An Assessment of the Key Factors that Influence the Environmental Sustainability of a Large Inland Industrial Complex

Volume IV: Governance Assessment

G Mvuma, F Hooijman, AC Brent, SHH Oelofse & DEC Rogers

WATER RESEARCH COMMISSION

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Volume II: Inventory of inland salt production and key issues for integrated cleaner production for waste salt management at the Highveld mining and industrial complex **(TT 545/12)**
Volume III: Development and assessment of technological interventions for cleaner production at the scale of the complex **(TT 546/12)**
Volume IV: Governance assessment **(TT 547/12)**
Volume V: Linking technologies to governance **(TT 548/12)**

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EXECUTIVE SUMMARY

BACKGROUND

To a large extent, South Africa's economic prosperity is associated with a few large industrial complexes that are more often located close to inland mining areas that are water stressed. Since they are a hub of economic growth, there is a need to ensure that they generate wealth in a sustainable way. To achieve sustainable economic growth from such inland industrial complexes the means must be explored by which the industries within a complex can exchange waste as a resource and can integrate cleaner production techniques, e.g. application of cleaner production technologies for water conservation which is a key success factor for the long term economic viability of SA mining and processing industries.

RATIONALE

The concept of governance has gained grounds in modern society because of its importance in ensuring that decision-making, by those trusted with responsibility, is done with the principles of all-fairness and equity in terms of resource distribution; this then holds true where the sustainability of inland industrial complexes needs to be governed.

The study outlined in this report is water-related and builds on the frameworks of two previous studies: a study of the South African Council for Scientific and Industrial Research (CSIR) on integrated pollution control in the Mpumalanga Province; and a study of the United Kingdom Department for International Development (DFID) on governance in water services. These frameworks describe governance in water services in terms of: policies and legal management; institutional arrangements; administrative and economic issues; financial management; and technical compliance and levels of participation.

The findings are outlined in accordance with this description of governance, and specifically according to the key factors that relate to the sustainability of an inland industrial complex: meeting the present needs for energy, namely the availability and affordability of energy; maintaining a resilient energy economy in South Africa in terms of resource use efficiency, and the feasibility of renewable energy; conserving the health of ecosystems in terms of area of changed landuse, stored waste, water quality, water quantity, greenhouse gas emissions, and other air pollutions; minimising the negative impacts on neighbouring communities in terms of health, economic stability and challenges, and stimuli; and environmental liabilities relating to inland industrial complexes.

OBJECTIVES AND AIMS

This report then presents the outcomes of the Governance Assessment. The objectives of the outcomes were to assess the key factors that influence the long term sustainability of large, inland industrial complexes, with a focus on the Highveld coal field mining and processing industry complex; and to determine the regulatory and other governance barriers that impede the implementation of synergistic reuse options and integrated technical solutions to improve the sustainability.

Aim 1

The first aim of this report is to evaluate the usefulness of two methods that were used to achieve the outcomes, namely a systems dynamics modelling approach, and the desired state protocol and stakeholder engagement method, for this industrial ecology context. For the systems dynamics approach, one aspect of its usefulness proved to be the ability of the modelling technique to resolve complex problems by prioritizing, for example, the key mass flows that affect the environmental sustainability. The other aspect is its ability to communicate and obtain consensus on the key physical parameters that may affect the environmental sustainability of inland industrial complexes. This is important in focussing the consultation process onto the main objective of the study. For the desired state protocol approach, its usefulness was in obtaining cooperation and transparency with stakeholders by providing a consultation procedure that identifies their benefits from cooperation with the other stakeholders. Other consultation methods, such as workshops, are more likely to focus on existing conflicts.

Aim 2

The second aim of this report is to synthesise and present stakeholders' views on the desired state and the sustainability of the industrial complex, based on utilising the systems dynamics and desired state protocol approaches, and uses this information to identify governance barriers that impede the implementation of synergistic re-use of waste products in the complex. Ultimately this will lay the foundation for the Integration report (Volume V) on governance and technology barriers affecting environmental sustainability.

METHODOLOGY

The methodology used to achieve the first aim was a literature analysis to facilitate the systems dynamics and desired state protocol approaches in terms of obtaining the stakeholders' consensus about the main issues. The second aim was achieved through synthesising the information obtained through the use of questionnaires and engagements with key stakeholders, namely individuals, from key organisations, companies and institutions, that are actively working in, or with, the Secunda inland industrial complex.

RESULTS AND DISCUSSION

In summary, representatives of seven stakeholders were interviewed. These were individuals from the previous Department of Water Affairs and Forestry (DWAF), the Mpumalanga Department of Agriculture and Land Administration (MDALA), Sasol, Sasol Mining, Evander Gold, Eskom, and the local municipality (LM) eMalahleni. It must also be noted that although the eMalahleni municipality had been consulted, the Govan Mbeki municipality is directly responsible for most of the Highveld area. Information from the local municipality Govan Mbeki was subsequently gathered from the report of a survey done by the CSIR on integrated waste management planning in the Mpumalanga Province, since municipal representatives from Govan Mbeki LM were not available. The previous national Department of Environmental Affairs and Tourism (DEAT) is partially represented by MDALA. The stakeholders AgriSA, the New Denmark colliery and the Waterval River Forum were further identified by the interviewed stakeholders. The Waterval River Forum was thus engaged, which also partially represented AgriSA.

The study has consolidated the main stakeholder issues summarised in the table below. The issues are based on the perceptions of individuals that represent companies, organisations, or institutions in the Secunda inland industrial complex, and the consequences or impacts related to these perceptions.

Issue	Perception / Consequence / Impact	Comments
Current water demand exceeds forecast	Perception of all: Raw water is abundant for the strategic industries in the study areas. Consequence: Water scarcity is experienced before the forecast time.	The forecast water demand estimates for Highveld area was 259 and 277.2 Mm^3/a in 2010 and 2020 respectively, but the study has shown that this has already been exceeded, namely currently at 350 Mm^3/a.
Price of water is low	Perception of industry: The price of raw water is so low, that it is cheaper for industry to waste water than to attempt to reduce consumption, and recycle and treat it. Perception of industry: The level of levies is not an economic incentive for industry to change the way they use water. Perception of government: Raising the price of water will raise the cost of living.	This implies the possibility of fixing the price of water to a demand supply ratio, but opinions in the public sector differed as to the effectiveness thereof.
Equity in application of water quality standards	Perception of industry: Lack of exercising more equity on the application of water quality standards across the board. Perception of industry: Currently the mines have a lee-way in not treating the mine water before transferring it to other industries for use as raw water. Consequence: In practise, the reuse of streams occurs seldom because of the variety in (mine) water quality with respect to the available plants. Impact: The variation of water quality that enters the facilities has direct operational impacts such as the cost of water on the site in terms of the additional treatment costs.	With deterioration of water feed, industries use more chemicals to treat the water and in the end produce more saline (salts) effluents. The impact in the increase of salinity in the ash water system is a large concern for industry. An important governance factor that emerged from the study is that there is a lack of enforcement of the water quality standards on the part of government, which contributes to liability (see issue below).
Liability for stored salts/wastes	Perception of industry: In terms of salt loads, waste residues are stored on site for purposes of use as a resource. This helps to minimise effluent discharge on site or as a regulatory “requirement” in order to operate as a zero-effluent facility. Consequence: Chemical reactions can take place when the insoluble salts are stored, after which they can diffuse into the ground water and surface water. Impact: Industrial and mining waste covers a large area above ground; greater than 33 km^2. Underground storage areas are larger but not quantified.	From a governance perspective this is just a mode of merely transferring the problem from one medium to another, namely transferring the problem into the future. Liability issue of who is responsible for the waste loads after mine closure becomes an important governance issue.
Who is responsible for Liability	Perception of all: Liabilities arise from the duties of care that are expressly provided for in NEMA, NWA and NEM: WA, MPRDA, and others.	Another aspect is the process of licensing which does not clearly spell-out the transfer of liability after the closure of the plant. For example, the issues around liability for waste (including mineral waste) upon transfer of such waste for reuse are not clear at present. This problem is exacerbated by the challenge of permit licenses taking too long during approval process. For some, they are already outdated by the time they are approved. This is clearly a hindrance to the concept of industrial ecology.

CONCLUSIONS

Aim 1

The ability of the system dynamics approach to resolve complex problems by prioritizing and communicating, and obtaining consensus, on the key physical parameters affecting the sustainability, was proven through the study. The desired state protocol was also shown to assist in providing transparency and obtaining cooperation from stakeholders by providing a consultation procedure that identifies their benefits from cooperation with the other stakeholders.

Aim 2

The systems dynamics and desired state protocol approaches greatly assisted in synthesising and presenting stakeholders views on the desired state and the sustainability of the industrial complex and use this information to identify governance barriers that impede the implementation of synergistic re-use of waste products in the complex. A number of observations were subsequently captured, which may guide the sustainability-oriented governance of future inland industrial complexes.

RECOMMENDATIONS AND FUTURE RESEARCH

- There is a clear need for coordinated planning and control on the storage and discharge of water and salt in the complex. This includes coordination of the regulations for ownership of waste and responsibility for consequent environmental pollution over the long term. For example under NEMA the polluter pays with a cradle to grave scope of liabilities. In contrast under the MPRDA responsibility transfers to the state either by sanctioned transfer of liability, or by obtaining a closure certificate. Experience in South Africa indicates that very large institutional problems take place with long term environmental sustainability of the solutions currently being implemented for post closure discharges of saline effluents. In the complex the mines report under the MPRDA and processing industries report under the NEMA. The NWA reporting systems are not functional for the municipalities.
- Economic controls on water demand management can assist the infrastructural and technology problems associated with unsustainable water and salt management. Prices are too low, with the result that demand is inelastic, and further economic growth results in larger environmental liabilities.
- Industry needs to work on closing the gap between the industrial desired state and the expected state for salt storage and disposal. As a corrective action incentivizing and changing behaviour is necessary in the water use performance agreements with DWA.
- The treasury via DWA should adopt a policy of ploughing back financial benefits from industry and economic productivity by way of infrastructure and incentives to ensure security of supply and long term environmental sustainability of water supplies.
- Inland complexes should be constructed where water transfer and unproven long term salt storage systems are not required to reduce costs.
- The treasury via the municipal finance and management Acts could improve the funding and management models of local municipalities who carry part of the responsibility for supply of clean water and disposal of waste water.
- Equity of enforcement standards must be applied to all stakeholders. Neither industrial, mining nor municipal stakeholders should enjoy unfair advantage in the complex.
- At local municipality level the problems observed with managing budgets and managing personnel must be removed.
- The DWA and the DMR should streamline the licencing process in order to spell out the transfer of liability after the closure of an industrial facility. In particular where the shortfalls in the MPRDA legislation and administration transfer long term risk for mine salts to industries which have been assigned responsibility under another set of regulations.

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LIST OF ABBREVIATIONS

CMA	Catchment Management Agency
COD	Chemical Oxygen Demand
CSIR	Council for Scientific and Industrial Research
DEAT	Department of Environmental Affairs and Tourism (Now Dept of Environmental Affairs)
DEA	Department of Environmental Affairs
DMR	Department of Mineral Resources
DSS	Decision Support System
DWAF	Department of Water Affairs and Forestry (Now Dept of Water Affairs)
DWA	Department of Water Affairs
EIA	Environmental Impact Assessment
Eskom	Electricity Supply Commission
GDP	Gross Domestic Product
I&APs	Interested and Affected Parties
IDZ	Industrial Development Zone
IPC	Integrated Pollution Control
kWh	Kilo Watt hour
KNPRRP	Kruger National Parks Rivers Research Programme
LCA	Life Cycle Assessment
LHWP	Lesotho Highlands Water Project
LM	Local Municipality
m^3	cubic metre (equivalent to 1 000 litre)
M	Mega
MAP	Mean Annual Precipitation
MDALA	Mpumalanga Department of Agriculture and Land Administration
MMC	Manganese Metal Corporation
Mt/a	Million metric tonnes per annum
MWh	Mega Watt hour
NCPC	National Cleaner Production Centre
NEMA	National Environmental Management Act (Act No 107 of 1998)
NERSA	National Energy Regulator of South Africa
NWA	National Water Act (Act No 36 of 1998)
P	phosphorous
RoD	Record of Decision
RQO	Resource Quality Objective
RWB	Rand Water Board
t	tonne (metric)
ToR	Terms of Reference
TSS	Total Suspended Solids
UCT	University of Cape Town
UKZN	University of Kwa-Zulu Natal
WMA	Water Management Area
WRC	Water Research Commission

1 INTRODUCTION AND OBJECTIVES

The terms of reference (ToR) of the WRC K5/1833/3 project stipulates that this component of the project is to assess the key governance factors that influence the long term sustainability of an inland industrial complex. These factors are to be derived from perceptions and views of various stakeholders of a specific complex.

This report was informed by:

- The inception report that identified the problems in the study area (Volume I); and
- The questionnaire interviews with representatives of the selected stakeholder groupings.

This work was carried out in parallel with the component that entailed compiling the inventory of water quality (Volume II).

1.1 Rationale

To a large extent, South Africa's economic prosperity is associated with a few large industrial complexes that are associated with, and in close proximity to, inland mining areas that are water stressed. Since these complexes are a hub of economic growth, there is a need to ensure that they generate wealth in a sustainable way. To achieve such sustainable economic growth would require exploring means in which the industries within a complex exchange wastes as a resource and also exercise cleaner production techniques; water is a key factor in the functioning of these industrial complexes. This report presents the outcomes of the assessment of the regulatory and other governance barriers that impede the associated implementation of synergistic reuse options and integrated technical solutions.

1.2 Objectives

The objectives were to assess the key factors that influence the long term sustainability of large, inland industrial complexes, and to determine the barriers to improve the sustainability, by utilising the system dynamics modelling and desired state protocol and stakeholder engagement methods.

2 BACKGROUND: LITERATURE REVIEW AND APPROACH

2.1 Good Governance

According to Ashton (2008) 'good governance' is "*recognized as a complex and multi-dimensional concept that incorporates a guiding philosophy or set of operating principles, a preferred process or way that people interact with each other, and a desired situation or outcome. The 'trialogue model' of the partnership between government, civil society and science offers useful insights into the attributes of good governance and the way that this underpins and facilitates prudent resource management*".

To this end, and focusing on water resources, this study builds on the frameworks of two previous studies: a study conducted by the South African Council for Scientific and Industrial Research (CSIR) on integrated pollution control in the Mpumalanga Province(Rogers & Masekoameng, 2008); and a study of the United Kingdom Department for International Development (DFID) (CSIR-NRE, 2008) (Plummer & Slaymaker, October 2007) on governance in water services. These frameworks describe governance in water services in terms of:

- Policies and legal management;
- Institutional arrangements;
- Administrative and economic issues;
- Financial management; and
- Technical compliance and levels of participation.

2.2 Industrial Ecology and Sustainability

The sustainability of water systems in South Africa, from a governance perspective, depends on the handling of complex, multi-disciplinary challenges, such as technological, economical and institutional, issues. Thus, the primary focus of the study was to determine: "*what constitutes the sustainability of an inland industrial complex with respect to governance issues*". This focus requires an investigation into what sustainability includes, and for whom, and why sustainability is pursued, so that the goals for various stakeholders can be defined. To obtain a comprehensive framework to govern the main sustainability issues of inland industrial complexes requires that the set of criteria or indicators are thorough and complete. In this way, one ensures that the problem is analysed and the different perceptions of looking at sustainable development are taken into account. These perceptions, in turn, provide insight into the problem from a broader perspective, and hence contribute to setting the boundaries correctly. This will, in the end, ensure that it is not only the technical, economical and environmental issues that are captured, but also the institutional issues; thus leading to good governance for the sustainability of an inland industrial complex.

A determining factor for the stability of ecosystems is the interface between man and the environment (Brent and Rogers, 2008). Accordingly, the sustainability of the ecosystem can be measured by how the available resources are managed. One approach to study how the social system is managing the ecosystems is to use measurements of the carrying capacity, namely how many resources can be extracted for use by the social system without reducing the available resources. This introduces the concept of optimizing the long term carrying capacity by understanding the science of the system. Where the long term sustainability of a system is not managed optimally, the amount of eco-services is reduced. For example, if mine water effluents are not managed during and after the economic life of the mine, the supply of clean water to the social system will have fewer resources than it had previously.

By applying these principles, the outcomes of this study will assist government officials to make decisions based on evidence. Current mistakes will not have to be repeated in the planning for future industrial complexes as corrective measures for the challenges currently being experienced – for instance the management of run-offs from the waste dumps (see Figure 1) – will be avoided through proper planning.

2.3 Consultation approaches

The consultations followed during this study utilized the systems dynamics and the desired state protocol approaches, similar to the method of 'Analysis of Complex Systems' (Enserink et al., 2004).

2.3.1 Analysis of complex systems

In this study a "*system*" is defined as part of the reality that is being investigated in response to an assumption of a problem. The focus of this study is on the effect of an inland industrial complex on the external environment and possibilities of how governance issues would affect the sustainability of the complex. The system boundary is set around all the variables that influence decision making on the sustainability of inland industrial complexes.

To evaluate the extent to which sustainable development has been achieved requires that criteria or performance indicators are set. These are the variables that can be used to measure the extent to which the goal has been achieved and in turn are influenced by the system.

The endogenous variables are the variables within the system that influence the criteria. The success of the system depends on the existing relevant instruments in the country. An instrument is a tool that the problem owner can use to change the system, such as policies, rules and regulation. In other words the system, and therefore the endogenous variables, can be changed by using an instrument. The system itself is also influenced by variables that cannot be influenced by the problem owner. These are called exogenous variables. The way the system works is shown schematically in Figure 2. This is the first input for the introduction of aspects in an evidence-based system for decision making.

Figure 1: Waste dump of power plants in Mpumalanga

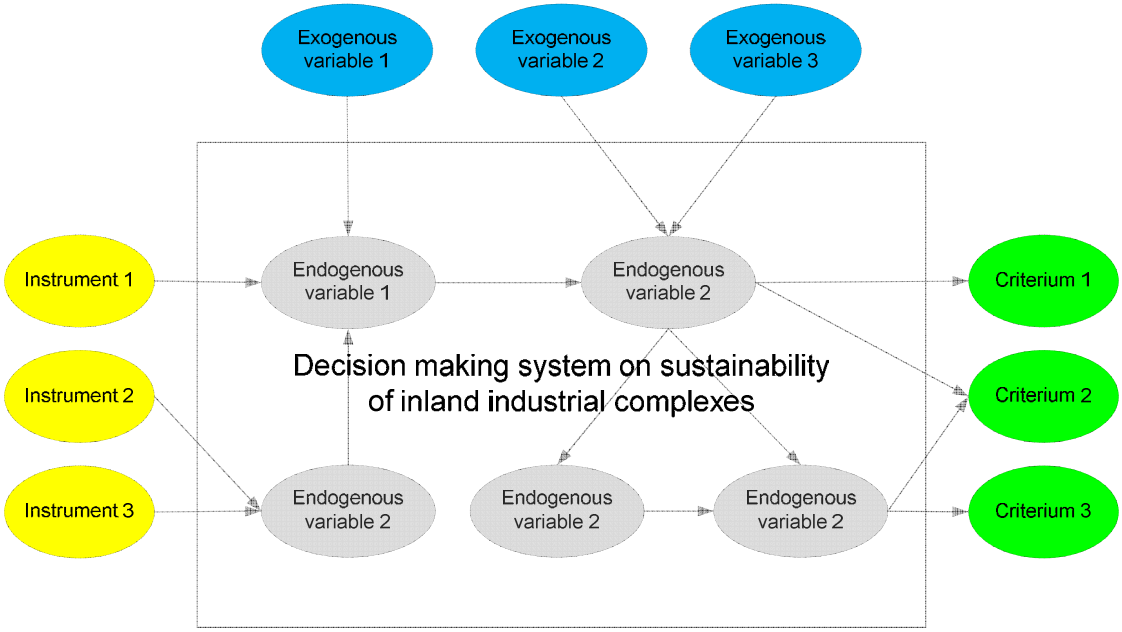

Figure 2: System diagram

2.3.2 Questions that are to be asked from a governance survey

The main question that is answered in this part of the report is: "*Can qualitative System Dynamics analysis of a complex system contribute to speeding up the process of consultation with stakeholders and gain consensus on the purpose of multi-party systems, in order to model and govern sustainability of inland industrial complexes?*" To achieve this, requires a few crucial steps.

The first step is to validate the hierarchical tree with stakeholders, namely to validate the position of the stakeholder with respect to the functionalities of the entire complex system. The main purpose of the validation is to test whether the stakeholders concur with the thoroughness/completeness of the set of criteria and that the criteria provides a good support when governing sustainability. To do this properly requires the second step, which is to know more about the stakeholders in the complex system. The key issues are to know their individual roles and interests and what their formal powers are and how the stakeholders are interdependent. Therefore an extensive stakeholder analysis is performed.

