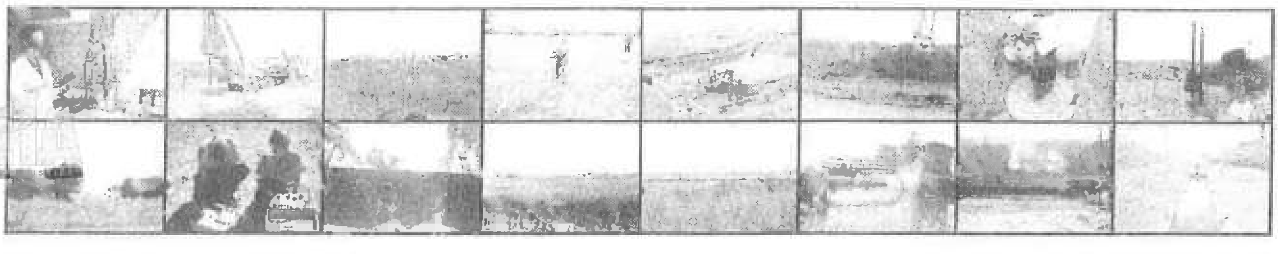
ISCOR VANDERBIJLPARK STEEL

ENVIRONMENTAL MASTER PLAN

SPECIALIST REPORT

MASTER PLAN INTEGRATION REPORT

SERIES I
DOCUMENT IVS/MP/005
JANUARY 2003



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Draft for discussion
CONFIDENTIAL
Research for IVS

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PREFACE

The anthropogenical introduction of chemicals to the environment, land, water or atmosphere, creates a possibility of affecting the biota of a specific media adversely. Adversely, does not necessarily imply loss of life (mortality), but could simply result in morbidity, which may or may not be easily cognisable, depending on degree, extent and duration thereof. Extinction of many a species through the ages, do not typically result due to a single, acute, cognisable eventuality, but rather due to those very slow, seemingly "nothing wrong" situations. These chronic, as opposed to acute situations, may for example have adverse effects with regard to reproduction i.e. smaller quantity of fertile eggs, species being shorter in length etc., resulting eventually in the extinction of species over time.

It is therefore inevitable that the need to know more about the impact of anthropogenically introduced chemicals in the environment will always be of paramount interest. Such knowledge is not only vital to those in industry, who carry the responsibility of the cradle-to-grave principle in their management of chemical substances, but also as vital to the Regulatory Authority who has the responsibility as custodian in making decisions involving environmental and human risks. In this regard it must be emphasized that the aim should never be to ban the use of chemicals, but to exert reasonable controls when they are needed – something not possible if impacts cannot be predicted.

Reasonable controls should result in pollution prevention, which must be practiced as a first priority in production processes, and be regarded as a necessity in effective compliance strategies. However, with regard to environmental management, pollution control measures introduced before and during industrial operations – specifically with regard to new developments – is relatively speaking of a more simplistic nature. A much more complex and capital intensive nature in environmental management, is the historical, often multi-media (land, water, air) contamination of the past.

A Century ago (1900 – 1940), neither scientists nor engineers or Regulatory Authorities were adequately knowledgeable regarding potential contamination of waters, air and soils, due to dumping or disposal practices of slags, sludges, effluents and all kinds of residues. These practices inevitably resulted in unprecedented contamination consequences all over the world, consequences, which have to be addressed in our present time.

The Iscor Vanderbijlpark Steel Works (IVS) falls within the category of industries developed a century ago. For many decades, wastes being *inter alia* slags, sludges and effluents have been disposed of in dams and dump sites without the precautionary measures expected and enforced in our present time, by for example The Waste Management Series of which the first edition was published by the Department of Water Affairs, only as recently as 1994. Thus, a history of contamination at IVS is not out of the ordinarily, but sadly in agreement with many practices from that period in history noted and recorded from all over the world (refer for example to the well-known USA Superfund Sites).

Environmental Management Plans (EMP) are normally those measures put into practice to ensure that contamination or pollution of the environment would be prevented. Thus it is part and parcel of the business strategy of modern novel industrial development. It endeavours to comply with the provisions in the Bill of Rights in the Constitution Act (Act 108 of 1996) in which it states *inter alia* that every one has the right to an environment that is not harmful to health or well-being and to have the environment protected for present and future generations.

However, due to the existence of historical sites, many an Environmental Management Plan has to provide for remedial and rehabilitation measures, in addition to those measures to prevent present and future contamination. Such an EMP would endeavour a study to characterize the environment in an integrated holistic approach in scope, in order to be able to address historical contamination of air, land and water in an integrated manner. Such an approach would ensure not only the best possible application of resources, but would also ensure that a single media orientated solution does not merely transfer the problem from one media to the other, so oftenly found to be the result of single media ad hoc studies.

This Specialist Report integrates the results and findings of twenty-two disciplines, to enable the formulation for IVS of an Environmental Master Plan. The twenty-two disciplines represent the multi-media approach (air, water, land) in environmental management. The resultant Environmental Master Plan is the result of the integration and prioritisation of 19 Management Areas according to the holistic assessment of impact and risk to human health and the environment.

The exercise finally resulted in some 220 measures proposed, ranked and costed for preferred options of alternatives, which should achieve compliance with the primary and secondary objectives upon which their selection was based. They represent a variable time scale of implementation, normally referred to as short, medium and long-term implementation.

It should be noted that some of the measures proposed, might need feasibility studies, authorizations and other EIA requirements before implementation thereof.

It would be futile to study this document without also reading the Appendix to the Integration Report. The latter is the concise integrated result and exposition of all findings during extensive interdisciplinary characterization of the environment, associated risks and impacts, and could well be termed the proposed IVS Environmental Master Plan.

OFT MASTER PLAN TEAM
PRETORIA

EXECUTIVE SUMMARY

Iscor Vanderbijlpark Steel (IVS) commissioned the development of an environmental Master Plan (MP) in 2000, in anticipation of the need for a holistic approach to environmental management at the Works. Several distinct, specialist environmental studies had been undertaken over the last ten to fifteen years by IVS, and the MP was needed to peer review those studies, undertake additional work and integrate the results into an Environmental MP. The MP approach followed, focused on the Internationally advocated principal of a holistic integration of a risk based approach in the multi-disciplinary characterization of the IVS environment and processes.

The integrated studies comprised of the following 22 specialist investigations:

- Toxicology
- Solid Waste
- Sediments
- Leachates
- Soils
- Air Quality
- Ground water
- Process Water system
- Geotechnical
- Geology
- Environmental Monitoring
- Land capability
- Terrestrial Eco-systems
- Surface Water
- Aquatic Eco-systems
- Consultation Process
- Noise
- Archaeology/Cultural
- Visual aspects
- Land use
- Socio-economics

which were conducted in nineteen Environmental Management Areas:

1. Consolidated Residue Management Facility (CRMF)
   - 1.1 Overall CRMF
   - 1.2 Existing Waste Dump
   - 1.3 Dam 10
   - 1.4 Dam 1 – 4
   - 1.5 Maturation Ponds
   - 1.6 Raw Materials Stockpiles Area
   - 1.7 Processed Material Storage Area
   - 1.8 CETP Sludge Dams
   - 1.9 Redundant Blast Furnace Sludge Dams
   - 1.10 Dam 11
2. Central Plant Area (CPA)
3. SE Slag and Open Veld (SESOVA)
4. SW Slag Area (SWSA)
5. Terminal Effluent Treatment Plant (TETP) and Main Treatment Plant (MTP)
6. Kiewiet Area
7. Perimeter and Immediate Surrounding Areas (PISA)
8. Rietkuilspruit and Rietspruit Canal (RRCA)
9. Leeuwspruit and Vaal River (LVRA)
10. Rietspruit and Vaal River (RVRA)

Management Areas can all be categorized, subject to the source - pathway - receptor approach into primarily three zones:

Zone 1 comprises the entire IVS works. The main objectives within this zone were to identify water impact sources related to IVS activities, as well as to confirm and describe the nature and extent of IVS related water impacts within this zone, not only with a view of impact assessment, but also with the aim of generating sufficient design parameters for the conceptual design of remediation and management measures. This zone would therefore represent the **Source** zone with respect to Risk Based Environmental Management.

Zone 2 comprises the IVS works perimeter. It was realized right at the outset that a definitive statement on ground and surface water characteristics, attributes, impacts and risks would have to be given on the IVS works perimeter. Representing both a legal and land use zoning boundary, the IVS woks perimeter will play an Important role in decision making with respect to impact and risk management. This zone represents the **Pathway** zone with respect to Risk Based Environmental Management.

Zone 3 comprises the receiving environment beyond the IVS works perimeter. It would be important to describe and delineate all IVS related water impacts and risks within this zone. This zone represents both the **Pathway** and **Receptor** zones with respect to Risk Based Environmental Management.

Remediation and management objectives were determined to support regulatory requirements. The objectives contained in this report, represent an OFT team effort, to be submitted to the authorities for consideration. The over-arching primary objectives were based on a **risk based environmental management approach**, and therefore relate to protection of human health and the environment. Secondary objectives were developed to ensure measurable targets against which to assess performance and compliance.

Taking cognizance of the site specific technical conditions, and subject to the selected objectives, **alternative remediation, pollution control and management measures** were considered. Preferred alternatives were selected in each instance for consideration by the authorities.

Measures comprised of two main categories, namely **Institutional Measures** and **Technical Measures**. **Institutionel measures** were motivated in terms of technical impracticability. Areas impacted on by activities within the CRMF and CPA can generally not be remediated to acceptable risk levels through technical measures, over the short and medium terms. Such measures will **for example** require flushing of the aquifers with "clean" water and/or steam and will in any event take several decades to improve the situation significantly. They are therefore considered impracticable to achieve risk compliance for large areas within the CRMF and CPA over the short and medium term. It is therefore proposed to apply an institutional control and to **re-zone areas** within the IVS perimeter (specifically also the entire CRMF), for specifically ground water usage. This implies that abstraction and application control must be institutionalized within the current ground water impacted area, to such a level that the current ground water quality is within compliance, subject to demonstration of continual improvement over the long term.

In addition to the above, **technical measures** are proposed to supplement institutional controls. Selections from, and combinations of measures will have to be applied to address the situation at the various water pollution sources within the CRMF, as well as in the aquifers receiving water from the sources. Their intention is to improve the situation over the short, medium and long term.

Several water pollution sources were identified and investigated within the IVS perimeter. Contamination observed, included both inorganic and organic constituents. Whereas a good correlation could be established between observed inorganic water quality and identified inorganic sources, the primary sources of the organic contamination could not all be delineated with total confidence. **Impact assessments** were performed through utilization of observed water impacts. The end result of the individual and collective impact assessments manifested in an understanding of related water **impacts**. Whereas most of the **ground and surface water** impacts occur within the IVS perimeter, five areas show **inorganic** ground water contaminant migration across the IVS perimeter. These areas are located opposite the TETP area across the western perimeter, opposite Dam 10 and the Existing Waste Site across the western perimeter, opposite Dams 1 - 4 across the northern perimeter, opposite the Kiewiet Area across the eastern perimeter, and opposite the South Eastern Slag Processing and Open Veld Areas, across the south-eastern perimeter. **Organic** ground water contamination (both free phase and dissolved phase) was observed beyond the IVS perimeter in only one area to the west of Dam 10. The extent of both the free and dissolved phases beyond the IVS perimeter, was delineated accurately.

Using impact results, **risks to both Human Health and the Environment**, could quantitatively be addressed.

With regard to ground water and contamination thereof aquifers pertaining to the regional study area are classified as **minor aquifer systems**. The **vulnerability**, or the tendency or likelihood for contamination to reach a specified position in the groundwater system after introduction at some location above the uppermost aquifer, is classified as **moderate**. **Aquifer susceptibility**, a qualitative measure of the relative ease with which a groundwater body can be potentially contaminated by anthropogenic activities, which includes both aquifer vulnerability and the relative importance of the aquifer in terms of its classification, is classified as **medium**.

Surface water management measures have been proposed to enable IVS to operate in an environmentally sound manner. Two critical surface water management compliance points are situated at the western outlet from the works towards the Rietspruit Canal and the eastern outlet over the Frikkie Meyer weir. As far as the Rietspruit Canal outlet is concerned measures are proposed consisting of the MTP and various changes to the infrastructure on the site to get this outlet to ZED status in 2005. Until that time it has been shown in the surface water baseline study investigation that contaminant levels can be limited to the outflow standards prescribed in the water license for most of the chemical constituents specified, utilizing the existing infrastructure. As far as the Frikkie Meyer weir outlet is concerned, it has been shown that ZED can currently be maintained under dry weather conditions at the Leeuwspruit outlet. Water discharge under wet weather conditions is currently out of compliance in accordance with the current water license conditions. Measures to bring this water component into compliance are twofold:

1) To put measures in place by which the stormwater quality will improve during wet weather conditions.

2) Negotiate with the authorities more realistic stormwater outflow standards for discharge over the Frikkie Meyer weir. Standards typically in line with SA drinking water standards have been proposed for this action.

With regards to surface water management on site, two specific areas have been identified within which surface waters will nead to be managed, namely the consolidated residue management facility (CRMF) and the consolidated plant area (CPA).

For the CRMF, measures proposad include to keep contaminated run-off water from entering the area and to remove dams within the CRMF area in order to hold back less uncontaminated runoff water. Additional measures are to cap and re-mediate areas in order to reduce contact between surface water and contaminated areas, and finally to monitor and contain water within the CRMF for discharge at two separate outlet points only.

As far as the consolidated plant area is concerned, surface water will be managed by splitting process water and surface water management systems completely. Upgrades within the plant areas are proposed to prevent process water from getting into the stormwater system. Monitoring of stormwater discharge points throughout the works are proposed in order to pinpoint sources of outflow discharge not related to stormwater. Finally a back-up sump arrangement is proposed at the western discharge channel from the site to ensure that ZED can be complied with.

Regarding stormwater management outside of the works perimeter it has been proposed to dismantle and clean up the existing Rietspruit Canal. Secondly measures need to be implemented along the Rietkuil Spruit to restrict contaminated ground water from the Louisrus South area from entering the surface water stream. A continued monitoring program within the Rietkuil Spruit and Rietspruit Canal system will be required in order to monitor progress made with cleanup of the system and the associated betterment of water qualities post ZED.

Regarding the very important air pollution discipline, ambient concentrations of the fine particulates and sulphur dioxide were astablished to be within benchmarks (standards or guidelines) but with little margin of safety. Should short term measures proposed implemented, point sources which are not in compliance be addressed, and the undetermined sources measured, the fine particulate situation will improve noticeably. The coke oven gas project will similarly improve the position regarding sulphur dioxide.

With the exception of the IVS southern boundary, dust fall-out is within the RSA residential guideline. Steps are in place to raduce in particular road dust, which is the main source along this perimeter section.

Compliance with point source legal emission limits varies continually as abatement equipment malfunction or requires maintenance. Non-compliance and failure to implement corrective action remains a risk. At the time of writing the compliance level was 76%, with a further 13% not determined.

New air pollution legislation has been in preparation for close on two years, however, no new legislation has been published yet. It is likely to be based on standards.

With regard to archaeology, visual impacts and noise, the activities that have taken place on the IVS premises during the last sixty years have had a severe impact and are of such a magnitude that heritage resources have been destroyed or disturbed, including the archaeological context of such features or sites.

The South Works contain the oldest infrastructure, such as the Coke Plant and towers associated with this plant, which may be almost sixty years old and may qualify as historical or industrial significant structures.

Visually the IVS plant infrastructure end more specifically thet of the CPA area, as man-made features, have significantly altered the natural appearance of the landscape and have also contributed to conspicuous man-made skyline in this part of the Highveld, visible from the national and other major roads passing IVS Works, as well as from neighbouring residential areas.

In general the industrial criterion for noise is exceeded only on the southern boundary of the IVS Works. However a significant buffer of land between the boundary of the IVS Works Area and the nearest residential area exists. The most critical area is the south-eastern borderline.

Finally, on completion of the characterization of the IVS environment, and subsequent quantification of impacts and risks, prioritisation of Management Areas were rated and ranked in terms of human health and environmental criteria. Measures were subsequently identified and formulated in priority areas, taking into account logic sequence of implementation. Hence, cost estimates were compiled for all listed measures in order to conclude the proposed Environmental Master Plan (MP) for ISCOR Vanderbijlpark Steel.

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1. INTRODUCTION

The management of IVS initiated the development of an Environmental Master Plan during July 2000.

The scope of the Environmental Master Plan was determined during a **Pra-Master Plan** study during the first six months of 2000.

The **outcome** of the Pre-Master Plan study and scoping of the Master Plan investigative work, were presented to the key regulatory authorities, DWAF and DACEL, during the second half of 2000. The objectives, scope and deliverables of the Master Plan development process, had subsequently been summarised in a **Master Plan Summary Document** and submitted to DWAF and DACEL for view and consideration.

