Environmental & Remedial Technology Holdings

A STUDY TO DETERMINE THE FEASIBILITY OF DEVELOPING A FULLY AUTOMATED OR LABOUR INTENSE WATER TREATMENT PLANT FOR EARTH

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Executive Summary

An article in (SWANEPOEL, Esmarie, 2009) suggested that South Africa is heading into a water crisis with a predicted shortfall of 21% by 2013. This shortfall can be prevented but not totally removed by the current gap in the market in the mining sector of South Africa for the treatment of the effluent water that collects at the bottom of the mines.

Environmental and Remedial Technology Holdings (Earth) has developed a new method of treating the effluent water by means of ion-exchange. This new method is currently being tested by way of a pilot plant based in Boksburg.

This project will outline the methods and Industrial Engineering practices that will be used in the development of a full commercial water treatment plant for Earth. A fully automated plant will be compared to a labour intense plant, using an economic analysis approach, to test the project's feasibility. This approach will allow Earth to gather information on their solution which can be used to attract investors.

The aim of this project is to develop a crucial asset in the development of an ion-exchange water treatment plant for Earth.

The implementation of this feasibility study will benefit Earth in the following ways:

- Lowering the implementation costs for new plant
- Attract investors
- Identification of the costs and benefits
- Take full advantage of the gap in the market
- Make an impact on various interest groups
- Enable Earth to make decisions at the correct time

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AMD: Acid mine drainage

CAPEX: Capital expenditure

DCF: Discounted Cash Flow

DME: Department of minerals and energy

DWA: Department of water affairs

Earth: Environmental and Remedial Technology Holdings

EF: Economic feasibility

IRR: Internal Rate of Return

IX: Ion-exchange

NPV: Net present value

OF: Operational Feasibility

OPEX: Operating expenses

SF: Schedule Feasibility

TF: Technical Feasibility

ROI: Return on Investment

Chapter 1

1.1 Introduction and Background

Earth (MergeCo) will be formed by the merger of Earth (Pty) Ltd and Ionex (Pty) Ltd. This new venture has strongly differentiated itself in the mining market as it has combined the ion-exchange (IX) and metallurgical expertise of Ionex with the proprietary approach of Earth that has made the ion-exchange economic and sustainable. They are currently seeking working capital to merge the two synergistic companies, and take advantage of the opportunity in the market that the two companies can address together.

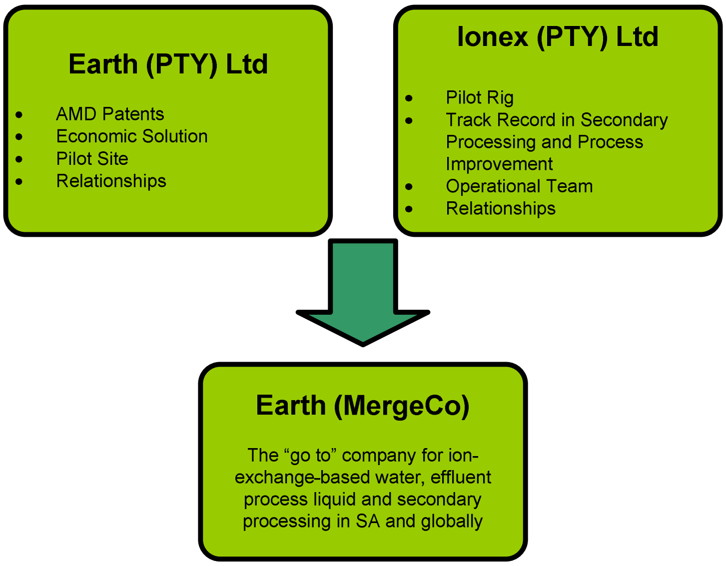

Figure 1: Synergies between the Companies

Earth (MergeCo) has identified three key areas in the mining market in which it can focus its business operations:

1. Acid Mine Drainage [AMD]
2. Process improvement in the vanadium industry and other mining industries
3. Reprocessing of secondary mineral resources

AMD is recognised as the largest single threat to the South African environment [Review of AMD in Annex B]. Earth will address this market need by providing an economically-sustainable and effluent-free solution to the AMD problem. Earth's solution will convert the AMD to portable water and saleable by-products including fertilizer.

In order to address the second key market area, Earth will make use of its IX expertise derived from its operations in the metallurgical side of mining [Review of ion-exchange in Annex C].

Earth will improve process efficiencies, which in short means that more of the desired mineral is extracted and less will report to the mine dump where it can leach back into the environment.

In the reprocessing of secondary mineral resources in mining, Earth has accumulated an understanding of how process and effluent streams occur. With this knowledge in hand, Earth will be able to identify the correct technology for any given secondary source or dump.

Earth has positioned itself as the company for IX-based solutions to effluent and process flows in the mining and metallurgical sectors. They develop world class, modular solutions from their base of strong intellectual property and deep industry knowledge.

With Earths extensive experience in IX, metallurgy and intellectual property and the combined company will have the capability to offer three business operations as shown below:

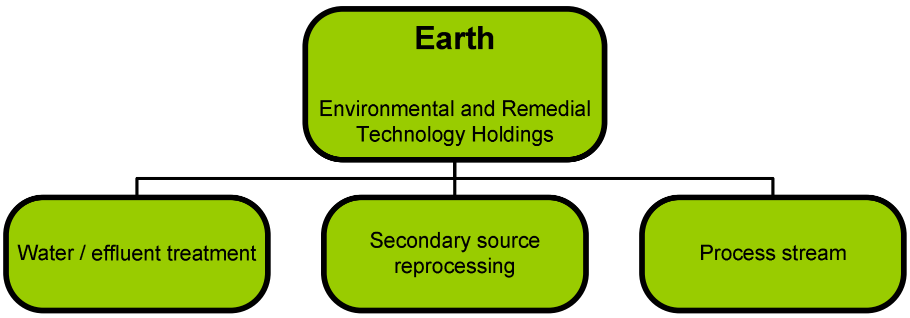

Figure 2: The three Business operations

The focus of this project will be on the feasibility of developing either a labour intense or fully automated plant from the findings of the ion-exchange pilot plant based in Boksburg.

1.2 Problem Description

Water is the most precious item to every creature on earth. Although it circles three fourths of the planet, most of the water can be deemed unusable. A further concern is that even with the population increasing daily, total water resources remain the same.

Earth would like to provide its investors with credible information on the development of a full commercial IX water treatment plant. The executives are interested in developing a fully automated plant. This approach will require a larger initial capital investment in the development stages that could scare off investors as in any new venture there is a level of risk.

As there is a large need for the treatment of effluent mine water, the executives believe that a fully automated plant will have the capability to process a higher volume at lower cost compared to a labour intense water treatment plant.

1.3 Project Aim

The aim of this project is to asses the feasibility of developing the IX pilot plant into either a fully automated or labour intense plant. This will be done by doing an economic analysis to evaluate the effectiveness, viability, cost and benefits of either project before any financial resources are allocated into the development of the plant.

This study will enhance the projects credibility and selling value that will convince investors on why a fully automated plant should be developed.

1.4 Project Scope

1.4.1 The Stakeholders

- Earth (MergeCo)
- Non Executive and Executives
- Shareholders and family trusts
- Mining companies
- The environment
- University of Pretoria
- Peter Boag

1.4.2 Project Obstacles

The current obstacles that are preventing Earth from developing the IX pilot plant to a full commercial plant:

- Initial capital
- Lack of interested investors
- External factors which cannot be controlled (The South African Economy)
- Confidence in the new technology that has been developed

1.4.3 Intermediate Objectives

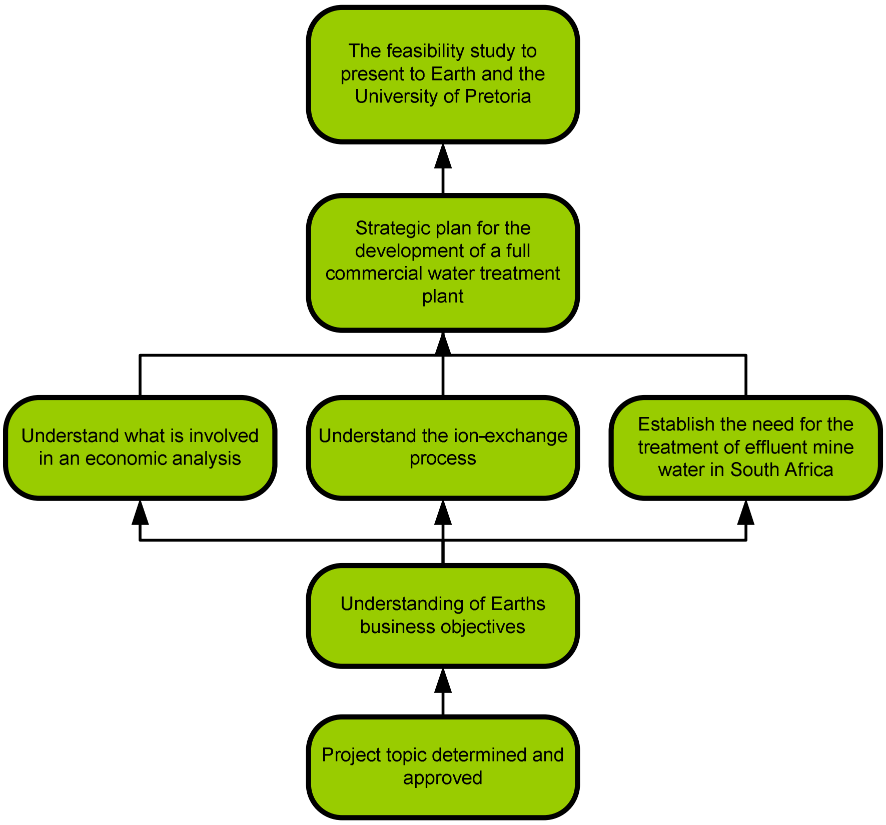

Figure 3: Intermediate Objectives

1.4.4 Tasks that must be completed in order to achieve the Intermediate Objectives

- Study and understand the business plan that has been developed by Dr Richard Doyle for Earth
- Determine the requirements for an economic analysis, regarding the development of a new technology
- Study literature on different ion-exchange methods to understand the processes involved
- Calculate the risks and costs involved

Chapter 2 Literature Review

2.1 Water issues in South Africa

(NDABA, Dennis, 2010) Water shortages are likely to be more prevalent by 2025, unless proper action is taken to provide more water infrastructure, it cautions Department of Water Affairs (DWA) infrastructure development chief director Willie Croucamp. If steps are taken to prevent this looming crisis, it will not only benefit the citizens of South Africa but the economy as (PRINSLOO, Loni, 2010) “the water supply is already impeding South Africa’s economic development in some localities”.

