the view that the highly visible project at the Springbok dump site helped to promote a general awareness of environmental and water issues among the workforce.

4.2 RESPONSE TO THE SITE VISIT AND QUESTIONNAIRE

The impression was obtained that the mine, at least initially, viewed the site visit and interviews with apprehension. It was stated by the mine that they would not like to emphasise the faults and it is hoped that this approach did not affect the responses obtained during the site visit and interviews. The impression was formed that the apprehensions regarding the site visit having negative implications for the mine, were somewhat allayed towards the end of the site visit.

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

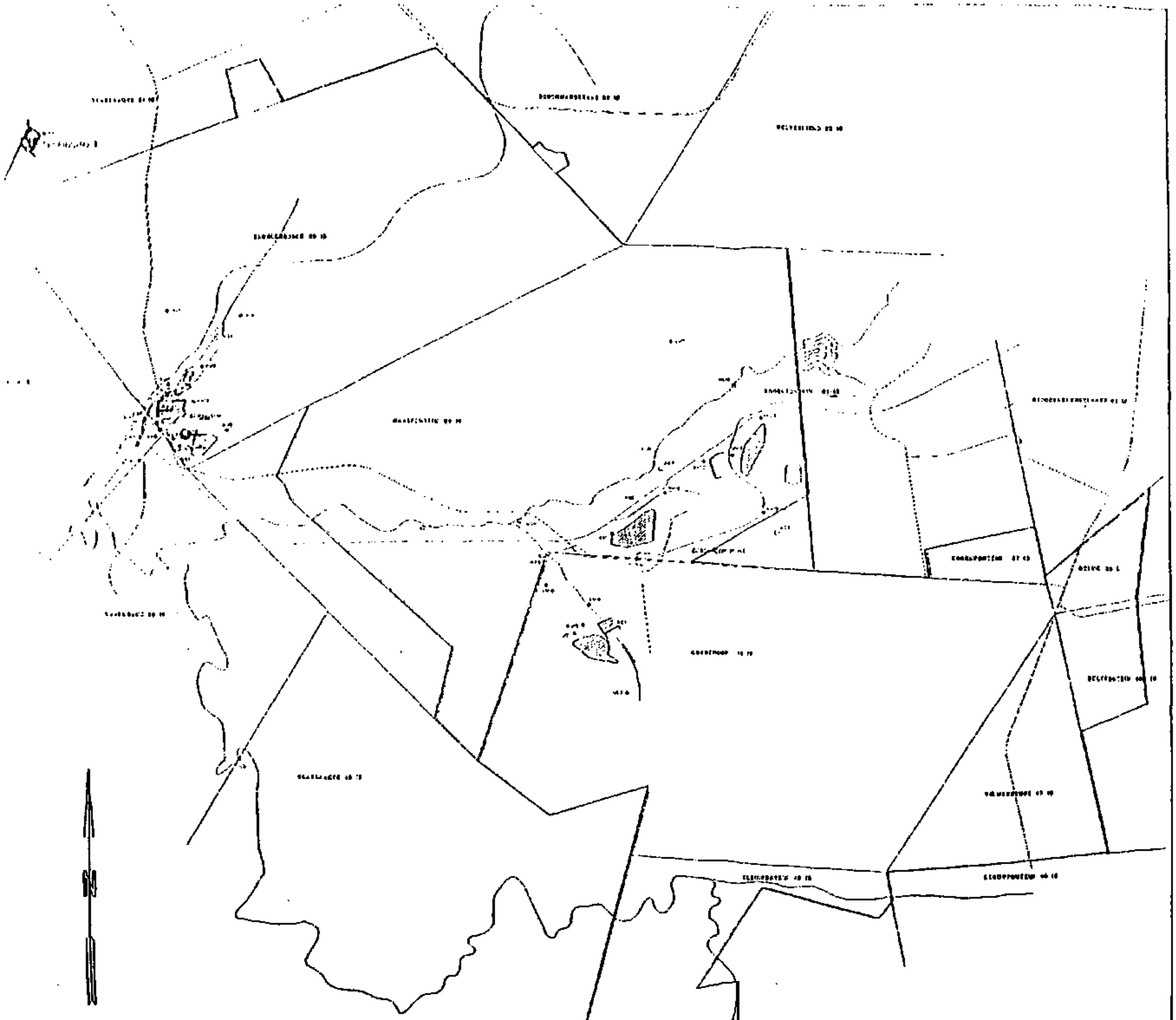
During the site visit, a number of pH and conductivity readings were taken at various locations on the mine. The following is a list of the readings taken:

	Description	pH	Cond. [mS/m]
1	*Dirty runoff channel - Goedehoop area*	7.4	80
2	Clean water runoff channel	8.1	277
3	Clean water channel - *temporarily containing contaminated water*	7.3	282
4	Goedehoopspruit at bridge next to slate dump	7.5	182
5	Channel from Hope shaft, plant and offices areas into return water dam	6.9	226
6	Koringspruit at 4 seam road crossing	2.9	418
7	Water cutoff drain north west of maturation pond	3.5	830
8	Seep from subsurface pipe below maturation pond	3	1191
9	Discharge from "pen stock" in acid water dam	2.9	1173
10	Northern acid dam bypass channel	2.8	836
11	Acid dam	2.9	753
12	Standing water below acid dam	6.5	183
13	Hopespruit downstream of dump	3.6	136
14	Springbok valley Dam 8	6.9	47
15	Dam 6	3	366
16	Dam 5A	4.5	100
17	Dam 5B	4.4	100
18	Dam 4	4.2	173
19	Dam 3 (in valley - not lined dam)	4.2	185
20	Dam 2	4.1	162
21	Maturation dam	3.7	170
22	Dam 1	3.4	375
23	Sump	3.5	541
24	Seep between road and dump	2.9	1141
25	Runoff next to dump	4.4	252
26	5m sump and drainage channels at Springbok.	3.4	253

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:

Photograph No	Description
1,2	Current slimes disposal facility
3	View from top of current co-disposal facility towards Goedehoopspruit
4	View from top of current co-disposal facility towards return water dam
5	View of new co-disposal facility
6	Dirty runoff channel - Goedehoop area
7	Polluted water collection dam (empty)
8	Clean water runoff channel
9	Clean water channel - temporarily containing contaminated water
10	Goedehoopspruit at bridge next to slate dump
11	Channel from Hope shaft, plant and offices areas into return water dam
12	Return water dam
13	Koringspruit at 4 seam road crossing
14,15	Toe paddocks at Hope dump, subsurface bidum drain pipe, maturation pond and acid dam
16	Water cutoff drain north west of maturation pond
17	Subsurface pipe below maturation pond
18	Discharge from "pen stock" in acid water dam
19	Northern acid dam bypass channel
20	Acid dam
21	Hopespruit - view towards Hope dump
22	View of lined dam and new dump at Springbok
23 - 28	View of Springbok valley
29	Water from surface dams into underground workings
30	Rehabilitated dump at Springbok
31	Runoff between road and dump
32	Drain around lined dam (water not from dam)
33	5m sump and drainage channels at Springbok.



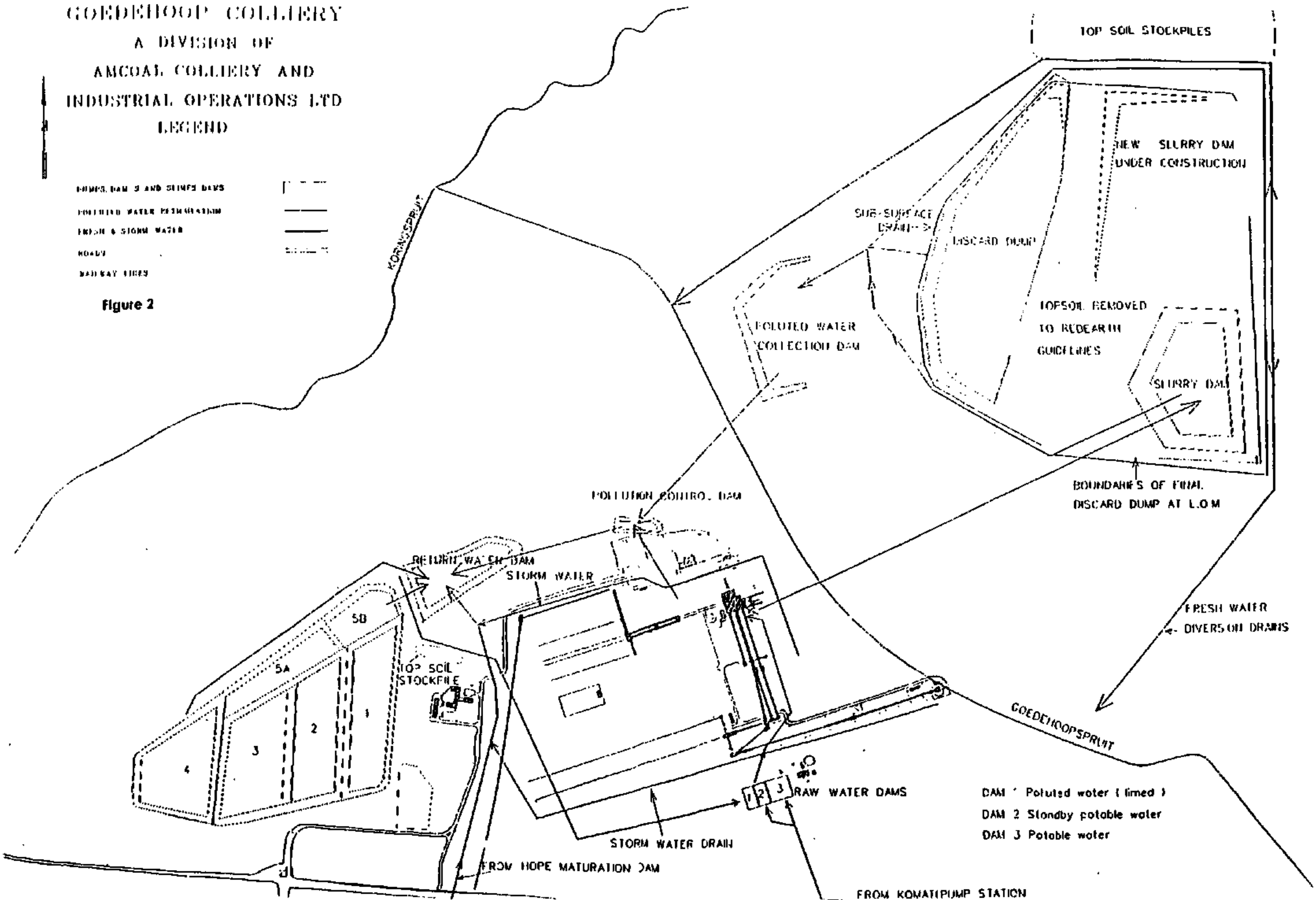
GOEDEHOOP COLLIERY
A DIVISION OF
AMCOAL COLLIERY AND
INDUSTRIAL OPERATIONS LTD

SURFACE AND GROUND
WATER SAMPLING POINTS

LEGEND

	GROUND WATER BOREHOL
	SURFACE SAMPLING POI
	STREAMS
	RAILWAYS
	ROADS
	DUMPS

figure 1


GOEDEHOOP COLLIERY
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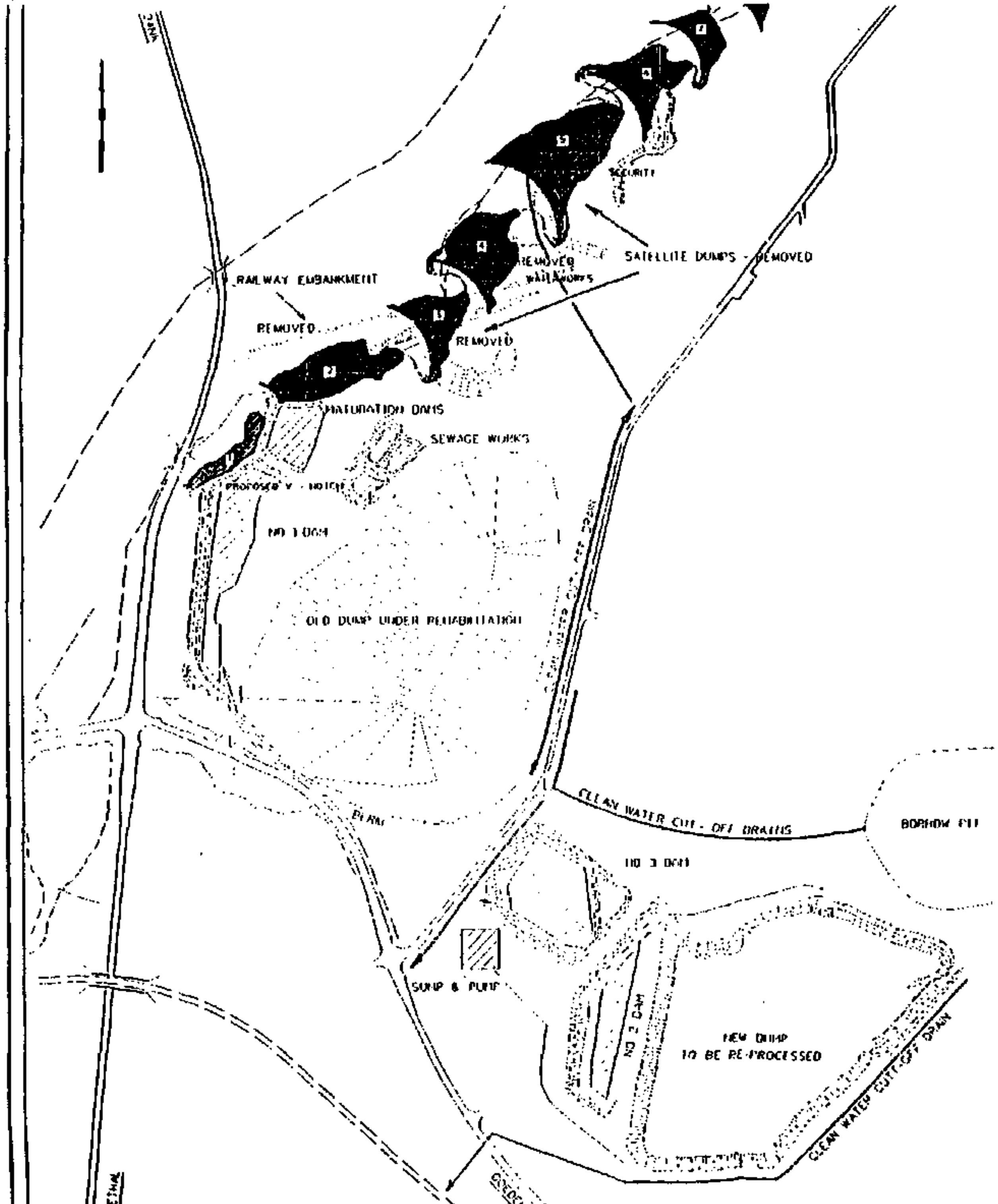
INDUSTRIAL OPERATIONS LTD
LEGEND
TOP SOIL STOCKPILES
NEW SLURRY DAM
UNDER CONSTRUCTION
SUB-SURFACE
DRAIN
DISCARD DUMP
TOPSOIL REMOVED
TO REDEARTH
GUIDELINES
POLUTED WATER
COLLECTION DAM
SLURRY DAM
BOUNDARIES OF FINAL
DISCARD DUMP AT L.O.M
POLLUTION CONTROL DAM
RETURN WATER DAM
STORM WATER
FRESH WATER
DIVERSION DRAINS
GOEDEHOOPSPRUIT
5B
5A
TOP SOIL
STOCKPILE
4
3
2
1
RAW WATER DAMS
DAM 1 Poluted water (limed)
DAM 2 Standby potable water
DAM 3 Potable water
STORM WATER DRAIN
FROM HOPE MATURATION DAM
FROM KOMATI PUMP STATION

Figure 2



GOEDEHOOP COLLIERY
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INDUSTRIAL OPERATIONS LTD

SPRINGBOK AFFECTED AREA

LEGEND

DUMPS, DAM WALLS AND EXCAVATIONS
STREAMS AND FURROWS
ROADS AND TRACKS
POLLUTED WATER
RAILWAY LINES

Figure 3

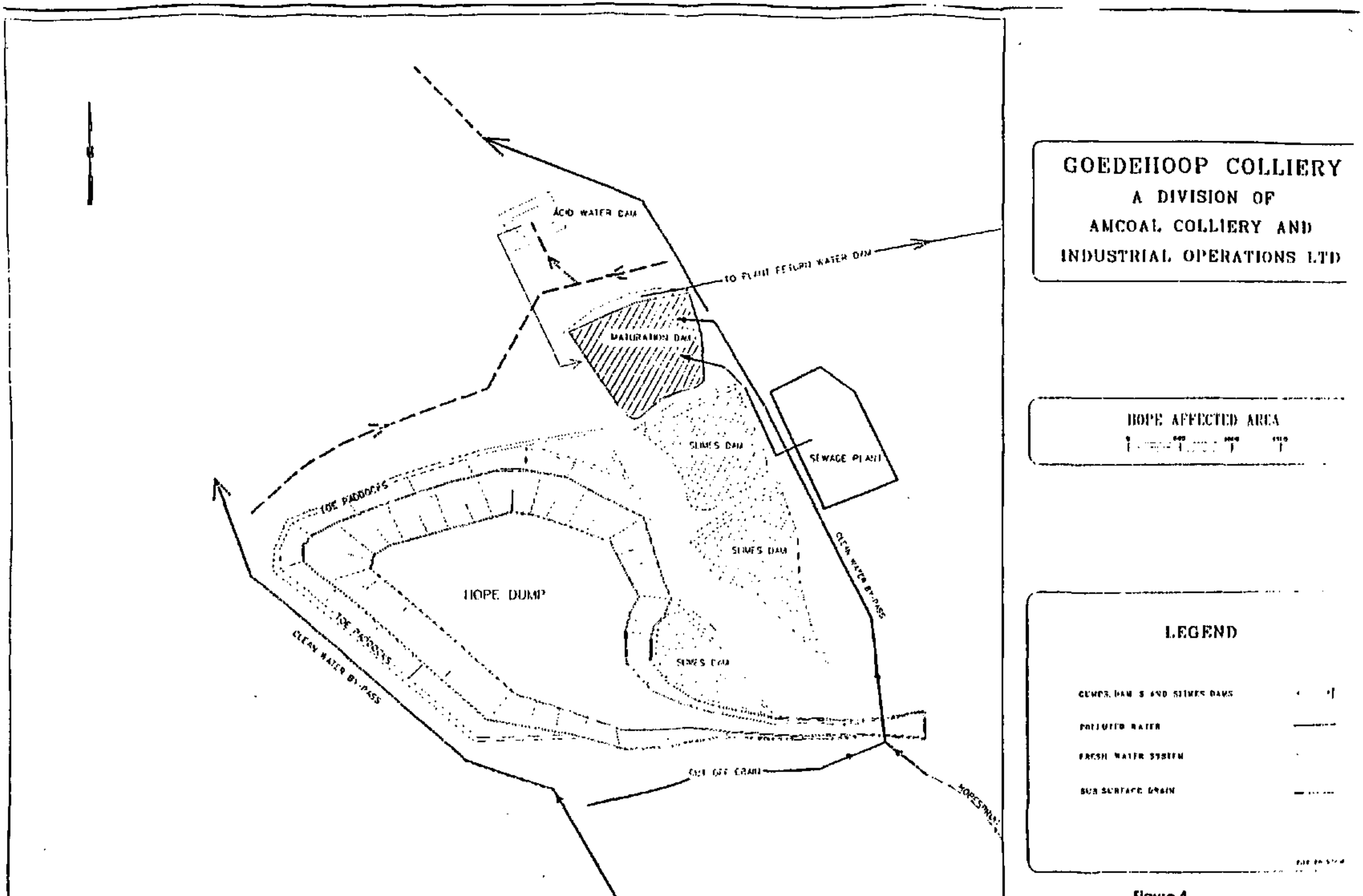

GOEDEHOOP COLLIERY
A DIVISION OF
AMCOAL COLLIERY AND
INDUSTRIAL OPERATIONS LTD
HOPE AFFECTED AREA
LEGEND
POLLUTED WATER
FRESH WATER SYSTEM
SUB SURFACE DRAIN
ACID WATER DAM
TO PLANT RETURN WATER DAM
MATURATION DAM
SLIMES DAM
SEWAGE PLANT
SLIMES DAM
SLIMES DAM
HOPE DUMP
TOE PADDOCKS
TOE PADDOCKS
CLEAN WATER BY-PASS
CLEAN WATER BY-PASS
CUT OFF DRAIN

Figure 4

Report on Greenside Colliery Site Visit

9 - 10 March 1994

1. GENERAL INFORMATION

Name of mine	Greenside Colliery
Name of person(s) interviewed	D Botha
Position of person(s) interviewed	Chief Engineer
Nearest town	Witbank
Name of catchment	Olifants River, Witbank Dam
Monthly coal throughput (rom)	420 000 tons
Monthly saleable product	243 000 tons
Monthly discard production	128 000 tons
Monthly slurry production	49 000 tons
Main product and market	Various
Current age of mine	46 years
Expected remaining life of mine	2 & 5 seam - 12 years 4 seam - 70 - 100 years
Type of mining carried out	Underground (bord & pillar, stooping) Opencast
Transport mode- mine to plant	Conveyor for u/g, road for opencast
Has the mine already produced an EMPR	Draft available

2. SITE VISIT PROGRAMME

2.1 Day 1 - 9 March 1994

- Short discussion of project background and objectives with Messrs A McLaren and D Botha.
- Detailed site visits with Messrs McLaren and Botha.

2.2 Day 2 - 10 March 1994

- Complete site visits with Mr Botha
- Underground visit
- Completion of questionnaire

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

3.1 Description of water circuits

The mine operations can be divided into three different areas as follows:

- Plant and main dump area;
- Underground workings; and
- Opencast area.

Detailed plans of the different areas were made available and a schematic sketch, prepared by outside consultants, showing the pH and conductivity sampling points is attached as Figure 1. A schematic water balance is attached as Figure 2. Both Figures 1 and 2 contain errors which will be discussed later in the report.

The mine is bounded by surface water courses to the North and to the West. The Noupoortspruit runs in a west to east direction along the Northern edge of the mine and accepts effluents which overflow from the Quarry dam, the pH plant, workshop wastewater, plant washdown water, treated sewage and discharge from the evaporation ponds adjacent to the discard dump and slurry dams. A natural watercourse, referred to here as the Greenside spruit flows in a south to north direction and joins the Naupoortspruit close to the point where effluent is discharged from the evaporation dam to the Naupoortspruit. This stream originates as a clean spring and is contaminated by effluent from No 13 shaft and seepage from the discard dump and slurry ponds.

3.2 DESCRIPTION OF WATER TREATMENT/MANAGEMENT SYSTEMS

3.2.1 Sewage treatment systems

The sewage treatment plant at Greenside is based on the use of trickling filters. Sludge produced at the sewage plant is buried. No operational problems are experienced with the sewage plant. Effluent from the sewage plant is used for irrigation of sports fields and the golf course, with excess reporting to the Naupoortspruit.

3.2.2 Potable water systems

Potable water is purchased from Witbank municipality and the mine does not have a potable water treatment plant. Potable water is softened for use in locomotive boilers. Potable water is supplied to the plant, offices, workshop, plant, village, hostels and underground for drinking purposes.

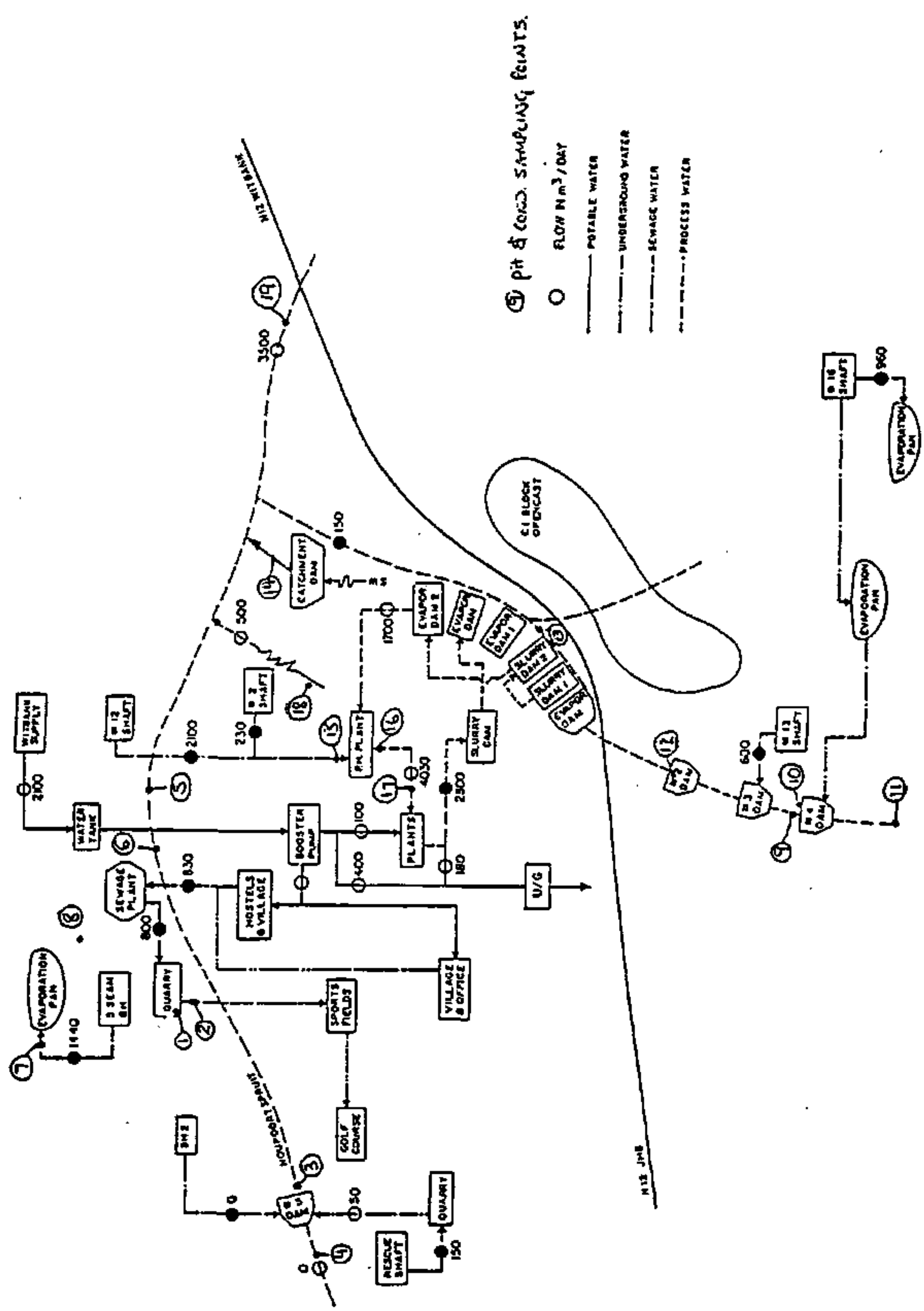


Figure 1 : pH and Conductivity Sampling Points

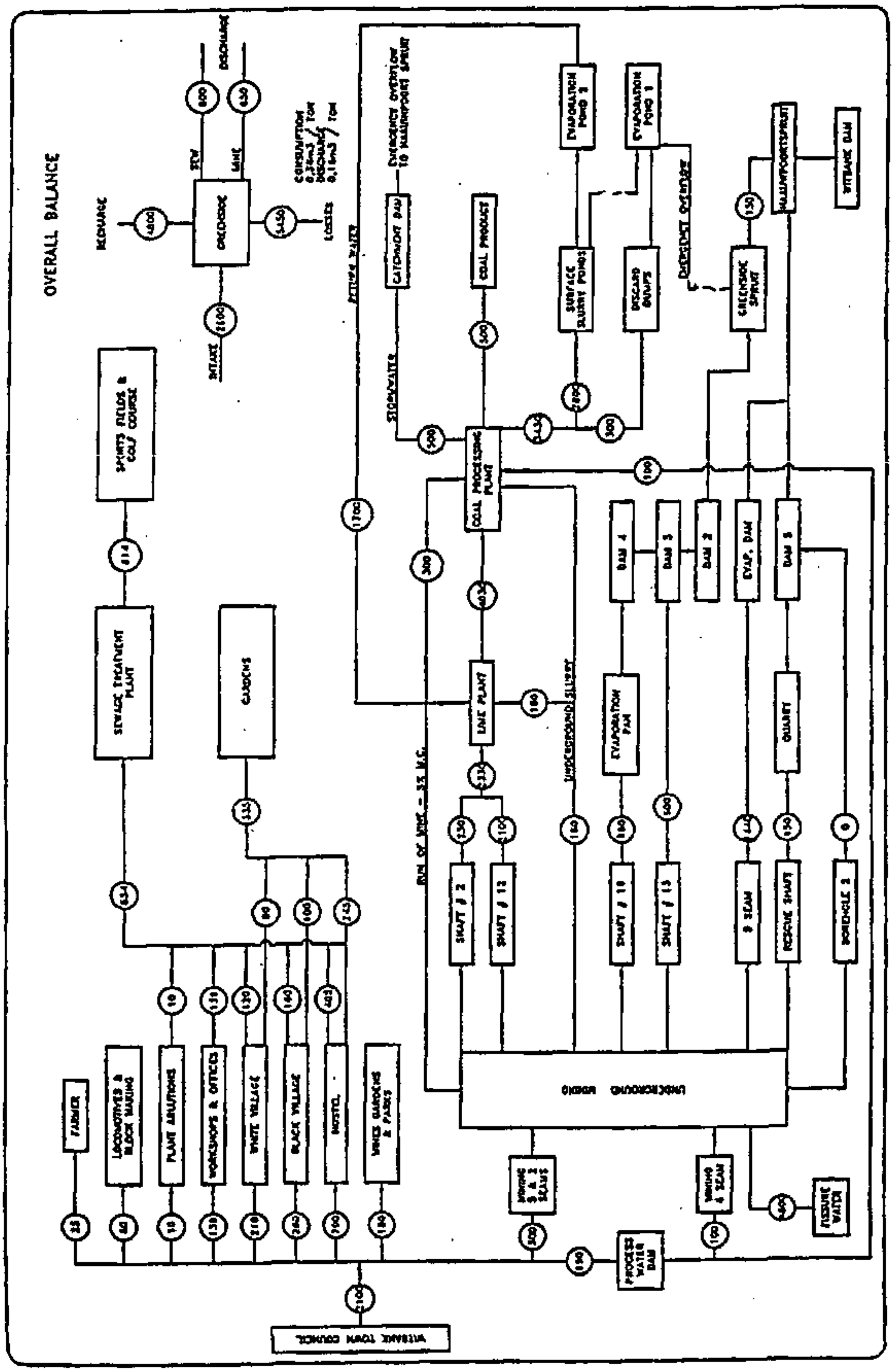


Figure 2 : Water Balance

3.2.3 Plant water circuits

The coal washing plant uses water which has been neutralised in the pH plant. The pH plant takes water from No 2 and No 12 shaft, as well as the evaporation dam draining the discard dump and slurry dam. An unknown volume of water is recycled within the plant circuits. Water is discharged from the plant in the product, coarse discard and slurry. Rainfall runoff and excessive plant spillages will report to the plant sump which, in extreme cases, could overflow to the Noupoortspruit. Washdowns from the plant area are drained to the Noupoortspruit. No water balance exists for the plant and associated water circuits. A schematic representation of these circuits is shown in Figure 3 below.

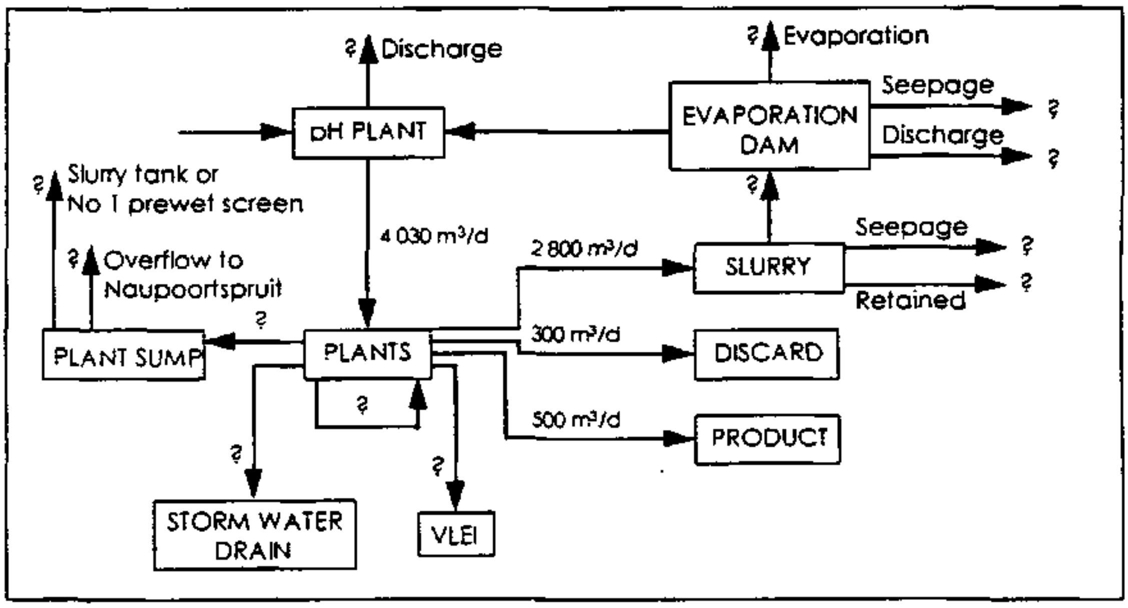


Figure 3 : Plant Water Circuits

3.2.4 Underground water circuits

A schematic diagram showing the underground mining water circuits is given in Figure 4 below. The underground mining operations obtain water from the pH plant and from inflows from the surrounding ground water aquifers. An unspecified amount of water is reused in the underground operations for dust suppression purposes. Excess water from the underground operations is pumped up to surface for treatment and reuse through the pH plant, while substantial volumes of the water are discharged to the various evaporation dams on the mine. As is the case for the plant circuits, no water balance has been developed for the underground mining operations.

3.2.5 Discard dumps

The mine operates one large discard dump of which large portions have been burnt. The slurry dams are constructed inside the discard dump. The total discard dump system is in the process of being modified and rehabilitated. Seepage from the discard dump and slurry dams occurs as is evident from the data shown in Appendix B. This contaminated seepage mixes with relatively clean water draining from No 2 dam. A portion of this flow is returned to the pH plant for treatment and reuse, while an unknown portion is discharged to the Noupoortspruit. No water balance exists for the discard and slurry circuits.

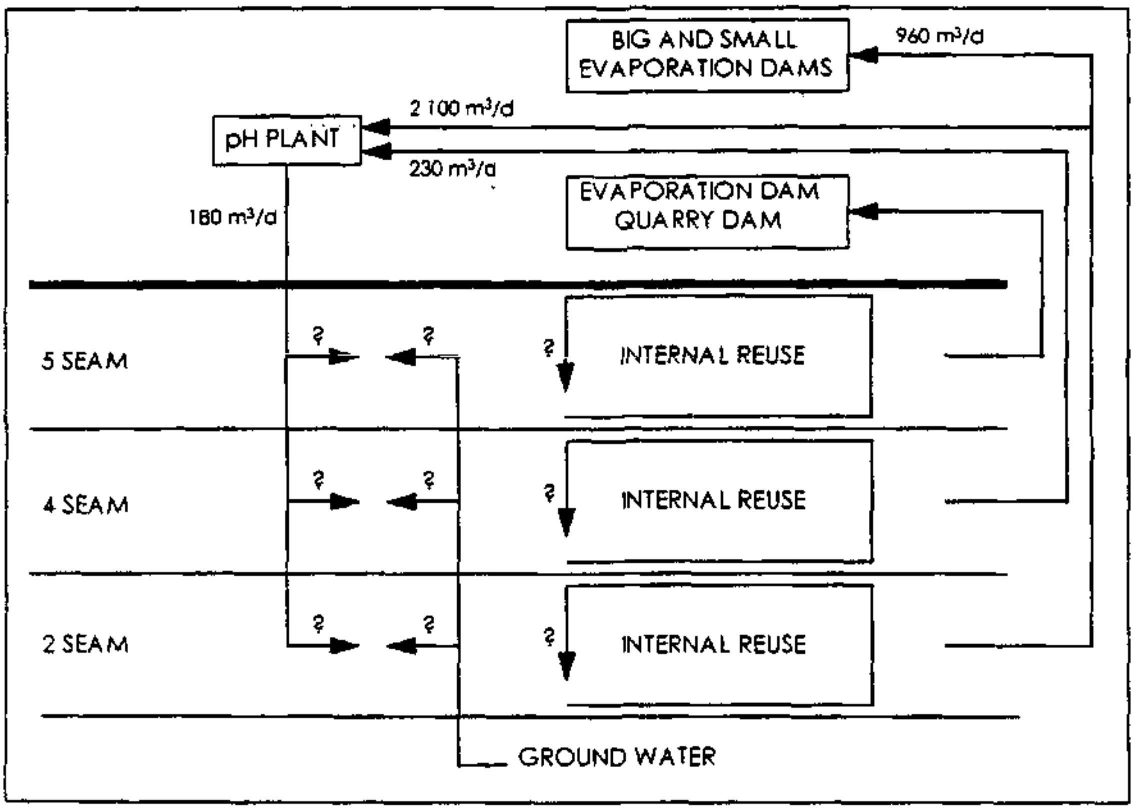


Figure 4 : Underground Water Circuits

3.2.6 Water monitoring systems

The only regular (monthly) monitoring being undertaken by the mine is as follows:

- flow of potable water supplied by Witbank Council
- water flow to/from pH plant, except discharge to the Noupoortspruit
- flows of water pumped up from underground
- flow and quality of treated sewage
- quality of water supplied by the pH plant

Additional water quality analyses have been undertaken at additional points on an infrequent ad-hoc basis.

3.2.7 Water management structure

The water management structure is shown in Figure 5 below.

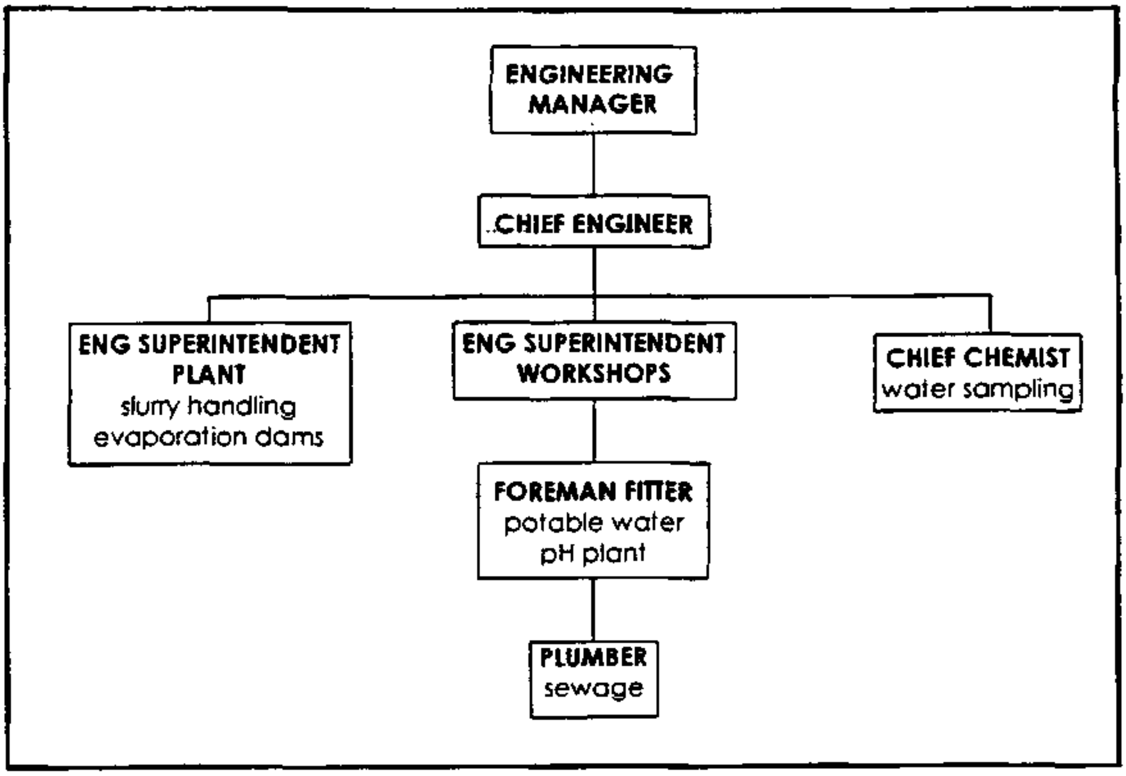


Figure 5 : Greenside Colliery Water Management Structure

3.3 POTENTIAL WATER TREATMENT/MANAGEMENT PROBLEMS AND NEEDS

As a result of the discussions and site visits, a number of issues were identified where knowledge gaps still exist.

3.3.1 Water and Salt Balance

The most fundamental and important water management tools available to the mine are the water and salt balances. To be useful, such balances must be accurate and contain sufficient detail to account for all significant inputs to and losses from the water circuits. Like most other mines, Greenside Colliery does not have a water balance and therefore cannot effectively manage its water circuits and effluent discharges. Due to the fact that no water balance is available and insufficient water quality data is collected, no salt balance is available either.

