SELECTION OF MINE WATER TREATMENT TECHNOLOGIES FOR THE EMALAHLENI (WITBANK) WATER RECLAMATION PROJECT

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ABSTRACT

Coal mining has an impact on the water management of the water scarce Upper Olifants River Catchment. A pre-feasibility study was done by Anglo Coal and Ingwe Collieries Limited to establish the water supply and demand in the catchment. A geo-hydrological model was used for the coalfields to determine the stored water and excess water available. Two distinct collective and treatment systems were proposed for the Witbank and Middelburg areas to treat excess water from the Anglo Coal and Ingwe Collieries Limited. The Emalahleni Water Reclamation Project for Witbank was initiated first. Water management and treatment experience gained at Anglo Coal was the cornerstone to develop the collection, treatment and distribution system. A pre-screening selection process was used to short list the water treatment technology suppliers. A full enquiry was issued to Keyplan, Veolia, Bateman Africa and IST Technik to construct, commission, operate and maintain a 20 Ml/day desalination plant to treat acidic, saline mine waters to a SANS 0241 Class 0 potable water. The technical adjudication process was done using twelve elements for evaluation and the tenderers were ranked accordingly. A financial adjudication process was done by comparing the tenderers costs on a 20 year life cycle analysis, including waste disposal. Keyplan were selected as the preferred water treatment supply company based on the technical and financial adjudication.

1. BACKGROUND

The background of this project reflects the work done by the coal mines on water management whilst taking cognisance of the water management needs in the Upper Olifants River Catchment. As a result of water stored in underground workings sterilising coal mining reserves and the obligation to address environmental liabilities, Anglo Coal and Ingwe Collieries Limited have decided to build a 20 Ml/day desalination plant to treat excess mine water. The plant will produce potable water and pass the water onto the Emalahleni Local Municipality in a sustainable public-private partnership project. The evolution of water treatment technologies, pioneered and matured at Anglo Coal, has been key to the confidence of technology selection for the 20 Ml/day Emalahleni Water Reclamation Project.

1.1 Upper Olifants River Catchment

The Upper Olifants River catchment stretches across the places of Witbank and Middelburg, with extensive coal mining operations (both existing and historic - over the past 100 years) covering a large portion of this area. Coal mining in the catchment has a significant effect on the hydrological cycle and it is essential that the coal mine’s water management systems dovetail with the water management of the catchment.

This catchment is a water scarce area with an average of only 700 mm of rain falling on an annual basis. Supply of water to communities and downstream users are prime objectives for this catchment. The water demand growth over the past 6 years has averaged 3.5 % per annum in Witbank and Middelburg areas. The Emalahleni Local Municipality, which incorporates Witbank and surrounding areas, is already over-abstracting the Witbank dam by about 11 Ml/day and is set to reach 20 Ml/day by 2015. The Steve Tshwete Local Municipality, which incorporates Middelburg and surrounding areas, is reaching it abstraction capacity from Middelburg and is set to exceed its permit conditions from 2008 onwards. With future mining developments earmarked for the short to medium term in the Middel Olifants and Steelpoort catchments, which are downstream of the the Upper Olifants Catchment, the water that is available requires crucial management.

Prof. FD Hodgson was commissioned to generate a comprehensive geo-hydrological water model related to mining activities, with a yearly incremental time step applied to beyond closure of the operations. This model generates accurate volumes of stored water in the underground workings, as well as, predicting the water make in each discreet compartment or hydraulic unit. The model is dynamic, with water level data being used to update the model, as well as, the model being able to accept updates in the mining plans. Figure 1 highlights the water flooded on the No. 2 Coal Seam as generated by the model. The solid blue shapes indicate the stored water, with the colours representing the floor contours. The elevations rise from the lowest depicted as light blue to green to orange to red at the highest point.