This is further impeded by the lack of skills that are required by the water sector of South Africa. This lack of skills will have a huge impact on the future water supply. (PRINGLE, Chanel, 2008) Points out that over the next 12 years only 5% of children in the education system will have the necessary intellectual skills to get university entrance and study the mathematical and scientific competencies to enter the engineering sector. But due to poor guidance by teachers, pupils have been found making poor decisions on subject selection. This poor subject selection is highlighted (PRINGLE, Chanel, 2008) that only once school learners complete grade 12 they learn of the fact that many career paths have been closed to them due to their subject selection. What further aggravates this issue, are the individuals that are leaving South Africa with the necessary skills to combat the water crises.

(MP, Gareth Morgan MP, Mpowele Swathe, 2008) The areas where South Africa’s water originates are being damaged by a generalised official disregard for the environmental consequences of industrial activity. The Departments of Environment at provincial level and national level continually find themselves in an ongoing battle with the Department of Mineral and Energy (DME) over the attempts to authorise mining in environmental sensitive areas. These ongoing battles between departments are usually found to be to the detriment of the local inhabitants of the area that is the topic of discussion. Mining always has a negative impact on the environment due to the chemicals and lack of respect for the impact it has on the area that is being mined.

One of the main issues is the Acid Mine Drainage (AMD) from mining activity. This was further emphasized by a report (PRINSLOO, Loni, 2010) that stated that South Africa has to immediately address the serious AMD problem.

Currently the treatment of AMD presents an untapped market that can be exploited. Not only for the obvious factor of creating wealth for investors but the positive affect it will have on the environment around the mines. By implementing AMD treatment plants at mines, will create work to tackle the unemployment rate that is found in rural areas where mines are usual found.

Water is a commodity that is reused constantly. (SMITH, Petronel, 2010) The reuse of water is the most effective short term solution to assist with water supply in water scarce areas. It has been found that waste water and water from industrial and mining sources can be reused successfully. The use of recycled water can lead to the reduction in operating costs if the treatment process is implemented correctly.

2.2 Acid Mine Drainage effect on the environment

An article from (EARTHLIFE, 2009) states that AMD is the flow or even seepage of polluted water from old mining areas. Depending on the mining activity, the water may contain toxic heavy metals and radioactive particles. AMD on the Witwatersrand has reached crisis point. This is because of the fact that some companies allow acid water to flow into stream, dams and sources of ground water. On the West Rand, toxic water has already destroyed life in Tweelopiespruit and the Robinson Lake near Randfontein. Even some borehole water is polluted. The mining companies and government have about two years from December 2009 to control mine drainage before huge amounts of toxic water under Johannesburg and the East Rand begins to flow into streams and rivers.

One can see that AMD is becoming a serious problem as outlined by the article. But to truly understand the effect of AMD is to understand what AMD is and what it can do to the environment if the problem is left unattended.

A typical chemical reaction that results in AMD is given by (LAWHORN, Walter)

1. $Fe^{+2} + \frac{1}{4}O_2 + H^+ \rightarrow Fe^{+3} + \frac{1}{2}H_2$

   Step two: Iron oxidizes to ferric iron

2. $FeS_2 + \frac{7}{2}O_2 + H_2O \rightarrow 2SO_4^{-2} + Fe^{+2}\,2H^+$

   Step three: Precipitation occurs with ferric iron to ferric hydroxide

3. $Fe^{+3} + 3H_2O \rightarrow Fe(OH)_3 + 3H^+$

   Step four: All combined to show a full formation of sulphuric acid

4. $FeS_2 + \frac{15}{4}O_2 + \frac{7}{2}H_2O \rightarrow 2H_2SO_4 + Fe(OH)_3^{+4}$

(LAWHORN, Walter) Say's that once the sulphuric acid lowers the pH of a water source, it will virtually kill any organism that cannot handle the stress of the stronger acidity levels. Another hazardous reaction resulting from the lowering of the pH comes from the $Fe(O[H)]_3$ precipitating out in the water. This can be seen in figure 4 that clearly shows the reddish deposits of $Fe(O[H)]_3$ deposits on the rock face.

Figure 4: Effect of AMD (LAWHORN, Walter)

Another way in which AMD affects an area is from the deposits of $Fe(O[H)]_3$ or other metallic compounds. A reaction occurs and the result is that of a heavy sedimentation that blankets and discolours the stream covering up vegetation and larger aquatic animals.

Figure 5: AMD blanketing of stream bed (LAWHORN, Walter)

Figure 6: West Rand Gold Fields affected by AMD (EARTHLIFE, 2009)

(OCEANS, GreenPeace Defending Our) Toxic elements such as copper, cadmium and zinc are often associated with AMD. Even though copper and zinc are trace element for plants and animal life, at higher doses they are toxic. Cadmium has no known beneficial properties.

2.3 Earths approach to Acid Mine Drainage

Earths newly developed technology is based on ion-exchange (IX). This new method of IX has been found to be highly effective in combating the AMD issues that have been found with the effluent run offs by mines in South Africa. This technology involves the following:

- Water is fed to a cation column to remove all cations
- The effluent is sent to an anion column to remove all anions to produce high purity water

This process produces high purity water that is well within domestic specifications.

Figure 7: ion-exchange columns in pilot plant (DOYLE, Dr Richard, 2009)

The cation column contains eluted nitric acid in excess of approximately 10% of nitric acid. This produces a mixed metal nitrate solution. The anion resin is eluted with ammonium hydroxide formed from ammonia gas. This is to avoid water addition and to give a final liquid effluent of ammonium sulphate.

The plants that will be built, will convert each of these two liquid eluates to solid products which can be sold as a mixed metal nitrate for explosives and fertilizer or for metallurgical industries. More specifically the metals in the cation eluate can be removed by precipitation with lime or ammonia. This will give a product of a metal hydrate with a final solution of calcium nitrate. The anion resin is eluted with ammonium hydroxide as before to give a final effluent of ammonium sulphate. Earth will combine these two solutions to produce insoluble calcium sulphate and ammonium nitrate solution which is a commodity in fertilizer. The calcium sulphate will be of a high purity which could command a high price for the use in building material.

Figure 8: Pilot Plant at Rand Uranium (DOYLE, Dr Richard, 2009)

In summary, the new technology will represent a radical departure from conventional approaches which have sought to only manage input costs. This is where Earth is moving on a tangent and focuses on the margins instead. Although the operating costs of operating this system will be higher due to the cost of ammonia and nitric acid, the by products will generate enough to offset the operating costs. With this new technology being proven effective with pilot plant testing, the only problem that exists from Earth's point of view, is the capital requirements for developing a large scale commercial plant to treat AMD water.

Figure 9: Ion Exchange columns (DOYLE, Dr Richard, 2009)

2.4 Feasibility Study approaches

The common feasibility study approaches by analysts are listed below:

1. Technical Feasibility (TF)

A technical Feasibility study will assess a projects feasibility within the limits of the current technology and if it is available within the given resource constraints (i.e. budget and schedule). (WOLFE, Lahle) One should think of a TF study as the logistical or tactical plan of how ones business will produce, store, deliver and track its products or services. This feasibility stated by (KIVENTO, Teppo, 2006) must be proven without building the new system. (WOLFE, Lahle) States further that the TF study must support the financial information that is available. An analyst can do this by including (WOLFE, Lahle):

- The material requirement costs
- The calculating of labour requirements
- Understanding the transportation and shipping requirements
- The physical location of the facility
- Technology requirements to run the plant

By including these points into a TF study, the investors will have a better understanding of the operations of the plant and how money can be made from the new technology.

2. Operational Feasibility (OF)

It is concluded in (LONNIE BENTLEY, Jeffery Whitten, 2007) that OF is the measure of how well a proposed system solves the problems and takes advantage of the opportunities identified during the scope definition and problem analysis. The PIECES framework can be used as the basis for analysing the project as in the following example (74401, 2007):

- Performance: Does the current operations provide adequate throughput and response time?
- Information: Does current method provide investors and managers with timely and useful information?
- Economy: Are there cost-effective operations? Will there be a reduction or increase in benefits?
- Control: Does current mode of operations protect against fraud?
- Efficiency: Does the current operations make maximum use of resources?
- Services: does current mode of operation provide reliable service?

3. Schedule Feasibility (SF)

(LONNIE BENTLEY, Jeffery Whitten, 2007) Concludes that SF is the measure of the given technical expertise available and how reasonable the project time table is, as some projects are initiated by specific deadlines. One must determine whether the deadlines are mandatory or desirable to deliver the proposed project.

4. Economic Feasibility (EF)

(LONNIE BENTLEY, Jeffery Whitten, 2007) In the early stages of a project, EF analysis amounts to little more than judging whether the possible benefits of solving the problem will be worthwhile. A better way to understand EF is to break it down into a cost/benefit analysis. According to (74401, 2007) the purpose of cost/benefit analysis is to answer:

- Is the project justified (because benefits outweigh costs)?
- Can the project be done within the given cost constraints?
- What is the minimal cost to attain a certain system?
- What is the preferred alternative among the candidate solutions?

A cost benefit analyses is used to determine which project direction to take. In figure 10 a summary of a feasibility studies dimensions and purpose are outlined.