The sustainability of an inland industrial complex cannot be controlled by the design option only, such as the size, type and location. The criteria for sustainability are influenced by many subsystems and how variables of these systems interact with each other. This is schematically described in Figure 3. The other systems include water provision, socio-economic issues, air pollution and land use, amongst other, which in turn are influenced by decisions of several stakeholders. Therefore the third step is to investigate the structural behaviour of the system. The structure can provide insight as to why the system is in or out of control. The defined criteria together with the insight of where action or attention is required and by whom can be used to ascertain the effects of policies, and other behaviours, such as institutional arrangements, that influence the system to evaluate the most appropriate sustainable development strategies for the government, and other involved parties. The aim is to improve sustainability and to avoid possibilities that may impede on the sustainable development of industrial complexes.

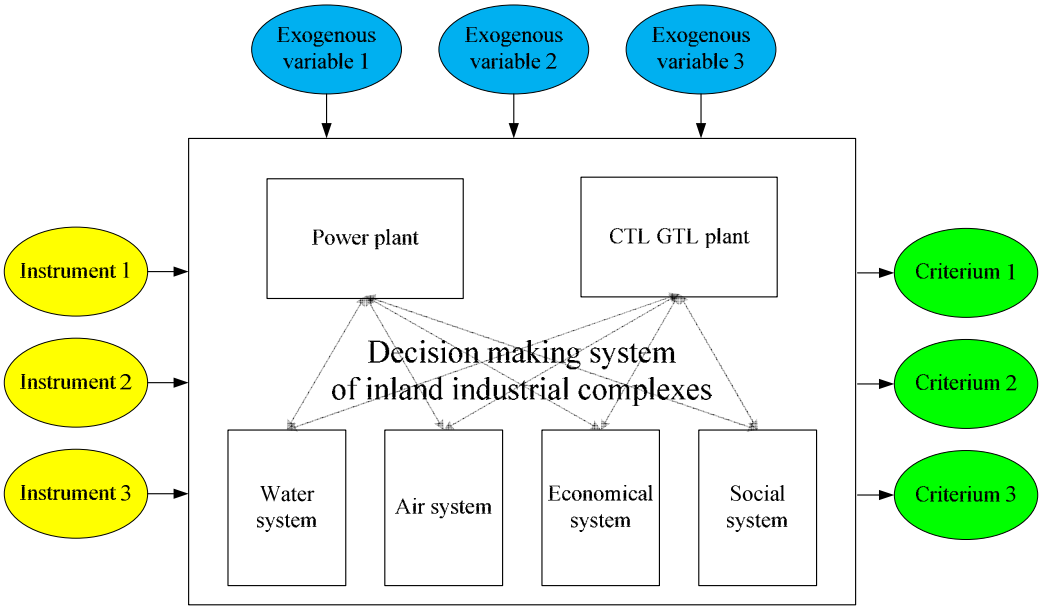

Figure 3: System diagram with subsystems

3 METHODOLOGY

The methodology that was used in this study has been identified in the Inception Report (Volume I). This methodology is based on the principles of the "desired state" and "systems dynamics". These conceptual approaches, which are briefly described in section 2.3 of this report, have been subjected to a SWOT analysis in order to highlight strengths and weaknesses of each approach. The combination of the two approaches became the basis of the following steps in the methodology:

- Design of the questionnaire;
- Identification of the stakeholders;
- Interviews and administration of the questionnaires (see Annexure A);
- Review of survey results with stakeholders;
- Establish a method for viewing results in the context of the sustainability of inland industrial complexes; and
- Collating the results and reporting on these.

3.1 Combination of two approaches: Systems dynamics and desired state protocol

The suitability of the system dynamics approach for this study is described in Annexure B. This method is then combined with that of the General Protocol for translating visions into goals for multi-party systems as developed by DEAT (Rogers and Bestbier 1997) as described below.

3.1.1 Qualitative application of the principles of system dynamics

In the system dynamics approach, the structural behaviours of complex systems are investigated through casual loops (see Annexure C for an explanation). This is directly linked to the qualitative application of the Principles of System Dynamics of Forrester (1961) and Sterman (Sterman 2000; van Daalen et al., 2006). Systems dynamics is a method to qualitatively describe, study and analyse complex systems in terms of the processes, information, organizational boundaries and strategies, which facilitate quantitative simulation modelling and analysis for the design of system structure and control (Wolstenholme, 1989). This methodology is based on identification of feedback loops that describe system controls for engineering and policy. According to Meadows (1980), system dynamics is a method of dealing with questions about dynamic tendencies of complex systems, that is, the behavioural patterns they generate over time. System boundaries are identified for the time of scope, geographical distance and stakeholders who describe the control options.

3.1.2 General Protocol for translating visions into goals for a multi-party system

The "desired state" approach is fully described by Rogers and Bestbier (1997). This consultative management process was developed as a strategy of the Kruger National Parks Rivers Research Programme (KNPRRP), in which interactions between stakeholders, managers and researchers were facilitated by a Decision Support System (DSS). The first two steps of the General Protocol are:

- Identify the parties in the multi-party system, their values and needs, which includes:
  - Identifying the stakeholders and the interested and affected parties;
  - Negotiating their level of participation; and
  - Identifying and recording the visions and objectives of each party for the issue at hand.
- Gain consensus on the multi-party systems, purpose and operating procedures, which is achieved by undertaking the following:
  - Integrate the visions and objectives of all parties using steps 3, 4 and 5 of the protocol for developing an Objective Hierarchy in order to develop a single common complementary vision for management. These three steps consist of documenting, evaluating and consolidating the strengths of the system and recording all the determinants of, and constraints and threats to the strengths.

Both of these methods have their strengths and weaknesses. A SWOT analysis was subsequently carried out to determine how they can best be combined and applied.

Experience at the CSIR in developing a multiparty consensus indicates that the establishment of public mandates and completion of negotiations could not be expected within the three year time horizon for the project (see Annexure F for the work plan). The intention instead was to use the expert group of researchers to identify common objectives for the water and salt management systems. This was to be followed by a workshop. However as has been reported in Volume II, agreement on the inventories was not achieved with individual members of the complex by September 2009, and the workshop was replaced instead by a call for comments by the WRC, with the final corrections and responses to inventory and definition of the salt storage problem received in July 2011. So it was not possible to get consensus on the desired state as regards the water salination, and salt storage problems in the complex. The objectives hierarchy was therefore not developed. This should be a follow-on research task if the governance study is to be continued.

Instead the stage of consensus building on the problem and the possible outcomes was analysed in the following framework of using key factors provided to each participant in the questionnaire (see Annexure A) by the CSIR and the University of Stellenbosch Governance Groups. The analysis is based on interviews and verification of the questionnaires during 2009. The data is reported in Section 4.3.3.1 under headings for:

- Any consensus on the description of the key factors
- The expectations for the future which is summarized as an expected situation
- causes for the expected situation based on cause and effect analysis
- Consequences
- Solutions and responsibilities.
- The approach followed in this component of the work plan was to identify the expected state, i.e., what was most likely to happen based on the perceptions of the members of the complex and the stakeholders, and to make recommendations for solutions.

3.2 SWOT

A SWOT analysis is mostly used to evaluate strengths, weaknesses, opportunities and threats of projects and businesses, in order to, for example, match strengths to opportunities or to convert weaknesses into opportunities. In this case it is used to compare and find possibilities to combine the two approaches (see Table 1).

Table 1: SWOT analysis of the system dynamics and desired state protocol approaches

Method	System Dynamics	Desired State Protocol
Strengths	The systems engineer is an independent, non expert and therefore not threatening. A system engineer has no prior judgements about right and wrong in the disciplines. The system dynamics approach can model complex systems in a way that can be easily understood by the involved stakeholders	Nationally accepted protocol. Used for multiple cases. Developed specifically for water systems.

Method	System Dynamics	Desired State Protocol
	and can create a tool for discussing policies. Three problems that are less cumbersome in system dynamics than in other modelling techniques are: 1) estimation of parameters, 2) sensitivity testing and 3) assessment of model validity. It is a proven tool, as it had been developed in 1961 and there has been further developed since then.	
Weaknesses	Systems dynamics needs experts on the governance, process engineering, ecologist, water systems, etc. The mechanics of modelling is relatively easy, therefore it can make the modeller overconfident and the simplicity of adding new elements and relationships to a model encourages the tendency to create over complex, incomprehensible structures (Meadows, 1980). Making a detailed model of the entire system is very comprehensive. The model can become large and does not give perfect outcomes. Making and testing a complete model is time consuming and difficult.	Takes many years, time and effort to conduct. Many protocols, the two steps are just a part of one of them. Sensitive information is required.
Opportunities	The systems engineer can put in corrections using feedback from interview situations. A qualitative model can be made first to test the need and feasibility of a quantitative model. To make the model more understandable for stakeholder a presentation mode can be made.	The steps can be conducted in less time when conducting a questionnaire and focussing on major problems.
Threat	The systems engineer will be misled, will understand, and will come up with model, which will not pass the test. The stakeholders might consider the model neither scientific nor technical enough. The long-time horizon and wide-boundary approach of System Dynamics can be problematic for modeller-client interaction (Meadows, 1980). This viewpoint is not usually consistent with the very real short-term pressures and constrains felt by most decision makers.	Important steps might be left out and consensus might not be reached. Not all desired data might be obtained. Stakeholders might be stars for a new approach.

3.3 Network and Stakeholder Analysis

3.3.1 Major users network

Water shortage is one of the major expected issues to consider when planning the expansion of inland industrial complexes. Therefore, in this study, the analysis is done in which the water users are described together with the determination of their relative requirements and their commitment to the project (see Annexure D). The expected deficit in water supply has been investigated by the national Department of Water Affairs and Forestry (DWAF) in each Water Management Area. A map of the locations of the DWAF priority measurement points relative to the boundaries of the case study areas is provided in Figure 4.

The Highveld area is mostly located in the Upper Vaal Water Management Area. The major users of water are mining and bulk industry, power generation, agriculture and communal users (urban and rural). The large industrial water users in the Highveld area may pose a severe water deficit on the Grootdraai Dam. A water pinch study has been done for the Grootdraai catchment. One major river, the Upper Vaal, drains the catchment, mostly supplied with water from rain and no rivers or streams entering the catchment (Singh and Strauss, 2004). Table 2 provides a summary of water consumption and supply of the Grootdraai dam.

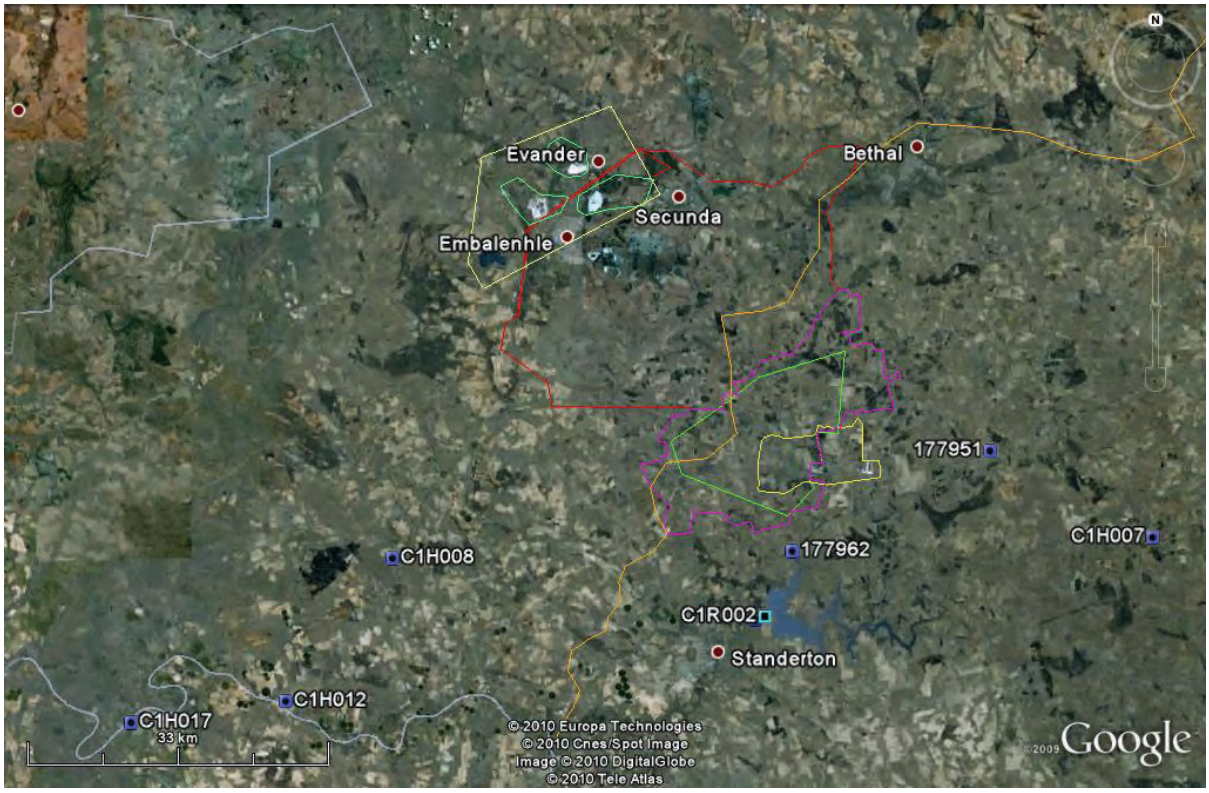

Figure 4: Boundaries of case study area, watershed and priority measurement locations

Locations of members of the complex are from top left:
Harmony mine (yellow) with 3 shaft complexes (green), Sasol Synfuels, Sasol Mining (red) watershed Waterval and Grootdraai (dark yellow), Anglo Coal-New Denmark (purple), ESKOM -Tutuka (bright yellow).

Table 2:Stakeholders commitments measured by water consumption in the Highveld area (Environmentek, 2000; Singh and Strauss, 2004; Rogers et al., 2008b)

	1998	2000	2005	2010	2020	2030
	Measured	Expected	Expected	Expected	Expected	Expected
	Mm^3/a	Mm^3/a	Mm^3/a	Mm^3/a	Mm^3/a	Mm^3/a
Grootdraai capacity	150	150	150	150	150	150
Sasol	63.6	106	112	112	112	112
Eskom power generation	52	57	86.6	92.1	93.7	93.7
Municipalities in the Grootdraai Subcatchment	5.8	6.2	7.5	9.4	14.3	21.8
Municipalities in the Western Highveld	14	14	15	15	15	15
Municipalities in the region B (Olifants)	18.8	24.9	37.9	48.7	78.3	112
1Agraculture Grootdraai subcatchment		45				
Total demand	154.2	253.1	259	277.2	313.3	354.5

The Grootdraai catchment is not the only catchment affected by the Secunda industrial complex area. Also, the order of magnitude for water requirement in the Highveld area is not yet clear, hence this has necessitated the investigation of the water requirement from the Wilge and Upstream and downstream of the Vaal dam.

The trend of magnitude of water demand is that mines and bulk industry require the largest amount of water followed by the power generation. For more details see Tables 3 and 4. Meanwhile, for downstream of the Vaal dam, urban requirements are the largest, since the highly densely populated area of Gauteng is supplied by water from this catchment. Nevertheless, in the projected future scenarios by DWAF, it is shown that the largest change in water requirements upstream of the Vaal dam is expected to shift more towards power generation. Table 4 shows the base scenario for 2025. The only difference with the requirements for water in the high scenario, compared to the base scenario, is the urban requirements, which are higher in this scenario.

Table 3: Year 2000 water requirements catchments affected by the Highveld area (DWAF 2004)

		Irrigation	Urban	Rural	Mining and bulk industrial	Power generation	Total requirements
Wilge	requirements (Mm^3/a)	18	27	15	0	0	60
	% of total	30%	45%	25%	0%	0%	100%
Upstream of Vaal dam	requirements (Mm^3/a)	29	32	17	99	39	216
	% of total	**13%**	**15%**	**8%**	**46%**	**18%**	100%
Downstream of Vaal dam	requirements (Mm^3/a)	67	576	11	74	41	769
	% of total	9%	75%	1%	10%	5%	100%

Table 4:Year 2025 base scenario water requirements catchments affected by the Highveld area (DWAF 2004)

		Irrigation	Urban	Rural	Mining and bulk industrial	Power generation	Total requirements
Wilge	requirements (Mm^3/a)	18	27	13	0	0	56
	% of total	32%	45%	23%	0%	0%	100%
Upstream of Vaal dam	requirements (Mm^3/a)	29	36	17	99	39	256
	% of total	**11%**	**14%**	**7%**	**39%**	**18%**	100%
Downstream of Vaal dam	requirements (Mm^3/a)	67	763	10	74	41	957
	% of total	7%	80%	1%	8%	5%	100%

The information that has been presented here is only about water use; it does not provide information about the level of pollution. It has been documented (Environmentek, 2000) that the acceptable level of ammonia (NH_3) has been exceeded as well as the acceptable level of Total Dissolved Solids (TDS). However, the contribution by each water user is unclear. It is difficult to assess due to limited monitoring in the footprint. For example, there was no aquatic or habitat data available from elsewhere in the footprint to assess the contribution from Sasol mining to the ecological integrity (Environmentek, 2000).

3.4 Stakeholder Analysis

3.4.1 Involvement of stakeholders

For the stakeholder analysis, all the relevant South African government departments and agencies, and commercial and other organisations, were identified upfront. The inception report (Volume I) had proposed a list of stakeholders to be involved in this project. This list was discussed with stakeholders and suggestions were made on additional stakeholders to include. This provided the starting point of all involved stakeholders.

3.4.2 Governmental organisations

- Department of Water Affairs (DWA);
- Water Research Commission (WRC) – the initiator of the research;
- Upper Vaal CMA (Catchment Management Agency);
- Water User Association;
- Department of Environmental Affairs (DEA);
- Provincial Government of Mpumalanga;
- District Municipalities (Nkangala, Gert Sibande);
- Local municipalities (Govan Mbeki, eMalahleni);
- Lesotho Highlands Water Project;
- Eskom;
- National Energy Regulator of South Africa (NERSA);
- Mpumalanga Department of Agriculture and Land Administration (MDALA);
- Water boards; and
- SANParks.

3.4.3 Commercial organisations

- Sasol Synfuels ;
- Sasol Mining ;

- Harmony Gold Evander;
- Eskom Tutuka power station;
- Anglo Coal New Denmark colliery.

3.4.4 Other organisations

- Mvula (water and sanitation NGO South Africa); and
- Waterval River Forum.
- Agri-SA;

3.4.5 Stakeholders interests, goals and problem perception

The differences between the current state and the desired state, as perceived by the different stakeholders, have revealed some gaps that need to be addressed. Therefore, in this report, causes of these gaps between the desired and the expected state are described and possible solutions to

solve them are proposed. Not all intended components could be obtained from the stakeholders, since it is seldom documented for the public domain concerning what the stakeholders really expect from the desired state. Besides, opinions might vary within organisations. However, it should be recognised that there would be value, in essence, of looking at the matter from different perspectives.

In complex multi-party systems, attention should be given to formal relations between the stakeholders, since this will provide insights into the structure of the network. Thus, in this study, the formal relations have been investigated for the governmental organisations. From the findings of the investigation, the following scenarios of relationships are drawn in terms of:

- the representatives;
- a hierarchical approach;
- the statutory or accountability; and
- factors influencing relations.

3.4.6 Critical and dedicated stakeholder analysis

The success of any project depends on the support by all critical actors. Critical actors are stakeholders that have vital resources and cannot be replaced by other stakeholders. The development of a sustainable inland industrial complex cannot succeed without the support of these critical actors.

The ability to get cooperation from the stakeholders, and the anticipation of obtaining behavioural change with these stakeholders to adhere to the new proposed ideas, is increased by analysing and understanding the formal and informal resources of the stakeholders in order to reach their respective goals. Resources can be, for instance, legal rights, information, knowledge, labour force, money or other forms of capital.

Having resources alone cannot make a stakeholder critical in the design process. For stakeholder to be considered critical, there must be dependency on those resources that the stakeholder has, and these must be irreplaceable by any other organisation. In other words, critical stakeholders must have vital and unique resources.

The critical stakeholders that have been identified for this project are:

- Department of Water Affairs (DWA);
- Department of Environmental Affairs (DEA);
- Local municipalities (potential large waste water user);
- Eskom Tutuka (large water user);
- Mpumalanga Department of Agriculture and Land Administration (MDALA);
- SANParks;
- Agri-SA (medium water user);
- Sasol Mining (large waste water supplier)
- Sasol Synfuels (large water user);
- Waterval River Forum (representatives of potential large water users); and
- Harmony Gold Evander (large waste water producer) Anglo Coal New Denmark (large waste water supplier)

The classification of the stakeholders as dedicated or non-dedicated, and aligned or conflicting interest is the last step of the stakeholder analysis. This, combined with the results from the analysis of the critical stakeholders, culminate into the table of Annexure E.

Besides the critical stakeholders, it is important to note that Sasol Mining and the Water User Association are not critical yet but might become critical in a later stage, because they might oppose to any other plans and have important resources. Also attention should be paid to Eskom. It is considered as non-dedicated on the basis of not being involved in the first round of interviews. It is an important organisation upon which South Africa is dependent for its energy supply. Reducing impact on the natural environment and on neighbouring communities probably does not have the same priority for Eskom. Hence, it could probably not be totally aligned with the government on all fronts. Another non-dedicated stakeholder that could be important is SANParks. It might pose some objections at a later phase of the project. For each phase, and after design choices, the list of stakeholders should be reviewed, to check whether potential partners and opposing stakeholders change or should be involved.