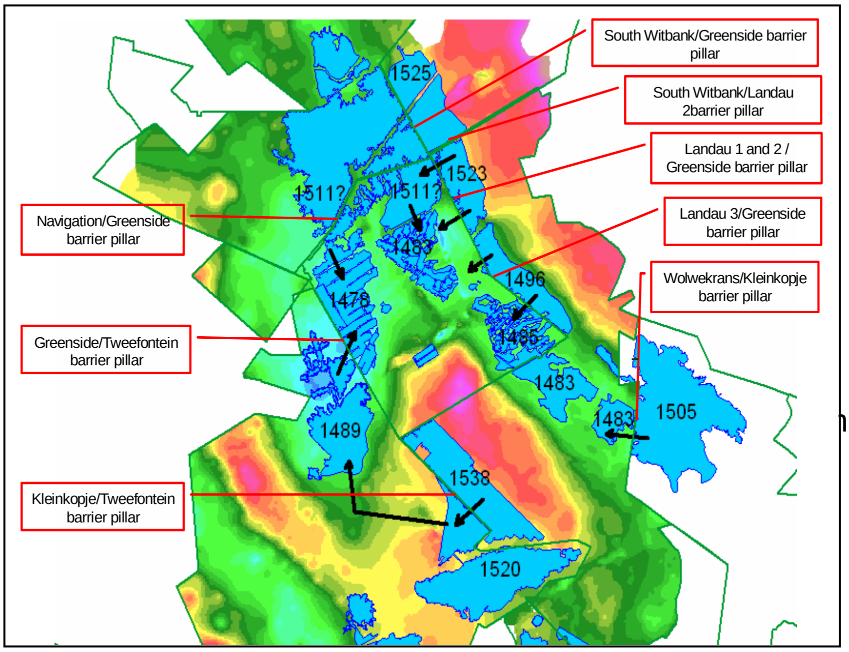


Figure 1 : Geo-hydrological model of the 2 Seam

Figure 2 is the graphical output of the model detailing the amount excess water in m^3/day over the next 40 years. The blue line indicates the total excess water generated, the pink line indicates the net excess water generated less the mines have usage and the green line is the water demand by the Emalahleni Local Municipality.

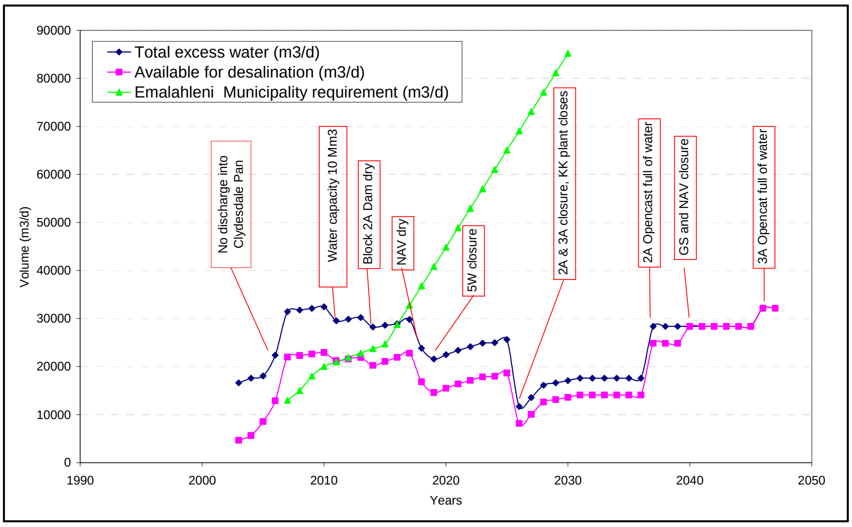


Figure 2 : Schematic of main components of the project

Coal mines have adopted the DWAF hierarchy of water management which aims to maximise clean and dirty water separation, minimise the import of clean water, maximise the reuse of dirty water, discharge of polluted water through the Managed Release scheme and the treatment of dirty water. Over the past 10 years mines have populated and produced detailed water balances which have been applied to the first 4 principles of the DWAF hierarchy. However, some mines have a high positive water balance, in that, not all the water can be managed according to those 4 principles only. Water treatment of these waters is inevitable but historically have required complex technologies associated with high costs and the generation of large waste loads.

1.2 Evolution on Water Treatment in Anglo Coal

Most coal mines in this catchment have a water quality associated with calcium-magnesium-sulphate, neutral type of water. Some mines do have additional problems of acidic types of waters yielding pH's below 3.

Anglo Coal's Landau Colliery currently mines, using opencast methods, the remaining pillars of coal left behind from underground mining which took place since the turn of the 20th century. This coal is fairly shallow (25 – 35 metres deep for 2 and 1 seams) and has leached out all the buffering associated (CaO) with the coal. The water quality has a pH < 3, calcium ~ 500 mg/l, magnesium ~ 100 mg/l, sulphates ~ 2500 mg/l and acidity associated with iron, manganese and aluminium.

In the early years of production at the Navigation Coal Processing Plant of Landau Colliery, water was not understood as the water quality was perceived to be slightly acidic and a lime neutralisation plant was assumed to solve any water quality issues. In the first years (1994 – 1995) of operation, the plant replaced almost 70 % of all steel piping in the plant, as well as, associated minerals processing equipment due to acidic water qualities. No focus was placed on water quality management and the lime neutralisation plant was not operated effectively.

The Council for Scientific and Industrial Research (CSIR) through Dr J P Maree was consulted to assist with rectifying the problem. This lead to optimising the lime neutralisation system, pioneering the limestone substitution of lime for the neutralisation process and solving the acidic water quality issue, but resulted in a secondary problem through heavy gypsum (calcium sulphate) precipitation. Membrane water treatment technology was the only real commercially proven option at the time, but with high capital and operating costs, low water recoveries and a high generation of waste streams (particularly the dissolved brine stream). A number of active water treatment technologies (some novel and not commercially proven) were piloted and demonstrated up to full scale over the past 10 years at Navigation Plant. Table 1 summarises the technologies evaluated versus the membrane technology 10 years ago.