The **first phase** of the MP work focused on the installation of Short Term pollution control measure and critical investigative work to address priority areas.

The baseline investigative work started during January 2001. (During this period the OFT Team was also consulted for information applicable to the court case against ISCOR, consuming substantial time and effort in the completion of the baseline studies). It entailed all the multi-disciplinary aspects related to i.e.:

- Source characterization of waste streams
- Groundwater / Gaology
- Surface water
- Terrestrial and Eco Aquatic systems
- Process water
- Air quality
- Soils
- Noise
- Visual/Landscaping
- Archaeology
- Geotechnical
- Land use and Land capability
- Regulatory requirements
- Consultation / Social
- Socio-economics

Each of the disciplines wera researched in detail during the baseline study phase of the project. However, the findings of the baseline studies needed to be integrated in order to produce a management plan for the complete site, where all aspects (disciplines) are addressed. The various discussions and workshops between team members of all disciplines resulted in an integrated MP, which is described in this integration report. This document is therefore not a summary of the discipline baseline reports, but a single management plan by which the critical aspects of each of the disciplines is addressed in a holistic, integrated manner.

2. PURPOSE OF THIS DOCUMENT

The purpose of this document is to provide IVS with an integrated environmental management plan, to be implemented over the longer term, whereby they will be able to conduct their business in a sustainable and environmentally sound fashion. The plan addresses both remediation of previously unsound practised areas (historical areas) as well as a vision for future sound practises to be adopted by IVS. It furthermore provides time frames, budget cost estimates and priority areas that will assist IVS to plan the implementation of the proposed plan in a sustainable way.

3. TERMS OF REFERENCE

The Terms of Reference given to the MP team was to develop a holistic integrated environmental MP for the IVS Works, whereby all disciplines would be thoroughly researched, all available historic information used and combined with the aim of providing an integrated environmental management plan for the Works.

This document forms the essence of information gathered and assessed in order to satisfy the Terms of Reference.

4. MASTER PLAN METHODOLOGY AND APPROACH

4.1 Holistic Integrated Management

The release of harmful substances and contaminants of concern to air, water and soil, results into a burdening effect to our planet with complex environmental problems, This has caused in many instances situations of disregarding the protection of health and well being, not only of man, but the ecology in its broadest sense.

Industry is faced on a continuous basis, with such problems and solutions are being seeked in terms of pollution prevention.

Pollution prevention could be described as the elimination, avoidance and reduction of pollution. It includes in particular waste minimisation at source and encompasses comprehensive environmental management of the multi-media, namely air, land and water.

This approach is regarded as the primary cornerstone of the environmental management strategy, with a starting point at the production processes, to ensure compliance to the environmental policies and objectives.

The environmental philosophy of pollution prevention, should however be placed into the correct context and ambit of the practices of older industries and new industrial complexes. During the period of the "technical explosion" a century ago, neither industrialists, scientists, engineers or regulatory authorities, were adequately knowledgeable regarding the potential contamination and impacts of water, air, soils and land, due to:

- Dumping of residue material in general
- Disposal practices of slags, sludges, dusts and all kinds of residues.

This fact inevitably resulted in unprecedented practices, the consequences of which have to be addressed in our present time.

The development of MP's is a study with the following key objectives:

- To characterize the environment of an industrial complex and it's activities in an integrated holistic approach
- To scope and conduct such a study in an integrated holistic manner.

Single disciplinary approaches, rules and regulations that focus on single media (air, land and/or water) may often create insufficient solutions and could result into single media orientated answers.

Whilst the intensions may be good, ad hoc studies often result to neglect the possibility that contaminants could be transferred from one medium to another. What is much more serious and complex is what is commonly referred to as "the historical pollution of the past", which require a more integrated approach end which requires eventually more capital investment.

The Iscor Vanderbijlpark Steel Works falls within the category of industries that began during the "technical explosion" of the past century. Since the works was developed and constructed, numerous laws, legisletion and regulations that address health, safety and the environment heve been enacted on the one hand, whilst more technical advanced industrial manufacturing processes were developed on the other hand.

Iscor Vanderbijlpark Steel has initiated during the last few decades ongoing evaluation replacement and refurbishment of equipment and IVS endeavours to adhere to current environmental criteria according to the principles of BPEO. Cheracterisation of possible historical contamination, including current practices at IVS, was performed strictly according to the principles described in this section i.e. integrated holistic menagement.

The integrated studies included the following 22 specialist investigations:

- Toxicology
- Solid waste
- Sediments
- Leachates
- Soils
- Air quality
- Terrestrial eco-systems
- Aquatic eco-systems
- Consultation process
- Noise
- Archaeology
- Visual and Aesthetic quality
- Land use
- Socio-economics
- Surface water
- Ground water
- Process water
- Geotechnical
- Geology
- Land capability

A project flow diagram is shown in figure 1.1

The approach, which was followed to achieve a MP, was to initially conduct a Pre-Master Plan investigation in which all the current/existing information was evaluated, while areas where information gaps existed were identified.

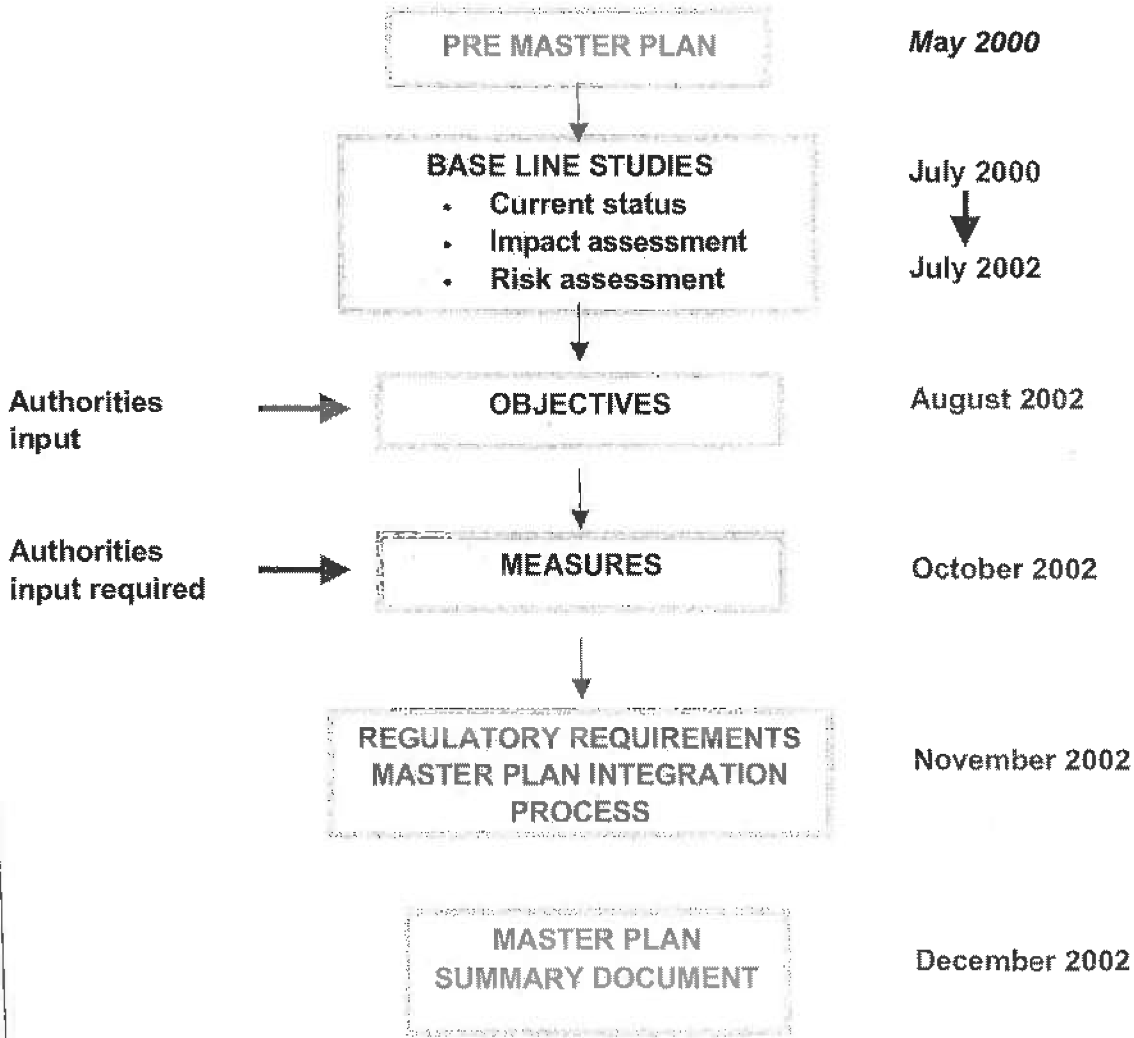
Information gaps were investigated during the baseline studies phase of the project. With the current status for each discipline known, impacts could be determined as well as their associated risks.

Once the status, impacts and risk were identified, objectives could be set for each aspect under consideration. Objectives are further described in paragraph 4.5 and are the guiding force for the proposal of management measures.

The measures need to address the objectives of all disciplines simultaneously. Furthermore, measures proposed for one area should not compromise another. This is achieved by the integration process of which this document is the result.

Subsequently measures proposed were tested against the regulatory requirements of the Authorities, costed, prioritised and programmed to produce the MP for IVS.

Fig. 1.1 MASTER PLAN PROCESS



4.2 Initial Site Assessment - Gap Analysis

IVS approached the OFT specialist team during November 1999 to scope and develop a MP for waste management and pollution control at IVS. The request was that such a MP should explicitly address amongst others a financial plan over a period of time, acceptable to both IVS and the relevant Authorities.

Subsequently the OFT team responded with a proposal to approach the task in 3 phases, i.e.

- A Pre-Master Plan Study (phase 1);
- Development of a MP (phase 2);
- Implementation of the MP (phase 3).

The rationale behind a pre-Master Plan Study was the assumption/recognition that a number of *ad hoc* studies were performed in the past 10 to 15 years at IVS, and that part – if not all – of the results of these might fulfil some of the requirements for the holistic approach of a MP phase 2 study. It would thus be a gap analysis to promote the scoping of a MP and secondly, prevent duplication of acceptable work to the MP, which inevitable would curb costs.

With the co-operation of Iscor personnel, some 77% of the information requested, was received. It was concluded that –

- The approach (strategies) for pollution control, rehabilitation, waste and water management did not fulfil the requirements for a holistic approach to satisfy the end goals to be achieved for IVS;
- Strategies followed to date, based on *ad hoc* studies, inevitably called for expenditure, which would not necessarily achieve the required implementation of measures to comply with legal and acceptable management requirements;
- Large gaps existed in quantitative information with regard to all disciplines e.g. surface water, ground water, air, solid waste etc., needed to develop a MP, to enable IVS Management to successfully negotiate a realistic timeframe with the Authorities for the implementation of proposed management and pollution control measures.

It was therefore strongly recommended –

- Not to engage in measures, strategies, and expenditure which cannot be fully substantiated by the holistic approach for water and waste management, pollution control and rehabilitation;
- To scope and implement the MP Study, as a matter of the greatest urgency, to put IVS in a position to address short-term pollution control measures;
- To engage with the relevant Authorities to reach interim agreements on the basis of the findings of the pre-Master Plan Study whilst the baseline studies are being conducted and an environmental MP for IVS are being developed; and to
- Negotiate, specifically with the Department of Water Affairs and Forestry, matters such as for example short-term pollution control measures, licensing according to the New Water Act, development of a proposed New

Waste Site, use of the Old Waste Site with the ultimate objective of closure, gradual rehabilitation of evaporation dams and ponds, implementing of air pollution measures on the 90/10 principle and to investigate the possibilities of recycling, re-use and treatment of solid waste as well as cost saving opportunities.

It was believed that with the necessary dedication from both the team and IVS personnel, that an integrated holistic MP Study on a risk based approach, would render and indicate the necessary measures needed to achieve legal compliance, prevention of environmental contamination, and rehabilitation strategies of historical misfortune.

4.3 Risk-based-Approach

Risk implies a possibility. It refers to the possibility of injury, harm or any other adverse effect. It is firstly however important to realize that absolute safety or "no-risk" situations do not exist. Secondly on the other hand, it is of extreme importance to note specifically with regard to contamination and pollution matters, that the mere presence of a substance does not *ipso facto* imply a detrimental effect. Summation of these two "laws" result in the concept of Acceptable Risk, not only with regard to pharmacokinetics, but also universally recognized and applied in for example, regulatory control of xenobiotics.

The starting point to formulate Acceptable Risk is to establish scientifically dose and response or cause and effect of the contaminants in question, taking in consideration the inherant properties of the said contaminants, and the selection of the most critical pathway (site-specific) from all pathways (not site-specific). However, determination of the probability and severity of adverse effects may well be the most elementary part in formulating acceptable risk, in that such data could be established experimentally. The fact remains that in the establishment of risk, and hence acceptable risk, both scientific data as well as social, economic and political factors must be considered in reaching an ultimate decision (acceptable risk) on the prohibition, control or management of contaminants in the environment.

To complicate the matter even more, it is accepted that nonbiological effects should also ba considered. These are for example aesthetic effects such as odours, tainting of food commodities, colouring of laundry, corrosion of structures and depletion of the ozone layer. It Is therefore exceedingly difficult to propose a value that everyone will agree on, none the less should the establishment of an acceptable risk level, and hence a risk based approach, be accepted as the only defensible and sensible rationale in environmental management as well as regulatory control.

The IVS MP Study, and more importantly the Integration Report, is based on a risk-based approach. This approach was followed not only for the reasons quoted above, but specifically to facilitate meaningful integration of management objectives and measures. Notwithstanding the risk-based approach, cognisance was thoroughly taken of current statutory requirements. Some guidelines, e.g. Minimum Requirements for the Handling, Classification and Disposal of

Hazardous Waste (DWAF) followed a risk based approach, whilst others such as Drinking Water Standards and Atmospheric Pollution Standards did not. Similarly in some legislation or guidelines reference is for example made to contaminate or polluted water as a generic entity without acceptable risk levels, whilst for many other contaminants (PAH's, volatile organics) no criteria exist.

In order to follow a quantitative risk based approach with the MP of IVS, for disciplines which lacked RSA guidelines and regulations based on such an approach, criteria was obtained by modelling and calculating acceptable / non-acceptable risk to both man and environment. This was done for ground and surface waters and all sources of possible contamination such as disposal of solid waste, waters and sediments in evaporation dams, soils, leachates and ambient levels of atmospheric releases where appropriate.

It is important to note that International benchmarks and standards were always considered as a first priority in the establishment of standards when they did not exist in RSA legislation or guidelines.

4.4 Base Line Studies

The risk based approach discussed in section 4.3, requires a quantitative approach to source - pathway - receptor description. The precautionary principle entrenched in South African Environmental Law and provided for in the NEMA, implies that "a risk averse and cautious approach is applied which takes into account the limits of current knowledge about the consequences of decisions and actions. " The above should be read in conjunction with the more general definition of the precautionary principle which states: "Where there are threats of serious or irreversible damage, lack of full scientific certainty should not be used as a reason for postponing measures to prevent environmental degradation".

In the context of the IVS MP, the above simply means that unless the environmental impacts and risks associated with IVS are understood, delineated and described quantitatively and accurately, measures could be required which are not necessarily commensurate with the actual situation, but which are deemed appropriate by the authorities. The option usually taken is that of "best practice" which more than often leads to measures which are either an "over kill" of the problem, or on the other side of the spectrum, measures which cannot achieve the required risk compliance profile for the site.

The OFT team has therefore opted in their approach to perform quantitative/ semi-quantitative base line studies for a range of environmental and related components, for the disciplines stated in paragraph 4.1.

The main objectives for the base line studies were to supply an accurate, quantitative description and understanding of the current environmental impacts related to IVS activities, the possible future development of these impacts, and the risks these impacts hold for human health and the environment. This information will then be used as the basis to determine the objectives and measures required to manage the environment, using a risk based approach.

4.5 Management Objectives

Once impacts and risks have been assessed, it follows logically that prior to management measures being designed and commissioned, the objectives to be achieved, be defined. Environmental management objectives relate to what needs to be achieved or adhered to, from a regulatory/legal perspective. For the purposes of this MP, primary and secondary objectives are applicable.

4.5.1 Primary Objectives

Primary or over-arching environmental management objectives are generic in nature and are in their fundamental form, non-valua based.

There are essentially only two primary objectives of relevance:

- Protection of Human Health
- Protection of the Environment

These over-arching objectives are entrenched in Environmental Legislation and are neither sita nor situation specific. The outcome of the MP base line studies, neither in terms of impacts identified/quantified, nor in terms of technical realities of the site, therefore has no influence on these objectives. They remain applicable and represent the final goal posts, which cannot be shifted. All other secondary objectives defined, and measures designed for the site, nead to give fulfilment of these objectives.