In the end, seven stakeholders were interviewed. These were the previous Department of Water Affairs (DWA), the Mpumalanga Department of Agriculture and Land Administration (MDALA), Sasol, Sasol Mining, Evander Gold, Eskom, and the local municipality eMalahleni. It must also be noted that although the eMalahleni municipality had been consulted, the Govan Mbeki municipality is directly responsible for the Highveld area. Information from the local municipality Govan Mbeki was subsequently gathered from the report of a survey done by the CSIR on waste management in the Mpumalanga Province in 2007, since municipal representatives were not available. The previous national Department of Environmental Affairs and Tourism (DEAT) is partially represented by MDALA. The stakeholders AgriSA, the New Denmark colliery and the Waterval River Forum were further identified by the interviewed stakeholders. The Waterval River Forum was thus engaged, which also partially represented AgriSA.

3.5 Structural Behaviour Methodology

3.5.1 Qualitative systems dynamics

As already described before, system dynamics is a method used to qualitatively describe a complex system, which facilitates quantitative simulation modelling and analysis for the design of system structure and control (Wolstenholme, 1989). Since system dynamics is a time consuming approach, only the major issues in the system and feedback loops will be validated with the stakeholders and used to gain consensus and create interaction.

There are several ways to conduct a system dynamics approach. Barlas (1996) describes the following six major steps:

- Problem identification;
- Model conceptualization;
- Model formulation;
- Model analysis and validation;
- Policy analysis and design; and
- Implementation.

In this component of the project, the first two steps were executed. It is only after this that the usefulness of performing the next steps is considered.

The goal of the conceptualisation of the model is that it "*focuses attention and draws out a shared view on the key driving forces that determine the future of the industry/business and the companies relative performance*" (Winch, 1990). Model conceptualisation will also gain understanding of relations between structure and behaviour of the problem.

Since "*a broad model boundary that includes important feedback effects is more important than a great amount of detail in the specification of individual components*" (Sterman, 1988), boundaries are

set broad. This should be explained clearly to the stakeholders, since, as is mentioned before, the long-time horizon and wide-boundary approach of system dynamics can be problematic for the modeller-client interaction (Meadows, 1980).

3.5.2 Validation of internal structures

Usually validation is performed after the model formulation. However, validation does exist in every stage of the methodology according to Barlas (1996). He explains validity of a system dynamics model primarily means validity of its internal structure. A white-box model, being a 'theory' about the real system, must not only reproduce or predict its behaviour, but also explain how the behaviour is generated. Accuracy of the model behaviour's reproduction of real behaviour is important too, but this can only be meaningful if there is already sufficient confidence in the structure of the model. Testing the validity of the qualitative system dynamics model, can be done by an empirical direct structure-confirmation test, see also Barlas (1996). There is a limit to the confidence in the model: "*One can achieve only a degree of confidence in a model that is a compromise between adequacy and the time and cost for further improvement*" (Forrester, 1994).

3.6 Interviews with stakeholders – Questionnaire design and administration

The first survey was done by administering the questionnaire to the stakeholders through personal interviews. The approach that was adopted was to contact these interviewees in parallel with the inventory group for the industry and mining sector; meanwhile, government institutions (national, provincial and local) were interviewed separately. In all, interviews were held with seven (7) major stakeholders as indicated before.

The entire questionnaire can be found in Annexure A. The questionnaire contains five parts: A, B, C, D and E.

Figure 5: Emalahleni Municipality offices

In Part A, the problem was introduced; and the stakeholder was given an opportunity to comment on the inception report. In this way consensus was reached on the initial problem description. The results are described in section 4.1.

The questions in Part B were formulated according to the desired state protocol for translating visions into goals for multi-party systems. The stakeholders were identified by mass flows of water and association with impacts by the CSIR; the interviewees were asked who else should be included in the study. This part has been discussed in section 4.2.

The questions in Part C were formulated from a qualitative system dynamics approach, which test dynamic hypothesis or confirm detected feedback loops. The structure of the inland industrial system was established, which included feedback loops and time delays. In addition to these, questions also addressed issues concerning the roles of stakeholders, relationships between stakeholders and responsible parties for necessary changes in the system. Specifically, questions in this section were centred on water use, quality and price, affordability and availability of energy, and impacts on neighbouring communities. This section forms the basis of this report and the study on governance issues. It is this section that presents the results concerning issues on expected and desired state in the complex area. The results are presented under section 4.3 of this report while analyses of the findings, based on the interviews with individuals[1], are provided in Annexure H.

Due to the complexity of issues that concern addressing expected and desired states of an inland industrial complex in the context of governance, this complexity was simplified by presenting results obtained from stakeholders according to key factors that relate to sustainability of an inland industrial complex. These factors are outlined as follows:

- Availability and affordability of energy;
- Resource use efficiency;
- Area of altered land;
- Stored waste load and waste management;
- Water quality;
- Water quantity;
- Greenhouse gas emissions;
- Other air pollutions;
- Health;
- Economic stability and challenges;
- Stimuli; and
- Environmental liabilities relating to inland industrial complexes.

Part D is an open ended question on sustainability in general. In this part, topics that had not been covered were addressed and opportunities for industrial ecology and other suggestions on improving sustainability were made. These results have been combined with Part C under section 4.3.

Part E is a supplement of questions specifically for industry and municipalities on water, waste, and energy resources. These results have also been tabulated in combination with Part C, under section 4.3.

[1] It is important to take note that findings are based on views and perceptions of individuals within the respective organisation/institutions – these are not formal statements by the organisations/institutions.

4 RESULTS OF THE SURVEY QUESTIONAIRE

4.1 Part A – Consensus on the problem as stated in the Inception Report

The inception report (Volume I) was sent to the stakeholders to read as a preparation for the questionnaire. Agreement on the problem as described in the report provides a good starting point for the rest of the interview. Unfortunately, most stakeholders did not fully read the report; they had just browsed through. However, after the detailed run down of the issues outlined in the inception report, there were no major disagreements on the problem as stated by the project team. The conclusion can be drawn that there was consensus on the initial problem description.

4.2 Part B – Identification of major I&APs

The identification of stakeholders was done to determine who should be involved in this phase of the research.

4.3 Part C – Structure of feedback loops sustainability of environmental management systems and waste production.

The presentation of results under this section has combined the findings from parts C, D and E because these were inter-related. These results are presented according to key factors relating to sustainability and governance in the industrial complex, listed in 5.3.6.

4.3.1 Feedback loops

The causal loop diagram has been made for the water system (see Annexure B). This is the main issue as was concluded in the inception report and most other systems relate to the water system. In addition, it aided to establish whether a qualitative system dynamics analysis contributes to speeding up the consultation process with stakeholders and gain consensus on the purpose of multi-party systems.

In this report, a causal feedback loop has been simplified in order to obtain a good understanding of this concept. A major issue in the complex is the salts from processes that create large stored waste loads. Industrial and mining waste covers a large area above ground; greater than 33 km^2 and underground not estimated. This is comprised of landfill, ash, slime dams, and effluent and product waste. More information is contained in the inventory report (Rogers et al., 2011). A view put forth by the industry is that stringent standards bring about production of more salts from the main stream. For example, if more stringent water quality measures are put in place by the government, then more process and product waste will remain after the treatment of the water (Du Toit Roux; Smit et al., 2009). Other complications arise because of the price for desalination and the low amount of measurements of the stored load. Lastly, there is not enough policing (Ashton, 2008),so that laws and regulation fail to control this issue.

An example from the study, which illustrates a positive feedback loop, for ion exchange boiler feed water treatment using raw water and process cooling water. Industry reports that as long as sodium (Na^+), chloride (Cl^-), and sulphate (SO_4^{2-}) concentrations must be below 400, 400, 1000 ppm respectively, then the system should be able to handle it.

The casual feedback loops below show different scenarios of complex salt loads. In the first feedback loop, the salt inventory is increased three times the amount of salt that is removed (Figure 6). An example of a negative feedback loop is the use of a crystallizer evaporator to recover salt by selective crystallization and water for the boiler feed. It is also possible to have a zero feedback desalinator, namely where there is no change in the net amount of waste salt stored in the waste salt system (see Figure 8).

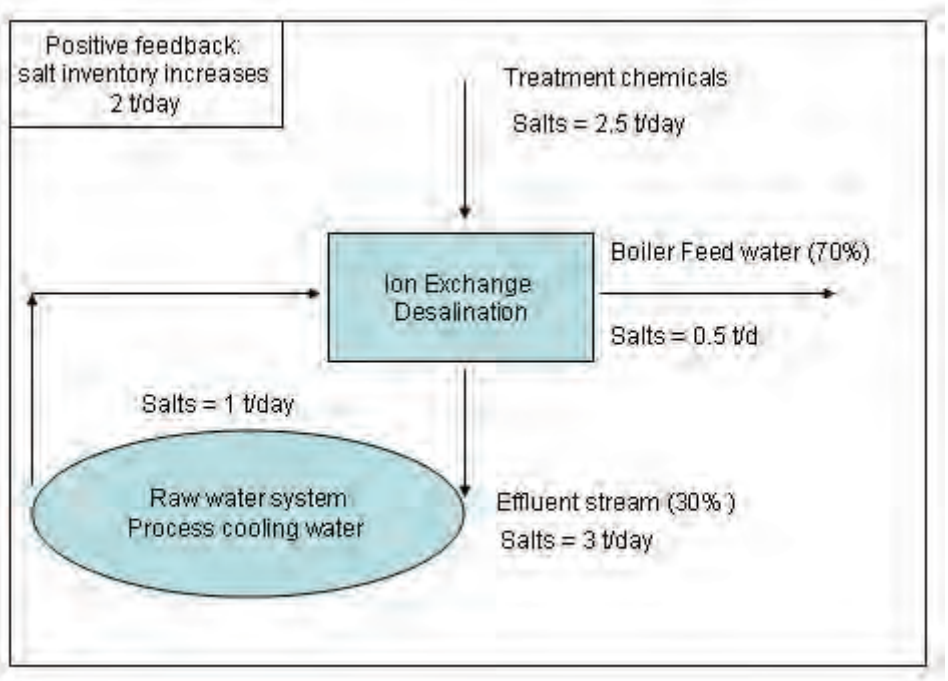

Figure 6: Positive feedback loop in water desalination obtained from the design intent of the Sasol SF waste water treatment system

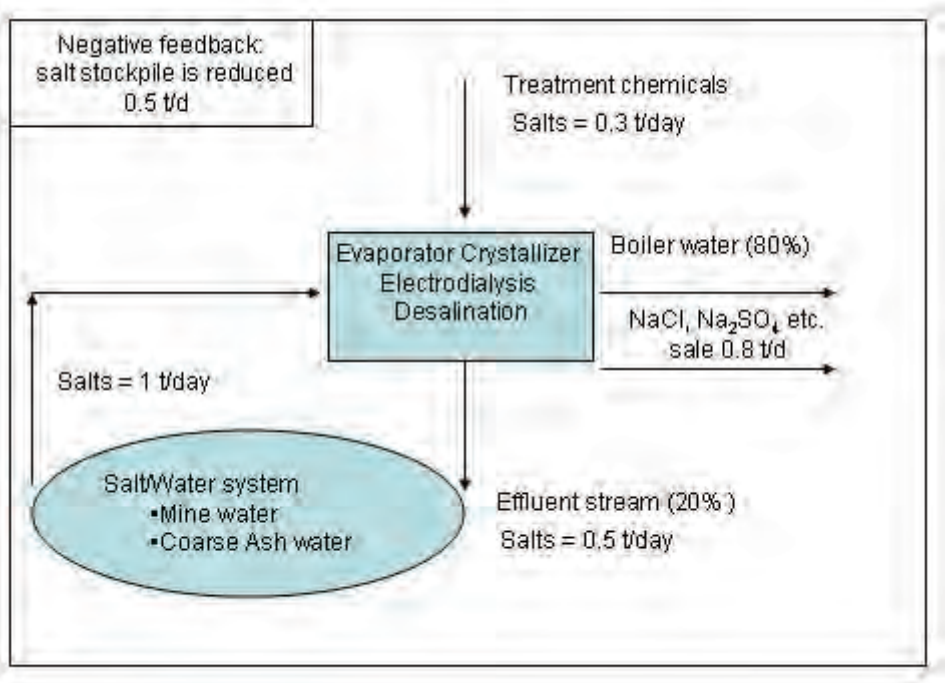

Figure 7: Example of negative feedback in water desalination obtained from the design intent of the Sasol SF waste water treatment system

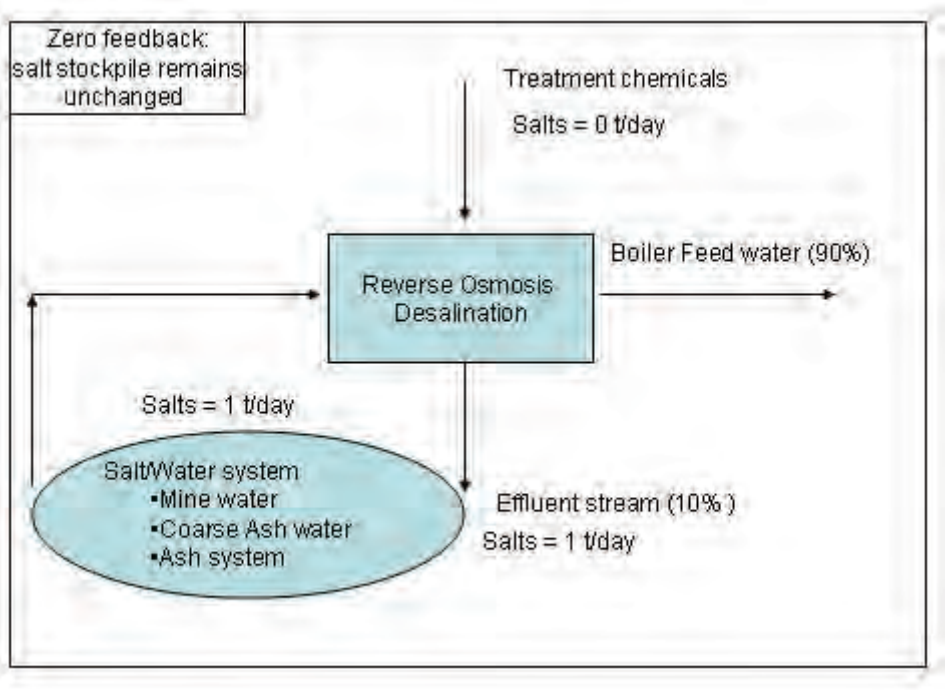

Figure 8: Example of a zero feedback desalination obtained from the design intent of the Sasol SF waste water treatment system

Systems analysis is also used to assist decision making in groups. These diagrams can be used to illustrate the effects of delays of multiple parties involved in decision-making in complex systems. These causal loops are also used to investigate the structural behaviour of a complex system (Enserink et al., 2004). In comparison with other Multi-Criteria Decision Assessment methods (Rogers and Masekoameng, 2008) the technique can be used to assess the impact of controls and response in dynamic systems (Meadows, 1980). Analyses require definitions of time, geographical boundaries and roles of players who respond to, and control, the system options. In this study the boundaries of the physical system have been defined by the inventories, and the boundaries of the responsibilities are defined by the responsibilities assigned under the National Water Act 1998.

4.3.2 Limits to growth

Most topics for conservation of ecosystems have been covered, but not emitted greenhouse gases and other emitted air pollutants. These are part of complex causal loop structures, to which the need for development is linked. The essence is that present needs for energy should enable the desired growth of wealth. High return on investments, local and national growth of GDP per capita and shrinking unemployment are important indicators for this increased wealth. Yet, this growth is limited by the price and the availability of the resources water, coal, gas and land. Alternative energy production from, for instance, wind and solar, and also gas would provide a good solution to the challenge. However, these renewable energy resources are limited by price.

The local community's desire to develop is affected by the above mentioned structural behaviour, caused by the need for affordability and availability of energy.

4.3.3 Key Factors for environmental sustainability

4.3.3.1 Meeting the present needs for energy

Availability of energy

Consensus
All stakeholders agree that an insecure energy supply will affect the level of achievement of development goals in South Africa.

Expected situation
According to Sasol, there is enough energy supply for expansion. However, stability of production and costs are issues. Sasol's expansion plans are highly dependent on gas supply from Mozambique. It also works the other way around; the plans are also based on the possibility of gas supply to Sasol.

Causes
Sasol is of the opinion that causes of shortage in energy or the delay in adapting supply to increased energy demand are economical in nature. Industries do not want to invest in infrastructure unless it is really necessary that it drives economic growth and personal gain. The perception of industry is that the DWA is responsible to ensure a long term balance between supply and demand for clean water by pricing for purchase and disposal of waste, issuing permits for use of water resources, and access to secure water supplies via well maintained infrastructure.

Solution
According to DWA more competition is not an option. It will lead to problems for the networks, because there is only one network.

According to Sasol, eventually, there should be a combination between government and Sasol on investments, which is observable in other parts of the world.

Responsibility
Government, industry and NERSA are responsible for ensuring a secure energy supply. But it is unclear who is responsible in the end.

Affordability of energy (price of electricity and liquid fuels)

Expected situation
There will be an increase in energy price.

Causes
- The price of coal.
  The stakeholders agreed that when coal reserves are depleting, the price of coal will go up significantly and therefore also the price of energy in South Africa.
- Expensive water transfer.
  According to DWA expensive water transfers do have an impact, eventually, on the cost to generate power. However, investments in water supply will only affect the price of those parties that get the water from the new systems.
- Air pollution regulation.
  New regulations of air pollutions do have an impact on the electricity price, especially the Clean Air Act.

4.3.3.2 Maintaining a resilient energy economy in South Africa

Resource use efficiency

Sasol is on track with energy efficiency and water use goals. If the plant expands, they will use more resources irrespective of efficiency goals.

Both MDALA and Sasol are of the opinion that the resource use efficiency can be improved; MDALA: "*Sasol is still overly reliable on coal and there is scope for improvement. There is still a lot of coal that ends up not being utilized*".

The target for improving energy efficiency at local municipality level is set by Eskom. That is where NERSA comes in; they want to reduce some of the powers Eskom has. For example, to reduce the amount of money small scale energy producers pay to ESKOM. To this end, NERSA might assist municipalities, which, at this point, are only distributers of electricity.

Feasibility of renewable energy

The LM is supportive and MDALA is the most positive. They think the initial plan, 15% renewable, is still achievable, because there are quite a variety of renewable energy sources available in South Africa. But there must be intervention. The major drawback has been that Eskom and the smaller scale producers cannot agree on the tariff.

DWA believes 5% might be reached. According to DWA, renewable energy is an economic and technologically feasible solution to growing air and water pollution because there are incentives, they push it and there is ongoing research. According to Sasol it is not: "*energy is too cheap so renewable and alternative energy can't compete*".

4.3.3.3 Conserving the health of ecosystems

Area of altered land

Expected/existing situation

Consensus: All stakeholders agree that the area of altered land is a serious concern. Surface mining is now going to (increasingly) move to protected areas. Therefore, land impact will grow. Agriculture is already stressed. There is land that is declared prime agricultural land, which cannot be used for industrial purposes. That has been in existence for the last ten to twenty years. But this now is going to change if the demand grows for coal mining because of the energy crises.

Possible causes

Mostly mining causes an increase in area of altered land. The department has been a strong exponent of the move towards increased encroaching of agriculture land, especially for coal resources but also in terms of water pollution.

Consequences
According to MDALA, because of the energy crisis, basically all the coalmines available in that area are now sub-serving the energy generation. It affects ground water, ecosystems, agriculture, food supply and biodiversity.

All stakeholders agreed that it will affect biodiversity. For example, according to Sasol, SO_x removal will generate huge piles of gypsum that take up land. There are areas that have always been of tourist interest in terms of rare species (biodiversity) that is not viable now. That is one of the direct consequences.

Solutions
No solutions were specifically put forward in the interviews. Possibly the stimulation of alternative energy is a solution. Gas is an option but will increase dependency from gas reserves and Mozambique.

Stored waste load and waste management

Consensus on problem
All stakeholders agreed that at the moment the stored waste load is a serious threat to the ecosystem because it is not designed, operated and monitored, controlled and managed correctly. They also agreed that if it is stored well, stored load is under control. But preferably it should be treated.

Expected situation
Because of the National Environmental Management: Air Quality Act, 2004 (Act No 39 0f 2004) more waste will be generated. It will remain a serious threat to the ecosystem.

Causes of problems with stored waste load
The LM has a problem with waste disposal sites that are not properly managed. In addition, illegal dumping is a reality with the consequence that waste in large quantities will end up leaching pollutants, infiltrating underground water sources. They monitor the rigged with five boreholes, but there is no lining. It was permitted that way. But in the next phase it is a requirement.