Table 1 : Evaluation of water treatment technologies

Technology Supplier	Type of Active Treatment Process	Purpose of Treatment	Year	Water Recovery (%)
Debex	EDR	HM & S removal	1994 – 1995	65
Keyplan	RO	HM & S removal	1995 – 2006	97
CSIR	HDS (lime)	HM & neutralisation	1995 – 1999	99
	HDS (limestone)	HM & neutralisation	1995 – 2005	99
	BSR (CSIROSURE)	HM & S removal	2000 – 2004	98
Gyp-Cix	IX	HM & S removal	1997 – 1999	79
Savmin	Ettringnite	HM & S removal	2000	95
Lektratek	Electrochemical	HM & S removal	1997 – 2000	95
IST Technik	BSR (Paques)	HM & S removal	1998 – 2003	99
Veolia	RO	HM & S removal	2004 – 2005	95
Wren	Hydrothermal	HM & S removal	2002 – 2004	95
Bateman	RO & hydrothermal	HM & S removal	2004 – 2005	99
Weir-Techna	RO	HM & S removal	2004	95

Note : HM = Heavy metals, S = Sulphate, BSR = Biological sulphate removal, RO = reverse osmosis membrane, IX = ion exchange, HDS = High density sludge, EDR = Electro-dialysis reversal

Through these investigations a number of key lessons were learnt namely ;

- understanding the feed water quality and the applicability / suitability of water treatment technologies to produce the desired water quality
- the importance and knowledge gained by scaling up successfully from laboratory to pilot to demonstration and finally to full scale plant installations
- to determine the optimal performance, with cost efficiency, of the selected water treatment technology through intimate involvement from the mine with the treatment technology supplier
- to dovetail the water treatment technology with that of the mine's water needs
- not to accept what was done before, but rather to maximise the performance criteria of each water treatment technology to meet the mine's overall requirements i.e. maximising water recovery from ~ 65 % to > 97 %
- utilising a scale-up factor of 10 for new technologies from demonstration plant scale to full scale
- determining the correct skills level of operators required to operate the plants, perform analytical procedures, data capture on computer, operate SCADA plant control computer systems, manage downtime, etc.
- development of an operator performance management assessment programme to measure the operators against a fixed scorecard and other operators
- tertiary education is not a prerequisite for the operator but rather a grade 12 Mathematics and Science combination is required

To summarise, the success of the pilot and demonstration plants is that they were fully automated, operated on a 24 hour shift basis and were sized at a flowrate of equal to or greater than 200 m^3/day. The treatment of the calcium – magnesium, acidic, heavy metal (iron, manganese, aluminium) and saline (sulphate) waters has matured through these investigations resulting in a very clear, confident understanding of what technology is suitable to treat this water in an optimal engineered and cost effective manner.

2. SELECTION OF WATER TREATMENT TECHNLOGY SUPPLIERS

In order to select the most suitable water treatment technology supplier a preliminary engineering study was undertaken to short list them.

2.1 Screening of Technology Suppliers

A basic enquiry was drafted to produce a preliminary engineering estimate of the capital and operating costs for treating the feed water to the product water specified in Table 2. The design feed water quality described in Table 2 is derived from the historical 95 percentile concentrations on the worst quality water in the area, i.e. the Navigation Coal Processing Plant. A design for a 10 and 20 Ml/day plant was required with full redundancy. A water recovery of > 95 %, engineering availability of > 95 % and plant utilisation of > 95 % was required. The battery limits excluded the power supply, water collection system and sludge disposal. The suppliers that were approached were:

- IST Technik – Paques biological sulphate removal (hydrogen or ethanol)
- Bateman – membrane desalination & Wren brine treatment
- Wren – hydrothermal sulphate removal
- Veolia – membrane desalination
- Weir-Techna - membrane desalination
- Keyplan - membrane desalination
- CSIR biological sulphate removal or barium sulphate removal

Table 2 : Feed and product water qualities

Constituent	Unit	Feed Water Quality	Product Water Quality
pH	-	3.12	7-8
Electrical Conductivity	mS/m	357	< 45
Acidity	mg/l $CaCO_3$	473	< 300
Total Dissolved Solids	mg/l	3918	< 40
Ca	mg/l	536	< 30
Mg	mg/l	164	< 30
Na	mg/l	71	< 100
K	mg/l	7	< 50
SO_4	mg/l	2500	< 200
Cl	mg/l	35	< 100
Fe	mg/l	81	< 0.1
Mn	mg/l	23	< 0.05
Al	mg/l	16	< 0.15

2.2 Selection of water treatment technology suppliers

Each design was evaluated in terms of process maturity and capital and operating costs over a 20 year life (no escalation) including sludge disposal costs. This yielded a short list of four technology suppliers, with four processes, namely:

- IST Technik – Paques biological sulphate removal (hydrogen)
- Veolia – Reverse osmosis membranes with brine evaporator
- Bateman – Reverse osmosis membranes with Wren hydrothermal brine treatment
- Keyplan – Multi-stage reverse osmosis membranes

This process revealed that only 2 processes are best to use namely, biological sulphate removal and reverse osmosis membranes and can be used to produce a high water recovery, whilst being cost effective. However, the waste disposal costs are still substantial even though the water recoveries are > 95 %. A separate waste trade-off study was initiated on the wastes produced from processes above during the preliminary engineering design stage to look at the best disposal options possible.