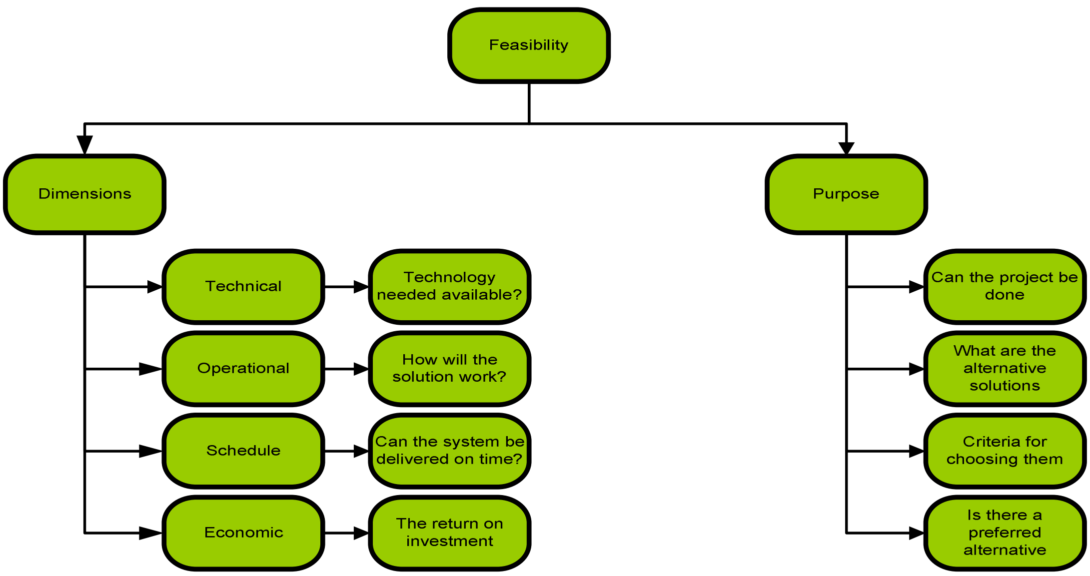

Figure 10: Summary of feasibility dimension and purpose

5. Explanation of economic terms

Net Present Value (NPV) as defined by (Business Dictionary, 2010) is the difference between the present values of the future cash flows from an investment. The present value of the expected cash flows is calculated by discounting them at a required rate of return. If the NPV of a project is found to be positive, it should be accepted and if negative be rejected as an unfavourable investment. The NPV is calculated by equation 1:

$$NPV = \left(\sum_{t=1}^{T} \frac{C_t}{(1+i)^t}\right) - I_0$$

$C_t = cash\ balance\ at\ time\ t$

$i = interest\ rate$

$I_0 = Initial\ investment$

Equation 1: Net Present Value

Internal Rate of Return (IRR) is where the NPV will be equal to zero. This can be better understood by (Investor Words, 2010) as the rate of return that will make the present values of future cash flows of an investment equal to the current market price of the investment. The IRR is used to determine if an investment is worthwhile to undertake for an investor.

Return on Investment (ROI) as define by (Investopedia, 2010) as the performance measure used to evaluate the efficiency of an investment. The ROI is calculated by equation 2:

$$ROI = \frac{(gain\ for\ investment - cost\ of\ investment)}{cost\ of\ investment}$$

Equation 2: Return on Investment

2.5 Literature Review conclusion

From the literature it is evident that many methods exist to solve the problem. One must take into account the data that is required by the end user of the feasibility study when deciding on which method to use in the study. A common choice when having to decide between two options is the cost/benefit analyses method.

By using the EF approach with a cost/benefit analyses one will be able to break down the problem into manageable headings that will be easily understood by investors. The monetary, tangible and to a lesser extent the intangible benefits will be out lined and compared to the cost that are involved. The common costs that the benefits are compared to are stated by (74401, 2007):

- Project related costs
- Development and purchasing costs
- Installation and conversion costs
- Maintenance costs
- The ongoings of operating the plant

Chapter 3 Conceptual Solution

3.1 Introduction

Earth has developed the new method of treating AMD that is currently being used in pilot plants. The pilot plants operate under a labour intense environment. The problem is that the developers of the technology want the full commercial plants to operate as automated plants. This means an Economic Feasibility study will be the optimal way forward to gather figures and draw conclusions on why a automated plant would be favoured over a labour intense plant.

Every successful project must be carried through a series of steps as illustrated in figure 11 by (WITT, Will, 2005)

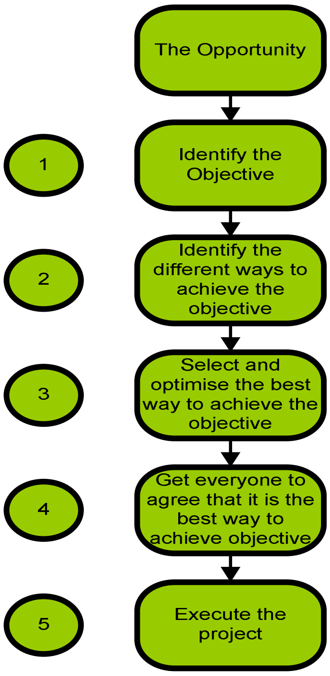

Figure 11: Successful Steps

In step 1 one must identify and clarify all the aspects of the projects objectives. Further in step 1 and step 2 one must show that the idea will work and finally step 3 and step 4 one shows how to make the idea work. Step 5 includes the execution of the project as the final step in the successful steps to follow in a project.

3.2 The approach to the Feasibility Study

For the feasibility study to be relevant and useful to Earths business plan the following strategy was chosen as illustrated in figure 12.

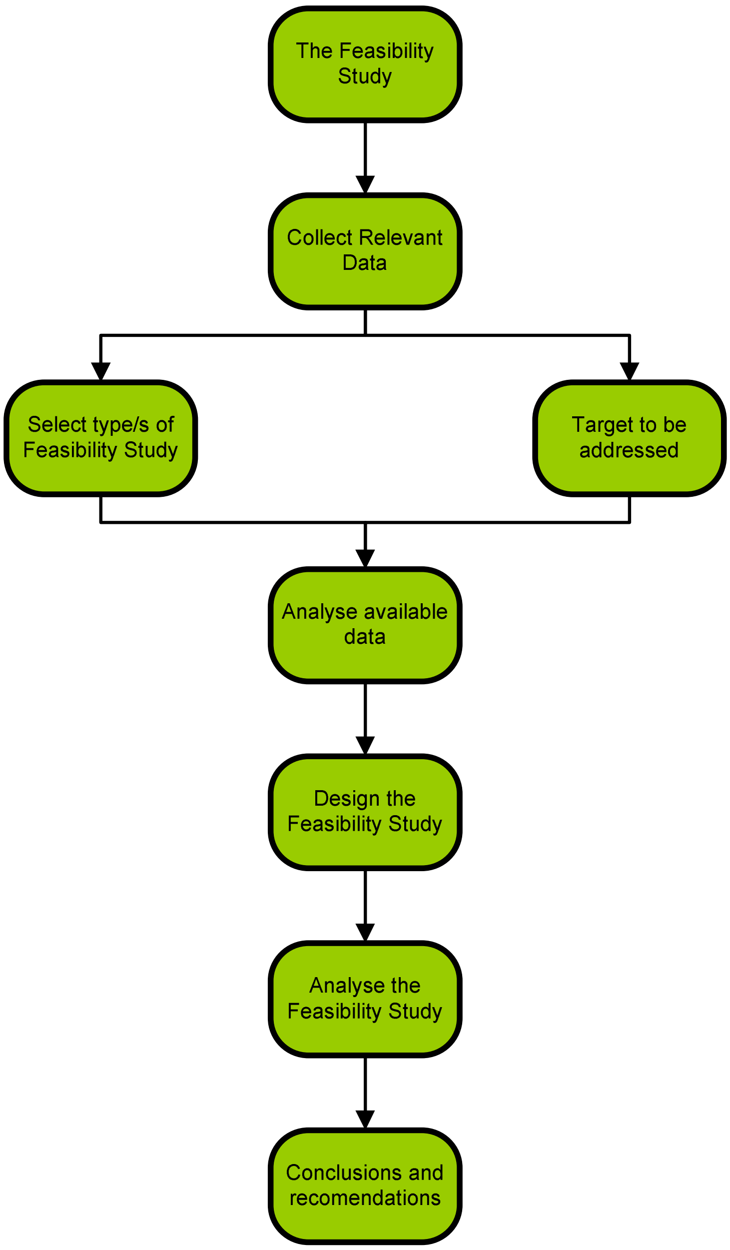

Figure 12: The Studies Strategy

The following decision parameters adapted from (WITT, Will, 2005) will be used in the feasibility analysis:

Stage 1: Opportunity identification

The initial investments have been made to begin Earth's IX processing pilot plant to start the testing phase of the new technology. In this phase, the IX method proved itself positive with the results that were produced and recorded such as:

- Capital cost estimate
- Operating cost projections
- Tranched payments against project milestone
- Projected Cash flows

Stage 2: Appraisal

Will include a comprehensive Economic feasibility study that will clearly identify the feasibility of a pilot plant that will be more attractive to investors by including:

1. The project objective and scope
2. Identification of funding options
3. Risk analysis
4. The feasibility study and investigation into the economics adapted from (BURKE, Rory, 2006)

Stage 3: Investment planning

1. Attracting the investors
2. Which companies can be targeted
3. The market penetration overview

Stage 4: Asset creation

1. A detailed design

Stage 5: Comparison between labour intense and automated plant

This will involve comparing the projected cash flows of the two plants with an economic approach. The results will enable the investor and project team to decide on which plant to develop.

3.3 Data and Information Gathering

It is stated by (TATUM, Malcolm, 2010) that a Feasibility study is the preliminary investigation into the potential benefits associated with undertaking a specific activity or project. The main purpose of the feasibility study is to consider all factors associated with the project, and determine if the investment of time and other resources will yield a desirable result.

With an understanding of the requirements for a feasibility study the data gathered was to be correct and relevant to the study. Another important aspect is to understand what investors are looking for. The topics that investors are interested in were identified as follows:

- Cost/benefit
- Return on investment (ROI)
- Net present value (NPV)
- Risk of investment
- The customers that will be targeted
- The market penetration

Chapter 4 Feasibility Results

Earth's IX AMD processing pilot plant viability is tested in the first 4 stages of the feasibility study. The opportunity that exists in the treatment of AMD and the market penetration opportunity will be outlined and discussed.

Stage 1: Opportunity identification

4.1.1 Capital Cost estimates

A high level breakdown of how capital will be deployed over the next two years is shown in table 1. Earth has assumed that during year 1:

- The pilot rig will be duplicated and it will be automated
- Assaying equipment will be procured to accelerate testing
- Earth will build a pilot scale helical IX contactor and test it
- A precipitation unit will be procured to extract valuable metals from effluents

In year two Earth intends to:

- Build a facility to separate the products back into reagents to reduce the dependence on inputs
- Develop a product beneficiation facility to dry the products and package them

Cost Projections - 24 months							
Role Activity	**Management**	**Marketing**	**Technical and design**	**R&D**	**Patents and legals**	**Admin,travel,etc**	**Totals**
Non-reimbursable Pilot activities	540k		3870k	3546k	400k	1000k	9356k
Business development and operations	540k	200k	4550k	900k	100k	1000k	7290k
Capital purchases (Assets)			3000k	1200k			4200k
Totals	1080k	200k	11420k	5646k	500k	2000k	**20846k**

Table 1: High level breakdown of use of capital

The capital cost estimates in table 1 suggests that an investor would make tranched payments as a percentage of capital cost estimates against the milestones as indicated in table 2. The tranche percentages where chosen as they best reflected to keep the projected cash flows positive.