The water balances prepared for the EMPR and attached as Figures 1 and 2 are not sufficient for water management purposes and contain a number of errors as follows:

- overflow from catchment dam to Noupoortspruit is not shown or quantified;
- treated sewage discharge to Noupoortspruit is not shown;

- diffuse pollution sources are not shown;
- overflow and underflow from pH plant discharged to the Noupoortspruit are not shown;
- effluent from the workshop and washdown from the plant to the Noupoortspruit are not shown;
- plant storm water drain and sump system and overflows to the Noupoortspruit are not shown;
- seepages, evaporation and other losses from the discard dump, slurry ponds and evaporation dams are not shown;
- the fact that the Greensidespruit starts as a high quality spring is not shown.

3.3.2 Management of point source discharges

The mine has a number of point source discharges to the surface water systems which are not quantified in terms of volume or quality. A number of these are discussed in section 3.3.1 above. Without a proper water balance, and monitoring of these point sources, the mine will not be able to regulate or reduce its impact on the surface water environment.

The Noupoortspruit upstream of the mine has a measured conductivity of 110 mS/m, while the Greensidespruit upstream of the mine has a measured conductivity of 2 mS/m. The Noupoortspruit downstream of the mine and downstream of the confluence with the Greensidespruit, has a conductivity of 281 mS/m, indicating very significant pollution from Greenside mine. The bulk of this pollution can be traced back to point source discharges.

Proper management of the water balance, together with adherence to the principle of keeping clear and dirty water separate, could significantly reduce point source discharges. Design and implementation of a water reclamation strategy will also assist in reducing point source discharges.

3.3.3 Management of diffuse pollution sources

Interpretation of the data presented in Appendix B, indicates that there are a number of sources of diffuse pollution at Greenside. These sources include the evaporation dams, discard dumps and slurry ponds and the impact will be felt on both the ground and surface water environments.

The bulk of this diffuse source pollution reports to the Greensidespruit. This spruit starts as a very clean spring (cond. 2 mS/m) and is still uncontaminated in No 4 dam (cond. 2.7 mS/m). By the time this water leaves the downstream No 2 dam, which has received water pumped up from No 13 shaft, the conductivity has increased to 60.6 mS/m. The outflow from No 2 dam flows through an evaporation dam and then adjacent to and eastwards of the discard dump and slurry ponds. The spruit is joined by another stream draining off the C1 block opencast area before being led into the evaporation dam system. Prior to entering the evaporation dams, the conductivity of the spruit has increased to 136 mS/m. The continuous deterioration of the Greenside spruit as it flows from its source to its confluence with the Noupoortspruit indicates the extent of diffuse pollution reporting to this spruit. Additional, but unquantified, diffuse pollution will also be reporting to the ground water system.

3.3.4 Management of clean and dirty water

One of the fairly fundamental principles of water management is to keep clean and dirty water systems separate. There are a number of instances at Greenside where this is not occurring.

The Greensidespruit originates as an ultra-pure spring with a conductivity of 2 mS/m. This stream becomes contaminated, as discussed in section 3.3.3 above, before being led into the evaporation dam system adjacent to the discard dump. The water discharged from the last evaporation dam (also known as the catchment dam) has a conductivity of 328 mS/m, in order to apply the principle of keeping clean and dirty water separate on the Greensidespruit, the following actions should be applied :

- Do not discharge water from No 13 shaft into Greensidespruit.
- Do not feed spruit into evaporation dam and catchment dam system.
- Isolate diffuse pollution source from C1 block opencast area and prevent it from entering the Greensidespruit.
- Route all uncontaminated runoff and rainfall into the Greenside spruit.

3.3.5 Lime dosing plant

The lime dosing plant is undersized and cannot properly treat the flowrate which enters it, in particular, the system does not allow for proper clarification and removal of the precipitates which are formed. As a result the treated water still contains significant amounts of suspended precipitates and the underflow is very dilute, thereby wasting water. The pH plant should be upgraded to include a proper clarification stage and the sludge which is generated should be disposed of in the slurry dams and not in the veld adjacent to the Noupoortspruit.

The present operating cost of the pH plant is approximately 8 c/m^3, excluding maintenance.

3.3.6 Management and monitoring systems

The staff employed by the mine to deal with the water management issues are shown in Figure 5 in section 3.2.7 above. Based on discussions with the Chief Engineer, it can be stated that all the staff require training in the basic principles of water management. The senior levels of management also require better access to information on research and development aspects relating to mine water management.

The mine also needs to institute a proper water quality and flow monitoring programme to enable it to manage its impacts on the water environment. All point source discharges should be monitored in terms of both flow and quality, while an attempt should be made to quantify the diffuse pollution sources. The development of an appropriate monitoring programme should be driven by the needs of the water and salt balance, in order to institute effective water management, the mine should consider setting up a computerised water and salt balance system which can aid management in identifying, monitoring and solving problem areas.

3.3.7 Ground water systems

No information is available on the impact of mining activities on the ground water systems and this will need to be rectified in order to manage the mine's environmental impact.

4. GENERAL IMPRESSIONS

It is believed that the EMPR has played a significant role in focusing attention on water management aspects at Greenside. The mine staff who were interviewed also exhibited great interest in improving their level of knowledge on mine water management, the most important aspect which needs to be addressed is the development of a water and salt balance with the required monitoring programme to provide the balances with the necessary data. These balances will assist the mine in addressing the point and diffuse pollution sources.

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. The following is a list of the readings taken:

No	Description	pH	Cond.
1	Quarry dam at golf course	7.97	128
2	Overflow from quarry dam	8.00	139
3	Outflow from No 5 dam	7.82	106
4	Naupoortspruit upstream of No 5 dam	8.70	110
5	Naupoortspruit at road from entrance to main plant	7.37	106
6	Drain from plant to Naupoortspruit upstream of point 5	7.36	113
7	5 seam water pumped into No 1 evaporation dam	7.76	145
8	Small evaporation dam for 2 seam water	7.43	310
9	Outflow from No 4 dam	7.60	2.7
10	Seepage through No 4 dam wall	6.90	15
11	Spring above No 4 dam	5.90	2.0
12	No 2 dam	7.10	60.6
13	Clean stormwater drain below / adjacent to dump	7.20	136
14	Discharge from evaporation / toe dam to Naupoortspruit	7.70	328
15	Inflow to pH plant	4.60	333
16	Outflow from pH plant	9.27	307
17	Neutralised water storage tank	7.20	313
18	Plant & workshop wash water discharge to Naupoortspruit	8.90	66
19	Naupoortspruit at bridge below mine	7.60	281

All conductivity measurements are in mS/m

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:

Photograph No	Description
1	Quarry dam at golf course
2	Breached wall of No 5 dam
3	Baseflow in Naupoortspruit exiting No 5 dam
4	Naupoortspruit under road from entrance to plant
5	5 seam water pumped into No 1 evaporation dam
6	Disinfection contactor on final sewage effluent
7	Outlet from 16 shaft (2 seam water) to small evaporation dam
8	Seepage through No 4 dam wall
9	Spring above No 4 dam
10	No 2 dam
11	View of plant from discard dump
12	View of plant from discard dump
13	View of plant from discard dump
14	View of plant from discard dump
15	Clean stormwater drain with discharge into evaporation / toe dams
16	Discharge from Greenside evaporation / toe dam to Naupoortspruit
17	View from discharge point to dump
18	View of pH plant
19	View of pH plant
20	pH plant lime dosing / pH probe system
21	Outflow from pH plant to Naupoortspruit
22	Plant washwater / workshop water discharge to Naupoortspruit
23	View of discard dump
24	Naupoortspruit at bridge on main road below mine

Report on Grootegeluk Colliery Site Visit.

27 - 28 October 1993

1. GENERAL INFORMATION

Name of mine	Grootegeluk Colliery
Name of person(s) interviewed	Mr P. Coetzer - Asst. Res. Eng. Mr. C. Dreyer - Chief Geologist Mr. W du Plessis - Sect. Head Mech. Services Mr. J. Esterhuysen - Chief Surveyor Mr. C. van Loggerenberg - Process Development Eng. Mr. S. Vermaak - Lab. assistant
Nearest town	Ellisras
Name of catchment	None - nearest Mogol river
Daily coal throughput (rom)	NA
Daily saleable product	NA
Daily discard production	NA
Main product and market	Iscor and Escom
Current age of mine	12 years
Expected remaining life of mine	>100 years
Type of mining carried out	Opencast
Transport mode from mine to plant	Titan Road haulers
Has the mine already produced an EMPR	Final draft submitted

2. SITE VISIT PROGRAMME

2.1 Day 1 - 27 October 1993

- Arrival
- Short discussion of project background and objectives
- Present at meeting:

P Coetzer	-	Assistant Resident Engineer
C. Dreyer	-	Chief Geologist
W du Plessis	-	Sect. Head Mech. Services.
J Esterhuysen	-	Chief Surveyor
C van Loggerenberg	-	Process Development Engineer
S Vermaak	-	Laboratory Assistant
L. de Lange	-	PHD

- Guided tour of the mine
- Completion of questionnaire

2.2 Day 2 - 28 October 1993

- Visit to coal preparation plant
- Completion of questionnaire

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

3.1 DESCRIPTION OF WATER CIRCUITS

There are essentially three sources of water available to the different users on the mine. These sources are:

- Water from the Hans Strijdom dam
- Water abstracted from the opencast pit
- Boreholes

The major users of water are the coal preparation plants and the mining activities in the pit. Other users include the workshops, potable water users etc. Although water is also supplied to the town of Ellisras, the Matimba Power Station and others, this report will focus on the water issues directly related to the mining activities on the Grootegeluk property.

A diagram showing the water balance for the mine, was supplied by the mine and is attached as Figure 1.

The water reticulation system was designed to allow the mine to supply major users from various sources depending on the demand and availability of water from a particular source.

From Figure 1, and as observed during the site visit, a high degree of recirculation of water is achieved.

3.2 DESCRIPTION OF WATER TREATMENT/MANAGEMENT SYSTEMS

There are no natural rivers or streams in the mining area and the terrain is flat and sandy. Any water due to a rainstorm will infiltrate to the groundwater system rather than entering a stream or river. The emphasis as far as environmental water management is concerned, is therefore on the groundwater system.

As far as the industrial or process water systems are concerned, the primary objective of the water management philosophy is to recycle as much water as possible and to minimise losses as far as possible. During the site visit, it was noted that this objective is actively pursued by the personnel responsible for water management.

3.2.1 Sewage treatment plants.

The sewage generated on the mine property is treated in oxidation and maturation ponds. The pond area is properly fenced off to prevent animals from using this as a watering hole.

The mine is responsible for operating the activated sludge plant treating the sewage of the town, however, the treatment plant is not situated on the mine's property.

3.2.2 Potable water treatment plant.

The mine is responsible for operating the water treatment plant producing potable water for Onverwacht, Ellisras, Marapong, Matimba power station and the Grootegeluk mine. Water is abstracted from the Hans Strijdom dam and transferred via a pipeline to the treatment plant where a portion of this water is treated for potable use. No potable water treatment plant is situated on the mine itself.

The treatment plant is staffed by properly trained operators and a sophisticated computerised system for monitoring flow, pH, pressure etc. on a continuous basis, is employed to assist in the operation of the water supply and distribution systems.

3.2.3 Settling dams and evaporation dams

A very high degree of water recirculation is achieved and only a minor portion of water is drained to ponds with the sole intention of evaporating the water. Most dams are fitted with pumps for water to be recirculated to the various users.

A study was done by the mine to determine the infiltration rate of water in the dams. According to the results, the infiltration rate in the Olifantskopdam has been estimated as 115 m^3/day. A substantial amount of water is thus lost as seepage into the groundwater system.

3.2.4 Opencast area

The main application for water in the opencast area is dust suppression. The water used in the pit for dust suppression is mainly water previously pumped from the pit area. The objective is to use as much of the groundwater that originated from the coal bearing area, in the same area again, and to minimise the use of this water in other areas. A certain portion of this water is supplied to the plant on demand.

Water draining from a small workshop in the area, containing a certain amount of oils and soaps, is also mixed with water from the Olifantskop dam and is used for dust suppression purposes.

3.2.5 Plant water circuits

The plant receives raw water from the Hans Strijdom dam, water from the opencast pit and borehole water. Water lost from the plant water circuits is mainly due to water retained in the product and discards. Some of the water lost with product and discard material drains from the stockpiles and is collected in sumps from where it is returned to the plant water circuits. Another portion is suspected to report to the groundwater and is indirectly recycled to the various users via this route.

A belt filter was installed and the water reclaimed in this manner is also recycled to the plant. Previously the plant used the slurry ponds to dispose of slurry, and the water reclaimed from the slurry ponds was generally less than the volume currently reclaimed. This caused an imbalance in the plant's water circuits and a certain volume of water is periodically released to the Olifantskop dam. In the Olifantskop dam, the water is mixed with water from the pit, and some of this water can again be supplied to the plant on demand.

One of the streams of recycled water used in the plant is sampled regularly and the analysis is used to check the quality of the water in the particular circuit. The extent of corrosion caused by process water has not been formally investigated as it is not perceived as a serious problem.

3.2.6 Discard dumps

The aim of the storm water control strategy is to retain the water on the dump itself and retaining walls have been constructed around the top perimeter of the dumps. A number of depressions on top of the dumps also serve to collect water and to prevent it from running off. The water running down the sides of the dumps is either collected in channels and drained to a dam or is left to drain into the ground. Due to the flat sandy terrain, drainage occurs quite rapidly.

Water percolating through the dumps can eventually be expected to report to the groundwater system, or to form seeps. However, to date no seeps have been observed and it is uncertain how much water reaches the groundwater systems. It is suspected that the high temperature of the burning dumps evaporates a certain volume of the water. In addition, the area has a relatively low rainfall, high temperatures and high evaporation figures and this may also play a role in explaining the absence of any seeps from the dumps.

3.2.7 Water monitoring systems

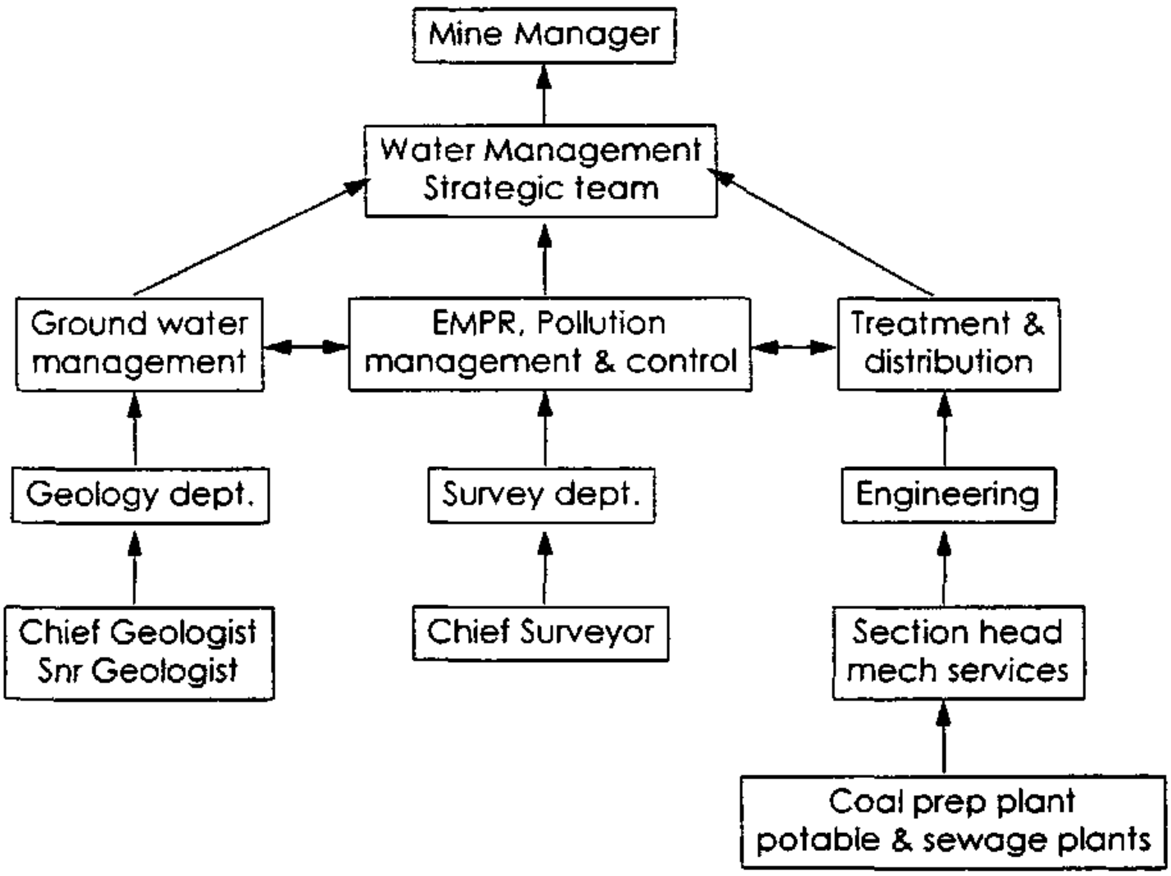
The mine has an extensive and comprehensive ground water and surface water quality monitoring programme. Water samples taken by the geology department on a six monthly basis are subjected to a reasonably detailed analysis schedule. In addition an ionic balance is performed on the data to verify the integrity of the data.

Water supplied to the plant is sampled weekly and more often if problems are experienced or suspected. Water from the pit is sampled weekly and a very basic analysis is performed by the mine's laboratory. Samples of the potable water are analysed by the mine and by Eskom. It can be assumed that any problems will be reported very soon after they have occurred.

Flow is monitored on all the major surface water reticulation systems and although it has never been attempted, a fairly good salt balance should be obtainable, if required. As far as the ground water system is concerned, it would not be possible to produce an accurate salt balance in terms of the contribution from different sources.

3.2.8 Water management structure

The following diagram, representing the water management structure with the various departments and personnel involved, was supplied by the mine.



3.3 NOVEL OR UNIQUE WATER TREATMENT AND MANAGEMENT SYSTEMS

3.3.1 Water quality management structure / personnel

The day-to-day management of water quality, supply, treatment and disposal of effluents is carried out by suitably qualified persons who exhibit a high degree of understanding of the fundamental issues involved. During the site visit it was observed that the various departments involved in water management issues, have a very good understanding of their function, role and responsibilities in the management system. The impression was gained that good communication channels exist, and the forum of the water management team is used effectively. These factors indicate that water quality and environmental management are accorded a high priority at the mine.

3.3.2 Water monitoring and management systems

The mine uses sophisticated computerised systems to assist in managing the water supply and reticulation systems. This is not only true for the water distributed from the Hans Strijdom dam, but also for the groundwater monitoring system.

The system monitoring the water supplied from the Hans Strijdom dam, automatically records flow, pH, chloride concentration etc. According to the mine personnel, the data collected so far, has proved to be very valuable in estimating future water requirements.

Groundwater monitoring is also computerised and the Hydrocom system is employed. Ground water levels, water chemistry and quality data, survey data, borehole construction information as well as geological data can be integrated to monitor the water system.

During the site visit it was observed that these systems are used continuously, thereby enabling the mine to actively manage its water systems.

3.3.3 Project to predict the quality of water in the final void

A final water filled void will be left once mining activities have ceased. The problem of predicting the quality of the water that will be left in the final void is currently being addressed. The idea is to use a mixture of discard material and power station ash as backfill material. The present focus of the study is to determine the optimum ratio for the mixture that will satisfy the required structural stability criteria for it to be used as backfill material. Once this has been determined, leaching tests will be conducted to enable the mine to predict the quality of the water in the final void.

3.3.4 High degree of water recirculation

During the site visit it was observed that the objective of minimising water wastage is actively pursued. As far as could be determined and observed, no water is discharged into the veld. Most water streams are directed into a reservoir or pumped to a point from where reuse can be facilitated.

3.4 POTENTIAL WATER TREATMENT/MANAGEMENT PROBLEMS AND NEEDS

As a result of the discussions and site visits, a number of issues were identified where problems and knowledge gaps still exist.

3.4.1 Computerised monitoring systems.

Problems are experienced from time to time with the computerised monitoring systems on the water supply circuit from the Hans Strijdom dam. The mine is currently too reliant on the original supplier for backup and service and the service is not always satisfactory. Alternative sources with the necessary technical expertise to service and maintain the system are often difficult to locate among South African companies.

Protection of remote field stations against lightning is a problem. In addition to the cost implication, information is also lost in the event of damage to equipment.

3.4.2 Rising water table north of the Daarby fault

The water table in the area north of the Daarby fault has risen steadily from the original level of 30m below surface to the current level of approximately 10m below the surface. The coal preparation plants are suspected to be the major contributors to ground water recharge with contaminated water. A project is underway to establish the amount of water that must be removed to lower the level of the water table. The rising water table may cause damage to foundations and infrastructure if unchecked.

It is hoped that this water can be used in the coal preparation plants instead of water from the Hans Strijdom dam. It is also the intention to contain any contaminated water and to prevent it from contaminating a wider area.

The need to line the surface dams containing contaminated water has been expressed by mine personnel.

3.4.3 Water balance for coal preparation plants.

As mentioned elsewhere, the plants are experiencing difficulty in maintaining a proper water balance and an unknown volume of water is spilled regularly to the Olifantskop dam. The excess water available due to filtration of the slimes, cannot be accommodated as the original design did not make provision for this. The volume of water discharged by the plant is still under investigation.

3.4.4 Salt accumulation and salt balance.

During the mining operations, there is a continuous liberation of salts and these are exposed to the water environment. Continuous recycling and high evaporative losses without any water streams leaving the mine, suggest that there must eventually be a build-up of salts in the system. The most likely possibility is an accumulation of salts in the soil profile. Although the available soil analyses do not indicate such a trend, the data is very limited and no official investigation of this nature has been launched.

A salt balance could theoretically be produced for the major water streams on the mine as flow rates are known for most of these streams and water quality data can easily be incorporated, although the water quality database may have to be extended. The quality monitoring programme, especially on the various recirculating water streams, may have to be extended to provide for more frequent sampling and more comprehensive analytical results. As far as the groundwater systems are concerned, the stage has not yet been reached where a confident salt balance can be produced.

3.4.5 Recharge and extraction dynamics of the groundwater system.

This has been identified as an area where a knowledge gap still exists. Future projects can be initiated in order to address this issue. If a definitive model can be developed to simulate this aspect, it could help the mine in more effective management of the rising water table as discussed in Section 3.4.2.

3.4.6 Results of water analyses reported by mine laboratory

The laboratory on the mine is primarily concerned with the analyses of coal samples. In some instances, water samples are also send to the lab for a limited analysis. It is important to recognise the limited application of these results. If for example, the data is needed for database applications, the analyses should be more comprehensive in terms of the chemical constituents identified and a reasonable ionic balance must be achieved.

3.4.7 Quality of water in final void.

Although this was also mentioned in the section dealing with novel treatment and management systems, it should also be mentioned in this section as it is still an unsolved problem.

4. GENERAL IMPRESSIONS

4.1 ROLE OF THE EMPR

Due to the dry climate and general shortage of water, water management has always been awarded a high priority on the mine. From the discussions, it was concluded that although a lot of work in terms of water management has preceded the EMPR, the EMPR served as a focus point and helped to create a broader awareness of the implications and importance of proper water management and treatment issues.

4.2 WATER QUALITY DATA REPORTED TO THE MINE

In addition to the water quality data obtained from the coal laboratory and other sources, a comprehensive analyses is obtained from laboratories in Pretoria on a six monthly basis. This data appears to be fairly comprehensive. The reported data is complete enough to enable the mine to evaluate water reclamation strategies should the need arise. This is in contrast to some other mines where important water quality determinants, for example alkalinity, are often omitted.

4.3 INFORMATION SYSTEMS

The personnel responsible for water management on the mine, do receive information and journals specifically related to water issues which will assist them in their jobs. They are well qualified and good communication channels exist. The key personnel are aware of relevant research being undertaken by various organisations such as the Water Research Commission. Some are also active members of professional bodies that have a direct relevance to water related issues.

Although there are not always answers to all the questions, it is obvious that the personnel involved have the ability to identify and prioritise the issues involved.

4.4 OPENNESS ABOUT WATER AND ENVIRONMENTAL MANAGEMENT ISSUES

The mine and the personnel interviewed were very open and willing to provide all the required information with regard to their water management and treatment systems.

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. The following is a list of the readings taken:

No	Description	pH	Cond.
1	Channel to Olifantskop dam downstream of desilting pits	7.58	235
2	Holding dam for spilled water, storm water etc. (Olifantskopdam)	8.5	193
3	Pit water storage tank for road wetting purposes	7.8	198
4	Pump station in open pit (bank 5)	7.7	230
5	Seep from bank in opencast pit	6.7	355
6	Dam for receiving storm water and wash water from area 06 at splitterbox	7.15	129
7	Thickeners at the coal prep. plant	7.5	250
8	Make-up tank at GG1	7.4	215
9	Channel collecting water seeping from product stockpile	7.4	285
10	Water in dam north of plant receiving water from slurry ponds	6.6	244
11	Water from slurry ponds measured upon entering 10 above	6.8	245
12	Water at slurry reclamation site (suspected to be largely rain)	7.8	88
13	Storage dam receiving water from decant towers in slurry ponds	6.8	246

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:

Photograph No	Description
1,2	Desilting pits below GG1
3	Channel to Olifantskop dam downstream of desilting pits
4	Pipeline transferring water from holding dam to plant
5,6	Holding dam for spilled water, storm water etc. (Olifantskopdam)
7	Buffer dam - Storage capacity for future - to be lined
8	Pipeline from opencast pit
9	Facility for filling water trucks - road wetting
10	Pit water storage tank for road wetting purposes
11	Pump station in open pit (bank 5)
12,13	Storage facility in open pit for runoff and liberated groundwater
14	Seep from bank in opencast pit
15 - 17	View of opencast activities
18	Dam for receiving storm water and wash water from area 06 at splitterbox
19	Storm water channel to dam in 18 above
20	View showing typical flat topography
21	Lucerne crop being irrigated with borehole water
22	Thickeners at the coal prep. plant
23	Raw water / make-up tank at coal prep plant
24	Make-up tank at GG1
25	Channel collecting water seeping from product stockpile
26	Dam north of plant receiving water from slurry ponds
27	Slurry reclamation site
28	Storage dam receiving water from decant towers in slurry ponds
29	Retaining walls on top of dumps to retain water on top of dumps.
30	Sewage oxidation ponds.

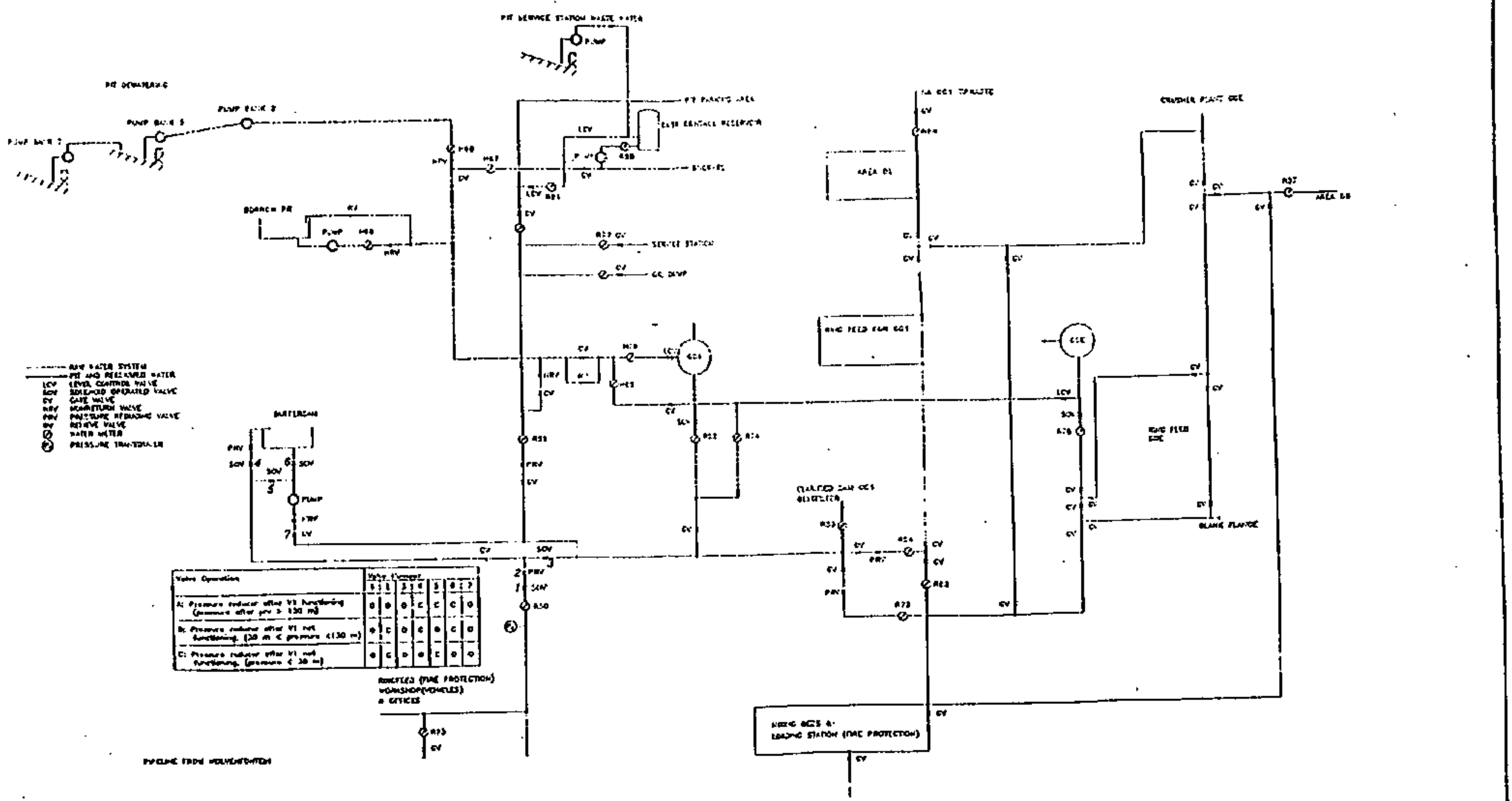


Figure 1

ISCOR YSKOR GROOTEGELUK

DATE 93.02.11

GROOTEGELUK
WATERSTELSEL
SKEMATIESE DIAGRAM

G0065395R00A1

Report on Hlobane Colliery site visit.

23 September 1993.

1. GENERAL INFORMATION

Name of mine	The Vryheid (Natal) Railway Coal and Iron Company Ltd.	
Name of person(s) interviewed	Louw Potgieter Jack Ross	
Position of person(s) Interviewed	Mining Technician Head Laboratory	
Nearest town	Vryheid	
Name of catchment	4 sub-catchments:	
	Sithebe	27.0 km^2
	Kwa-Gamakazi	10.7 km^2
	Kongolwana	22.9 km^2
	Tshoba	2.5 km^2
Daily coal throughput (rom)	5156 tons per day	
Daily saleable product	1679 tons per day	
Daily discard production	3331 tons per day (coarse & fine)	
Main product and market	Iscor	
Current age of mine	ca. 100 years	
Expected remaining life of mine	ca. 5 years	
Type of mining carried out	Underground - varying methods depending on coal seam characteristics	
Transport mode from mine to plant	Conveyors and trucks from outlying areas	
Has an EMPR already been produced	In final draft stage	

2. SITE VISIT PROGRAMME

2.1 23 September 1993

- Arrival
- Short discussion of project background and objectives
- Discussion of the mining operations and various aspects of the water system at the mine
- Present at meetings:
  L Potgieter - Mining Technician, Hlobane
  L de Lange - PHD
- Guided tour of the mine premises
- Completion of questionnaire
- Visit potable water treatment plant and sewage treatment plant

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

3.1 DESCRIPTION OF WATER CIRCUITS

A plan of the mine showing all the sampling points and the major elements of the water pollution control system was supplied by the mine. In addition, a water balance for the mine's water reticulation system, was provided.

The mine has a separate potable and industrial water system. Potable water is abstracted from the Vaalbank dam and treated at the mine's water purification plant.

The main users of potable water on the mine are the office complex, the hostel complex and as drinking water at the various other locations where mining activities are in progress.

The main source of industrial water is the underground water. A large volume of water is stored in underground reservoirs and the availability of water is not perceived as a problem. The water is pumped to surface and used untreated in the various applications.

The service water used in the underground operations is used in a closed loop manner. The main applications are dust suppression and drilling. Water discharged by the users is collected at a low point in the working area and recirculated to the users without treatment. It is assumed that some suspended material is settled and removed in the collection dams.

The main mine complex includes the offices, the plant, stockpile and workshop areas, and a fairly large discard dump. All the surface runoff from the mine office complex, which is situated above the plant, workshops, stockpile and dump area, is collected and transferred via a large diameter concrete pipe underneath the dump and stockpile area, and is discharged directly into the Sithebe river. Dirty water from the plant and dump area is collected in a trench and is discharged into the slurry ponds below the dump.

A drawing was supplied which shows the main components of the surface water systems of the mine. It shows the various streams, sampling points as well as the position of the various dumps and evaporation dams. No information regarding the volume of surface runoff or infiltration rates was available.

3.2 DESCRIPTION OF WATER TREATMENT/MANAGEMENT SYSTEMS

The following discussion draws on both the visual observations during the site visit as well as the information contained in the EMPR.

3.2.1 Sewage treatment plant

The general impression formed about the sewage treatment plant is that it is well maintained and kept neat. As far as could be determined superficially, all equipment was kept in a state of good repair.

The plant is an extended aeration-activated sludge plant which works on the Pasveer Ditch principle.

Inspection of the available chemical analyses, indicated that the effluent from the plant is not monitored for phosphates. It could not be established if problems due to high nutrient loads are experienced after disposal of plant effluent into the Sithebe river. According to the mine personnel, no indication of this happening has been observed.

3.2.2 Potable water treatment plant

The potable water treatment plant is operated by the mine with one full time operator on duty. The plant is situated some distance from the main complex and at the time of the site visit the operator was engaged elsewhere and not available for an interview regarding the treatment plant's operational aspects.

Water is purified by dosing a flocculant (Floccotan, a wattle bark extraction) directly into the main pipeline. Settling takes place in six settling cones with V-notch launders at the top to collect the clear water overflow. The water is gravity filtered in three circular steel sand filters. The filtered water is disinfected with chlorine gas and pumped to the main potable water sump. The filters are backwashed daily.

3.2.3 Reedbeds

There are two reedbed systems on the mine to be considered. The one reedbed system in the Sithebe river, receives water from the area to the south west of the main plant complex. The reedbeds are clearly indicated on the pollution control plan, (drawing supplied by the mine). In this area there are dumps, rehabilitated old opencast areas etc. that influence the quality of water flowing into the reedbed.

An analysis of the water entering the reedbed and the water draining from the reedbed was obtained from the mine. Table 1 below is a summary of the data.

Although the data in the above table suggests that the reedbed is having a beneficial effect on the effluent, e.g. reductions in hardness and sulphate, the table also exhibits some inconsistencies. In particular, the reported reduction in total dissolved solids is not reflected in the conductivity which has not decreased by the same amount. The substantial increase in pH is also somewhat unusual. The precise mechanisms which are operative within the reedbed can only be verified on the basis of a proper water and salt balance around the reedbed. The reported analyses do not allow an ionic balance to be prepared and proper evaluation of the reedbed would require additional data such as magnesium and carbonates.

Table 1 : Water Quality Before and After Hlobane Reedbed

Determinant	Before	After	Determinant	Before	After
pH	5.1	8.1	Cl	8.83	19.9
Susp Solids	17	5	K	52.6	34.9
TDS	4004	2606	Cu	ND	ND
Ca -hardness	1080	670	Pb	ND	ND
Tot Hardness	2502	1049	Na	10.8	8.6
Conductivity	362	314	Mn	7	0.2
SO4	1386	1202			

The other reedbed is a very small system and is essentially a small dam overgrown by reeds. Water pumped from the underground workings through the Tshoba adit is discharged to this dam/reedbed system. The water flows overland for approximately 500 - 600m and is mostly in contact with sandstone. According to the observations of the mine personnel, the water pumped from the adit is fairly acidic with a pH of 3-5 and cattle in the vicinity have historically refused to drink the water. However, after the introduction of the reeds, the cattle started drinking the water and a watering point for cattle has been constructed directly below the outlet of the dam.

3.2.4 Settling dams and evaporation dams

A number of evaporation and settling dams were constructed at various locations. The following were identified as the more important evaporation dams on the mine:

- Three evaporation dams in series receiving water from the plant, dump, stockpile area and workshops. Water from these areas is collected and transported to the evaporation dams via storm water ditches constructed for this purpose. These dams also receive water seeping and flowing from the main discard dump.

It was observed that water is seeping from the side of the dump away from the evaporation dams. This problem will be addressed by excavating a drainage ditch down to bedrock, and lining it with an impervious material, probably clay. The intent is to intercept any water from this side of the dump and to redirect it into the evaporation dams.

- Three slurry ponds on top of the main discard dump receiving the slurry from the coal preparation plant.
- A series of evaporation dams below the dumps in the vicinity of the HCP plant.

- Two evaporation dams under construction in the area close to the Langgelegen adit. These dams will serve the proposed new scalping rock dump.

Problems with seeps and separation of clean and dirty water are experienced at some of these dumps. The mine is aware of these problem areas and is taking steps to address these problems.

3.2.5 Underground circuits

Except for the potable water supply, all the water used in the underground circuits is extracted from the underground workings. The old workings are being utilized as an underground storage compartment (ca. 654 000 m^3). This compartment also receives water seeping through the surface from dumps and rehabilitated opencast areas situated above it. Water entering other mining areas is also pumped to this reservoir. Water for mining purposes and water for use in the coal preparation plant is extracted from this reservoir.

The two main applications for water underground are dust suppression and drilling. Each area has a local closed loop water circuit where spent or used water drains to a dam at the lowest point in the area, from where it is recirculated. No treatment (e.g. addition of flocculant, softening, pH adjustment) is applied. The water is not sampled for analysis and no quality information is available for the service water. It was pointed out that, to date, no complaints about bad smells, fouling and blocking of spray nozzles, or corrosion have been received.

In the Waterfall area, there are two adits: one is being used to bring coal to surface and the other, somewhat lower down the slope, is not being used for mining purposes. Provision is made for surface runoff from the coal stockpile in this area to be diverted back into the underground system via the unused adit, thereby preventing this water from entering the natural watercourses.

3.2.6 Plant water circuits

The plant receives water from underground and this water is used in the plant without any form of treatment. The water is not sampled nor analysed as the need to do so has never arisen.

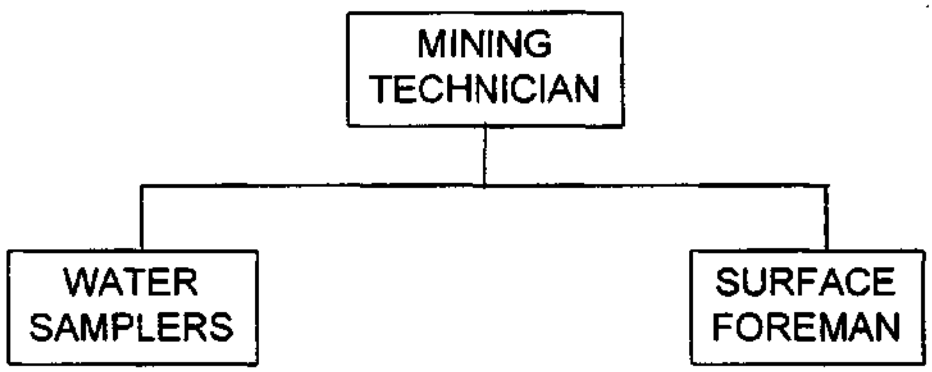
3.2.7 Liming plant at Vryheid Coronation

This plant was built to treat excess underground water from this adit before discharge into the surface water system. The plant is only operated when excess water from underground needs to be discharged. It is envisaged that after mining activities have stopped, this plant will continue to be operational for an indefinite period of time. There are plans to modify this plant in the future to become fully automatic. The responsibility for maintaining this system will revert back to Vryheid Coronation once Hlobane has finished its activities on site.

3.2.8 Water management structure

Mr L Potgieter is the person responsible for the water management on the mine. The head of the laboratory Mr J Ross, is responsible for the water monitoring programme as well as the sewage water treatment plant.

The following diagram representing the water management structure with the various departments and personnel involved was supplied by the mine.



3.3 NOVEL OR UNIQUE WATER TREATMENT AND MANAGEMENT SYSTEMS

3.3.1 The design for a new dump for disposal of scalping rock

A new approach regarding the handling of water from this dump is discussed in a report provided by the mine. A detailed drawing showing the main features of the design was also provided by the mine.

In summary, the design philosophy postulates that for a dump constructed of sized material, in the absence of fine material, it is only the first 10% and the last 5- 10% of the water volume represented by the hydrograph that is polluted. The rest of the water from the dump should be of an acceptable quality, suitable for direct discharge into the surface water systems.

The structure collecting and deflecting runoff water from the dump is therefore designed to deflect the contaminated water i.e. the first 10% and the last 5 - 10%, into the evaporation ponds. The design allows the rest of the water to overflow into the surface water system.

3.4 POTENTIAL WATER TREATMENT/MANAGEMENT PROBLEMS AND NEEDS

The following are observations that were made during the site visit and are related to potential problems or knowledge gaps that still exist.