3. ENQUIRY FOR THE 20 ML/DAY EMALAHLENI DESALINATIONPLANT

An enquiry for the 20 Ml/day Emalahleni desalination plant was issued to the short listed tenderers in section 2.2 in November 2004. The enquiry document was drafted by the client, the client's consultant company Golder Associates Africa and a quantity surveyor company Venn & Milford. This section describes the information required from the enquiry. The main components of the project are detailed in the schematic in Figure 3 below, with figure 4 showing the general location of the main project components.

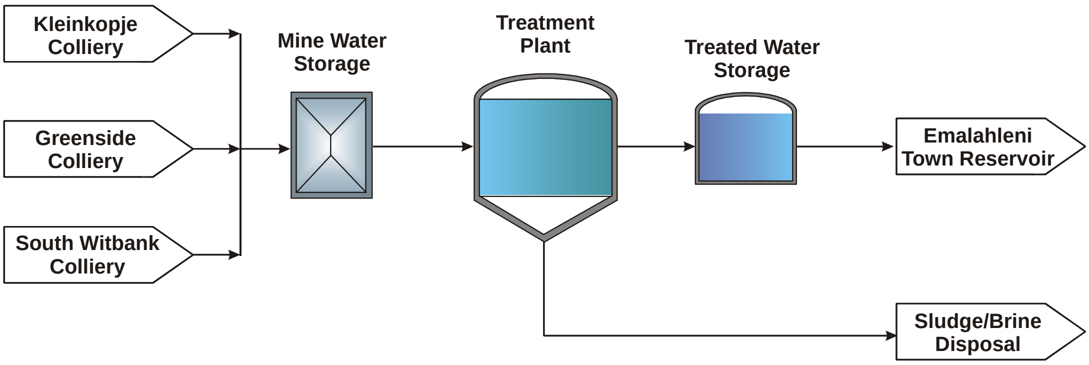


Figure 3: Schematic of main components of the project

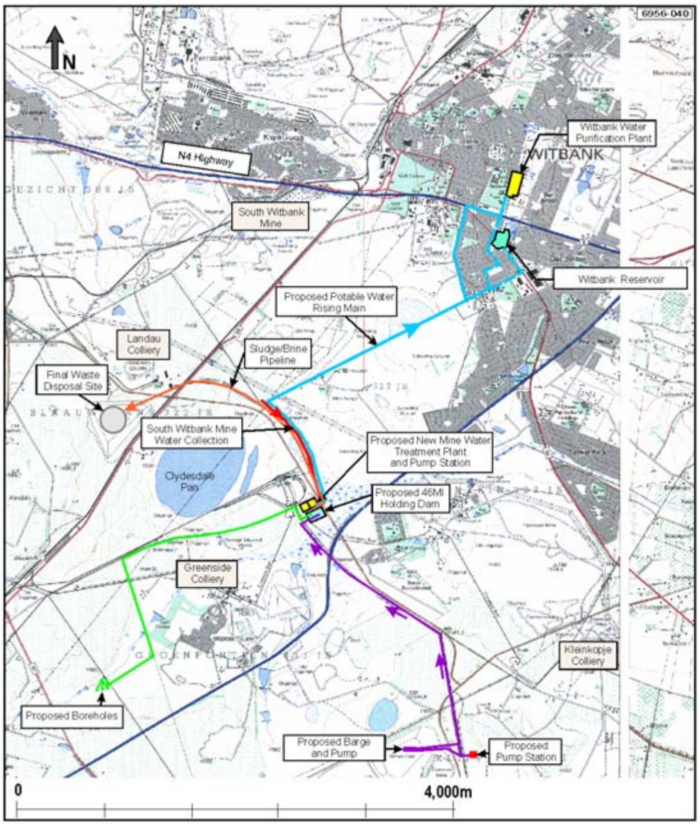


Figure 4: Main physical components and location of key infrastructure elements

3.1 Basis of design

Three different mine water sources are pumped from an extensive collection system to the desalination plant and a specific blend ratio was provided. The treated water design flow was specified as a minimum of 20 Ml/day, with a peak capacity of 24 Ml/day. The design feed water and treated water qualities used in the enquiry are provided in Table 2, with the SANS 0241 Class 0 standard being used for the treated water quality.

In hindsight, as the design treated water is earmarked for drinking water purposes the trace elements of the feed waters should have been included in the enquiry. However, the mine waters are not typically analysed for trace elements and a separate independent sampling run had to be done over 6 weeks on the various feed waters.