Number	Month	Milestone	Tranche
	1	Upfront payment for working capital and to fund construction of pilot plant	30%
1	4	Secure first paid pilot project	20%
2	9	Second paid pilot plant secured, first pre-feasibility study commissioned	20%
3	16	Third pilot study commissioned	20%
4	21	Three pilot studies run, at least two successfully. At least two feasibility studies underway for clients	10%

Table 2: Milestone Table

4.1.2 Cash Flows

As indicated in figure 13, Earth pilot plant shows a strong solvency forecast by year 11. These projections will result in positive dividends for investors. As these amounts are all positive Earth will be able to invest in new lines of business operations such as developing new plants and retire any debts. A full break down of the cash flows can be seen in Annex C.

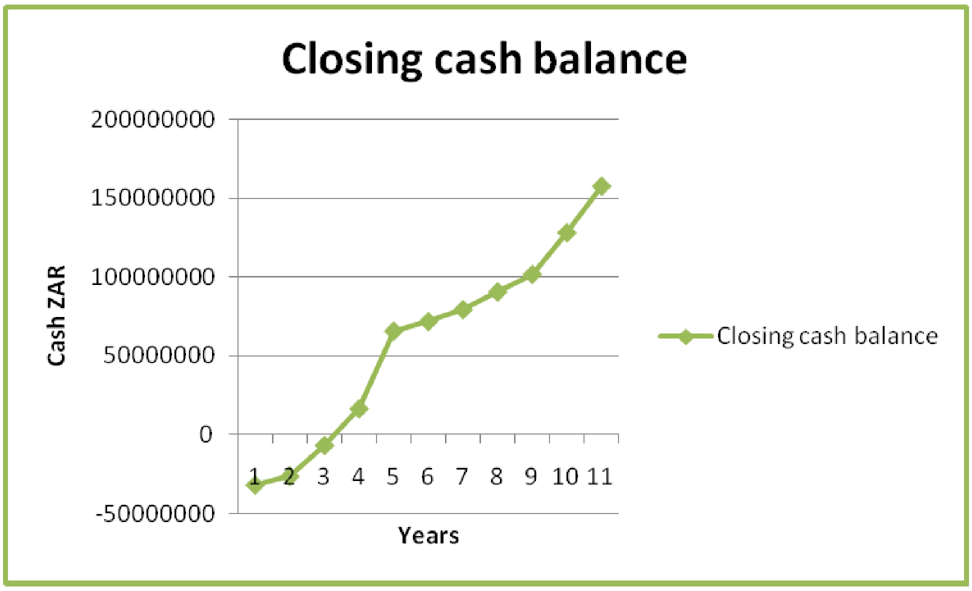

Figure 13: Closing cash balance Pilot

Stage 2: Appraisal

4.2.1 The project objectives and scope

Earth is seeking working capital, by offering a percentage of the equity in the development of the IX treatment plant. This plant will provide an economic and sustainable solution to AMD, specifically in the mining sector.

The development of a new plant will result in:

- A better means for mines to access resources in sustainable and effluent manner
- A means to mitigate against the impeding AMD crises in Gauteng
- For mine workers and their families to have access to water and fertilizer that will result in sustainable employment post mine closure

The new plant will allow Earth a larger scale to convert AMD to portable water and the sealable by products including fertilizer. A second opportunity for Earth is using the IX platform in the metallurgical side of mining. By improving the process flows by extracting more mineral that is desired and resulting in less reporting to the dumps where it can leach back into the environment. The third opportunity lies in the complete treatment of secondary sources. This is insured by the extraction of metals and other minerals are taken into solution during the IX process and extracting these separately for resale.

4.4.2 Identification of funding options

The following have been identified as funding options:

- Infrastructure funds such as the Development Bank of South Africa
- Private equity funds that have interest in the mining sector
- Mining companies that have their own funds under management
- Royalties on a license to use Earth's intellectual capital. This could be one or both a design fee which will be once off or a license to operate technology which would be related to the throughput of the plant
- The DME and DWAE to understand how mining Liability Funds may be released for the sort of projects Earth is developing

4 .2.3 Risk Analysis

Swot analysis has been used to asses the risk of the investment opportunity being offered by Earth.

	Strengths	Weakness	Opportunity	Threat
Nature	Use of state of the art, patented technology	Complex business with regulatory over layer	Immediate need for water solutions in SA	Competition is further ahead
Response		Speaking to DWAE and other stakeholders-keeping on top of issues		Speaking to government and stakeholders for inclusion
Nature	Diversified approach with AMD and processing opportunities	Start up with limited capital in risk averse industry	Government concedes it needs help in water needs	If the economics are unattractive, Earth will require government intervention
Response		Raising venture funds until Earth has momentum		Understanding the needs at a national level will rewrite the simple economics position
Nature	Strong Board and Executive team	Skills shortage in technical market	Mines are being fined for transgression	Earth is capital intensive
Response		Have close work ties with universities and other companies		Mitigated by water being an essential resource
Nature	Technical results show the approach to be sound and the economics can only improve	Need to balance the short term need of mines with sustainable solutions	Global market for secondary processing	If markets turn, clients may choose better established approaches with poorer performances
Response		Work closely with mines		Move quickly to first commercial installation

Table 3: SWOT Analysis

4.2.4 The feasibility study and investigation into the economics

4.2.4.1 Pilot's Payback period

The payback period method has been used as it will enable the investor to see the time taken to gain a financial return on the original investment. Even though the uncertainty of the forecasted cash flow has been reduced it still does not take the time value of money into account. As seen in figure 14, an investor could expect Earth to break even with the initial investment in year 4.5 with regard to the pilot plants operation.

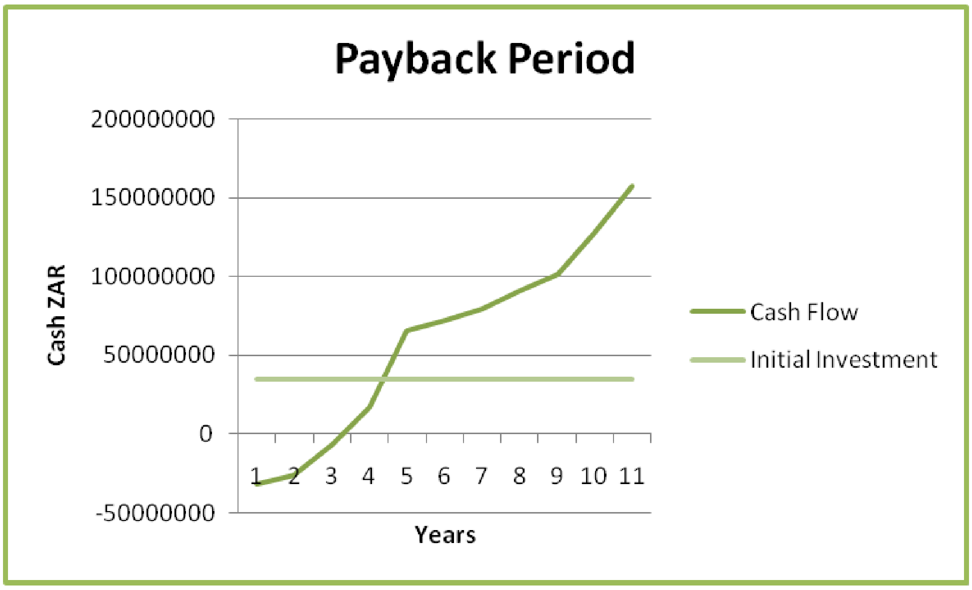

Figure 14: Payback Period Pilot

4.2.4.2 Pilot's Return on Investment

The ROI considers the cash flow over the whole project. The total outcome of the project has now been expressed as a percentage that will easily be understood by management and an investor. The ROI calculated in table 4 indicates that an investor can expect a 31% return on their initial investment.

Return on Investment Pilot		
Profit	122730000	
Annual Profit	11157272.73	
Return on Investment	31.87792208	%

Table 4: Return on Investment Pilot

4.2.4.3 Pilot's Net Present Value

It was decided to use a 15% interest rate with calculating the NPV. The 15% was chosen as it would reflect the way in which Earth must earn on the investment to satisfy the investors.

Years	Cash Flow	Discount factor	Present value
0	-35000000	1	-35000000
1	-31756000	0.8696	-27615017.6
2	-26217000	0.7561	-19822673.7
3	-6677000	0.6575	-4390127.5
4	16593000	0.5718	9487877.4
5	65913000	0.4972	32771943.6
6	71867000	0.4323	31068104.1
7	79481000	0.3759	29876907.9
8	90704000	0.3269	29651137.6
9	101807000	0.2843	28943730.1
10	128279000	0.2472	31710568.8
11	157730000	0.2149	33896177
		Total NPV	140578627.7

Table 5: Net Present Value Pilot

As calculated in table 5 an investor can expect his/her investment of 35million will add 140million rands worth to Earth.

4.2.4.4 Pilot's Internal Rate of Return

The IRR has been found to lie between 30 and 35% by use of the trial and error method calculated in table 6.

Using interest rate of 30%			
Years	Cash Flow	Discount factor	Present value
0	-35000000	1	-35000000
1	-31756000	0.7692	-24426715.2
2	-26217000	0.5917	-15512598.9
3	-6677000	0.4552	-3039370.4
4	16593000	0.3501	5809209.3
5	65913000	0.2693	17750370.9
6	71867000	0.2072	14890842.4
7	79481000	0.1594	12669271.4
8	90704000	0.1226	11120310.4
9	101807000	0.0943	9600400.1
10	128279000	0.0725	9300227.5
11	157730000	0.0558	8801334
		Total NPV	11963281.5

Using interest rate of 35%			
Years	Cash Flow	Discount factor	Present value
0	-35000000	1	-35000000
1	-31756000	0.7407	-23521669.2
2	-26217000	0.5487	-14385267.9
3	-6677000	0.4064	-2713532.8
4	16593000	0.3011	4996152.3
5	65913000	0.223	14698599
6	71867000	0.1652	11872428.4
7	79481000	0.1224	9728474.4
8	90704000	0.0906	8217782.4
9	101807000	0.0671	6831249.7
10	128279000	0.0497	6375466.3
11	157730000	0.0368	5804464
		Total NPV	-7095853.4

Table 6: Internal Rate of Return Pilot

Stage 3: Investment Planning

4.3.1 Attracting the investors

The skills that are on offer and the expertise of Earth allows for a modular approach that is very flexible. It is based on the IX core but still allows Earth to customise the front end depending on the inputs and the back-end depending on the products that a client requires.

The value proposition for a client is graphically depicted in figure 15.