The time scale for primary objectives vary from short, through medium to long term. The protection of human health is usually seen as the highest priority and therefore always need attention as a short-term objective.

4.5.2 Secondary Objectives

Secondary objectives relate to technical goals that are to be set on a site and situation specific basis, in order to have strategies, standards and criteria against which to design measures, as well as against which to measure the performance of measures in achieving compliance in terms of both the secondary and primary objectives.

Secondary objectives can be non-value based e.g. the attainment of continual improvement, the minimization of infiltration, the reversal of ground water flow etc, or value based e.g. the compliance with specific water quality standards, the achievement of specific ground water de-watering elevations, etc.

The time scale for secondary objectives also vary from short, through medium to long term. Certain specific technical outcomes cannot be achieved over the short and even medium terms, in which case the secondary objective of continual improvement becomes paramount in the management of certain impacts and risks. A good example in this regard is the technical remediation of ground water contamination plumes to certain predetermined quality standards, an objective that could take decades to achieve, and in some instances, might even not be technically feasible at all.

4.6 Consideration of alternatives

4.6.1 Introduction

The baseline studies performed by each specialist are reported in the baseline study reports. The baseline studies reflect a detailed description of the current status and the identification and formulation of potential impacts and risks. The impact and risk assessments were done on a quantitative and semi-quantitativa basis for the majority of the disciplines, taking into consideration the primary objectives and site specific management objectives.

Technical, environmental, economic and regulatory criteria were taken into account during the process, to identity and develop altemative mitigatory measures. The process of consideration of alternatives to manage impacts and to reduce risks to ensure compliance to acceptable risk levels per discipline and area has been taken a step further, through the MP integration process. Alternative mitigation and management strategies were identified, listed and considered for each environmental management area in a multi-disciplinary approach. The alternatives are listed and briefly described in Chapter 6 of this document.

The process of consideration of altematives performed by the project team during the MP integration process, resulted in a preferred option. The **preferred option** as proposed in certain management areas, represents a combination of measures, which addresses a multi-disciplinary solution. The preferred option or most likely strategy proposed for implementation is described in Chapter 6 and cost estimates were done to determine a cost profile for implementation.

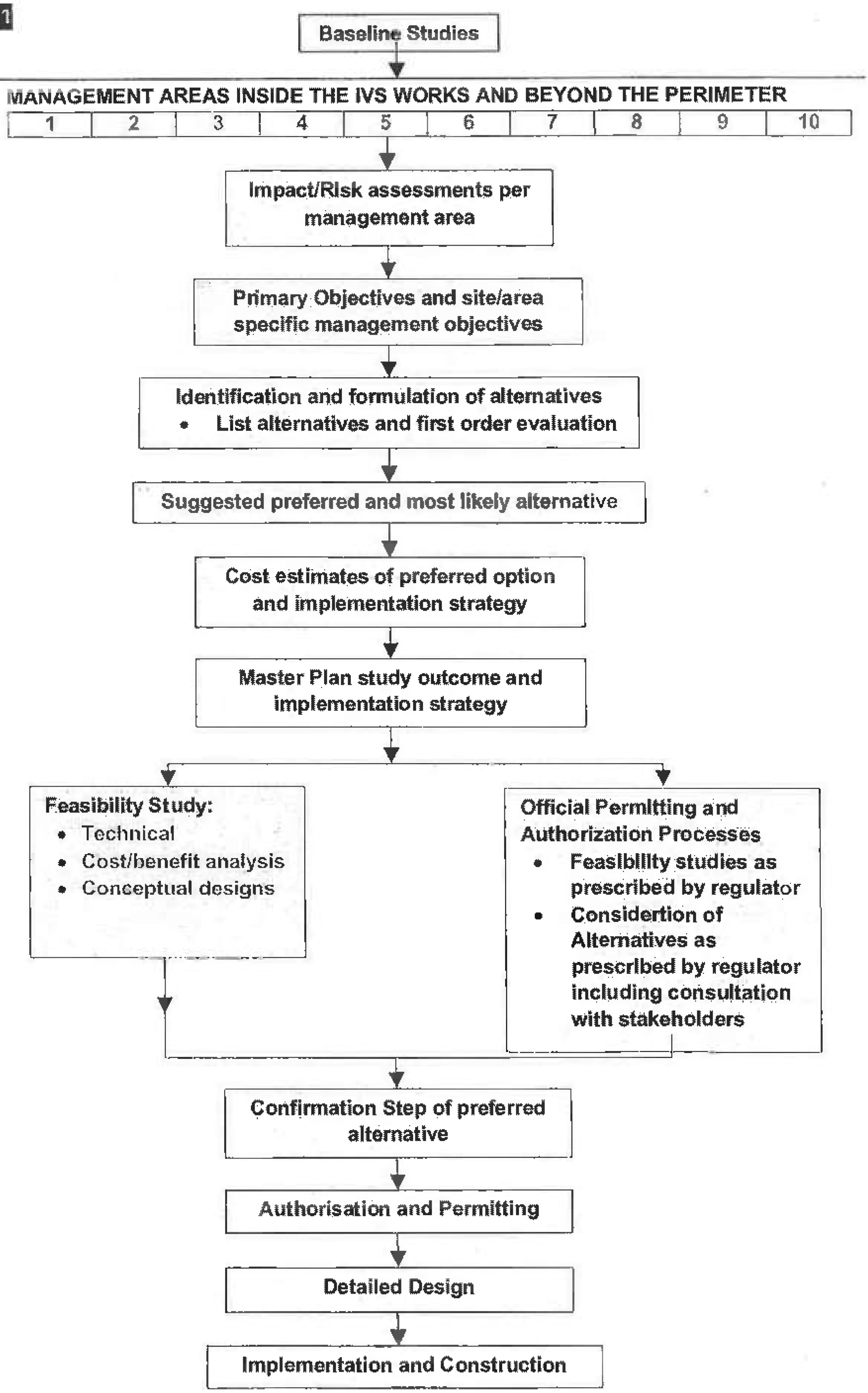
It is anvisagad that the aspect of consideration of alternativas may have to be re-visited during the commissioning of detailed feasibility studies and the initiation of formal permitting and authorization processas on a project-by-project basis. Alternatives proposed or considerad should howaver always fit in with tha MP as a whole, witbout compromising any other disclpline.

4.6.2 Process of consideration of alternatives

The process of consideration of alternatives was scoped in broad terms during the MP integration process, outlining the key steps. The Diagram 1.1 on the following page displays the overarching approach:

STEP-WISE DEVELOPMENT PROCESS OF THE MASTER PLAN AND CONSIDERATION OF ALTERNATIVES

Diagram 1.1



4.6.3 Alternative Options

This MP integration document does not propose to present a detailed discussion of alternatives for the various aspects of design and technology, but rather to concentrate on the larger issues that are of key interest to the proponent, the regulatory bodies and other interested and affected parties.

The discussion of alternatives was therefore centred principally around the following issues, i.e. alternatives to -

- the proposed residue management processes;
- the process water management processes;
- the ground water and surface water management systems;
- environmental management per discipline/environmental component in each management area, and
- alternatives, which relate to air quality management.

The alternatives that were identified and formulated would subsequently be subjected to detailed technical, environmental and economic assessments to confirm the preferred option.

The technical feasibility for each proposal will have to be assessed and it should ensure that the environmental requirements are met and maintained over the life cycle of the facility. The economic evaluation should include the key criteria of:

- Capital costs
- Operating costs
- Effect on the nett present value/business plan and sustainability of the company.

4.6.4 Range of alternatives

Each environmental management area was evaluated by applying brainstorming techniques, to identify a range of alternatives. For certain management areas, the range of alternatives was slightly more comprehensive due to for example the brownfield nature of part of the site.

The identified alternatives were categorised according to:

- Demand (energy efficiency)
- Activity (type of transport, materials handling)
- Location (locality alternatives)
- Process (re-use, waste minimisation, energy efficient technology)
- Scheduling (time related measures)
- Input alternatives (raw materials, energy)

The listed alternatives in chapter 6 fitted into the above listed categories and should be site specifically reviewed.

4.7 Proposed Management Measures

The management measures identified from the available alternatives must be able to achieve compliance with the primary and secondary objectives upon which their selection was based. In this regard it is important to note that two types of measures are recognized for application at IVS, namely:

- Institutional Measures
- Technical Measures

Institutional measures are used where technical impracticebility can be shown for the attainment of primary objectives, within the required time frame. An example of this would be the attainment of the protection of humen health in an area of extensive ground water usage, but where the ground water aquifer has been contaminated to levels, which represent an unacceptable risk to human health. It is a well known fact that polluted ground water aquifers cannot be technically remediated over-night, and therefore the only way to comply with the primary protection of human health objective, would be to implement an institutional control such as re-zoning of the area for ground water abstraction/application, supported by measures such as buy out, or alternative water supply and/or compensation.

For the same example, technical measures such as pump and treat could then be commissioned to achieve secondary objectives such as continual improvement, reversal of ground water flow, and possibly the achievement of certain water quality standards over the long-term.

The measures proposed in the IVS MP, should be seen in context with the history of the site. In many instances technical measures cannot achieve primary objectives within reasonable time frames, and are therefore proposed to achieve continual improvement over the long term, in conjunction with institutional controls. Many such measures therefore relate to minimization of impects at source, rather than to actively pursue technical impracticable objectives.

Following the listing and formuletion of alternative strategies for each management area, the project team focused on a preferred option and management strategy. Management measures were subsequently defined and conceptualised to meet the overarching primary objectives and site-specific management objectives.

The key issues in terms of potential impacts and risks as identified, are described in Chapter 6 of this Report.

4.8 Integration/Optimisation

The integration of the proposed management measures has been undertaken in such a way as to result in the optimal solution for each situation together with adjacent ectivities and their associated aspects and impacts. These steps are depicted in Diagram 1.1 above (refer to paragraph 4.6.2)

The impacts and risks identified during the Baseline studies per Management Area are assessed and compared with local, national and international criteria. Both primary and secondary objectives are set – the latter for specific sites and situations. Alternative mitigation measures are identified and evaluated at a first order level. The preferred option or combination of measures is then evaluated in more detail, and if feasible, a cost estimate made to implement that measure. The costs of management, maintenance and monitoring are also included in the estimate. Subsequent to the MP, the measures should be implemented on the basis of prioritisation (refer to section 4.10) in order that the most optimal solution for the Works be implemented.

4.9 Verification of Technical/Economical Feasibility

During the MP integration process the various alternative options were listed and discussed through conducting a series of workshops.

The technical and economical benefits and constraints associated with the options were debated and noted. As the integration process unfolded, the more attractive and feasible options were identified and formulated. These may require more intensive investigation by IVS as part of the MP implementation phese.

The MP integration process encompasses a first order verification of the listed options, and alternatives and the proposed measures linked to the preferred option. The first order verification is based on the professional judgement and opinions of the various specialists, who performed the baseline studies, impacts, risk assessments and resultant mitigatory measures, including altemative strategic approaches.

The following **key questions** were raised during the first order verification process step, applying the relevant technical, economical and environmental criteria:

- What is the extent of the impact in a specific zone or area?
- What is the magnitude or extent of exceedence?
- What do the applicable regulatory requirements or international benchmarking standards indicate?
- What are the available strategic approaches, which can be employed to mitigate the impact?
- What are the altemative optlons?
- Whet alternative would represent the base case?
- Would the current practice(s) represent a defensible base case?
- What alternatives would be technically sound?
- What options would be economically feasible for IVS?
- Would the listed alternative reduce the impact or risk to an acceptable level?
- By implementing the measures, would the current practices be improved and upgraded to ensure compliance with regulatory requirements?

A second tier verification process step was required, once all the preferred options have been prioritised. This process include:

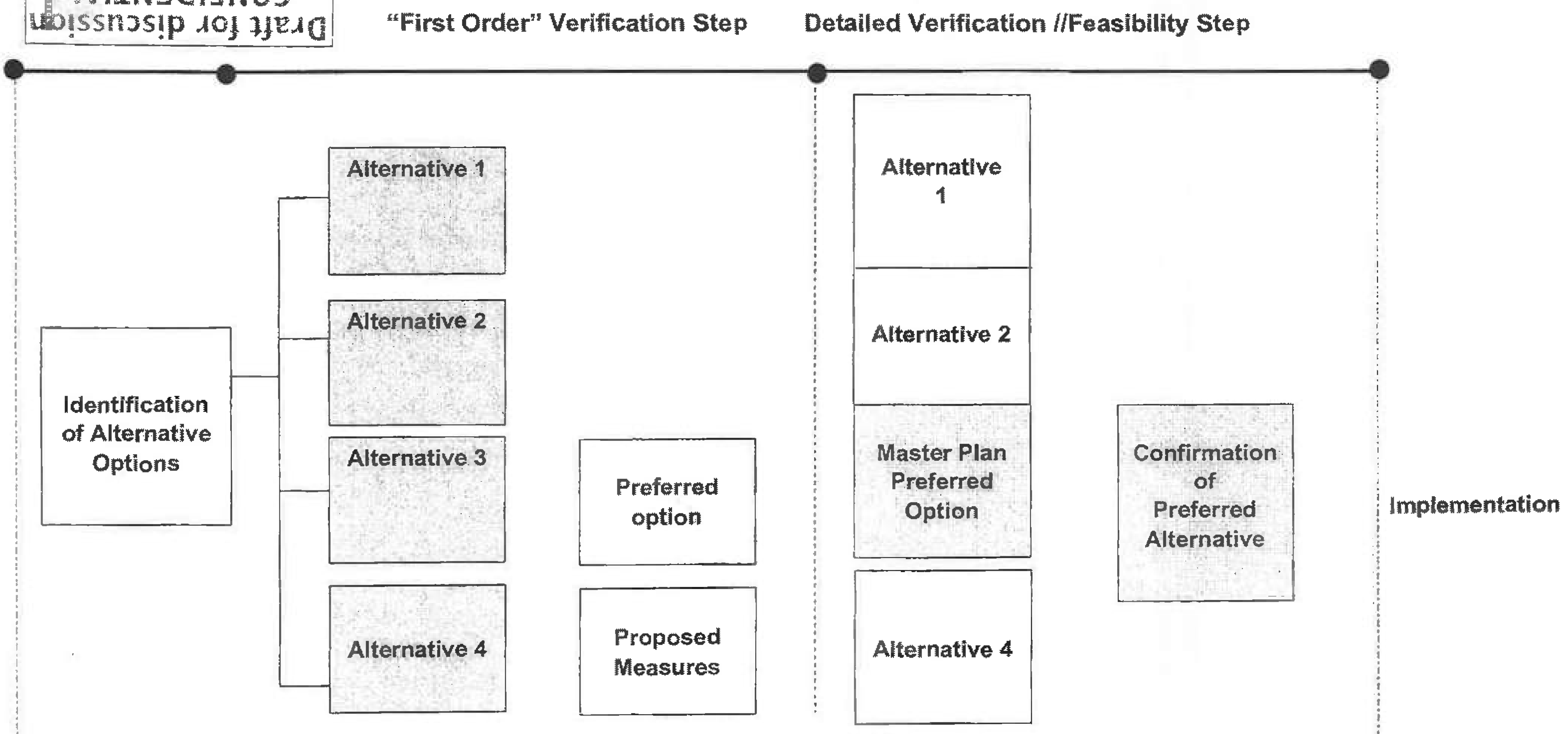
- A detailed review of those alternatives with a high level of confidence of viability
- A comparative analysis of the **base case** with the preferred option in terms of the applicable criteria
- A confirmation of the preferred option which may include consultation with stakeholders
- A detailed feasibility study on the preferred option
- Initiation of permitting and authorization processes.

In certain instances a third tier verification process step may be required by the regulator and key stakeholders, which may include detailed risk assessments, life cycle analyses and comprehensive Environmental Impact Assessments, in which the objective would *inter alia* be the determination of the current regulatory status and compliance profile in terms of permitting and licensing requirements. In this regard MP implementation processes have to be aligned with the official permitting and licensing processes, scoping needs to be performed on the official processes in close co-operation with the authorities, and IVS need to officially enter the required steps of these processes.

A **Permitting and Licensing Sub-Committee** was formed during June 2001 as a sub-section of the Master Plan Project Team and Steering Committee to attend too this aspect of the project.

The **Sub-Committee was tasked** to identify the mainstream processes, which are required, to avoid duplication of processes for various permits/licenses, to streamline the regulatory control matters in order to assist with effective management of the processes and to reach a position of ongoing regulatory compliance. The sub-committee subsequently concluded *inter alia* the Water Use Licensing process in terms of the National Water Act (NW), Section 21 and the Section 20 process of the Environment Conservation Act (ECA) to be of primary importance to IVS, specifically with regard to renewal of the water license, and the CRMF principle for waste disposal and rehabilitation strategies.