According to MDALA, Sasol's general waste and ash dumps are not lined and they also have slimes dams in the area. Within the LM itself, the challenges are larger according to MDALA: "*They don't have a permitted site in Secunda. They have a disposal site but its incorrectly located, just close to water. There is no municipal land suitable for land filling. So we are looking for about 15 hectares of land for a Gas-to-Liquid (GTL) and also for a hazardous waste complex.*"

The issue identified is that there is no available land.

Sasol stores waste instead of treating it due to excessive costs; it is cheaper to store than to recycle, reuse, transport and treat it. It is cheap salt in huge volumes. At the moment it is not economical to recover the salts internally and the markets outside do not exist. Another problem is that it is energy intensive and desalination requires expensive material of construction.

According to Sasol technically, a solution can work quite well, but to get passed the perceptions of NGOs is difficult. So there is also an institutional problem, based on trust. However, according to DWA, the success of this depends on their monitoring. DWA is responsible to see to it that the plant is operated well by checking and monitoring the final effluents and verifying the data that Sasol or the industry involved compiles.

Enforcement of waste and water treatment from municipal effluent by DWA might be difficult because of the way the law is structured: "*One sphere of government cannot take another sphere of government to court. If it does happen, then there is a connotation of interference in the workings of government. For example, the constitution of South Africa says you can only approach the court as the last resort, if you are not able to deal with state problems. The other thing you can do is to issue fines against municipal managers or councils. The problem is you have to recover that*".

Solutions
MDALA believes it should be treated instead of stored. You could use the waste somewhere else. Thus, there should be more incentives to treat. Or avoid waste by stimulating gas use and alternative energy.

Water quality

Feedback loop
For technical reasons more water will be used if water is polluted more.

Expected state
DWA 'hopes' that water quality will be in control: "*Any infrastructure development has an impact on the environment. For all these developments EIAs must be done. The necessary permit authorizations must be obtained from the environmental authorities. That is the rigorous process that has to be gone through. That RoD will tell us what is allowed and what is not and how to mitigate the impacts, which there will always be*". DWA is busy investigating the implementation of a waste discharge charge system whereby the industries will pay a penalty if they discharge water which is of a poorer quality than what they are allowed to. "*We hope that this will also contribute to it that industries will not discharge water of a poor quality*."

Sasol expects water quality to deteriorate significantly: "*The salinity is going to increase, and there is going to be an organic problem, because of the water from the Grootdraaidam and Vaal, which could be contaminated by dissolved solids resulting from untreated municipal effluents and contributions from agricultural activities.*"

Causes of water quality deterioration according to Sasol
Organic and nitrate pollution is a new concern: "*Historically, the focus was on the salinity deterioration of the water, but now there is organic and nitrate pollution of the water, because the sewage treatment does not work. From an industry point of view, the water treatment processes are not geared to dealing with organics from the raw water, and nitrates and phosphate*".

Those organics and nitrates are a result of the fact that w*aste streams are not always treated to the legal requirement.* All stakeholders agree that waste streams are not always treated according to the legal requirements, especially those of local municipality. There are many reasons for that. The agriculture sector also contributes organic and nitrate pollution through untreated return flows.

Water transfer: Transfers result in changes of water quality to plants and this requires capital equipment interventions – 40 Cents/m^3 to pump – and this also depends on heat and distances.

There is a need to change how the water quality standards are applied because currently, all users are linked to drinking water quality, thus the need for better water regulations.

Eskom considers the issues around Deep Injection of the salts into underground reservoirs as an important aspect to consider. Therefore it proposes that the disposal of salts into deep mines should be evaluated as an option.

Who owns the water for the mines needs clarity. This issue is equally important because it links to the concerns to the government's good governance practices. The challenge is if Eskom takes water from the mines, the government reduces Eskom's raw water intake from the river, yet Eskom treats the polluted water that it takes from the mines. Worse still, if there is drought, it means Eskom will suffer because its water allocation according to the permit has been reduced and hence cannot access the river water that it requires, despite power generation being a strategic water use.

Standards should be equally applied to all concerned industries. Currently, the practice does not meet this requirement. The mines are given preference. For example, the New Denmark mine is allowed to discharge effluent that does not meet the water quality requirements, and yet when Eskom re-uses this effluent, is required to treat it to the required specifications. It can be concluded that when the mines pollute, Eskom takes the burden to correct the pollution created by the mines.

There is a need to determine the water quality background for the area in order to make sustainable plans. If the water quality of different sources is known, it would promote re-use of the water from different sources because the requirements for improvements on the water quality from these sources (such as mines and municipal waste water) will be known and hence easy to cost its treatment and use in the plant.

DWA monitoring, capabilities and money: It was recorded that the political will to monitor is improving substantially and hopefully that will improve with time. It is also a mindset of municipalities, industries that contribute to poor quality of water. In the end it all comes back to capabilities and money. Many municipalities in the area do not have even a technician on their staff list. Subsequently, they have no technical capacity and capabilities in many cases.

Local Municipalities expressed that it was very costly to treat waste. This was also observed in the proceedings of the meeting with Waterval Forum held on 19 February 2009. In this meeting all municipalities indicated an extent of deterioration in water quality in the area (see Annexure G). It was also expressed in this meeting that sometimes they run out of budget. It was also reported during the meeting that there was polluted water from the mines (acid water). In order to contain this: "*DWA has constructed a plant to treat the water, but that plant is not operating as it should. Stakeholders pointed out that there were other mine water sources in the areas that do feed into this dam and this water is not even treated; it just runs into Olifants River and Loskop dam.*"

There was a general view that sewage is a problem that would require extra resources to resolve. There was also a general agreement that the pollution contribution from waste is as a result of not managing it and of the lack of implementing an education and *awareness campaign in the communities.* These could be achieved at a minimal cost.

According to MDALA, the *probability of an offender to be caught and fined is low* and expressed that their laws had been very relaxed. MDALA further re-iterated that many Local Municipalities did not have the required skills. Those responsible for operating sewage works in many of the LMs did not have an understanding of the scientific theory behind processes due to the loss of many of their qualified water specialists.

Industry in the area is of the opinion that one of the challenges within DWA is a lack of expertise and *human resource capacity*. For example: "*Sasol has a pool of knowledge, and could work together in a team with the government, or alternatively, the government should provide funding to industry in order to assist in solving the problem*".

Industry emphasised that South Africa has one of the best water quality Acts in the world and, in addition to this, it has all the relevant legislative frameworks and strategies in place. However, little has so far been done because authorities were not in a position to manage the enforcement. There was no reason for waste discharge systems not to function if penalties were collected and re-invested back into the system. The failure to enforce these legislative frameworks could be attributed to lack of competency in DWA resulting from the high turnover of staff. These circumstances created an opportunity for offenders to get away with polluting the water resources and putting salts down the river, because the polluter does not pay. Besides that, in local municipalities, there was no proper maintenance strategy for their sewage works.

Consequences for industry, especially for Sasol and Eskom

All the industries expressed the view that the reuse of mining water was lower than agreed upon because of the quality of this water as the mines do not treat it to meet the requirements of other treatment plants. Industry maintains that government should apply equity in the enforcement of the water quality standards because currently, it seems to favour the mines. Therefore, in practise, reuse of streams occurs very seldom because of the *variability in (mine) water quality* with respect to the available plants. Industries have problems making the specification of the salts as the plants are designed for a certain feed composition, and if it changes the system does not operate optimally.

The variation of water quality that comes in has direct operational impacts such as the cost of water on the site in terms of the additional treatment costs. With the deterioration of water feed, industries use more chemicals to treat the water and in the end produce more saline (salts) effluents. The impact in the increase salinity in the ash water system is a large concern for industry. The direct comparison between incoming water quality to the waste water cost and the cost of ownership of water is known and therefore it should be easy for the government to make a decision on quantifying the increase resulting from untreated mine water and hence be able to compensate accordingly. The poor water quality affects efficiency of industry's cooling towers and that affects the carbon footprint and losses.

Solutions

Government should exercise equity in the implementation of its water quality standards. This will make the water quality to be predictable. Equipment could handle more pollution, but the water quality of the feed should be predictable and stable. Besides this, there should be more suitable (both in terms of experience and capability to do the job) human resource capacity within Local Municipalities and DWA. In addition, for sewage works to improve requires financial resources and therefore more funds should be made available and there should be proper monitoring. Monitoring could be a cooperation between industry and DWA; there should be incentives to treat for industry.

Institutional problems

Institutional (monetary) issues should be taken into account when considering industrial ecology. For example, local municipalities want industry to buy water from them, instead of Rand Water, or they want a toll or other benefit.

Water quantity

Expected state according to industry:

There was a general view by industry that water shortage would become a problem sooner than is realised. Industry was concerned about the availability and the assurance of water supply. DWA might not be able to meet that assurance of supply: "*The expansion of the Lesotho project should have started four years ago*". Industry warns government of its heavy reliance on the strategy of reducing illegal irrigation, which is highly questionable in terms of how effective that is going to be.

Industries, such as Sasol and Eskom, would have their liquid discharge improved, but the ground water impact was going to deteriorate, if viewed from a mining perspective. The impact will be greater because the industries would be physically expanding.

However, DWA had opposing views. It emphasised that the insufficient water supply was "*unimaginable*", and this was "*not an option*" but a fact. DWA reaffirmed that it could get the water to industry and South Africa at all costs. If the problem of water shortage became unbearable, DWA could ultimately initiate the desalinisation of seawater and pump it to wherever it would be required. But it warned that it was going to cost a lot more as the process would need much energy.

Responsibility
According to DWA, multiple parties are responsible for increased water supply and shortage. However, it is mainly DWA and the LM.

According to DWA:
Community – The local municipality is mandated to supply water for human consumption to their area of responsibility and make sure there is enough water.

Agriculture – If it is not available, they can't get it, because it is not economically viable to import water for agriculture from far. Agriculture uses a lot of water illegally. DWA is responsible to control it and there is monitoring. DWA re-iterated that it was putting systems in place to take legal action against the illegal users of water.

Industry – Within affordability limits, industry (and agriculture) can expand as long as they can afford it Their elasticity of demand is very low, because they do not have alternative technologies for water use with the same economic output.

Ecology – The National Water Act of 1998 implies (not explicitly) that the ecosystem has a right to water. So DWA must ensure it that the reserve is adequately sustained.

Corrective actions taken DWA
In the northern part, all the available water resources within the acceptable yield have already been allocated. So according to DWA any increases will have to be thought of in an innovative way. DWA stated that the water that it would have to supply to the new power stations in the northern part would have to be pumped there, augmented from other systems, like Lesotho. DWA indicated that the water for the new complex would come from the Crocodile River, that water comes from the Vaal River and the Vaal River receives water from other sources. It emphasised that current plans should be sufficient, since they are addressing long term supply.

Payment for water supply
According to DWA users should only pay for transferred water from other basins if the user uses it. However, Sasol indicated it is the one that pays but was sure it was not the only user. The extra water needed is for the communities and agriculture.

Water from Lesotho
The stakeholders do not know when the growth of water supply from Lesotho is going to end. The majority of industries indicated the next decade or 15 years. According to DWA, with the Lesotho water scheme phase two in place, they would supply water for the next 20 years, but added that if it can implement effective water conservation measures, it could extend that considerably, up to 50-60 years. All this relies on an effective water conservation drive.

The benefit of the use the water transfers from Lesotho is that it conserves energy because it is gravity fed.

Consequences if there is not enough water anymore

Most stakeholders indicated that the ecology would suffer first if there was no water, according to the LM eMahahleni, MDALA, Evander Gold, ESKOM, Sasol Synfuels and Sasol Mining. The view was that this was so because the country had not even started addressing ecology.

According to DWA, if there was drought, agriculture is always curbed before industrial and domestic use because it uses water from the entitlement of the normal flows in the rivers.

Causes

All the stakeholders were of the opinion that the price of raw water in South Africa is too low. For example, according to Sasol the price of water should be adapted. The price of water does not provide incentives to Sasol to be more efficient. Also the levies are not an economical incentive for Sasol to change. "*The price of raw water is so low, that it is cheaper for industry to waste more water than to try to recycle and treat it. That is a general dilemma. Sasol had told DWA that the level of levies is not an economic incentive for industry to change*".

DWA hopes the price of water does respond to the demand, and that it is in control. For example, MDALA and DWA have indicated that the price of water goes up if there is less water available, and this would result in less water being used. However, Sasol did not concur with this perception. Sasol expressed that the price change to supply is a slow reaction. Sasol also indicated that it was one of the last to be affected by a water shortage, because it was a strategic industry. Industry re-iterated that the price of water was too low, resulting in people wasting it. But DWA's argument against raising the price of water was that it would be bad for the private individual because whatever one buys that is water based would cost more and also domestic water uses would cost more. This would result in a rise of cost of living.

Delay of adapting demand for water to supply

The lead time to increase water availability is at least 6 to 7 years. That is why DWA works with long term demands. However, even though the municipalities try and plan the time delay, due to funding problems, the implementation is very late.

There is little interaction among the industry and government in water demand and supply issues. For example, after Eskom has done its work it goes to DWA with its requirement for water without interacting with other relevant stakeholders. So, would Sasol.

Another issue is maintenance. According to industry pumping systems are in a bad condition because there is too little maintenance. DWA concurs: "*more investment should be made for water supply in upgrading and maintaining or renewing it. In the new power station there would be huge investment*".

Solutions

The first step that a local municipality must take immediately, is water conservation demand management. There are "huge" water losses in their own networks. Standerton, for example, has a 40% undercount of water, and they have no records of the invoices to people. If you repair your pipelines it will cost money, hence there is need to recover that cost.

The importance or effectiveness of fixing the price of water to a demand supply ratio is questionable. According to the LM a low price for water is a basic need (for development). According to MDALA the price should create awareness and force efficiency. Sasol and Eskom believe costs should control use. If possible, the price of water should be adapted immediately to demand and supply.

Furthermore, there is a need that industry requesting for more water should share their plans with other relevant stakeholders.

Industry on how they could close the gap between desired and expected state for water and salt wastage:

As a corrective action industry should be more active, but it is a challenge obtaining decision makers' interested in supporting that. Another soft issue is incentivising and changing people's behaviour by building it in to their performance agreements. Currently there is not enough focus on environmental sustainability from industry. For example, there is a need for technologies that use less water, less electricity and generate fewer salts. A salt reduction target, not just a water use reduction target is required.

Individuals in industry indicated that finances become an issue because the management looks at the bottom line and not at the right thing to do on environmental issues. However, there is an indication of openness to listen but perhaps there were other priorities. For example, if the expected state is that the water pollution is going to increase and nobody is going to do something about it, then industry could form a strategic water group, like the one on electricity. This group would then drive initiatives on the water side, because pollution of the water supply is seen as a strategic threat to industry, especially Sasol.

Suggestions from Industry (especially Sasol and Eskom) to the government

The state needs to start pricing water correctly. So on the water quantitative part there should be correct pricing and other incentives.

Industry believes that they have good environmental principles within individual complexes. For example, Sasol used to have a quarterly meeting with authorities, they invited central and provincial authorities, and they have forums and share information. Industry's frustration is that the government officials often fail to attend these meetings. Despite this, there is willingness to share information and point out the risk, and engage pro-actively, through an early warning system.

Suggestions for industry and government together

The waste discharge charge system only works with proper monitoring and policing; that is crucial. Industry and the government could work together better; although there already is collaboration, this is not enough for managing the catchment. The Green Scorpions need to become visible. They need to clamp down on polluters and illegal water users.

Conclusions

Pipelines should be maintained by local municipality. Funds should be (made) available to do that. Cheap water for industry should be reconsidered. What is the benefit if there is water shortage as a result of water being polluted, and hence raising the costs in this way? Costs should control the use of water before the water transfers control the price automatically.

Industries should be more pro-active. Their water use reduction targets should be higher. Government should provide incentives, price water correctly and be more active in forums. Government should apply water quality standards equitably. Industry and the government could work together on monitoring.

Greenhouse gas emissions

Expected state

Government, especially MDALA, is of the view that this is a major problem because they expect industry (Sasol/Eskom) to expand even more. Hence more emissions are expected. According to Sasol achieving goals for emitted greenhouse gases might be affected by world economy. Overall the stakeholders were of the view that the CO_2 emission pricing in the offering might be good, but considerations should be made on how this would affect the viability (financially) of the inland industrial complex. Some industries have already undertaken some measures. For example, Evander Gold has Carbon Disclosure Project (CDP), which is as a response to Climate Change Adaptation calls by the government.

Solution to greenhouse gas emissions

Gas growth plans such as those in Sasol are part of meeting the energy and carbon reduction targets. There are less greenhouse gas impacts with gas-to-liquids (GTL) than with coal-to-liquid (CTL) and it is less energy intensive. For Sasol, "*CO_2 is the least problem compared to the already existing water problem*", but they are indeed concerned about the CO_2 emissions.

Solution to CO_2 (and depleting reserves)

Government (MDALA) believes biomass is one of the intervention areas. But it will mostly be used by smaller scale energy suppliers and this might be a significant input. However, the challenge is that in Secunda they do not have much municipality land; most of it belongs to industry and mines. Therefore it would encourage industry to take this initiative and this would indirectly benefit the area because it will not alter too much land.

Responsible stakeholder

NERSA fixes the price in the end. If the price to produce that electricity goes up, because of those emissions, they can approve it.

Other air pollutions

Consensus

There was a consensus that other air pollution regulations might influence the price for energy or viability of the new industrial complex, especially the National Environmental Management: Air Quality Act, 2004 (Act No 39 of 2004).

Sasol and Eskom expect that the cost of energy would rise quite significantly as a result of the Air Quality Act. The effect on electricity is probably much higher. For hydrogen sulphide (H_2S), if the standard is going to be put into place, Sasol would have to spend about 50 billion on mitigation. Currently, the sulphur recovery plants cost a fortune, yet the price for sulphur is not economical. One of the problems is off gas, which is of very low pressure, and low concentrations. Sasol was of the view that this would not lead to shut down of plants. It might affect the fuel specifications, though, and this contributes to the increase in costs, but it would certainly not provide more profits.

4.3.3.4 Minimizing the negative impacts on neighbouring communities

Health

Consensus

All stakeholders concurred that inland industrial complexes have a significant effect on human health, but it was unclear what the main cause would be. They expressed that the impact should be minimal,

within acceptable norms, if stakeholders managed their waste treatment plants well. But they also noted the socio-economic problems, such as costs of clean water and education.

Causes
Waste is not treated to legal requirements. According to the LM there is ignorance. People should be made aware on a regular basis and find innovative ways of disseminating this information. This is a challenge. For example, "*Most people know about HIV, but they still do it*". Therefore there is need for enough awareness raising campaigns of the dangers of pollution, and this should be coupled with effective enforcement of legislation against air and water pollution.

Solution
According to DWA water quality should not affect human health too much if all of the authorities do their job. For example, when municipalities purify their water and operate and maintain their waste water facilities adequately this problem would not be there. It was reported that DWA had started to take legal actions against some of the municipalities that did not adapt to quality standards. How effective and possible this could be is questionable because according to the legislative frameworks, it is discouraged for a government department to take another sphere of government to court[2]. This is an important governance issue.

There should be more awareness in the communities. Solutions need to be found to socio-economic problems, as described below.

Economic stability and challenges
Even though all the stakeholders expressed the view that industrial complexes create economic stability, they however acknowledged that there is high unemployment in the area. For example, MDALA re-iterated that the kind of jobs that Secunda was creating attracted people looking for a better living from outside the area. Therefore there was mushrooming of informal settlements, and yet most local people were not employed. This has created pressure on service delivery provision and a lot of social problems.

It was also noted that the transfers of water result in changes in water quality that is pumped into plants and this requires capital equipment interventions for it costs in the magnitude of 40 Cents/m^3 to pump, and this also depends on heat and distances.

It must be re-iterated that all the stakeholders acknowledged that the price of raw water in South Africa was relatively low, but recommended that this has to be looked into from various perspectives, such as the rise in prices of food and essential goods that are linked to water supply.

Challenges: Costs associated with pollution
Stored waste: Triple-line system on ash-heaps could work, but brine remains a complicated problem. This depends on the type of liner. For example, the costs of the liner will vary depending on whether it is clay or another type of liner used such as triple-line. Therefore the government should take into account the cost of the liner with respect to society's needs when comparing with the value of the resource being protected. One good example that would send the right message is the clay liner used at Medupi. The cost of a clay liner is estimated at R2 Billion for the protection of a 600 hectare ash dump site.

At industrial level, some insights surfaced. For example, Eskom emphasised that the waste treatment is not always done, not necessarily because of the costs, but because of lack of technology

[2] According to Section 41(1) (h) (vi) of the Constitution of the Republic of South Africa of 1996 the spheres of government should avoid legal cases against one another (but if all else fails, it is still allowed, as various recent court cases illustrate).

absorption at local market level. Research is still being carried out in order to find appropriate ones that could be easily absorbed. Options are available to link to markets for Calcium Carbonate ($CaCO_3$), but sodium will always remain a problem due to low market value.

Industry expressed that mine water comes to other users such as Eskom and Sasol at a high cost. This means the value of this water has partial incentives. The reason being, government still expects users (such as Eskom) of untreated mine water, to pay for it. For example, when Eskom treats mine water and uses it, the government then reduces or cuts the raw river water allocation to Eskom. This increases the costs for Eskom taking into account that the company pays market price for the mine water, and the end result is the government makes a profit of 14 cents per litre from the mine water.