3.4.1 In house water quality and management expertise of personnel responsible for water management

Environmental management staff and activities are focused largely on land rehabilitation. The mine does not have staff with formal training in water related aspects and with primary responsibility for water management. The personnel involved are specialists in other mining related activities with water management constituting an additional/ sideline responsibility rather than a main responsibility.

3.4.2 Water management coordination with external parties

The mine cannot quantify how it is or could potentially be influenced by activities on neighboring mines, nor can it quantify its own influence on its neighbors. The concept of investigating water related issues in a co-ordinated fashion with neighbouring water users and adopting water management principles that make provision for external participants, was raised. The mine assesses the potential impact of the discharged effluents on downstream users to be minimal and has, therefore, not identified a need for such regional co-ordination.

3.4.3 Water quality data reported to the mine

The mine obtains its water quality data from the Iscor laboratory in Newcastle. Inspection of the laboratory results indicated that neither the alkalinity of the water, nor the carbonate speciation of the water is indicated in the results. It will be to the advantage of the mine to include alkalinity in the data reported, since it would allow the mine to perform certain calculations with the data. For example, water characteristics such as the potential for $CaCO_3$ and $CaSO_4$ scaling and the chemical dosing requirements for neutralisation or softening with various chemicals could then be determined.

Inspection of the water quality data indicated that an ionic balance could not be obtained. It must, therefore, be concluded that the performed analyses are inadequate and that some major constituents are being ignored.

3.4.4 Water quality - "fitness-for-use" criteria

The mine appears to be in the fortunate position of possessing underground water which is of a sufficiently high quality, that it is possible to use it for a variety of applications without concern. For this reason, the mine does not see a need for fitness-for-use criteria for its various water users.
However, the lack of appropriate fitness-for-use criteria is judged, by the research team, as a need which will have to be addressed before optimal water management can be applied. Such criteria would enable the mine to reuse its dirtiest water (up to the allowable limits) and discharge its cleanest water, while ensuring that no process or materials problems occurred due to poor water quality.

3.4.5 Prediction of water quality impacts

The mine has a water balance which shows the different users of potable and process water, as well as the estimated consumption of each. However, if the definition of the system is expanded to include other surface water and groundwater systems, the information is less detailed. For example, the amounts of water that will reach the surface water systems once all mining activities have ceased, the probable decant points, and the quality to be expected cannot be predicted with the current level of information.

3.4.6 Information systems

Although a lot of interest is shown in water related problems, the personnel involved were not aware of the substantial amount of information that is freely available to them. Information such as results of research projects and periodicals and magazines dealing with water issues, is not regularly accessed by the various persons involved. This may be largely due to the fact that water management is not their primary interest or area of expertise.

3.4.7 High TDS levels in water discharged from the mine

Release of sulphate to the surface water bodies was not considered by the mine to be a major water quality problem. The DWA has never indicated that they have a specific problem with regard to any of the effluents leaving the boundaries of Hlobane. There are no major dams directly downstream of the mine that are used as a potable water source for any large communities.

However, the mine is concerned about the receiving water quality objectives approach of the DWA. In particular, the major problem is with regard is the high TDS of the water released. As far as the mine is concerned, the same water was discharged and used by the downstream farmers for many years, with no major complaints. The concern was expressed that the quality requirements for downstream users, especially the farmers, will now be set at levels unobtainable by the mine. The need for revised or site-specific fitness-for-use criteria was therefore expressed.

4. GENERAL IMPRESSIONS

4.1 LOW SULPHUR CONTENT OF COAL - RECOVERY OF WATER QUALITY

It was pointed out that the coal mined at Hlobane is of a very high quality and contains very little sulphur (0.7 - 0.8%). The potential for acid mine drainage is therefore very low. Past experience with water draining from underground workings has indicated that after an initial period of poor quality water, the quality of the water improves such that it can be used directly by farmers for stock watering. An example quoted is the water flowing into the Kwa-Gamakazi from old adits on the northern side of Vrede mountain.

4.2 ABSENCE OF CARBONACEOUS MATERIAL

As far as could be observed during the site visit, the mine property is kept fairly clean of any loose carbonaceous material. This material was only observed in areas where it would be impossible to avoid this, such as the stockpile areas and transport routes to the dumps etc.

4.3 REEDBEDS

During the site visit it became evident that reedbeds are considered as a very important component of a water treatment/management system with a lot of potential for application on the mine. Mine staff are particularly interested in such systems and have undertaken a number of related ad-hoc investigations. It may to the benefit of the mine and the industry as a whole, if these investigations can be undertaken on a more formal scientific basis.

4.4 MIXING OF LIMING PLANT SLUDGE "YELLOW BOY" WITH MATERIAL USED TO FILL OLD OPENCAST PITS

Old opencast pits are currently filled with a material consisting mainly of sandstone. The sludge from the liming plant containing ferric hydroxide precipitate ("yellow boy") is also dumped in the pits. The sandstone material used to fill the pits, contains only a relatively small proportion of carbonaceous material. The intent is that the yellow boy should have a neutralising effect on the initial acidic conditions that may exist due to leaching of water through the pit into the underground workings.

This approach has, however, not been properly investigated and validated. The volume of applied sludge is small compared to the volume of filler material and it is uncertain whether any beneficial effects in terms of neutralisation will be achieved. The potential for resolubilisation of the ferric hydroxide and resultant contamination of the water is also unknown.

4.5 WATER QUALITY MONITORING PROGRAMME

All indications are that the water sampling and monitoring programme of the surface water systems is fairly comprehensive in terms of number of sampling points. The only concern is with regard to the determinants being analysed for, as discussed in 3.4.3 above. In addition, flow measurements are also made at the various sampling points, thereby supplying the mine with a lot of the basic information required to compile an accurate water and salt balance. The accuracy of the flow measurement systems, and their ability to record peaks and dips in the flow was not assessed.

4.6 ROLE OF THE EMPR

From the discussions, it is concluded that the EMPR is an important factor that has guided the mine in identifying and addressing its water management issues.

4.7 WILLINGNESS TO PROVIDE INFORMATION

The mine has been very willing to provide information with regard to aspects relating to their water management and treatment systems. The mine was fully willing to provide copies of documents and/or drawings and also provided a full copy of their draft EMPR.

4.8 DURATION OF SITE VISIT

The site visit had to be condensed into a single day due to other commitments of the mine personnel involved in the visit. This led to the situation where the questionnaire could not be completed to the desired level of detail and additional information had to be obtained subsequent to the visit.

Appendix A - List of photographs taken during the site visit.

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

Photograph No	Description
1	Waterval adits - diverting surface runoff back underground
2	Construction of evaporation ponds for the new scalping dump
3	Inpit pumping - dirty water circuit
4	Vrede liming plant
5	Dirty water ditches around dump to evaporation ponds
6	Evaporation ponds below dump and plant area
7	Tshoba seep before small reedbed/pond
8	Tshoba small reedbed/pond
9	Pollution control below dump at High Carbon Products
10	Wetlands in Sithebe river
11	Exit point of wetland in Sithebe river
12	Dump, stockpile and main plant area
13	Potable water treatment plant
14	Sewage treatment plant

Report on Kleinkopje Colliery Site Visit.

16 - 17 November 1993

1. GENERAL INFORMATION

Name of mine	Kleinkopje Colliery
Name of person(s) interviewed	Mr DRW Dingemans - Div. Geologist Mr S Timm - Hydrologist
Nearest town	Witbank
Name of catchment	Olifants 210
Monthly production (ROM)	600 000 t/m
Monthly saleable product	400 000 t/m
Monthly discard production	200 000 t/m
Main product and market	Export steam coal, Inland steam coal
Current age of mine	Opencast - 14 yrs, Previously underground mining - 70 yrs
Expected remaining life of mine	Opencast - 20 yrs
Type of mining carried out	Opencast strip mining
Transport mode from mine to plant	Road haulers
Has the mine already produced an EMPR	In process - ca. 80% complete

2. SITE VISIT PROGRAMME

2.1 Day 1 - 16 November 1993

- Arrival
- Presentation by mine personnel on water management
- Guided tour of the mine

2.2 Day 2 - 17 November 1993

- Completion of questionnaire
- Visit various places on mine premises

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

3.1 DESCRIPTION OF WATER CIRCUITS

A locality plan showing the major components of the surface water systems was supplied by the mine and is attached as Figure 1. In addition, a diagram showing the various components of the various water users on the mine was also obtained and is attached as Figure 2.

3.2 DESCRIPTION OF WATER TREATMENT/MANAGEMENT SYSTEMS

3.2.1 Sewage treatment plants.

The Kleinkopje sewage treatment plant, treats approximately 300 m^3/d of sewage effluent. The treated effluent is disposed of by returning it to the Kleinkopje clear water return dam. The water from this dam is mainly used in the coal preparation plant. Due to time constraints, it was not possible to visit this plant. No phosphate removal is done in this plant.

3.2.2 Potable water treatment plant.

Water for use as potable water on the mine and for gland service water in the Kleinkopje coal preparation plant, is treated at the Kleinkopje water treatment plant. According to information supplied by the mine, the water is sampled and analysed weekly for various constituents. The possibility exists, therefore, that problems with regard to the quality of potable water, may only be detected too late.

3.2.3 Settling dams and evaporation dams

The major settling dams are the slurry ponds receiving slurry from the coal preparation plant. Slurry from the coal preparation plant is disposed of in the new co-disposal facility. Water from this facility is returned to the clear water dam for reuse in the plant.

One of the water management options considered by the mine, is the use of the Tweefontein pan to evaporate excess water. Although there are evaporation losses from other water bodies, the Tweefontein pan will be used with the sole intent of evaporating excess water.

3.2.4 Clear water or return water dam

A central dam functions as the hub of the process water circuits. Dirty water from various points on the mine is pumped to this dam which is referred to as the clear water dam. The plant abstracts most of its water from this dam. Concern has been expressed about the limited capacity of this dam in relation to the volumes of water in circulation, especially in wet seasons.

3.2.5 Opencast area

The main use of water in the opencast area is for dust suppression. Water accumulating in the pits, mostly rain water, is normally pumped to the clear water dam. In the past, the situation has arisen where excessive amounts of water accumulated in the pits, and the disposal of this water became a problem. Because the water could not be discharged to public streams, it had to be left in the pits for long periods of time, leading to excessive deterioration in water quality and the associated disposal problems. The mine believes that the quality of the water would not be too severely affected if it could be discharged to public streams soon after a rainfall event.

A water management strategy currently being employed in the opencast areas, is to minimise the operating mining window. This strategy requires that rehabilitation keeps up with the mining operation and that the exposed and disturbed area is kept to a minimum. By reducing the active / disturbed operating window, the amount of water that can accumulate due to the poor runoff characteristics of these areas, will be reduced.

3.2.6 Plant water circuits

The coal preparation plant receives most of its make-up water from the clear water dam and as such, uses recycled water. Potable water is supplied as gland service water. Raw, untreated water from the Olifantsriver is also used as process make-up water when required, but not on a continuous basis. The total amount of water in circulation in the plant at any given time was not immediately available, but could be calculated from pump curves if necessary.

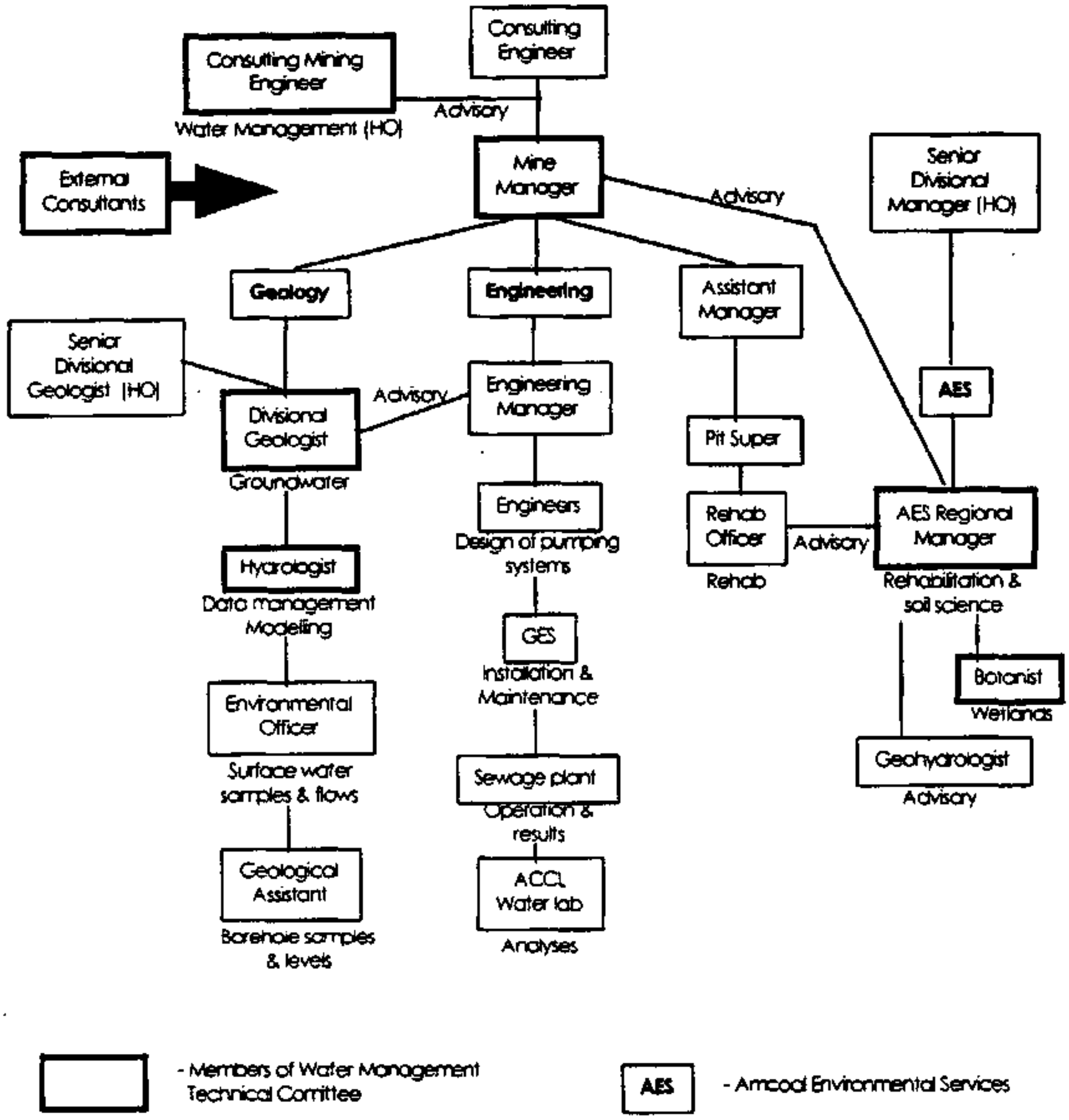
3.2.7 Water monitoring systems

The mine has a fairly detailed water monitoring programme. Most of the important points for monitoring water have been identified and are being monitored. The quality data reported to the mine is fairly comprehensive and the data is checked by the responsible personnel. Spot checks are performed on some of the data by way of an ionic balance and results are queried if problems are detected.

Information with regard to the flow rates of various water streams, both natural streams and those due to various mining activities, is very limited. Unfortunately, as the flow monitoring programme is not complete, the water monitoring programme cannot be regarded as complete and it is not possible to calculate or manage the salt loads being generated.

3.2.8 Water management structure

The following diagram, representing the water management structure with the various departments and personnel involved, was supplied by the mine.



3.3 NOVEL OR UNIQUE WATER TREATMENT AND MANAGEMENT SYSTEMS

3.3.1 Water quality management structure / personnel

The day-to-day management of water quality, supply, treatment and disposal of effluents is carried out by suitably qualified persons who exhibit a high degree of understanding of the fundamental issues involved. The impression was gained that good communication channels exist, and the forum of the water management technical committee is used effectively. These factors indicate that water quality and environmental management are accorded a high priority at the mine.

3.3.2 Water monitoring and management systems

Computerised models varying in sophistication, are widely used for water management purposes. Groundwater monitoring is computerised and the Hydrocom system is employed. At the time of the site visit, only a certain portion of the full capacity of the system was used. The personnel interviewed expressed the intent of utilising the full potential of the system in future.

The responsible personnel are actively and continuously involved in identifying methods and instrumentation that will enable them to optimise the monitoring programme within budget and practical constraints. For example, new continuous monitoring stations are under consideration for some of the major water courses on the mine's property.

The personnel involved are employing sophisticated hydrological models such as the SCSSA and WRSM90 in predicting surface runoff volumes. They are also familiar with methods for statistical manipulation of continuous flow data as well as other computerised models that may be used to assist them in their tasks.

During the site visit it was observed that these systems are used continuously. Provided the current expertise available on the mine is utilised to the full, and is allowed to steer further developments, the mine should be in a position where it can actively manage and control the water systems.

3.3.3 Project to investigate the functioning of the natural wetland in the Landau Spruit

The personnel involved with monitoring the natural wetland situated in the Landau spruit, believe it is effective in removing sulphates and improving the acidity of the acid water leaching from the Landau dump toe dam into the wetland. The services of the CSIR were obtained with the view of investigating the system on a scientific basis. Unfortunately, due to the fact that this is a joint project between the CSIR and the mine, the results and reports related to this study were not made available. However, the endeavors of the mine to come to an understanding of the system on a scientifically sound basis, is recognised.

3.3.4 Acid water organic sludge amelioration system (AWOSAS)

This project is also a joint project between the mine and the CSIR and again the results and reports relating to this study were not made available. The aim of this study is to investigate the option of treating acid mine water by utilising the sulphur reducing bacteria in sewage sludge. The bacteria will remove sulphates by reducing it to H2S which will then be released into the atmosphere.

3.3.5 Impact of improved rehabilitation methods on water management strategies.

The weathered C-horison of the geological profile is removed in a pre-stripping operation ahead of the dragline operation. This material is then used to fill the spoils behind the drag line operation before the final top soil layer is added. The purpose of using the C-horison as a filler material, is to reduce the permeability of the rehabilitated spoils. It is believed that less water will infiltrate into the spoils and therefor less water will be contaminated due to contact with spoils material.

3.4 POTENTIAL WATER TREATMENT/MANAGEMENT PROBLEMS AND NEEDS

As a result of the discussions and site visits, a number of issues were identified where knowledge gaps still exist.

3.4.1 Practical implementation of continuous monitoring systems.

There are a number of practical issues concerning the protection of remote field stations against lightning, theft and vandalism. It is found that these installations are often a target, and although a lot of useful information can be generated, the systems can become impractical if solutions to these problems cannot be found.

In addition, it is often found that probes on continuous monitoring stations are unreliable and do not last long. Replacement cost becomes a practical consideration.

3.4.2 Long term functioning of wetlands.

During the site visit, the concept of wetlands as a long term management strategy was discussed. Although the factors that make wetlands an attractive option are recognised; the danger of regarding wetlands as the cure-all for all effluent treatment problems must be recognised.

3.4.3 Sulphate removal

The effective treatment / management of sulphates in the effluent streams, was identified as one of the more important challenges facing the mine - hence the studies and projects aimed at ameliorating this problem.

3.4.4 Flow measurement

As mentioned elsewhere, accurate flow data is an essential component of a monitoring programme aimed at providing input into a water management strategy. In view of the waste load allocation policy advocated by the DWAF, it would not be possible to formulate an effective water management strategy if salt loads cannot be predicted or calculated.

With regard to surface water systems, pump curves and pumping hours are used to calculate flow rates for some of the water transfer operations. The inherent inaccuracies of this method render it unsuitable in the long term and proper flow measurement methods should be investigated. Considering the practical problems with monitoring flow in the mining environment, this is also considered to be a challenge for the personnel responsible for water management.

During the discussions, the problem of quantifying the volumes of water infiltrating into the old underground workings was mentioned as another area where more work could possibly be done.

3.4.5 Modeling of discard dumps before and after rehabilitation.

The relative merits of retaining rainwater on top of dumps rather than shedding the water as soon as possible is unknown. The effects of sealing discard dumps to reduce the amount of water seeping through the dump and reporting as an acid seep, or reporting in the groundwater system, need further investigation. Different considerations were mentioned for which the practical implications are not clear. These were:

- sealing the dump with an impermeable layer before rehabilitation
- lining the dump site before construction
- the method of construction - whale back or terraced.

The method of construction favored by the mine is the terraced construction. The whole question of a water and salt balance around a discard dump is an issue which requires further investigation and can be considered to be an industry-wide issue.

3.4.6 Disposal of excess water.

The mine has an excess of water and has to investigate options for disposal of the excess water. The underground storage capacity is nearly exhausted and cannot be used as a storage facility for much longer. The option of using the Tweefontein pan as an evaporation facility is currently under investigation.

Another aspect that is receiving attention is the concept of free mine drainage where the aim is to discharge the water from the opencast pits and spoil areas as soon as possible after a rainfall event. This is in order to minimise contact time of the water with the spoils and it is hoped that the level of pollution will be small enough for discharge into public streams.

3.4.7 Gland service water

The coal preparation plant is currently utilising potable water as gland service water on the slurry pumps. The main quality criteria for gland service water is:

- the water must be free of suspended solids
- it must not be corrosive
- it must be non scaling

At present it is assumed that the potable water supply to the mine satisfies the abovementioned criteria. The daily water demand for this application is approximately 850 m^3/d. During the discussions it was suggested that the mine look into the possibility of treating water from another source such as water from the clear water dam in order to replace the potable water. Considering the fact that the disposal of excess water is a problem, there may be some merit in investigating this option.

It is not clear where the 850 m^3/d of potable water is coming from as only 330 m^3/d is treated in the water treatment facility at Kleinkopje.

3.4.8 Final river diversion.

The impacts of the placement of a final river diversion over rehabilitated spoils is an aspect that requires further research. The mine is currently planning such a research project and this could be of benefit to the whole industry

3.4.9 Calibration of runoff model parameters.

The hydrological models used for prediction of runoff volumes rely on the accuracy of input parameters. Some of these parameters reflect the percentage of water infiltrating into the ground, the percentage of the water that evaporates and the percentage that actually reports as runoff. The values of these parameters, especially for the operating mining window, are currently under investigation.

3.4.10 Leakage of underground water along the Ogies dyke.

Based on certain inconsistencies in the data for the underground water levels, one of the hypothesis is that water is actually leaking from the underground areas along the Ogies dyke. An investigation will be launched to confirm or discard this theory.

4. GENERAL IMPRESSIONS

4.1 ROLE OF THE EMPR

It is believed that the EMPR has played a significant role in focusing attention on water management aspects.

4.2 INFORMATION SYSTEMS

The personnel responsible for water management on the mine are well qualified and good communication channels exist. The key personnel are aware of relevant research being undertaken by various organisations such as the Water Research Commission.

Although there are not always answers to all the questions, it is obvious that the personnel involved have the ability to identify and prioritise the issues involved.

4.3 OPENNESS ABOUT WATER AND ENVIRONMENTAL MANAGEMENT ISSUES

The mine and the personnel interviewed were quite prepared to provide all the required information with regard to their water management systems. This is also true for the treatment systems, excluding the projects jointly undertaken with the CSIR.

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

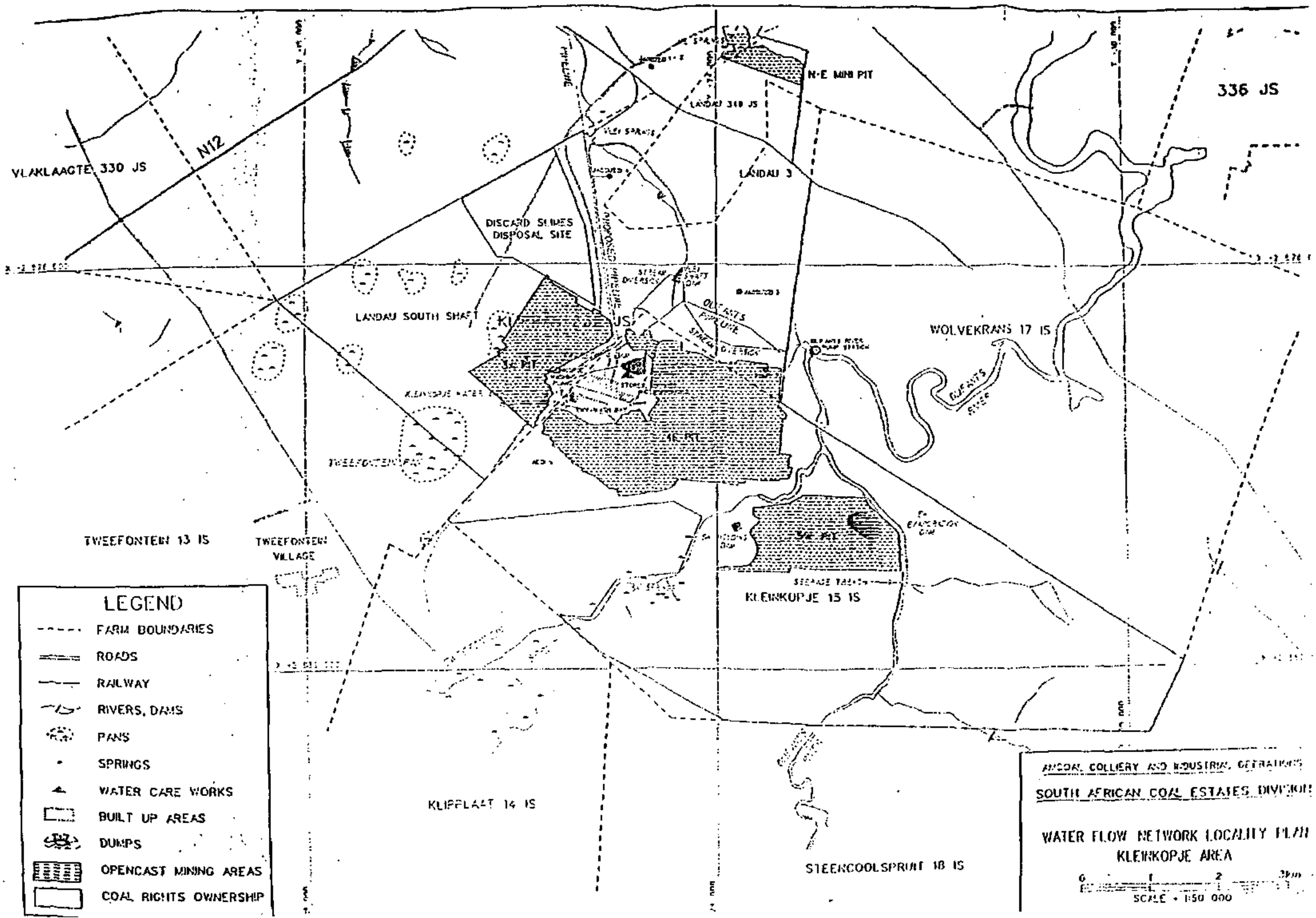
During the site visit, a number of pH and conductivity readings were taken at various locations on the mine. The following is a list of the readings taken:

No	Description	pH	Cond.
1	Slimes disposal within co-disposal facility	7.8	242
2	Water below new discard dump	7.1	342
3	NE spruit beneath NE rehab area - flow into Witbank dam	5.6	90
4	Wetland in Landau spruit - start	7.4	262
5	Landau dump toe dam	3.8	530
6	Wetland at Landau dump - close to dump	6.4	281
7	Same as 6 above but more towards center of wetland	7.0	219
8	End of Landau spruit wetland	7.05	109
	River diversion at overflow into Olifants river	7.35	119
9	Clear water / holding dam	7.4	225
10	Clarified water at coal preparation plant	7.65	238

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:

Photograph No	Description
1 - 3	View of mining operation - direction towards Olifants river
4	Ramp in block 3A area
5	View of 3A area
6	Slimes disposal within co-disposal facility
7	Water below new discard dump
8	North East area - rehabilitation in progress
9	NE spruit beneath NE rehab area - flow into Witbank dam
10 - 12	Wetland in Landau spruit - start
13	Landau dump toe dam
14	Wetland - direction upstream of Landau dump
15	Wetland - direction downstream of Landau dump
16	End of Landau spruit wetland - direction towards Landau dump
17	River diversion - overflow into Olifants river
18,19	Clear water / holding dam - direction towards plant
20	Area below clear water dam wall
21,22	Coal prep plant thickeners



336 JS
N-E MINI PIT
LANDAU 3
VLAKLAAGTE 330 JS
N12
DISCARD SLIMES
DISPOSAL SITE
LANDAU SOUTH SHAFT
WOLVEKRANS 17 IS
TWEEFONTEIN 13 IS
TWEEFONTEIN
VILLAGE
KLEINKOPJE 15 IS
KLIPPLAAT 14 IS
STEENCOOLSPRUIT 18 IS
LEGEND
FARM BOUNDARIES
ROADS
RAILWAY
RIVERS, DAMS
PANS
SPRINGS
WATER CARE WORKS
BUILT UP AREAS
DUMPS
OPENCAST MINING AREAS
COAL RIGHTS OWNERSHIP
AMCOAL COLLIERY AND INDUSTRIAL OPERATIONS
SOUTH AFRICAN COAL ESTATES DIVISION
WATER FLOW NETWORK LOCALITY PLAN
KLEINKOPJE AREA
SCALE 1:50 000

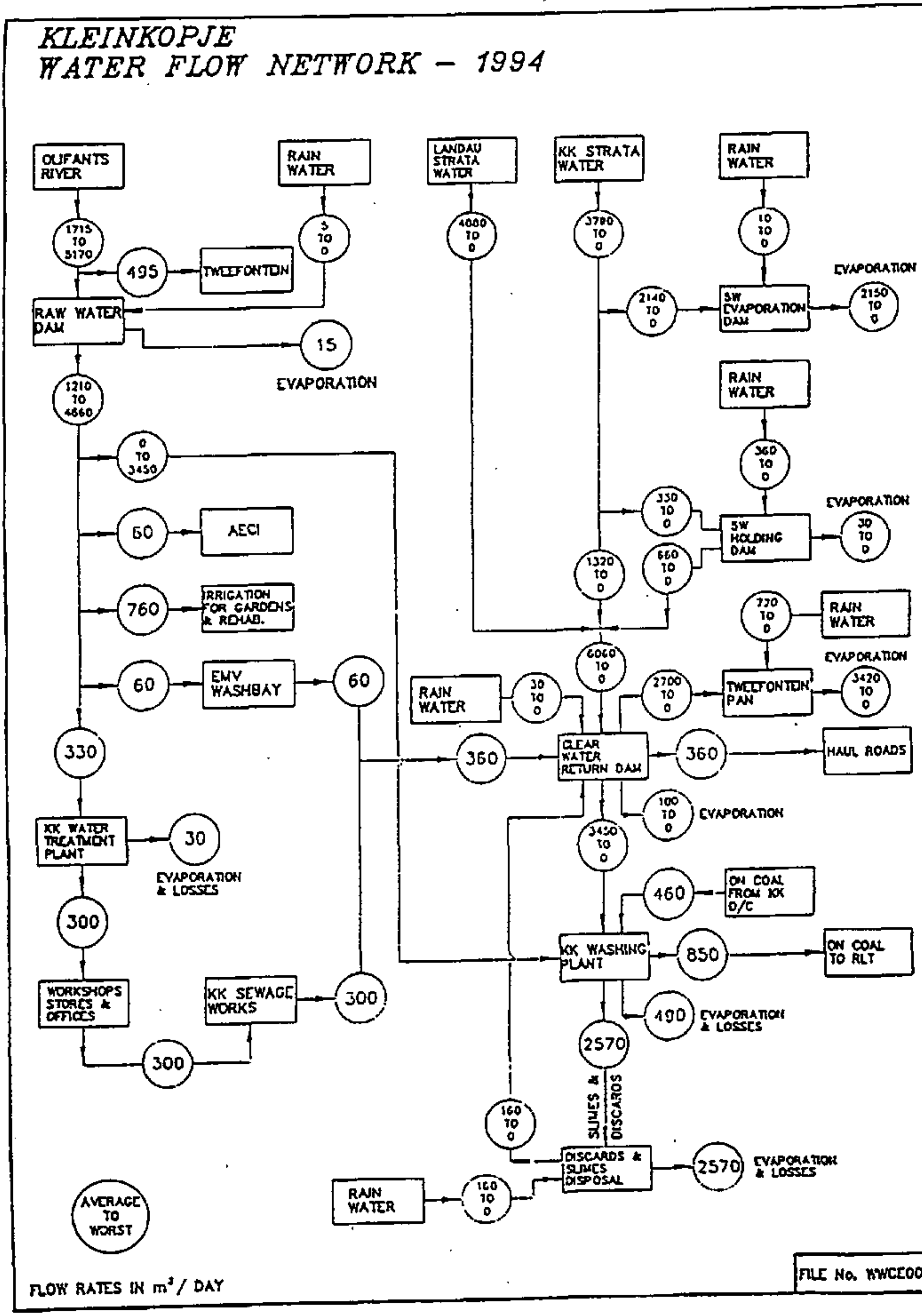

KLEINKOPJE
WATER FLOW NETWORK – 1994
OLIFANTS RIVER
RAIN WATER
LANDAU STRATA WATER
KK STRATA WATER
RAIN WATER
1715 TO 5170
5 TO 0
4080 TO 0
3780 TO 0
10 TO 0
495
TWEEFONTEIN
EVAPORATION
RAW WATER DAM
2140 TO 0
SW EVAPORATION DAM
2150 TO 0
15
EVAPORATION
1210 TO 4660
RAIN WATER
0 TO 3450
360 TO 0
EVAPORATION
60
AECI
330 TO 0
SW HOLDING DAM
30 TO 0
1320 TO 0
660 TO 0
760
IRRIGATION FOR GARDENS & REHAB.
720 TO 0
RAIN WATER
6060 TO 0
EVAPORATION
60
EMV WASHBAY
60
RAIN WATER
30 TO 0
2700 TO 0
TWEEFONTEIN PAN
3420 TO 0
330
360
CLEAR WATER RETURN DAM
360
HAUL ROADS
100 TO 0
EVAPORATION
KK WATER TREATMENT PLANT
30
EVAPORATION & LOSSES
3450 TO 0
460
ON COAL FROM KK O/C
300
KK WASHING PLANT
850
ON COAL TO RLT
WORKSHOPS STORES & OFFICES
KK SEWAGE WORKS
300
490
EVAPORATION & LOSSES
2570
300
SLIMES & DISCARDS
160 TO 0
DISCARDS & SLIMES DISPOSAL
2570
EVAPORATION & LOSSES
RAIN WATER
160 TO 0
AVERAGE TO WORST
FILE No. WWCE00
FLOW RATES IN m³ / DAY

Figure 2

Report on site visit to Landau Colliery - Kromdraai Colliery

25 April 1994

1. GENERAL INFORMATION

Name of mine	Kromdraai Colliery
Name of person(s) interviewed	Mr DRW Dingemans - Div. Geologist Mr S Timm - Hydrologist Mr P de Garis - Planning Manager Mr D Limpitlaw - M Sc Student
Nearest town	Witbank
Name of catchment	Wilge and Olifants
Monthly production (ROM)	400 000 t/m
Monthly saleable product	300 000 t/m
Monthly discard production	100 000 t/m
Main product and market	Export coal (90%), Inland coal (10 %)
Current age of mine	Opencast - 1.5 yrs Previous underground - 1926 - 1966
Expected remaining life of mine	Opencast - 27 yrs
Type of mining carried out	Opencast mining
Transport mode from mine to plant	Road haulers to ROM crusher plant - to Navigation HMS plant by rail
Has the mine already produced an EMPR	Completed - reviewed copy submitted to DWA

2. SITE VISIT PROGRAMME

2.1 25 April 1994

- Arrival
- Brief discussion of project objectives
- Short overview of mining activities
- Guided tour of the mine
- Completion of questionnaire

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

3.1 DESCRIPTION OF WATER CIRCUITS

A locality plan showing mainly the location of the mine relative to the major components of the surface water systems in the region, was supplied by the mine and is attached as Figure 1. This plan shows the position of the old underground workings, as the current opencast pit is still a relatively small portion of the mining area. The mine is situated on the watershed between the Wilge and the Olifants rivers catchments. In addition, a flow diagram showing the various water users on the mine was also obtained and is attached as Figure 2.

Due to the geology of the area, the water seeping from the old underground workings has a very low pH (pH 2.8 - 3.5), but at the same time a suprisingly low electrical conductivity (100 - 200 mS/m). In addition, the lack of calcite resulted in oxidation of feldspars and sandstones and aluminum is more easily released than in most other mining areas. Pyrite got into the alunite stage which is less soluble than normal pyrite and this is probably the reason for the lower than expected electrical conductivity of the water.

3.2 DESCRIPTION OF WATER TREATMENT/MANAGEMENT SYSTEMS

3.2.1 Sewage treatment plants.

The sewage treatment plant at Kromdraai is designed to treat 42 kl/day. The effluent from this plant flows into a polluted water dam. Water from this dam is pumped to the raw water reservoir at the crushing plant. A diagram showing the layout of the sewage treatment plant is attached as Figure 3.

3.2.2 Potable water treatment plant.

There are two potable water treatment plants at Kromdraai and both are considered as unusual as both are reverse osmosis plants. Sources of potable water are too far away from the mine to consider piping potable water to the mine. Boreholes are not a feasible option as the whole area is undermined and the water in the old workings is very acidic. The RO process for producing potable water enables the mine to utilise polluted water as a source of potable water.

One plant is designed to treat 14 kl/h. It treats a mixture of water from a pollution control dam, water treated in the liming plant and water from the Klipspruit. A diagram showing the layout of the plant is attached as Figure 4.

A second 2 kl/h RO plant is situated at the Kromdraai liming plant. The water treated in this plant is abstracted from Graham dam, which typically has a low pH (3-4) and low conductivity (30 -40).

3.2.3 Settling dams

There are two dams functioning as settling dams. One is situated near the pit and receives water pumped from the opencast pit. Most of the settleable solids is removed from the water before it is discharged to the liming plant.

Another settling dam is situated close to the ROM tip area. This dam receives mainly dirty water from the ROM tip area, crushing plant area and workshops. Water from this dam is allowed to evaporate and a portion of this water is pumped to a small dam where it is mixed with water from the liming plant and water from the Klipspruit. This mixture is used for road wetting and a portion is fed to the potable water treatment plant (14 kl/h)

A series of cut-off drains are constructed around the pollution control dams to prevent clean surface runoff from entering these dams.

3.2.4 Evaporation dams

There are a series of evaporation dams situated below the liming plant. These dams were specially designed for the purpose of evaporating the treated water discharged from the liming plant - approximately 10 Ml/d. There are 5 dams each approximately 1.5 - 2 km long, 50 m wide and 0.5 - 1m deep. Figure 5 is map showing details of the surface water monitoring points. This map is included as it is useful for obtaining an idea of the size and location of the evaporation dams.

Water from the evaporation dams seeps into the Kromdraaispruit and this is a problem area. Investigations indicated that the existence of seeps from an old dump above the evaporation dams, aggravated the pollution problem. The dump is being removed and the situation will be monitored to determine if there is any improvement in the situation.

3.2.5 Liming plant

Due to the geology of the area, the mine produces an acid water. Acid water is decanting from the old underground workings and a liming plant was installed to treat this water. A diagram showing the process layout and details is attached as Figure 6. The plant is currently treating an approximately of 10 Ml/d of acid water.

The sludge or "yellowboy" is discharged to an evaporation facility and the treated water is used in various mining operations, however, the bulk of the treated effluent is discharged to the evaporation dams for evaporation.

3.2.6 Opencast area

The main use of water in the opencast area is dust suppression. The opencast operation is primarily concerned with re-mining the areas which were previously mined in an underground operation. As a result, water accumulating in the pits is water from the old underground workings, as well as rain water and ground water inflow. The water has a low pH and is pumped to a settling dam from where it is pumped to the liming plant.

3.2.7 Plant water circuits

The coal extracted at Kromdraai is treated in the HMS plant at Navigation Colliery. The ROM coal from the pits is transported by road to a crushing plant. After crushing, it is transported by rail to Navigation Colliery. There is no HMS plant with it's associated water circuits in the Kromdraai water reticulation system.

3.2.8 Water in the old underground workings.

There are a number of water bodies in the old underground workings. The water contained in these sections is very acid and a number of seeps have developed over the years. One of the management strategies is to transfer water via a series of boreholes and pipes from the different underground areas (Excelsior block and South block) to a central point from where it is allowed to decant. The water is then pumped to the liming plant for treatment.

Despite the efforts to transfer water from the outlying areas, there are still a number of seeps present which are scattered throughout the mining area.

The water collected in the underground workings has to be removed before any opencast activities can proceed in any particular area. This is done by making an excavation in the area ahead of the opencast pit. Water collected in the excavation is pumped to the liming plant.

3.2.9 Water monitoring systems

The mine has a fairly detailed and sophisticated water monitoring programme. Most of the important points for monitoring water have been identified and are being monitored. The water quality data reported to the mine is comprehensive and the data is checked by the responsible personnel.

Information with regard to flow rates of various water streams, i.e. natural streams, those due to various mining activities, as well as water decanting and seeping from the old workings, is limited. Some of these aspects are being addressed, e.g. a continuous monitoring station will probably be installed in the Klipspruit in the near future. Unfortunately, as the flow monitoring programme is not complete, the water monitoring programme cannot be regarded as complete and it is not possible to calculate or manage the salt loads being generated.