An area of specific concern was the possible duplication of multiple applications and processes in the application for permits and licenses. An example is the CRMF area consisting of a present (and possible future) waste disposal facility, several evaporation and holding dams and ponds, as well as stockpiling facilities in the same geographical area. Permitting and licensing of individual activities with individual EIA[s], seems not to be a viable solution.



Verification of Technical and Economical Feasibility

4.10 Prioritisation

4.10.1 Pre-requisites to the prioritisation process

Prioritisation as part of the MP integration process was a complex step.

It was only feasable, once all the management areas had been analysed in terms of:

- A current status description based on sound baseline information
- A semi-quantitative or quantitative impact and risk determination.

A clear understanding had to be developed of the nature, magnitude and extent of the impacts and risks, in collaboration with the process activities and characterisation of all the sources of impact and risk. Alternative options also had to be identified and evaluated to find a preferred option. Subsequently measures associated with the preferred option had to be formulated and conceptualised.

4.10.2 The prioritisation process

A three level prioritisation process was followed, applying human health and environmental criteria.

(i) Level one - Prioritisation

A level one coarse screening was performed on the Environmental Management Areas. The nine sub-zones of the CRMF area were to be included and a total of seventeen areas were evaluated.

A matrix evaluation was used, to rate the management areas in terms of overarching health and environmental criteria. Each area was rated for all the key environmental media, which included ground water, surface water, land (soils, eco-systems etc) and air. Rating numbers, a procedure commonly used to identify, rate and rank risks, incorporating consequence and severity, was applied.

The following 17 Areas were addressed:

Area No.	Management Areas
1	Overall CRMF
2	Existing waste dump
3	Dam 10
4	Dams 1 – 4
5	Maturation ponds
6	Raw material stockpiles
7	Processed material stockpiles
8	Sludge dams
9	Redundant blast furnace sludge dams
10	Dam 11
11	CPA
12	South eastern slag area
13	South western slag area
14	TETP and MTP area
15	Klewiet area
16	Perimeter and immediate surrounding areas
17	Rietkuilspruit and Rietspruit canal

The Rietspruit and Leeuspruit areas, which fall outside the boundaries of the IVS jurisdiction, but inside the Catchment Management Areas, were not included in the **level one** prioritisation process.

From this process the management areas with the highest ratings could be identified. The key environmental media in each area could be separated from others with lower risks, and the areas with higher risks could be rated as "red flags".

(ii) Level Two – Prioritisation

A ranking process was followed by summarizing the ratings for each environmental management area. Averages were determined for each environmental area and key environmental media per management area, which resulted in a final ranking in terms of human health and environmental criteria. Subsequently A priorities (Major projects already committed) and P priorities (Management Areas) emerged.

(iii) Level Three - Prioritisation

Measures, which were identified and formulated in each priority area, were listed, taking into account the logical sequence of implementation. These priorities were the prioritised measures as per prioritised management area, and were termed M-priorities.

4.10.3 Applicable criteria

The evaluation process was based on applicable primary criteria such as health and environment, and on secondary criteria such as technical feasibility, profile of compliance to regulatory requirements, applying best practice/available technology, and economic considerations/cost effective measures. The cost of proposed measurers did not influence the prioritisation process. The effect of cost is only to be considered, once prioritisation of Areas and Measures are performed. The prioritisation process is more fully illustrated in chapter 7.

4.11 Costs

Cost estimates were compiled for all the listed measures of the prioritised environmental management areas. The costs were calculated for each measure and it is summarised in the Appendix tables of the **Appendix to the Integration Report.**

4.12 Time Frame

A proposed implementation schedule was drawn-up for each of the 17 Environmental Areas, over a timespan of 20 years, which includes a lifecycle approach in certain instances i.e. rehabilitation and closure of the existing waste dump.

5. MANAGEMENT AREAS AND ZONES

The baseline studies were conducted in **three** main sub-study areas, namely the:

- Larger study area
- Zones within the IVS Works area
- Zones in the receiving environment beyond the IVS perimeter

Geographical information was used to delineate the sub-study arees. Aerial photographical map information on scale was used for the larger study area and for the works area. The aerial photographical map information is supplemented with contour information, which varies from 5 metre contour intervals for the larger study area to 2 metre contour intervals for the works aree. In addition IVS expressed the need to develop management areas and zones, which should refer to current operational business units (BU's). Subsequently were the total study area grouped into 10 Management Areas, of which 6 of the Management Areas were within the IVS perimeter containing the business units as tabulated

Diagram 1.2

Iscor Vanderbijlpark Works
Delineation of entire works area into 42 Units (MU's)

↓

Iscor Vanderbijlpark Works
Consolidation of MU's into logical, geographical and operable zones (MP zones). These zones would serve as Environmental Management areas

Management Areas within the perimeter	Management Areas outside the perimeter
1. Consolidated residue management facility (CRMF)	7. Perimeter and immediate surrounding areas
2. Consolidated plant area (CPA)	8. Rietkuilspruit and Rietspruit
3. South-eastern slag and open veld area	9. Leeuwspruit and Vaal River
4. South-western slag area	10. Rietspruit and Vaal River
5. TETP and MTP area	
6. Kiewiet area	
(6 management areas)	(4 management areas)

The Consolidated Residue Management Facility (CRMF) is further sub-divided into sub-zones due to the diversity of activities that is performed in the CRMF, as well as complexity of the geographical locality of the waste and wastewater facilities inside the CRMF. The management objectives and measures for the CRMF sub-zones vary from area to area.

The **CRMF** is subdivided into the following **Sub-Management Areas**:

1.1 Existing waste dump
1.2 Dam 10
1.3 Dams 1 – 4
1.4 Maturation ponds
1.5 Raw material storage
1.6 Processed material storage
1.7 Sludge dams
1.8 Redundant Blast Furnace Sludge Dams
1.9 Dam 11

Management areas outside the IVS perimeter were also delineated. These areas are located either in the larger study area or in the surrounding zone of the receiving environment beyond the IVS perimeter.

5.1 The Larger Study Area

The **Larger Study Area** is an area, which extends from the **Vaal River** in the **south to** the residential areas to the **north** of the Works area.

It includes the confluence of the Leeuwspruit into the Vaal River in the east **up to** the Rietspruit to the west of the works. The confluence of the Rietspruit and the Vaal River at the Vaal Barrage is included.

Baseline study work was done in the larger study area, which includes, inter alia:

- Surface water e.g. water quality
- Ground water e.g. hydro-census
- Eco-aquatic and terrestrial survey
- Air quality monitoring
- Consultation processes e.g. sub-sector consultation groups and forums, i.e. the Rietspruit Forum.

The **land-use activities** in the larger study area vary **from** residential (mainly in the south, north and east) **to** Industrial (secondary industries, mainly to the south) **and** agriculture (mainly to the west of the works).

The key environmental components, which could potentially impact upon the receiving environment in the larger study area, have been identified and baseline studies were conducted accordingly.

The MP integration process encompasses a coarse screening of potential impacts and risks on the receiving environment, which could possibly emanate from the IVS works and/or other land-use activities in the larger study area. Potential sources which could contribute to potential impacts and risks on the receiving environment have been identified through the MP study.

Management objectives for the larger study area would require a regional environmental management approach. The regulatory authorities and representatives of all key stakeholders, including residential communities, industry and agriculture should participate to set management objectives and targets for the larger study area and develop regional environmental strategies and implementation plans. The Rietspruit Forum would be an ideal vehicle, which could be expanded to promote consultation and public participation in the larger study area. IVS is a member of the Rietspruit Forum. The Catchment Management Agency (CMA) would focus on the water quality objectives, compliance standards and water management practices in the larger study areas, which could be consolidated in three Management Areas, i.e. Rietkuilspruit and Rietspruit Canal, Leeuwspruit and Vaal River, and Rietspruit and Vaal River.

The IVS related impacts and risks, suggested management objectives and proposed measures and monitoring requirements are described in Chapters 6.8, 6.9 and 6.10.

5.2 Zones within the Iscor Vanderbijlpark perimeter

The IVS works were sub-divided into business unit zones. The business units are categorised into the following main management categories, namely:

- Steelmaking (SM)
- Central services (CS)
- Materials management (MM)
- Coated products (CP)
- Ironmaking (IM)
- Industrial company (IC)
- Contractors (CO)

The business unit inventory items are listed in the following table:

Project Inventory ID No.	Master Plan Zone ID No.		BU description
SM01	South-eastern slag and open veld area	Area 3	Steelserv Area
SM02	Consolidated plant area	Area 2	BOF plant
SMO3	South western slag processing areas	Area 4	Open areas and Electro Slag Areas
SM04	Consolidated Plant area	Area 2	Electric Arc furnace
SM05	Consolidated Plant area	Area 2	Direct reduction plant
CS01	Consolidated Plant area	Area 2	Southern Storage area
CS02	Consolidated Plant area	Area 2	Administration and Services
CS03	South Western area	Area 4	Ellispark and Open Areas
CS04	Consolidated Plant area	Area 2	Olympus Switch Yard "C"

Project Inventory ID No.	Master Plan Zone ID No.		BU description
CS05	Consolidated Plant area	Area 2	TETP plant and Contractors area
CS06	CRMF	Area 1	Dam 10
CS07	CRMF	Area 1	Solid Waste dump
CS09	CRMF	Area 1	Maturation ponds
CS10	CRMF	Area 1	CETP sludge dams
CS11	Consolidated Plant area	Area 2	CETP plant
CS12	Central Open Area	-	Central Open Veld Area
CS13	CRMF	Area 1	Dams 1 – 4
CS14	Kiewiet area	Area 6	Kiewiet area
CS15	Consolidated Plant area	Area 2	Suprachem Raw Storage area
CS16	Consolidated Plant area	Area 2	Water Plants
CS17	Consolidated Plant area	Area 2	Substation Area Switchyard "E"
CS18	Consolidated Plant area	Area 2	North Works Support Services
CS19	Consolidated Plant area	Area 2	Siding area
CS20	CPA	Area 2	Kwamadala and Open areas
CS21	South-eastern Slag and Open veld area	Area 3	South-eastern open-veld area
CS22	CRMF	Area 1	CETP sludge dams
MM01	Consolidated plant area	Area 2	Refractory area
MM02	Consolidated plant area	Area 2	Scrap area
MM03	Consolidated plant area	Area 2	Plant store
MM04	Consolidated plant area	Area 2	North containerised storage area
CP01	Consolidated plant area	Area 2	South mills
CP02	Consolidated plant area	Area 2	VANTIN
CP03	Consolidated plant area	Area 2	Coil-storage area
CP04	CRMF	Area 1	PVA Plant area (defunct)
UP01	Consolidated plant area	Area 2	North works
IM01	Consolidated plant area	Area 2	Blast furnaces
IM02	Consolidated plant area	Area 2	Blast furnaces C and D
IM03	Consolidated plant area	Area 2	Blast furnace slag Granulation and sinter plant
IM04	CRMF	Area 1	Stacking and reclaiming of raw materials
IM05	CRMF	Area 1	Veld Coke area
IC01	Consolidated plant area	Area 2	Suprachem
Co01	Consolidated plant area	Area 2	Air products

The business unit zones were logically grouped into six environmental management areas namely the CRMF (with it's 9 sub-management areas), the Consolidated Plant Area (CPA), South-eastern slag and open veld area, South-western slag area, TETP and MTP area and the Kiewiet area.

Please refer to the Inventory Maps in the Master Plan: Book of Plans, which gives a comprehensive overview of the locality of all the business units (MU's) and the management areas inside the IVS Works area.

5.3 Zones in the Receiving Environment beyond the IVS perimeter

The majority of the baseline studies were focused on areas inside the IVS Works. A certain amount of baseline studies were conducted on the perimeter of the IVS Works e.g. groundwater, monitoring points, noise, dust fall-out visual and aesthetic quality observations.

Through performing the baseline studies on the perimeter and in certain instances beyond the perimeter e.g. ground water and visual, it became clear that another sub-study area was required in between the larger area and the IVS Works area.

This area is defined as: the Perimeter and Immediate Surrounding Areas.

The extent of the zone varies from a few metres (measured from the works boundary fence) up to 1000 metre and more, pending the potential zone of influence of e.g. ground water, air quality and aesthetic quality. The exact locality of the zone of influence would require more detailed investigative work in terms of risk and impact assessments, discussions with the authorities and stakeholders and agreement of buffer zones in terms of the primary objectives and the application of site specific health and environmental criteria.

6. INTEGRATION PROCESS DESCRIPTION

The Environmental Management Areas differ from the MP Zones described initially in the Base Line Studies Reports, in that for certain zones, Management Areas either sub-divide or combine Master Plan Zones. This departure from the Master Plan Zones were necessary to facilitate an effective integrated management plan in preparation for an Environmental Management System.

The secondary management objectives, measures and monitoring programme as recommended for each of the selected management areas, support the primary objectives for the larger, integrated Management Areas.

The following Management Areas have been defined for the Works area.

6.1 Consolidated Residue Management Facility (CRMF)

6.1.1 CRMF
6.1.2 Existing Waste Site

6.1.3 Dam 10
6.1.4 Dams 1 – 4
6.1.5 Maturation Ponds
6.1.6 Raw Material Stockpiles Area
6.1.7 Sludge Dams/Old Maturation Ponds Area
6.1.8 CETP Redundant Blast Furnace
6.1.9 Sludge Dams
6.1.10 Dam 11

6.2 Central Plant Area (CPA)
6.3 SE Slag and Open Veld (SESOVA)
6.4 SW Slag Area (SWSA)
6.5 Terminal Effluent Treatment Plant (TETP) and Main Treatment Plant (MTP)
6.6 Kiewiet Area
6.7 Perimeter and Immediate Surrounding Areas (PISA)
6.8 Rietkuilspruit and Rietspruit Canal (RRCA)
6.9 Leeuwspruit and Vaal River (LVRA)
6.10 Rietspruit and Vaal River (RVRA)

Due to Management Area 1 became known as the CRMF, Management Area 2 as the CPA etc., the IVS works Area was numbered as 6.0.

6.0 Iscor Vanderbijlpark Steel (IVS) Works Area (IVSWA)

6.0.1 Activity

From an archaeological point of view, the bulk of the IVS infrastructure was established and constructed during the last five to six decades on the farm Cyferpan. Infrastructure associated with the IVS plant includes the older Southern Works (established between the 1940's and the 1970's) and the more modern Northern Works (established during and after the 1970's).

The main manufacturing activities of Iscor are situated along the southern and eastern borders of the property. On the western border activities can be associated with the transport and disposal of waste products.

6.0.2 Impact

Impacts with respect to most environmental disciplines are described within the paragraphs to follow for each management area. Impacts on plant and animal life, visual, noise and archaeology are common to the total site area and are therefore described here for the total IVS area.

With respect to **plant and animal life**, the activities that occur within the Works area are such that both components experience ongoing high levels of disturbance. Within IVSWA, very few sites could be identified where any plant life/animal life information could be gathered, primarily due to the nature and extent of the disturbance due to industrial activities in this area.

For **plant life,** these impacts relate to the disruption of the soil profile, loss of topsoil, destruction of vegetation, trampling, increased edge effect and invasion of alien species. This is clearly evident from the fact that a large percentage of the species found in the area commonly occur in disturbed areas. A large number of invader, alien and weedy species occur.

For **animal life,** these impacts relate to destruction of habitat, disturbance in migration patterns, loss of food sources and increase in pest species. However, the abundance of water in the IVSWA (dams and ponds) does attract bird life to the area. Due to the lack of suitable habitat, it is unlikely that the larger mammal species will occur in the IVSWA. However, an abundance of small mammals such as members of the family Rodentia could occur, including snakes and reptiles.

No endangered, rare or vulnerable plant and animal species were recorded during the site observations, and none are expected to occur, due to the high level of industrial activity.

The activities that have taken place on the IVS premises during the last sixty years have had a severe impact and are of such a magnitude that **heritage resources** have been destroyed or disturbed, including the archaeological context of such features or sites.

The South Works contain the oldest **infrastructur**e, such as the Coke Plant and towers associated with this plant, which may be almost sixty years old and may qualify as historical or industrial significant structures. There are no early or late Iron Age sites.

In regard to **visual** impacts, the IVS plant infrastructure and more specifically that of the CPA area, as man-made features, have significantly altered the natural appearance of the landscape and have also contributed to a conspicuous man-made skyline in this part of the Highveld, visible from the national and other major roads passing Vanderbijlpark as well as from neighbouring residential areas.

In general the industrial criterion for **noise** is exceeded only on the southern boundary of the IVS Works. However a significant buffer of land between the boundary of the IVSWA and the nearest residential area exists. The most critical area is the south-eastern borderline.

The typical noise levels for Industrial Districts, as defined by SABS 0103, are specified as 70 dBA, 65 dBA and 60 dBA. The present ambient noise levels are the highest along the southern border of the CPA. The Industrial District noise criterion is exceeded during the evening and at nighttime. No IVS related impacts were measured at the measuring point to the north of the dams on the R54 provincial road. Noise is dominated by traffic noise on the R54, natural sounds caused by birds and crickets and community noise from residential settlements to the north. Noise measurements on the perimeter of the Existing Waste Dump (opposite the dump) found that the main contribution was from the R553 (Golden Highway) at 55 dBA. The dump is visible from both the R553 and the R54 and has socio-economic implications.