At local municipality level, the challenges that contribute to the poor water quality in the areas are many, but most important ones to be cited are budgets and staffing constraints. For example, it is reported in the CSIR study on development of a Municipal IPC model for Mpumalanga (MDALA, 2008) that, in Govan Mbeki local municipality boundary, there is seven (7) wastewater treatment plants, and of these, only one is considered as well operated. More importantly, none of these plants had a DWA licence at the time of the study.

Solutions
Local municipality should control the influx of people into that particular area. They must be able to create more jobs outside the industrial areas. Therefore one of the aims should be to decentralise the economic activity.

The government should implement equity in the enforcement of water quality standards to ensure all industries and concerned institutions such as municipalities meet the requirements of the extended producer responsibility and polluter pays principles.

And lastly, there is supposed to be sufficient funds for the LM and strategies to retain manpower.

Stimuli
According to MDALA opposition from inhabitants in the area where the new inland industrial complex would be located should not be underestimated; it is a threat. Especially in an area where there is historical mistrust in environmental and health protection. However for the LM this would not have an effect on them because they do have the power over the setting of industries. But they recommend that there should be public consultation, through the EIA, and continued negotiations until the complex is established.

4.3.3.5 Environmental liabilities relating to inland industrial complexes

The question of liability featured prominently with almost all industries involved in this study. For example, the major institutional governance issue was salt waste water problems concerning whose responsibility it is over the salts disposed on terrace sites (i.e. evaporation ponds on land) after the mine closure. This is a challenging and sensitive issue because there is an argument that for those who offload their waste salts or waste water effluent into the river system, they do not have a liability, yet those that try to contain the problem so that it can be managed properly are being penalised for liability. Industry is of the opinion that, in principle, the government is supposed to take care of the salts after mine closure.

With these differing views, therefore liability as a governance issue needs to be addressed at all costs. Indeed South Africa is littered with a multitude of human-induced contaminated and disturbed areas. Some of which arose as a result of mining and industrial activities that took place many years

ago. The question to answer is: "*Who bares the obligation to rehabilitate such areas and to what extent is this liability retrospective?*" (Sampson, n.d.)

Literature shows that the nature of environmental liability in South Africa has changed significantly since 1994 (Godfrey et al., 2007). Liabilities have been expanded both in terms of people who bear liability and the range of matters that may result in liability. Prior to 1994, liability was closely linked to ownership, but in light of the post 1994 legislation, ownership as well as involvement in certain activities and/or the legal status of a person needs to be determined in respect of certain liabilities. In addition, there is an ongoing debate on whether the National Environmental Management Act of 1998 (as amended) extends to liability for historical pollution or degradation that pre-dates the commencement of this act (International Law Office, 2009). The issue of liability is therefore complex and requires a case-by-case assessment (Godfrey et al., 2007).

For this study, it is therefore very important that a relevant legislative framework to this subject is brought to the fore, and more details unpacked, so that when the design of the new complexes is done the legislative framework can be taken into account. Sections in the following Acts are of relevance when determining environmental liabilities:

- The Constitution of the Republic of South Africa, 1996 (Act 108 of 1996);
- National Environmental Management Act, 1998 (Act 107 0f 1998) (NEMA) as amended;
- National Water Act, 1998 (Act 36 of 1998) (NWA) as amended;
- National Environmental Management: Waste Act, 2008 (Act 59 of 2008) (NEM:WA); and
- Mineral and Petroleum Resources Development Act, 2002 (Act 29 of 2002) (MPRDA).

Constitution

Section 24 of the Constitution guarantees the right to an environment that is not harmful to human health or well-being, and an environment that is protected for the benefit of current and future generations (RSA, 1996). In addition, section 32 provides every person the right to access to information that is required for the exercise or protection of rights, be it held by the state or another person (RSA, 1996). According to Godfrey et al. (2007) the inclusion of these two rights has resulted in substantial changes in environmental liability. In this regard, the environmental right has extended the range and types of issues that may be taken to court. "*In addition, there is a possibility that the environmental right applies horizontally"* (Godfrey et al., 2007). In this regard, it is imperative that both juristic and natural persons must exercise a duty of care in order to avoid liability on the basis of this right.

National Environmental Management Act, 1998 (NEMA)

In line with international approaches and the Constitution, NEMA expanded liability for environmental matters by introducing a duty of care in respect of environmental matters (RSA, 1998a). In terms of section 28(1) the duty is imposed on every person who causes, has caused or may cause significant pollution or degradation of the environment to take reasonable measures to prevent such pollution or degradation from occurring, continuing or recurring, or, in so far as such harm to the environment is authorized by law or cannot reasonably be avoided or stopped, to minimize and rectify such pollution or degradation of the environment (RSA, 1998a). The duty extends to include the owner, the person in control of the land or a person who has a right to use the land on which the pollution or degradation of the environment occurred. Waste management activities will fall within the scope of the duty, although the extent to which the duty applies to actors throughout the life cycle of waste is not explicit (Godfrey et al., 2007).

The act is not prescriptive on the measures that must be taken to discharge the duty, but merely provides an indicative range of measure in section 28(3). The measures required in terms of section 28(1) may include measures to:

- Investigate, assess and evaluate the impact on the environment;
- Inform and educate employees about the environmental risks of their work and the manner in which their tasks must be performed in order to avoid causing significant pollution or degradation of the environment;
- Cease, modify or control any act, activity or process causing the pollution or degradation;
- Contain or prevent the movement of pollutants or the causant of degradation;
- Eliminate any source of pollution or degradation; or
- Remedy the effects of the pollution or degradation.

The list is not exhaustive, therefore other measures may be required if the measures are reasonable. However, the Act does not provide guidance on what constitute reasonableness.

Enforcement of the duty rests with government or by private persons (Godfrey et al., 2007). Government enforcement is through the issuing of directives to take specific measures within a prescribed time period. Failure to comply with government directives may result in government taking the required action and recovering the costs. Costs may be recovered from a range of people, including the person responsible for the activity or situation, the owner of the land or their successor-in-title, the person in control of the land at the time and any person who negligently failed to prevent the situation from occurring (RSA, 1998a).Failure to comply with a directive and the duty of care has not been criminalized (Godfrey et al., 2007).

National Water Act, 1998 (NWA)

The duty of care contained in NEMA follows the same approach as that contained in Section 19 of the NWA. According to Godfrey et al. (2007) the wording of the duty in the NWA provides for "*faultless – or strict liability*". The duty of care as contained in the NWA is applicable to activities that may cause, or are likely to cause pollution of the water resource. It does not contain any reference to the term "degradation" as is the case in NEMA. However, by including activities that are "likely to cause pollution" broadens the scope of the duty of care in this act. Land-based activities or situations can therefore also trigger the application of the duty (Godfrey et al, 2007). The scope of this provision merely refers to pollution and not significant pollution as in NEMA. Any pollution can therefore attract liability in terms of the NWA. The duty of care will therefore also apply to waste management activities that impact or are likely to impact negatively on a water resource.

Similar to NEMA the list of measures (RSA 1998b; section 19(2)) to be taken is neither prescriptive nor exhaustive and include:

- Cease, modify or control any act, activity or process causing pollution;
- Comply with any prescribed waste standard or management practice;
- Contain or prevent the movement of pollutants;
- Eliminate any source of the pollution; and
- Remedy the effects of any disturbance to the bed and banks of a watercourse.

It is noted that this section expressly refers to waste standards or management practices.
Enforcement of the duty rests with the catchment management agency who may direct any person to whom the duty applies to take the required actions to remedy the situation. On failure to comply with the directive, the catchment management agency may implement the required measures and recover the costs thereof from any of a wide range of people. The costs may be recovered from the person responsible for the pollution, the owner or successor in title of the land, the person in control of the land, who has the right to use the land and the person who negligently failed to prevent the activity or situation from occurring.

Failure to comply with a directive is a criminal offence and failure to comply with the duty has also been criminalized by virtue of section 151(1) (i) (Godfrey et al., 2007).

National Environmental Management: Waste Act, 2008 (NEM: WA)
This Act expands environmental liability to include noise, odour and visual impacts. The scope of liability in terms of this act also includes aspects relating to the generation and reduction of waste as well as human health and contaminated land. The person bearing the liability is defined very broadly as the "*holder of waste"* including any person who imports, generates, stores, accumulates, transports, processes, treats, or exports waste or dispose of waste (RSA, 2008). In addition, the Act also introduces the concept of extended producer responsibility aimed at extending the responsibility for products and consumer goods to the post-consumer stage of the product lifecycle (Nahman, 2010).

As with the NEMA and NWA the measures listed to discharge the duty is not prescriptive or exhaustive and includes:

- Investigate, assess and evaluate the impact of the waste in question on health or the environment;
- Cease, modify or control any act or process causing the pollution, environmental degradation or harm to health;
- Comply with any norm or standard or prescribed management practice;
- Eliminate any source of pollution or environmental degradation; and
- Remedy the effects of the pollution or environmental degradation.

Enforcement of the duty is not clearly spelt out in the Act. Failure to implement the measures as listed above is a criminal offence and penalties are stated.

The Act also provides for authorities to declare land to be a remediation site and remediation costs for historic contamination may be recovered from persons "responsible for undertaking the remediation". The Act is not specific on whom the costs should be recovered from and a land occupier could be liable, especially if high- risk activities, which may contribute to pollution, are undertaken (International Law Office, 2009).

Mineral and Petroleum Resources Development Act, 2002 (MPRDA)
The MPRDA creates layers of rights under the auspices of the custodianship role of the State (Godfrey et al., 2007). A range of factors can influence the nature of liability attracted in terms of this act, the most important being the type of mineral right that is held. In terms of Section 38 of the MPRDA, the holders of permits and rights are required to:

1. Appraise themselves of potential environmental impacts;
2. Manage any environmental impacts; and
3. Rehabilitate the environment in so far as is reasonably possible.

The section also provides that the holder is responsible for any environmental damage, pollution or ecological degradation, which occurs inside or outside of the boundaries to which the right or permit relates. The nexus of liability is therefore between the activity that caused the pollution or degradation and the holder of the right or permit (Godfrey et al., 2007). In this regard, the directors and members may be jointly and severally liable where there is an unacceptable negative impact on the environment. It can therefore be stated that the MPRDA provides for environmental liability based on broad responsibilities of the holder of a right or permit. In practice, the extent of the liability may be limited by the pollution and degradation that occurs with an approved environmental management plan or environmental management programme (Godfrey et al., 2007).

However, the MPRDA does not attempt to extend the range of people to whom liability can attach as is the case with the environmental legislation discussed above. Liability created in terms of Section 38

is not infinite. Environmental liability may be terminated either by sanctioned transfer of liability or on the obtaining of a closure certificate.

Liabilities that arise from the duties of care that are expressly provided for in NEMA, NWA and NEM: WA, clearly illustrate government's intention to implement the polluter-pays-principle. The people in respect of whom liability can attach is much broader defined in the environmental legislation than in the MPRDA. Notwithstanding the capping of liability in terms of the MPRDA, it is possible that liability may still be attracted in terms of NEMA or the NWA. The duty of care under section 28 of NEMA includes significant pollution or degradation that occurred before the commencement of the Act (International Law Office, 2009). The duty to remediate the environment even where pollution or degradation occurred before the commencement of the Act is likely to have far-reaching effects. Liability for retrospective environmental degradation is also evident through the declaration of remediation sites as provided for in NEM: WA.

The issues around liability for waste (including mineral waste) upon transfer of such waste for reuse are another complexity that is not clearly outlined at present. The debate around the difference of by-products and waste is also ongoing. The NEM:WA states that waste ceases to be waste once re-used, recycled and recovered (RSA, 2008), but there is no indication of when liability ends or gets transferred. This remains a challenge for the concept of industrial ecology (Brent et al., 2008).

5 DISCUSSION AND CONCLUSION

5.1 Governance issues

It has been reported that the current water demand exceeds the forecast estimates. For example, the forecast water demand estimates for Highveld area was 259 and 277.2 Mm^3/a in 2010 and 2020 respectively, but the study has shown that this has already been exceeded, namely currently at 350 Mm^3/a. On water transfers from one catchment to another, it was also noted that the transfers of water result in changes in water quality that is pumped into plants and this requires capital equipment interventions as it costs in the magnitude of 40 Cents/m^3 to pump, and this also depends on heat and distances.

The study revealed the perception that the price of raw water is too low. For example, it is cheaper for industry to waste water than to attempt to reduce consumption, and to recycle and treat it. That is a general dilemma – the level of levies is not an economic incentive for industry to change the way they use water. However, DWA argues against raising the price of water. The view of the individual from DWA is that raising the price would be bad for the private individual because manufacturing of many consumer goods consumes water to some degree and raising water tariffs will be transferred to the consumer. In addition, an increase in water price will increase the cost of domestic water to consumers. This would result in an overall rise in the cost of living. This implies the possibility of fixing the price of water to a demand supply ratio, but opinions in the public sector differed as to the effectiveness thereof.

The survey has established that, according to the industry participants, waste residues are often stored on site for purposes of use as a resource. Even though this helps to minimise effluent discharge on site or as a regulatory "requirement" in order to operate as a zero-effluent facility, it presents a mode of merely transferring the problem from one medium to another, namely transferring the problem into the future. The problem that is created is that chemical reactions take place where the insoluble salts are stored, and the products of these reactions mix with the ground and surface water, hence causing pollution. In addition to this, turbulence can also cause erosion and this contributes to the distribution of pollution. Currently, the process of waste storage covers around thirty three squared kilometre of ash and slime dams. The waste product is in magnitude of millions of tonnes. There are also other challenges associated with stored waste. Among them is the cost of

managing this storage. For example, the cost of the liner will vary depending on whether clay or other types of liners are used, such as triple-line. Therefore, one industry participant says, the government should take into account the cost of the liner with respect to society's needs when comparing with the value of the resource being protected.

An important governance factor that emerged from the study is that there is a lack of enforcement of the water quality standards on the part of government. All stakeholders emphasised that South Africa has one of the best National Water Acts in the world and, in addition, it has all the relevant legislative frameworks and strategies in place. However, little has so far been done because authorities were not in a position to manage the enforcement. This view has been echoed by others. In his report, Ashton (2008) re-iterated that there is not enough policing, and this makes laws and regulation fail to control this issue; meanwhile, according to the individual from MDALA, the probability of an offender to be caught and fined was low and that their (provincial) laws had been very relaxed.

In cases where policing does occur, the government does not exercise equity on the application of the water quality standards across the board of stakeholders. For example, currently there is a perception that the mines have a lee-way in not treating the mine waste water before transferring it to other industries for use as raw water. Related to the enforcement issue is how the government puts in place stringent measures. There is a need to change how the water quality standards are applied because currently, all users are linked to drinking water quality, thus the need for better water regulations. The more stringent the measures are for the allowed level of pollution in water, the more process and product waste will remain after the treatment of the water (Du Toit Roux; Smit et al., 2009). Other complications arise because of the price for desalination and the low amount of measurements of the stored load. For example, it is expected that, if the water the industries receive is of bad quality, they need more water for their processes. This is because the equipment can only handle a certain amount of pollution during, for example, reverse osmosis. In addition, with the deterioration of water feed, industries use more chemicals to treat the water and in the end produce more saline (salts and effluents). The impact in the increased salinity in the ash water system is a large concern for the industry participants. This increases the costs as more chemicals are used and much more energy is consumed. Therefore, in practise, the reuse of streams occurs seldom because of the variability in (mine) water quality with respect to the available plants. Industries have problems making the specification of the salts as the plants are designed for a certain feed composition, and if it changes the system does not operate optimally.

Importantly, the lack of skilled manpower at municipality level and the lack of resources to maintain the sewage works emerged as some of the governance challenges that the area experiences. For example, MDALA re-iterated that many Local Municipalities in the area did not have the required skills. There were cases whereby the operation personnel responsible for sewage works in many of the LMs did not have an understanding of the scientific theory behind processes due to loss of a lot of their qualified water specialists. This challenge was also highlighted in a report of a study undertaken by MDALA (2008).

It has been established in this study that the water demand from the industry increases, especially because of the increased demand for electricity as more water is used in the process of electricity generation. This results in less water available in the catchment. Under normal free market conditions the scarcity of a resource should increase the price. However, the price is set by the government. Eskom and Sasol, which are being considered as strategic industries, are given priority in the pricing of water. The study has also established that the water shortage in the catchment would be exacerbated further by the increased demand for water from the growing population in the area. The population is attracted because of the (perceived) created jobs and the natural growth. This aspect also decreases the water quality more, since the sanitation services are not adequate.

In terms of desired state for water and energy, all stakeholders agreed an insecure energy supply will affect the level of achievement of development goals in South Africa. The essence is that present needs for energy should be met to reach the desired growth of wealth. Meanwhile, high returns on investments, local and national growth of GDP per capita, and shrinking unemployment are important indicators for this increased wealth. Yet, this growth is limited by the price and scarcity of resources including water, coal, gas and land.

Hence alternative energy production from, for instance, wind and solar, and also gas would provide a good solution to the challenge. To achieve this requires an investment by both government and industry such as Sasol. The stakeholders agreed that when coal reserves are depleting, the price of coal would go up significantly and hence the price for energy in South Africa. According to DWA expensive water transfers do have an impact, eventually, on the cost to generate power. Thus investments in water supply will only affect the price of those parties that obtain the water from the new systems.

Linking desired state with the availability of water, all stakeholders agreed that in order to meet the desired state it must have water available. Therefore to achieve this would require all role players to do the right things in terms of making right decisions and playing their roles according to regulations and legislative requirements.

The issues for DWA are monitoring, capabilities and financial resources. It was recorded that the political will to monitor is improving substantially and hopefully that will improve even more with time. DWA alluded to this improvement, but added that it is also a mindset of both municipalities and industries that contribute to the poor quality of water. In the end it all comes back to capabilities and financial resources by municipalities. DWA echoed the point that many municipalities in the area do not even have a technician on their staff list. They have no technical capacity and capabilities in many cases.

Concerning sources of water from external transfers, the industry participants were of the view that the government should not heavily rely on this. For example, the expansion of Lesotho project should have started four years ago; yet up to now no progress has been made. Industry warns government of its heavy reliance on the strategy of reducing illegal irrigation, which is highly questionable in terms of how effective that is going to be, given the sentiments of lack of enforcement. However, the response from DWA was that the insufficient water supply was “unimaginable”, and this was “not an option” but a fact. DWA reaffirmed that it could get the water to industry and South Africa at all costs. If the problem came to a critical level, DWA could ultimately initiate the desalinisation of seawater and pump it to wherever it could be required. But it warned that this would come at a cost as the process would require much energy.

In general, the desired and expected state remains challenging. For industry, as to how they could close the gap between desired and expected state for quality and quantity of water, a corrective action is to be more active. However, it is a challenge obtaining decision makers interested in supporting that. Another soft issue is incentivising and changing people’s behaviour in high management by building it into their performance agreement as, currently, there is not really enough focus on environmental sustainability in industry. For example, within Sasol there is the need to be more responsible from a corporate citizen perspective, and examine its process efficiency, and water use efficiency. In other words there is a need to look at technology that use less water, use less electricity and generate fewer salts. The water use reduction target is not enough, and it could be higher.

An institutional governance issue is exemplified by the uncoordinated planning of the industries in the area, namely there is little interaction among the industries and government in water demand and

supply issues. For example, after Eskom has done its planning work it goes to DWA with its requirements for water without interacting with other relevant stakeholders in the area. This is also the case with Sasol.

Under the National Water Act of 1998 municipalities are supposed to manage and account for water. Unaccounted loss is rampant in the municipalities in the area. Therefore the first step local municipalities must take immediately is water conservation demand management. There are “huge” water losses in their own networks. To repair pipelines would cost money; hence there is a need to recover that cost. At local municipality level, the challenges that contribute to the poor water quality in the areas are many, but the most important ones that were highlighted by the participants are budgets and staffing constraints.

According to DWA water quality should not affect human health if all of the authorities do their job. For example, when municipalities purify their water and operate and maintain their waste water facilities adequately this problem would not be there. It was reported that DWA had started to take legal actions against some of the municipalities that did not comply to discharge qualities. How effective and possible this could be is questionable because according to the legislative frameworks, a government department is discouraged from taking another sphere of government to court. Cooperative governance is then the hindering principle here.

In terms of social benefits, a view has emerged from the public sector that it is doubtful if the expansion of the inland industry in South Africa will contribute to economic sustainability in terms of contributing to the eradication of poverty for the surrounding communities. This is because, although at a national level the complexes are the pillars of the country’s economy and the source of job creation, the benefits are not fairly shared with everybody in the immediate area.

In this study the importance of identifying positive feedback loops in social control systems has been shown to be as important in the environmental control system. Delays in decision making and the feedback loops in government policy and implementation can be of the order of 10 to 15 years before stabilization of the system can take place. This is in part due to the mismatches in response times of feedback loops and cyclical supply and demand in control systems. Three parameters that affect the time availability of water for the complex and an estimate of the response times and cycle times are proposed in Table 5.