3.2.10 Water management structure

Figure 1 represents the water management structure with the various departments and personnel involved, was supplied by the mine.

3.3 NOVEL OR UNIQUE WATER TREATMENT AND MANAGEMENT SYSTEMS

3.3.1 Water quality management structure / personnel

The day-to-day management of water quality, supply, treatment and disposal of effluents is carried out by suitably qualified persons who exhibit a high

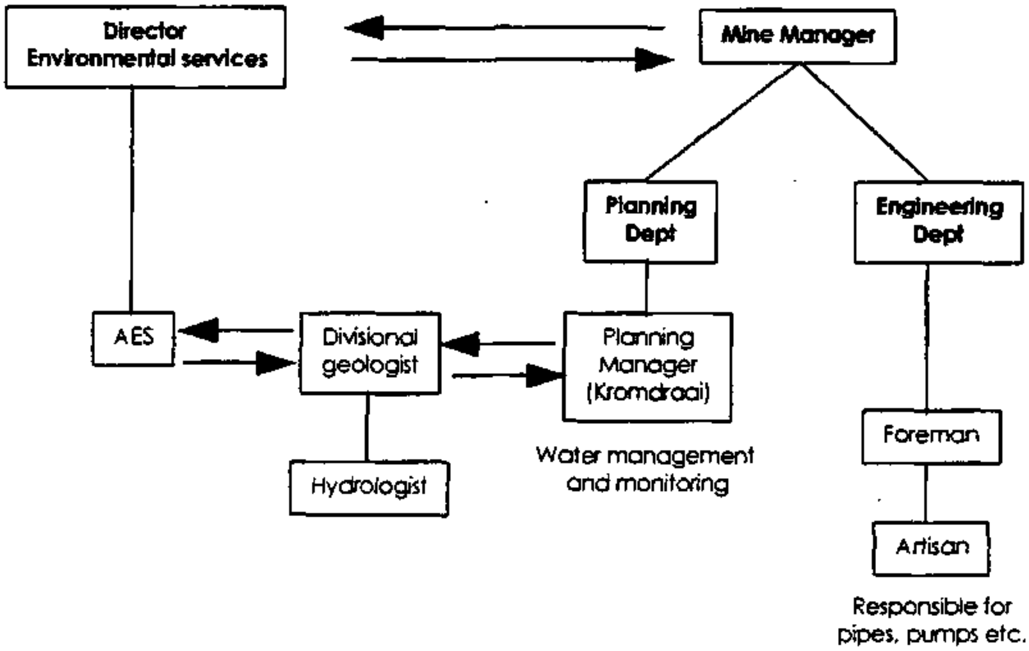


Figure 1 : Water Management Structure

degree of understanding of the fundamental issues involved. Regular meetings involving senior management are used effectively and the results of this policy are clearly visible in the efforts to address environmental and water issues in particular. These factors indicate that water quality and environmental management are accorded a high priority at the mine.

3.3.2 Water monitoring and management systems/personnel

Computerised models varying in sophistication, are applied for water management purposes. The personnel involved are skilled in the use of sophisticated hydrological models. They are also familiar with methods for statistical manipulation of continuous flow data as well as other computerised models that may be used to assist them in their tasks.

The responsible personnel are actively and continuously involved in identifying methods and instrumentation that will enable them to optimise the monitoring programme within budget and practical constraints. For example, a down-the-hole EC logger is used to provide EC profiles for selected boreholes. This enables the mine to determine which aquifers are polluted. Packer tests and Theis pump tests are also done by the responsible personnel in order to determine the potential of the rock to store water and to determine the flowrate of water through the rock.

During the site visit it was observed that these systems are applied. Provided the current expertise available on the mine is utilised to the full, and is allowed to steer further developments, the mine should reach a stage where it can actively manage and control the water systems.

3.3.3 Potable water plants

This aspect was discussed previously but it is considered to be a unique feature of the water treatment systems on the mine. The concept of utilising polluted water as a source of potable water by treatment in an RO plant, qualifies it to be regarded as unique.

3.3.4 Impact of improved rehabilitation methods on water management strategies.

After the layer of topsoil has been removed, a further layer of weathered material is removed in a pre-stripping operation ahead of the dragline operation. This material is then used to fill the spoils behind the drag line operation before the final top soil layer is added. The purpose of the pre-stripping operation, is to reduce the permeability of the rehabilitated spoils. It is believed that less water will infiltrate into the spoils and therefor less water will be contaminated due to contact with spoils material.

3.3.5 Irrigation trials

A project to determine the viability of using high salinity water to irrigate various crops and grass, is under way. The trials will be conducted over a period of 5 years.

3.3.6 Use of Eucalyptus trees to manage water seeping from the old underground workings.

As mentioned previously, there are a number of acid seeps scattered throughout the mining area. At a number of these sites, trials are under way to evaluate the effectiveness of *Eucalyptus trees to evaporate the water* seeping out, as well as to reduce the recharge into the seep.

Two different types of Eucalyptus species are used. *E. nitens* above the seep, and the more acid resistant *E. mcArthii* in the area affected by the seep. Preliminary indications are that despite a good raining season and the relatively young and small trees, the amount of visible water seeping from the various areas, was reduced.

3.3.7 Project to investigate the functioning of constructed wetlands to treat acid mine water.

The Dixon dam is fed by a natural spring and acid water seeping out of the underground workings, caused contamination of the dam. In order to prevent continued pollution of the dam, a herringbone system of drainage channels was constructed, together with a plantation of Eucalyptus trees on the seep. The acid water draining away from the area, is currently contained in a dam. However, the dam will eventually overflow and the polluted water will enter the Klipspruit.

A wetland will be constructed in this area and will be the subject of a M Sc. thesis. The aim of the thesis will be to quantify the effectiveness of the wetland as far as amelioration of water pollution is concerned. In particular the effectiveness in terms of the removal of heavy metals and sulphates will be investigated. In addition, operating parameters and management guidelines for effective operation of the wetland will be established.

3.3.8 Recycling of oil

A system of oil traps were constructed in the storm water drains around the workshop area. Oil trapped in this system is extracted for re-use on the mine. It is used mainly for general lubrication applications in the opencast pit. It is from time to time sold to local firms specialising in the recycling of used oil.

3.4 POTENTIAL WATER TREATMENT/MANAGEMENT PROBLEMS AND NEEDS

As a result of the discussions and site visits, a number of issues were identified where knowledge gaps still exist.

3.4.1 Establishing a water model for the mine.

The development of a calibrated and reliable water model for the mine was mentioned as an area where work still needs to be done. This will include testing and validation of assumptions and refining model parameters such as recharge rates, run off volumes, evaporation etc.

3.4.2 Corrosion due to acid water

Pipes and especially pumps are quickly corroded due to the acidic nature of the water handled on the mine. The cost implication of replacement and prevention of corrosion is a cause for concern.

3.4.3 Acid mine drainage, sulphate and aluminum removal

The effective treatment / management of acid water seeping from the old workings, as well as removing the sulphates and aluminum in the effluent streams, can be viewed as one of the more important challenges facing the mine.

3.4.4 Flow measurement

The measurement of flow is an important aspect of any monitoring programme. Development of methods to measure or estimate the volumes of water transported in the mining environment, especially the volumes seeping from various areas or flowing into and out of the underground workings, will be of significant value to the mine.

3.4.5 Prediction of post closure scenarios

The lack of reliable methods for predicting long term water quality and quantity aspects, such as in a post closure scenario, was identified as a problem area.

3.4.6 Practical implementation of continuous monitoring systems.

There are a number of practical issues concerning the protection of remote field stations against lightning, theft and vandalism. It is found that these installations are often a target, and although a lot of useful information can be generated, the systems can become impractical if solutions to these problems cannot be found.

3.4.7 Effects of unknown sources of pollution

During the discussions and the site tour, it was mentioned that there are a number of areas that have never been visited by the personnel presently involved in the water management program. As there are also many unknown factors regarding the water bodies in the old underground workings, there is always the potential for seeps and sinkholes to appear at any time on the mine property. Therefore a number of undiscovered seeps and/or sinkholes may exist in the mining area. The possibility of flying over the area in order to make an assessment of affected areas was discussed.

The potential for these "unknown" sources to have an influence on the water quality of water bodies in the region, could be investigated.

3.4.8 Disposal of excess water.

The mine is currently evaporating quite a substantial amount of water from the evaporation dams. There are certain projects in progress to try and find alternative applications for the water e.g. the irrigation trials. A viable alternative to evaporation will have significant benefits for the mine.

4. GENERAL IMPRESSIONS

4.1 ROLE OF THE EMPR

The EMPR is regarded as being an important element in the process of identifying problems and focusing the efforts of the personnel in systematically identifying and addressing the water and environmental problems.

4.2 INFORMATION SYSTEMS

It is obvious that the personnel involved in the water management issues on the mine, are well qualified and have specialist knowledge that, given the necessary support from senior management, will enable them to formulate strategies and manage water issues successfully.

In this regard it was mentioned that quarterly meetings are held with senior mine and group managers about pollution control issues. The view was expressed that these meetings are very successful. Better financial support for projects related to pollution issues has been obtained as a direct result of the increased interest and involvement of senior management.

4.3 OPENNESS ABOUT WATER AND ENVIRONMENTAL MANAGEMENT ISSUES

Information was readily obtained and the personnel interviewed were quite prepared to discuss all the issues raised during discussions.

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. The following is a list of the readings taken:

No	Description	pH	Cond.
1	Water from Fairview adit	3.0	100
2	Water in pollution control dam - expit water	3.2	115
3	Seep close to liming plant	4.3	31
4	Water flowing into liming plant	2.9	170
5	Liming plant effluent - treated water	7.0	133
6	Excelsior adit	2.9	150
7	Seep in Excelsior area	2.9	160
8	Turnbull dam	3.1	170
9	Dixon dam	3.0	120
10	Seep in Dixon dam area	3.2	130
11	Spring water flowing into Dixon dam	5.5	15

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:

Photograph No	Description
1	Fairview adit draining north mining block
2	Water pollution control dam for water pumped from pit
3	Seep at liming plant
4,5,6	Liming plant - aerator and settler
7a	Liming plant effluent - ~~treated~~ water
7b	Spillage at liming plant
8	2-Upper dump - in process of being cleaned up
9,10	"Yellowboy" - liming plant sludge discharge area
11	North pit rehab area with current mining activities in background
12	Open cast operation
13	Sink hole with owl nests
14	Excelsior adit
15	Seep in Excelsior area
16	Area below seep in Excelsior area
17	Dixon dam
18	Seep above Dixon dam
19	Dixon dam - future wetland study area
20	Clear water spring flowing into Dixon dam

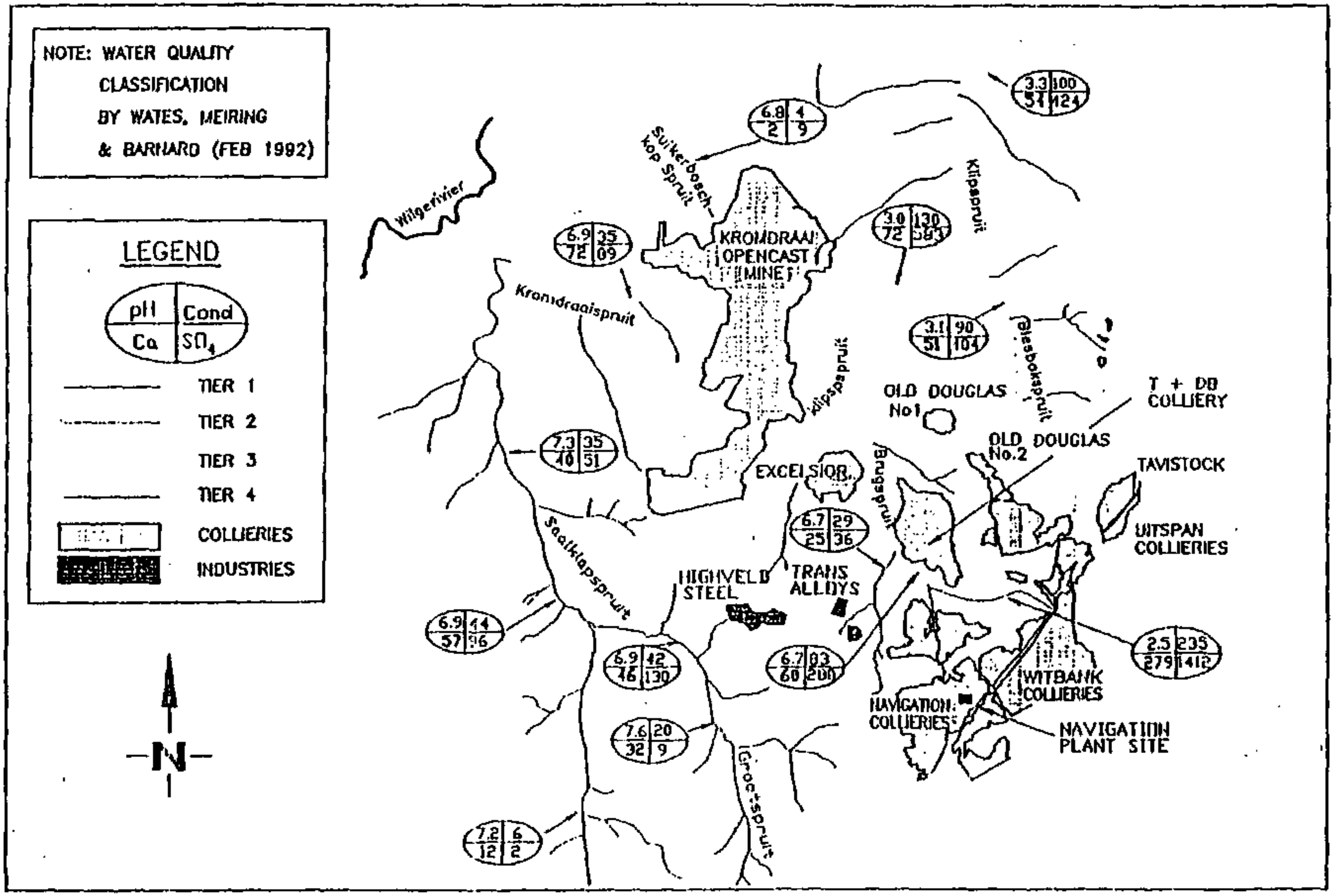


Figure 1 : Water Quality in the Kromdraai Area

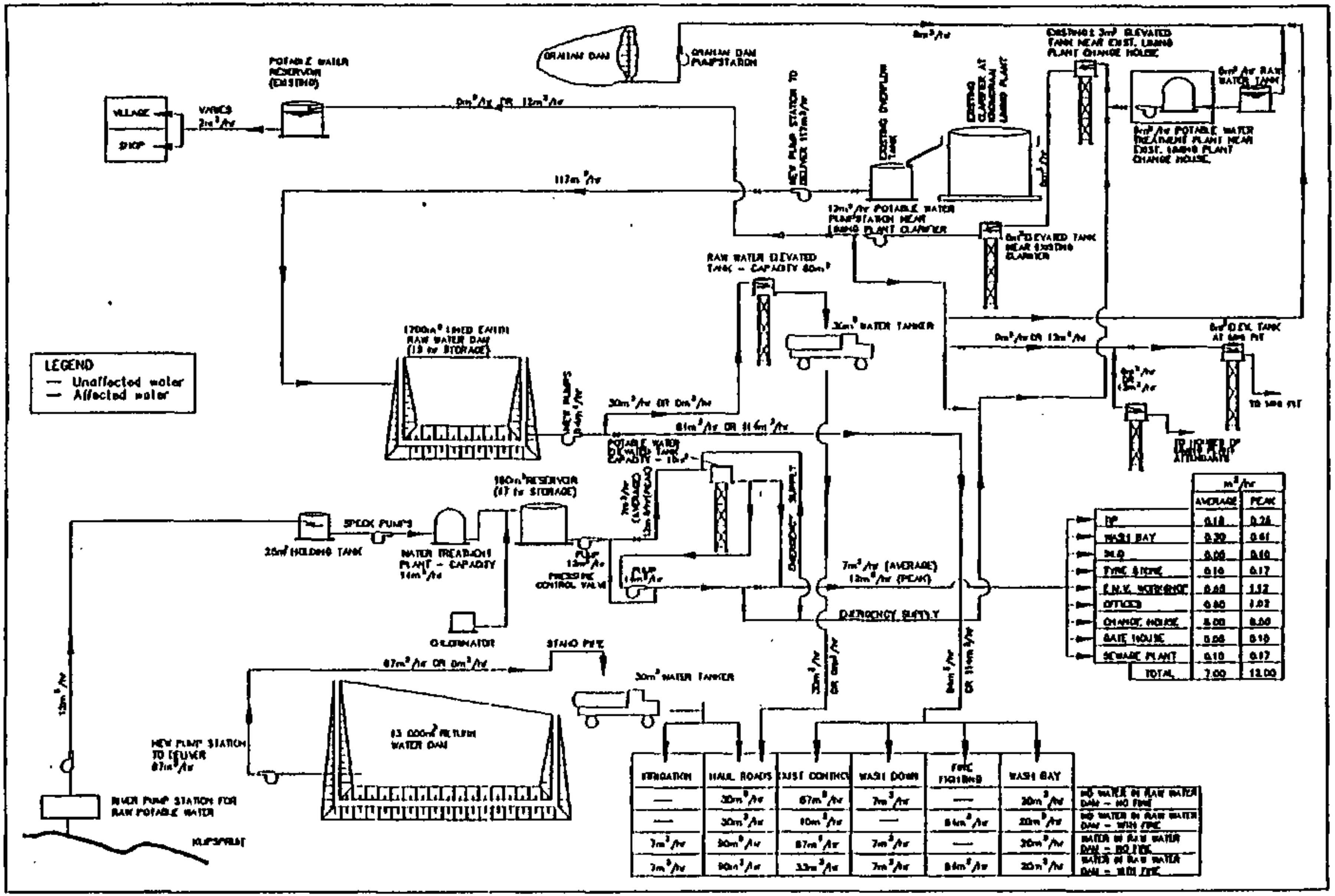


Figure 2 : Kromdraal Water Flow Network

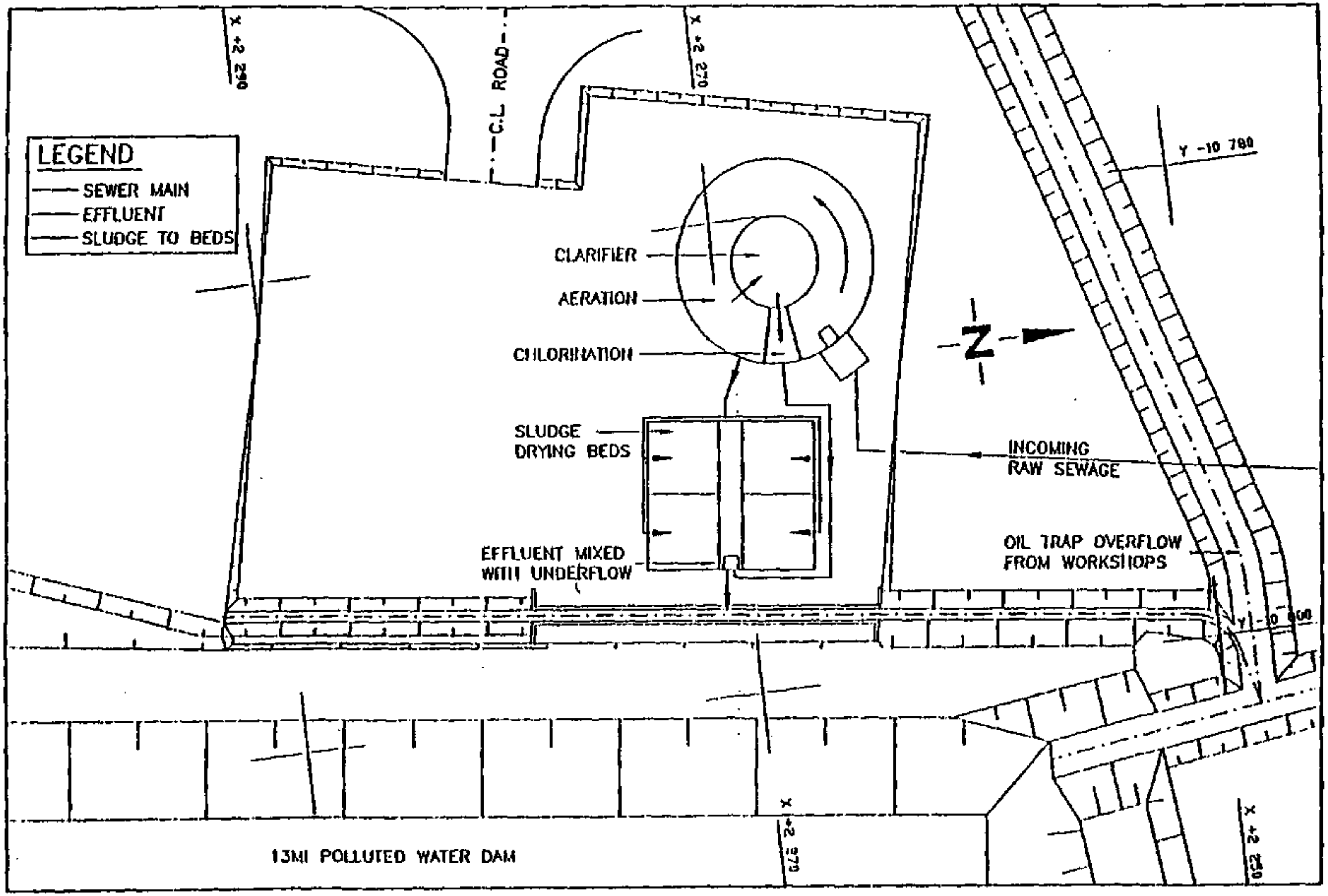


Figure 3 : Layout of Kromdraai Sewage Treatment Plant

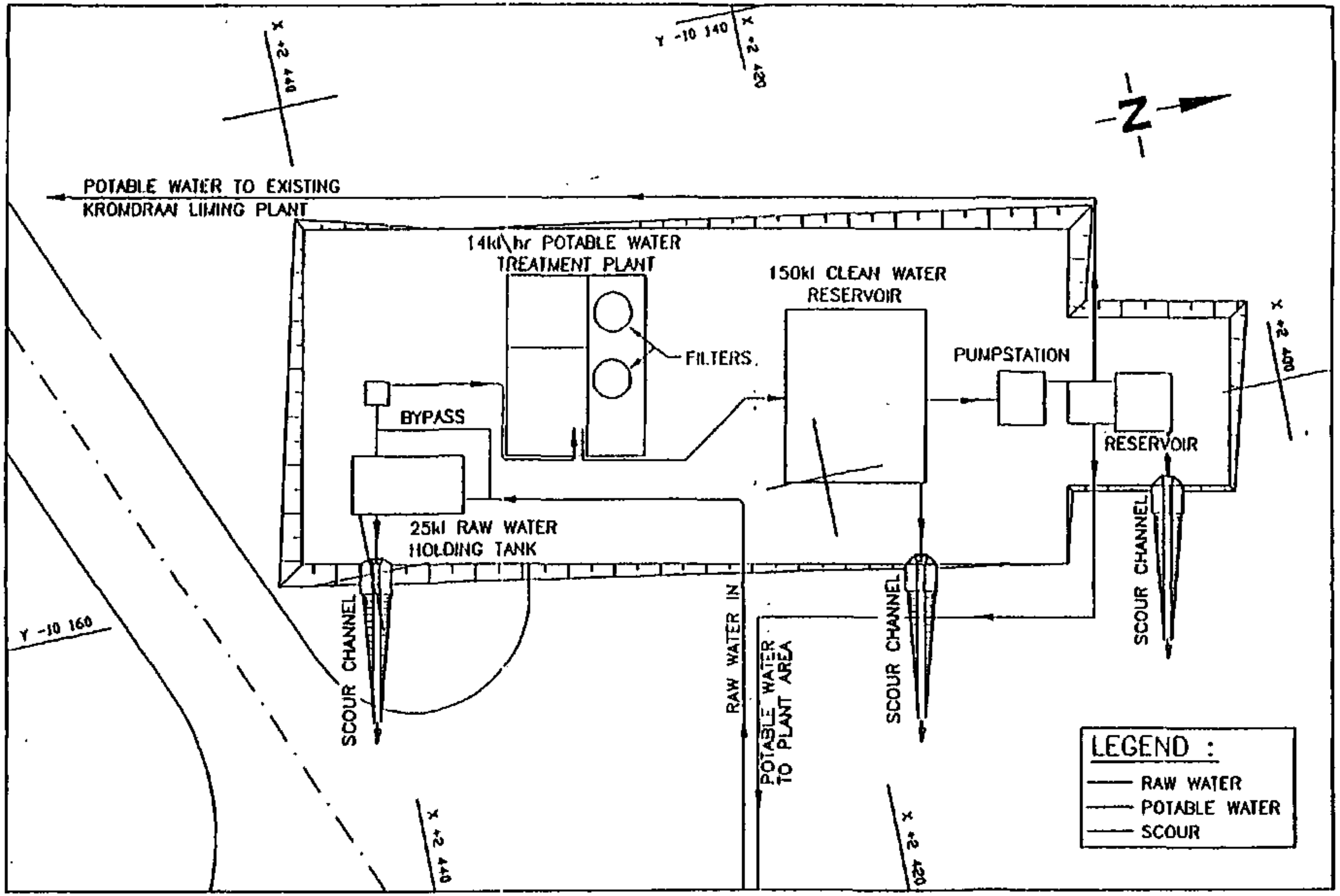


Figure 4 : Layout of Kromdraai Water Treatment Plant

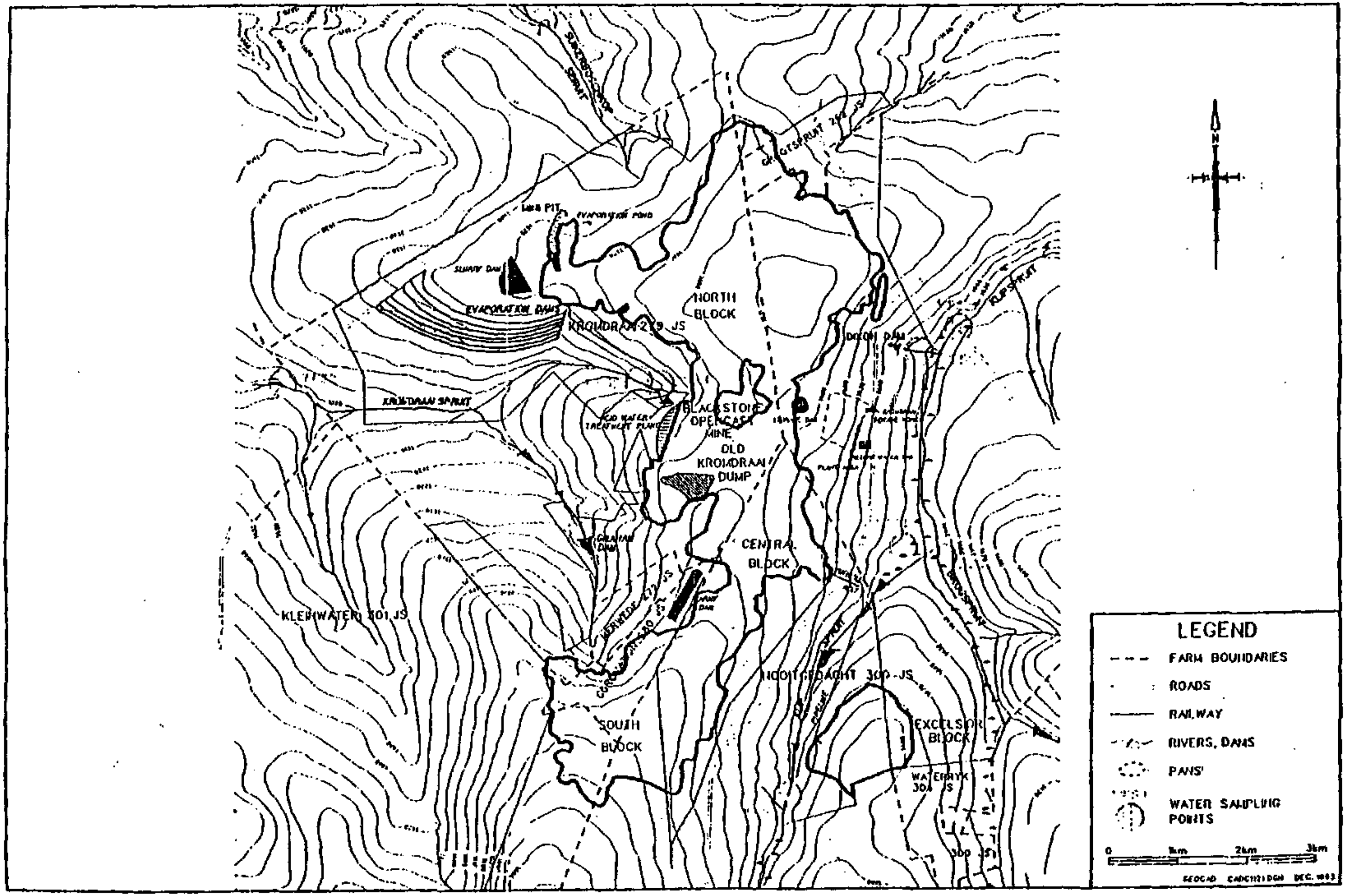
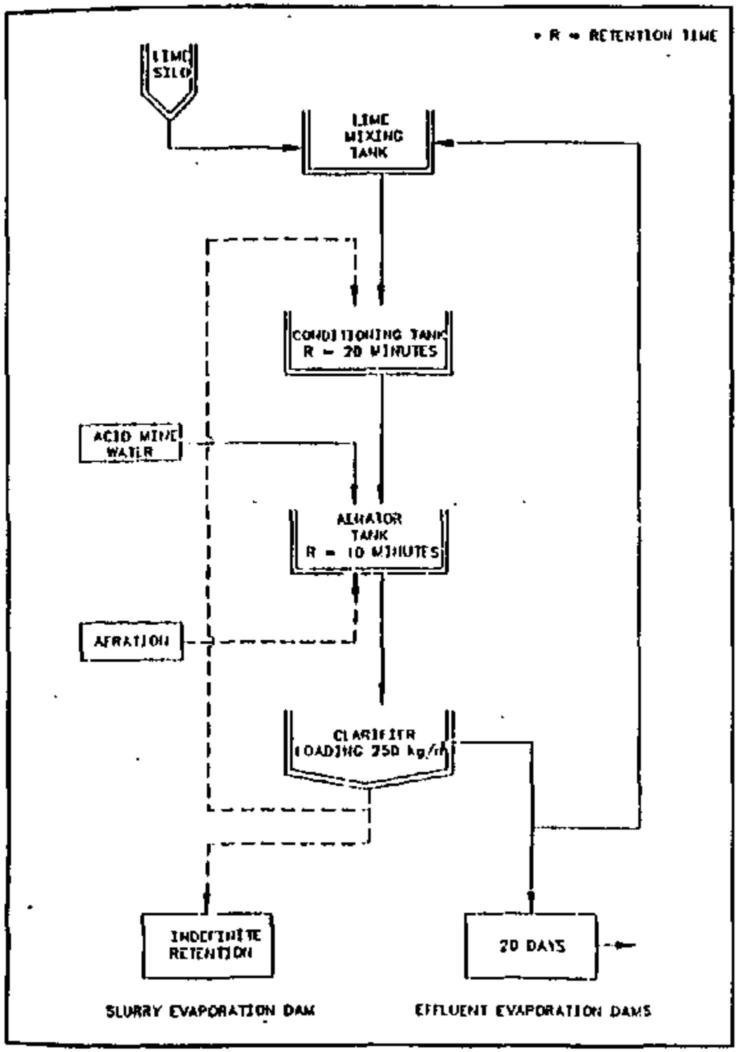


Figure 5 : Locations of Surface Water Monitoring Points : Kromdraai

KROMDRAAI ACID MINE WATER TREATMENT PLANT

OBJECTIVE

1. INCREASE pH TO 7.5
2. REMOVE HEAVY METALS
3. REDUCE TDS



PLANT LAYOUT
CAPACITY 14 000m^3 /d

PROBLEM

IRON OXIDE PRECIPITATE HAS LOW DENSITY

LIME SLURRY $Ca(OH)_2$

- LIME CONTENT 20%
- pH 12.0

CONDITIONING OF RETURNED SLUDGE

RETURNED SLUDGE AGED
FERROUS IRON HIGH (Fe^{2+})
FERRIC ION LOW (Fe^{3+})
MIXING SLOW TO PREVENT FLOC DISINTEGRATION

- pH 10.0

ACID MINE WATER

REACTIONS IN MINE

$2FeS_2 + H_2O + 7O_2 \rightarrow 2FeSO_4 + 2H_2SO_4$ — BACTERIA
$FeS_2 + 14Fe^{3+} + 8H_2O \rightarrow 15Fe^{2+} + 2SO_4 + 16H^+$

- pH 2.5
- FERROUS 0 - 140mg/l
- FERRIC 30 - 200mg/l
- TDS 1750mg/l
- SO_4 1150mg/l
- TOTAL IRON 170mg/l

NEUTRALISATION & PRECIPITATION

REACTIONS IN LIME PLANT

$Ca(OH)_2 + H_2SO_4 \rightarrow CaSO_4 + 2H_2O$
$Ca(OH)_2 + FeSO_4 \rightarrow Fe(OH)_2\downarrow + CaSO_4$

$4Ca(OH)_2 + 4FeSO_4 + 2H_2O + O_2 \rightarrow 4Fe(OH)_3\downarrow + CaSO_4$

IRON HYDROXIDE PRECIPITATES

SLOW TO SETTLE BECAUSE :
IRON MOLECULES SURROUNDED BY H_2O MOLECULES

THICKENING POOR BECAUSE :
HYDRATED IRON MOLECULES NEGATIVELY CHARGED & REPEL EACH OTHER THEREFORE REQUIRES RECIRCULATION

CLARIFICATION

SLUDGE

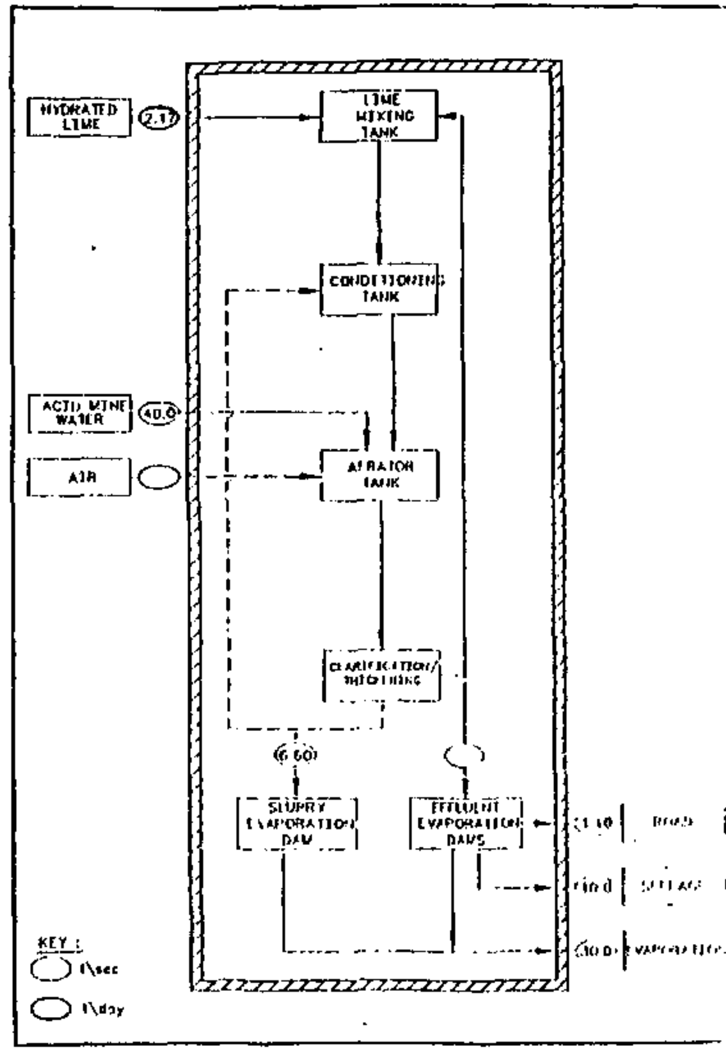
- Fe 400mg/l
- pH 7.5
- FERROUS 5.8% } DRY BASIS
- FERRIC 20.2% } DRY BASIS

LIQUID

- pH 7.5
- FERROUS 1mg/l
- FERRIC 30mg/l
- TDS 1800mg/l
- SO_4 1150mg/l

SOLUTION

1. RECYCLE PRECIPITATE
2. AGE RETURNED SLUDGE
3. IRON SHOULD BE IN FERROUS FORM IN CONDITIONING T



CURRENT FLOW NETWORK

Report on Matla Colliery Site Visit

2 December 1993

1. GENERAL INFORMATION

Name of mine	Matla Colliery
Name of person(s) interviewed	J Cronje
Position of person(s) interviewed	Superintendent Environmental Services
Nearest town	Kriel
Name of catchment	Olifants River
Monthly coal throughput (rom)	790 000 t
Monthly saleable product	Eskom power station - 790 000 t
Monthly discard production	0
Monthly slurry production	0
Main product and market	100 % coal to Kriel power station
Current age of mine	14 years
Expected remaining life of mine	30 years
Type of mining carried out	U/g bord & pillar, longwall, shortwall
Transport mode- mine to plant	Overland conveyor
Has the mine already produced an EMPR	Yes, final draft

2. SITE VISIT PROGRAMME

2.1 Day 1 - 2 December 1993

- Short discussion of project with Mr J Cronje
- Detailed site visit with Mr J Cronje
- Completion of questionnaire with Mr J Cronje

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

3.1 DESCRIPTION OF WATER CIRCUITS

This is a large underground coal mine situated in the Olifants River catchment. In general terms, the mine has minimal impact on the water resources for the following reasons:

- all mining operations are underground
- coal transport is by overland conveyor
- there is no washing plant and only small amounts of discard are produced

A simplified water distribution network and balance is shown in Figure 1 below.

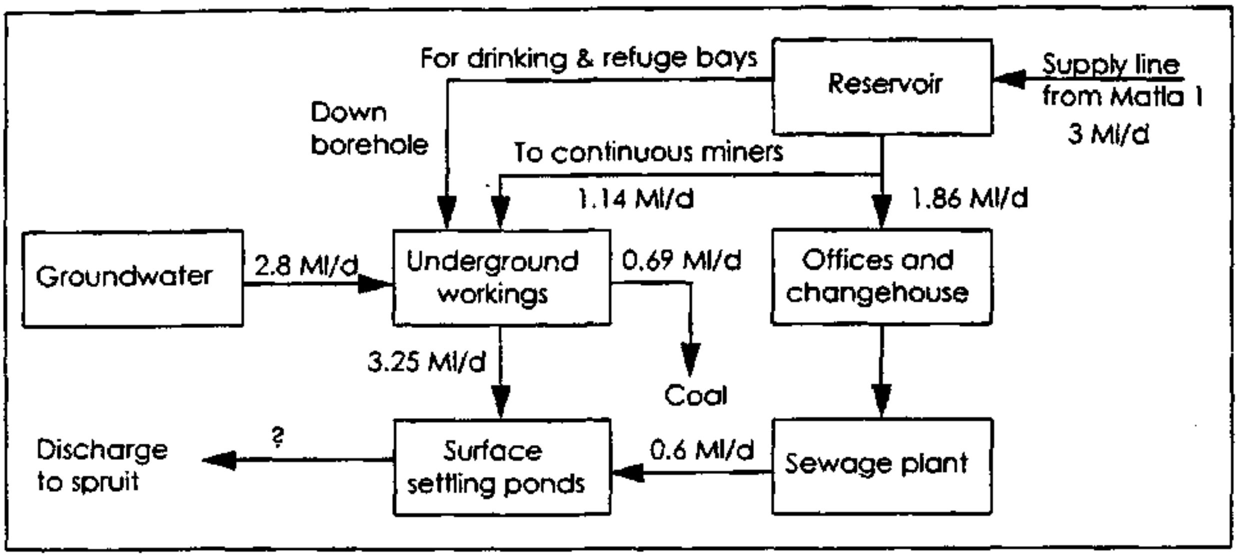


Figure 1 : Matla Colliery simplified water system diagram

As shown in Figure 1, the basic supply of water to Matla 2 and 3 mines is as potable water from the Kriel power station. The potable water is used for normal domestic purposes in the offices and changehouse and is also piped underground via a borehole for drinking purposes to the working areas and refuge bays.

A substantial amount of ground water is liberated by the longwall mining process and this water, together with the return water from the continuous miners, is pumped to settling/evaporation dams on surface.

The sewage is treated in a sewage treatment plant at each mine and the treated effluent is then also discharged into the settling dams. A certain amount of water evaporates and seeps from the settling dams, with the balance being discharged to the surface water systems.

The mine has a small waste rock dump (receiving about 3 tons/day of waste rock). This dump is constructed on a compacted base with pollution control berms to keep clean water out and direct polluted runoff to lined pollution control dams.

Diversion berms are also in place to divert clean runoff around the shaft areas to the surface water courses. The mine has no major diffuse pollution sources other than the settling/evaporation dams. The surface hydrology and needs of downstream users are fairly well defined and understood by the mine.