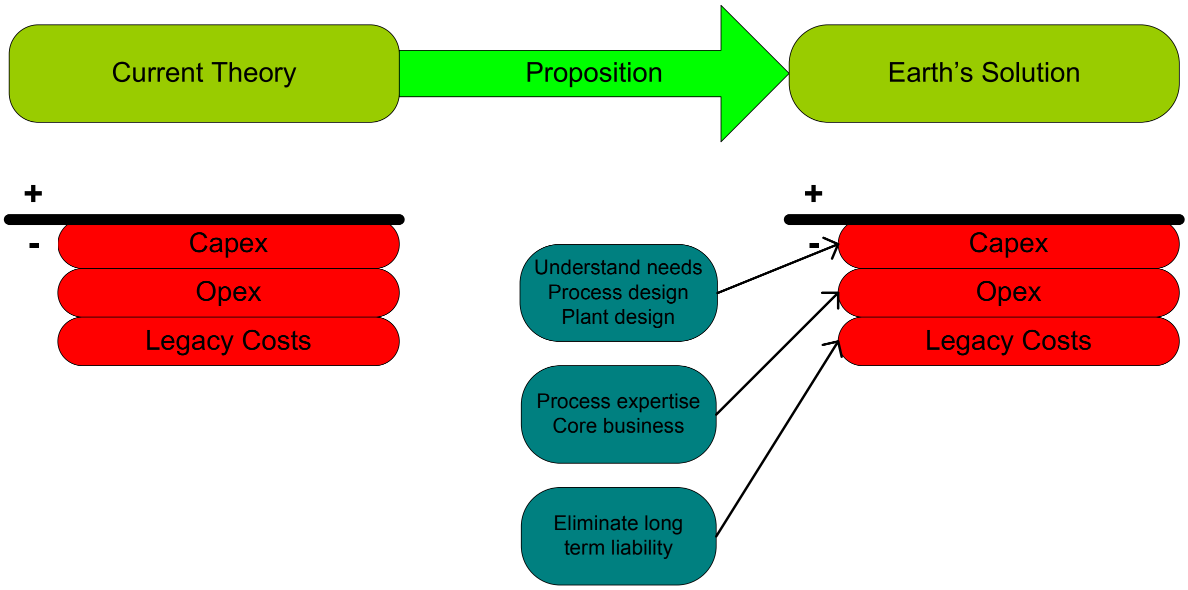

Figure 15: Earth Value position

Figure 15 can be summarised as Earths business philosophy, by reducing the capital, operational and legacy costs of polluted effluents and creating revenue streams. As these solutions have been designed to reduce costs and environmental issues and make them a main priority in whichever industry it operates in.

The business approach for Earth has been summarized in table 7.

Gate	Activity	Commercial approach
1	General interest is established	Marketing effort, technical work, proposal development
2	Problem identification and problem statement	
3	Minimum royalty level agreement	
4	Proposal	
	Acceptance of budget, timeline etc	
5	Research: inputs, chemical, flow diagram, markets	Earth reimbursed for technical work
	Scoping study	
6	Pre-feasibility study: choice but no alterations	Reimbursed technical work with client imposed inputs
	In principle go-ahead	
7	Feasibility	
	Final go-ahead	
8	Construction	Contract
	Commissioning	
9	Operation	Annuity income

Table 7: Earth's Gate business model

4.3.2 Companies that can be targeted for investment

These companies have been identified as ones which can profit from Earths approach to AMD treatment:

- Rand Uranium
- Anglo Coal
- Eskom
- Sasol
- BHP Billiton
- Coal Tech
- Rand Water
- Optimum Coal
- Battery Manufacturers

4.3.3 The market penetration

It has been assumed by Earth that a 40% market penetration can be achieved over an 11 year period. It is believed this market penetration is realistic as there are effectively only two main competitors in the market and the AMD problem is a current issue. The AMD problem in South Africa which is emphasised by the news article in Annex D shows that there is a gap in the market to facilitate in effluent free mining operations.

Taking into consideration the economic value of water run offs from mining operation in South Africa. The total of the 900 million litres per day which is believe to be produced in the gold, coal and base metal mines in South Africa, if Earth assumes a value of R2/kl (which is the price that Rand Water pays DWAE for water from Lesotho), the value is found to be R680 million per annum. From this deduction Earth can assume to sell water at the average price it is sold to consumers which is closer to R5-R7 per kl. To show how elastic this market is, Namwater will be selling water from its desalination plants to uranium plants for R20/kl.

The market is very elastic which will be sufficient enough to absorb the secondary process products such as ammonium sulphate and the mixed metal nitrate.

There is a current declining trend in the amount of resources in South Africa, only the chrome, coal and platinum mining industries are expected to grow until 2020. The other mining industries are in decline and the mining operations are shutting down, which will be more prevalent from 2020 onwards. When a mine shuts down its operations, AMD is still an issue and the opportunities in this market will only grow in the future to come. This is where Earth can offer a true mine closure solution.

The approach by Earth in the treatment of AMD water is a commercial competitive approach to AMD with zero effluent run offs.

Stage 4: Asset Creation

4.4.1 Detailed Design

In figure 16 is an over view of the design of the pilot plant. It indicates the different stages and what is done in the treatment process of AMD water.

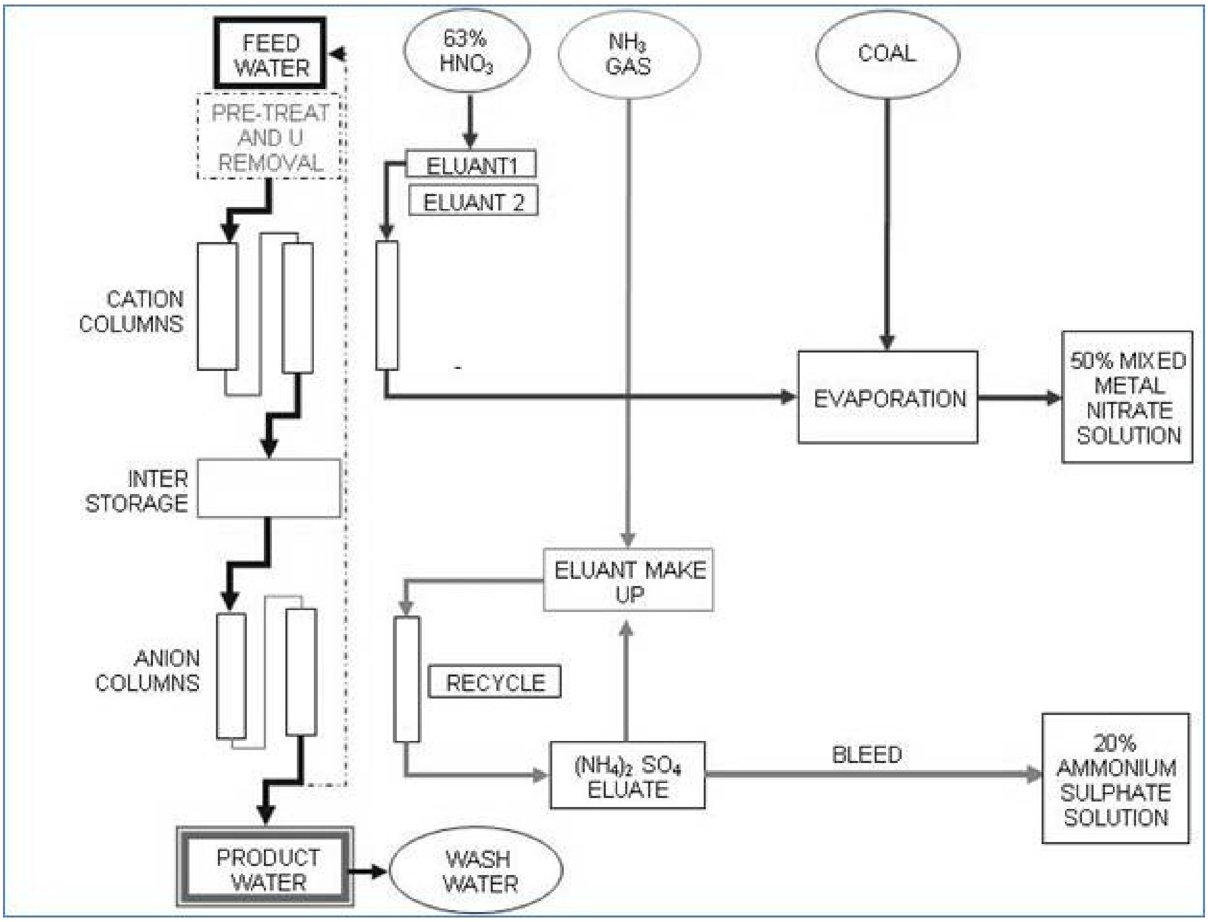

Figure 16: Detailed Design

Stage 5: The comparison between a labour intense and automated plant

4.5.1 Cash Flows

The initial investment of the automated plant is higher when compared to the labour intense plant. As seen in figure 17, the automated plant even with the larger capital requirement will result in a larger closing cash balance.

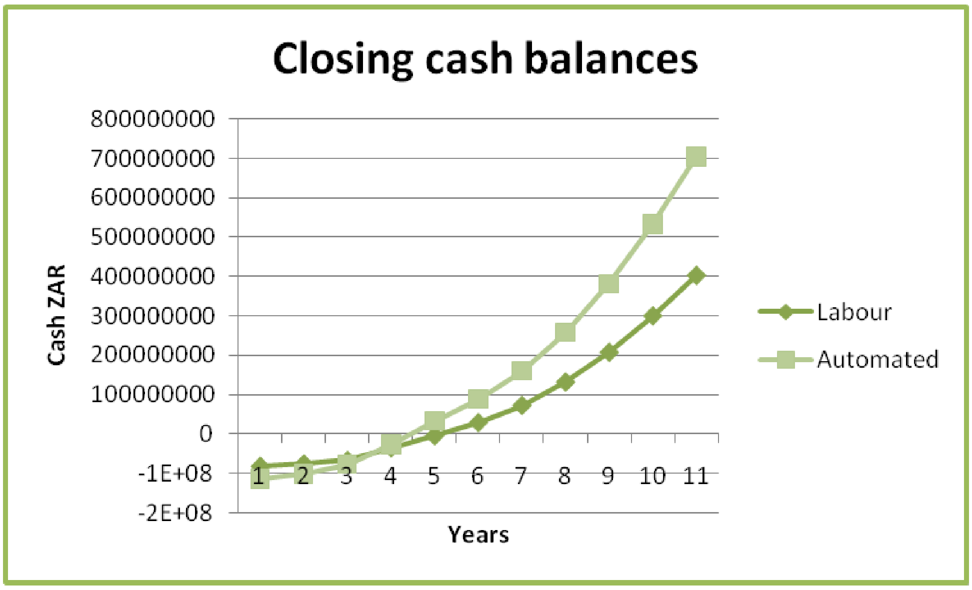

Figure 17: Labour intense and automated plant cash flows

To conclude on figure 17, the automated plant can be expected to make a larger profit as it output and efficiency will be superior when compared to the labour intense plant.

