

EXECUTIVE SUMMARY

1. INTRODUCTION

In order to be able to plan research initiatives and to have benchmarks against which mine water management on coal mines could be measured, a need was identified to develop a generic water balance for the coal mining industry. When the research project was undertaken, there were sixty-five operating coal mines of various sizes in South Africa. A total of forty-one mines have been included in the database used in this investigation, which represents 66% of the total number of operating coal mines in South Africa. In terms of the run-of-mine total production, this investigation included mines that represented 88% of the total coal production in South Africa.

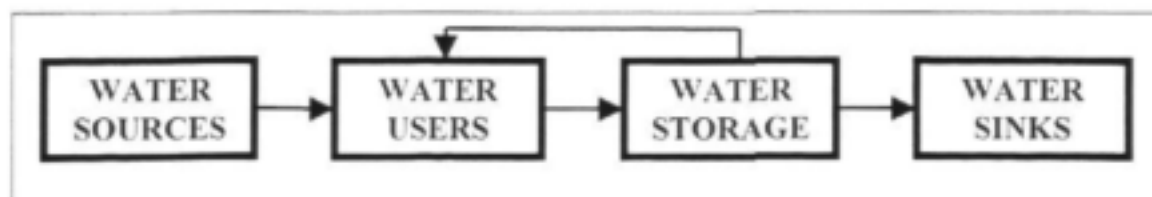
The development of an industry-wide water balance enables the mines, authorities and other role players to set some benchmarks that can be used to evaluate the water management performance of individual mines. It was also felt that the development of such an industry-wide water balance would assist in informing future research priorities.

2. RESEARCH METHODOLOGY

A generic water balance was developed for the following types of coal mining operations:

- Open cast with beneficiation plant.
- Open cast without beneficiation plant.
- Underground bord and pillar with beneficiation plant.
- Underground bord and pillar mine without beneficiation plant.
- Underground total extraction mine with beneficiation plant.
- Open cast and underground bord and pillar mining with beneficiation plants.
- Open cast and underground bord and pillar mining without beneficiation plants.

The prepared water balances have been devised to be both sufficiently generic to be of use for a wide range of mines and sufficiently detailed to show useful information. In a generic sense, the overall balance has been constructed on the basis of a 4-stage process as shown schematically below.



The various water sources that are considered are:

- Board water
- River water
- Ground water (either through boreholes or ingress into mine workings)
- Rain water
- Unspecified sources (unspecified combination of the above)

Water users that are considered in the generic balance are:

- Potable water treatment plant (treating river or ground water)
- Domestic water users (drinking and ablution water in houses, hostels, offices, plant and mine, but excluding industrial users of potable water)
- Sewage treatment plant
- Irrigation of treated sewage
- Mine workings (underground or open pit)
- Beneficiation plant
- Slurry dam
- Road wetting for dust suppression

Provision is made for intermediate storage of the following types of water:

- Potable water
- Treated sewage
- Dirty water (including water pumped from mine workings, plant process water, slurry dam return water, contaminated stormwater, etc.)

Sinks for discharged water are:

- Human consumption
- Surface water on coal product and coarse discard
- Discharge to rivers
- Evaporation
- Discharge to unspecified sinks (unspecified combination of all of the above plus ground water)

This project was severely hampered by the following:

1. Reluctance of mines to provide data, resulting in repeated requests for information.
2. Generally inadequate water balances provided by mines, requiring extensive manipulation of data by the project team and resulting in large percentages of unspecified water sources and sinks.

3. DISCUSSION OF RESULTS

The overall summary water balance for the coal mining industry (based on the survey mines) is shown in Figure I below, with a more detailed generic water balance shown in Figure II. Summary data is shown in Tables I and II. Similar water balances have been prepared for all the following categories of mining:

- Open cast mines with beneficiation plant.
- Open cast mines without beneficiation plant.
- Underground bord and pillar mines with beneficiation plant.
- Underground bord and pillar mines without beneficiation plant.
- Underground total extraction mines with beneficiation plant.
- Open cast and underground bord and pillar mines with beneficiation plants.
- Open cast and underground bord and pillar mines without beneficiation plants.
- All mines located in the Olifants River catchment.
- All mines located in the Vaal River catchment.