A number of points are sampled regularly for water quality. The mine also plans to implement a continuous monitoring system for conductivity, flow and pH at a number of key points.

3.2 DESCRIPTION OF WATER TREATMENT/MANAGEMENT SYSTEMS

3.2.1 Sewage treatment plant

The sewage treatment plant at Matla Colliery is a conventional activated sludge system with secondary clarifier and sludge recycle to the aerated reactor. Clarified effluent is disinfected with chlorine gas before being discharged to the settling ponds where it is mixed with water pumped up from underground. Waste sludge is dried in drying beds.

3.2.2 Shaft and Workshop Areas

Effluent and runoff from the shaft and workshop areas is isolated and passed through oil separators before being discharged to the settling ponds.

3.2.3 Water Monitoring & Data Management Systems

The mine has a fairly comprehensive water quality monitoring system covering surface and ground water. All monitoring data is entered into Hydrocom and comprehensive monthly reports are produced using this data. Although there are still some notable deficiencies in the monitoring programme (see section 3.4.4), the system in place at Matla can be considered as advanced in comparison with most other mines visited (see 3.3.1).

3.2.4 Water management structure

The water management structure is shown in Figure 2 below.

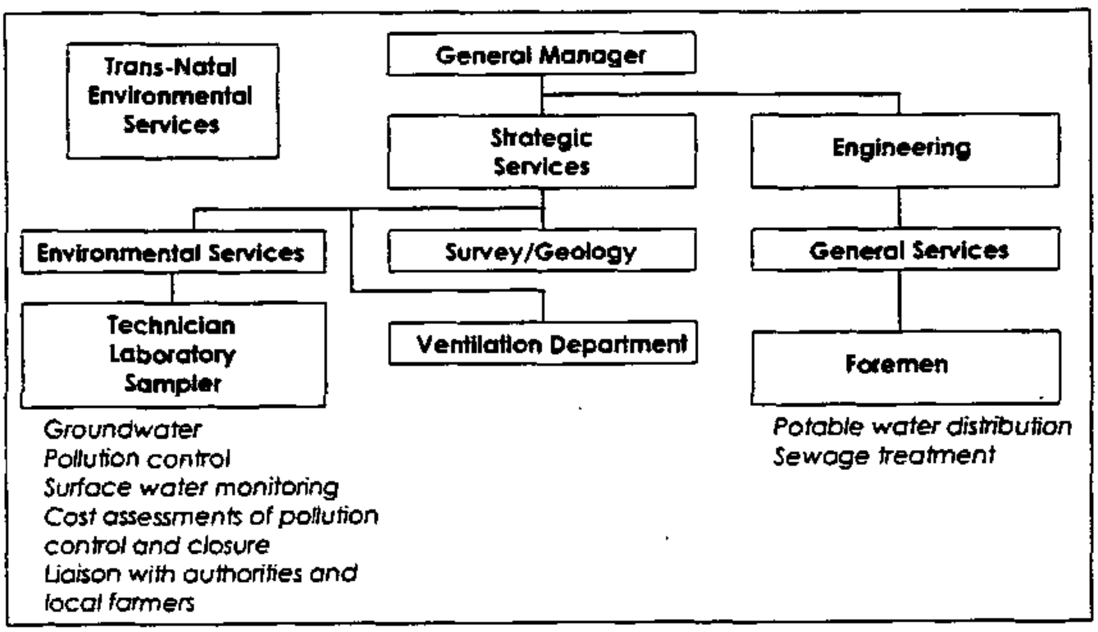


Figure 2 : Matla Colliery Water Management Structure

A discussion on perceived deficiencies in the mine's water management structure is given in section 3.4.7.

3.3 NOVEL OR UNIQUE WATER TREATMENT AND MANAGEMENT SYSTEMS

3.3.1 Monitoring Programme and Information Management

As mentioned earlier the mine has a fairly extensive water quality monitoring programme in place and is planning to install a number of continuous monitors. More importantly, however, the environmental services department appears to make fairly good use of the information at its disposal for management purposes.

3.3.2 Diffuse Pollution Sources

Of all the coal mines visited during the survey, Matla stands out as being visually the cleanest mine with only minimal diffuse pollution sources such as the settling dams, conveyor routes, drive houses and workshops.

3.3.3 Personnel

Matla Colliery is one of the few mines that clearly has suitably qualified personnel in charge of the environmental and water management activities. In addition to the academic qualifications and expertise, the personnel also have access to and utilise specialist water management journals to obtain information.

3.4 POTENTIAL WATER TREATMENT/MANAGEMENT PROBLEMS AND NEEDS

As a result of the discussions and site visits, a number of issues were identified where knowledge gaps still exist.

3.4.1 Impacts of Longwall Mining

The practice of longwall mining has a number of potential negative impacts on surface and groundwater systems, including :

- destruction of near-surface aquifers and production of large volumes of water which then need to be discharged to the surface water environment
- surface subsidence which can result in the formation of pans and destruction / interference with normal drainage patterns
- potential long-term effects on the quality and level of re-established aquifers

The long-term effects, in particular, require further quantification.

3.4.2 Discharge / Treatment of Excess Water

As mining continues and larger areas are subjected to longwall mining, more and more excess effluent is generated and pumped to the settling dams. Already this excess water is causing problems in terms of disposal and this problem will get bigger all the time. It is also possible that the quality of the excess water will deteriorate as it moves through a more tortuous path through the collapsed strata with associated pyrites. Treatment of this water by way of a desalination plant will prove to be expensive and alternative solutions must be found (see section 3.4.3).

3.4.3 Water Reclamation Strategies

A significant need can be identified to investigate, develop and implement appropriate water reclamation strategies at the mine. At the moment large volumes of potable water are purchased from Eskom and large amounts of polluted water are discharged. A significant potential exists for the successful reclamation and reuse of contaminated water pumped up from underground - to replace potable water sent to the continuous miners.

3.4.4 Monitoring systems

Due to the lack of reliable and accurate flow measurements, it is not possible to properly quantify the impact of the mine on the water environment or to evaluate the beneficial effect of applied water management strategies. Although the mine could benefit from water reclamation strategies, the lack of important water quality data such as alkalinity will hinder this process as scaling tendencies cannot then be calculated.

There is also a distinct need to institute appropriate monitoring measures to enable the accurate determination of a water and salt balance around the settling dams to provide the data missing from Figure 3 below.

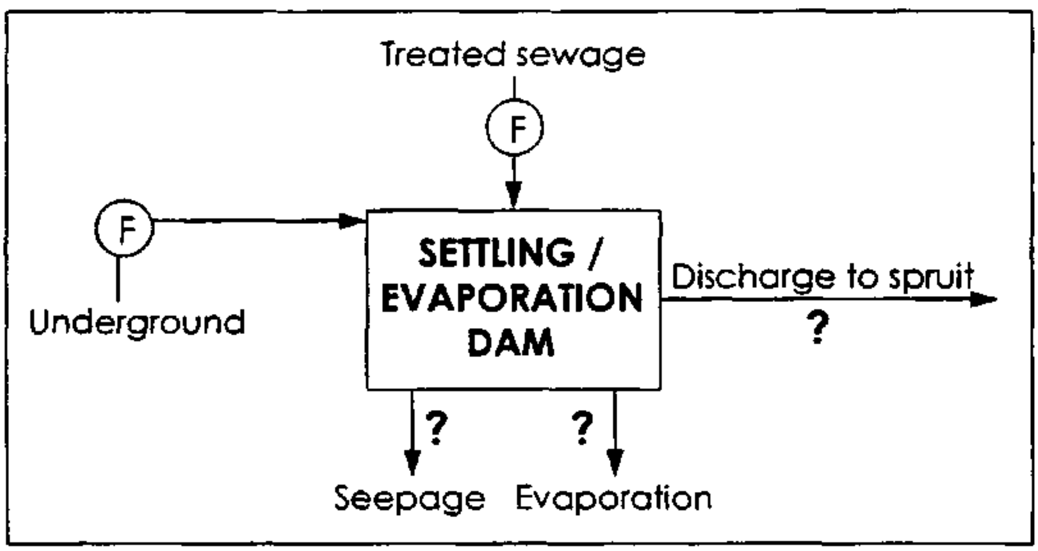


Figure 3 : Schematic Water Balance Around Settling Dams

3.4.5 Settling Dams

The settling dams / evaporation ponds at Matla 2 and 3 are not being operated correctly for a number of reasons, including :

- hydraulic short-circuiting (poor inlet and outlet arrangements)
- poor settling of suspended solids
- no facility for removal of settled sludge from settling dams
- seepage and leakage through dam walls

Although these problems prevent the settling dams from working properly, they can be rectified fairly easily.

3.4.6 Water and Salt Balances

Although the mine collects a substantial amount of data for surface water systems which enable the production of coarse overall water and salt balances, insufficient data is available to support the development of properly detailed and complete water and salt balances. Due to the size of the operations at Matla and the amount of data which will need to be manipulated to provide up-to-date and useful water and salt balances, the mine will require access to computerised balance models to prevent the generation of these from becoming a full-time task.

3.4.7 Water Management Structure

Although the mine has well qualified personnel looking after water management issues and the environmental services section does not report to engineering or production mangers, a problem of proper co-ordination still exists. In particular, the potable and sewage water circuits are managed independently of the environmental services section.

4. GENERAL IMPRESSIONS

The general impression gained from the site visit is that the mine has a minimal and manageable impact on the surface water environment and perhaps also on the groundwater environment. Environmental and water management are accorded a high priority as is evidenced by the employment of appropriately qualified professional staff. It is again clear that the advent of the EMPR process has been instrumental in improving water management at the mine.

The most important need for the mine is to address the issue of water reclamation to deal with the ever-increasing volumes of excess water pumped from underground.

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. The following is a list of the readings taken.

No	Description	pH	Cond.
1	Matla 3 - settling ponds 4 at sump	8.6	76
2	Matla 2 - settling pond overflow to vlei	7.5	72
3	Rain water from culvert under road to Matla 2	7.2	29
4	Rietspruit upstream of Matla 2 (at road bridge)	8.2	91
5	Rietspruit downstream of Matla 2	7.4	62
6	Evaporation pan receiving u/g water from Matla 2	9.2	245
7	Stream from Kriel power station - Rietspruit	7.0	69
8	Rietspruit tributary downstream of Matla 1 - stagnant	7.4	38
9	Matla 1 - big evaporation pond	9.2	54
10	Evaporation dam below waste rock dump	7.9	108

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:

Photograph No	Description
1	Matla 3 settling ponds
2	Matla 2 settling ponds 1 & 2 inlet
3	Matla 2 vlei below settling ponds
4	Matla 1 big evaporation pond

Report on Middelburg Colliery Site Visit.

22 - 23 November 1993

1. GENERAL INFORMATION

Name of mine	Middelburg Mine Services
Name of person(s) interviewed	Mr R Armstrong - Geologist Mr J Visagie - Planning Officer Mr I Price - ARE mechanical
Nearest town	Middelburg
Name of catchment	Olifants river - subcatchment B128
Monthly production (ROM)	640 000 t/m
Monthly saleable product	425 000 t/m
Monthly discard production	215 000 t/m
Main product and market	Export steam coal
Current age of mine	12 yrs
Expected remaining life of mine	25 yrs
Type of mining carried out	Opencast strip mining
Transport mode from mine to plant	Road haulers
Has the mine already produced an EMPR	Still to be submitted

2. SITE VISIT PROGRAMME

2.1 Day 1 - 22 November 1993

- Arrival
- Short discussion on site visit objectives
- Guided tour of the mine

2.2 Day 2 - 23 November 1993

- Completion of questionnaire

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

3.1 DESCRIPTION OF WATER CIRCUITS

A map, showing the layout of the mine and the locality of surface water and ground water flow monitoring stations was supplied by the mine. This map is attached as Figure 1. Two diagrams, compiled by external consultants, were supplied by the mine. These diagrams show a summer and winter water balance for the mine and are attached as Figure 2 and Figure 3. These diagrams show the various users and producers of water on the mine as well as the way they interact to form the water reticulation system on the mine. Another diagram, showing a schematic plan of industrial water flow was supplied by the mine. This diagram is attached as Figure 4.

3.2 DESCRIPTION OF WATER TREATMENT/MANAGEMENT SYSTEMS

3.2.1 Sewage treatment plants.

The sewage treatment plant at Middelburg mine is treating approximately 400 m^3/d in an activated sludge process. The plant is supervised by personnel who have sufficient experience in operating a sewage treatment plant. During discussions it appeared as if the person responsible for the sewage treatment plant, has a good understanding of the principles involved in operating the sewage treatment plant. The plant is over designed and problems are experienced with maintaining appropriate sludge ages. Certain design problems which cause short-circuiting of influent were pointed out.

The effluent from the treatment works is discharged into the Niekerk spruit. Inspection of the analyses of the effluent showed a phosphate concentration varying between 1 and 4 mg/l. No signs of excessive algal growth could be detected in the Niekerk spruit downstream of the sewage works.

3.2.2 Potable water treatment plant.

The same person responsible for the sewage treatment plant, is also responsible for operating the potable water treatment plant. Again it became apparent that the unit processes employed at the plant are well understood and operated accordingly. Water enters the plant and is flocculated and settled in an upflow clarifier. The clarified water is passed through three sand filters and is disinfected using gas chlorination. Lime is dosed at a rate of 2 - 3 mg/l to obtain a positive Langelier saturation index.

3.2.3 Surface water systems

There are two streams of note on the mine property - the Niekerk spruit and the Spookspruit. Spookspruit enters the property from the neighboring Bank Colliery and exits onto a farmer's land. The Niekerkspruit originates on the mine property and exits onto a farmer's land. Both these streams eventually flow into the Olifants river.

Spookspruit receives predominantly clean run off and only flows after good rains. During the site visit it was observed that there could be a possibility of contamination from two sources. The one source is seepage from the Bankfontein rehabilitated area and the other is the water spilled at the water transfer point where tankers are filled with pit water for road wetting purposes.

Although a small stream, the Niekerk spruit flows continuously for most of the year. The reason for this is probably because it receives the effluent from the sewage treatment plant. The Niekerk spruit flows alongside a series of five dams receiving contaminated water from various sources on the mine. There was some debate as to whether the Niekerk spruit was diverted to allow construction of the five settlement dams in the original water course and to prevent contamination of the Niekerk spruit with dirty runoff from the dump and plant areas. The last of the five dams has an overflow into the Niekerk spruit. The Niekerk spruit is monitored daily for flow (V-Notch readings) and weekly for quality parameters.

An extensive series of channels and ditches was constructed in areas such as the plant and discard dump areas, as well as around the opencast operations to separate the clean surface runoff from the runoff from spoil piles etc. Water from unmined or rehabilitated areas is, for management purposes, classified as clean water and any water that was in contact with disturbed areas, is considered as dirty water. Dirty water is either used in the plant, for road wetting or it is evaporated.

All dams on the property as well as some of the farm dams downstream of the mine's property, are monitored for water quality on a monthly basis. The results of the water quality monitoring programme are fairly comprehensive. The possibility of including alkalinity or acidity in the results could be considered.

Groundwater is monitored by a series of 20 piezometer holes scattered across the property. 32 Piezometers are installed with two of the holes in spoil material. The holes have been placed according to decisions of the mine in consultation with external specialists. The piezometers are mostly situated on the boundaries of the mine with some in places of specific interest such as expected decant points and around the slurry ponds.

The water monitoring programme will start in earnest as soon as all the equipment that was ordered has arrived. It is expected that the monitoring programme will be on a monthly basis for the first year and quarterly thereafter.

3.2.4 Evaporation dams

There are four dams in the Goedehoop area with the sole purpose of evaporating dirty water. At the time of the site visit, there was some uncertainty about the volumes they were designed to dispose of.

3.2.5 Clear water or return water dams

A series of five dams collects all the dirty water from the Hartebeestfontein area, including the plant and workshop areas. The water in these dams is used in the plant and for road wetting purposes.

3.2.6 Opencast area

The main use of water in the opencast area is dust suppression. Water accumulating in the pits, mostly rain water, is normally pumped as soon as possible to the clear water dams or evaporation dams, depending on the position of the pit.

According to the mine personnel, the water in the Bankfontein area does not deteriorate as quickly and severely as the water in the Goedehoop area. The specific reasons for this are still uncertain but could be related to the geological characteristics of the two areas.

In the past, the situation has arisen where excessive amounts of water accumulated in the pits, especially in the Goedehoop area and the disposal of this water became a problem. The water is associated with a dyke in the area as well as with water seeping as a fountain from the highwall into the pit. The accumulated water has deteriorated to a point where pumping is extremely difficult due to the corrosive properties of the water. It is hoped that the rain will dilute the water in the pit and make it easier to pump the water out of the pit.

3.2.7 Plant water circuits

The coal preparation plant receives most of its make-up water from the clear water dam and as such, uses recycled water. Normal process water is used for gland service water but potable water is used as flocculant make-up water. The plant treats the water from the return water dams with slaked lime to increase the pH and to reduce the chances of corrosion. Lime is added at a rate of approximately 330mg/m^3.

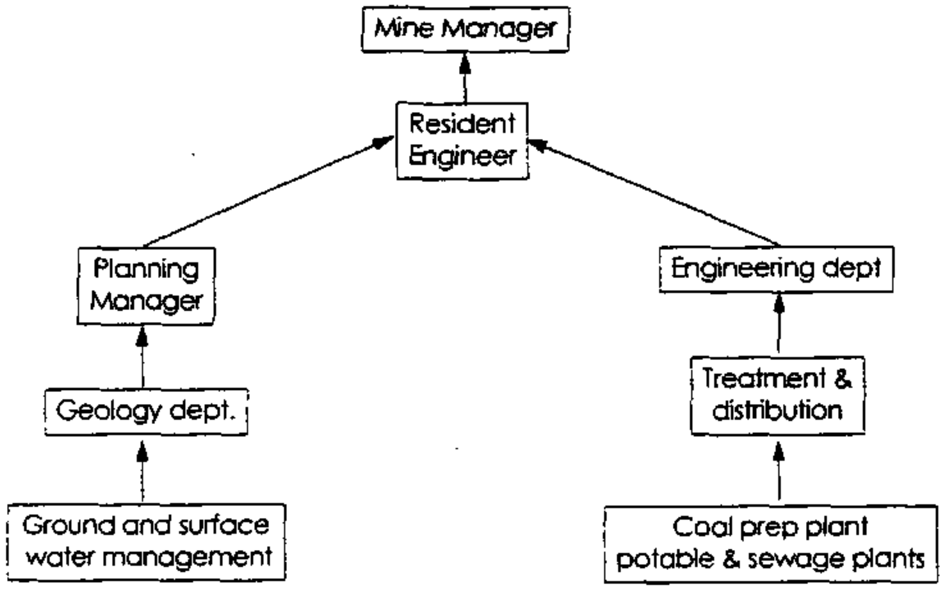
3.2.8 Water monitoring systems

The monitoring programme on the mine is fairly comprehensive as far as quality monitoring of surface water is concerned. No sophisticated computerised systems are employed to manipulate data or to predict impacts or trends. The data is manipulated on a spreadsheet and reports, mostly for the Department of Water Affairs, are generated on this basis.

The groundwater monitoring system is still in the process of being developed and should be operational in the near future.

3.2.9 Water management structure

The following diagram, representing the water management structure with the various departments and personnel involved, was supplied by the mine.



3.3 NOVEL OR UNIQUE WATER TREATMENT AND MANAGEMENT SYSTEMS

3.3.1 Silt traps to reduce the amount of top soil lost with runoff.

In the initial phases after rehabilitation, the runoff from the newly rehabilitated areas causes erosion of the topsoil. In an effort to reduce the amount of topsoil lost in this manner, a series of silt traps were installed in the channels collecting the surface runoff. The traps consist of a rectangular pit approximately 4m deep with the channel veering off at right angles to the pit with the overflow outlet close to the inlet to the pit. Visual inspection of these pits indicated that they are successful in collecting silt but the effectiveness in terms of the percentage of the total silt load trapped in the pits, is unknown.

3.4 POTENTIAL WATER TREATMENT/MANAGEMENT PROBLEMS AND NEEDS

As a result of the discussions and site visits, a number of issues were identified where knowledge gaps still exist.

3.4.1 Flow measurement

Accurate flow data is an essential component of a monitoring programme aimed at providing input into a water management strategy. In view of the waste load allocation policy advocated by the DWAF, it would not be possible to formulate an effective water management strategy if salt loads cannot be predicted or calculated.

With regard to surface water systems, pump curves and pumping hours are often used to calculate flow rates for some of the water transfer operations. The inherent inaccuracies of this method renders it unsuitable in the long term and proper flow measurement methods should be investigated. Considering the practical problems with monitoring flow in the mining environment, this is also considered to be a challenge for the personnel responsible for water management.

It is believed that the construction of continuous monitoring stations in Spookspruit and Niekerkspruit, as considered by the mine, will go some way in addressing this need.

Presently the mine cannot characterise their groundwater system in terms of flow characteristics. Quality can be monitored with the various piezometers but flowrates into different areas through aquifers and other features cannot be predicted or defined.

3.4.2 Prediction and simulation facilities

One of the gaps discussed was the absence of a definitive model for the mine's water systems. The data collected in the monitoring programmes should ideally be fed into a model or system that can be used to predict impacts, decant points and flows or qualities to be expected from certain sources or at specific points. Such a system will enable the mine to define more effective management strategies and will help with prioritising remedial or preventive actions.

3.4.3 Modeling of discard dumps before and after rehabilitation.

At present the mine cannot define the impact of water seeping through the discard dumps on the environment. It is assumed that the water will flow along the impermeable geological layers below the dump towards the pits from where it can be pumped to the return water dams. The volumes and quality of the water originating from this source cannot be quantified or estimated. The whole question of a water and salt balance around a discard dump is an issue which requires further investigation and can be considered to be an industry-wide issue.

3.4.4 Water management functions.

Various departments and people are responsible for various aspects of the water management and treatment functions on the mine. During the visit and the discussions with the various people involved it appeared as if there is not a strong co-ordinated water management system in place. There is uncertainty in the various departments with regard to issues resorting under other departments.

One of the reasons for this may be the fact that there is not a single center of responsibility and expertise for water related issues. Most of the people interviewed characterised their involvement with water management as an additional "sideline" responsibility. Their qualifications and primary responsibilities are centered around other mining activities.

3.4.5 Possibility of contamination of natural water courses.

During the visit it was observed that the Niekerkspruit is situated directly alongside the five settling or return water dams containing highly polluted water. In addition, the last of the five dams has an overflow into the Niekerk spruit and the Niekerk spruit receives the overflow from the sewage treatment plant. To date the analyses of the water as collected at the point where the spruit exits the mine's property do not indicate serious pollution from the return water dams. To date no formal investigation was launched to investigate the situation and to quantify the potential for pollution under different circumstances.

It was also observed that a side stream is flowing into the Spookspruit from an adjacent property. The water appears to be coming from an area on which a brickworks and old adits with smallish spoil heaps are situated. The potential of this area to act as a pollution source is unknown and could be investigated.

3.4.6 Reliance on external consultants.

It was observed that the mine is very reliant on the results of studies by external consultants. Although this in itself is not a problem, it may be a problem if the mine does not have personnel who could evaluate the results of these studies in the context of the mine's needs, priorities and circumstances.

3.4.7 Silt entrainment

As discussed elsewhere, the topsoil lost from rehabilitated areas with surface runoff was identified as a problem. If the silt cannot be intercepted on the mine's property, the farmer's dams may silt up forcing the mine to clean the dams and in addition, valuable soil has been lost.

3.4.8 Impact of water used for road wetting purposes.

Although it is assumed that the water used for road wetting purposes either evaporates or infiltrates, and that the pollution impact is negligible, this assumption needs to be validated as the salts within the wetting water must be accumulating on or near the roads.

4. GENERAL IMPRESSIONS

4.1 ROLE OF THE EMPR

It is believed that the EMPR has played a significant role in focusing attention on water management aspects but, according to the personnel interviewed, mostly in those departments or sections that deals directly with the EMPR. The view was expressed that a greater awareness of water management issues, especially among production staff, should be cultivated and promoted.

4.2 OPENNESS ABOUT WATER AND ENVIRONMENTAL MANAGEMENT ISSUES

Practically all of the personnel interviewed were prepared to provide all the required information with regard to their water management systems.

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

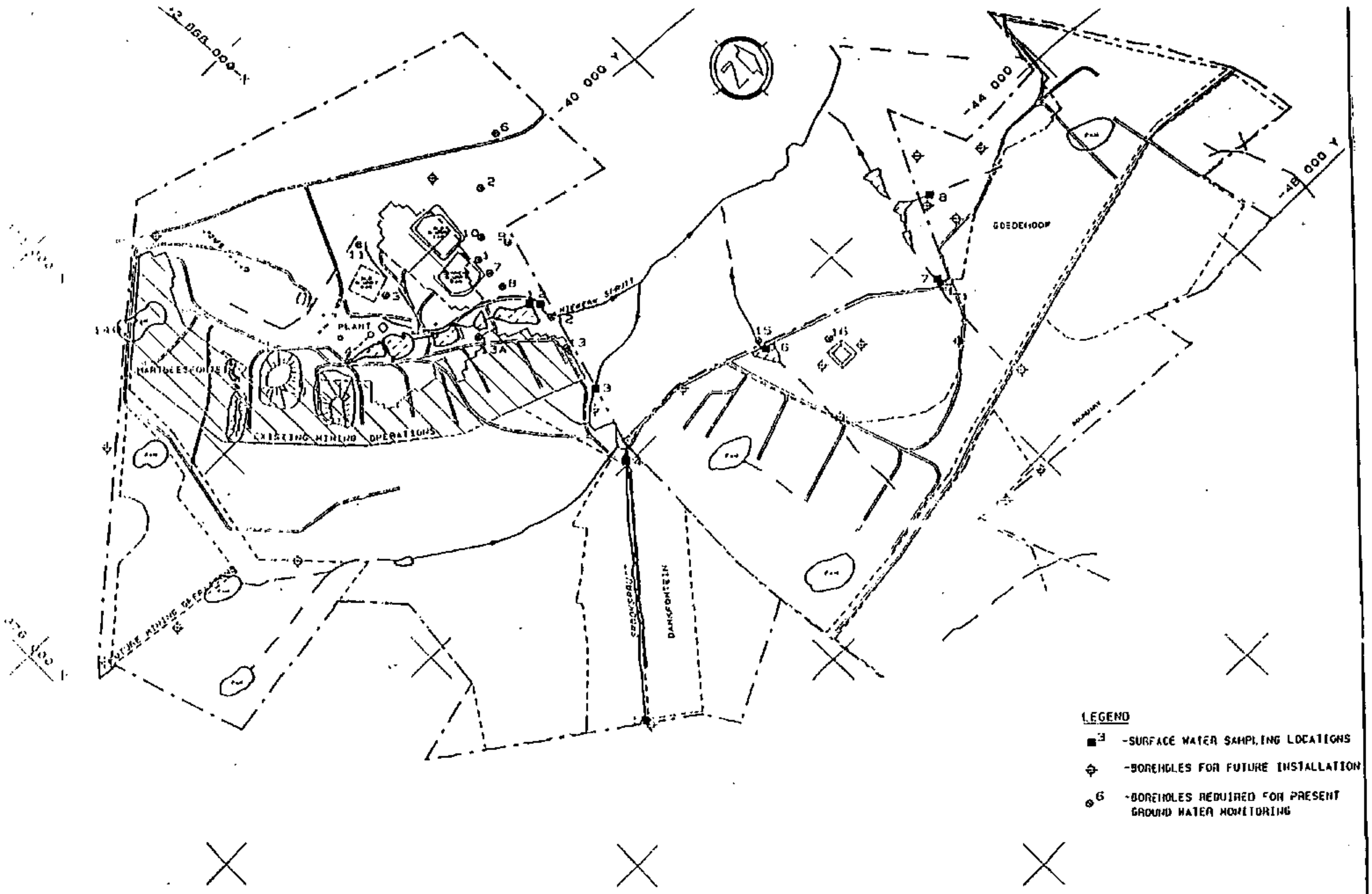
During the site visit, a number of pH and conductivity readings were taken at various locations on the mine. The following is a list of the readings taken:

	Description	pH	Cond. [mS/m]
1	Dam 5 - dirty/process water storage on Hartebeestfontein	5.8	262
2	Niekerk spruit - exit point	7.3	38
3	Spookspruit - exit point	7.0	42
4	Spookspruit below Bankfontein rehab area	8.1	38
	Spookspruit upstream of MMS property - entry point	7.3	22
5	Side stream entering from brickworks and adits on adjacent property	6.4	33
6	Pit water at tanker filling point	7.7	242
7	Hartebeestfontein fresh water dams in unmined area	9.2	8.2
8	Dirty water collection ditch from discard dump area	4.3	385
9	Dam No 1 - return water dam	5.5	335
10	Stream from Open pit into dam No 3	8.0	256
11	Dams 3 & 4	7.4	282
12	Seep into G2 ramp in Goedehoop area	6.5	80
13	Pit water in Goedehoop area - to be pumped to evaporation dam	2.7	300
14	Evaporation dam - Howard's dam	3.7	55 (?)

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:

Photograph No	Description
1	Dam 5 - dirty/process water storage on Hartebeestfontein
2	Niekerk spruit - exit point
3	Spookspruit - exit point
4	Spookspruit below Bankfontein rehab area
5	Spookspruit upstream of MMS property - direction towards MMS
6	Side stream entering from brickworks and adits on adjacent property
7,8	Water in pit - used for road wetting
9	Water tanker filling point - spilling into Spookspruit
10	Spookspruit below water tanker filling point
11,12	Opencast operations
13,14	Hartebeestfontein fresh water dams in unmined area
15	Dirty water collection ditch from discard dump area
16	Dam No 1 - return water dam
17	Stream from Open pit into dam No 3
18	Dams 3 & 4
19	Slurry dam in old North pit area
20	Piezometer hole - below slurry dam
21	Silt trap - in clean water runoff system
22	Seep into G2 ramp in Goedehoop area
23	Pit water in Goedehoop area - to be pumped to evaporation dam
24	Evaporation dam - Howard's dam
25	Evaporation dams - Goedehoop area - empty



JOB No.		FIG No.
193265	LOCATION OF SURFACE WATER AND GROUND WATER QUALITY AND FLOW MONITORING STATIONS	1.

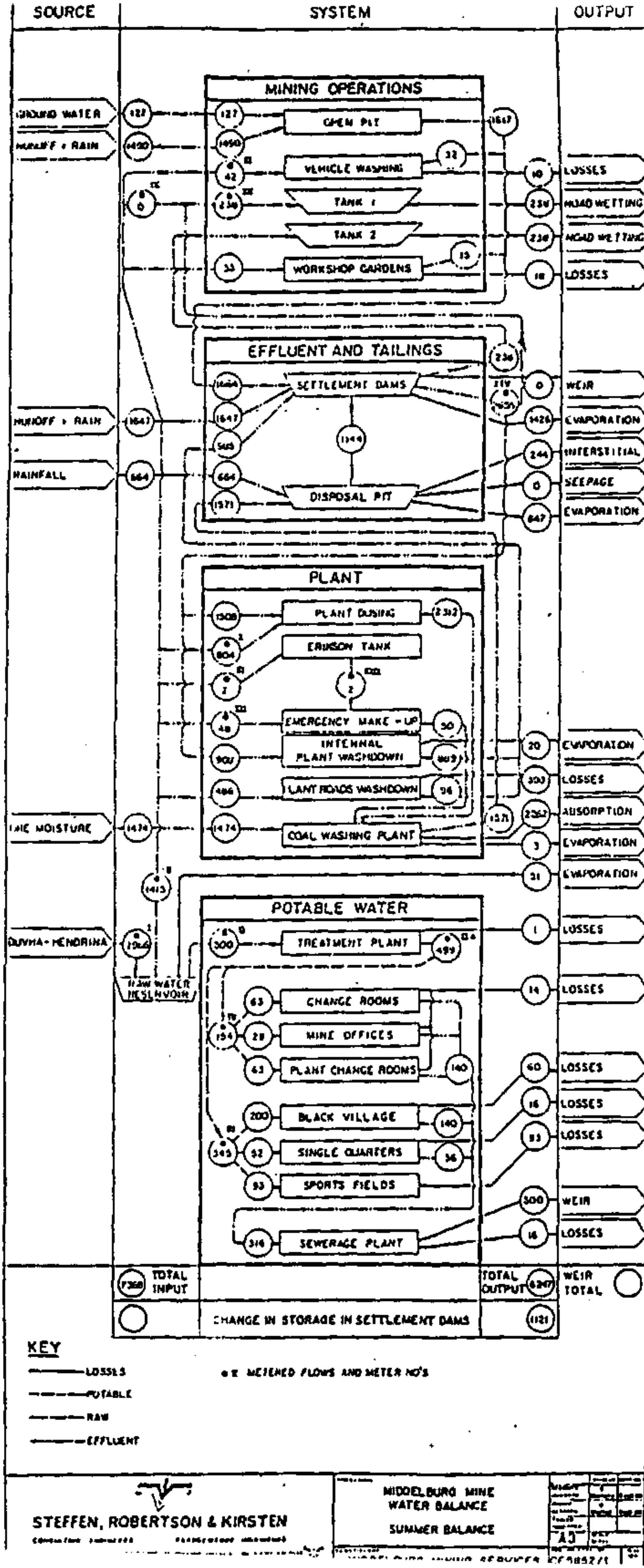
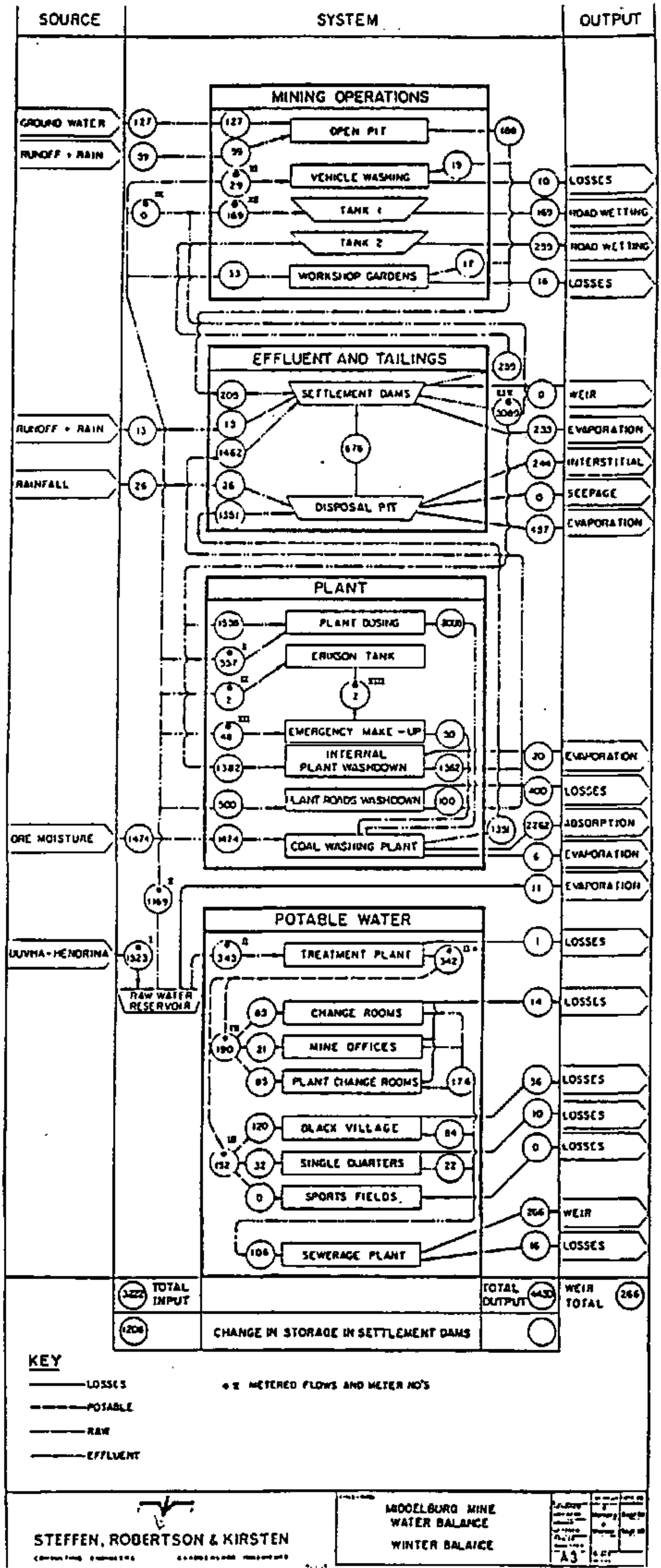

SOURCE
SYSTEM
OUTPUT
MINING OPERATIONS
GROUND WATER
RUNOFF + RAIN
OPEN PIT
VEHICLE WASHING
TANK 1
TANK 2
WORKSHOP GARDENS
LOSSES
ROAD WETTING
ROAD WETTING
LOSSES
EFFLUENT AND TAILINGS
SETTLEMENT DAMS
DISPOSAL PIT
RUNOFF + RAIN
RAINFALL
WEIR
EVAPORATION
INTERSTITIAL
SEEPAGE
EVAPORATION
PLANT
PLANT DOSING
ERIKSON TANK
EMERGENCY MAKE-UP
INTERNAL PLANT WASHDOWN
PLANT ROADS WASHDOWN
COAL WASHING PLANT
ORE MOISTURE
EVAPORATION
LOSSES
ABSORPTION
EVAPORATION
EVAPORATION
POTABLE WATER
DUVHA-HENDRINA
RAW WATER RESERVOIR
TREATMENT PLANT
CHANGE ROOMS
MINE OFFICES
PLANT CHANGE ROOMS
BLACK VILLAGE
SINGLE QUARTERS
SPORTS FIELDS
SEWERAGE PLANT
LOSSES
LOSSES
LOSSES
LOSSES
LOSSES
WEIR
LOSSES
TOTAL INPUT
TOTAL OUTPUT
WEIR TOTAL
CHANGE IN STORAGE IN SETTLEMENT DAMS
KEY
LOSSES
POTABLE
RAW
EFFLUENT
METERED FLOWS AND METER NO'S
STEFFEN, ROBERTSON & KIRSTEN
MIDDELBURG MINE
WATER BALANCE
SUMMER BALANCE

Figure 2


SOURCE
SYSTEM
OUTPUT
MINING OPERATIONS
GROUND WATER
RUNOFF + RAIN
OPEN PIT
VEHICLE WASHING
TANK 1
TANK 2
WORKSHOP GARDENS
LOSSES
ROAD WETTING
ROAD WETTING
LOSSES
EFFLUENT AND TAILINGS
SETTLEMENT DAMS
DISPOSAL PIT
RUNOFF + RAIN
RAINFALL
WEIR
EVAPORATION
INTERSTITIAL
SEEPAGE
EVAPORATION
PLANT
PLANT DOSING
ERIKSON TANK
EMERGENCY MAKE-UP
INTERNAL PLANT WASHDOWN
PLANT ROADS WASHDOWN
COAL WASHING PLANT
ORE MOISTURE
EVAPORATION
LOSSES
ABSORPTION
EVAPORATION
EVAPORATION
POTABLE WATER
TREATMENT PLANT
RAW WATER RESERVOIR
LOSSES
CHANGE ROOMS
MINE OFFICES
PLANT CHANGE ROOMS
LOSSES
BLACK VILLAGE
SINGLE QUARTERS
SPORTS FIELDS
SEWERAGE PLANT
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CHANGE IN STORAGE IN SETTLEMENT DAMS
KEY
LOSSES
POTABLE
RAW
EFFLUENT
METERED FLOWS AND METER NO'S
STEFFEN, ROBERTSON & KIRSTEN
MIDDELBURG MINE
WATER BALANCE
WINTER BALANCE

Figure 3

MIDDELBURG MINE SERVICES EMPR

SCHEMATIC PLAN OF INDUSTRIAL WATER FLOW

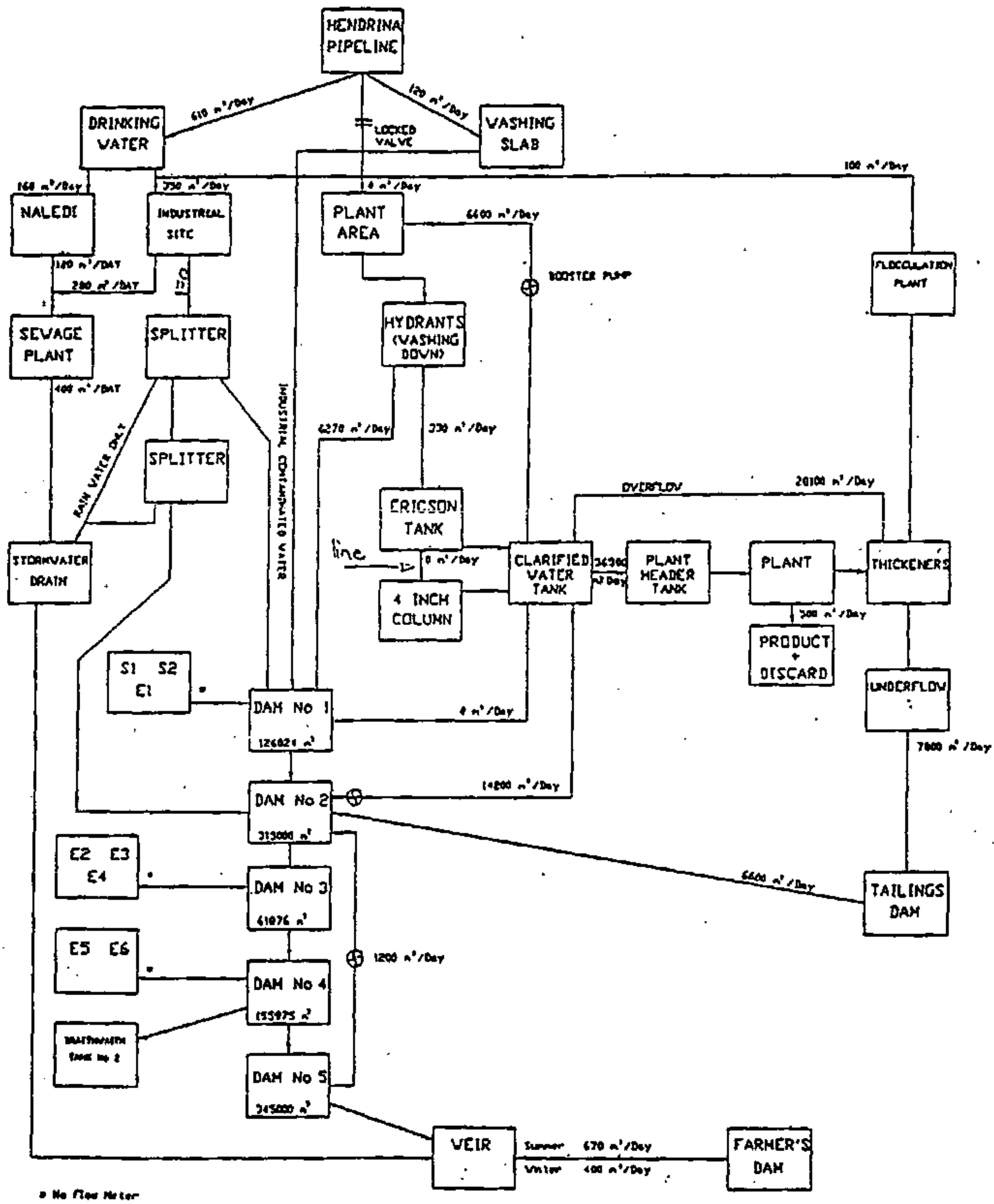


Figure 4

Report on Natal Anthracite Colliery Site Visit

3 November 1993

1. GENERAL INFORMATION

Name of mine	Natal Anthracite Colliery
Name of person(s) interviewed	HC van Zyl
Position of person(s) interviewed	Senior Divisional Mining Engineer
Nearest town	Vryheid
Name of catchment	Black Mfolozi & Mkuze
Monthly coal throughput (rom)	Mine closed - total of 37 Mt mined
Monthly saleable product	80 %
Monthly discard production	15 %
Monthly slurry production	5 %
Main product and market	Anthracite (steam coal)
Current age of mine	Boschhoek - 50 years Enyati - 53 years
Expected remaining life of mine	0 years
Type of mining carried out	Underground total extraction
Transport mode- mine to plant	Endless rope haulage
Has the mine already produced an EMPR	Not applicable

2. SITE VISIT PROGRAMME

2.1 Day 1 - 3 November 1993

- Short discussion of project with Messrs. G Hutchinson, L Longueira and J Pressly
- Detailed site visit with Mr G Hutchinson, Mr L Longueira & Mr J Pressly

2.2 Day 2 - 8 December 1993

- Completion of questionnaire with Mr HC van Zyl

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

3.1 DESCRIPTION OF WATER CIRCUITS

This is a defunct mine which is in the process of being decommissioned for closure. The washing plant is still operational treating some of the waste material from earlier mining operations. The main activities, however, are related to decommissioning and rehabilitation. Although the mine does, therefore, not have major operational water circuits, a number of point and diffuse water pollution sources exist and the surface water circuits can be divided into different areas from this perspective, as follows:

- Old slurry dams;
- Enyati water adit;
- Office and Buffalo dumps;
- Boschhoek No. 1 water adit; and
- Boschhoek No. 2 water adit;

A detailed plan of the whole area was made available and a simplified plan, showing the pH and conductivity sampling points is shown in Figure 1.