4.5.2 Payback period

The payback method is appropriate in the comparison of the two plants as the technologies involved are of a high standard that are continuously changing in this modern age. It will enable investors to better understand, as it will summarises the results in terms they can understand.

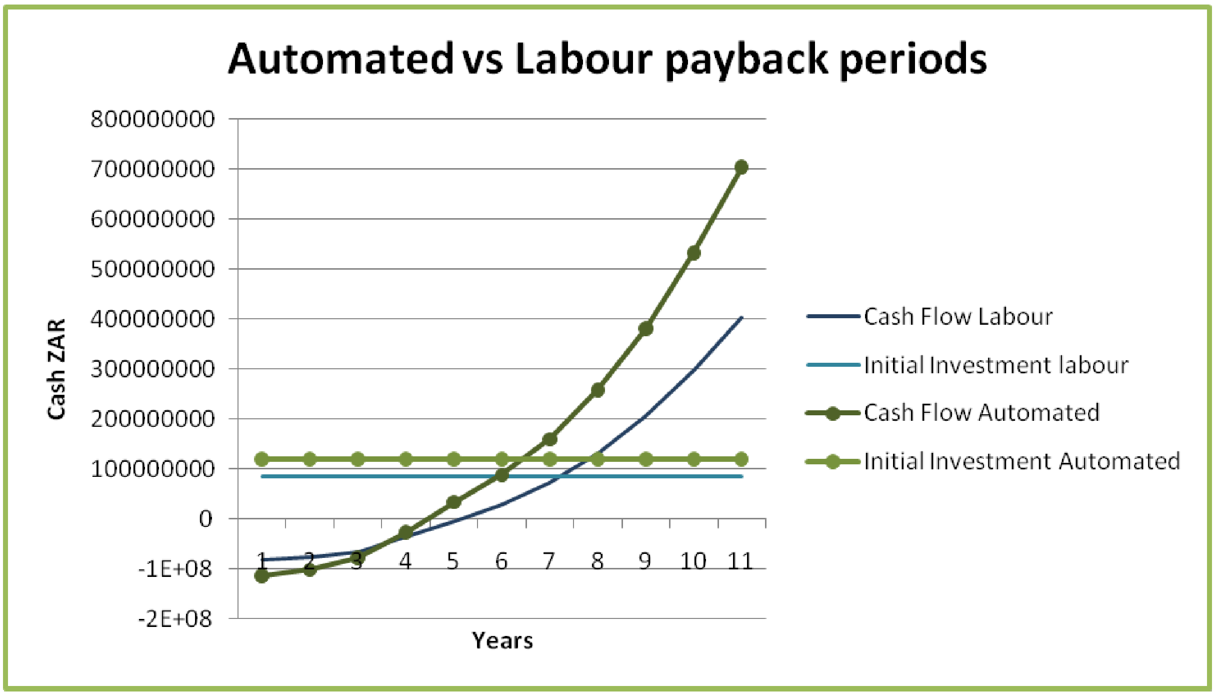

Figure 18: Automated vs Labour payback periods

The automated plants payback period is 6.3 years and the labour intense plant is 7.4 years. The automated plant payback period is shorter as the result of the higher output that can be expected from this plant.

4.5.3 Return on Investment

The return on investment takes the entire projects cash flow into consideration. Each plants ROI has been calculated separately and the outcomes for each plant has been expressed as a profit and percentage return on the initial investments made.

Return on Investment labour intense		
Profit	316829823	
Annual Profit	28802711.15	
Return on Investment	33.88554253	%

Table 8: Return on Investment labour intense

Return on Investment automated		
Profit	584270499	
Annual Profit	53115499.87	
Return on Investment	44.26291656	%

Table 9: Return on Investment automated

A 44% return can be expected from an investor's point of view for the automated plant and a annual profit of R28802711.15. This is a substantial return on the initial investment that was made.

4.5 Discounted Cash flow

This technique has been used as it takes the time value of money into consideration. This can be shown by calculating the net present value and internal rate of return. This DCF technique enables a decent comparison between the automated and labour intense plants as the initial investments and projected cash flows are different.

4.5.1 The Net Present Value comparison

The 15% interest rate has been used in calculating the NPV in the comparison of the two plants. The NPV will indicate the value added to Earth by undertaking the development of either plant. This is done by giving a more accurate forecast as it allows for inflation.

Net Present Value of labour intense			
Using a interest rate of 15%			
Year	Cash flow	Discount Factor	Present Value
0	-85000000	1	-85000000
1	-82062000	0.8696	-71361115.2
2	-76159600	0.7561	-57584273.56
3	-67047192	0.6575	-44083528.74
4	-35248049	0.5718	-20154834.21
5	-4306460.1	0.4972	-2141171.964
6	28917673	0.4323	12501110.04
7	72259936.7	0.3759	27162510.21
8	131651019	0.3269	43036718.17
9	206875501	0.2843	58814705.05
10	299193556	0.2472	73960647.03
11	401829823	0.2149	86353228.9
		Total NPV	21503995.7

Table 10: Net Present Value of labour intense

Net Present Value of Automated plant			
Using a interest rate of 15%			
Year	Cash flow	Discount Factor	Present Value
0	-120000000	1	-120000000
1	-113332000	0.8696	-98553507.2
2	-101826600	0.7561	-76991092.26
3	-77125492	0.6575	-50710010.99
4	-26300688.6	0.5718	-15038733.76
5	33420021.5	0.4972	16616434.69
6	88345172.88	0.4323	38191618.24
7	160339222.9	0.3759	60271513.87
8	257776349.2	0.3269	84267088.55
9	381348351.2	0.2843	108417336.2
10	532858011.2	0.2472	131722500.4
11	704270498.6	0.2149	151347730.2
		Total NPV	229540877.9

Table 11: Net Present Value of Automated plant

The NPV of the automated plant is calculated to be R229540877.7 which is favourable when compared to the R21503995.7 NPV of the labour intense plant.

4.5.2 The Internal Rate of Return comparison

The IRR is the value of the discount factor when the NPV is zero. The method used in calculating the IRR was the trial and error method.

Labour intense plant Using interest rate of 12%			
Years	Cash Flow	Discount factor	Present value
0	-85000000	1	-85000000
1	-82062000	0.8929	-73273159.8
2	-76159600	0.7972	-60714433.12
3	-67047192	0.7118	-47724191.27
4	-35248049	0.6355	-22400134.91
5	-4306460.1	0.5674	-2443485.463
6	28917673	0.5066	14649693.14
7	72259936.7	0.4523	32683169.37
8	131651019	0.4039	53173846.64
9	206875501	0.3606	74599305.8
10	299193556	0.322	96340325.01
11	401829823	0.2875	115526074
		Total NPV	95417009.43

Labour intense plant Using interest rate of 18%			
Years	Cash Flow	Discount factor	Present value
0	-85000000	1	-85000000
1	-82062000	0.8475	-69547545
2	-76159600	0.7182	-54697824.72
3	-67047192	0.6086	-40804921.05
4	-35248049	0.5158	-18180943.49
5	-4306460.1	0.4371	-1882353.712
6	28917673	0.3704	10711106.08
7	72259936.7	0.3139	22682394.13
8	131651019	0.266	35019171.1
9	206875501	0.2255	46650425.56
10	299193556	0.1911	57175888.54
11	401829823	0.1619	65056248.29
		Total NPV	-32818354.27

Table 12: Labour intense plant's Internal Rate of Return

Automated plant Using interest rate of 22%			
Years	Cash Flow	Discount factor	Present value
0	-120000000	1	-120000000
1	-113332000	0.8197	-92898240.4
2	-101826600	0.6719	-68417292.54
3	-77125492	0.5507	-42473008.44
4	-26300689	0.4514	-11872130.85
5	33420021.5	0.37	12365407.95
6	88345172.9	0.3033	26795090.93
7	160339223	0.2486	39860330.8
8	257776349	0.2038	52534819.96
9	381348351	0.167	63685174.65
10	532858011	0.1369	72948261.73
11	704270499	0.1122	79019149.94
		Total NPV	11547563.74

Automated plant Using interest rate of 24%			
Years	Cash Flow	Discount factor	Present value
0	-120000000	1	-120000000
1	-113332000	0.8065	-91402258
2	-101826600	0.6504	-66228020.64
3	-77125492	0.5245	-40452320.55
4	-26300688.6	0.423	-11125191.29
5	33420021.5	0.3411	11399569.33
6	88345172.88	0.2751	24303757.06
7	160339222.9	0.2218	35563239.63
8	257776349.2	0.1789	46116188.87
9	381348351.2	0.1443	55028567.08
10	532858011.2	0.1164	62024672.5
11	704270498.6	0.0938	66060572.77
		Total NPV	-28711223.25

Table 13: Automated plant's Internal Rate of Return Automated

The IRR for the labour intense plant is found between 12 and 18% and the automated plants IRR is between 22 and 24%. The automated plant's IRR is the favourable IRR as it is the highest.

4.6 Conclusion on the economic results

The comparison between the labour intense and automated plants projected cash flows proves that the automated plant will be the economically viable solution.

The automated plant even with the higher initial capital requirements, payback period is 1.1 years shorter when compared to the labour intense plant. This is the result of the automated plant having a larger output volume of secondary processes where most of the money is expected to be made. The net present value of the automated plant is R 229540877.9 and the labour intense plant is R 21503995.7.

The internal rate of return for the automated plant was found to be between 22 and 24% which is higher compared to the labour intense plant and has the better possibility of being economically profitable. The main reason why the automated plant is the favourable choice is when comparing the return on investment. The automated plants ROI is calculated to be 44% which is an encouraging return on such a large investment.

The automated plant will be the optimal choice for Earth to develop as the returns are favourable and are more inclined to attract investors that are targeted.

Conclusion

In any new technology tests must be run to prove the effectiveness of it. The technology that was developed by Earth has been tested by means of pilot plants that have proved the effectiveness of the process.

Once the problem that Earth is being faced with was better understood, an idea of what was required was identified. The type of feasibility study to be conducted was selected from articles about which type of feasibility studies can be done and what each proves. The Economic Feasibility study was finally chosen as it would best solve the issues that Earth is facing by giving figures that will take the time of money into consideration.