Due to the industrial nature of the IVS Works and other industries surrounding the IVS Works, its appearance has impacted **visually** on neighbouring residential areas in the vicinity.

The Existing Waste Dump does constitute a significant, negative visual impact.

Dams 1-4 have no negative visual impact from viewpoints (determined during the baseline studies) towards the north of the Works.

Although Dam 10 covers a relatively large area, its visibility from the perimeter of the Works is low as it is screened-off by the existing dam wall/rail line embankment. Due to its low elevation, the visual impact of the dam facility is low. The rail line embankment is unsightly.

A windblown dust from the fine fraction of materials stockpiled within the IVSWA compromises both the quality of **air** and, to a lesser degree the surface water. The contaminated surface water also infiltrates into the groundwater system.

6.0.3 Risk

Both the **plant and animal ecology** is at high risk within the areas of the IVSWA that are highly disturbed (especially the larger mammals), due to the unsuitable habitat, whilst the smaller mammals are less at risk. The risk to the terrestrial ecology is equivalent to that to be expected within a highly industrialized area. No endangered, rare or vulnerable plant or animal species are at risk.

Heritage resources in critical plant areas may be affected by future development activities.

The risk on visual components of the environment is characterised by the presence of **industrial buildings and infrastructure** associated with industrial manufacturing processes, which present an unnatural / un-aesthetic profile to the environment.

The south and eastern part of the Works is much closer to residential areas than the rest of the Works area, although the heavy industrial activities, e.g. arc furnace plant activities, are quite a distance further away.

The occurrence of **noisy** single events, such as the handling of materials, which could exceed the Industrial Districts noise criterion, could increase the risk to Human Health. The specialist opinion states however, that the noise emissions are generally in compliance with the prescribed standards.

6.0.4 Management Objectives

The short-term management objectives for **plant and animal life** within the highly disturbed areas relates to the identification and protection of all threatened species. For the medium term the objective should be to monitor the general health of the flora and fauna, whilst the long-term objective (post rehabilitation and closure) should be to attempt to restore the vegetation and animal communities to a healthy condition with both high species richness and diversity. This is also dependant on the final land use objectives.

An ongoing management objective would be adherence to the requirements of the National Heritage Resources Act, including following guidelines to obtain relevant permits from South African Heritage Resources Agency (SAHRA).

The **visual** management objectives for the IVSWA include reduction of visual impacts, especially along the southern, south-eastern and western borders of the IVS Works area to curb negative perceptions about the IVS manufacturing activities in general and to strive to restore its sense of place. These could include screening mitigation measures located at identified vantage points along the outer-perimeter of the Works.

Rehabilitation, topsoiling and vegetation of the waste dumps and dams (including the rail line embankment) would reduce **visual** impacts.

The **noise** management objectives for the IVS Works Area include the reduction of noise emissions (noisy single events), to ensure compliance to the Industrial Districts Noise criterion.

A general management objective for air quality is to reduce uncontrolled dust generation still further: In the short term, dust suppression should continue where practical.

6.0.5 Measures

The following possible management measures have been identified for **fauna and flora** subject to the actual activity and resulting impact within a specific area for IVSWA, for implementation according to the life cycle phase of the specific activity and impact.

- Identification and transplanting or protection of threatened species - short-term.
- Ongoing monitoring - medium and long term.
- Selective soil stockpiling - medium and long term.
- Establishment of a seed bank of natural species - medium and long

term.
- Re-introduction of natural vegetation to denuded areas under rehabilitation - medium and long term.
- Prevention of unnecessary species disturbance/removal - medium and long term.
- Limit the number of roads, traffic and other forms of disturbance of pristine areas - medium and long term.
- Control alien and invader species – short, medium and long term.
- Limit human access to sensitive areas where possible- medium and long term.
- Institute a buffer zone around activities - medium and long term.
- Restrict activity area – short, medium and long term.
- Limit and control vehicular traffic - medium and long term.

A detailed evaluation of **infrastructure** at the South Works by a historical specialist is recommended. Where applicable, a SAHRA permit should be applied for and included in a specific, management area EMP. Collation of historical documentation for safe archiving is recommended before decommissioning and/or demolition of items or areas of archaeological and/or cultural value.

The Steelserv area is the most critical area in terms of **noise** emissions, especially single noise events. IVS indicated that this operational area would be relocated in the medium to long term, which will reduce noise from the area.

The proposed mitigation measures could include the **landscaping and vegetation** of identified critical areas to effectively screen unsightly industrial infrastructure from the public view using vegetative clusters.

A full **visual** impact assessment may be required, as part of the EIA for the CRMF. Over the medium term, it is recommended that IVS extend the rehabilitation programme to the entire waste dump and other areas within the IVSWA that cause a negative visual and/or air quality impact. These should, in the long term, be managed, maintained and aftercare applied to the vegetation and screening measures.

The rehabilitation of the Dam 10 area is planned to be completed over the next few years. Thereafter, it is recommended that IVS establish screening clusters with shrubs and trees. In the long term, maintenance of the structure will ensure that the visual mitigation measures remain effective.

The existing dust monitoring programme should be continued to assess and confirm that an acceptable risk profile is maintained.

6.0.6 Monitoring

Monitoring of the applicable environmental variables for **plant and animal** life is necessary to prevent further degradation of the ecosystem. A floral and faunal survey should be conducted once a year, in which species lists are compiled and the abundance of each of the specific species recorded. Throughout the year, any unusual occurrences in the floral and faunal communities should be monitored.

The air quality monitoring system currently in use should be audited bi-annually.

Ongoing monitoring of the **noise** will be required on a quarterly to six monthly bases.

A number of measurement points were selected on or near the border of the IVS Works. At each of these points an ambient noise level was sampled at representative times of a 24-hour period. Estimates of the ambient noise climate on the border of the IVS Works area were made from this.

Ongoing monitoring and aftercare of visual improvement measures is recommended.

Establish and continue with bi-annual meetings of an integrated environmental monitoring committee.

6.0.7 Regulatory Authorisations

The outcome of consultative processes to date, was that the Public Participation processes for the MP had to focus on the **planning** of forthcoming authorisation processes, in contrast to the ideal situation where the public were consulted as to the Terms of Reference of the MP and prioritisation of the impacts identified and assessed therein.

The planning for Public Participation undertaken during the MP should serve as the foundation on which future authorisation processes will run. In addition, the "dove-tailing" of associated processes should be more clearly identifiable and implemented.

An Integrated Environmental Monitoring Committee should facilitate the Public Participation legally required for the authorisation processes for various components of the Works. The establishment of such a Committee should not detract from the existing Rietspruit Management Forum, but should rather complement it.

6.1 Management Area 1: Consolidated Residue Management Facility (CRMF)

6.1.1 Overall CRMF

6.1.1.1 Activity Description

This brownfield site is used to stockpile, store, process and/or dispose of solid and liquid waste streams arising from the steel-making operation and raw and processed materials storage. It covers an area of 773 ha, and has been divided into the following sub-zones, which will be described in Sections 6.2.1 to 6.1.10.

- Existing Waste Dump
- Dam 10
- Dams 1-4
- Maturation Ponds
- Raw Material Stockpiles Areas
- Processed Material Storage Areas
- CETP Sludge Dams
- Redundant Blast Furnace Sludge Dams
- Dam 11

The CRMF falls within the western catchment of the site, which drains predominantly westwards towards the Rietkuilspruit. The CRMF is situated to the north of the Central Plant Area (CPA), and is situated in the north-western quadrant of the Works area.

Limited run-off water from the Kiewiet site enters the CRMF upstream of the site to the West. Water discharge from the CRMF is via the Hattingh canal or via an open drain downstream of the Dam 10 embankment. All surface water discharged from the CRMF eventually reports to the Western outlet point at the Rietspruit canal

The aim of the consolidation of the various components within this area is that the CRMF becomes managed and controlled as an integrated unit under a single permit. A temporary Water Use Licence has been issued under Section 21 of the National Water Act (NWA) 36 of 1998 until June 2003.

The CRMF was delineated and defined during the Master Plan study as an operational area where solid waste, sludge material and waste water is managed. The area accommodates the main water management facilities, where excess process and contaminated runoff water is stored in dams. Sludge materials have been dumped in sludge dams. The area is also used to stockpile by-products for processing and reclamation. The Raw Material Storage and Blending Yards are also located within the CRMF.

6.1.1.2 Impacts

In order to support the ground water impact assessment for the overall CRMF, a broad overview of the geology is given. The CRMF area is almost entirely underlain by the Silverton Shale Formation of the Pretoria Group of the Transvaal Sequence. A small part along the eastern CRMF boundary includes the Daspoort and the Strubenkop formation quartzites.

Two major regional geological structures occur within the area, namely a left lateral slip fault end a dolerite dyke. The fault transects the area with a horizontal displacement of more than 2 km. The strata north of the fault zone seem to be pivoted upwards in the southeast, the hinge being to the northwest, roughly from where the displacement of the Daspoort Formation took place. The displaced Daspoort Formation arches back from outside the IVS property and the fault zone, past the south-eastern corner of the IVS property, the arch being to the northwest. The displaced formations south of the fault zone arch back from the fault zone outside the IVS property, past the south-eastern corner of the property.

A major dolerite dyke transects the CRMF area from east to northwest. This dyke is approximetely 80 m thick and its orientation dip is near vertical with an east-west strike.

The sub-zones listed in the activity description and described in sections 6.1.2 to 6.1.10, have been identified as theoretical potential sources for contamination of ground water.

For this CRMF discussion, only broad/general impacts, risks, management objectives and measures will be given as the detailed discussion, per smaller management area, can be viewed in sections 6.1.2 to 6.1.10.

With regard to ground water, within the overall CRMF, two aquifer types ere present, namely the perched aquifer and the shallow weathered zone aquifer. The thickness of the unsaturated zone is impacted by insufficient free surface water drainage and mounding beneath the footprints of the individual unlined dumps, dams, ponds and stockpiles. This thickness averages at about 2 meters. Saturated thicknesses for the perched aquifer are some 3 meters, whilst the shallow weathered zone aquifer is saturated up to a thickness of some 18 meters.

Few lateral aquifer boundaries are active within the area. The fault zone was extensively investigated and concluded not to be a hydraulic or physical boundary. The dyke on the other hand is both e hydraulic and physical boundary, but due to the ground water flow directions within the CRMF, which largely parallels the dyke, does not manifest a significant boundary effect. **The main surface water divid**e which runs from north to south through the IVS property, also represents a groundwater no flow boundary.

However, this boundary is located to the east of the CRMF, and does not actively influence ground water conditions within the CRMF.

Borehole yields in the area vary from low to medium. The aquifer hydraulic parameters (storativity and permeability) are low, whilst porosities vary from moderate to high, suggesting slow ground water flow, and restricted volumes of ground water. Piezometric levels in the two aquifer zones differ with a primarily positive gradient from the deeper to the perched aquifer. Natural recharge from rainfall is estimated at 2% to 3% of MAP.

The regional ground water flow direction for this area is from east to west. Despite the presence of mounding underneath the dump, dams, ponds and stockpiles, the extent of the mounding are insufficient to alter the regional ground water flow pattern. Using the observed hydraulic parameter values for the area, together with the average hydraulic gradient, **the ground water flow velocity is in the order of 10 to 15 meters per year**.

No ground water abstraction occurs for any application within the CRMF area.

The aquifer(s) underlying the area are classified as ***Minor Aquifer Systems***, whilst their vulnerability is classified as ***medium***. Aquifer susceptibility is classified as ***medium***, resulting in an overall aquifer protection classification of a ***medium protection level***.

The fault and dolerite dyke cutting through the CRMF area generically represents a ground water fatal flaw with respect to waste management. **However, drilling, pump testing and sampling investigations along both these structures have indicated no preferential contaminant migration to date**. The reason for this is that the higher than average permeabilities observed along these features are cancelled by the higher than average porosities of the flow paths along these features, which result in similar ground water seepage velocities along these conduits, than those present in the surrounding host rock.

The fact that no significant abstraction from boreholes along these features is currently taking place **further prevents preferential contaminant migration along the fault and dyke**.

With reference to the activity description for the CRMF, there are mainly two impact manifestation mechanisms of importance, namely, hydraulic and hydro-chemical manifestation.

As soon as (waste, product, raw materials or water) material placement commences, residual water not drained effectively will start to infiltrate through the footprints of dumps, dams, ponds and stockpiles into the underlying aquifers. The actual volume of water/leachate that will enter into the underlying ground water regime, will be a function of:

- rainfall
- the hydraulic conductivity of the footprint
- the hydraulic conductivity of the underlying unsaturated zone
- the hydraulic conductivity of the aquifers
- the piezometric head in the dump/dam/pond/stockpile, as well as
- the piezometric distribution in the underlying aquifers

Once into the underlying aquifer(s), the contaminated ground water will start to flow horizontally through the aquifer(s), as a function of permeability, porosity, hydraulic gradient and concentration gradient. Vertical flow will only occur if vertical hydraulic gradients exist, as was observed for several areas within the CRMF. However, DNAPL's will migrate vertically into the sub-surface purely as a result of their density. Once in the sub-surface, DNAPL's can dissolve into ground water (albeit very slowly).

Contaminant migration in the ground water system, primarily occurs subject to two mechanisms, namely:

- Advection/convection/dispersion whereby the contaminant mass transport is a function of the ground water flow, and/or
- Diffusion whereby contaminants transport occurs as a result of concentration gradients.

Whereas the former mechanism predominates in higher permeability environments, diffusion dominates as a mechanism at extremely low hydraulic conductivities. It follows logically that convective/dispersive contaminant transport accounts for much higher magnitudes of transport, than diffusive transport. Additional to these transport mechanisms, chemical thermodynamics, as well as other processes (adsorption, ion-exchange, desorption, buffering, etc.), may alter the original chemical composition of the water on its flow path through the aquifer.

The mechanisms for the hydro-chemical manifestation of ground water pollution relate to the generation of leachates as infiltrating water percolates through dumps, stockpiles or contaminated soils, or else simply through seepage of contaminated surface water, process water or effluents contained in dams and ponds into the ground water regime.

Ground water chemistry results obtained from boreholes in the greater CRMF area, confirm elevated concentrations of Ca, Mg, SO_4, Cl, K, Na, NO_3, F, Fe and Mn within both the perched and shallow weathered zone aquifers. However, the degree of concentration elevation is generally less for the shallow weathered zone aquifer.

Organic ground water chemistry observed in the boreholes indicates the presence of both free phase and dissolved phase DNAPL (coal tar) (both not necessarily present in all the boreholes).

The extent of the contamination in both the perched and shallow weathered zone aquifers includes the footprints of all the sources listed, as well as areas beyond these footprints. In this regard it is especially the area to the west of the Existing Waste Dump and Dam 10, up to, and beyond the IVS western perimeter, which have been impacted. The lateral migration of contamination plumes is largely a function of the observed regional ground water flow patterns.

However, these sources have been extensively characterized for potential contamination of ground waters by waste deposited, waters in the evaporation dams and sediments in the dams and ponds, for both inorganic and organic contaminants. Integration of these results will be addressed in the sub-sections referred to.

The extent of the organic contamination in both the perched and shallow weathered zone aquifers includes localized areas within the CRMF and areas extending beyond the IVS perimeter. Contribution to the dissolved phase from residual DNAPL pools observed also occurs. The DNAPL pools observed, has been discussed under the sections dealing with the Redundant Blast Furnace Sludge dams (section 6.1.9) as well as Management Area 2 - Consolidated Plant Area (section 6.2).

The extent of the contamination beyond the IVS western perimeter will be discussed in the Receiving Environment (Management Area 7). Apart form this; no other Management Area boundary is compromised by the ground water contamination in the CRMF Management Area.

Soils in the CRMF have been significantly impacted on by inorganic salts, typically present in leachates, dusts, slags and sludges, normally expected at a steel plant. Impacts and risks from soils will be dealt with in addressing the different potential sources.

The majority of the CRMF area is sterilised by dumping and stockpiling activities, and water storage facilities.

Both plant and animal life will experience ongoing high level disturbances, due to the activities, which occur within the CRMF.

For **plant life** these impacts relate to disruption of the soil profile, loss of topsoil, destruction of vegetation, trampling, increased edge effect and invasion of alien species. This is clearly evident from the fact that a large percentage (56%) of the species found in the area commonly occur in disturbed areas. A large number of invader, alien and weedy species occur.