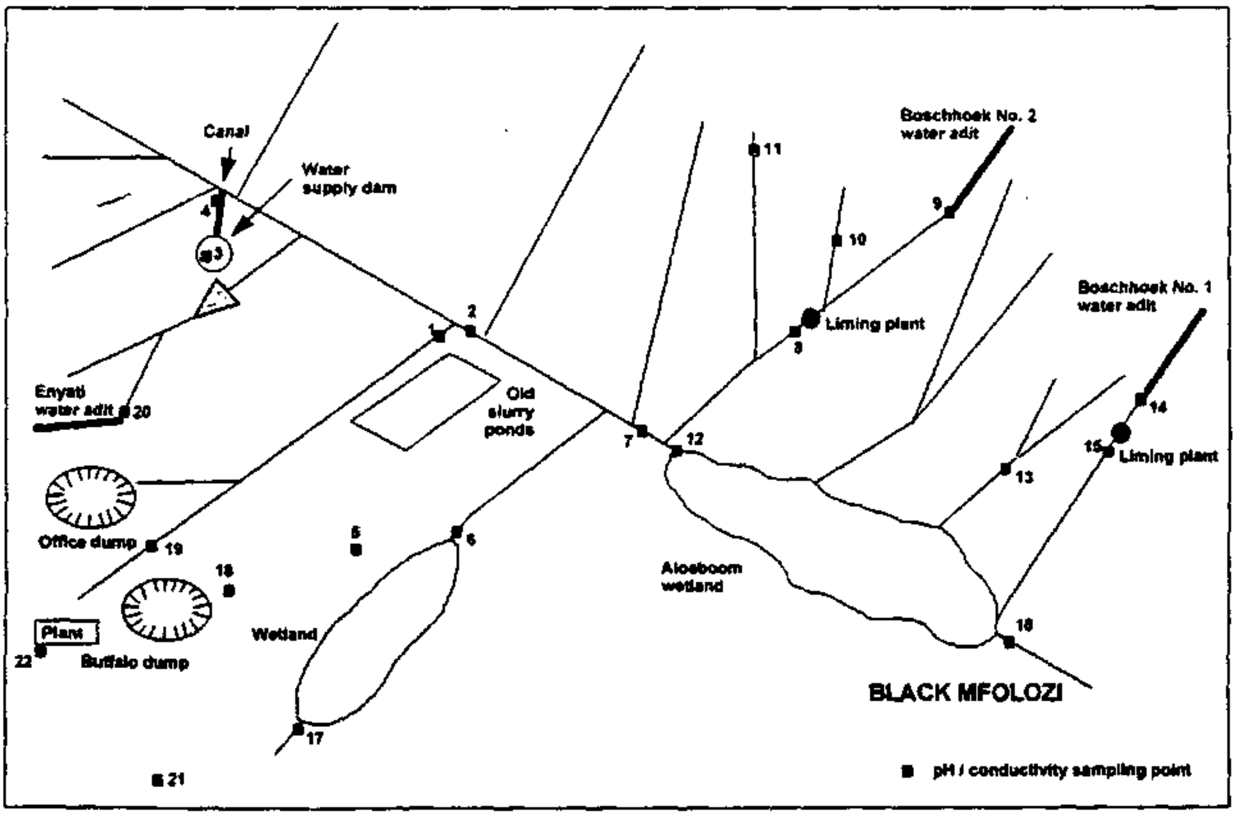


Figure 1 : Natal Anthracite Surface Water Systems

The site visited consists of two distinctly different and separate mining operations - the Enyati (not mined by NAC) and the Boschhoek (mined by NAC) mines. These mines are situated on opposite sides of a valley which makes up the headwaters of the Black Mfolozi river. The washing plant is situated at the Enyati section as are the two main discard dumps - the Office and Buffalo dumps and all coal from the Boschhoek mining operations was transported across the valley to the plant by a continuous rope haulage. Slurry discard from the washing plant was also disposed of in slurry ponds on the Enyati side of the river.

The mining operations have ceased and the adits have all been sealed off. However, as this area makes up the headwaters of the Black Mfolozi, the springs are very active and the underground workings which were located in the upper sections of the hills surrounding the valley, are flooded. For this reason, water adits have been constructed into the underground workings in order to enable the water to be drained out as point source discharges rather than as seepages along the outcrop. The Enyati section has one water adit which discharges neutral water with a moderate conductivity into the Black Mfolozi. The Boschhoek section is drained by two different water adits. At the time of the site visit, both adits were draining acid water with a pH of between 3 and 4, although water quality records held by the mine indicate that the No. 1 adit is generally close to a neutral pH.

Additional features of the water systems at NAC are as follows:

- A canal has been constructed to take water from the upper reaches of the Black Mfolozi, before it becomes contaminated, to a storage dam for use by the mine.
- The slurry dams are situated directly alongside the Black Mfolozi and discharge effluent into the river.
- The mine has two lime dosing plants which dose lime to the Boschhoek Nos. 1 and 2 water adits.
- The area between the points where Boschhoek Nos. 1 and 2 adits discharge into the Black Mfolozi contains a large wetland known as the Aloeboom wetland.
- The Black Mfolozi and its tributaries have various water quality sampling points which are sampled regularly by the mine.

3.2 DESCRIPTION OF WATER TREATMENT/MANAGEMENT SYSTEMS

3.2.1 Lime dosing plants

The mine operates two lime dosing plants, which feed lime directly into the streams receiving the drainage from the Boschhoek Nos. 1 and 2 water adits. These lime dosing systems are automated to discharge lime in accordance with a pH probe reading in the stream. However, the location of the pH probes and the layout of the dosing systems indicated that the pH control would not be smooth and would fluctuate between overdosing and underdosing. These lime plants also require a fairly high degree of supervision in terms of closure requirements, insofar as lime needs to be added to the dosing tanks on a daily basis. According to information provided by the mine, the operating costs of the lime dosing systems was 55 c/m^3.

3.2.2 Water adits

NAC has constructed 3 water adits into the underground workings to drain these workings as a point source effluent which can then be monitored, managed and treated. Without these water adits, the water would emanate as series of seeps along the outcrop which would create a pollution problem which would be difficult to manage. As these mines are located in the head waters of the Black Mfolozi, there is a very high flux of water through the underground workings. The quality of water emanating from these adits varies from one to the other and over time. The reasons for this cannot be defined with certainty and the driving forces influencing the water quality are not understood. These water adits will continue to discharge in perpetuity, with a water of unknown quality.

3.2.3 Wetlands

The site visited has two major wetlands which accept mine drainage. The smaller one accepts drainage and runoff from the Enyati Buffalo area. At the time of the site visit, the water quality was deteriorating, in terms of macro contaminants, as it moved through this smaller wetland as shown in Table 1 below. On the other hand, a number of the heavy metals, including aluminium, barium, cobalt, iron, manganese, nickel and zinc decreased. This data suggests that the dynamics of the wetland are not understood and there is either an additional unknown stream entering the system, or the wetland has received past spillages of carbonaceous material which are still oxidising to contaminate the water.

Table 1 : Water Quality Through Small Wetland

PARAMETER	UNIT	WATER IN	WATER OUT
pH	pH unit	3.70	3.75
Conductivity	mS/m	135	200
Sulphate	mg/l	432	800
Calcium	mg/l	85	191
Magnesium	mg/l	37	69
Iron	mg/l	1.87	0.18
Manganese	mg/l	9.1	4.0
Aluminium	mg/l	4.04	2.56

The Aloeboom wetland is fairly large and has been the subject of numerous previous studies. Problems are being experienced in managing the wetland to serve both as a purification system and a source of water for local farmers.

3.2.4 Discard dumps

The discard dumps at NAC have been profiled and rehabilitated to shed water rapidly to minimise infiltration and seepage. Water is not retained on top of the dumps - despite this seepages are occurring from the dumps and it is planned to contain and treat them. These dumps have been constructed on very steep slopes and special precautions are being taken to address potential problems with erosion.

3.2.5 Water monitoring systems

The mine does not have any continuous water flow or quantity measurement or monitoring systems. Flow measurement from the water adits is fairly crude and with unknown accuracy. Grab samples are taken at a number of points on a monthly basis for a quality analysis. These points give a good coverage of the area affected by the NAC mining operations. The mine has a fairly comprehensive water quality database going back a number of years.

3.2.6 Water management structure

The water management structure is shown in Figure 2 below.

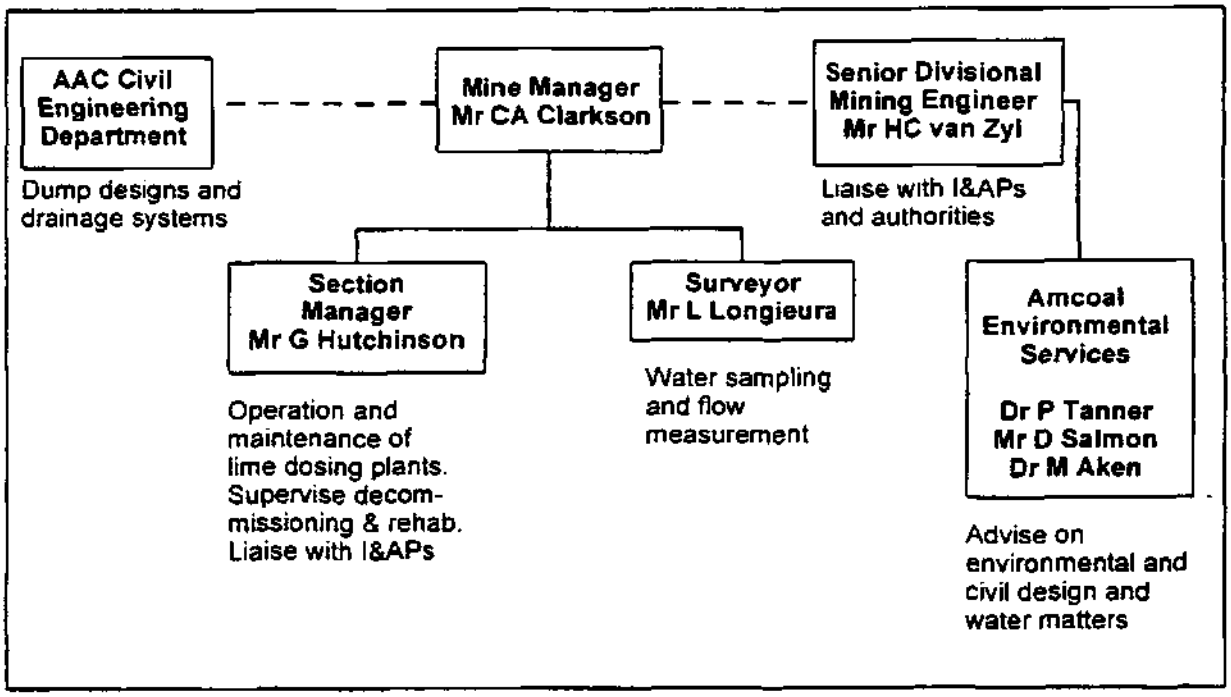


Figure 2 : Natal Anthracite Water Management Structure

The decommissioning operations at the mine are being undertaken by suitably qualified staff who are backed up by an assortment of technical specialists as and when required.

3.3 NOVEL OR UNIQUE WATER TREATMENT AND MANAGEMENT SYSTEMS

3.3.1 Decommissioning procedure

The mine is undertaking a very thorough decommissioning operation to address all the environmental aspects of its past operations. A number of skilled staff are being employed to supervise this operation.

3.3.2 Enyati Valley Committee

Some years ago, the mine initiated the Enyati Valley Committee to co-ordinate all aspects of water pollution and management on a sub-catchment basis. A consulting company was contracted to undertake the necessary studies and these were paid for by the contributing mining companies. The requirements of various downstream users were determined and, in consultation with the authorities, waste load allocations were made.

3.3.3 Wetlands

The Aloeboom wetland on the Black Mfolozi has been studied fairly extensively by the mine and consultants appointed by it. The water into and out of the wetland has also been monitored on an ongoing basis for many years and a large database is available. These wetlands are definitely performing a positive function in removing contaminants from the effluent streams, particularly in terms of heavy metals.

3.3.4 Lime dosing plants

Although the lime dosing plants at NAC have certain problems in terms of their design, operation and maintenance, the fact that automated lime dosing systems, which are controlled by a pH probe feedback loop, are in place is fairly unique within the South African mining industry where most control systems are manual and ineffective.

3.3.5 Water adits

the water adits extending into the underground workings are beneficial in terms of preventing widespread diffuse pollution problems. An interesting detail of these water adits is that they have been designed with air locks on the outlets in order to prevent oxygen entering the workings to drive the pyrite oxidation reactions. The beneficial impact of the air lock will depend on the mine ensuring that oxygen does enter from other sources such as cracks in the overlying ground.

3.4 POTENTIAL WATER TREATMENT/MANAGEMENT PROBLEMS AND NEEDS

As a result of the discussions and site visits, a number of issues were identified where knowledge gaps still exist.

3.4.1 Management of diffuse pollution sources

During the 50 years of operation of the mines, large amounts of carbon-aceous material have been deposited in the valley due to spillages from the dumps, slurry ponds, plant area and continuous rope haulage. It can be anticipated that this material, unless it is removed or rehabilitated in an acceptable manner, will provide a long term source of diffuse pollution

3.4.2 Management and treatment of point source discharges

The water adits at NAC can be expected to discharge contaminated water in perpetuity, although it is probable that at some unknown time in the future, the quality of the water will start to improve as the exposed pyrites become exhausted. In order to deal with these discharges, the mine requires a *sustainable, low maintenance passive water treatment* system, primarily capable of removing sulphates and increasing the pH.

3.4.3 Overall water and salt balance

Although the mine is presently in the process of final decommissioning, it does not have an overall mine-wide water and salt balance which pinpoints and quantifies the different sources of pollution - both diffuse and point sources. The discussion presented in Section 3.2.3 highlights but one of the unknown or unquantified sources of pollution - the site visit indicated that due to past spillages and practices, a number of sources of pollution exist. The water and *salt balance remains the most powerful tool* available to the mine to manage its water systems and impacts.

3.4.4 Control of lime dosing plants

The site visit indicated problems with the lime dosing plants in terms of their control. The feedback loop on the lime dosing plant and the effectiveness of the control is very dependent on the correct placement of the pH probe and adequate upstream mixing of lime and effluent. Where the pH probe is too far downstream, such as at the NAC plants, the pH of the treated water will vary between 3 and 12 as the probe is too slow in reacting to the dosage of lime - *this precise variation was observed and measured during the site visit.*

The lime dosing systems installed are also not optimal for a closed mine as they require electrical power, daily recharge of lime and regular maintenance and supervision. A "passive" or low maintenance lime dosing or neutralisation system is required.

3.4.5 Monitoring systems

Due to the lack of reliable and accurate flow measurements, it is not possible to properly quantify the impact of the mine on the water environment or to *evaluate the beneficial effect of applied water management strategies.*

3.4.6 Final slurry disposal

The slurry ponds are situated directly next to the Black Mfolozi and, although they will be rehabilitated prior to closure, there is a potential that they may have a long term impact on the water quality of the river.

3.4.8 Seepage from dumps

Although the dumps have been rehabilitated to shed water and to minimise water retention and infiltration, some seepage is still occurring at the base of the dumps. This may prove to be a long term problem which will require collection and some form of passive treatment.

4. GENERAL IMPRESSIONS

The general impression gained from the site visit is that the mine has significant impacts on the surface water systems. Although these impacts are well understood and are being addressed, the lack of a salt balance for the whole mine makes it impossible to say for certain that the mine is addressing all the issues adequately. The decommissioning procedure being followed by NAC is very thorough and is being driven by well qualified people.

The mine and its staff appear to be dedicated to achieving a successful mine closure which addresses all the major impacts - this is evidenced by the numerous technical studies which have been undertaken and the catchment-wide studies which the mine initiated.

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. The following is a list of the readings taken:

No	Description	pH	Cond.
1	Overflow from slurry pond	5.1	160
2	Swart Mfolozi downstream/adjacent slurry pond	6.05	56
3	Lower water supply dam	6.45	33
4	Swart Mfolozi above mine at takeoff canal	7.1	21
5	Stream draining dump below catchment dam	3.55	261
6	Stream draining from wetland at rope haulage	3.80	132
7	Swart Mfolozi at haulage bridge	6.13	64
8	Upstream of No. 1 liming plant	4.04	128
9	Water leaving No. 1 adit	3.80	140
10	Kwa Mawelawela stream	7.02	88
11	Mine sampling point 14 - from N.Ammonium	3.53	171
12	Schmidts bridge - inflow to top of vlei	4.83	96
13	Sample point N5	6.70	16
14	No 2 adit	3.13	187
15	No 2 adit liming plant	3.40	115
16	Aloeboom bridge - exit from vlei	3.78	112
17	Top end of wetland for sample 6	3.57	82
18	Seepage from office dump	3.32	380
19	Seepage from western side of office dump	3.25	291
20	Post Office stream	7.5	73
21	Seepage out of top of hill	4.6	52
22	Seepage out of top of hill	4.86	52

All conductivity measurements are in mS/m

Report on Optimum Colliery Site Visit

22 - 23 November 1993

1. GENERAL INFORMATION

Name of mine	Optimum Colliery
Name of person(s) interviewed	R Hugo & D Kruger
Position of person(s) interviewed	R Hugo - Environmental Manager D Kruger - Environmental Officer
Nearest town	Middelburg
Name of catchment	Klein Olifants, Middelburg Dam
Monthly coal throughput (rom)	1.2 Mt
Monthly saleable product	Export coal - 475 000 t Eskom power station - 475 000 t
Monthly discard production	200 000 t
Monthly slurry production	50 000 t
Main product and market	50 % coal to Hendrina power station 50 % coal to export customers
Current age of mine	22 years
Expected remaining life of mine	20 years
Type of mining carried out	Open cast
Transport mode- mine to plant	Road and conveyor
Has the mine already produced an EMPR	Yes, draft stage

2. SITE VISIT PROGRAMME

2.1 Day 1 - 22 November 1993

- Short discussion of project with Messrs. R Hugo and D Kruger
- Detailed site visit with Messrs. R Hugo and D Kruger

2.2 Day 2 - 23 November 1993

- Detailed site visit with Messrs. R Hugo and D Kruger
- Completion of questionnaire with Messrs. R Hugo and D Kruger

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

3.1 DESCRIPTION OF WATER CIRCUITS

This is a large open cast mining operation in the drainage basin of the Woestalleen, Zevenfontein & Klein Olifants Rivers. Earlier open cast operations in the Optimus area have mined through the watercourse (Eastern Woestalleen) and have then re-established the watercourse and a dam on the rehabilitated, backfilled pit area. The Optimus section contains a number of ponds and dams on the rehabilitated spoils, resulting in the formation of a large sponge which is contributing contaminated seepage water to the Woestalleen Spruit at the rate of almost 7 Ml/day.

The new mining operations in the Pullens Hope section are being preceded by a large scale river diversion to dam the Eastern Woestalleen Spruit and its tributaries and to divert it by gravity pipeline around the mining area. Open cast operations along the Zevenfontein and the Western Woestalleen Spruit remain outside the 1:50 year flood lines.

Discard and slurry are disposed of in the pit (ramps and final voids) and return water from the slurry is recycled to the washing plant. Runoff from the plant area is collected in pollution control facilities and reused within the plant and for dust suppression on the haul roads.

Potable water is obtained from the Hendrina power station and treated sewage is discharged to the Eastern Woestalleen Spruit, although it was planned to route this into pollution control facilities.

A number of points are sampled regularly for water quality. The mine has also implemented a continuous monitoring system for flow, pH and conductivity at 6 points within the mine's area. A groundwater monitoring programme is also in operation at the mine.

Additional detail is given in the following attached figures:

Figure 1 : Catchments and drainage paths
Figure 2 : Optimum Colliery simplified water system diagram
Figure 3 : Optimum Colliery water balance

3.2 DESCRIPTION OF WATER TREATMENT/MANAGEMENT SYSTEMS

3.2.1 Sewage treatment plant

The sewage treatment plant at Optimum Colliery is a conventional Pasveer ditch system with mechanical aeration. Aerated effluent is treated in a secondary clarifier with sludge recycle to the Pasveer. Clarified effluent is disinfected in a plug flow contactor with chlorine before being discharged to the surface stream (this effluent was planned to be sent to an evaporation dam).

3.2.2 Plant water circuits

The coal washing plant uses a combination of raw water supplied by Hendrina power station and recycled decant water from the slurry pond in the Optimus final void. Losses from the circuit include surface water on the plant product and coarse discard. Contaminated runoff from the plant area is collected in evaporation ponds where water is lost through evaporation, seepage and overflow to the West Woestalleen spruit.

The wash bay and workshop area collect the runoff in an oil and grease trap where the oil is skimmed off for recycling. The effluent from the grease trap flows into a concrete storage dam from where the water is either recycled to the workshop/wash bay or is abstracted for use in dust suppression on the haul roads.

3.2.3 Discard Disposal

As mentioned earlier, the mine discharges its discard material to the remaining voids with coarse discard going into the ramps and slurry being pumped into the final voids. As a result, the water management activities associated with conventional disposal methods are not required. However, approximately 2 Ml/day of water is recovered from the slurry and is pumped to an evaporation dam from where it is reused in the plant and for wetting of haul roads.

3.2.4 River Diversion

The Optimus opencast operation which included mining through and reconstituting a water course has resulted in substantial water pollution (seepage) problems. To prevent a re-occurrence of this, the new opencast operation in the Pullens Hope area is being preceded by a major river diversion exercise. The Woestalleen East Spruit and its tributaries upstream of the Pullens Hope area have been impounded in dams which are inter-connected to a major dam from where the water is pumped to the Woestalleen West Spruit, thereby bypassing both the Pullens Hope and the Optimus areas.

3.2.5 Water Monitoring & Data Management Systems

The mine has a fairly comprehensive water quality monitoring system covering surface and ground water. The mine also has six continuous monitoring stations at various points as shown in Figure 1. All monitoring data is entered into Hydrocom and comprehensive monthly reports are produced using this data. Although there are still some notable deficiencies in the monitoring programme (see section 3.4.6), the system in place at Optimum can be considered as very advanced in comparison with most other mines visited (see 3.3.4).

3.2.6 Water management structure

The water management structure is shown in Figure 4 below.

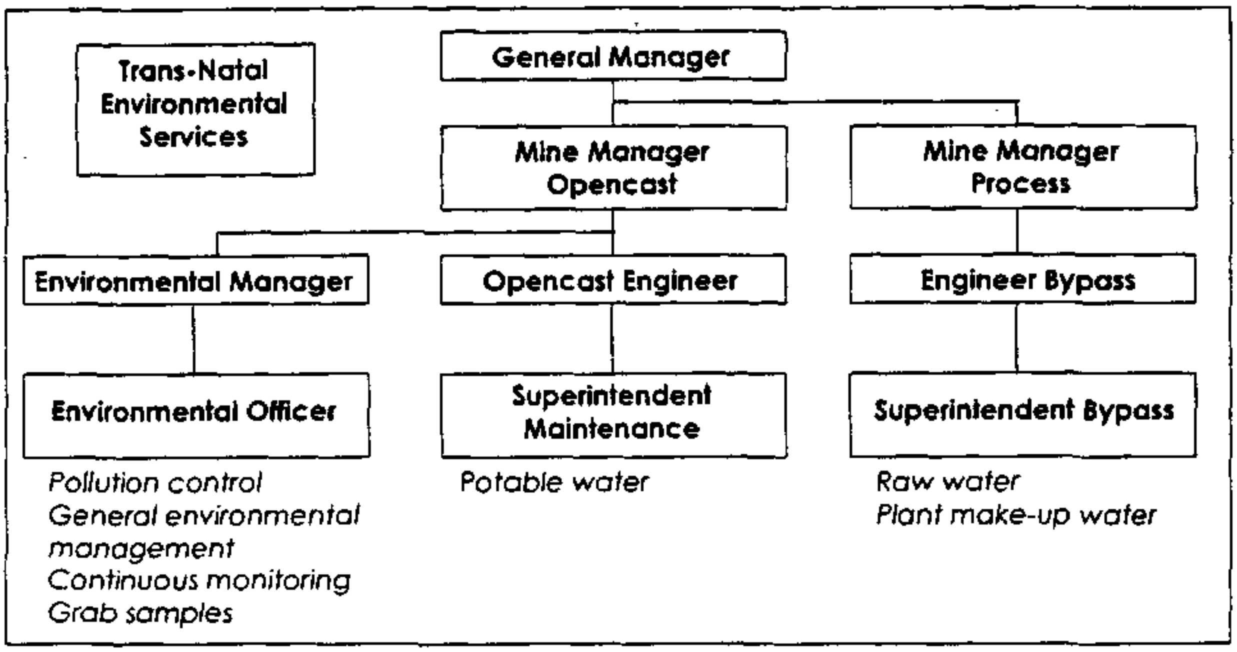


Figure 4 : Optimum Colliery Water Management Structure

Optimum Colliery is one of the few mines that has an appointed Environmental Manager. A discussion on perceived deficiencies in the mine's water management structure is given in section 3.4.7.

3.3 NOVEL OR UNIQUE WATER TREATMENT AND MANAGEMENT SYSTEMS

3.3.1 End Land Use Planning

In the rehabilitation planning for the opencast areas, the mine is embarking on a number of novel initiatives, including the following:

- planting fruit trees on rehabilitated land
- planting Eucalyptus trees on 800 ha of rehabilitated land at a density of 1000 trees/ha
- undertaking studies to develop initiatives to promote the establishment of small scale farmers on rehabilitated land

Although these initiatives may, at first glance, appear to be unrelated to water management, it is believed that success will lead to improved water management and reduced impact (particularly of the Optimus sponge) on the water environment.

3.3.2 River Diversion

The river diversion around the Pullens Hope opencast area has been planned in great detail and is, to a large degree, indicative that the mine has learnt from the problems which have manifested themselves with the Optimus area and has planned activities to ensure that these problems are not repeated. This particular river diversion exercise may prove to be a good example to other collieries regarding how to undertake a diversion with minimal significant impact on the broader environment.

3.3.3 Discard Disposal

The use of ramps and final voids for disposal of coarse discard and slurry is unusual within the South African mining industry. Although some of the long term effects of this strategy (particularly on groundwater) have not been quantified, intuitively it appears to be a good solution to the long term problems associated with conventional discard dumps and slurry dams, certainly from a surface water and land use viewpoint. The cost-effectiveness of this option (bearing in mind long term rehabilitation and post-closure costs) is unknown.

3.3.4 Monitoring Programme and Information Management

As mentioned earlier the mine has a fairly extensive water quality monitoring programme in place, including six continuous monitors. More importantly, however, the environmental management department appears to make very good use of the information at its disposal for management purposes. Detailed monthly reports are produced and the information is evaluated against set requirements and objectives, with corrective actions being initiated in the event of variance. Although this is the only logical use for monitoring data, the standard practice at many mines is simply to file collected data and never to use it.

3.3.5 Infiltration Studies

The mine is undertaking a series of detailed infiltration studies in order to evaluate the effect of different covers, slopes, topsoil thickness, spoil size fraction, compaction, etc. on infiltration, runoff, evapotranspiration, evaporation, etc. Unfortunately, the results of this study will remain confidential to Trans-Natal (now Ingwe Coal Corporation).

3.4 POTENTIAL WATER TREATMENT/MANAGEMENT PROBLEMS AND NEEDS

As a result of the discussions and site visits, a number of issues were identified where knowledge gaps still exist.

3.4.1 Management of diffuse pollution sources

The mine has a number of diffuse pollution sources, in addition to the Optimus sponge, which are either not adequately understood, monitored or managed. For example, a number of the haul roads (particularly in the Zevenfontein area) are constructed from discard/spoils and are adjacent to surface streams without adequate pollution control facilities. Contaminated Optimus pit water is also used for dust suppression on the haul roads, with unquantified effects in terms of adding to the diffuse pollution problems. Detailed water and salt balances are not undertaken to quantify the diffuse pollution problems.

3.4.2 Optimus Sponge

The long-term behaviour of the Optimus sponge is uncertain although it is currently being extensively investigated. The effect of the upstream river diversions may prove to be beneficial in the long term. During the site visit, a number of ponding areas were observed on the rehabilitated area which will act as recharge points to the sponge. This sponge is the mine's biggest pollution problem and probably contributes significantly to the catchment's water quality problems.

3.4.3 Groundwater Systems

Although the mine has commissioned a number of ground water studies and has improved its knowledge in this area substantially, there are still a number of unresolved issues which need to be addressed, including aspects relating to in-pit discard disposal and prediction of long term behaviour, monitoring and management of the Optimus sponge. The mine would benefit from employing a suitably qualified person to address these issues on an ongoing basis.

3.4.4 Discard disposal

Although the in-pit disposal of coarse discard and slurry may prove to be a cost effective and environmentally-friendly option, there are a number of unresolved issues such as the long-term behaviour of these discards and impact on ground water systems.

3.4.5 Monitoring systems

Due to the lack of reliable and accurate flow measurements, it is not possible to properly quantify the impact of the mine on the water environment or to evaluate the beneficial effect of applied water management strategies. The level of water quality and flow monitoring within the plant water circuits can be substantially improved. Although the mine has stated a desire to increase the level of water reclamation within the plant, the lack of important water quality data such as alkalinity will hinder this process as scaling tendencies cannot then be calculated.

The mine also does not have an adequate groundwater monitoring system in place although plans have been made to address this problem. Practical problems are also experienced with the collapse of monitoring holes being drilled into the spoils. The continuous monitoring stations are also prone to damage from theft and vandalism and problems with data reliability stemming from probe damage and calibration / maintenance problems.

3.4.6 Water and Salt Balances

Although the mine collects a substantial amount of data for surface water systems which enable the production of coarse overall water and salt balances, insufficient data is available to support the development of properly detailed water and salt balances. Very little data is available for the internal plant water circuits and no useful water and salt balances can be developed.

Due to the size of the operations at Optimum and the amount of data which will need to be manipulated to provide up-to-date and useful water and salt balances, the mine will require access to computerised balance models to prevent the generation of these from becoming a full-time task.

3.4.7 Water Management Structure

Although the mine is progressive insofar as it has an environmental manager with environmental support staff, the following problems with the existing water management structure can be identified:

- pollution control, sampling, potable water, sewage and plant water responsibilities are split and not co-ordinated at an appropriate level
- the environmental manager reports to production management personnel rather than to the General Manager and conflicts of interest may arise where environmental management considerations become secondary
- the mine does not have resident groundwater expertise

4. GENERAL IMPRESSIONS

The general impression gained from the site visit is that the mine accords a high priority to environmental and water management and is determined not to repeat past mistakes which have led to the situation where the mine currently has significant impacts on the surface water systems. The personnel at the mine were generally very well informed and technically competent in addressing the issues at hand and were very helpful in providing the required information. By and large, despite having serious existing pollution problems (particularly the Optimus sponge) this mine stands out as one which has and is implementing strategies to address these problems and prevent future problems. It is again clear that the advent of the EMPR process has been instrumental in improving water management at the mine.

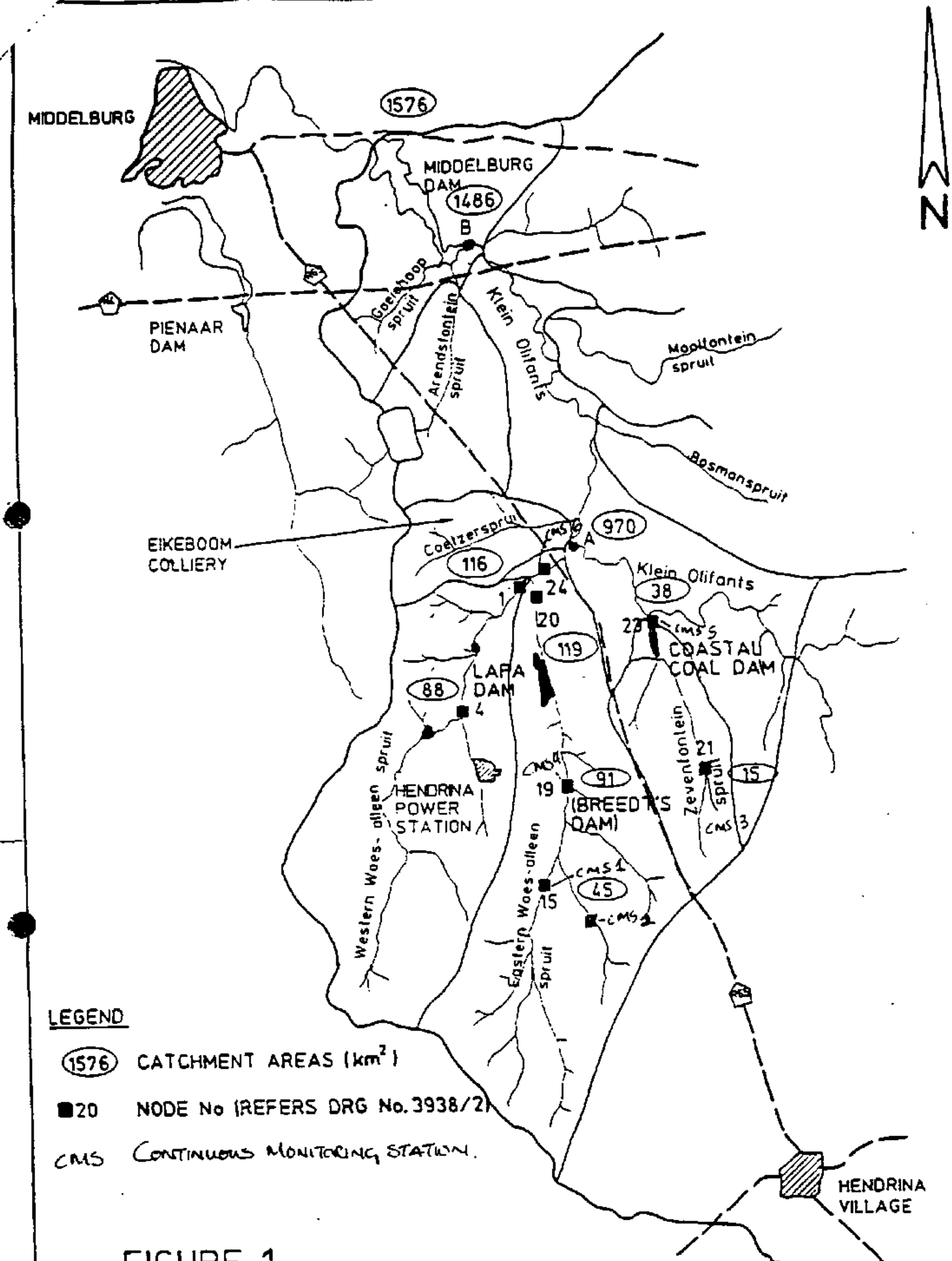
Appendix A - List of pH and conductivity readings taken during the site visit.

Due to a problem with the instruments, no pH and conductivity readings were taken during the site visit.

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:

Photograph No	Description
1	View of oil/grease trap at main Workshop
2	Close-up of oil trap belt removing oil
3	Dirty water collection dam below workshop
4	Dam on rehab spoils
5	Fruit planting trial on rehab
6	Ponding on rehabbed. Groot Rietpan area
7	Return water from slurry pond
8	Slurry in final void
9	Weir No 6 & continuous monitoring, downstream on Woestalleen
10	Typical evap. dam for pit water
11	Haul road from ramp 3 parallel to Woestalleen spruit
12	Water bowser at main evap. dam
13	Zeventontein haul road - seep to Zeventontein spruit
14	Dirty stormwater collection dam. Zevenfontein left, spillway at end
15	Water bowser wetting haul road
16	Final effluent from sewage plant to Breedts Dam
17	Sewage treatment plant
18	Stormwater drain from bypass plant area, adjacent to sewage plant



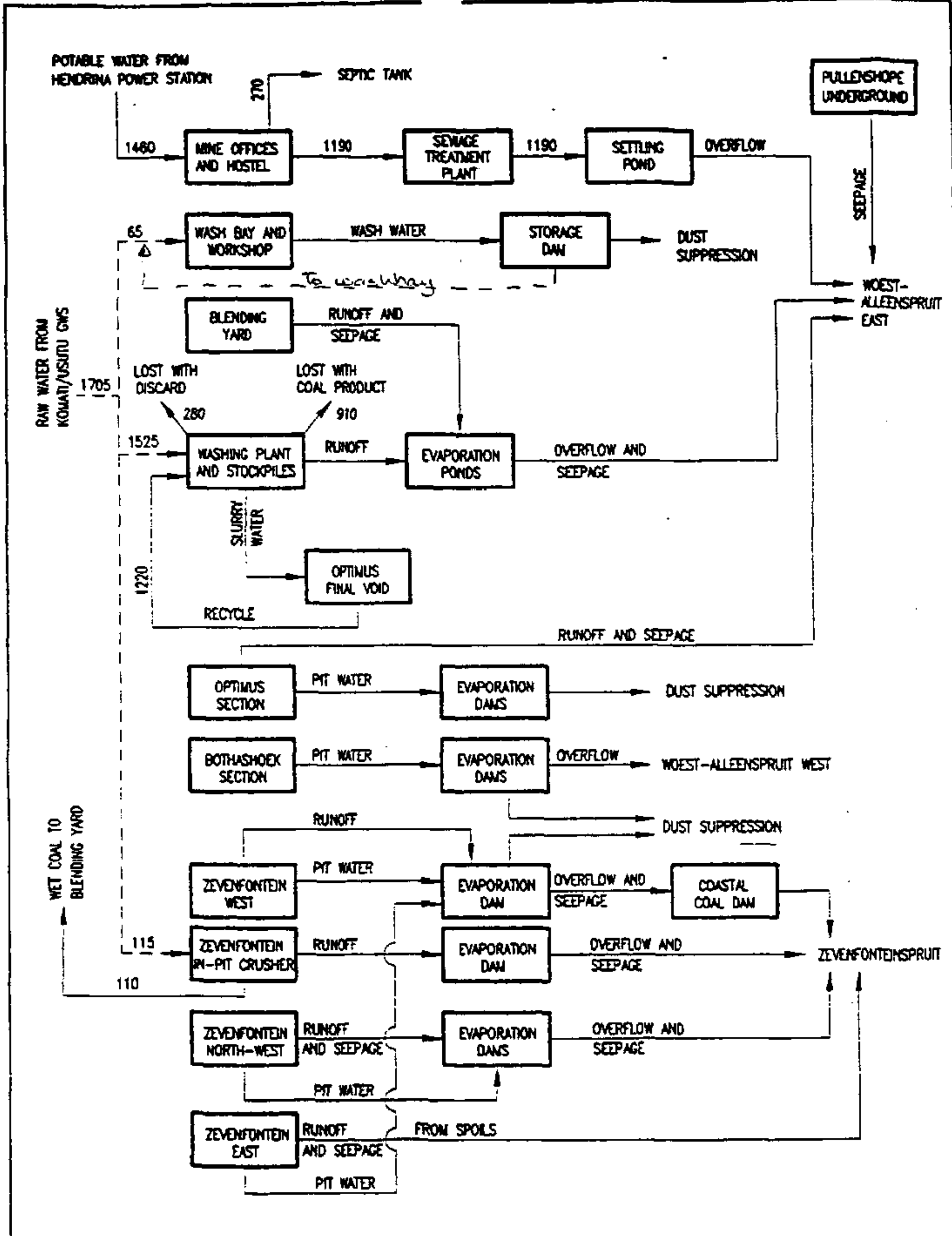
LEGEND

(1576) CATCHMENT AREAS (km^2)

■20 NODE No (REFERS DRG No. 3938/2)

CMS CONTINUOUS MONITORING STATION.