3.2 Project deliverables

Each tenderer was asked design a fully functional, automated and operational plant and to provide the necessary enquiry documentation in terms of process flow diagrams, piping and instrumentation diagrams, general arrangement drawings, equipment lists, etc. The tenderer will be required to conduct a formal hazard and operability review (Hazop), with participation from the client. Various procurement, construction and commissioning deliverables were also requested.

3.3 Performance guarantee

Five main performance guarantees were requested by the tenderer, namely treated water flow, treated water quality, engineering availability, operational utilisation and water recovery. The engineering availability and operational utilisation are required to greater than 95 % each and are defined in an example in table 3 below.

Table 3: Calculation of engineering availability and operational utilisation

Total possible hours / month	**744.0**	A
LESS: Planned Maintenance	50.0	
Available Hours	**694.0**	**B**
LESS: Engineering Downtime	35.0	
Available Hours for Processing	**659.0**	**C**
LESS: Operational Downtime	33.0	
Utilised Hours (DOH)	**626.0**	**D**
Engineering Availability	**95.0**	**C/B*100**
Operational Utilisation	**95.0**	**D/C*100**

A minimum water recovery of 95 % is required with recovery being calculated as:

$$\text{Recovery} = Q\ \text{product} / Q\ \text{feed} \times 100\% \qquad [1]$$

Where Q feed = feed water flow (m^3/day)
Q product = product water flow (m^3/day)
Q sludge = sludge/residue flow (m^3/day)

3.4 Redundancy

A minimum of 2 identical process trains was required, each capable of producing a minimum of 14 Ml/day. All critical mechanical and electrical components required to keep the plant at full design capacity must have an installed standby.

3.5 Operation and maintenance

The mines will provide the capital input and own the plant but the O&M is to be done by the water treatment technology supplier. Therefore as the operation and maintenance (O&M) of water treatment plants by the coal mines is non-core to their business plans each tenderer was required to provide the O&M cost for plant. A performance guarantee was required for the O&M portion as well.

3.6 Battery limits

Battery limits for the construction and O&M portions were defined.

3.6.1 Construction battery limits

The tenderer was to design and produce costs for the construction of water treatment plant, with the feed being from the feed water holding dams. The downstream battery limit was at the treated water outlet to the potable water reservoirs and the discharge of waste from the plant to the waste disposal sites.

3.6.2 O&M battery limits

For the O&M portion the tenderer was to cater for the O&M of the entire system from the operation of the water collection system to the feed water holding dams, the water treatment plant, potable water reservoirs and distribution system, as well as, the waste disposal sites. The tenderer will be party to the design and approval of the various system that they were not designing themselves.

3.7 Treatment residue information

A policy of waste minimisation was requested to all tenderers to look at methods of eliminating the waste, reducing the toxicity and / or reducing the volume of the wastes. Workshops were held with each tenderer to assist with this process. All waste compositions were to be supplied and a classification as per the SABS 0228 Minimum Requirements was done to determine the hazard rating of each waste. Actual samples were requested but it was not compulsory for the evaluation.

The classification of the wastes was used to determine and the life cycle cost (capital, operating and operating capital costs required for a 20 year life) of the waste disposal facilities. Each tenderer was told that they would be evaluated on the life cycle cost of the entire water treatment system i.e. the water collection system, treatment plant, waste disposal facilities and potable water reservoirs and distribution system, even though they had not designed it themselves.

3.8 Costs

All the capital, O&M and operating capital (capital replacement or future capital) was to be supplied for a 20 year life cycle costing analysis. Each of these costs was divided into four basic categories, namely: pre-treatment, desalination treatment, polishing treatment and waste handling/treatment. In addition, the life cycle costs for the water collection system, potable water reservoirs and distribution system and the waste disposal facilities were provided by the client and Golder Associates. This basis was used to determine the financial ranking of the tenderers in a financial model.

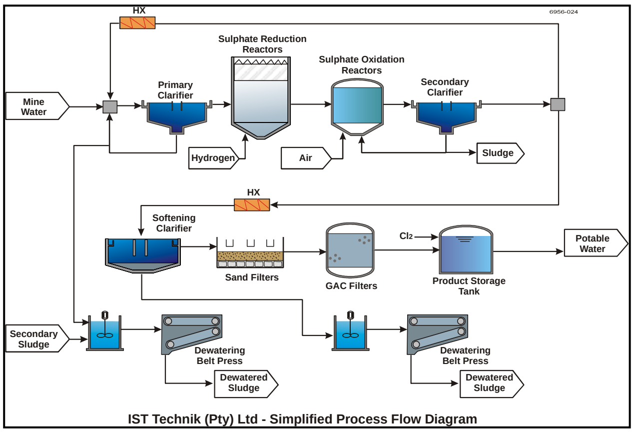
3.9 Other

Other items like the format of the technical information supplied by the tenderer, quality control and quality assurance plan, safety, health and environment and a routine monitoring system were also required to be submitted.