Through the use of the Economic Feasibility study, the pilot plant operations where proven to be successful. The automated plant will be the favourable commercial plant to build as shown when comparing it with the labour intense plant.

The implementation of this feasibility study will benefit Earth by:

- Lowering the implementation costs involved for developing a full commercial plant
- Increasing the attractiveness of the proposal for investors
- Reducing the risks involved
- Improving Earth's ability to take full advantage of the gap in the market
- Improving the impact the proposal will have on various interest groups
- Improving Earth's decisions timeline

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Annex A: Review of AMD

(DOYLE, Dr Richard, 2009) "When rock surfaces are exposed to air and rain, a reaction can occur with the elements in the rock which results in a change in the characteristics of the water that drains off. If the rock contains sulphides, a natural oxidation process can acidify the water. This is known as acid drainage (also acid rock drainage (ARD) or acid mine drainage (AMD)). As the water becomes more acidic, its capacity to leach out other elements from the rock, such as metals, increases. The resulting drainage can become very acidic and contain a number of harmful constituents. In some cases, elements from the rock can leach out into contact water without acidification and result in water contamination – this is known as metal leaching (ML). In either case, polluted water drains away from the exposed rock and can have significant impacts on surrounding water bodies (rivers, lakes, coastal areas, and ground-water) and the wildlife or people who come in contact with these sources. Although this is a natural process, mining activities can trigger this phenomenon by exposing large surface areas of rock to water and oxygen. Rock is exposed on the walls of open pits and underground structures - but the most significant newly exposed rock surfaces are in the fragmented pieces of waste rock that are removed from the ground and placed in dumps."

Annex B: Review of ion-exchange

(DOYLE, Dr Richard, 2009) Ion-exchange is a process that has been developed to remove or add low levels of impurities or additives to dilute solutions. It involves the use of specially designed resin particles that are treated in such a way that they “exchange” ions - giving the solution something it needs in exchange for something it is beneficial for it to give up.

For ion exchange to take place the solid must have an open permeable molecular structure so that ions can move freely in and out of the structure. All ion exchangers (resins) are insoluble in water and organic solvents and have active ions that exchange reversibly with other ions in a surrounding solution without any significant physical changes occurring to the ion exchanger. Conventional ion exchange technology makes use of synthetic, organic polymers as ion exchangers.

Ion exchange resins consist of two structural parts; the matrix and the functional group. The matrix is a flexible three-dimensional cross-linked hydrocarbon framework and the functional group is hydrophilic and consists of either acidic or basic ionisable functional groups chemically bonded to the matrix. The organic matrix is fixed, insoluble and chemically inert. The functional group, however, consists of fixed ions that are firmly attached to the matrix by covalent bonds as well as ions of opposite charge that are bound by electrostatic forces to the fixed ions. The counter ions are the active ions that will exchange with ions of the same charge in the surrounding solution.

Demineralisation is normally preceded by a clarification step to remove any insoluble solids that may block the resin beds. Clarification of water using ion-exchange is followed by demineralisation using two-step ion-exchange. The first step is usually the removal of cations using a cationic resin in the hydrogen form. Cationic removal is normally in the leading position to inhibit the formation of undesirable precipitates common to demineralisation with ion exchange. During cationic exchange metal-ions are removed from the influent and free acids are formed with the anions left behind in the effluent. Cationic demineralisation strips cations from solution releasing acid-forming hydrogen ions into the effluent. The second demineralisation step is the stripping of the anions such as sulphates using anionic resin in the hydroxide form. During this step the anions are exchanged with hydroxide ions, neutralising the acids in the influent. This combined process removes most of the ions from solution leaving demineralised water of reduced impurity concentrations;

$$H_{+\,cationic} + OH_{-anionic} \rightarrow H_2O$$

Annex C: Cash Flows

	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10	Year 11	Totals
Receipts												
Sales (Fees)	3120000	11700000	18900000	13750000	10000000	13500000	14500000	15500000	16500000	17500000	19500000	154470000
Sales - Royalties		1500000	8500000	18500000	48850000		1500000	4000000	3000000	18500000	21000000	125350000
New equity inflow	10000000	5000000										15000000
Total receipts	13120000	18200000	27400000	32250000	58850000	13500000	16000000	19500000	19500000	36000000	40500000	294820000
Payments												
Accounting/ CFO services	150000	180000	180000	200000	200000	200000	200000	200000	200000	300000	350000	2360000
Airfares	60000	105000	100000	100000	100000		100000			100000	100000	765000
Attorney's fees	60000	60000	50000	50000	100000		100000			50000	100000	570000
Bank charges	22000	22000	20000	20000	20000	6000	6000	7000	7000	8000	9000	147000
Capital purchases (Equipment)	3700000	3000000										
Insurance	84000	84000	160000	100000	100000	100000	100000	140000	150000	170000	190000	1378000
Miscellaneous	120000	120000	120000	100000	100000	30000	30000	30000	30000	100000	120000	900000
Motor vehicle expenses	240000	240000	240000	200000	200000	60000	60000	60000	60000	200000	250000	1810000
Patenting	230000	230000	80000	500000	1000000	20000	20000	20000	20000	500000	1000000	3620000
Professional fees	100000	100000	50000				50000					300000
Reagents/consumables	330000	100000	120000	100000	100000	100000	100000	100000	130000	130000	130000	1440000
Rental/office expense	210000	300000	480000	500000	500000	50000	600000	600000	600000	600000	700000	5140000
Repairs and maintenace	120000	140000	80000	70000	70000	20000	60000	60000	60000	70000	70000	820000
Marketing - website etc	150000	100000	80000	100000	100000	20000	20000	20000	100000	100000	100000	890000
Salaries and wages - Management	1440000	1680000	1800000	1600000	1600000	1600000	1600000	1700000	1700000	1700000	2000000	18420000
Salaries and wages - Projects	3370000	5770000	3800000	4800000	4800000	4800000	4800000	4800000	4800000	4900000	5200000	51840000
Salaries and wages - Admin etc	120000	120000	140000	140000	140000	140000	140000	140000	140000	150000	180000	1550000
Telephone and internet	150000	310000	360000	400000	400000	400000	400000	400000	400000	450000	550000	4220000
Total payments	10656000	12661000	7860000	8980000	9530000	7546000	8386000	8277000	8397000	9528000	11049000	96170000
Cash flow surplus/deficiet (-)	3244000	5539000	19540000	23270000	49320000	5954000	7614000	11223000	11103000	26472000	29451000	192730000
Opening cash balance	-35000000	-31756000	-26217000	-6677000	16593000	65913000	71867000	79481000	90704000	101807000	128279000	
Closing cash balance	-31756000	-26217000	-6677000	16593000	65913000	71867000	79481000	90704000	101807000	128279000	157730000	

Table 14: Cash Flow Pilot Plant

Receipts	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10	Year 11	Totals
Clean water sales	2100000	2730000	5187000	9855300	10840830	9648339	12542840	17559976	17208777	18929655	26501516	133104233
Ammonium Sulphate	2500000	4250000	8075000	15342500	20252100	19644537	27502352	36853151	51594412	62429238	68672162	317115453
Mixed Metal Nitrate	1500000	2250000	4275000	8122500	9828225	9808569	12751139	16576481	21549425	30169195	33186115	150016648
Toll cost to mine	1800000	3060000	5814000	11046600	11819862	10519677	11571645	15274571	18634977	22921022	27505226	139967580
Total receipts	7900000	12290000	23351000	44366900	52741017	49621121	64367976	86264180	108987591	134449110	155865019	740203915
Payments												
Nitric acid	320000	448000	582400	780416	936499	1217449	1460939	1782345	1746698	2270708	2951920	14497375
Ammonia	210000	336000	561120	937070	1218192	1461830	1900379	2660530	3458689	4565470	5113326	22422606
Electricity	520000	676000	1128920	1885296	2450885	3186151	4205719	5467435	8201152	9841383	12990625	50553568
Labour	650000	910000	1519700	2537899	2791689	3350027	4690037	5721846	7438399	9669919	11797301	51076817
Resin	650000	845000	1411150	2356621	3063607	3737600	4485120	5965210	7754773	9305727	12097445	51672253
Insurance	120000	147600	246492	411642	440457	572594	687112	838277	1089760	1416688	1700026	7670646
Maintenace	100000	143000	238810	398813	638100	625338	750406	840455	1176637	1553160	2019108	8483827
Purchase of equipment			5500000		6500000			700000				12700000
Bank charges	22000	22000	20000	20000	20000	6000	6000	7000	7000	8000	9000	147000
Salaries and wages - Management	1440000	1680000	1800000	1600000	1600000	1600000	1600000	1700000	1700000	1700000	2000000	18420000
Rental/office expense	210000	300000	480000	500000	500000	50000	600000	600000	600000	600000	700000	5140000
Telephone and internet	150000	310000	360000	400000	400000	400000	400000	400000	400000	450000	550000	4220000
Patenting	230000	230000	80000	500000	1000000	20000	20000	20000	20000	500000	1000000	3620000
Professional fees	100000	100000	50000				50000					300000
Salaries and wages - Admin etc	120000	120000	140000	140000	140000	140000	140000	140000	140000	150000	180000	1550000
Miscellaneous	120000	120000	120000	100000	100000	30000	30000	30000	30000	100000	120000	900000
Total Payments	4962000	6387600	14238592	12567757	21799428	16396988	21025712	26873097	33763109	42131055	53228753	253374092
Cash flow surplus/deficiet (-)	2938000	5902400	9112408	31799143	30941589	33224133	43342264	59391082	75224482	92318055	102636267	486829823
Opening Cash balance	-85000000	-82062000	-76159600	-67047192	-35248049	-4306460	28917673	72259937	131651019	206875501	299193556	
Closing cash balance	-82062000	-76159600	-67047192	-35248049	-4306460	28917673	72259937	131651019	206875501	299193556	401829823	