FIGURE 1
CATCHMENTS & DRAINAGE PATHS



LEGEND

115	AVERAGE FLOWS IN m3/DAY
– – –	UNAFFECTED WATER
———	WATER AFFECTED BY MINING

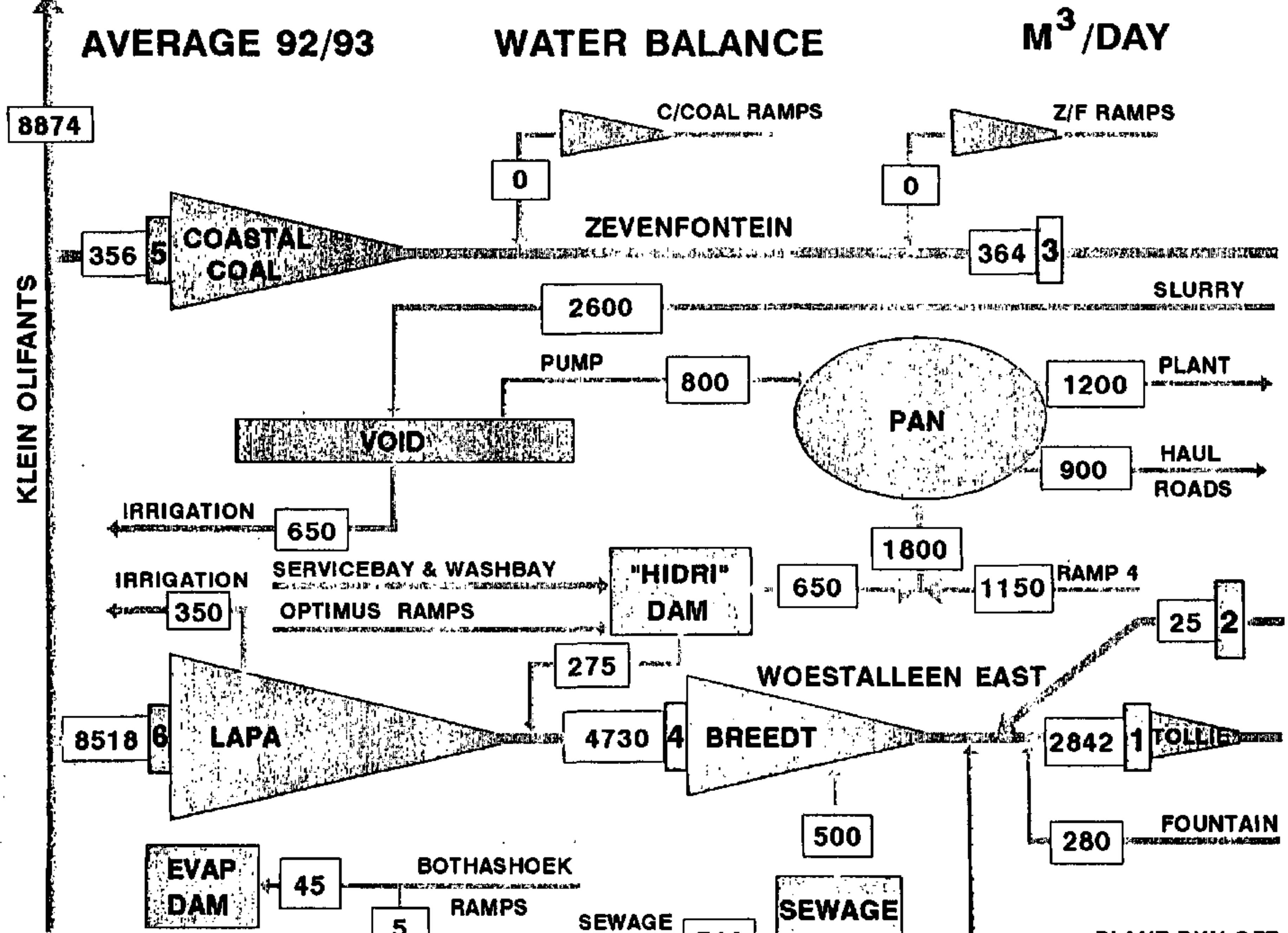
FIGURE 2

JONES & WAGENER
CONSULTING CIVIL ENGINEERS
RIVONIA TEL (011) 803-1455

OPTIMUM COLLIERY
SIMPLIFIED WATER SYSTEM DIAGRAM

Figure 3

OPTIMUM COLLIERY



Report on Tavistock Collieries Site Visit

7 - 8 October 1993

1. GENERAL INFORMATION

Name of mine	Tavistock Collieries Limited
Name of person(s) interviewed	Piet Wessels Mark Surmon
Position of person(s) interviewed	P Wessels - Chief Ventilation Officer M Surmon - Env. Superintendent
Nearest town	Witbank
Name of catchment	Olifants river, Steenkoolspruit
Daily coal throughput (rom)	10.5 Mta
Daily saleable product	Confidential
Daily discard production	ATC - 73 000 t/m, ATCOM - 115 000 t/m Phoenix - 42 000 t/m, Tavistock - 8 000 t/m South Witbank - 17 000t/m
Main product and market	ATC & ATCOM - Export Others - inland market
Current age of mine	ATCOM - ca. 2 years, others - older
Expected remaining life of mine	ATC - 18 yrs, ATCOM - 22 yrs Phoenix - 17 yrs, Tavistock - 61 yrs South Witbank - 36 yrs
Type of mining carried out	Open cast and underground
Transport mode from mine to plant	Conveyors
Has the mine already produced an EMPR	Final EMPR document submitted

2. SITE VISIT PROGRAMME

2.1 Day 1 - 7 October 1993

- Arrival
- Short discussion of project background and objectives
- Present at meeting:

L. McEwan	-JCI Head Office
M.Surmon	-Environmental Supt.
P.Wessels	-Chief Ventilation Officer
W. Pulles	-PHD

L. de Lange -PHD

- Guided tour of the mine

2.2 Day 2 - 8 October 1993

- Complete guided tour of the mine
- Completion of questionnaire

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

3.1 DESCRIPTION OF WATER CIRCUITS

A plan of the mine showing all the sampling points was supplied by the mine and is attached as Figure 1. In addition, a summary water balance for the mine's water reticulation system, was provided and is attached as Figure 2.

The mine has separate potable water and process/industrial water systems. Potable water is provided in containers for use by the underground workforce.

Although the visit is recorded as a visit to a single mine, Tavistock Collieries comprises of the following five mines:

- Arthur Taylor Colliery (ATC)
- Arthur Taylor Colliery Open cast Mine (ATCOM)
- Phoenix Colliery
- Tavistock Colliery
- South Witbank Colliery

As a result of the physical size of these mines it was impossible to visit and assess all the water related aspects within the two days. The guided tour of the mine took 1.5 days to complete, excluding any visits to plant-related water treatment and management systems.

3.2 DESCRIPTION OF WATER TREATMENT/MANAGEMENT SYSTEMS

3.2.1 Sewage treatment plants.

The general impression formed about the sewage treatment plants, are that they are well maintained with good housekeeping. As far as could be determined superficially, all equipment was kept in a state of good repair.

There are four activated sludge plants and one trickling filter unit at the various sites. The sewage plants appear to operate well, although analytical results show that the final clarifiers are not as effective as they could be

Effluents are discharged to the surface water systems except for one instance at the South Witbank Coal Mine plant where the sewage effluent is discharged to the Dixon underground dam.

3.2.2 Potable water treatment plant.

The potable water treatment plant usually treats water from the Olifants river. Under certain conditions, for example when the Olifants river salinity is too high, water is extracted from Phoenix dam. At the time of the site visit, the Olifants river had a high TDS and was not used for potable water abstraction. The treatment applied is flocculation, settling, filtration and disinfection. A certain volume of water is softened by a cation removal plant for use as loco boiler feed water.

The plant is well maintained and as far as could be visually determined, all process equipment was functioning properly. It was noted that the plant was highly automated and designed for easy sampling of water to monitor plant efficiencies.

3.2.3 Settling dams and evaporation dams

Due to time constraints, it was not possible to physically visit all the settling and evaporation dams at the various locations and only the three settling/evaporation dams at ATCOM ramp 1 were visited. It was noted that a number of the settling dams are in fact being used as evaporation dams, i.e. no settled water is recovered from the dams and all the water is allowed to evaporate.

3.2.4 Underground circuits

The main application for water underground is dust suppression. No treatment is applied to this water. The water is not sampled for analysis and no quality information is available for the service water. The underground water circuits are essentially operated in a closed loop manner with a high rate of recirculation.

3.2.5 Plant water circuits

The plant receives water from underground and this water is used in the plant without any form of treatment. The water is neither sampled nor analysed. Although it has not been formally investigated, no complaints were received about excessive corrosion or any other problems related to water quality.

3.2.6 Discard dumps

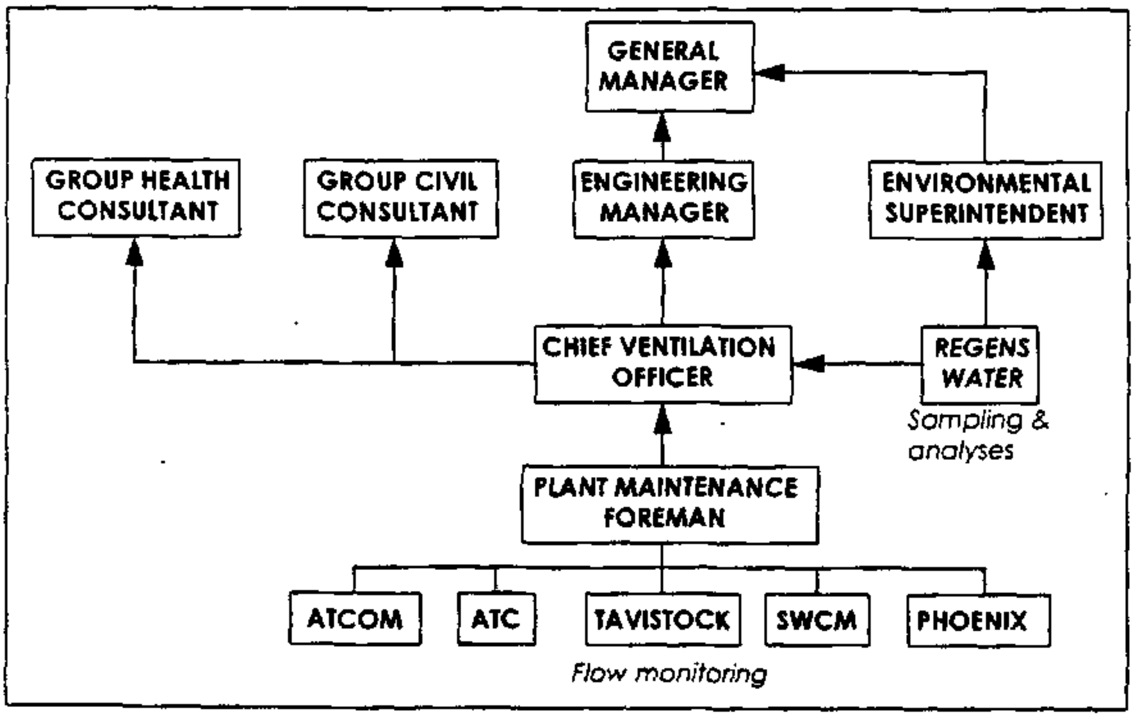
Problems are experienced at some of the dumps with separation of clean and dirty water. The Phoenix Beath dump produces extremely acidic and saline seepage which is captured in an evaporation dam. The dam wall leaks and the highly saline seepage could, with sufficient rainfall, be washed down into the Steenkoolspruit.

3.2.7 Water monitoring systems

The mine has an extensive and comprehensive ground water and surface water quality monitoring programme, with the ground water component still being expanded. The samples are subjected to a reasonably detailed analysis schedule. Additional samples are taken at less regular intervals and analysed in more detail. Unfortunately, as no flow monitoring is undertaken, the monitoring programme is not complete and it is not possible to calculate or manage the salt loads being generated at the various sources.

3.2.8 Water management structure

The following diagram, representing the water management structure with the various departments and personnel involved, was supplied by the mine.



The Environmental Superintendent has responsibility for the environmental aspects of water management and effluent discharge, while the Chief Ventilation Officer has responsibility for water supply and sewage treatment. Both these people co-ordinate their functions and communicate on a regular basis.

3.3 NOVEL OR UNIQUE WATER TREATMENT AND MANAGEMENT SYSTEMS

3.3.1 Water quality management structure / personnel

The day-to-day management of water quality, supply, treatment and disposal of effluents is carried out by suitably qualified persons who exhibit a high degree of understanding of the fundamental issues involved. The Environmental Superintendent also has a direct reporting line to the General Manager. These factors indicate that water quality and environmental management are accorded a high priority at the mine.

3.3.2 Potable water treatment plant

The potable water treatment plant is automated and appears to perform well. A number of convenient sampling/monitoring points are provided. Flocculants and operating procedures are modified according to changes in raw water supply, indicating that the process dynamics of potable water treatment are well understood.

3.3.3 Potable water balance

The mine maintains a detailed computerised record of consumption of all potable water users. This means that potable water use and distribution can be actively managed.

3.3.4 Seepage through spoils

The mine intends undertaking a full scale test to determine the impacts of establishing a permanent river diversion over rehabilitated spoils. This test will include extensive ground water monitoring and, presumably, river flow rates. The outcome of such a test would be of interest to the coal mining industry as a whole.

3.4 POTENTIAL WATER TREATMENT/MANAGEMENT PROBLEMS AND NEEDS

As a result of the discussions and site visits, a number of issues were identified where knowledge gaps still exist.

3.4.1 Measurement of flow

The need to quantify the volume of water leaving the property was identified as an important aspect of the water management system that needs attention. The importance of addressing this need, and its relevance with regard to waste load allocation, is fully recognised by the mine. A detailed knowledge of the volumes of water leaving the mine is a fundamental requirement for calculating the salt load discharged by the mine.

Mine water and salt balances should be seen as the most fundamental and dynamic management tools available. Without flow information (including sub-catchment hydrology) this basic tool will remain unavailable and the mine will not be able to manage its allocated waste load.

This knowledge will also assist the mine in estimating the contribution from neighbouring mines in instances where a certain stream leaves the mine boundaries at a certain point, flows through the property of an adjacent mine, and re-enters the mine again at another point.

3.4.2 Sulphate and fluoride removal

The effective treatment / management of sulphates, and in some instances fluoride, in the effluent streams, was identified by mine personnel as one of the more important medium term challenges facing the mine.

3.4.3 Wetlands

During the discussions it was noted that wetlands are perceived as being almost a cure-all for the treatment of effluents. The use of wetlands was mentioned in terms of problems with sulphate, sodium and fluoride - non of which can presently be effectively removed by wetlands. This perception of wetlands as a solution to most effluent problems appears to be fairly widespread within the industry and is considered worrisome. The danger exists that wetlands and other passive treatment systems will be incorrectly applied with the inherent potential for later backlash against such treatment systems.

3.4.4 Separation of clean and dirty water systems

A number of sites were pointed out by the mine personnel where they are considering options to separate clean and dirty water systems. The management of diffuse pollution sources, such as waste coal on haul roads, discard used for road construction, etc. requires attention. It would appear that the mine is aware of this and is planning to implement management strategies at the more obvious problem sites.

In the proposed management strategies, the mine has defined "clean" water as that which does not exceed the old General Effluent Standards. This definition is considered too lax, as surface runoff which just complies with the General Effluent Standard could still result in a major pollution load to the surface water systems and could, in certain instances, account for the bulk of the mine's waste load allocation.

3.4.5 Final river diversion

The impacts of the final placement of the river diversion over rehabilitated spoils is an area that requires substantial research. The mine is currently planning such research which would benefit the industry as a whole.

3.4.6 Regional water management co-ordination

As is the case with other mines, no formal co-ordination of water supply and pollution issues occurs. Although the mine has some idea as to how it could be impacted on by the activities of upstream water users and how it could impact on downstream users, no formal forum exists for discussing these issues. The mine pointed out that although initial and informal contact was made with some of the neighbouring mines in this regard and that the initial response was positive, at present, no formal co-ordination takes place.

3.4.7 Prediction and management of surface water quality impacts

The mine has a fairly detailed water balance with regard to piped potable and process water. However, substantially less information is available with regard to the surface water and groundwater systems. In order to properly predict and manage the water quality impacts, a total mine water balance must be developed which takes account of ground water systems, catchment hydrology and diffuse water pollution sources.

For example, the volume **and** quality of surface runoff water that will reach the surface water systems during and after mining operations, the probable decant points and quality of ground water entering the surface streams, cannot be predicted with the current level of information.

Access to a reliable total mine water and salt balance will enable the mine to predict the beneficial impacts of proper separation of clean and dirty water and residual impacts after closure. This would facilitate cost comparison and benefit studies of various water management strategies.

3.4.8 Ground water systems

With the possible exception of ATCOM, insufficient information exists to understand the geohydrology and its impacts on the mine and the mine's impacts on the ground water systems. For example, although groundwater levels in the affected areas may be restored within 35 years of closure, it would appear that there is insufficient information to predict the occurrence and position of seep zones / springs, the quality and volume of the seep, and the regional impact thereof on ground and surface water systems.

3.4.9 Water management on dumps

The relative merits of retaining rainwater on top of discard dumps rather than shedding the water as soon as possible is unknown. The whole question of a water and salt balance around a discard dump is an issue which requires further investigation. This could be viewed as an industry-wide issue to be resolved.

3.4.10 Wetting of haul roads

The long-term impacts of using saline water for haul road wetting are not understood. This practice essentially converts a point source salt load into a diffuse one and the significance of the impacts of such an action require further investigation. Again this is a widespread practice within the coal mining industry.

4. GENERAL IMPRESSIONS

4.1 ROLE OF THE EMPR

From the discussions, it was concluded that the EMPR is a major factor that has guided the mine in identifying and addressing its water management issues.

4.2 WATER QUALITY DATA REPORTED TO THE MINE

The mine's water quality data appears to be fairly comprehensive with the exception of some heavy metals. The reported data is complete enough to enable the mine to evaluate water reclamation strategies should the need arise. This is in contrast to some other mines where important water quality determinants, for example alkalinity, are often omitted.

4.3 INFORMATION SYSTEMS

The personnel responsible for water management on the mine, do receive information and journals specifically related to water issues which will assist them in their jobs. The Group Head Office appears to be fairly instrumental in providing relevant technical information. The mine personnel were, however, not aware of the relatively large amount of potentially useful information on prior research that is available from the Water Research Commission free of charge.

4.4 OPENNESS ABOUT WATER AND ENVIRONMENTAL MANAGEMENT ISSUES

The mine and the personnel interviewed were very open and willing to provide all the required information with regard to their water management and treatment systems.

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. The following is a list of the readings taken:

No	Description	pH	Cond.
1	South Witbank Coal Mine dam	8.2	250
2	Rainwater on dam wall	8.2	23
3	SWCM railway line runoff	9.3	134
4	South Witbank Plant runoff - sampling point 26	8.1	193
5	SWCM sewage drain hole to Dixon u/g dam	7.8	
6	Treated sewage at SWCM sewage treatment plant	7.9	126
7	Water upstream of Tavistock dam	7.9	38
8	Over flow from maturation pond at Tavistock STP	7.1	120
9	Tavistock dam	7.9	95
10	Leakage from Tavistock dam	7.9	95
11	Under ground water pumped to Tavistock coal prep plant	7.7	220
12	Raw water from Phoenix dam to Tavistock PWTP	7.8	118
13	Purified water at Tavistock PWTP	8.2	117
14	"Suez canal" - monitoring point 11	8.4	58
15	Confluence of u/g water and ATC stream	5.8	152
16	ATC stream - upstream of monitoring pt 11		119
17	Gillfillan stream		109
18	Zaaiwaterspruit upstream of dump		104
19	Overflow from Phoenix dam before confluence with Zaaiwater spruit		134
20	Zaaiwater spruit downstream of Phoenix North Dump		100
21	Olifants river - pump station - Monitoring pt. 6	7.4	115
22	Phoenix Beath pond		674
23	Dam below Phoenix Beath pond - seepage water		1100
24	Steenkool spruit downstream of ATCOM		44
25	Water from Albion mine flowing into Steenkoolspruit upstream of ATCOM		400
26	Continuous monitoring pt in Steenkool spruit upstream of ATCOM - monitoring pt 25	7.4	39
27	Kromfontein dam		62
28	Settling / evaporation dams - ATCOM - sampling pt 20	8.3	113
29	Gillfillan spruit upstream of Zaaiwater - monitoring pt		133
30	Product of spoils seepage experiment	7.5	366

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:

Photograph No	Description
1	South Witbank Coal Mine dam
2	South Witbank Plant runoff - sampling point 26
3	South Witbank discard dump
4	SWCM sewage drain hole to Dixon u/g dam
5	Aerators at SWCM sewage treatment plant
6	Maturation pond at Tavistock sewage treatment plant
7	Chlorine contactor - Tavistock sewage treatment plant
8	Pump station to plant - downstream of Tavistock dam
9,10	Tavistock dam
11	Automatic filter at Tavistock water purification plant
12	Settler and filter at Tavistock water purification plant
13	Sample take off points at settler - Tavistock water purification plant
14	Water softening plant - Tavistock water purification plant
15	"Suez canal" - monitoring point 11
16	Effluent stream leaving mine property - Monitoring point 10
17	"Suez canal" next to AT stockpile
18	Glenfillan stream
19	Zaaiwaterspruit upstream of dump
20	Overflow from Phoenix dam before confluence with Zaaiwater spruit
21	Biofilter plant - towards dump
22	Zaaiwater spruit downstream of Phoenix North Dump
23	Olifants river - pump station - Monitoring pt. 6
24	Phoenix Beath pond
25	Dam below Phoenix Beath pond - seepage water
26 - 29	Steenkool spruit downstream of ATCOM
30	Water from Albion mine flowing into Steenkoolspruit upstream of ATCOM
31	Continuous monitoring pt in Steenkool spruit upstream of ATCOM - monitoring pt 25
32	River diversion at ATCOM showing the 90 degree deflection
33	Settling / evaporation dams - ATCOM - sampling pt 20

1993/09/24

DVD/WH/TAVGRP

TAVISTOCK COLLIERIES LIMITED

GROUP PLAN

E M P R

SURFACE WATER MONITORING

NOT TO SCALE

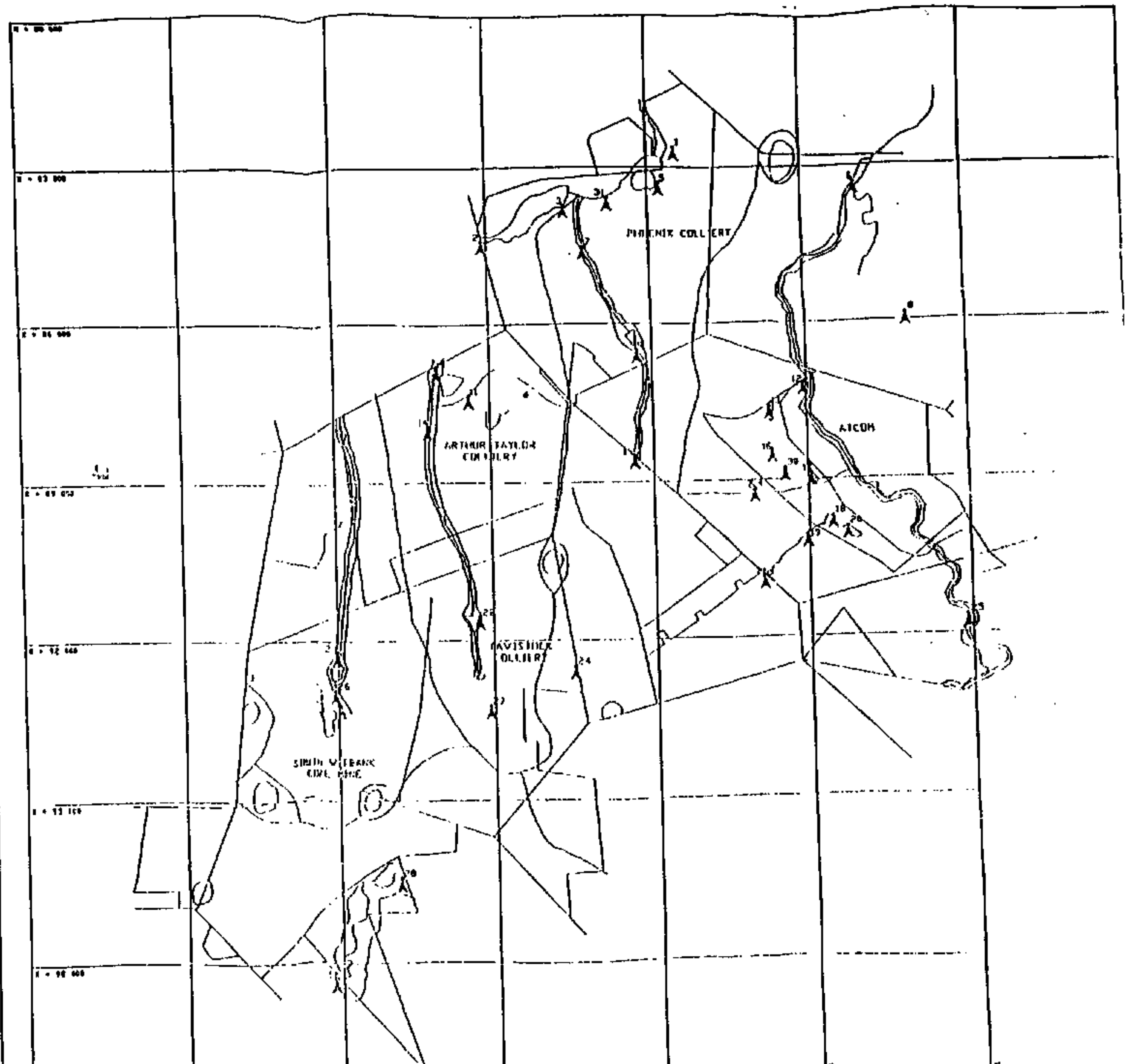
SURVEY SYSTEM :

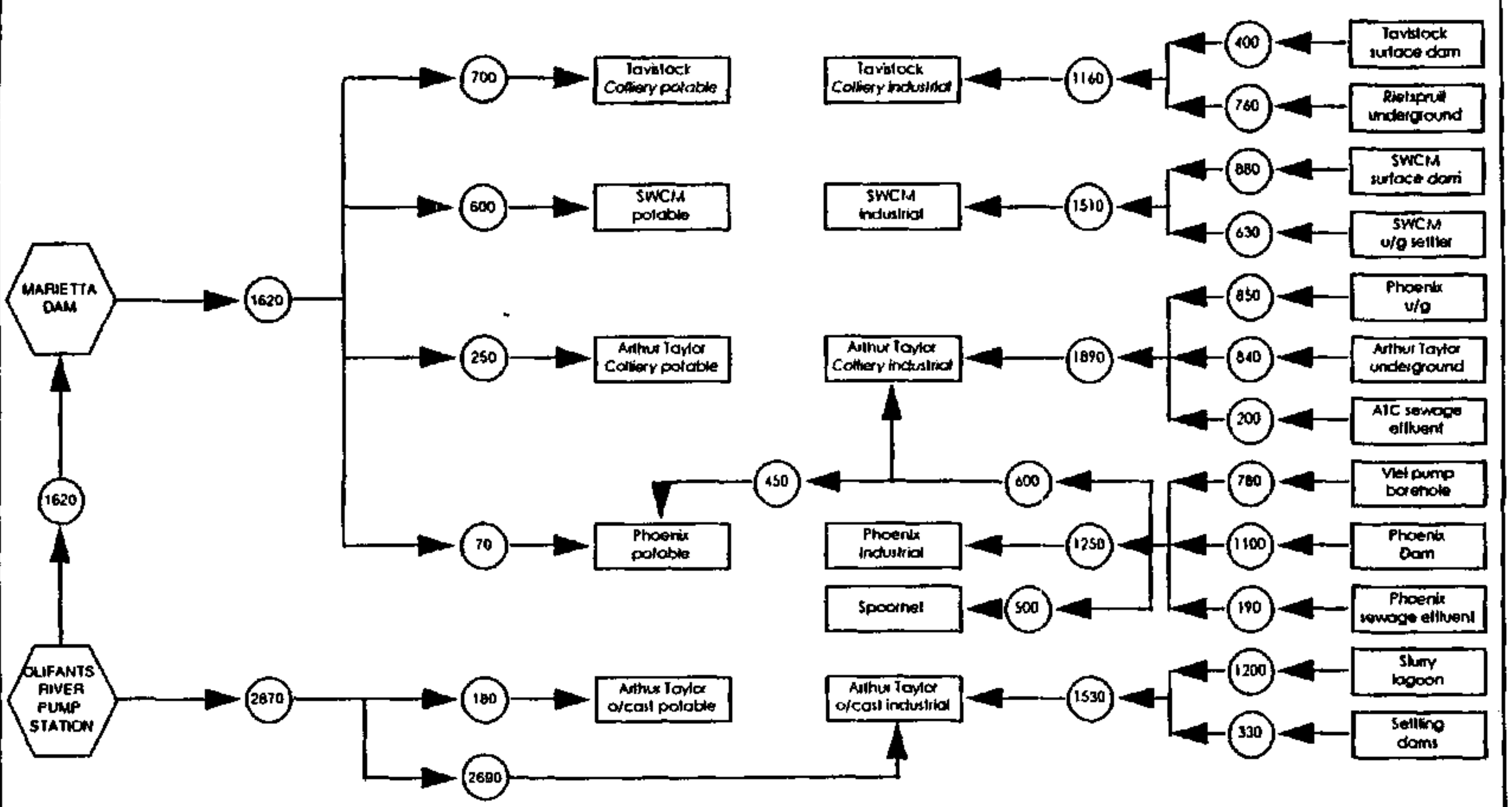
GAUSS CONFORM PROJECTION
CENTRAL MERIDIAN LO 29 EAST

CONSTANTS :

LEGEND :

MINE BOUNDARY
FARM BOUNDARY
WATER SAMPLE POINTS
FLOODLINE (50 YEAR)
CATCHMENT & SUBCATCHMENT BOUNDARIES
WATERCOURSES
STREAMS
RIVERS
DAMS
PANS
SETTLING DAMS
DUMPS





NOTE : Measured and estimated daily flow volumes in m3 indicated inside circles

FIGURE 2

TAVISTOCK COLLIERIES OVERALL GROUP WATER BALANCE DIAGRAM

Report on site visit to Tweefontein Colliery and Witbank Consolidated Colliery.

19 April 1994

1. GENERAL INFORMATION

Name of mine	Tweefontein Colliery & Witcons Colliery
Name of person(s) interviewed	Mr J. B. Du Plessis - Res. Eng. Mr. J. D. Du Plessis - Section Manager Mr. D Farrel - Exterior works supervisor
Nearest town	Ogies / Witbank
Name of catchment	Olifantsriver
Monthly production (ROM)	Tweefontein - 400 000 t/m Witcons - 155 000 t/m
Monthly saleable product	Tweefontein @ 300 000t/m Witcons - 110 000 t/m
Monthly discard production	Tweefontein - 100 000 t/m Witcons - 45 000 t/m
Main product and market	Export and Inland markets
Current age of mine	Tweefontein - 90 yrs Witcons - 50 yrs
Expected remaining life of mine	No specific period mentioned, but it is expected to be a lengthy period.
Type of mining carried out	Mostly underground with a small opencast area at Witcons
Transport mode from mine to plant	Conveyors
Has the mine already produced an EMPR	In process of developing EMPR

2. SITE VISIT PROGRAMME

2.1 25 April 1994

- Arrival
- Brief discussion of project objectives
- Short overview of mining activities
- Guided tour of the mine
- Completion of questionnaire

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

3.1 DESCRIPTION OF WATER CIRCUITS

The mine is still in the process of completing an EMPR and this is done largely by outside consultants. As a result, the personnel interviewed were reluctant to give information on various aspects for fear of the information given being outdated and/or inaccurate. This was primarily the reason why for example, a flow diagram of the mine's water reticulation systems could not be obtained.

A map showing the major elements of the mine's surface water system was supplied by the mine. The sole purpose of the diagram is to indicate the positions of the various surface water monitoring points. Although it does not contain detailed information, it does give some indication of the main components of the surface water system. This map is attached as Figure 1.

The mining activities are mostly underground and the impact on surface water systems is mostly the result of discard dumps situated in the area, water decanting from underground, and possibly runoff from the plant areas etc. Large volumes of water is situated in the underground areas.

The mine has separate potable and industrial water circuits. Potable water for the underground workforce is provided in containers.

3.2 DESCRIPTION OF WATER TREATMENT/MANAGEMENT SYSTEMS

3.2.1 Sewage treatment plants.

There are two sewage treatment plants - one serving Tweefontein and the other at Witcons. Details regarding flowrates and capacities could not be obtained at the time as this information was still in the possession of the consultants responsible for the drafting of the EMPR.

The overflow from the sewage treatment plants is used in the industrial water circuits and no effluent is discharged to public streams.

3.2.2 Potable water treatment plant.

Potable water is obtained from a natural spring and the water needs to be disinfected only. During winter, it is often necessary to augment the supplies with water from the Tweefontein dam. Water from the Tweefontein dam requires additional treatment. The pH is adjusted with lime, followed by flocculation, settling, filtration, softening and disinfection before use as potable water.

The pH, chlorine concentration and total dissolved solids concentration of the water is monitored daily. A more comprehensive analysis of the water is performed once every two months.

3.2.3 Settling/evaporation dams

There are a number of dams in the area functioning as settling and pollution control dams. Some of the dams are situated around the dumps as well as the coal preparation plant and stockpile areas. The water captured in these dams is reused in various applications and the rest is left to evaporate.

One of the major dams in the mining area is the Tweefontein dam. According to the personnel interviewed, the dam receives mostly natural runoff. However, the high conductivity of the water as measured in the dam, as well as inspection of water quality data, suggests contamination from other sources. The source of pollution could not be identified at the time, but it was mentioned that the consultants responsible for the EMPR are investigating the situation and will identify the sources of pollution as part of the study.

3.2.4 Liming plant

Water pumped from underground is treated in a liming plant. Water treated in the liming plant is reused in the various mining activities.

3.2.5 Plant water circuits

Although most of the water used in the coal processing plant is recirculated water, it is not considered to be a cause of problems such as corrosion etc. Flow meters are installed to determine the amount of make-up water used in the plant. The volume of make-up water is approximately 51 m^3/h while the total amount of water in circulation in the coal processing plant is in the order of 125 m^3/h. Slurry from the coal washing process is pumped underground via a borehole.

3.2.6 Underground water circuits

There are substantial volumes of water in the underground workings. Due to the age of the mine there is a lack of information regarding the old worked out areas, which makes it extremely difficult to obtain an accurate estimate the volume of water in the underground compartments.

As far as water for underground mining activities are concerned, enough water is available to supply all the users. Water is used in a closed loop manner and is used mainly for dust suppression. The water is not treated in any manner. No flowrates are measured underground as it is not considered to be important.

3.2.7 Discard dumps

There are a number of old disused discard dumps situated in the mining area. Some of these dumps are situated partly in or very close to streambeds. The old dumps are not rehabilitated and no water management measures other than pollution control / retaining walls around the dumps are presently in place.

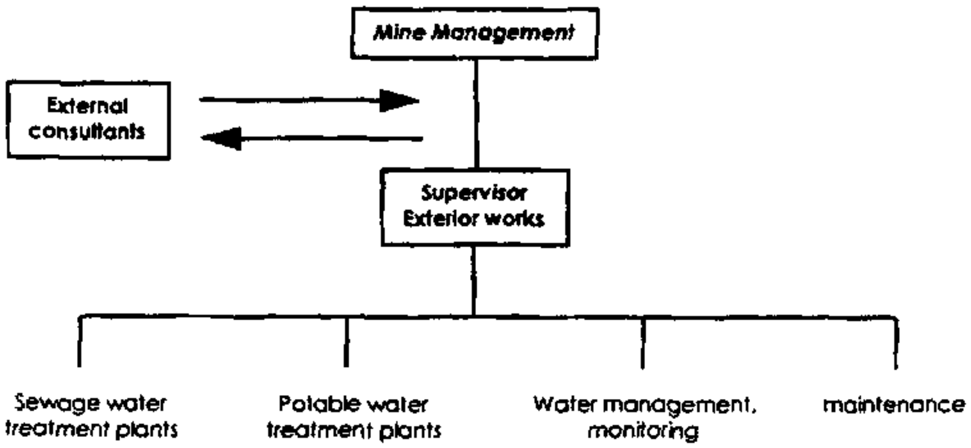
3.2.8 Water monitoring systems

The water monitoring programme of the mine is still in the development phase. The mine is fairly reliant on external consultants for implementation and scheduling of their water monitoring system. Most of the important points for monitoring surface water have been identified and are being monitored. The water quality data reported to the mine is adequate in terms of the parameters included in the analyses.

Information with regard to flow rates of various water streams, i.e. natural streams, those due to various mining activities, as well as water decanting and seeping from the old workings, is limited. As the flow monitoring programme is not complete, the water monitoring programme cannot be regarded as complete and it is not possible to calculate or manage the salt loads being generated.

3.2.9 Water management structure

The following diagram, representing the water management structure was supplied by the mine.



3.3 NOVEL OR UNIQUE WATER TREATMENT AND MANAGEMENT SYSTEMS

During the discussions with the mine personnel, it was concluded that there are no systems or practices on the mine that can be regarded as unique or novel.

3.4 POTENTIAL WATER TREATMENT/MANAGEMENT PROBLEMS AND NEEDS

As a result of the discussions and site visits, a number of issues were identified where knowledge gaps still exist.

3.4.1 Existing and potential sources of pollution

During the site visit, it was observed that a number of the old discard dumps are situated very close to and even partly in existing water courses. Although measures for retaining runoff is in place, it is still considered to be a source of pollution. The effectiveness of retaining walls, if such a structure is already in the stream path, is doubtful. The potential for pollution due to subsurface transfer of polluted water should also be investigated. Boreholes could play an important role in monitoring the existence and dynamics of potential pollution plumes under these dumps.

Although the mine seems to be getting a handle on their point sources of effluents, there still appears to be some uncertainty with regard to diffuse sources of pollution.

3.4.2 Flow measurement

The measurement of flow is an important aspect of any monitoring programme. Development of methods to measure or estimate the volumes of water transported in the mining environment, especially the volumes seeping from various areas or flowing into and out of the underground workings, will be of significant value to the mine.

During the discussions, it was mentioned that the salt loads generated as a result of mining activities cannot presently be predicted or calculated. A detailed knowledge of the quantities of water flowing to and from the mine, is a fundamental requirement for calculating the salt load discharged by the mine. The importance of addressing this need when evaluated in the light of a future waste load allocation, is recognised by the mine. Without this basic knowledge, it will be impossible for the mine to formulate strategies to comply with a future waste load allocated to the mine.

3.4.3 Groundwater monitoring

At the time of the site visit, the ground water monitoring programme has not started yet. This aspect of the monitoring programme will be implemented as soon as the recommendations from the external consultants responsible for it's development become available.

3.4.4 Presence of fluoride

The presence of a stream with a high fluoride concentration in the Witcons area was mentioned as a cause for concern since the water cannot be used as a potable water supply. The source of the fluoride is unknown and to date, no investigation has been launched in order to identify the origin of this element.