For **animal life** these impacts relate to destruction of habitat, disturbance in migration patterns, loss of food sources and increase in pest species. However, the abundance of water in the CRMF (dams and ponds) does attract bird life to the area. Due to the lack of suitable habitat, it is unlikely that the larger mammal species will occur in the CRMF. However, an abundance of small mammals such as members of the family Rodentia will occur. Snakes and reptiles could also still occur in this area. No endangered, rare or vulnerable plant and animal species were recorded during the site observations, and none are expected to occur, due to the high level of disturbance from industrial activity.

Surface water flowing in from outside of the CRMF drains into the area, predominantly from the eastern boundary of the CRMF where it interfaces with the Kiewiet Area.

Rain falling onto the CRMF area becomes contaminated on contact with contaminated surfaces. Infiltration of this contaminated surface water into the ground has an impact on the quality of ground water, and also raises the levels of ground waters. Dams within the CRMF raduce the effective catchment area of the Rietkuilspruit.

Water discharged from the site through the Hattingh canal is of poor quality during dry and wet weather conditions. Reason for this is the large areas within the CRMF that are exposed i.e. contaminating water on surface and also allowing higher infiltration rates into beaps and stockpiles, contributing to toe leach and ground water contamination. Stockpile areas are furthermore unbunded and leachate of the coal stocking yard for example is discharged diractly into the Hattingh canal.

The dust fall-out rate at the main cross roads within the CRMF araa was measurad as high as 0.9 gram/m^2/day, which is a level normally expected within heavy industry. A ring of monitors operated for a year along the CRMF perimeter returned a dust fall-out of on average about 0.125 gram/m^2/day which is about half of the guideline for residential land use.

A total of 11 noise measurement points were selected on the perimeter of the Works. Noise emanating from the CRMF is broadband in nature, mainly caused by trains, locomotive hooters and mobile equipment. A measuring point on the western boundary indicates that the noise levels are dominated by traffic on the R553 (rafer to the Master Plan Book of Plans).

The noise contribution from the CRMF, measured on the perimeter, is well below the Industrial Critarion.

The existing waste dump is highly visible, with a height ranging between 30m and 40m, being a significant feature within the CRMF. In general most of the CRMF has a disturbed landscape and the area is characterised by large industrial dumping and stockpiling activities. Thase facilitias are highly visible and prominent especially from tha lines of sight from:

- The northern perimeter
- North-western perimeter
- Western perimeter of the works

The Dams 1-4 has no negative visual impact from viewpoints (determined during tha baseline studies) towards the north of the Works.

6.1.1.3 Risks

The risk to human health is represents by the exposure through the ground water pathway for drinking water application. The risk to the environment is raprasants by the exposure through the aquatic ecosystems pathway. The areas for which both these risks is genarally unacceptable, ralates to the footprints of the facilities/sources within the CRMF. Beyond these footprints, the risk to human health and the environment is genarally unacceptable in the area between these facilities and the IVS westarn perimeter, and also for a distance beyond the IVS western perimeter.

For both the aquifer zones, the risk to human health and the environment generally relates to elevated inorganic concentrations for Ca, Mg, SO_4, Cl, Na, K, NO_3, F, Fe and Mn. Detail pertaining to the site specific risks to human health and the environmant is discussed under sections 6.1.2 - 6.1.10.

The risk to human health and the environment for organics, relates to the entire observed free phase DNAPL pool as well as several organic components observed in dissolved phase in some boreholes within the CRMF.

With regard to the more potent micro-contaminants, mobility of the impacted CRMF soils indicated a potential unacceptable risk (pathway being ground water) of manganese to the environment, and a potential unacceptable risk of aluminium and iron to human health.

Both the plant and animal ecology, is at risk within the CRMF. Plants that cannot adapt to the changed habitat will disappear, whilst invader, alien and weedy species will flourish. Especially also the larger mammals, due to the unsuitable habitat, are at risk, whilst the smaller mammals are less at risk. The risk to the terrestrial ecology is commensurata with that to be expected within a highly industrialized area. No endangered, rare or vulnerable species have been found in the area probably due to the level of disturbance.

Noise emissions from the CRMF are well below Industrial Criterion. Risk of exceedance of allowable noise levels is low.

Large and unsightly facilities in the CRMF can cause negative perceptions and a possible risk of reduction of property value of neighbouring land.

Surface water runoff from the CRMF has the potential for an unacceptable risk to human health and the environment if it is not treated before being released into the receiving environment.

The surface water management system on site however captures all of this water and routes it towards the TETP for treatment before release into the Rietspruit Canal.

The dust fall-out at the perimeter of the CRMF as measured continuously over a year did not pose a significant risk to man or the environment.

6.1.1.4 Management Objectives

The overarching primary environmental management objectives for IVS and therefore also for the CRMF are:

- Protection of Human Health
- Protection of the Environment

In the final analyses all measures must support these objectives.

Reference to these primary objectives in the forthcoming discussion of Management Areas, will not be repeated.

Due to the technical impracticability to remediate the observed ground water pollution within the CRMF to levels that will represent acceptable risk to human health and the environment, these objectives will most probably have to be reached through institutional controls. However, technical measures must be commissioned to achieve continual improvement subject to the following secondary short term (ST), medium term (MT) and long term (LT) objectives:

- Minimize contaminant concentration at source (ST).
- Minimize contaminant infiltration at source (ST).
- Cut of migration of contaminated ground water as close as feasible to source, to prevent the movement of contaminated ground water across boundaries - legal or arbitrary compliance boundaries (ST).
- Manipulate pollution plume migration to protect pre-defined areas (MT).
- Improve ground water quality to agreed/negotiated water quality standards (LT).

These objectives are complemented by those of surface waters, i.e.

- Minimise infiltration of pollutants at source
- Prevent migration of ground water contamination across the IVS perimeter
- Separate clean and dirty water
- Prevent clean water from entering the area
- Minimise dust fallout

The short-term management objectives for plant and animal life within the CRMF relate to identification and protection of all threatened species. For the medium term the objective should be to monitor the general health of the flora and fauna, whilst the long-term objective (post rehabilitation and closure) should be to attempt to restore the vegetation and animal communities to a healthy condition with both high species richness and diversity.

With regard to dust, the objective will always remain to reduce generation of dust to a minimum.

Visually the CRMF objective would be to rehabilitate, vegetate and screen to acceptable levels.

6.1.1.5 Measures

Various measures have been identified being in general terms for the CRMF. More situation and/or site-specific measures are addressed when discussing the different sub-areas:

- Shape, cap, re-vegetate areas to reduce infiltration
- Install infiltration galleries in perched aquifer
- Install abstraction boreholes in weathered zone aquifer
- Establish a buffer zone
- Install surface water diversion berms
- Install dust suppression measures
- Minimise footprints, consolidate dumping

Measures for ground water comprise two main categories:

- Institutional Measures
- Technical Measures

Institutional measures must be motivated in terms of technical impracticability.

Institutional measures:

The aquifer(s) impacted on by the activities within the CRMF can generally not be remediated to acceptable risk levels through technical measures, over the short and medium terms. Such measures will require flushing of the aquifers with "clean" water and/or steam and will in any event take several decades to improve the situation significantly. They are therefore considered impracticable to achieve risk compliance for large areas within the CRMF over the short and medium term.

Re-zone area within IVS perimeter (specifically also the entire CRMF), for ground water usage. This implies that abstraction and application control must be institutionalised within the current ground water impacted area, to such a level that the current ground water quality is within compliance, subject to demonstration of continual improvement over the long term.

Technical measures:

Selections and combinations of the following measures should be applied to address the situation at the various ground water pollution sources within the CRMF, as well as in the aquifers receiving water from the sources. Their Intention is to improve the situation over the short, medium and long term.

- Optimise waste streams in terms of contaminant load through waste minimization and selective placing.
- Optimise shaping, capping and re-vegetation of dumps, dams and footprints to minimize rainfall infiltration.
- Optimise dust suppression irrigation to minimize related infiltration.
- Whilst existing footprints cannot be lined at this stage, it must be kept as small as possible - no extension onto unlined areas.
- Control leachate at the toe of dumps, dams, ponds, and stockpiles, to prevent contaminated surface run-off and soil contamination.
- Whilst dams contain water, optimise water quality to as low as possible concentrations.
- Whilst dams contain water, minimize infiltration by keeping the water level as low as possible until it is emptied.
- Empty and rehabilitate dams where possible.
- Whilst stockpiles are operational, minimize infiltration by keeping the piles as small as possible - consolidate and minimize total footprint.
- Control any leachate at the perimeters of the stockpiles to prevent contaminated surface run-off and soil contamination.
- Relocate stockpiles to new prepared, lined facilities with leachate collection systems and rehabilitate the footprints.
- Delineate DNAPL source at surface through detailed geotechnical investigations.
- Remove any free phase DNAPL and dispose of at permitted waste disposal facility.
- Install drainage galleries to intercept contaminated ground water migration through the perched aquifer away from the facilities towards the IVS perimeter and surrounding receiving environment. These trenches must intercept seepage up to depths ranging between 4 and 6 meters.
- Install abstraction wells into the shallow weathered zone aquifer between the facilities and the IVS perimeter, to intercept contaminated ground water migration through the shallow weathered zone aquifer, across the IVS perimeter. The intention of these wells will also be to manipulate the plume migration patterns, in that a reversed ground water gradient will be established, thus forming a local reversal of

ground water flow from the surrounding receiving environment towards the IVS perimeter. In the long run, this could also cause an improvement in ground water quality in the areas beyond the borehole abstraction line.

- In addition also consider commissioning of an infiltration gallery of clean water to the west of the dissolved phase organic plume to force the dissolved phase back towards the IVS perimeter as well as to improve ground water quality in this area.
- Consider removal of the Residual DNAPL pools at depth through possibly a combination of steam injection, pumping, flushing and soil vapour extraction (alternative measures considered).
- Fencing around area
- Formalize Internal access roads
- Surface water drainage canals
- Perched water abstraction system
- Deep aquifer abstraction system
- Surface water monitoring system at CRMF discharge
- Cut-off uncontaminated discharge water at Kiewiet site from entering the CRMF
- Remove surface water dams as soon as possible
- Reduce surface water contamination sources by capping or containing affected areas. This reduces contact between surface water and contaminating substances or allows this contact, but captures the resulting contaminated water for treatment
- Infrastructure for determining waste streams entering and exiting the site
- Institutional control of impacted zone
- Institutional control of buffer zone
- Institutional control of area under CRMF
- Environmental awareness training
- Cleanup of various open areas within CRMF
- Vegetation - trees & shrubs around area

Alternative Measures Considered for the CRMF:

- Line facilities
- Vegetation - trees & shrubs around area
- Decommission/remove sources and rehabilitate
- Commission new facilities
- Seepage drains/drainage galleries
- Slurry walls
- Sheet piling
- Reactive barriers

- Pump and Treat
- Pump and Flush
- Infiltration galleries
- Steam Injection
- Solvent Injection
- Soil Vapour Extraction

For plant and animal life, the following management maasures should be considered:

- Identification of threatened species - short term.
- Ongoing monitoring - medium and long term.
- Selective soil stockpiling - medium and long term.
- Compile seed bank of natural species - medium and long term.
- Re-introduce natural vegetation to denuded areas - medium and long term.
- Prevent unnecessary species removal - medium and long term.
- Limit the number of roads - medium and long term.
- Control alien and invader species - medium and long term.
- Limit human access whera possible- medium and long term.
- Institute a buffer zone around activities - medium and long term.
- Restrict activity area - medium and long term.
- Limit and control vehicular traffic - medium and long term.
- Control invader species - medium and long term.

The preferred options to mitigate the effects of the overall CRMF with regard to the aesthetics of the area include:

- Initiate a detailed rehabilitation plan of the waste dump – north western slope profiling
- Include shaping vegetation and screening in the above rehabilitation.
- Over the medium term, it is recommended that IVS extend the rehabilitation programme to the entire waste dump and other adjacent areas within the CRMF, being managed, maintained and aftercare applied to the vegetation and screening measures in tha long term.

6.1.1.6 Monitoring

With regard to contamination of ground waters, should monitoring be performed to verify the efficiency of the proposed measures in attaining the stated objectives. This should be executed through current ground water quality and level monitoring borehole pairs (shallow and deep) within, and on the perimeter of the CRMF include IVB-2; IVB-3; IVB-4; IVB-5; IVB-6; IVB-7; IVB-17; IVB-18; IVB-19; IVB-20; IVB-42; IVB-45; IVB-46; IVB-47; IVB-52; IVB-53; IVB-54; IVB-55; IVB-56; IVB-57; IVB-58; IVB-59; IVB-60; IVB-61; IVB-65; IVB-66; IVB-67; IVB-71; IVB-72; IVB-74; IVB-75; IVB-80, IVB-81, IVB-93, IVB-124; IVB-125; IVB-150 and single borehole IVB-D153.

The existing dust monitoring programme is to be continued, to assess and confirm that an acceptable risk profile is maintained.

Additional ground water quality and level monitoring boreholes will be commissioned during implementation of the proposed measures, to monitor measure efficiency and overall compliance with objectives for the CRMF.

For plant and animal life, monitoring of the applicable environmental variables is necessary to prevent the degradation of the ecosystem. A floral and faunal survey must be conducted once a year, in which species lists are compiled and the abundance of each of the specific species recorded. Throughout the year, any unusual occurrences in the floral and faunal communities should be monitored.

Noise level measurements should be ongoing on the northern and western boundary of the CRMF, whilst ongoing monitoring and aftercare of visual improvement should be measured.

6.1.1.7 Regulatory Authorizations

The following legal authorization processes may be required for the CRMF:

- Registration of abstraction and monitoring wells.
- Water licence for ground water use/abstraction/infiltration.
- EIA for abstraction system.
- Permit for new site - CRMF.
- EIA for new site - CRMF.
- DNAPL removal - EIA.
- Apply for Permits and Licenses (section 20, 21, as needed)

6.1.2 Existing Waste Dump

6.1.2.1 Activity Description

This dump has been in operation since 1943 and is used as a depository for all solid residues and sludges resulting from the Works over the years. It covers an area of 179 ha, with a volume of 26.7 million m^3 and has reached a height of 40 m. It is unlined and the different materials were not segregated. The dump overlies a geological fault. The material is placed by wheeled vehicles and consists essentially of leachable materials. The implications are that both surface and ground water have been impacted upon. The movement of vehicles, both by day and night, has noise and dust implications. The dump is visible from various public roads.

Waste is transported to the site by means of train and road transport. There are some 24 waste streams going to the waste site of which almost

50% consists of BOF slag. Other streams *inter alia* include BOF Baghouse dusts, EAF Baghouse dusts, and several sludges.

An unlined pollution water control dam (du Preez Corner Dam) is located immediately adjacent to the dump along its north-western tip. The dam is used for the control of surface run-off during flood events and is kept empty, thereby effectively reducing the risk of both overtopping as well as infiltration to the ground water.

6.1.2.2 Impacts

The entire waste dump is underlain by the Silverton Shale Formation. A regional geological fault zone runs underneath the dump, cutting from the south-eastern tip of the dump in a north-westerly direction, and leaves the dump slightly east of its north-western tip.

Two aquifer types are present in the area namely the perched aquifer and shallow weathered zone aquifer. The thickness of the unsaturated zone is impacted by infiltration from the dump (mounding), but measures some 1 to 2 meters further away. Saturated thicknesses for the perched aquifer are some 2 to 3 m, whilst the shallow weathered zone aquifer is saturated up the thickness of some 15 meters.

No lateral aquifer boundaries are active within the area. The fault zone was extensively investigated and concluded not to be a hydraulic or physical boundary.

Borehole yields in the area vary from low to medium. The aquifer hydraulic parameters (storativity and permeability) are low, whilst porosities vary from moderate to high, suggesting slow ground water flow and restricted volumes. Piezometric levels in the two aquifer zones differ with a positive gradient from the deeper to the perched aquifer. Natural recharge from rainfall is estimated at 2% to 3% of MAP.

The regional ground water flow direction for this area is from east to west. The presence of mounding underneath the dump is insufficient to alter the regional ground water flow pattern. Using the observed hydraulic parameter values for the area, together with the average hydraulic gradient, the ground water flow velocity is estimated to be in the order of 10 to 15 meters per year.

The existing waste dump is located entirely within the IVS works perimeter and no ground water abstraction occurs for any application.

The aquifer(s) underlying the area are both classified as ***Minor Aquifer Systems***, whilst their vulnerability, is classified as ***medium***. Aquifer susceptibility is classified as ***medium***, resulting in an overall aquifer protection classification of a ***medium protection level***.

The fault cutting through the dump footprint generically represents a ground water fatal flaw with respect to waste management. However, drilling, pump testing and sampling investigations along the fault have indicated no preferential contaminant migration along the fault to date.

With reference to the activity description, the ground water impact mechanism associated with the dump relates to infiltration of rain water and dust suppression irrigation water into the dump, the generation of leachate as water percolates downward through the dumped material, then entering the ground water system as seepage/infiltration through the footprint of the dump into the underlying perched aquifer. Infiltration into the shallow weathered zone aquifer will be limited due to the positive hydraulic gradient from this zone towards the upper zone. However, this gradient could be compromised in certain areas and therefore contamination of the deeper aquifer will most probably also occur.