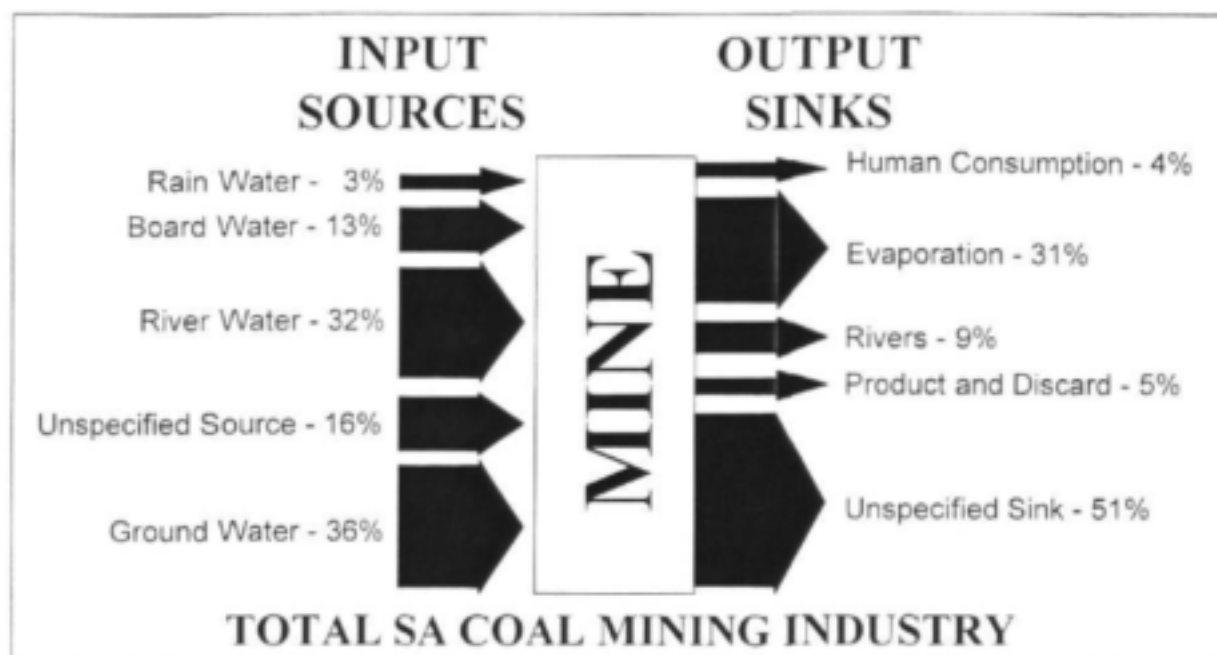


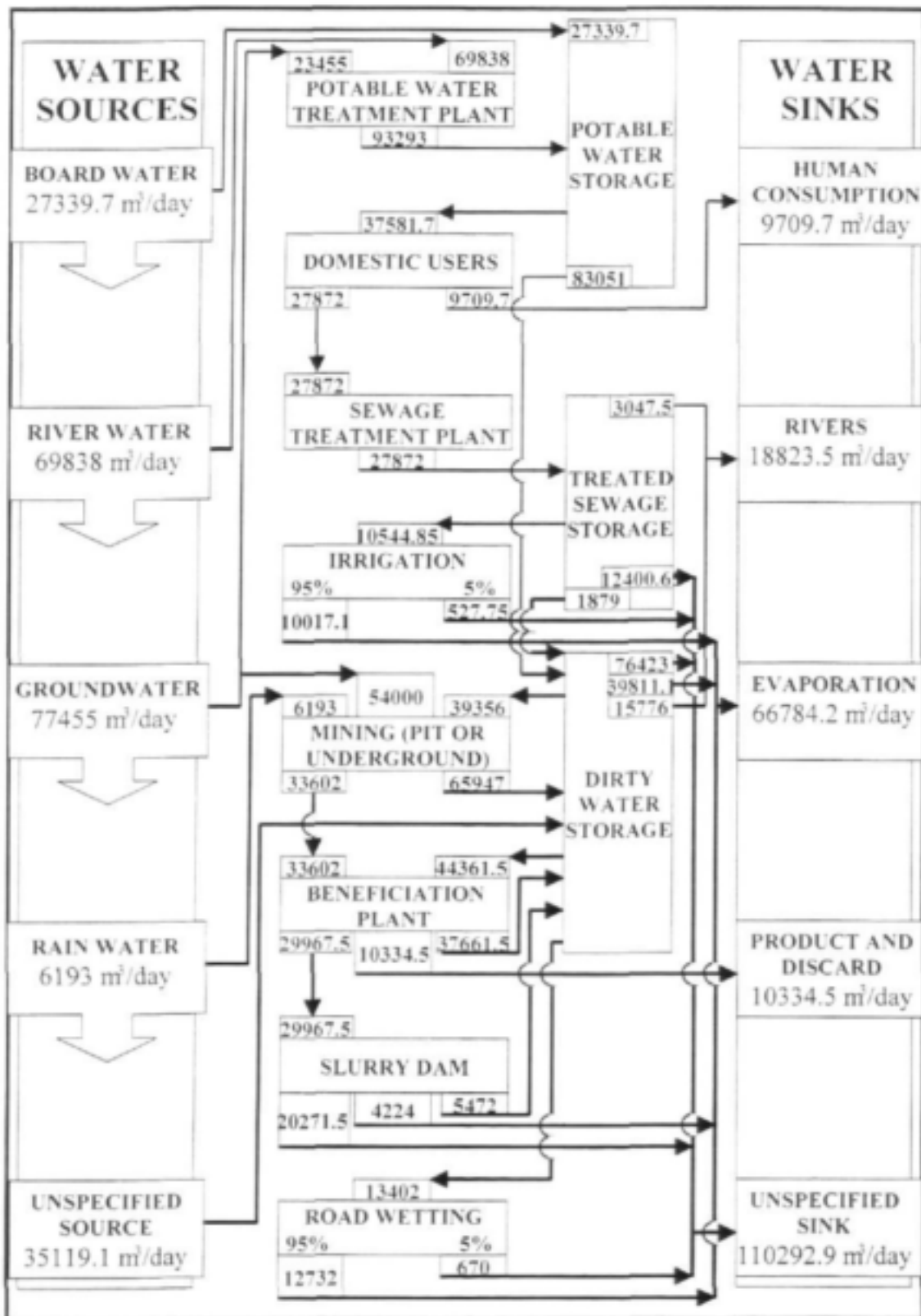
Figure I: Summary water balance for the South African coal mining industry

The overall water balance for the South African coal mining industry indicates that on average, 133 l of water is used for each ton of coal that is mined. A large percentage, approximately 85%, use underground or pit water as a water source compared to some 57% that extract board water as a water source. Volumetrically, the primary source of water came from ground water and river water, contributing 35.9% and 32.3% respectively. Board water as a primary source, contributed 12.7% of the total water source.

Beneficiation plants consumed the largest portion, *i.e.* 36.1%, of the water used by the industry, compared to mining operations that used 25% of the available water. Six percent of the total water consumed by the coal mining industry was used for road wetting. Approximately 31% of the available potable water is used for domestic purposes, with 18.8% of the latter volume of water actually being consumed.

Only ten mines, *i.e.* 25% of the total number of mines, have included seepage as a parameter in water balance calculations, creating the erroneous perception that seepage from coal mines is not a problem. This omission reflects, among others, the lack of detail contained in water balances produced by the majority of mines. In general, the water balances provided by the mines suffer from a lack of detail, *e.g.* 40% have not included evaporation in their water balance.