3.4.5 Use of water quality data

The water quality data reported to the mine appears to be reasonably comprehensive. The water quality data is inspected and then filed without further manipulation. The data is adequate for further manipulation and it could for example, be statistically manipulated to provide valuable information such as trends etc. which in turn can be used as a predictive tool or a mechanism that gives early warning of developing problems.

3.4.6 Water management functions and reliance on external consultants

The water management structure on the mine as shown in a previous diagram, appears to be rather simplistic when all the aspects to be dealt with in a detailed water management system are considered. At first it was believed that certain functions were omitted but the personnel interviewed were satisfied that the diagram as shown, is complete.

A proper, effective and scientifically accountable water management system has many different aspects such as the development of a definitive water model for the mine, ongoing validation of model parameters, running and calibrating hydrological models, predicting post closure scenarios, implementing and evaluating different rehabilitation and remedial strategies, interpreting and evaluating water quality data, effective implementation and management of ground and surface water monitoring programmes, normal production related water scheduling and supply, maintenance of equipment, etc. to name a few. This normally calls for the involvement of a number of specialists from various disciplines.

It is therefore difficult to see how a single person can deal with all these matters as is suggested by the diagram. More than one conclusion could be drawn from this observation. On the one hand it may indicate an unawareness with regard to the components of an extensive water management programme while on the other, it may indicate an over reliance on external consultants to provide inputs.

This situation is encountered on other mines as well. It could largely be the result of the fact that mining has traditionally focused on issues related to the production and selling of coal and water management was seen in a fairly narrow sense meaning largely the supply and disposal of water. As was also observed by the mining personnel during the visit "it does not sell coal". This results in the situation where a number of people are taking responsibility for issues which they are not fully familiar with. In addition, some water management functions calling for specialised knowledge or skills, are more than often beyond their current level of training, or it is not their primary area of expertise, nor in many cases their primary area of responsibility. It is therefore not surprising that there are certain aspects of an extensive water management system that a mine is not aware of, or unaware of it's importance.

It was observed that the mine is very reliant on the results of studies by external consultants. Although this in itself is not a problem, it may be a problem if the mine does not have the expertise on the mine who could evaluate the results of these studies in the context of the mine's needs, priorities and circumstances.

4. GENERAL IMPRESSIONS

4.1 ROLE OF THE EMPR

The EMPR could be an important element in the process of identifying problems and focusing the efforts of the personnel in systematically identifying and addressing the water and environmental problems. It may introduce new elements in the field of water management or change the perceptions with regard to certain aspects that were previously considered not to be of importance.

4.2 OPENNESS ABOUT WATER AND ENVIRONMENTAL MANAGEMENT ISSUES

The impression was gained that the personnel interviewed were not fully at ease with the objectives of the site visit. For example, when asked to list the major water related problems on the mine, the answer was that the mine does not really have water problems of note. Although this might be true, it is highly unlikely that a mine the size of Tweefontein and Witcons will be without problems for which the answers are less obvious.

Information were not readily available as most of the information required is still with the consultants preparing the EMPR. The personnel interviewed however, were quite prepared to discuss all the issues of which they had knowledge but seemed to be careful not to preempt the findings and recommendations of the EMPR.

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. The following is a list of the readings taken:

No	Description	pH	Cond.
1	Waterpan vlei area above Waterpan plant	7.5	123
2	Water in Waterpan reservoir	7.3	280
3	Liming plant - treated water	6.6	250
4	Waterpanspruit beneath Waterpan dump	7.3	155
5	Water flowing into Tweefontein dam	7.3	187
6	Tweefontein dam	7.4	175
7	Tweefonteinspruit	7.5	184
8	Water at V-notch in spruit from Tavistock	7.7	138
9	Klippoortjie/WCCM spruit at railway line	7.6	143
10	Klippoortjie/WCCM spruit at V-notch beneath hostel	7.6	144
11	Storage dams at WCCM plant	7.8	167

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:

Photograph No	Description
1 -3	Waterpan vlei - view of plant and old dump
4	Waterpan plant - collecting point for effluent and runoff in plant area
5	Waterpan plant reservoir
6	Waterpan liming plant
7,8	View from new dump at Waterpan towards boreholes & evap dams
9	View towards Waterpan dump from Minnaar/Coalville road
10	Stream flowing towards Tweefontein dam - view away from dam
11	Stream flowing towards Tweefontein dam - view towards dam
12	Tweefontein dam
13	Sewage treatment works
14	No 2 dump - view from tarred road
15	Witcons open cast area
16	V-notch in spruit entering from Tavistock
17	Klippoortjie spruit at Witcons
18	Old WCCM 4-seam dump
19	Water decanting from underground
20	Retaining wall for pollution control around WCCM plant area
21	Storage dams for industrial water at WCCM plant
22	Slurry pumped underground

Report on Douglas Colliery - Vandyksdrift Section Site Visit.

14 December 1993

1. GENERAL INFORMATION

Name of mine	Douglas Colliery - Vandyksdrift Section
Name of person(s) interviewed	Mr. W Grove - Man. Env. Services Mr. G Trussler - Randcoal HO Mr. D Hattingh - Snr. Env. asst. Mr. D Oliver - Chief Surveyor (o/c) Mr. G Venter - Chief Surveyor (u/g)
Nearest town	Witbank
Name of catchment	Olifants river and Steenkoolspruit
Monthly production (ROM)	Douglas complex - LAC - 330 000 t/m .... PSS - 430 000 t/m Van Dyksdrift - 300 000 t/m (u/g) .... 50 000 t/m (o/c)
Monthly saleable product	LAC - 210 000 t/m PSS - 280 000 t/m
Monthly discard production	18 000 t/m from LAC plant 25 000 t/m from PSS plant
Main product and market	LAC - *Export* PSS - 80 000 local, 200 000 export
Current age of mine	46 yrs
Expected remaining life of mine	20 - 30 yrs
Type of mining carried out	Underground (b&p), mini pit opencast
Transport mode from mine to plant	Conveyors from u/g trucks from open pit
Has the mine already produced an EMPR	To be completed

2. SITE VISIT PROGRAMME

2.1 Day 1 - 14 December 1993

- Arrival
- Short discussion on site visit objectives
- Short overview of mining activities
- Guided tour of the mine
- Completion of questionnaire

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

3.1 DESCRIPTION OF WATER CIRCUITS

Vandyksdrift Section of Douglas Colliery Limited is located on the northern bank of the Olifants river, downstream of the confluence with the Koringspruit and upstream of the confluence with the Steenkoolspruit.

A detailed water balance or diagrammatic representation thereof with accurate information is not yet available. A report from external consultants dated August 1992, contains a diagram which shows the major features of the mine's water circuits. The information with regard to flowrates etc. was discussed, and the conclusion was drawn that some uncertainty with regard to flowrates and volumes of water used, still exists.

The mine operates a potable water as well as a sewage treatment plant. The available underground storage capacity, is an important component of the mine's water management strategy as water for different uses such as raw water and recycled water is stored in different compartments. This ability to store water underground is to the mine's advantage in times of drought when limited amounts of water can be abstracted from the river.

Flowrates are measured at only two sites by means of a V-notch weir. Readings are taken monthly and no continuous monitoring of flow is done.

3.2 DESCRIPTION OF WATER TREATMENT/MANAGEMENT SYSTEMS

3.2.1 Sewage treatment plants

The sewage treatment plant consists of two identical activated sludge units linked in series. Both units operate on the Pasveer ditch principle. According to a diagram supplied by the mine, the plant treats approximately 1900 m^3/d. The effluent is used in the PSS plant.

The quality of the effluent is determined monthly and no flow measurement is done.

3.2.2 Potable water treatment plant.

The potable water treatment plant is fed from an underground storage compartment. Raw intake water is dosed with PACl as coagulant and lime for pH adjustment. Clarification takes place in a floc blanket clarifier. Settled water is stored in an intermediate storage tank from where it is pumped through three pressure sand filters. Water is disinfected with chlorine after sand filtration and the water is stored in elevated tanks for distribution.

The plant is designed to treat 2700 m^3/d and under normal circumstances approximately 2235 m^3/d is treated.

3.2.3 Surface water systems

One of the more important characteristics of Vandyksdrift Section of Douglas Colliery Limited is the fact that it is located on the northern bank of the Olifants river, downstream of the confluence with the Koringspruit and upstream of the confluence with the Steenkoolspruit.

A series of wetlands was constructed in the Springbok spruit as part of the rehabilitation of old opencast areas that were situated in the spruit. The wetlands are a combination of shallow and deep ponds with the aim of creating aerobic and anaerobic sections in the wetland.

The wetland receives a very poor quality water from the Springbok area of the neighboring Goedehoop mine. In addition, a sewage transfer station is situated close to the inflow to the wetland and sewage is frequently spilled into the system.

A series of storm water drains and pollution control dams, together with the favorable contours of the area below the dumps and coal preparation plants, makes it possible to discharge the contaminated runoff at a single point into the underground storage facilities for reuse in the coal preparation plants.

Backwash water from the water treatment plant is discharged into the veld below the water treatment plant. The water eventually finds it way into the underground storage facility via the system described above for the runoff from the discard dumps.

A minipit is situated right on the banks of the Olifants river and at the time of the site visit, the pit was flooded. An error led to the situation where the minipit was situated in a position where water from the Olifants river could enter the pit. The impact that flooding of the pit has on the quality of the water in the Olifants cannot be quantified.

3.2.4 Evaporation dams

Although evaporation takes place as a natural process at all the surface reservoirs, they are operated without the intention of evaporating excess water. All pollution control dams are fitted with pumps and water is reused in the coal preparation plants.

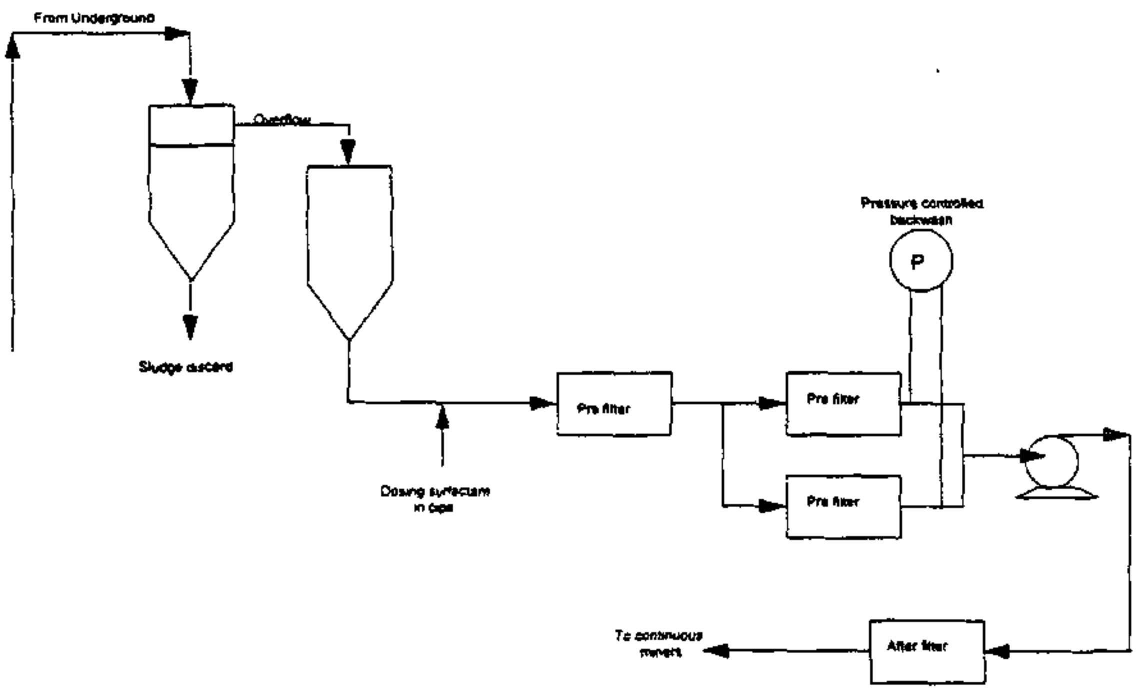
3.2.5 Clear water or return water dams

The return water dams are located close to the treatment plants. They receive water from a number of sources of which the underground storage facility is the most notable. Sewage effluent is returned to the return water dam at the PSS plant.

3.2.6 Underground operations.

Water is used in the underground sections mainly for dust suppression. The water is used in a closed circuit manner with spent water gravitating to the lowest point in the section, where it is allowed to settle unaided and water is returned to the point of use.

The exception is where continuous miners are employed as they cannot tolerate a high suspended solids concentration in the water. The spray nozzles used with the continuous miners have very fine apertures and treatment to remove suspended solids from the water is required. The following diagram shows the steps included in the treatment applied to underground water that is returned for use with the continuous miners.



Unfortunately no flowrates are measured and the amount of water used in the different applications is unknown.

3.2.7 Plant water circuits

The mine operates two plants, the power station smalls (PSS) plant and the low ash coal (LAC) plant. The plants are the major users of water on the mine. The plants are treating the combined ROM from the whole Douglas Colliery complex of which Vandyksdrift is one section. According to estimates done for the mine by external consultants, the two plants have a combined water demand of approximately 6000 m³/d. During discussions, the water balance around the plants was examined and the conclusion was drawn that there is still a lot of uncertainty with regard to flowrates and volumes of water entering the plants and water volumes lost for various reasons. No flowrates are measured and this is the main reason for this uncertainty.

3.2.8 Discard dumps

There are essentially two main areas with discard dumps namely the PSS dump and the LAC dump. The main feature of the water management system around the dumps is the construction of channels and pollution control dams to retain the contaminated runoff and prevent it from reaching the Olifants river. The surface contours are such that some of the runoff can be collected and discharged into an underground storage facility at a single point. Two boreholes are situated next to each other and water is fed into an underground compartment.

The possibility of water seeping into the Olifants river via subsurface strata is deemed to be remote when considering the very shallow sandstone bed. It is the mine's opinion that the existence of a channel excavated down to the sandstone bedrock level will intercept any water seeping in the subsurface layers. Unfortunately no boreholes exist and subsequently no groundwater data is available to validate the assumption.

One of the discard dumps will be reprocessed in future and as such will significantly reduce the available sources of contamination.

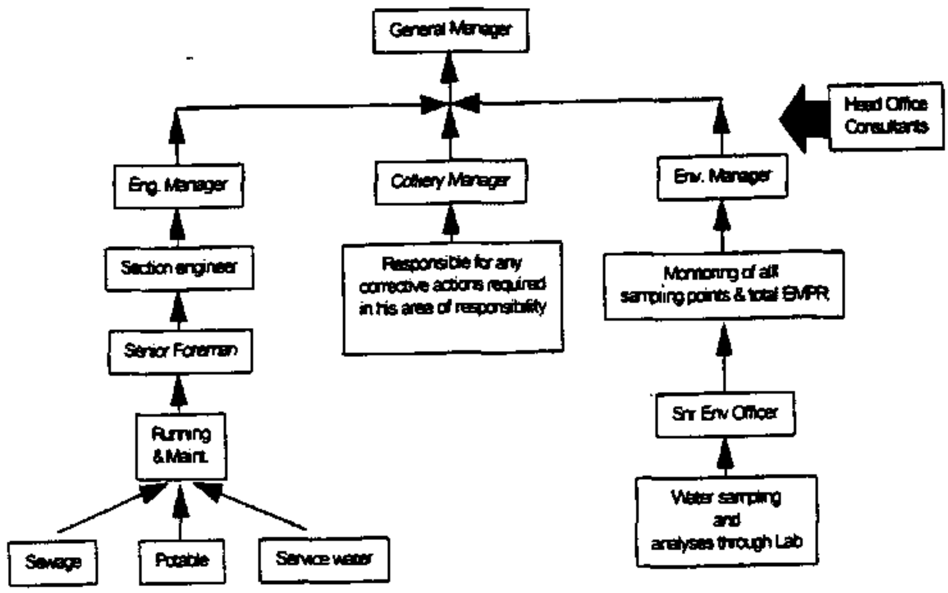
3.2.9 Water monitoring systems

At present no continuous flow measurement is done and the V-notch weirs are monitored on a monthly basis. The question of flow monitoring will be addressed in future for the purposes of completing an EMPR.

Water quality is monitored monthly at a couple of selected sites in the wetlands and the Olifants river, the potable water distributed to the various users and the treated sewage effluent.

3.2.10 Water management structure

The following diagram, representing the water management structure with the various departments and personnel involved, was supplied by the mine.



3.3 NOVEL OR UNIQUE WATER TREATMENT AND MANAGEMENT SYSTEMS

3.3.1 Management of underground water storage facilities.

The underground areas are an integral part of the water management system on the mine. The unique feature of this system is the accuracy with which water levels and volumes in the different areas or compartments are known. According to the personnel involved, these figures are accurate to within 10%.

Another unique feature is the fact that different compartments are used to store water for different purposes. The raw water for potable use is stored underground as well as the contaminated runoff from the coal preparation plants and discard dump areas. Excellent information with regard to the dimensions and location of underground compartments enable the mine to confidently store water of different qualities underground.

3.4 POTENTIAL WATER TREATMENT/MANAGEMENT PROBLEMS AND NEEDS

As a result of the discussions and site visits, a number of issues were identified where knowledge gaps still exist.

3.4.1 Monitoring systems

Accurate flow data is an essential component of a monitoring programme aimed at providing input into a water management strategy. In view of the waste load allocation policy advocated by the DWAF, it would not be possible to formulate an effective water management strategy if salt loads cannot be predicted or calculated. At present the flow monitoring programme and facilities do not support the calculation of pollution loads. Considering the practical problems with monitoring flow in the mining environment, this is considered to be a challenge for the personnel responsible for water management.

Presently the mine cannot characterise their groundwater system in terms of flow and quality characteristics. The dynamics of the groundwater systems such as flowrates into different areas through aquifers and other features, cannot be predicted or defined.

Although the data reported to the mine in terms of water quality parameters is fairly comprehensive, it may be worthwhile to consider more frequent sampling of the various monitoring stations, especially the potable water supplied to the mine. More frequent analysis of the potable water quality will enable the mine to identify health hazards in time and will aid efficient operation of the potable water treatment plant.

3.4.2 Prediction of impacts and simulation facilities

Largely through a lack of sufficient and reliable data as well as insufficient monitoring facilities, the mine cannot predict impacts, decant points and flows or qualities to be expected from certain sources or at specific points. The present monitoring system will not be sufficient to allow the mine to develop a model which can be used to integrate the results of a monitoring programme and subsequently simulate the effects of changes in the system. If such a system can be developed, it will enable the mine to define more effective management strategies and will help with prioritising remedial or preventive actions.

Although potential impacts can be qualitatively described, they cannot be defined quantitatively. Prediction of long term and post closure impacts is not possible at present.

3.4.3 Quantifying the impact of the flooded minipit on the water in the Olifants river.

The exact effects that flooding of the open pit may have on the quality of the water in the Olifants river was discussed. It is the opinion of the mine that the impact may not be significant for two main reasons. The first is the reasonable low acid potential of the coal in the area and the second is based on the quality data recorded upstream and downstream of the flooded areas.

To date no formal investigation has been launched and it may be worth the effort to launch such a formal investigation with the aim of defining and quantifying the impacts.

3.4.4 Modeling of discard dumps before and after rehabilitation.

The possibility of water seeping into the Olifants river and groundwater systems via subsurface strata is deemed to be remote when considering the existence of a very shallow sandstone bed. It is the mine's opinion that the existence of a channel excavated down to the sandstone bedrock level will intercept any water seeping in the subsurface layers. Unfortunately no boreholes exist and subsequently no groundwater data is available to validate the assumption.

At present the mine cannot define the impact of water seeping through the discard dumps on the environment. The volumes and quality of the water originating from this source cannot be quantified or estimated. The whole question of a water and salt balance around a discard dump is an issue which requires further investigation and can be considered to be an industry-wide issue.

3.4.5 Roads constructed from discard material.

A number of roads constructed from discard material, are located on the mine. Although the impact of these roads cannot be quantified, the mine is fully aware of the potential for negative environmental impacts.

3.4.6 Water quality data reported to the mine

Inspection of the laboratory results of water sample analyses, indicated that neither the alkalinity of the water, nor the carbonate speciation of the water is indicated in the results. It will be to the advantage of the mine to include alkalinity in the data reported, since it would allow the mine to perform certain calculations with the data. For example, water characteristics such as the potential for $CaCO_3$ and $CaSO_4$ scaling cannot be determined, nor can the chemical dosing requirements for neutralisation or softening be determined from this data.

3.4.7 Training of personnel responsible for water management.

One of the needs identified during the discussions was the need for short courses dealing with different aspects of mine water management.

4. GENERAL IMPRESSIONS

4.1 ROLE OF THE EMPR

It is believed that the EMPR has played a significant role in focusing attention on water management aspects.

4.2 WETLANDS TECHNOLOGY

A series of wetlands have been constructed by the mine and the mine view this as a major component of their water quality management programme. It is the mine's opinion that the wetlands have a beneficial effect on the very poor quality water it receives from the neighbouring mine. The wetlands are considered to be effective even if the benefits are limited to the enhanced evaporation effects. According to the mine it helps to prevent the highly contaminated water from reaching the Olifants river. The wetlands will only overflow into the Olifants during flood conditions.

The concept of wetlands as a long term management strategy was discussed, and although the factors that make wetlands an attractive option are recognised, the danger of regarding wetlands as the cure-all for all effluent treatment problems must be recognised. The perception of wetlands as a solution to most effluent treatment problems appears to be fairly wide spread within the industry and is considered worrisome.

4.3 LOW ACID POTENTIAL OF COAL

During the site visit, it was observed that the pH values of the water from different sources were not acidic. The only stream with a notably acidic character was the stream that enters the wetlands from a neighbouring mine.

4.4 RESPONSE TO THE SITE VISIT AND QUESTIONNAIRE

The mine was very open and responsive to all aspects of the site visit and the information required was provided wherever it was possible to do so.

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. The following is a list of the readings taken:

	Description	pH	Cond. [mS/m]
1	Pollution control dam at old rock dump	6.9	186
2	Channel between old and new PSS dumps	7.3	303
3	Water next to road between old and new PSS dumps	7.5	230
4	View towards LAC dump,plant and old PSS dump showing dirty water channel	7.7	171
5	Old slurry ponds	7.6	155
6	PSS plant tailings dam below new PSS dump (Rainwater diluted)	7.6	55
7	Weir in Olifants river - upstream of property	7.9	33
8	Wetland in Springbok spruit - Contaminated with sewage	6.7	156
9	Water over weir into wetlands	3.7	150
10	Coal preparation plant - return water dam	6.7	160

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:

Photograph No	Description
1	Potable water treatment plant
2	Pollution control dam at old rock dump
3,4	View towards Vandyksdrift weir from dump
5	Channel between old and new PSS dumps
6	Water next to road between old and new PSS dumps
7	Vlei area
8 - 10	View towards LAC dump,plant and old PSS dump showing dirty water channel
11	Old slurry ponds
12	Water below damwall of PSS plant tailings dam below new PSS dump (Rainwater diluted)
13	Weir in Olifants river - upstream of property
14	Minipit - water from river pushes into pit when river has a high level
15,16	Wetland in Springbok spruit - Contaminated with sewage
17 - 19	Sewage treatment plant
20	Coal Preparation Plant thickeners

Report on Vryheid Coronation Colliery Site Visit

4 November 1993

1. GENERAL INFORMATION

Name of mine	Vryheid Coronation Colliery
Name of person(s) interviewed	HC van Zyl
Position of person(s) interviewed	Senior Divisional Mining Engineer
Nearest town	Vryheid
Name of catchment	Nkongolwana
Monthly coal throughput (rom)	Mine closed 1993 - 90 000t /month
Monthly saleable product	70 %
Monthly discard production	20 %
Monthly slurry production	10 %
Main product and market	50 % coking coal to Iscor 50 % as coke to various customers
Current age of mine	70 years
Expected remaining life of mine	0 years
Type of mining carried out	Underground total extraction and open cast
Transport mode- mine to plant	Endless rope haulage, conveyor and road
Has the mine already produced an EMPR	Not applicable

2. SITE VISIT PROGRAMME

2.1 Day 1 - 4 November 1993

- Short discussion of project with Messrs. L Longueira and J Pressly
- Detailed site visit with Messrs. L Longueira & J Pressly

2.2 Day 2 - 8 December 1993

- Completion of questionnaire with Mr HC van Zyl

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

3.1 DESCRIPTION OF WATER CIRCUITS

This is a defunct mine which is in the process of being decommissioned for closure. The washing plant is still operational treating some of the waste material from earlier mining operations. The main activities, however, are related to decommissioning and rehabilitation. Although the mine does, therefore, not have major operational water circuits, a number of point and diffuse water pollution sources exist and the surface water circuits can be divided into different areas from this perspective, as follows:

- Old discard dumps and evaporation dams;
- West water adit;
- South water adit;
- North water adit;
- Seeps from rehabilitated open cast areas; and
- adits draining from Vrede section;

A detailed plan of the whole area was made available and a simplified plan, showing the pH and conductivity sampling points is shown in Figure 1.

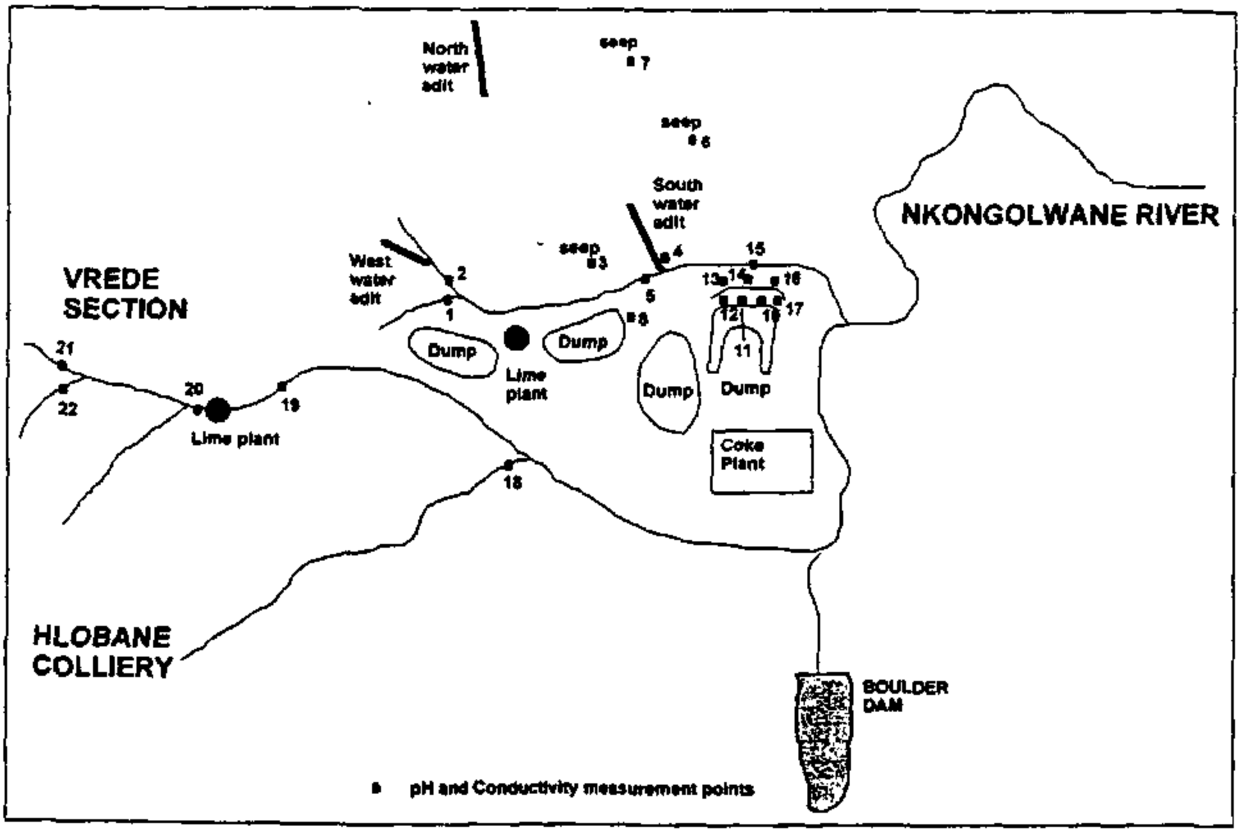


Figure 1 : Vryheid Coronation Surface Water Systems

The mine consists of two distinctly different and separate mining operations - the main VCC area and the Vrede section which is being mined by Hlobane

Colliery. The Nos. 2 and 3 dumps are being rehabilitated while the No.1 dump is being reclaimed. At the time of the site visit, the No. 4 dump was still in use.

The underground workings at Coronation have been sealed off and three water adits have been constructed. The North adit discharges to the Gamakazi River on the other side of the hill. The West and South water adits discharge into the Nkongolwana River. Again, as at Natal Anthracite, the two water adits (West and South) have very different water qualities. The West adit is acid and saline (pH 3.23, Cond. 274 mS/m) while the South adit is neutral and saline (pH 6.40, Cond. 250 mS/m). The driving forces which are responsible for these differences in water quality are not understood and the long term behaviour is also not known. A consultant is to be appointed to address these problems and predict the long term behaviour of the decanting water.

A number of the rehabilitated open cast operations have developed seep zones which drain both into the Kwa Ceba River and the Nkongolwana River. The No. 1 discard dump also has seepage at its toe, while the No. 4 discard dump discharges water and seepage into a toe dam which itself leaks badly into the adjacent Nkongolwana River.

The mining operations at the Vrede section are being undertaken by Hlobane Colliery, although the historical environmental responsibility remains with VCC. There are a number of acidic discharges from old adits in the Vrede section, with pH values as low as 3.4 and conductivities as high as 320 mS/m. The dominant flow and salt load in the Nkongolwana river at this point emanates from Hlobane Colliery with a pH of 7.7 and a conductivity of 224 mS/m, compared to the treated discharge (at a lower flowrate) from the Vrede section with a pH of 6.7 and a conductivity of 266 mS/m.

Additional features of the water systems at VCC are as follows:

- A concrete canal has been constructed to take water from the upper reaches of the Notshelwa stream (a tributary of the Nkongolwana River) around and below the No. 1 dump, into a series of dams, before the overflow, if any, mixes with the discharge from South adit.
- The mine has two lime dosing plants which dose lime at the Coronation and Vrede sections (Coronation lime plant no longer in operation).
- The Nkongolwana, Notshelwa, Kwa Ceba and Gamakazi Rivers and their tributaries have various water quality sampling points which are sampled regularly by the mine.

3.2 DESCRIPTION OF WATER TREATMENT/MANAGEMENT SYSTEMS

3.2.1 Lime dosing plants

The lime dosing plants which have been installed at VCC's Coronation and Vrede sections are sophisticated well designed and controlled plants which incorporate thickeners for removing lime sludge. These lime plants also require a fairly high degree of supervision and maintenance and are not really suitable for operation and use in the post-closure phase of the mine, where passive treatment systems would be preferred.

3.2.2 Water adits

The mine has constructed 3 water adits into the underground workings at Coronation to drain these workings as a point source effluent which can then be monitored, managed and treated. Without these water adits, the water would emanate as a series of seeps along the outcrop which would create a pollution problem which would be difficult to manage. As these mines are located in the head waters of the Nkongolwana River, there is a very high flux of water through the underground workings. The quality of water emanating from these adits varies from one to the other and over time. The reasons for this cannot be defined with certainty and the driving forces influencing the water quality are not understood. These water adits will continue to discharge in perpetuity, with a water of unknown quality.

3.2.3 Seepages

The mine has a number of seepages emanating form the following points:

- Bundu adit
- No. 1 dump
- No. 4 dump and toe dam
- German adit/open cast area
- East adit/open cast area
- Far east open cast area

Table 1 : Water quality of various discharges from VCC

SOURCE	pH -	Cond. mS/m	SO_4 mg/l	Ca mg/l	Mg mg/l	Mn mg/l	Fe mg/l	Al mg/l	Zn mg/l	B mg/l
Far East seep	3.3	400	2200	383	287	31	9.7	62	4.7	0.36
West adit	3.0	360	1700	314	138	23	49	57	3.1	0.42
No 1 dump seep	3.4	480	2600	532	232	32	13	71	3.3	0.72
No 4 dump seep	4.6	800	4100	567	401	44	287	0.8	2.0	1.13
South water adit	6.5	380	1700	491	208	12	1.3	0.4	0.5	0.42
North water adit	-	-	310	200	94	0.1	0.02	0.2	0.2	0.1

These seepages tend to have a rather poor quality as shown in Table 1 above, although their impact, in terms of load, on the receiving water systems was unknown and unquantified at the time of the visit.

3.2.4 Discard dumps

The discard dumps at VCC vary considerably. Dumps Nos. 1 and 2 were end tipped and have been burning. Dumps Nos. 3 and 4 have been constructed in compacted lifts. Dump No. 2 was about to be rehabilitated, dump No. 1 is to be reclaimed, dump No. 3 has been rehabilitated and dump No. 4 is still in operation. Dump No. 4 has a number of seeps at its toe which are collected in a toe dam. The toe dam itself leaks through at its base, with the seepage possibly extending into the adjacent Nkongolwana River, above and below the soil surface.

3.2.5 Water monitoring systems

The mine does not have any continuous water flow or quantity measurement or monitoring systems. Flow measurement from the water adits is fairly crude and with unknown accuracy. Grab samples are taken at a number of points on a monthly basis for a quality analysis. These points give a good coverage of the area affected by the VCC mining operations. The mine has a fairly comprehensive water quality database going back a number of years.

3.2.6 Water management structure

The water management structure is shown in Figure 2 below.

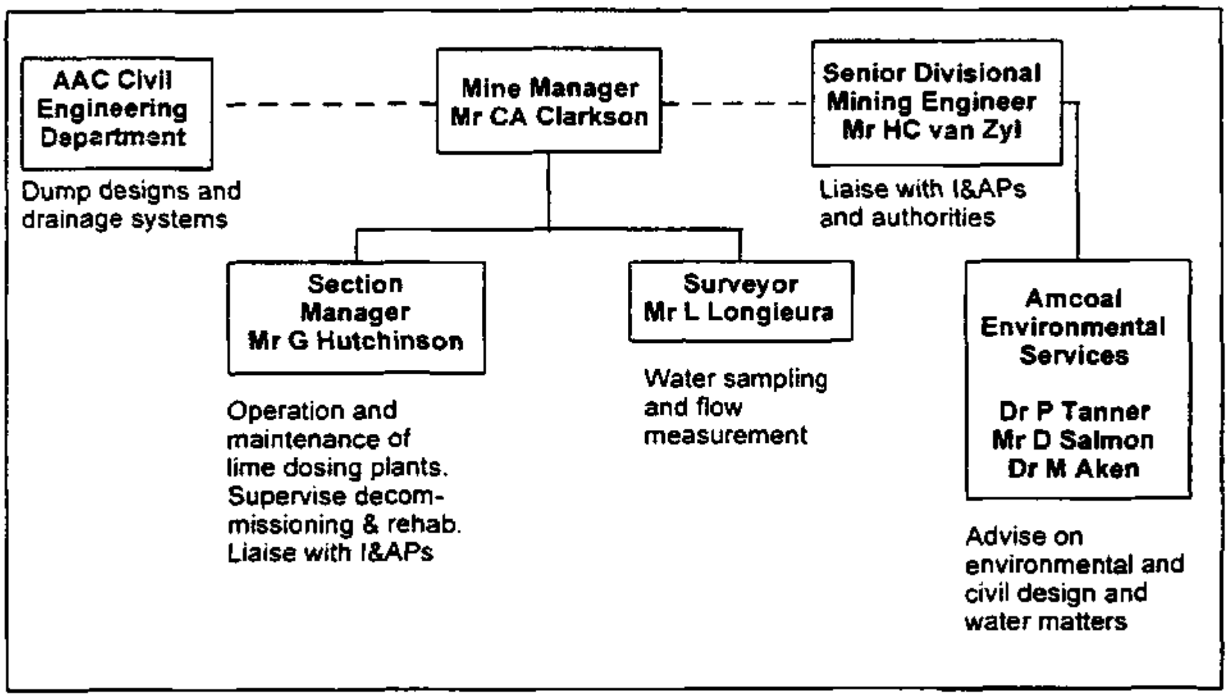


Figure 2 : Vryheid Coronation Water Management Structure

The decommissioning operations at the mine are being undertaken by suitably qualified staff who are backed up by an assortment of technical specialists as and when required.

3.3 NOVEL OR UNIQUE WATER TREATMENT AND MANAGEMENT SYSTEMS

3.3.1 Decommissioning procedure

The mine is undertaking a very thorough decommissioning operation to address all the environmental aspects of its past operations. A number of skilled staff are being employed to supervise this operation. it would appear, however, that a solution for the water pollution problems is lagging behind, with most of the other environmental issues being well addressed.

3.3.2 Regional Coordination

Although not as advanced as the Enyati River Committee, regional coordination is being undertaken to address the pollution problems in the Nkongolwana River - initiated by the Department of Water Affairs and Forestry.

3.3.3 Lime dosing plants

The lime dosing plants at VCC were designed by Anglo American and are fairly sophisticated plants when compared with those found elsewhere in the mining industry. The fact that automated control systems are being used, together with clarifiers for lime sludge removal is fairly unique within the South African mining industry.

3.4 POTENTIAL WATER TREATMENT/MANAGEMENT PROBLEMS AND NEEDS

As a result of the discussions and site visits, a number of issues were identified where knowledge gaps still exist.

3.4.1 Management of diffuse pollution sources

The mine has a number of diffuse pollution sources, in the form of seeps, as shown in Table 1 above. The reclamation of the No. 1 dump will address seepage problems from this area, although the extent to which the soil below the dump is contaminated, and its long term pollution potential, is unknown. These seepages are characterised by low pH values and high heavy metal contents and will need to be addressed in the decommissioning and post-closure phases. It is also interesting to note that the discharges from the Bundu and West adits are heavily infested with algae.

3.4.2 Management and treatment of point source discharges

The water adits at VCC can be expected to discharge contaminated water in perpetuity, although it is probable that at some unknown time in the future, the quality of the water will start to improve as the exposed pyrites become exhausted. In order to deal with these discharges, the mine requires a sustainable, low maintenance passive water treatment system, primarily capable of removing sulphates and increasing the pH.

3.4.3 Overall water and salt balance

Although the mine is presently in the process of final decommissioning, it does not have an overall mine-wide water and salt balance which pinpoints and quantifies the different sources of pollution - both diffuse and point sources. The discussion presented in Section 3.2.3 highlights some of the unquantified sources of pollution. The water and salt balance remains the most powerful tool available to the mine to manage its water systems and impacts and should be used.

3.4.4 Stormwater management

The existing systems at VCC do not enable runoff from contaminated areas such as the dumps and seepage areas to be separated effectively from clean runoff. Although a concrete canal has been constructed to divert the Notshelwa River around No. 1 dump, the upstream catchment allows free mixing of clean and dirty water. The dams below No. 1 dump.are also full and have no capacity to retain any significant runoff from their polluted catchment area.

3.4.5 Monitoring systems

Due to the lack of reliable and accurate flow measurements, it is not possible to properly quantify the impact of the mine on the water environment or to evaluate the beneficial effect of applied water management strategies.

3.4.6 Surface subsidence

The hillside above the total extraction underground workings have slumped badly in a number of places, allowing free access to oxygen and water to drive the pyrite oxidation process in the underground workings which feed the water adits. This can be expected to result in an increased salt load which will be discharged by the mine to the water environment.

4. GENERAL IMPRESSIONS

The general impression gained from the site visit is that the mine has significant impacts on the surface water systems. Although these impacts are well understood and are being addressed, the lack of a salt balance for the whole mine makes it impossible to say for certain that the mine is addressing all the issues adequately. The decommissioning procedure being followed by VCC is very thorough and is being driven by well qualified people.

The mine and its staff appear to be dedicated to achieving a successful mine closure which addresses all the major impacts - this is evidenced by the numerous technical studies which have and are being undertaken.

Long term passive treatment solutions will need to be found to address the pollution from the various seeps and water adits which can be expected to continue after mine closure.

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. The following is a list of the readings taken:

No	Description	pH	Cond.
1	West Adit (C10)	3.23	274
2	Seepage from u/g (C12)	3.07	218
3	German adit o/cast drainage	3.25	166
4	Main Coronation water adit	6.40	250
5	Main stream including seep. sewage at adit act.	3.31	181
6	Seep from u/g workings east adit o/c area	3.27	226
7	Seep for far far east o/c	3.24	273
8	Seep from toe of No 1 VCC dump	3.33	340
9	Dam below No 1 dump	3.60	178
10	Drainage from No 4 dump	6.10	588 - 620
11	Drainage from No 4 dump	3.60	615
12	Drainage from No 4 dump	3.17	720
13	Seepage through No 4 dump toe dam	3.2	472
14	Seepage through No 4 dump toe dam into river	3.1	522
15	River below No 4 dump toe drain	3.86	199
16	Seepage through No 4 dump toe dam	3.08	510
17	Drainage into No 4 dump toe drain	3.36	377
18	River from Hlobane mine under Cliffdale Rd.	7.70	224
19	Nkongolwana River (VSB) leaving Vrede property	6.69	266
20	Water before Vrede lime plant	3.41	319
21	Seepage from Vrede west	3.5	164
22	Seepage from Vrede west	4.6	185

All conductivity measurements are in mS/m