4. SELECTION OF WATER TREATMENT TECHNOLOGY SUPPLIER

4.1 <u>Process description and flow diagram</u>

Prior to detailing the selection process a brief technical description of the treatment technology proposed by each tender is given. The respective process flow diagrams are shown in figures 5 to 8.



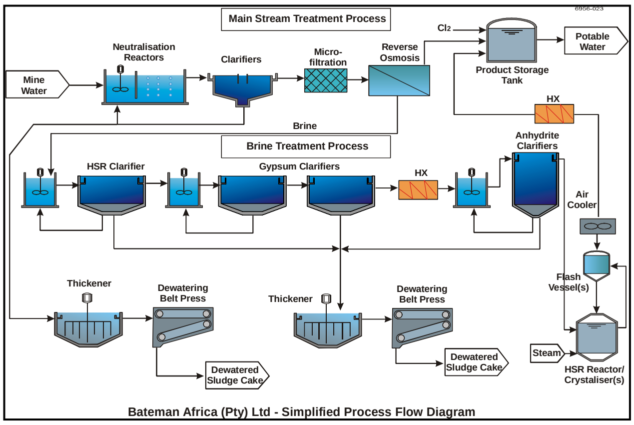
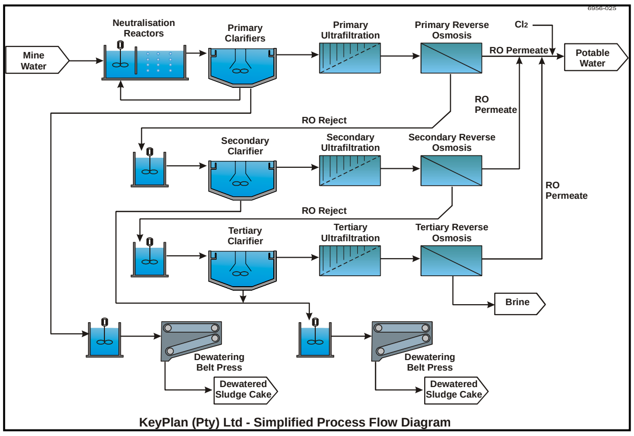


Figure 5 : IST Technik process flow diagram

Figure 6 : Bateman process flow diagram



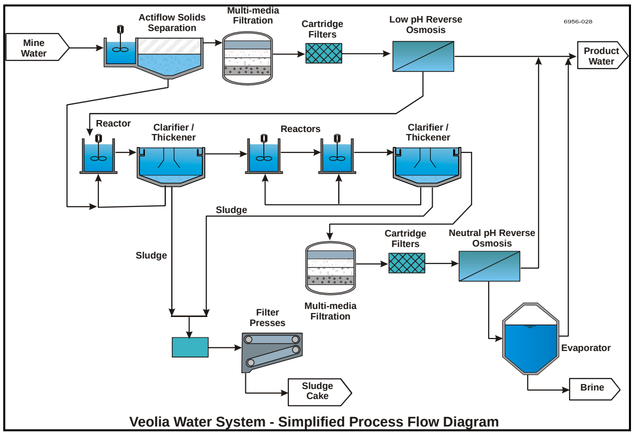


Figure 7 : Keyplan process flow diagram

Figure 8 : Veolia process flow diagram

4.1.1 <u>IST Technik (Pty) Ltd</u>

The IST Technik (Pty) Ltd tender was based on the Paques biological sulphate removal process followed by cold lime softening, recarbonation, filtration and disinfection. Figure 5 shows the IST Technik simplified process diagram.

4.1.2 <u>Bateman Africa (Pty) Ltd</u>

The Bateman simplified process flow diagram is shown in figure 6. The Bateman Africa (Pty) Ltd technology proposes lime neutralisation, filtration , reverse osmosis desalination and brine treatment with the proprietary hydrothermal Wren process.

4.1.3 <u>Keyplan (Pty) Ltd</u>

The Keyplan (Pty) Ltd process uses the CSIR limestone neutralisation, ultra-filtration and reverse osmosis desalination, with the brine being concentrated up through 3 reverse osmosis stages. The Keyplan simplified process flow diagram is shown in figure 7.

4.1.4 Veolia Water (Pty) Ltd

Veolia Water proposed a two stage reverse osmosis desalination process, with a low pH reverse osmosis as pre-treatment, followed by neutral reverse osmosis and an evaporator for brine concentration. Figure 8 shows the Veolia simplified process diagram.

4.2 Technical Adjudication

The technical adjudication of the tenders was conducted by a team of representatives from Anglo Coal, BHP Billiton, Golder Associates and Venn and Milford. The proposals were considered in terms of the performance criteria such as potable water production, product water quality, plant availability and sludge and brine production. In addition to this, the technical criteria included project team resources, risk management, reference projects, project schedule, reliable achievement of project targets and safety, health and environment issues. A total of twelve groupings of technical criteria were developed and are detailed below:

4.2.1 Project team resources

The capacity of the tender project teams in terms of project management and contracts administration were considered. The intent to use and the credentials of sub-contractors specifically relating to civil engineering, earthworks, mechanical engineering, electrical and instrumentation work was an important factor. The dependence on specialist suppliers also featured in this evaluation.