The downward migration of water/leachate leaving the dump is governed by a combination of the pressure head distribution in the dump, the hydraulic parameters of the infiltration interface (footprint and unsaturated zone), the hydraulic parameters of the underlying aquifers (permeability, porosity), as well as the piezometric pressure distribution within the two aquifer zones.

Contaminant mobility tests (TCLP) on the streams currently disposed of, indicate that the more potent micro inorganic constituents could leach from the dump to ground water. These would include Al, Cd, Fe, Mn, Se, V, Zn and Pb. These results are generally in agreement with those observed in waters from boreholes in the area.

Ground water chemistry obtained from the boreholes in this area, confirm elevated concentrations for Ca, Mg, SO_4, Cl, Na, Fe and Mn within both the perched and shallow weathered zone aquifers. However the degree of elevation is less for the shallow weathered zone aquifer.

Similarly, did mobile organic contaminants in waste streams indicate leachates from the dump to be devoid of BTEX and PAH compounds, i.e. below the detection limit of 50 parts per billion (ppb). These observations are generally in agreement with those from ground water analysis, which indicated that no dump related organic contamination was evident from samples taken from any boreholes in the dump area. These results are of particular interest in that whilst the impacts observed from the waste streams indicate possible contamination from current disposal practices, do ground water observations also include possible impacts due to historical disposal practices.

The extent of the contamination in both the perched and shallow weathered aquifers includes the entire footprint of the dump, as well as an area to the west of the dump, up to and beyond the western IVS perimeter. Once again, the concentration distribution within the plumes differs with higher concentrations observed in the perched zone. In other directions from the dump the lateral extent of the contamination is restricted due to the ground water flow pattern.

The ground water below the dump is mounded. The perched aquifer contains increased concentrations of inorganic constituents, mainly comprising Ca, Mg, SO_4, Cl, Na, Fe and Mn. Boreholes have however provided no evidence of increased flow of contaminants in the ground water along the fault which lies from the south-eastern tip towards the north-west in the vicinity of Du Preez corner. The ground water flow is from east to west underneath the dump with some mounding. The deeper weathered zone aquifer is less contaminated than the perched aquifer due to a positive ground water gradient from the deeper to the perched aquifer. No organic contamination of either the perched or the shallow weathered zone aquifer could be found.

The extent of the contamination beyond the IVS western perimeter will be discussed in the Receiving Environment Management Area 7. Apart form this, no other Management Area boundary is compromised by the ground water contamination in this Management Area.

The dump impedes the free movement of surface run-off. Uncovered areas cause contaminated run-off while the leachate is also contaminated and infiltration contributes to ground water contamination.

The dump material is of coarse consistency and captures a large amount of water as infiltration into the dump, which either emanates as contaminated dump toe leachate or infiltrates into the ground water regime. The risk of contaminated surface water existing the site from the dump is however eliminated or curbed by the presence of the Du Preez dam.

The dust fall-out towards both the west and north along the perimeter was insignificant, below 0,13 gram/m^2/day during 2000 and 2001, but increased during the dump shaping in 2002 to just less than 0,38 gram/m^2/day. The respirable dust fraction on the western perimeter during the period of active dump shaping in 2002 was at timed as high as 110 microgram/m^3 but reduced to less than 50 microgram/m^3 by November 2002.

6.1.2.3 Risks

The risk to human health represents the risk through the ground water pathway for drinking water application (adult of 60 kg drinking 2 litres of water/day). The risk to the environment represents the risk through the aquatic ecosystems pathway. The area for which both these risks is unacceptable, relates to the entire footprint of the existing waste dump, as well as the area to the west up to, and beyond the western IVS perimeter. The risk assessment for the area beyond the perimeter will be discussed in Management Area 7. The risk to human health relates to elevated concentrations of Ce, Mg, SO_4, Cl, Na and Fe, whilst the risk to the environment relates to elevated concentrations of Ca, Mg, SO_4, Cl, Na, Fe and Mn.

The run-off from uncovered areas, the toe leachate and the penetration to ground water has a potential unacceptable risk to both human health and the environment. The same applies to both the perched and weathered zone aquifers.

Potential unacceptable risk to the environment from current disposal practices is mostly due to the presence of mobile manganese and zinc, and due to lead and cadmium to a much lesser extent. The waste streams contributing to possible contamination of ground waters, is indicated to be BOF Slags > sludges > dusts. These results are strengthened by indications from monitoring over the pest year that neither the dust fall-out nor respirable dust poses a significent risk to the environment.

Ambient air pollution beyond the site boundary is not an unacceptable risk to human health, nor an identifiable risk to the environment.

With regard to noise and visuals could rehabilitation operations and continued nighttime operations elevate noise emissions beyond acceptable levels, whilst negative perceptions could result due to the unsightly profile of the existing facility.

6.1.2.4 Management Objectives

Overarching primary as well as secondary environmental management objectives have previously been discussed and referred to

Due to the technical impracticability to remediate the observed ground water pollution at this site to levels, which will represent acceptable risk to human health and the environment, these objectives will have to be reached through institutional controls. However, technical measures must be commissioned to achieve continual improvement subject to the following secondary short term (ST), medium term (MT) and long term (LT) objectives:

- Minimize contaminant concentretion at source (ST).
- Minimize contaminant infiltration at source (ST).
- Cut of migration of contaminated ground water as close as feasible to source, to prevent the movement of contaminated ground water across boundaries - legal or prescribed compliance boundaries (ST).
- Manipulate pollution plume migration to protect pre-defined areas (MT).
- Improve ground water quality to agreed/negotiated water quality standards (LT).

Notwithstanding the finding that there is no risk, the objective must remain to control and limit the evolution of dust as far as practical, to ensure that no risk will develop.

6.1.2.5 Measures

Measures comprise two main categories:

- Institutional Measures
- Technical Measures

Institutional measures must be motivated in terms of technical impracticability. The aquifer(s) impacted on by the existing waste dump, cannot be remediated to acceptable risk levels through technical measures over the short and medium terms. Such measures will require flushing of the aquifers with "clean" water and will in any event take several decades to improve the situation significantly. They are therefore considered impracticable to achieve risk compliance over the short and medium term.

The recommended **institutional measure** would be to **re-zone** the area within the IVS perimeter for controlled ground water usage. This implies that abstraction and application control must be institutionalised within the current ground water impacted area, to such a level that the risk of ground water use falls within acceptable levels of risk, subject to demonstration of continual improvement over the long term.

The following **technical measures** will address the situation at source, as well as in the aquifers receiving contaminated water from the source. The intention of the measures is to improve the situation over the short, medium and long terms.

Referring to mitigation of groundwater impacts and risks:

- Optimise waste streams in terms of contaminant load through waste minimization and selective placing. This is of particular importance to BOF slags, which are responsible for almost 50% of the current waste stream load being disposed of. In this regard could it be timely to dispose of this material on an engineered footprint according to Minimum Requirements, including the necessary pollution control measures normally required, whilst alternative used for this material is being researched. The remainder of the waste streams (sludges and dusts) should be considered for treatment to immobilize contaminants, and hence delisting of the material to general waste quality. Immobilization of contaminants will not only result in an appreciable smaller footprint needed for a proposed new waste facility, but more importantly would result in acceptable risk to man and the environment.

- Optimise shaping, capping and re-vegetation of dump to minimize rainfall infiltration
- Optimise dust suppression irrigation to minimize related infiltration
- Whilst the footprint cannot be lined at this stage, it must be kept as small as possible - no extension onto unlined areas.
- Control leachate at the toe of the dump to prevent contaminated surfaca run-off and soil contamination.
- Install drainage gallery to intercept contaminated ground water migration through the perched aquifer away from the dump towards the north, northwest and west. This trench must be commissioned along the northern, north-western and western toes of the existing dump, and must intercept seepage up to depths ranging betwaan 4 and 6 meters.
- Install abstraction wells into tha shallow weathered zone aquifer between the western toe of the dump and the IVS western perimeter, to intercept contaminated ground water migration through the shallow weathered zone aquifer, across the western IVS perimeter. The intention of these wells will also be to manipulate the plume migration patterns, in that a reversed ground water gradient will be established, thus forming a local reversal of ground water flow from the west towards the IVS perimeter. In the long run, this could also cause an improvement in ground water quality in the areas to the west of the borehole abstraction line.

The following measures are recommended to mitigate the impacts and risks associated with surface water, and consequently, also air quality and visual impacts:

- Shaping of the North/West (N/W) benches
- Construction of drainage canals N/W
- Construction of chutes N/W for runoff control
- Construction of a berm on top of the dump
- Relocation of the railway line
- Topsoiling of the N/W area
- Grassing of the N/W area
- Upgrading surface water drains towards du Preez dam
- Installation of a toe seepage trench along the N/W faces
- Seepage collection sump and pipe system at du Preez dam
- Incremental capping of the dump over time
- Shaping and preparation for a G-liner on top of the dump
- Installation of a G-liner system over the dump area
- Shaping of existing dump east to south bench (E/S)
- Drainage canal construction on the E/S face
- Chute construction of the E/S face
- Berms on top of the E/S edge
- Topsoiling and capping of the E/S face

- Vegetation of the E/S face
- Toe drain system at the E/S face toe
- Rehabilitation of soil borrow area(s)
- Rehabilitation and closure of the residue transfer station
- Shaping of the dump
- Topsoiling and capping
- Water management berms
- Vegetation of shaped, capped and topsoiled areas
- Removal and rehabilitation of railway line to transfer station
- Weir/service arrangement at the du Preez dam
- Water quality monitoring equipment at the du Preez dam

Alternative Measures Considered:

- Line the dump (impracticable)
- Decommission and rehabilitate (need facility for several years)
- Seepage drain/drainage gallery (**preferred option**)
- Slurry wall (does not facilitate abstraction)
- Sheet piling (not technically feasible)
- Reactive barriers (not applicable to chemistry)
- Pump and Treat (**preferred option**)
- Pump and Flush (not indicated as necessary - source of flush water a problem)

6.1.2.6 Monitoring

Monitoring must be performed to verify the efficiency of the proposed measures in attaining the stated objectives.

Current ground water quality and level monitoring borehole pairs (S-shallow and D-deep) dedicated to the waste dump and immediate surrounding area include IVB-5, IVB-18, IVB- 56, IVB- 57, IVB-67, IVB-74, IVB-75, IVB-93, IVB-104, as well as single borehole IVB-D153.

Additional ground water quality and level monitoring boreholes will be commissioned during implementation of the proposed measures, to monitor measure efficiency and overall compliance with objectives.

The existing air quality monitoring programme is to continue to confirm acceptable conditions.

Monitoring must be performed to verify the efficiency of the proposed measures in attaining the stated objectives.

6.1.2.7 Regulatory Authorizations

The following legal authorization processes may be required for the Existing Waste Dump.

- Registration of abstraction and monitoring wells.
- Water license for ground water use.
- EIA for abstraction system.

6.1.3 Dam 10

6.1.3.1 Activity Description

Dam 10 was built around 1964 to receive process water, sludges and tars from the Coke Ovens and Suprachem. It is situated on the western boundary of the CRMF, within the western catchment and has an area of 64 ha, slopes from 0 to 6m deep, has an estimated capacity of 1.0 million m^3 and has no overflow, spillway or lining. The dam wall on the western side was built from slag and carries the rail line to the residue transfer station of the Existing Waste Dump. There is a shallow drainage canal by which the seepage is pumped back to the dam.

Dam 10 is in the process of being decommissioned and the rehabilitation programme is currently being developed. There is a negative water balance, as no further effluent is disposed of in the dam, and evaporation exceeds the rain falling onto the dam together with runoff from the limited catchment.

6.1.3.2 Impacts

The entire Dam 10 area is underlain by the Silverton Shale Formation. Two aquifer types are present in the area, namely the perched aquifer and shallow weathered zone aquifer. The thickness of the unsaturated zone is impacted by infiltration from the dam (causing mounding), and further away measures some 1 to 2 meters. The saturated thickness of the perched aquifer is some 2 to 3 meters, whilst the shallow weathered zone aquifer is saturated down to a depth of some 18 meters.

There are no lateral aquifer boundaries within the area.

Borehole yields in the area vary from low to medium. The aquifer hydraulic parameters (storativity and permeability) are low, whilst porosities vary from moderate to high, suggesting slow ground water flow and restricted volumes. Piezometric levels in the two aquifer zones differ with a positive gradient from the deeper to the perched aquifer. Natural recharge from rainfall is estimated at 2% to 3% of MAP.

The regional ground water flow direction for this area is from east to west. Despite the presence of mounding underneath the dam, the extent of the mounding is insufficient to alter the regional ground water flow pattern. Using the observed hydraulic parameter values for the area, together with the average hydraulic gradient, the ground water flow velocity is in the order of 10 to 15 meters per year.

The entire Dam 10 area is located within the IVS works perimeter and no ground water abstraction occurs for any application.

The aquifer(s) underlying the area are both classified as ***Minor Aquifer Systems***, whilst their vulnerability is classified as ***medium***. Aquifer susceptibility is classified as ***medium***, resulting in an overall aquifer protection classification of a ***medium protection level***.

No ground water fatal flaw with respect to waste management is present within the Dam 10 area. With reference to the activity description, the ground water impact mechanism associated with Dam 10 relates to the infiltration of water (rain and process) downward through the dam footprint, entering the ground water system as seepage/infiltration into the underlying perched aquifer. Infiltration into the shallow weathered zone aquifer will be limited due to the positive hydraulic gradient from this zone towards the upper zone. However, this gradient could be compromised in certain areas (e.g. directly under the dam) and therefore contamination of the deeper aquifer will most probably also occur.

The downward migration of water leaving the dam is governed by a combination of the pressure head distribution in the dam (varying water level in the dam), the hydraulic parameters of the infiltration interface (footprint and unsaturated zone), the hydraulic parameters of the underlying aquifers (permeability, porosity), as well as the piezometric pressure distribution within the two aquifer zones.

The water of Dam 10 indicated to be homogeneous in composition throughout the dam with regard to inorganic micro and macro contaminants. Only manganese of the more potent micro contaminants presented a relatively high concentration for waters (3.5 ppm) whilst elevated concentrations of the common salts were observed. This is in agreement with the observations from borehole chemistry. Ground water chemistry obtained from the boreholes in this area (essentially in the area between the dam and the western IVS perimeter), confirm elevated concentrations for Ca, Mg, SO_4, Cl, Na, Fe and Mn within both the perched and shallow weathered zone aquifers. However, the degree of concentration elevation is less for the shallow weathered zone aquifer.

Organic ground water chemistry observed in the boreholes indicates the presence of both free phase and dissolved phase NAPL (both not necessarily present in all the boreholes).

A conclusion that contamination of borehole water with organics, eminates from Dam 10 water *per se*, should be viewed with caution. Waters of Dam 10 portrayed a picture of not being homogeneously present in the water. Low concentrations (2 – 37 ppb) of only 7 compounds from 118, which could be present considering the activities at IVS, were present at only 50% of locations measured throughout the dam. These were present in bottom waters with none recorded in surface samples.

The extent of the contamination in both the perched and shallow weathered aquifers includes the entire footprint of the dam, as well as an area to the west of the dam, up to and beyond the western IVS perimeter. Once again, the concentration distribution within the plumes differs with higher concentrations observed in the perched zone. In other directions from the dam the lateral extent of the contamination is restricted due to the ground water flow pattern.

The extent of the organic contamination in both the perched and shallow weathered aquifers includes the entire area west of Dam 10 up to and beyond the IVS perimeter. Investigations into the sediments of Dam 10 have indicated the sediments to be contaminated with organics to a very large extent. Thus it is possible that the dissolved phase of organics observed in boreholes could eminate from this source. However, contribution to the dissolved phase from residual DNAPL pools observed in the area is also possible. The DNAPL pools observed will be addressed under the section dealing with the Redundant Blast Furnace Sludge dams (section 6.1.9) as well as the section for Management Area 2 - Consolidated Plant Area (section 6.2).

The extent of the contamination beyond the IVS western perimeter will be discussed in the Receiving Environment Management Area 7. Apart from this, no other Management Area boundary is compromised by the ground water contamination possibly related to Dam 10.

It is however to be noted that mobility tests conducted for inorganics on sediments of the dams, indicated the micro contaminants to be immobile and not likely to contaminate ground water to unacceptable levels. Considering the extremely low solubility of volatile and semi-volatile PAH's and the adsorption characteristics of these compounds to clay, soils and organic matter, it would be prudent to investigate the mobility of these compounds, in order to be able to ascertain the contribution to ground water contamination from Dam 10 sediments.