Planning is an important governance issue because it is the basis of informed decision making. An indication of the planning horizon for the members of the complex can be taken from the planned economic production for each of the industrial operations. These were obtained from interviews and reports from the stakeholders and are summarized in Table 6.

Table 7 provides a summary of governance related issues in accordance with the definition of governance as outlined by the study on Mpumalanga Integrated Pollution Control (MDALA, 2008), which was based on the DFID rethinking Governance in Water Services (DFID, 2007). This framework describes governance in water services in terms of policies and legal management, institutional arrangements, administrative and economic issues, financial management; and technical compliance and levels of participation.

Table 5: Typical operating cycles that indicate the types of response times required for sustainable water supply system

Parameter	Observed impacts	Operating cycle	Observed Mitigation actions
Natural precipitation cycles	Wet and dry periods can change annual average stream flows by a factor of two (Rogers and Hobbs, 2010)	10 years +	National water management system where water from one area is transferred to another, and dams storage is matched to 5 year consumption cycles
Population growth	1.7% pa for indigenous population; 1-5% pa for migrating populations, e.g., from Zimbabwe (CSIR, 2008)	100 years + <1 year +	Coordinated planning of urban infrastructure for water supply with 5 year planning cycles. Deficit budgets None in place currently
Sustainable Development policy	Expectations from underserviced communities for increased supply of domestic potable water, and sanitation reticulation for Y million underserviced households in Govan Mbeki (CSIR, 2008)	Millennium Development Goal 15 years	Limit growth in demand in industry water supply to existing technology industries, transfer available growth to underserviced housing

Table 6: Stakeholder planning horizons for economic production from resources in the inland industrial complex

Stakeholder	Current planning horizon (commencement date)	Resource Factors that may affect production
Sasol Synfuels	2040 (1982)	Factors that affect the planned life include the availability of Planned life -; extensions or changes from coal to gas energy source.
Sasol Mining	2040 (1982)	Extension of mining for export coal market; continuation of Sasol Synfuels production from coal beyond 2040. Reserves of Y years. Requirements for carbon sequestration and limited capacity in these coal fields.
Harmony Gold	2010 (1958)	Depends upon the gold price and the electricity price put a limit on how much water can be pumped.
Eskom Tutuka	2040 (1982)	With a refurbishment in 2020, the power station may still operate for up to 60 years from date of construction (1980). Quality and quantity of coal from New Denmark is limiting production and increasing cost of electricity compared to other power stations.
Anglo Coal New Denmark	(1982)	Depends upon the coal price; yields of 4.5mT/a are less than half of the 11 mT/a that the mine was planned for.
Local Municipality	2014 (+1900)	Access to resources for a competitive Industrial economy after gold and coal mine and Sasol Synfuels plant closures mine are not proven.
Irrigation and animal husbandry	2100+ (1900)	Level of acid mine water releases to irrigation and animal and potable water supplies, and provision of piped potable water supply to the farms. Reduction in 30+Ml/d of water released into the Waterval system by industry.

Table 7: Summary of governance related key issues affecting sustainability of industrial complex

Issue	Impact/perception/consequence	Comments
Current water demand exceeds forecast	Perception of all: Raw water is abundant for the strategic industries in the study areas. Consequence: Water scarcity is experienced before the forecast time.	The forecast water demand estimates for Highveld area was 259 and 277.2 Mm^3/a in 2010 and 2020 respectively, but the study has shown that this has already been exceeded, namely currently at 350 Mm^3/a.
Price of water is low	Perception of industry: The price of raw water is so low, that it is cheaper for industry to waste water than to attempt to reduce consumption, and recycle and treat it. Perception of industry: The level of levies is not an economic incentive for industry to change the way they use water. Perception of government: Raising the price of water will raise the cost of living.	This implies the possibility of fixing the price of water to a demand supply ratio, but opinions in the public sector differed as to the effectiveness thereof.
Equity in application of water quality standards	Perception of industry: Lack of exercising more equity on the application of water quality standards across the board. Perception of industry: Currently the mines have a lee-way in not treating the mine water before transferring it to other industries for use as raw water. Consequence: In practise, the reuse of streams occurs seldom because of the variety in (mine) water quality with respect to the available plants. Impact: The variation of water quality that comes in has direct operational impacts like the cost of water on the site in terms of the additional treatment costs.	With deterioration of water feed, industries use more chemicals to treat the water and in the end produce more saline (salts) effluents. The impact in the increase of salinity in the ash water system is a large concern for industry. An important governance factor that emerged from the study is that there is a lack of enforcement of the water quality standards on the part of government, which contributes to liability (see issue below).
Liability for stored salts/wastes	Perception of industry: In terms of salt loads, waste residues are stored on site for purposes of use as a resource. This helps to minimise effluent discharge on site or as a regulatory “requirement” in order to operate as a zero-effluent facility. Consequence: Chemical reactions can take place when the insoluble salts are stored, after which they can precipitate in the ground water and surface water. Turbulence can also cause erosion. Impact: Process waste covers around five squared kilometre of ash and slime dams and product waste has the order of magnitude of thousand million tonnes	From a governance perspective this is just a mode of merely transferring the problem from one medium to another, namely transferring the problem into the future. Liability issue of who is responsible for the waste loads after mine closure becomes a important governance issue.
Who is responsible for Liability	Perception of all: Liabilities arise from the duties of care that are expressly provided for in NEMA, NWA and NEM: WA, MPRDA, and others.	Another aspect is the process of licensing which does not clearly spell-out the transfer of liability after the closure of the plant. For example, the issues around liability for waste (including mineral waste) upon transfer of such waste for reuse are another complex issue that is not clearly outlined at present. This problem is exacerbated by the challenge of permit licenses taking too long during approval process. For some, they are already outdated by the time they are approved. This is clearly a hindrance for the concept of industrial ecology.

5.2 Desired state with respect to governance issues

A summary of answers to the expected and desired state can be made based on the issues highlighted in the above section and the given tables.

a. Identification of stakeholders:
Stakeholders acknowledged that for desired state to be realised, it required the identification of critical stakeholders who will need to interact and liaise at all times. In this study, the critical stakeholders, who have vital and unique resources, are: DWA, DEA, LM, ESKOM, MDALA, SANParks, Agri SA, Sasol and the Waterval River Forum, Evander Gold and New Denmark. For each phase and after design choices, the list of stakeholders should be reviewed, to check whether potential partners and opposing stakeholders change or should be involved.

b. Availability of clean water:
The first hypothesis of desired state: If water is polluted more, the industry uses more water; this was found to be true.
This occurs because of technical reasons; the equipment is not suitable for any level of water quality other than the one on the specifications. For example, the untreated mine water that could be used by industries does not meet the requirement, hence requires treatment before use. Besides, most municipal sewage works in the area are non-functional and discharge effluents that do not meet the water quality requirements. Another important point to note is that the costs for industry will go up when it uses polluted water as feed. To solve this, the water quality should be made predictable, and more stable. A third important effect of using polluted water as source of raw water is that the amount of stored load will increase.
A reliable waste water treatment by a LM is most likely the largest issue on that part, and this again is a consequence of too little monitoring.

The second hypothesis: If water is scarce, the price does not go up under free market conditions; this was found to be true.
This is because the price is determined by the government.

The third hypothesis: There is a time delay to adapt the price of water to the scarcity; this was also proved to be true.
All stakeholders agreed that there is not enough water (concurrence with the inception report). Most stakeholders are of the opinion that if the price of water goes up, it may result in less water use. However, one of the major users (Sasol) has a slightly different view that this reaction is very slow and that the change in price of water will not be enough; it will not result in less water use. The current price of water does not provide incentives to industry to be more efficient. Also the levies are not an economical incentive for industry to change. From this it can be concluded that the feedback loop is correct – the availability of water does not control the demand for water.
Currently strategic industries obtain the water they require as long as they can afford the price to cover the costs for DWAF. It is not clear whether the price of water for people should go up. The practice at the moment is that every inhabitant has the right to 25 litres a day. If they can afford it they could pay for more. Therefore several questions arise: Is water a basic need and therefore the price should stay low, or should the price create more awareness in communities and force efficiency?
The stakeholders gave the impression that the formulation of major issues, using feedback loops, gave clarity and encouraged the stakeholders to supplement and explain. Despite the simplified representation of reality, the stakeholders did not give the impression that the analysis is incomplete. Here, the “desired state” approach played an important role. This way the stakeholders could first share their thoughts on the cause of and solution to problem as they experience it. However, this needs to be confirmed with the problem owner, WRC and experts.

6 RECOMMENDATIONS

- There is a clear need for coordinated planning and control on the storage and discharge of water and salt in the complex. This includes coordination of the regulations for ownership of waste and responsibility for consequent environmental pollution over the long term. For example under NEMA the polluter pays with a cradle to grave scope of liabilities. In contrast under the MPRDA responsibility transfers to the state either by sanctioned transfer of liability, or by obtaining a closure certificate. Experience in South Africa indicates that very large institutional problems take place with long term environmental sustainability of the solutions currently being implemented for post closure discharges of saline effluents. In the complex the mines report under the MPRDA and processing industries report under the NEMA. The NWA reporting systems are not functional for the municipalities.
- Economic controls on water demand management can assist the infrastructural and technology problems associated with unsustainable water and salt management. Prices are too low, with the result that demand is inelastic, and further economic growth results in larger environmental liabilities.
- Industry needs to work on closing the gap between the industrial desired state and the expected state for salt storage and disposal. As a corrective action incentivizing and changing behaviour is necessary in the water use performance agreements with DWA.
- The treasury via DWA should adopt a policy of ploughing back financial benefits from industry and economic productivity by way of infrastructure and incentives to ensure security of supply and long term environmental sustainability of water supplies.
- Inland complexes should be constructed where water transfer and unproven long term salt storage systems are not required to reduce costs.
- The treasury via the municipal finance and management Acts could improve the funding and management models of local municipalities who carry part of the responsibility for supply of clean water and disposal of waste water.
- Equity of enforcement standards must be applied to all stakeholders. Neither industrial, mining not municipal stakeholders should enjoy unfair advantage in the complex.
- At local municipality level the problems observed with managing budgets and managing personnel must be removed.
- The DWA, and the DMR should streamline the licencing process in order to spell out the transfer of liability after the closure of an industrial facility. In particular where the shortfalls in the MPRDA legislation and administration transfer long term risk for mine salts to industries which have been assigned responsibility under another set of regulations.

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ANNEXURE A: QUESTIONNAIRE

Governance and stakeholders:
First survey to evaluate the potential symbiosis within a large inland industrial complex for waste and water management

5 December 2008

Project Manager: Godfrey Mvuma

General information:
Title report: An assessment of the key factors that influence the environmental sustainability of a large inland industrial complex

Author(s): DEC Rogers, G Mvuma, AC Brent, FR Hooijman
Project no: WRC K5/1833/3

Introduction

CSIR is coordinating the WRC project on industrial ecology and has the objective of improving opportunities for reducing pollution build up in inland industrial complex areas so as to protect clean water supplies and to increase the productivity of water use by waste minimization and cleaner production. Universities that are collaborating on the project are UCT, UKZN and TU Delft (the Netherlands).

The CSIR and TU Delft are initiating the research with a questionnaire and interview based survey of the needs of Interested and Affected Parties (I&APs) in the Secunda Industrial Complex, and expectations of the structure of an environmentally sustainable system. Institutional requirements are expected to ensure technical, economic, social and ecological sustainability. The questionnaire consists of four parts.

In Part A the problem is introduced; an opportunity is given to comment on the inception report.

In Part B the I&APs are identified by mass flows of water and association with impacts. The institutional objectives and actions are recorded, as provided by the institution knowledge system and, specifically, the environmental management system, e.g. ISO 14000, and the regulatory compliance reporting of environmental sustainability, which is incorporated in the overall sustainability report.

In Part C the structure of the inland industrial system is established, e.g. roles of I&APs, relationships between I&APs, feedback loops and time delays. Responsible parties for necessary changes in the system are identified.

Part D is an open ended question on sustainability in general. In this part, topics that have not been covered are addressed and opportunities for industrial ecology and other suggestions on improving sustainability can be made.

Part E is a supplement of questions specifically for industry and municipalities on water, waste, and energy resources.

<u>Part A</u>: Introduction of the problem

The major problem as described in the inception report will be clarified, during the interview, with a discussion on a systems dynamics approach to the problem.
The questions put forward to all stakeholders are:

- ***Is there agreement on the problem as described?***
- ***Are there any suggestion?***
- ***Are there any further comments on the inception report?***

Part B: I&APs

The questions in Part B are formulated according to the *General Protocol for translating visions into goals for multi-party systems* as developed by DEAT. The methodology is based on a "desired state" approach which is used for obtaining consensus. The protocol is part of the *Goal setting protocol and procedure for strategic adaptive management* as described in *Development of a protocol for the definition of the desired state of riverine systems in South Africa*. The first two steps of the General Protocol will be conducted, using this questionnaire. These steps are:

- Identify the parties in the multi-party system, their values and needs
- Gain consensus on the multi-party system purpose and operating procedures

Identify major I&APs

- ***List all parties that are, or could be, involved in an inland industrial complex***

  (Open question)
- ***In the list, distinguish between interested party and affected party.***

Interested parties are users of water and other ecosystem resources. Affected parties are innocent recipients of benefits or negative consequences from the system operations.

Stakeholders are the sum of I&APs.

Formulation of multi-party system purpose for an inland industrial complex

- ***In your opinion, for the inland industrial complex, what are the desired states (goals) and expected states for meeting the present needs for energy covered by the industrial complex, i.e.***

- Availability of energy (load shed, fulfilment demand for liquid fuels)
- Affordability of energy (price of electricity and liquid fuels)

- ***In your opinion, what causes the gap between the desired and expected states, and how may the gap be resolved?***

- ***In your opinion, for the inland industrial complex, what are the desired states (goals) and expected states for meeting the future needs for energy covered by the industrial complex, i.e.***

- Efficiency of resource use in (energy) production
- Renewable energy (R&D, production, enfoncement)
- Total return on investments of companies (economic development, viability)
- Increase in GDP per capita
- Price of water

- ***In your opinion, what causes the gap between the desired and expected states, and how may the gap be resolved?***

- ***In your opinion, for the inland industrial complex, what are the desired states (goals) and expected states for the conservation of ecosystems in the area affected by the industrial complex, i.e.***

- Emitted greenhouse gasses
- Emitted air pollution
- Area of altered land (area covered by mining, industry, agriculture for biomass)
- Stored load (e.g. ash and salt dumps)
- Water quality in catchments (water management class)
- Sufficient surface water in catchments
- Sufficient ground water in catchments

- ***In your opinion, what causes the gap between the desired and expected states, and how may the gap be resolved?***

- ***In your opinion, for the inland industrial complex, what are the desired states (goals) and expected states for impacts on communities in the area affected by the industrial complex, i.e.***

- Impact on human health of industrial complex
- Unemployment rate in the area
- Safety incidents related to work
- Sensor stimuli (noise, smell, aesthetics, vision)
- Increase in local GDP per capita (community wealth)

- ***In your opinion, what causes the gap between the desired and expected states, and how may the gap be resolved?***

The list above is derived from a goal analysis from multiple perspectives and multiple methods to reach sustainable development. These criteria represent the end point indicators of sustainability development of inland industrial complex. Thereby possible solutions and strategies to improve the sustainability of inland industrial complexes might be identified.
These criteria should measure the achievement of the goal and the effectiveness of strategies. The question in mind for this goal hierarchy was: *what do we precisely want? How can the goals be defined and specified as sub goals?* This means that the criteria should focus on the overall sustainability goals, not solutions, nor variables that affect the criterion.

- ***Are there important criteria missing?***

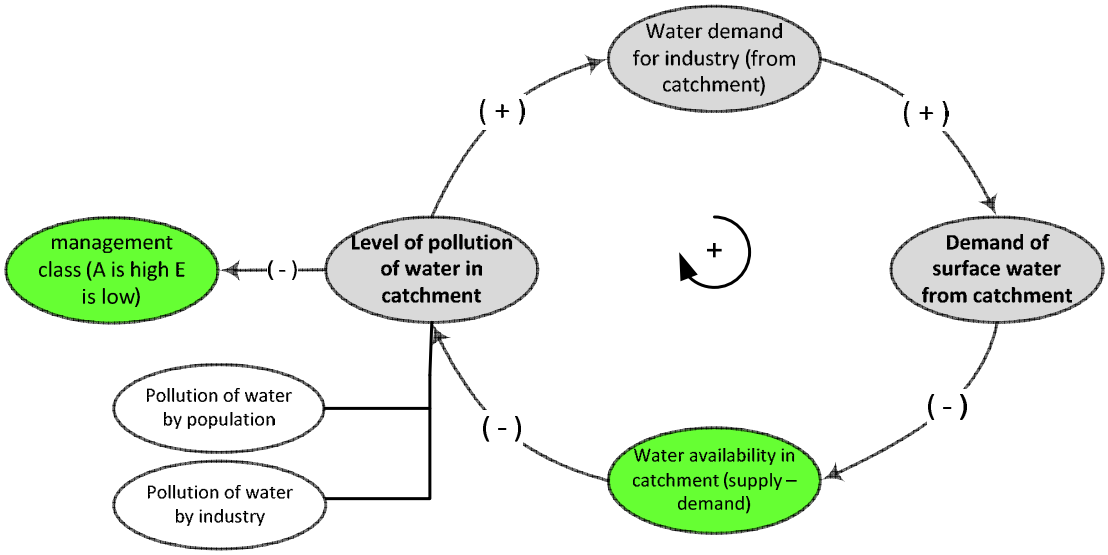
- ***Any other suggestions?***

<u>Part C</u>: Structure

The questions in Part C are formulated from a qualitative System Dynamics approach, which tests dynamic hypothesis or confirms detected feedback loops. The structure of the system is investigated, e.g. roles of I&APs, relationships between I&APs, feedback loops and time delays. Responsible parties for necessary changes in the system are identified.

First, questions will be asked on water use, quality and price. Then affordability and availability of energy is investigated, which includes the viability of a new inland industrial complex in a changing environment. Finally, there will be questions on the impacts on neighbouring communities.

Water use, quality and price



1. ***Related to the feedback loop above, to what extent do you agree with the following statement?***

   If the water supply is polluted, industry uses more water (e.g. in order to obtain cleaner water in processes and to fulfil output requirements)

   ☐ I strongly agree
   ☐ I agree
   ☐ I disagree
   ☐ I strongly disagree

   Because,

   _____

   ☐ I don't know

2. ***Who is responsible for increasing water demand and shortage? Who should control this positive feedback loop? (Open question)***

   _____

   _____

3. ***To what extent do you agree with the following statement?***

Stored waste load is a serious threat to the ecosystem

- ☐ I strongly agree
- ☐ I agree
- ☐ I disagree
- ☐ I strongly disagree

Because,

- ☐ I don't know

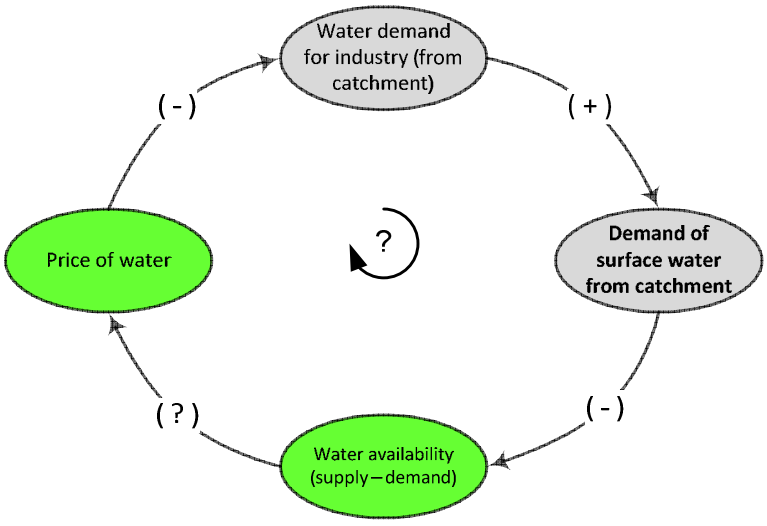
4. ***To what extent do you agree with the following statement?***

Waste streams are not always treated to the legal requirement, because of the costs of the treatment

- ☐ I strongly agree
- ☐ I agree
- ☐ I disagree
- ☐ I strongly disagree

Because,

- ☐ I don't know



5. ***Related to the feedback loop above, will the price of water go up when there is <u>less</u> water available?***

Assumption: supply <u>just covers</u> the demand from agriculture, population, ecology and industry

- ☐ Yes, significantly, it will result in less water use
- ☐ Yes, but not enough for less water use
- ☐ No, it stays the same
- ☐ No, the price will go down

Because,

☐ I don't know

6. ***Will the price of water go up if there is <u>not enough</u> water available?***

Assumption: supply does not cover the demand from agriculture, population, ecology and industry

☐ Yes, significantly, it will result in less water use
☐ Yes, but not enough for less water use
☐ No, it stays the same
☐ No, the price will go down

Because,

☐ I don't know

7. ***Will the price of water go up if more water should be transferred from basins outside the catchment in the area of the complex?***

Assumption: the supply in the catchments does not cover the demand

☐ Yes, significantly, it will result in less water use
☐ Yes, but not enough for less water use
☐ No, it stays the same
☐ No, the price will go down

Because,

☐ I don't know

8. ***When do you think the <u>growth</u> in supply of water from Lesotho will end?***

☐ 2009 (± 1 year)
☐ 2012 (± 1 year)
☐ 2015 (± 1 year)
☐ Never

Because,

☐ I don't know

9. ***To what extent do you agree with the following statement?***

The energy consumption of water transferred from basins outside the catchment in the area of the complex results in significantly more internal energy consumption for the complex. This will change the price for energy noticeably in South Africa (more than 50% higher in the context of other factors that remain the same or change under normal conditions) and also the demand for energy

☐ I strongly agree
☐ I agree
☐ I disagree
☐ I strongly disagree

Because,

☐ I don't know

10. ***According to competition law water demand should be influenced by the price of water and the other way around.***

    How long will it take before an increased demand of water will change the price of water?