4.2.2 Key factors and pertinent issues

Several key project aspects were looked at in this grouping. These included the project design criteria employed, the ability to deal with variable mine water flows and qualities and the overall process control strategy.

4.2.3 Operability Issues

The operability of each of the proposed processes was evaluated according to the below-listed criteria:

- Complexity of the mainstream process train
- Number of individual unit treatment processes and process equipment units
- Availability of industrial grade product water
- Number and complexity of required support services
- Complexity and risks associated with storage, make-up and dosing of chemicals
- Process monitoring requirements in terms of sampling and analysis
- Potential for further optimisation in terms of sludge and brine production, processing and recovery of saleable products

4.2.4 Management of risk

Engineering risks, commissioning risks, performance risks and quality related risks were evaluated over the life cycle of the project.

4.2.5 Reference projects

The enquiry required the submission of reference projects completed in South Africa and internationally. These were evaluated taking the scale of project and type of water treated into account.

4.2.6 Project schedule

Execution of the project is within a tight time frame. The time allowance for key project phases as well as the handling of long lead items was scrutinized. The identification of key milestones in terms of procurement, construction, installation and commissioning were evaluated.

4.2.7 Project Redundancy Aspects

The project commits to the reliable supply of potable water. The redundancies of the main stream processes were evaluated in terms of ability to continue supply with one or more unit processes offline.

4.2.8 Reliable achievement of project targets

This grouping evaluated the team's confidence in the achievement in terms of the five stated project performance criteria, namely:

- Reliable supply of product water flow
- Reliable production of potable water quality
- A high level water recovery
- Availability and utilisation of plant
- Sludge and brine production levels

4.2.9 Client standards and preferred suppliers

The proposals were evaluated in terms of compliance with the project standards and preferred suppliers of key equipment as laid out in the enquiry document.

4.2.10 Battery Limits

The tenders were evaluated to confirm that the battery limits were correctly identified in terms of:

- Mine water intake
- Product water delivery
- Sludge/brine stream discharge
- Support services

4.2.11 General technical aspects

Important technical aspects such as the handling of off-spec water, peak production capacity and sludge/brine processing were evaluated under this heading. The general functionality and economic design of the plant layout was considered as well as the adequate provision of office, laboratory, stores and workshop facilities.

4.2.12 Safety, health and environment

The commitment and track record of the four tenderers in terms of executing projects in a safe manner and the management of potential environmental impacts were evaluated.

4.3 Technical adjudication results

A consolidated rating was performed in a workshop setting of each of the technical aspects of each tenderer. The twelve adjudication criteria were assigned a weighting based on the following:

●	considered but can be negotiated to suit project requirements
●	significant impact on project success
●	key project success factor

The results of the technical adjudication process are listed in table 4 below:

Table 4: Technical adjudication process

Technical Adjudication Criteria	**Weighting**	**IST Technik**	**Veolia Water**	**Bateman Africa**	**Keyplan**
Project team resources	●	☺☺☺	☺☺☺	☺☺☺	☺
Key factors and pertinent issues	●	☺☺	☺☺	☺☺	☺☺☺
Operability issues	●	☺	☺☺	☺☺	☺☺☺
Risk management	●	☺	☺☺	☺☺☺	☺☺
Reference projects	●	☺☺☺	☺☺☺	☺	☺☺
Project schedule	●	☺	☺☺	☺☺☺	☺☺
Redundancy aspects	●	☺☺	☺	☺☺	☺☺
Reliable achievement of project targets	●	☹	☺	☺☺	☺☺☺
Clients standards and preferred suppliers	●	☺☺	☺☺	☺☺	☺☺
Battery limits	●	☺☺☺	☺☺☺	☺☺☺	☺☺☺
General technical aspects	●	☺☺	☺☺	☺☺☺	☺☺
Safety, health and environment	●	☺	☺☺☺	☺☺	☺☺☺

4.4 Financial Adjudication

The financial assessment of the tenders was performed by comparing the life cycle costs for each of the proposals over a twenty year period. The life cycle costing methodology considers all costs incurred in the installation, operation, maintenance, refurbishment and disposal of a capital project over its useful lifetime.

The costs used in the financial model were primarily obtained from the tender submission documents. Where specific information was not supplied in the tender, assumptions were made based on similar information supplied in other tenders or the reasonable estimates of professionals in the tender adjudication team.

The capital expenditure and operational costs were broken down into processes and categories that facilitated the implementation of the life cycle costing methodology. The life cycle costs for each tender were calculated using escalated costs and base money value costs. Escalated costs are based on the initial costs grown at an annual rate of inflation. These costs represent predictions of the actual cash flows occurring in a given year. On a cumulative basis, the costs represent the actual expenditure over the entire life of the project. Table 5 compares the tenders costs in terms of magnitude.