The incompleteness of water balances on South African coal mines is reflected in the large percentage, *i.e.* 51.1%, of effluent being discharged into unspecified sinks. These unspecified sinks could include loss of water that is difficult to quantify, such as ground water, but could also indicate a lack of good water balance information for each individual mine. In general, water is lost in the following manners: human consumption – 4.5%; rivers – 8.7%; evaporation – 30.9%; and water lost as moisture with the coal and discard material – 4.8%.



All values in m³/day

Figure II: Overall generic water balance for the South African coal mining industry

Table I: Summary of water sources data for all survey mines

Stream	Opencast with beneficiation plant	Opencast without beneficiation plant	Underground bord&pillar with beneficiation plant	Underground bord&pillar without beneficiation plant	Total extraction with beneficiation plant	Opencast and bord&pillar with beneficiation plant	Opencast and bord&pillar without beneficiation plant	TOTAL SURVEY MINES
Coal production (t/d)	159056	1168333	130650	6167	833	137693	26052	1628784
No of mines	8	2	13	3	1	11	3	41
BOARD WATER								
Volume (m ³)	2537	1205	18336	0	0	3576	1686	27340
% of budget	4	8	25	0	0	7	48	13
Specific usage (l/t)	15.95	1.03	140.34	0	0	25.97	64.72	16.79
RAIN WATER								
Volume (m ³)	2106	1377	0	0	0	2710	0	6193
% of budget	3	9	0	0	0	6	0	3
Specific usage (l/t)	13.24	1.18	0	0	0	19.68	0	3.80
RIVER WATER								
Volume (m ³)	18824	10822	15427	90	3500	20673	502	69838
% of budget	31	68	21	10	31	42	14	32
Specific usage (l/t)	118.35	9.26	118.08	14.59	4201.68	150.14	19.27	42.88
GROUND WATER								
Volume (m ³)	26726	2442	30004	828	1300	15914	241	77455
% of budget	45	15	40	88	11	33	7	36
Specific usage (l/t)	168.03	2.09	229.65	134.26	1560.60	115.58	9.25	47.55
UNSPECIFIED SOURCES								
Volume (m ³)	10495	0	10838	25	6540	6146	1075	35119
% of budget	17	0	14	2	58	12	31	16
Specific usage (l/t)	65.98	0	82.95	4.05	7851.14	44.64	41.26	21.56
TOTAL WATER SOURCES								
Volume (m ³)	60688	15846	74605	943	11340	49019	3504	215945
% of budget	100	100	100	100	100	100	100	100
Specific usage (l/t)	381.55	13.56	571.03	152.91	13613.45	356.00	134.50	132.58

An evaluation of the different components of the water balance is presented in the following sections of this chapter. The data shown in Tables I and II clearly indicate that there are two categories of mine that deviate substantially from the average values. The 2 mines classed as opencast without a beneficiation plant account for a large percentage (71.7%) of the overall coal production but exhibit an extremely low water usage based on supplied data. On the other hand, the single total extraction mine with a beneficiation plant has a very small coal production but an extremely high water usage. If the data for these three mines are excluded then the average data for all the survey mines changes substantially as shown below:

- Average specific board water usage changes from 16.79 l/t to 56.86 l/t
- Average specific rain water usage changes from 3.80 l/t to 10.48 l/t
- Average specific river water usage changes from 42.88 l/t to 120.79 l/t
- Average specific ground water usage changes from 47.55 l/t to 160.38 l/t
- Average water usage from unspecified sources changes from 21.56 l/t to 62.18 l/t
- Average human consumption of water changes from 5.96 l/t to 18.94 l/t
- Average water discharge to river changes from 11.56 l/t to 40.96 l/t
- Average water loss to product and discard moisture changes from 6.34 l/t to 22.48 l/t