Table 15: Cash Flow Labour Intense

Receipts	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10	Year 11	Totals
Clean water sales	3000000	3900000	7410000	14079000	15486900	13783341	17918343	25085681	24583967	27042364	37859309	190148905
Ammonium Sulphate	3690000	6273000	11918700	22645530	29892100	28995337	40593471	54395251	76153352	92145556	101360112	468062409
Mixed Metal Nitrate	1800000	2700000	5130000	9747000	11793870	11770282	15301367	19891777	25859310	36203034	39823338	180019978
Toll cost to mine	2400000	4080000	7752000	14728800	15759816	14026236	15428860	20366095	24846636	30561362	36673635	186623440
Total receipts	10890000	16953000	32210700	61200330	72932686	68575196	89242041	119738804	151443265	185952316	215716393	1.025E+09
Payments												
Nitric acid	320000	448000	582400	780416	936499	1217449	1460939	1782345	1746698	2270708	2951920	14497375
Ammonia	210000	336000	561120	937070	1218192	1461830	1900379	2660530	3458689	4565470	5113326	22422606
Electricity	520000	676000	1128920	1885296	2450885	3186151	4205719	5467435	8201152	9841383	12990625	50553568
Labour	150000	210000	350700	585669	644236	773083	1082316	1320426	1716554	2231520	2722454	11786958
Resin	650000	845000	1411150	2356621	3063607	3737600	4485120	5965210	7754773	9305727	12097445	51672253
Insurance	120000	147600	246492	411642	440457	572594	687112	838277	1089760	1416688	1700026	7670646
Maintenace	100000	143000	238810	398813	638100	625338	750406	840455	1176637	1553160	2019108	8483827
Purchase of equipment			200000		300000			700000			450000	1650000
Bank charges	22000	22000	20000	20000	20000	6000	6000	7000	7000	8000	9000	147000
Salaries and wages - Management	1440000	1680000	1800000	1600000	1600000	1600000	1600000	1700000	1700000	1700000	2000000	18420000
Rental/office expense	210000	300000	480000	500000	500000	50000	600000	600000	600000	600000	700000	5140000
Telephone and internet	150000	310000	360000	400000	400000	400000	400000	400000	400000	450000	550000	4220000
Patenting	230000	230000	80000	500000	1000000	20000	20000	20000	20000	500000	1000000	3620000
Professional fees	100000	100000	50000				50000					300000
Total Payments	4222000	5447600	7509592	10375527	13211975	13650045	17247991	22301678	27871263	34442656	44303906	200584233
Cash flow surplus/deficiet (-)	6668000	11505400	24701108	50824803	59720710	54925151	71994050	97437126	123572002	151509660	171412487	824270499
Opening Cash balance	-120000000	-113332000	-101826600	-77125492	-26300689	33420021	88345173	160339223	257776349	381348351	532858011	
Closing cash balance	-113332000	-101826600	-77125492	-26300689	33420021	88345173	1.6E+08	257776349	381348351	532858011	704270499	

Table 16: Cash Flow Automated Plant

Annex D: News articles relating to the AMD issue in South Africa

Uasa worried about Jhb acid water

2010-07-22 19:23

Johannesburg - Trade union Uasa on Thursday expressed dismay at government's failure to act sooner regarding the highly acidic mine water said to be rising up under Johannesburg.

Related Links

Acid water threatens Joburg
Acid seas wrecking coral

"While the union welcomes that the water affairs department at long last acknowledges the crisis at hand, it is dismayed that nothing has been done sooner," United Association of SA spokesperson André Venter said in a statement.

He said Uasa was amazed and irritated that Parliament's water affairs portfolio committee expressed shock at hearing about the rising levels of acidic mine water, because "the alarm had frequently been sounded in the media since 2002 when the acid mining drainage started decanting on the West rand".

Venter said the union had presented the "dangerous situation" to Connie September, adviser to the minister of water affairs in May, met with the department's deputy director water quality management, Marius Keet, and wrote to Minister in the Presidency Trevor Manuel.

"Save for an acknowledgement of receipt, no response (from Manuel) has been received to date.

"The extent and details of the threat should be well-known by now."

Uasa had since hosted two widely publicised water security seminars, with panels of experts highlighting the same problem.

Parliament's water affairs portfolio committee was told on Wednesday that millions of litres of highly acidic mine water was rising up under Johannesburg and, if left unchecked, could spill out into its streets some 18 months from now.

The acid water is currently about 600m below the city's surface, but is rising at a rate of between 0.6m and 0.9m a day, Keet told MPs.

"(It) can have catastrophic consequences for the Johannesburg central business district if not stopped in time. A new pumping station and upgrades to the high-density sludge treatment works are urgently required to stop disaster," he warned.

\- SAPA

Jhb acid mine water 'ridiculous'

2010-08-10 21:40

Parliament - Minister in the Presidency Trevor Manuel on Tuesday warned MPs there were "private sector interests" driving debate on the environmental threat to Johannesburg posed by rising acid mine water.

Related Links

MPs: Acid water a big problem
Joburg water safe to drink
Parts of Joburg without water

"What we need is a rational discussion... informed by an empirical basis, because the idea that there will be acid mine drainage running through the streets of Johannesburg next week, and that we should all walk around in gum boots, is completely ridiculous."

Manuel was responding in the National Assembly to a statement made earlier by Independent Democrats MP Lance Greyling, who told the House an environmental crisis was unfolding in Gauteng, and decisive action was needed from government to arrest it.

"The central basin upon which Johannesburg sits is filling up with acid mine drainage at the rate of one metre a day, and unless a decision is taken within the next few weeks, we will not have the time to put in place the engineering solution to deal with the impending catastrophe."

Greyling called on the department of mineral resources to force mining companies to properly comply with all of their environmental responsibilities.

Last month, a senior government official told Parliament's water affairs portfolio committee that millions of litres of acid mine water, currently 600 metres below Johannesburg, was rising at a rate of between 0.6 and 0.9 metres a day.

Private sector interest

"(It) can have catastrophic consequences for the Johannesburg central business district if not stopped in time. A new pumping station and upgrades to the high-density sludge treatment works are urgently required to stop the disaster," water affairs deputy director water quality management, Marius Keet, told MPs at the time.

In the House on Tuesday, Manuel appealed for "rational" discussion on the issue.

"I just want to make an appeal that we try and be rational because it does appear that there is all manner of private sector interest driving particular agendas here...

"There are private sector interests that we need to guard against and we can take rational decisions... it's a complex set of issues that we need a discussion about without pointing fingers this way and that because that's unlikely to allow us to resolve (it) in a reasonable period of time," he said.

Manuel did not name the private sector interests.

Earlier on Tuesday, Democratic Alliance MP Gareth Morgan called for an urgent debate on the rising acid mine water, noting that it would flow into the Johannesburg central business district "in early 2012" if something was not done.

- SAPA

MPs: Acid water a big problem

2010-07-27 16:03

Johannesburg - Acid mine water drainage in Springs, Gauteng was "more serious than expected", a group of MPs said on Tuesday.

Related Links

Miners die while waiting for pay

Miners not paid for months - union

"From visiting the area we can see the problem is more serious than expected," said chairperson of the water and environment affairs department's portfolio committee Maggie Sotyu.

The committee was visiting the Grootvlei mine, owned by Aurora Empowerment Systems.

Marius Keet, acting director of institutional establishment in the water affairs department, said acid mine water posed a serious threat to human and animal life, the environment, buildings and future mining, if left untreated.

"We are visiting the areas so we can assess what needs to be done to fix the problem and we will compile a report to hand to Parliament," Sotyu said.

Attending the walkabout at the mine on the East Rand were representatives from the departments of water affairs and mineral resources and Aurora.

- SAPA

Acid water threatens Joburg

2010-07-21 21:52

Johannesburg - Millions of litres of highly acidic mine water is rising up under Johannesburg and, if left unchecked, could spill out into its streets some 18 months from now, Parliament's water affairs portfolio committee heard on Wednesday.

The acid water is currently about 600m below the city's surface, but is rising at a rate of between 0.6 and 0.9m a day, water affairs deputy director water quality management Marius Keet told MPs.

"(It) can have catastrophic consequences for the Johannesburg central business district if not stopped in time. A new pumping station and upgrades to the high-density sludge treatment works are urgently required to stop disaster," he warned.

Speaking at the briefing, activist Mariette Liefferink, from the Federation for a Sustainable Environment, said the rising mine water posed an "enormous threat", which would become worse if remedial actions were further delayed.

"This environmental problem is second (in SA) only to global warming in terms of its impact, and poses a serious risk to the Witwatersrand as a whole. At the rate it is rising, the basin (under Johannesburg) will be fully flooded in about 18 months."

Mine drainage

She said the rising mine water had the same acidity as vinegar or lemon juice, and was a legacy of 120 years of gold mining in the region.

Acid water is formed underground when old shafts and tunnels fill up. The water oxidises with the sulphide mineral iron pyrite, better known as fool's gold. The water then fills the mine and starts decanting into the environment, in a process known as acid mine drainage.

Keet said the problem was not just confined to Johannesburg, which is located atop one of several major mining "basins" in the Witwatersrand, known as the Central Basin.

In 2002, acid mine drainage had started decanting from the Western Basin, located below the Krugersdorp-Randfontein area. The outflow had grown worse earlier this year after heavy rains, prompting his department to intervene.

However, a lack of treatment capacity in the area "compelled in-stream treatment as a short-term intervention".

This intervention saw the department pouring tons of lime, an alkali, into the Tweelopies Spruit in an effort to neutralise the acid mine water. This had led to problems with the resulting sludge that had formed in the water course.

Water Affairs is currently taking legal action against the mine, after it allegedly failed to comply with a departmental directive to treat the pumped water before discharging it.

On stopping the growing threat below Johannesburg, Keet said about R220m was needed to establish pump stations, pipelines and treatment works. Responding to a question, he said there were plans to tackle the problem.

"The idea is to build a pump station; the challenge is where the money will come from," he said.

Liefferink said if the acid mine water rose to the surface in Johannesburg's CBD, it posed a threat to the city's inhabitants, its buildings and the surrounding environment.

She told MPs that residents of many of Gauteng's poorer communities were living alongside, and in some cases on top of, land contaminated by mining activities. They were exposed to high concentrations of cobalt, zinc, arsenic, and cadmium, all known carcinogens, as well as high levels of radioactive uranium.

"In some cases, RDP houses are being erected next to radioactive dumps," she told MPs, who expressed shock and concern at the news.

Liefferink said acid mine drainage was exacerbating the problem, because it dissolved the heavy metals and precipitated them in water sources and wetlands, where people grew crops and abstracted water.

She also warned that some of the heavily polluted streams drained into the Vaal River system, and posed a threat to the region's water supply.

Liefferink, who backed up her presentation with a series of photographs showing, among other things, shacks erected on top of an old mine tailings dump, received a round of applause from MPs.

Mining started on the Witwatersrand about 120 years ago. More than 43 000 tons of gold and 73 000 tons of uranium have been extracted from the region's mines.

According to Liefferink, this mining activity has left a legacy of about 400km² of mine tailings dams and about six billion tons of pyrite tailings containing low-grade uranium.

"Waste from gold mines constitutes the largest single source of waste and pollution in South Africa... Acid mine drainage may continue for many years after mines are closed and tailings dams decommissioned," she said.