Table 5: Life cycle cost comparison

Present Value	**IST Technik**	**Veolia Water**	**Bateman Africa**	**Keyplan**
Capital Expenditure	$$$	$$$$	$$	$$
Operational Expenditure	$$$$	$$$	$$	$
Total Expenditure	**$$$**	**$$$$**	**$$**	**$**

On a life cycle cost basis, Keyplan submitted the lowest tender. The incremental expenditure per year is shown in figure 9 and the cumulative expenditure is shown in figure 10.

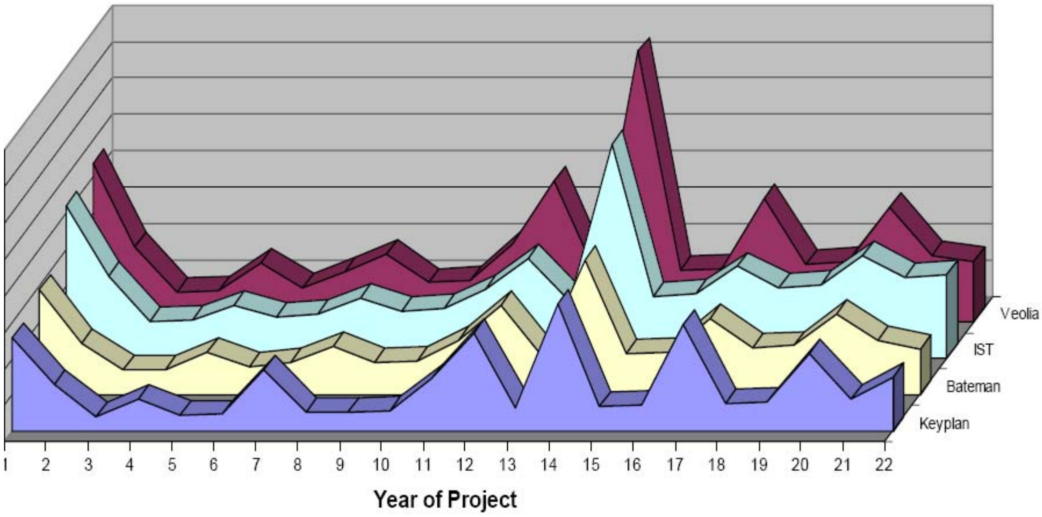


Figure 9: Incremental life cycle costs comparison

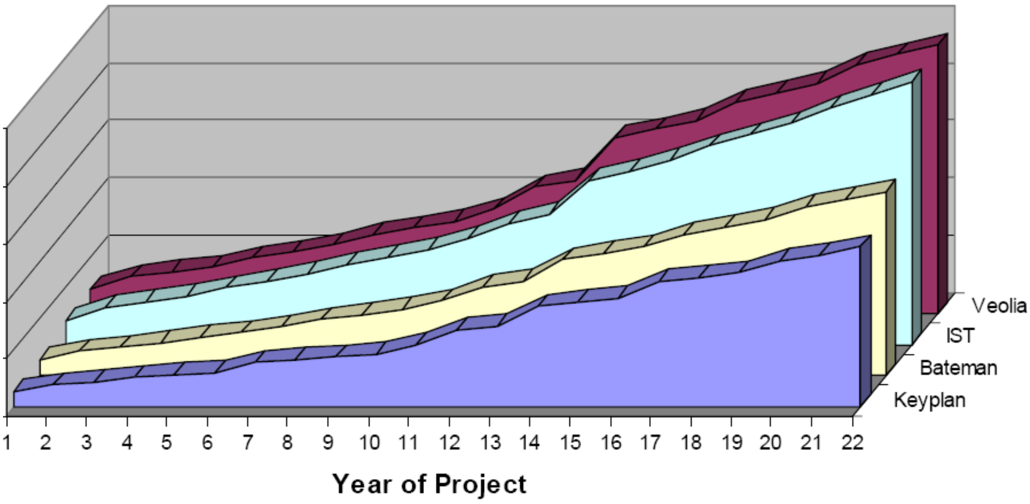


Figure 10: Cumulative life cycle costs comparison

4.5 Tender adjudication outcome

Based on the tender documentation submitted and further information sessions, the technical and financial adjudication processes selected Keyplan (PTY) Ltd to be the preferred technology provider based. The selection process continued with a vendor audit of four of Keyplan's recent projects in the water desalination field.

Concluding remarks

In conclusion, the selection of a water treatment technology supplier was very thorough and the water treatment knowledge and experience the mining companies have has helped in the selection process. Together the mining companies and water treatment technology suppliers have to continue to a co-operative relationship to make further advancements in mine water treatment. By making the decision, through a well researched pre-feasibility study, the treatment of mine waters to potable standard has converted an environmental liability into a public-private partnership asset.

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