- Average evaporative water loss changes from 41.00 l/t to 144.76 l/t
- Average water discharge to unspecified sinks changes from 67.71 l/t to 183.56 l/t
- Average total water usage changes from 132.58 l/t to 410.69 l/t

Table II: Summary of water sinks data for all survey mines

Stream	Opencast with beneficiation plant	Opencast without beneficiation plant	Underground bord&pillar with beneficiation plant	Underground bord&pillar without beneficiation plant	Total extraction with beneficiation plant	Opencast and bord&pillar with beneficiation plant	Opencast and bord&pillar without beneficiation plant	TOTAL SURVEY MINES
Coal production (t/d)	159056	1168333	130650	6167	833	137693	26052	1628784
No of mines	8	2	13	3	1	11	3	41
HUMAN CONSUMPTION								
Volume (m ³)	1005	132	5081	29	875	2297	291	9710
% of budget	2	1	7	3	8	5	8	4
Specific usage (l/t)	6.32	0.11	38.89	4.70	1050.42	16.68	11.17	5.96
DISCHARGE TO RIVERS								
Volume (m ³)	1101	0	6193	61	0	11468	0	18824
% of budget	2	0	8	6	0	23	0	9
Specific usage (l/t)	6.92	0	47.40	9.89	0	83.29	0	11.56
PRODUCT & DISCARD MOISTURE								
Volume (m ³)	6005	0	2219	0	4	2111	0	10334
% of budget	10	0	3	0	0	4	0	5
Specific usage (l/t)	37.75	0	16.98	0	4.81	15.33	0	6.34
EVAPORATION								
Volume (m ³)	36200	153	15295	815	95	11611	2615	66784
% of budget	59	1	21	87	1	24	75	31
Specific usage (l/t)	227.59	0.13	117.07	132.16	114.05	84.33	100.38	41.00
DISCHARGE TO UNSPECIFIED SINKS								
Volume (m ³)	16377	15561	45817	38	10366	21532	598	110293
% of budget	27	98	61	4	91	44	17	51
Specific usage (l/t)	102.96	13.32	350.69	6.16	12444.18	156.38	22.95	67.71
TOTAL SINKS								
Volume (m ³)	60688	15846	74605	943	11340	49019	3504	215945
% of budget	100	100	100	100	100	100	100	100
Specific usage (l/t)	381.55	13.56	571.03	152.91	13613.45	356.00	134.50	132.58

4. CONCLUSIONS AND RECOMMENDATIONS

The lack of good water balance data for the survey coal mines makes it impossible to make meaningful conclusions about water usage patterns on the coal mines. The primary conclusions that must be drawn however are the following:

1. In general terms, the state of water balances at coal mines is poor with insufficient detail being provided to enable a proper assessment of the status of water management at these mines. It must, therefore, be concluded (on the basis that one cannot manage what you cannot measure) that there is an equivalent problem with the status of water management on coal mines.

2. The primary problems with the water balances are an inadequate consideration of the effects of seepage and evaporation losses and the effect of rainwater as an input to the water balance.
3. The inadequacy of the water balances is most pronounced with regard to the losses of water from the mine water reticulation systems with 51% of all water losses being unaccounted for.
4. There are a few exceptions to the above generalisations where mines, although not perfect, have made significant effort to develop detailed water balances that are being refined and improved upon on an ongoing basis.
5. The lack of appropriate water balances is believed to be a serious hindrance to effective mine water management that needs to be addressed and remedied as a matter of priority.

No recommendations are made for further studies on water balances at coal mines although the discussion contained in this report should clearly motivate for the mines and authorities to expend considerable more effort in ensuring that proper water (and salt) balances are developed for the mines. A special need can be identified to ensure that the effects of seepage, evaporation and rainwater are included in the water balance. Upgrading of mine water balances is not a research topic and must be undertaken as an operational issue by the mines themselves.

It is believed, however, that mines will benefit greatly from the ready availability of a user-friendly computerised water and salt balance model that is capable of being easily updated as and when mine water reticulation systems change.