    ☐ It changes immediately
    ☐ A few months
    ☐ A few years
    ☐ It won't change

    Because,

    ☐ I don't know

11. ***Who is responsible for the price of water in relation with demand and supply? (Open question)***

12. ***If there is not enough water available, who will 'suffer' first?***

    ☐ Agriculture
    ☐ Communities
    ☐ Ecology
    ☐ Industry

    Because,

    ☐ I don't know

Comment, possible solutions, additions on water use, quality and price:

Affordability and availability of energy (present needs and future needs)

13. ***When <u>do you think</u> the price for emitting CO_2 is going to change the price for energy noticeably in South Africa (*****more than 50% higher in the context of*** ***other factors that remain the same or change under normal conditions)?***

    ☐ 2009 (± 1 year)
    ☐ 2012 (± 2 year)
    ☐ 2016 (± 2 year)
    ☐ 2025 (± 5 year)
    ☐ After 2030
    ☐ Never

    Because,

    ☐ I don't know

14. ***When <u>should</u> the price for emitting CO_2 change the price for energy noticeably in South Africa* (more than 50% higher in the context of *other factors that remain the same or change under normal conditions)?***

- ☐ 2009 (± 1 year)
- ☐ 2012 (± 2 year)
- ☐ 2016 (± 2 year)
- ☐ 2025 (± 5 year)
- ☐ Never

Because,

_____

- ☐ I don't know

15. ***What is the time delay between an increase in price for CO_2 and an increase in energy price for the end users?***

- ☐ It changes immediately
- ☐ A few months
- ☐ A few years
- ☐ It won't change

Because,

_____

- ☐ I don't know

16. ***Who is responsible for the change in price for CO_2 and the price for energy for the end user? (Open question)***

_____

_____

17. ***To what extent do you agree with the following statement?***

The growth in price for emitting CO_2 is a threat to the financial viability of industry in South Africa (worst case scenario is early shut down)

- ☐ I strongly agree
- ☐ I agree
- ☐ I disagree
- ☐ I strongly disagree

Because,

_____

- ☐ I don't know

18. ***What other regulation, laws or policies concerning air pollutions could affect the viability of industry in South Africa?***

_____

_____

19. ***What other regulation, laws or policies concerning air pollutions could affect the price of products of industry in South Africa?***

_____

_____

20. ***To what extent do you agree with the following statement?***

If the reserve of coal resources are depleting, the price of coal will go up significantly and therefore also the price for energy in South Africa (**more than 50% higher in the context of** ***other factors that remain the same or change under normal conditions)***

- ☐ I strongly agree
- ☐ I agree
- ☐ I disagree
- ☐ I strongly disagree

Because,

_____

- ☐ I don't know

21. ***Do you expect the area of altered land to grow notable, due to an inland industrial complex and how much, because of i.e.***

- Quality of coal (more area altered for the same caloric value)
- Construction of pipelines for gas
- Biomass production
- Accessibility of coal
- Carbon capture

22. ***Do you think the growing area of altered land is a concern?***

_____

_____

23. ***Who is responsible for the effects of growing area of altered land?***

_____

24. ***What do you think of spreading different parts of the inland industrial complex, in order to minimize affects on local communities?***

_____

25. ***To what extent do you agree with the following statement:***

If the mining area is more than 300 km away from the industrial complex, this will change the price for energy noticeably in South Africa (**more than 50% higher in the context of** ***other factors that remain the same or change under normal conditions)?***

- ☐ I strongly agree
- ☐ I agree
- ☐ I disagree
- ☐ I strongly disagree

Because,

_____

- ☐ I don't know

26. ***What could cause a growing price for energy in South Africa most:***

- ☐ Water costs, because of shortage
- ☐ Water costs, because of transfer energy consumption

☐ Coal resource costs (including transport)
☐ Price for emitting or sequestrating CO_2
☐ Regulation
☐ Other, namely

Because,

☐ I don't know

27. To what extent do you agree with the following statement:

More renewable energy is an economically and technologically feasible solution to growing air and water pollution in South Africa

☐ I strongly agree
☐ I agree
☐ I disagree
☐ I strongly disagree

Because,

☐ I don't know

28. To what extent do you agree with the following statement:

Carbon capture and storage is a economically and technologically feasible solution to growing air and water pollution in South Africa

☐ I strongly agree
☐ I agree
☐ I disagree
☐ I strongly disagree

Because,

☐ I don't know

29. To what extent do you agree with the following statement:

The price for <u>20%</u> renewable energy will be more than 50% higher than the price of only non renewable energy until 2020.

☐ I strongly agree
☐ I agree
☐ I disagree
☐ I strongly disagree

Because,

☐ I don't know

30. To what extent do you agree with the following statement:

An achievement of at least <u>20%</u> renewable energy is very feasible in a new inland industrial complex

☐ I strongly agree
☐ I agree
☐ I disagree
☐ I strongly disagree

Because,

☐ I don't know

31. ***To what extent do you agree with the following statement:***

An insecure energy supply will affect the level of achievement of development goals in South Africa

- ☐ I strongly agree
- ☐ I agree
- ☐ I disagree
- ☐ I strongly disagree

Because,

- ☐ I don't know

32. Who is responsible for security of energy supply? (Open question)

---

33. What is the time delay between changes in energy demand and adapting to that change by increasing supply? (Open question)

---

34. What is the main cause for that delay?

- ☐ Little competition in the energy market
- ☐ Governance
- ☐ Infrastructure
- ☐ Electricity grid

Because,

- ☐ I don't know

Comment, possible solutions, additions on affordability and availability of energy:

Impact on neighbouring communities

In this part other impacts on the ecosystem and neighbouring communities are investigated

35. To what extent do you agree with the following statement:

The impact of a new inland industrial complex on the <u>health</u> of inhabitants of neighbouring communities is significant

- ☐ I strongly agree
- ☐ I agree
- ☐ I disagree
- ☐ I strongly disagree

Because,

- ☐ I don't know

36. If yes:

What is the main cause for that?

- ☐ Inadequate health care
- ☐ HIV
- ☐ Air and water pollution
- ☐ Education
- ☐ Other, namely

Because,

- ☐ I don't know

37. What is a possible solution? (Open question)

---

38. Who is responsible for the health of inhabitants of neighbouring communities? (Open question)

---

39. What industry causes the most negative impacts on communities created around an industrial complex (including mining)?

- ☐ Coal mine
- ☐ Gold mine
- ☐ Power plant
- ☐ Coal to liquid manufacturer
- ☐ Other, namely

Because,

- ☐ I don't know

40. To what extent do you agree with the following statement:

A new inland industrial complex will cause <u>local</u> economic stability

- ☐ I strongly agree
- ☐ I agree
- ☐ I disagree
- ☐ I strongly disagree

Because,

- ☐ I don't know

41. Do you think an inland industrial complex causes noise, smell, bad aesthetics and poor sight because of smog and could this hinder the fulfilment of your objectives?

- ***Because of opposition from inhabitants of the area where the new inland industrial complex will be built?***
- ***Because of a shortage in competent employees?***

42. ***What is your view related to safety incidents?***

- ***Should significant additional efforts be made to lower incidents?***
- ***Who do you think is responsible?***

Comment, possible solutions, additions on impact on neighbouring communities:

Part D: Comments on sustainability

Is there anything not covered yet, i.e. problems, opportunities for industrial ecology, other suggestions for sustainability?

Do you have any corrections or short falls in the inception report?

<u>Part E</u>: Detailed questions for industry and municipalities

Water and waste process

Institutional objectives and actions are reported in the institutional knowledge system and environmental management system.

Is anything missing in e.g. the ISO 14000 and the regulatory compliance reporting of environmental sustainability?

On:

- Specific water and resource use, technology benchmarks, and ecosystem carrying capacity for water supply
- Ecological limits for water levels in the supply catchment, and eco-service for long-term absorption capacity of pollutants from operations and post closure waste storage
- Institutional requirements to ensure technical, economic, social and ecological sustainability.

Detailed questions for industry

How much waste in water do you produce per year?

- Total Dissolved Solids (TDS)
- Phosphate (PO4)
- pH
- Dissolved Oxygen
- Water temperature
- Total Suspended solids
- Ammonia
- Ortho phosphate to total phosphate ratio
- Fluoride
- Sulphate

TDS, pH and ammonia have been used as indicators/have been identified as the most critical according to the Strategic Environmental Assessment on the complex.

What is your classification according to an environmental management system

- *What permits do you have?*
- *What water use permits?*
- *What waste permits?*
- *What resource use permits?*

Your thoughts on the appropriate management structures, and paradigms of management, to support industrial symbiosis and sustainability in general.

Annexure B: Suitability of System Dynamics for this study

A number of characteristics of a system can be described, to consider a range of possible modelling techniques (Daalen 2006). These are type of time space and time functions, absence or presence of input variables, type of relations between input and output, implicitly or explicitly time-independent. These are described, followed by a discussion of appropriateness of System Dynamics, as a modelling tool for this project.

1. Type of time space and time functions (continuous versus discrete)

The time space is the set of all moments at which the system is being considered (Daalen 2006). The system is not represented as a discrete set of times, but continuous. The system could be described at each moment between certain time intervals, for this project until 2040.

The time function is called continuous if a range of values could be added at a point in time. The time space of the decision making system of a new inland industrial complex seems to be mostly continuous but there are some discrete components like a discrete decisions about building a plant or increasing the price of water. However Forrester (Forester 1961) gives several reasons for recommending initial formulation of a continuous model. One of the reasons is:

“It provides a good starting point from which to add later the greater reality of separated actions where such a representation is necessary”. Another reason is that “real systems are more nearly continuous than is commonly supposed. There may be an annual budget, but it is frequently modified by new conditions” (Forester 1961).

2. Absence or presence of input variables (open versus closed)

Forrester (1971) defines an open system as a system that is characterized by outputs that respond to inputs but where the outputs are isolated from and have no influence on the inputs. Building a new inland industrial complex is an open system. Energy demand, for example, is not considered to be controlled by the system, but it does influence the decision making of building a new inland industrial complex and the output availability and affordability of energy. So building a new inland industrial complex is an input or an instrument as it is called in this report.

However Forrester (1968) focuses on interaction within the system that produces growth, fluctuation and change. Decisions imply in this case more than human decision making, it is a decision process that controls any system action.

3. Type of relations between input and output (linear versus non-linear)

A model is linear if the super-position principle applies. This means that cause has the result A and cause b the result B and that if the causes are added; the result can be added as well. If the system is non-linear this means that these relationships are more complex. If the system is non linear and relations are for example exponential or feedback loops exist, system dynamics is more suitable.
The system discussed is non-linear. This can be explained by the amount of waste in water by population. If the population increases with 10 percent, let’s say the amount of waste in water by population might increase with 10 % too. If the percentage of people with access to sanitary increase with 10%, it is assumed that the amount of waste in water by population will decrease with 10 %. If the system is linear, you could assume the amount of waste in water is stable and therefore the level of pollution of water in the catchment too. The linear system is shown in figure 14.

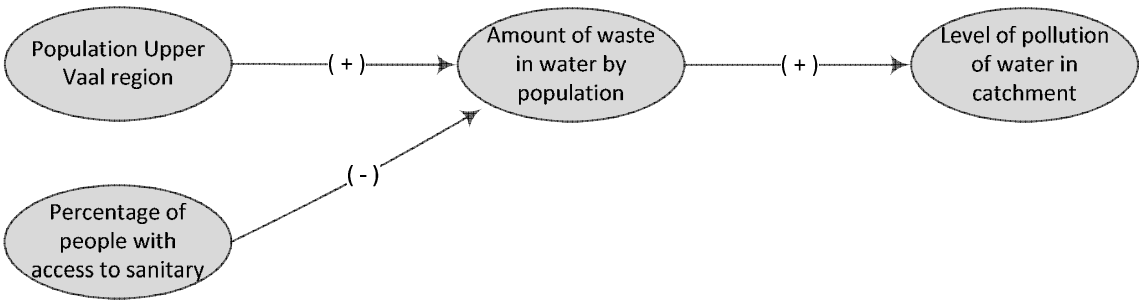


Figure 9: Linear system

However, the population will increase the demand for water; therefore there is less water available in the catchment and since the amount of waste by population stays the same, the level of pollution of water in the catchment will go up. This means the system is not linear. This is shown in Figure 15.

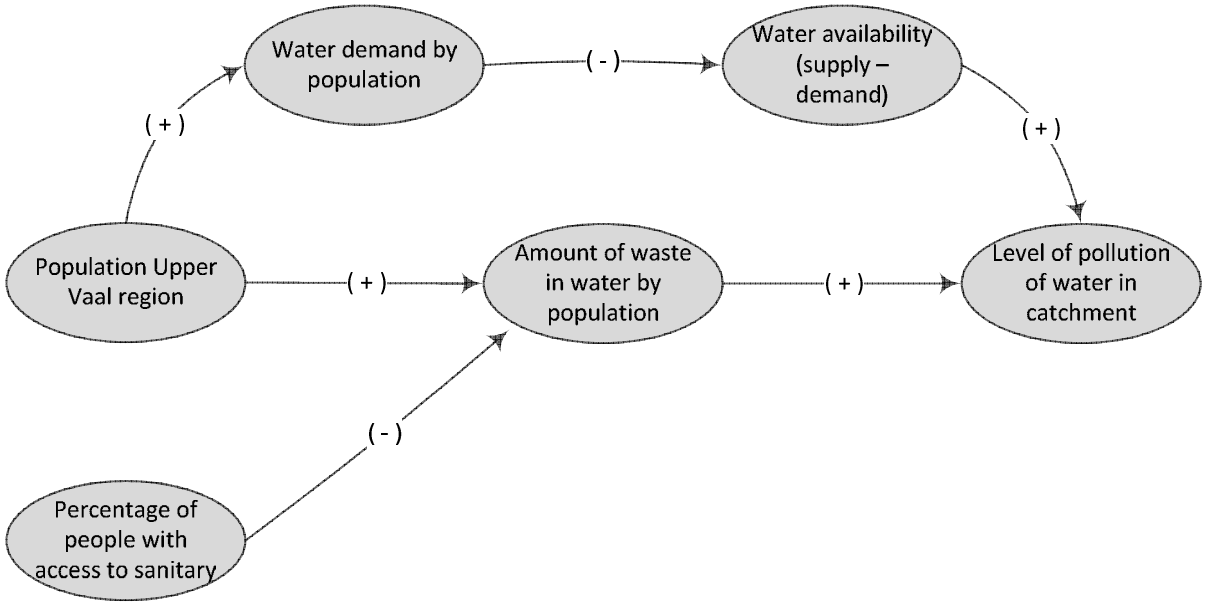


Figure 10: Non linear systems

4. Time-dependency (static versus dynamic)

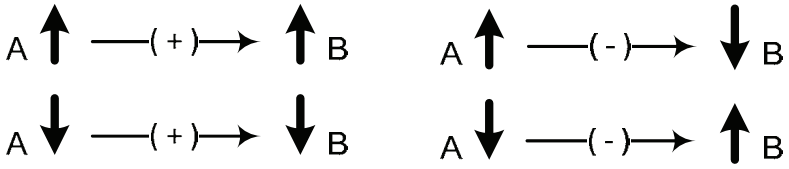
In a dynamic model, the output variable at a moment in time does not only depend on the input variable at that moment, as in static models, but also on the behaviour of the input variable over the previous time (Daalen 2006). If there is a change in energy demand the energy producers cannot immediately adapt to this change and increase their capacity, they first have to decide to expand and built the extra capacity. This is one example of the time-dependency of the system and shows it is dynamic.

5. Conclusion

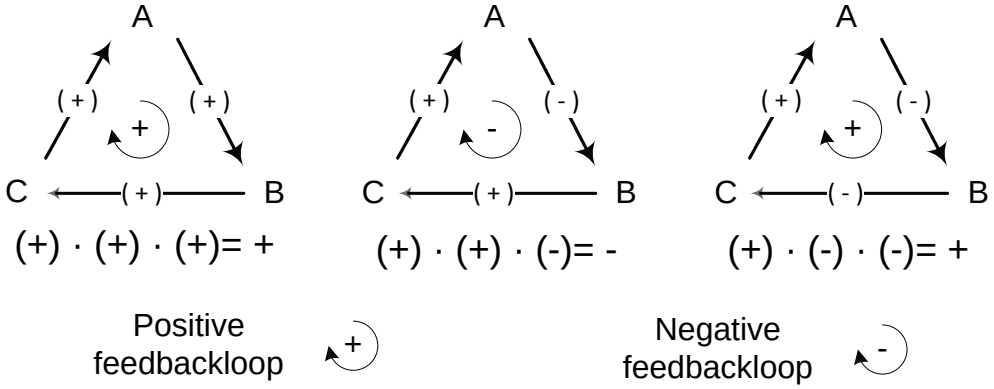
The characteristics of the decision making system of a new inland industrial complex have been described. It has continuous time space and function, it is an open system, there are non-linear relationships and the behaviour of the system is time dependent. These are characteristics of System Dynamics models. The purpose of System Dynamics is to help people make better decisions when confronted with complex, dynamic systems.

Annexure C: Explanation of causal loop diagrams

Annexure C.1 Explanation of the symbols



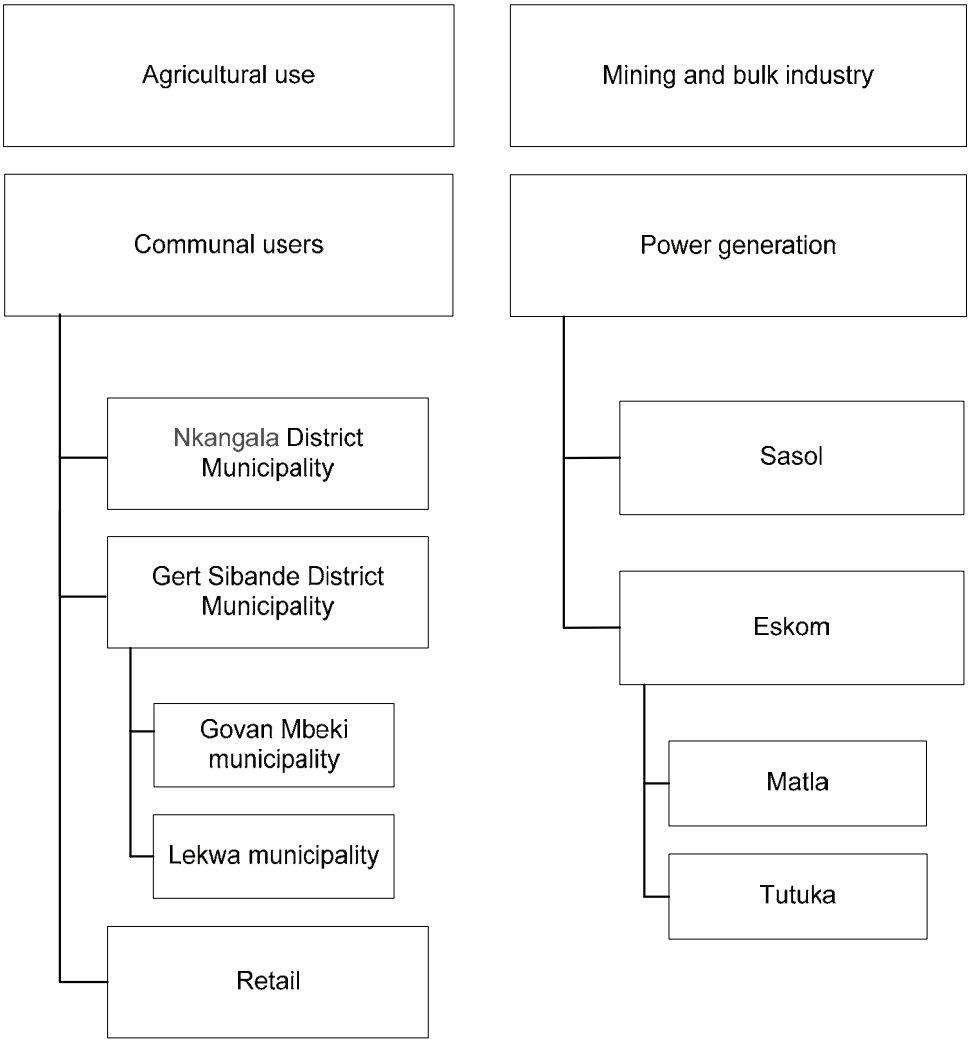
A positive relationship means that if A goes up B goes up as well, or that they both go down. A negative relationship means that if A goes up, B goes down or if A goes down, B goes up.



A positive feedback loop "diverges or moves away from the goal" (Principles of Systems, Forrester 1968). It means that this part of the system is out of control. The "negative feedback loops can range from smooth achievement of the goal that the loop is seeking, to wild fluctuation in search of the goal" (Principles of Systems, Forrester 1968). A feedback loop can be controlled by interference of an external influence.

Annexure D: Water users and requirements in Secunda

Annexure D.1 Major water users in the Highveld area



Annexure D.2 Water requirements and supply Highveld area

Reconciliation of requirements and available water (million m3/a) in Wilge and up and downstream of Vaal dam (DWAF 2004)

		Water available			Water requirements			
		Local yield	Transfers in	Total	Local requirements	Transfers out	Total	**Balance**
Base Scenario*	**2000**	1132	1630	2762	1045	1379	2424	**339**
	2025	1229	1639	2859	1269	1634	2903	**-44**
High scenario	**2025**	1486	1630	3116	1741	2140	3881	**-765**

*With yield of Mohale dam

Annexure D.3 Map of Highveld area

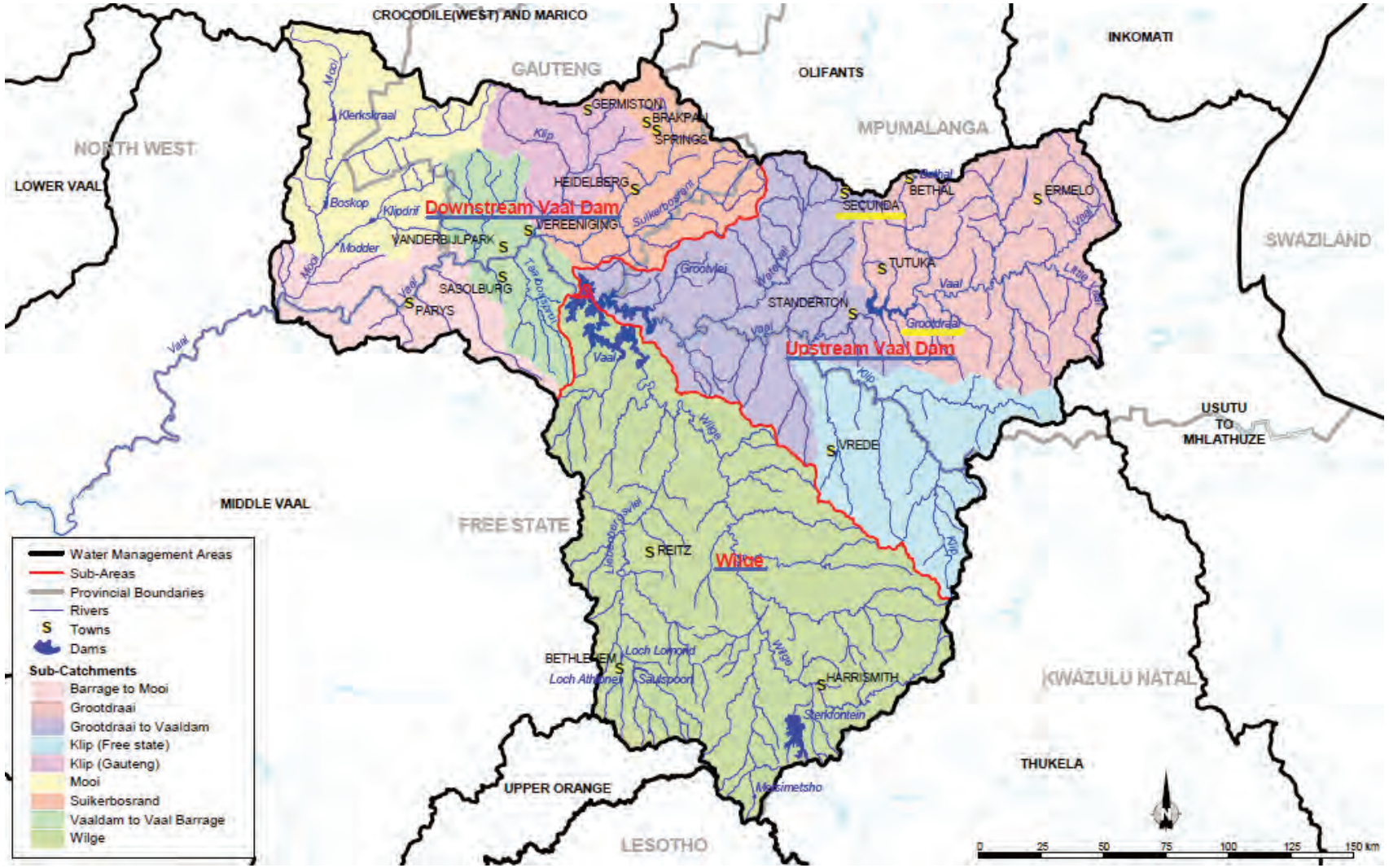


Figure 11: Location of Secunda, Grootdraai and Upstream Vaal dam

Annexure E: Critical and dedicated stakeholders

	Dedicated		Non dedicated	
	Critical stakeholders	**Non-critical stakeholders**	**Critical stakeholders**	**Non-critical stakeholders**
Aligned interest with national government	- Department of Water Affairs and Forestry DWAF - Department of Environmental Affairs and Tourism DEAT *Will most likely participate and are potential partners*	- Upper Vaal CMA (Catchment Management Agency) - Provincial government of Mpumalanga - National Energy Regulator of South Africa NERSA - (WRC) *Will most likely participate and are potential partners*	- Eskom (non-dedicated?) - Evander Gold *Critical stakeholders that are hard to motivate*	- District municipalities - Lesotho highlands water commission - Water boards *Stakeholders that do not need to be included in first instance*
Conflicting interest	- Local municipalities - Sasol Synfuels (aligned with government?) - Mpumalanga Department of Agriculture & Land Administration MDALA - Agri SA - Waterval River Forum *Potentially hinder certain changes*	- Sasol Mining Mpumalanga - Water User Association - New Denmark *Potentially oppose to and criticize certain changes*	- Parks Board *Potentially hinder without action*	- Sappi - AECI - Evander Gold Mines - Mvula *Stakeholders that do not need attention in first instance*

Annexure F: Gant Chart for implementation of the project

Gantt chart of tasks and outputs from research plan (Sept 2008)

				2008		2009		2010	
Deliverable		**Output**		**Apr**	**Sept**	**Apr**	**Sept**	**Apr**	**Sept**
1	Inception	1	Criteria and recommendations for selection of complex						
2	database	2Eng	Inventory: input output and storage of products and waste, reports and publications						
3	I/O Balance	2Lim	Inventory: input output and build-up of pollutants reports and publications						
4	Sustain	3Eng	Environmental sustainability: water use efficiency, pollution of water systems, reports, publications						
		3Lim	Environmental sustainability: ecoservices water ecological limit, system cleaning capacity, reports publications						
5	Tech Assess	4	Complex cleaner production opportunities: reuse water and reuse waste using integrated technologies						
6	Gov Assess	5	Gov Barriers to CP opportunities, identify and recommend actions for water use efficiency and waste minimization						
7	Rep Cap	6	Capacity Building						
8	Rep Art	7	Publications Report						
9,10	Ann Prog		Project management and reporting						

ANNEXURE G: Summary of minutes of Waterval River Forum

Meeting held on 19 February 2009

WATERVAL FORUM

MINUTES OF THE WATERVAL CATCHMENT FORUM MEETING, HELD ON THE 19th FEBRUARY 2009, AT ROSES INN, SOUTPANSBERG, SECUNDA.

ATTENDANCE : Please refer to attendance register

	DISCUSSION	**ACTION/ FOLLOW UP**
1.	**WELCOME AND INTRODUCTION OF ATTENDEES**	
1.1.	F. Mamabolo apologised for the change of venue and introduced Joyce Lekoane as the new official of the Waterval Catchment and requested everyone around the table to introduce themselves.	
2.	**APOLOGIES**	
2.2.	Apologies from the following people were noted. • Karren Chetty • Thembi Masilela • Frik van Staden • Jaco Linde • Hemesh Dhulab • Gail Nussey • Emile Blaauw • Bertie Botha • Boet Conradie • Esther Pilane • Noel De Villiers • Tsunke Hlanyane	
3.	**MINUTES OF THE PREVIOUS MEETING**	
3.1.	• Minutes were accepted as a true reflection of the previous meeting.	All
4.	**MATTERS ARISING FROM PREVIOUS MINUTES**	
4.1	F. Mamabolo apologised on behalf of the Department for the way matters were dealt with Water Week celebration. She indicated that next year it will be organised and celebrated by the forum.	All
4.2	F. Mamabolo stated that Govan Mbeki Municipality acknowledge the problems that they are facing and are implementing measures. Action plan was received	

	DISCUSSION	ACTION/ FOLLOW UP
	by the Department and stated that by the end of June the plant will be fully operational. Progress report was also sent by Mr. Moase.	
5. 5.1. 5.1.1. 5.1.2. 5.1.3. 5.1.4.	**ADDITIONS TO THE AGENDA** The following points were raised by the forum members as the additions to the agenda • Presentation by Dr Roger / Dr Mvuma (CSIR), to present under feedback. • Monitoring points F Mamabolo indicated that the Department will be reviewing all the monitoring points and/especially all the level 3 are not going to be monitored until further notice. • WDCS J. Lekoane announced that all water users must register their water uses for the WDCS that will be implemented soon. The forms will be given to the water users and/or can be downloaded from the Department website for registration. Presentation by Dragana Ristic, DWEA (It was agreed by the member that the presentation will be given next forum as it requires a lot of time)	All
6. 6.1.1	**Correspondence** There were no correspondences.	
7. 7.1.	**FINANCE AND MEMBERSHIP RENEWALS** The report could not be given as Mr J Linde was absent.	J. Linde
8. 8.1.	**NEWSLETTER** The report could not be given as Mr J Linde was absent.	J. Linde
9. 9.1.1	**FEEDBACK** **Presentation by CSIR** • The presentation was about assessment of the factors that influence long term environmental sustainability of industrial complex and potential synergy for re-use of waste products. • Dr Mvuma indicated that they are concerned about the impact caused by industries to the community and involvement of community during the planning phase. It was discussed after the presentation that Joyce must sent it to Rand Water to be placed at the website. Dragana asked if the presentation can be placed at the DWAF website as it looks like we are advertising ourselves (DWAF) to Rand Water. F. Mamabolo said that it can be looked for in the future and M. Likhethe advised that it is not about advertising but giving information to the public.	Dr Roger/ Dr Mvuma

	DISCUSSION	ACTION/ FOLLOW UP
	It was asked if the research focuses only on the industries and not municipality and if the pesticides and insecticides contribute to pollution into our streams and is regarded as part of pollution. Dr Roger explained that insecticides and pesticides form part of pollution and that their research is focused on Sasol Complex.	
9.1.2	**ISSUES OF CONCERN FROM THE PRESENTATION** What does the forum / agriculture production want: • Up stream users to do • Government to do • Water suppliers to do F. Mamabolo mentioned that the farmers requested that if there is a pollution incident upstream they must be notified so that they can take preventable measures to protect livestock.	All
9.2	**Water Quality Report: Rand Water** M. Likhethe pointed out the under-mentioned regarding the water quality during the last quarter: • The water quality for Trichardtspruit is deteriorating. • There was an increase in COD at all the monitoring points. Conductivity and Alkalinity are also not acceptable at almost all the points. • Evander and eMbalenhle WWTWs did not comply in terms of *Feacal coliforms*.	M. Likhethe
9.3. 9.3.1.	**Water Quality Report: DWAF** J. Lekoane gave presentation with regard to water quality status. J. Lekoane indicated that different water quality guideline were used for different points, she indicated that In-stream water quality guideline for Waterval catchment were used for the points on the streams, for STW special limits for General Authorisation (GA) were used, for Sasol Synfuels Water Use License was used, for Evander Gold Mine the old GA was used. J. Lekoane indicated that Sasol Synfuels has complied most of the time during last quarter based on the conditions on the Water Use License except for the STW and further indicated that Govan Mbeki Municipality is not complying according to the special limits.	J. Lekoane
9.4 9.4.1.	**Water Quality Report: Govan Mbeki Municipality** S. Makombothi indicated that there were no changes in terms of the water quality status and further pointed out that the consultants are busy on site refurbishing the plant. Pictures that were taken recently were also included in the presentation. She further indicated that by the end of June the plant will be fully operational and the status of water quality will improve. The Department	S. Makhombothi

	DISCUSSION	ACTION/ FOLLOW UP
	will receive their WULA by the end of June.	
9.5. 9.5.1	**Drinking Water Quality Report: Govan Mbeki Municipality** It was indicated that there is a school which collects water from nearby town and they are experiencing problems with their drinking water quality.	J Dunn
9.6. 9.6.1.	**Harmony Gold Mine** There was only one incidents experienced and the Department was notified. The mine was requested to prepare a presentation for next forum.	Harmony Gold Mine
9.7.	**Sasol Synfuels** • No spillage during this quarter. It was mentioned that since J. Linde is not present there is nothing to present. • The forum indicated that next time when you send someone on your behalf, full information must be given to that particular person	J. Linde
9.8. 9.8.1.	**Sasol Mining** There was one incident that occurred during this quarter at one of the dams. They were also experiencing cable theft at the plant. F. Mamabolo informed the forum that at Sasol Synfuel they have Ostrich as security measure and that maybe they can also apply the same at the plant.	Sasol Mining
9.9. 9.9.1.	**FARMERS UNION** No representative from the farmer's union	Farmers
9.10. 9.10.1.	**FFS REFINERS** No representative	FFS
10. 10.1.	**WATER USE LICENSE STATUS** J. Lekoane presented the water use license application status for the activities in the catchment. • Sasol Synfuels: License issued in November 2008 but the Department is busy with the amendment. • Sasol Mining: Regional Office is still busy with the license • Govan Mbeki Municipality: The Department awaits the WULA • Harmony Gold Mine: Meeting was held with the Mine and it was agreed that the document for WULA will be resubmitted as they need to include the new project (Libra) on the WULA.	J. Lekoane
11. 11.1. 11.2.	**CMA** **Vaal Dam Catchment Executive Committee (VDCEC)** • F. Mamabolo indicated that DWAF will sit internally and discuss the way forward and the date of the next meeting will be communicated to the stakeholders **Upper Vaal Reference Group:**	DWAF

	DISCUSSION	ACTION/ FOLLOW UP
	Dragana Ristic indicated that Upper Vaal Reference Group is influenced by the VDCEC hence nothing can be reported before the VDCEC is in place.	
12. 12.1. 12.2.	**DISCUSSIONS OF ADDITIONS TO THE AGENDA** It was discussed that the next meeting will commence at 10:00 and not 09:30 and the venue must be Rose's Inn. The Department will investigate the reason behind Sasol Club and if we fail then Rose's Inn. F. Mamabolo indicated that the Charter will be discussed in the next forum.	All
13.	**NEXT MEETING** • 20August 2009 • Venue to be confirmed.	
14. 14.1 14.2	**CLOSURE** It was suggested that the licence of each industry must be presented to the forum and be discussed around the table. Dragana said that could be for the forum to have information on the licence and not to discuss it, as once it is signed there are no discussions around that. • F. Mamabolo thanked everyone for attending the meeting. Dr Mvuma thanked the Department for giving them a chance to present and that they appreciate it.	Chairperson All

Annexure H: Analysis of questionnaire

No	Question	Stakeholder				Analysis
		DWAF	MDALA	eMalahleni	Sasol	
1	Polluted water → more water use	2*	1	Don't know	1, also more costs & waste. Can be controlled	Technically yes
2	Responsible increased water supply	LM(com)/DWAF (eco,ind)/ ?(agri)	DWAF	LM	DWAF	Multiple parties are responsible
3	Stored waste load → threat	1	1	1	1/2, not if designed, operated & monitored correctly	If it is stored well, the problem is under control, but it should be treated. People dump waste illegally
4	Reasons not treated waste stream to legal requirements	2	-1	1	-2 (Sasol does treat), 2 (others don't, regulation)	LM have no technical capacity and capabilities in many cases (DWAF) Lack of resources, costs and awareness communities. Functioning treatment plant. Mines do not even treat (LM) probability to be caught and fined, relaxed laws (MDALA) regulation (Sasol)
5	Responsible treating waste streams	Skipped	skipped	Mines	Skipped	
6	More water per Rand added value	Industry	skipped	Industry	Skipped	
7	Price up if less water	2	2	2	1 (strategic industry, slow reaction)	If the price of water goes up, it results in less water use (-->technically it will possible)

No	Question	Stakeholder				Analysis
8	Price up if not enough water	1, 2	skipped	Skipped	skipped	
9	Price up if more transferred	Skipped	2	Skipped	skipped	MDALA: government passes cost to the consumer
10	When Lesotho growth ends	Never	-1	Skipped	next decade	Unclear (unknown?)
11	Transfer ~ price ~ demand energy	-2	skipped	1	skipped	It generates electricity
12	Competition price water	Skipped	yes, aware & eff	no, is basic	skipped	Conflicting, is it a basic or should you create awareness, force efficiency??
13	Time delay demand price water	Skipped	skipped	Skipped	very slow reaction	
14	Responsible price water ~ DS	Skipped	LM(reg)/DWAF (natural)	Skipped	skipped	
15	Suffer first	agr, com/ind, Eskom, eco	eco, simultaneously	Ecology	Eco, agri, com, ind (DWAF will ask to ind first)	Ecology will not suffer as in all other have to cut in use first. But if there is nothing, ecology will suffer
16	CO_2 ~ price energy	I don't know	2025	After 2030	never, politics	
17	CO_2 ~ price energy when?	I don't know	skipped	skipped	skipped	
18	Time delay price CO_2 ~ energy price	I don't know	skipped	skipped	skipped	
19	Responsible CO_2 ~ energy price	Nersa	skipped	skipped	skipped	
20	CO2 threat industry	1	1	skipped	skipped	
21	Other means air poll industry	regulations, price elasticity	air quality act	skipped	regulation, clean water act	Other air pollution regulation might influence the price for energy/ viability of the new industrial complex

No	Question	Stakeholder				Analysis
22	Other means ~ price of products	Skipped	skipped	skipped	skipped	
23	Coal ~ price energy	2	2	skipped	skipped	If the reserves of coal resources are depleting, the price of coal will go up significantly and therefore also the price for energy in South Africa
24	Grow area altered land	???	mining	???	skipped	
25	Area altered land concern	yes, ground water, eco	yes,mining>agri land, food,biod	yes, definitely	yes, more ash removal, more piles,-> less coal	Area of altered land is a concern because it affects ground water, ecosystems, agriculture, food supply, biodiversity
26	Responsible area altered land	skipped	skipped	DME	skipped	
27	spreading to minimize effects	skipped	skipped	should be close	skipped	
28	Spreading price	skipped	skipped	skipped	skipped	
29	Cause price of energy	I don't know	regulation, planning	resouces	skipped	
30	Feasibility renewable ~ pollution	1	skipped	-1	-1, eco issue not a technical issue	
31	Feasibility CCS	skipped	1, large scale nog	skipped	skipped	
32	Renewable and price- more, more?	1, up or down	skipped	skipped	skipped	
33	Feasibility renewable energy	- 1/2 (5% guess)	1 (15% 2025), poss,tariff Eskom	0, if international help but more coal	skipped	Unclear
34	Energy supply ~ development	2	2	2	2	An insecure energy supply will affect the level of achievement of development goals in South Africa

No	Question	Stakeholder				Analysis
35	Responsible energy supply	nersa	skipped	need skilled HR and money	Difficult – both government and industry	
36	Time delay adapting to demand	2012 (>5 years?)	skipped	10-15 years	economically driven	
37	Cause delay adapting to demand	governance	skipped	skipped	economics	
38	Complex ~ health	1, always potential impact	1	2	2, but not sure what cause is	
39	Cause health effect	probably air and water pollution	skipped	air and water pollution (socio, eco)	several	
40	Solution impact health	manage their waste treatment well	socio eco	enforce legislation (awareness,edu)	skipped	
41	Responsible health	skipped	skipped	LM (enforce),Nat(reg),Ind(improve)	skipped	
42	Industry biggest impact	skipped	skipped	mine, power plant	skipped	
43	Complex economic stability	1	1, attracts too many	2	1, direct and indirect jobs	
44	Hinder of stimuli for success	under control, EIA, mitigate hinder	threat, it can (mistrust)	negotiate till its set, unemployment	little	
45	Safety incidents	skipped	skipped	implementation, ind, gov	skipped	

* 2 means "I strongly agree", 1 means "I agree", -1 means "I disagree", -2 means "I strongly disagree", skipped means not asked