The sediments in Dam 10, being estimated to be of the order of 1.9×10^6 m^3, portrays a potential to impact on ground water by both inorganic and organic contaminants. Sediments in the eastern part of the dam were found to be more contaminated than those in the western half of the dam. Inorganic contamination is represented by almost all the macro contaminants as well as micro contaminants such as Al, Cr, Fe, Mn, Ti and Zn, whilst organic contamination comprises almost all the volatile and semi-volatile contaminants which could eminate from the kind of activities present at IVS.

A significant potential impact from sediments to the environment and humans therefore exists for both inorganics (several) and organics (several).

This pollution control dam reduces the runoff to the Rietkuilspruit and contaminates clean rainfall. The water is contaminated both organically and inorganically and will have to be returned to process via the MTP. The process water system must be able to accommodate Dam 10 water in order to empty the dam during the rehabilitation programme.

6.1.3.3 Risks

The risk to human health represents the risk through the ground water pathway for drinking water application. The risk to the environment represents the risk through the aquatic ecosystems pathway. The area for which both these risks is unacceptable, relates to the entire footprint of the dam, as well as the area to the west up to, and beyond the western IVS perimeter.

Only manganese of the more potent inorganic micro contaminants in the dam waters, indicate a potential risk to the environment, whilst manganese and titanium indicate a potential risk to humans. Almost all the inorganic macro contaminants (Cl, SO_4, etc.) indicate potential risk to both the environment and humans, the pathway being ground water. However for such risk indicated by macro compounds, drinking water quality standards were used as benchmark in the absence of health and environmental criteria being available. It should therefore be interpreted with caution.

Only 5 of the 17 surface and bottom dam water samples indicated very low concentrations of only a few (7) organic compounds being present in dam waters. Acceptable risk levels for both the environment and humans for these few compounds are however very low, and do the positive samples indicate a potential risk, albeit relatively small.

Inorganic **micro** contaminants in sediments, indicate a potential larger risk to ground water than the same contaminants present in dam waters. The **inverse** is true for **macro** contaminants, indicating water to be of potential larger risk to ground water than sediments. It is however again emphasized that mobility tests for inorganics in dam sediments, indicated the micro contaminants to be largely immobile resulting in a much reduced risk to man and the environment.

Organics in sediments (being largely absent in dam waters) indicate to be of unacceptable potential risk to man and the environment, however it is to be expected that these compounds would be largely immobile to ground waters.

It is to be concluded that manganese and macro contaminants (Cl, SO_4, etc.,) in the **waters** of the dam could be responsible for unacceptable risks observed in ground waters. The source (Dam 10) being responsible for contamination of ground water by inorganic micro and organic contaminants present in sediments, should be interpreted with caution.

The risk assessment for the area beyond the perimeter will be discussed in Management Area 8: Perimeter and immediate surrounding areas. The risk to human health relates to elevated concentrations of Ca, Mg, SO_4, Cl, Na and Fe, whilst the risk to the environment relates to elevated concentrations of Ca, Mg, SO_4, Cl, Na, Fe and Mn in borehole waters.

The possible risk from soils to the environment and man through the ground water pathway for the Dam 10 area, indicated:

Sampling position 3:

Mn levels can cause an unacceptable risk to the environment ($8.57x10^{-2}$),
Mn also has the potential to exceed the SA Guideline Value
(603 ppb > 50 ppb), and
There is no unacceptable risk to human health via the ground water pathway, the margin of safety being 44%.

Sampling position 20:

Mn has the potential to cause unacceptable risk to the environment ($9.67x10^{-2}$),
Mn has the potential to exceed SA Guideline Value (614 ppb > 50 ppb),

Al has the potential to exceed the SA Guideline Value
(202 ppb > 150 ppb), and an unacceptable risk to humans (135%). It is thus possible that unacceptable manganese levels observed in ground water, could originate from soil contamination.

6.1.3.4 Management Objectives

Due to the technical impracticability of remediating the observed ground water pollution at this site to a level of risk acceptable to Human Health and the Environment, institutional controls will rather need to be implemented to achieve the required objectives. However, technical measures will also need to be commissioned to achieve continual improvement subject to the following proposed secondary short term (ST), medium term (MT) and long term (LT) objectives:

- Minimize contaminant concentration at source (ST).
- Minimize contaminant infiltration at source (ST).
- Cut off migration of contaminated groundwater as close as feasible to source to prevent the movement of contaminated ground water across boundaries (legal or arbitrary compliance boundaries) (ST).
- Manipulate pollution plume migration to protect pre-defined areas (MT).
- Improve ground water quality to agreed/negotiated water quality standards (LT).
- Cover and close *in situ* (preferred option)

6.1.3.5 Measures

Measures comprise two main categories:

- Institutional Measures
- Technical Measures

Institutional measures will be necessary to mitigate the impacts and risks, such as to **re-zone** the area within IVS perimeter for restricted ground water usage. This implies that abstraction and application control must be institutionalised within the current ground water impacted area to such a level that the risk of ground water use is within acceptable levels, subject to the demonstration of continual improvement over the long term.

The following **technical measures** will address the situation at source, as well as in the aquifers receiving contaminated water from the source. The intention of the recommended measures is to improve the situation over the short, medium and long term.

- Reduce the concentration of contaminants as low as possible while there is water in the dam.
- Whilst the dam contains water, minimize infiltration by keeping the water level as low as possible until it is emptied.
- Control leachate at the toe of the dam by means of a subsoil drain system to prevent contaminated surface run-off and soil contamination.
- Empty the dam to process water using a barge pump station and pipeline. Rehabilitate the dam using a "Tensar" mat for stability and BOF slag to landscape the area to free draining.
- Construct an outlet structure (pipe-jacking under the rail line).
- Landscape, topsoil and vegetate the sides of the basin (free-draining).
- Topsoil and vegetate the rail line embankment.
- Construct runoff control measures over the site and link up with adjacent areas.
- Install monitoring system in the dam until empty.
- Install a sump and pump station for leachate control.
- Excavate unsuitable pockets for specific treatment and disposal.
- Install a drainage gallery to intercept contaminated ground water migrating through the perched aquifer away from the dam towards the west. This trench must be commissioned along the western toe of the dam, and must intercept seepage up to depths ranging between 4 and 6 meters.
- Install abstraction wells into the shallow weathered zone aquifer between the western toe of the dam and the IVS western perimeter,

to intercept contaminated ground water migration through the shallow weathered zone aquifer, across the western IVS perimeter. The intention of these wells will also be to manipulate the plume migration patterns, in that a reversed ground water gradient will be established, thus forming a local reversal of ground water flow from the west towards the IVS perimeter. In the long run, this could also cause an improvement in ground water quality (inorganic and dissolved phase organics) in the areas to the west of the borehole abstraction line.

Alternative Measures Considered:

- Line the dam (to be decommissioned)
- Empty the dam and rehabilitate (**preferred option**)
- Seepage drain/drainage gallery (**preferred option**)
- Slurry wall (does not facilitate abstraction)
- Sheet piling (not technically feasible)
- Reactive barriers (not applicable to chemistry)
- Pump and Treat (**preferred option**)
- Pump and Flush (not indicated as necessary - source of flush water a problem)
- Empty the dam by evaporation
- Empty the dam by treatment (CETP) to (TETP)
- Pump H_2O to the lined dam – treat and recycle as process water
- Remove sediments to the old dump [not practical (1.9 million m^3), enhance risk at dump]
- Remove to Holfontein (not practical, too costly)

6.1.3.6 Monitoring

Monitoring should be performed to verify the efficiency of the recommended measures in attaining the suggested objectives. The current ground water, quality and level monitoring borehole pairs (shallow and deep) dedicated to Dam 10 and immediate surrounding area include: IVB-52, IVB-53, IVB- 54, IVB- 55, IVB-56, IVB-57, IVB-58, IVB-59, IVB-65, IVB-66, IVB-67 and IVB-150.

Additional ground water quality and level monitoring boreholes will be commissioned during implementation of the proposed measures, to monitor and measure efficiency and overall compliance with the recommended objectives.

6.1.3.7 Regulatory Authorizations

The following legal authorisation processes may be required for Dam 10:

- Registration of abstraction and monitoring wells.
- Water license for ground water use/abstraction.

The dam is not registered with the DWAF Dam Safety Office.

6.1.4 Dams 1 - 4

6.1.4.1 Activity Description

These unlined dams were commissioned sequentially during the 1980's as additional holding facilities for effluent which could not be accommodated in Dam 10 or du Preez Dam. The dam system is situated in the western catchment of the Works and falls within the CRMF. The dams have a shallow seepage trench on the western side from which the process water is pumped back into the dam system. Essentially these dams act as evaporation impoundments with a very small rainwater catchment. The total surface area is approximetely 86.7 ha and the holding cepacity is 1.0 million m^3 mege litres. There are no spillways and the dams are not registered with the DWAF dam safety office.

6.1.4.2 Impacts

The dams reduce the catchment yield by reducing runoff to the Rietkuilspruit. Water quality is also reduced by contamination of clean rainfall and runoff by water in the dams. The process water system will need to accommodate water from Dams 1-4 in order to empty the dam. There are potential cumulative impacts on the leachate generation of the dump should the water be used as a dust suppression spray. The area to the west of the dams is saturated (perched aquifer at surface), which further impacts on surface water quality in the area. Secondary impacts also exist on land-use and the capability of the area.

Dams 1 to 4 are underlain by the Silverton Shale Formation. A regional dolerite dyke runs underneath the dams in an east to west direction.

Two aquifer types are present in the area namely the perched equifer and shallow weathered zone aquifer. The thickness of the unsaturated zone is impacted by infiltration from the dams (mounding), but measures some 2 to 5 meters, further away. Saturated thicknesses for the perched aquifer is some 2 to 3 meters, whilst the shallow weathered zone aquifer is saturated up to a thickness of some 18 meters.

No lateral aquifer boundaries are ective within the erea. The dolerite dyke zone was extensively investigated and concluded not to be a hydraulic or physical boundary (ground water flow direction is from eest to west).

Borehole yields in the area vary from low to medium. The aquifer hydraulic parameters storativity and permeability are low, whilst porosities vary from moderate to high, suggesting slow ground weter flow, and restricted volumes. Piezometric levels in the two aquifer zones differ with a positive gradient from the deeper to the perched aquifer. Naturel recharge from rainfall is estimated at 2% to 3% of MAP.

The regional ground water flow direction for this area is from east to west.

Despite the presence of mounding underneath the dams, the extent of the mounding is insufficient to alter the regional ground water flow pattern. Using the observed hydraulic parameter values for the area, together with the average hydraulic gradient, the ground water flow velocity is in the order of 10 to 15 meters per year.

The existing dams are entirely located within the IVS works perimeter and no ground water abstraction occurs for any application.

The aquifer(s) underlying the area are both classified as ***Minor Aquifer Systems***, whilst their vulnerability is classified as ***medium***. Aquifer susceptibility is classified as ***medium***, resulting in an overall aquifer protection classification of a ***medium protection level***.

The dolerite dyke cutting underneath the footprint of the dams generically represents a ground water fatal flaw with respect to waste management. However, drilling, pump testing and sampling investigations along the dyke have indicated no preferential contaminant migration along the dyke to date.

With reference to the activity description the ground water impact mechanism associated with the dams relates to infiltration of water (rain and leachate from the existing dump pumped back to Dams 1-4 from Du Preez corner sump) as water percolates downward through the dams' footprints, entering the ground water system as seepage/infiltration through the footprints into the underlying perched aquifer. Infiltration into the shallow weathered zone aquifer will be limited due to the positive hydraulic gradient from this zone towards the upper zone. However, this gradient could be compromised in certain areas (e.g. immediately underneath Dams 1-4) and therefore contamination of the deeper aquifer will most probably also occur.

The downward migration of water through the footprints of the dams is governed by a combination of the pressure head distribution in the dams, the hydraulic parameters of the infiltration interface (footprints and unsaturated zone), the hydraulic parameters of the underlying aquifers (permeability, porosity), as well as the piezometric pressure distribution within the two aquifer zones.

Ground water chemistry obtained from the boreholes in this area, confirm elevated concentrations of Ca, Mg, SO_4, Cl, Na, K, NO_3, F, Fe and Mn within the perched aquifer and elevated concentrations of Ca, Mg, SO_4, Cl, Na, Fe and Mn within the shallow weathered zone aquifer. However the degree of concentration elevation is less for the shallow weathered zone aquifer.

Waters from dams 1-3 indicate almost no possible impact to the environment with regard to inorganic contaminants. Only cadmium of the micro contaminants indicated a very limited impact, but this was due to it's classification according to the precautionary principle in the RSA. Cadmium was not observed in waters from the boreholes and are the impact results from the dam waters therefore in agreement with those from the ground water chemistry. Similarly did the dam waters indicate possible impacts for the macro inorganic contaminants, also in agreement with hose from the ground water chemistry. The waters of dam 4 however differed from the other dams in that high concentrations of specifically manganese, and to a lesser extent lead, were observed, in agreement with the manganese elevated levels in the ground water chemistry.

Organic ground water chemistry observed in the boreholes indicates the presence of low to moderate concentrations of the dissolved phase in two of the six shallow weathered zone boreholes.

The waters of dam 1-4 were devoid of organic contamination. The low concentrations of dissolved organic phase observed in these two boreholes, should therefore be interpreted with some caution as to waters *per se* being the origin of these observations.

The extent of the contamination in both the perched and shallow weathered aquifers includes the entire footprints of the dams, as well as an area to the west of the dams, up to the western IVS perimeter. Once again, the concentration distribution within the plumes differs with higher concentrations observed in the perched zone near the toe seepage trench to the west of the dams. This is, however, not true for the concentration observed in the boreholes on the perimeter west of the dams where the inverse applies, probably as a result of the efficiency of the shallow seepage cut-off drain along the dams' western walls. In other directions from the dams the lateral extent of the contamination is restricted due to the ground water flow pattern.

The sediments of the 4 dams indicate, similar to Dam 10 to be contaminated by both micro and macro inorganic contaminants (Al, Fe, Cu, Mn, Ti, V, Zn and macros). However, similar to dam 1, did the mobility characteristics of the contaminants in the sediments indicate to be largely immobile. However, mobile manganese in the sediments – albeit that the tests were carried out at low pH values, in contrast to the high alkaline pH of waters – remain to indicate a potential impact to ground water.

The extent of the organic contamination in the shallow weathered zone aquifers is observed in two of the six boreholes up to the IVS perimeter to the west. From the investigations in the sediments in Dams 1-4, it is concluded that the dissolved phase observed in the boreholes originate from these sediments. Dams 1-4 display, relative to Dam 10, only a few semi-volatile organic compounds in sediments. These observations were very localized, being mainly at only 3 sampling points some distance from the inlet points of waters.

The extent of the contamination beyond the IVS western perimeter will be discussed in the Receiving Environment Management Area 7. Apart form this, no other Management Area boundary is compromised by the ground water contamination in this Management Area.

6.1.4.3 Risks

The area for risks relates to the footprints of the dams, as well as the area to the west up to the western IVS perimeter. The risk assessment for the area beyond the perimeter will be discussed in Management Area 7. For the perched aquifer, the risk to human health for inorganics relates to elevated concentrations of Ca, Mg, SO_4, Cl, Na, K, NO_3, F, Fe and Mn, whilst the risk to the environment (inorganics) relates to elevated concentrations of Ca, Mg, SO_4, Cl, Na, K, NO_3, F, Fe and Mn. For the shallow weathered zone aquifer, the risk to human health (inorganics) relates to elevated concentrations of Ca, Mg, SO_4, Cl, Na, Fe and Mn, whilst the risk to the environment (inorganics) relates to elevated concentrations of Ca, Mg, SO_4, Cl, Fe and Mn.

However waters from dams 1-3 indicate with regard to inorganics, to be of acceptable risk to the environment (ground water). Dam 4 waters however indicate potential unacceptable environmental risk to manganese and all the macro contaminants. Unacceptable risk to human health (pathway being ground water) is indicated for cadmium, manganese, titanium and lead, and all the macro contaminants should drinking water standards be the criteria, from the waters of dam 4 only.

The risk to human health and the environment for organics, relates to Naphthalene and Phenanthrene observed in two boreholes to the west of Dams 1-4, in the shallow weathered zone aquifer. No meaningful correlation could be drawn with the possible source of this organic contamination.

Dam waters were of no concern to the environment as well as human health, organics not being present. Margins of unacceptable risk were indicated for both the environment and man, specifically phenanthrene, chrysene and some of the benzo-fluoranthene compounds. Naphthalene (observed in boreholes) however, was not present in any of the sediment samples from the 4 dams and is the conclusion of no meaningful correlation above, justified.

6.1.4.4 Management Objectives

In the final analysis, all measures must support these objectives. Various **technical measures** are recommended to address the following secondary objectives in the short, medium and long terms:

- Minimise the infiltration of contaminants at source.
- Improve the water quality to meet sustainable standards.

Due to the technical impracticability to remediate the observed ground water pollution at this site to levels that will represent acceptable risk to Human Health and the Environment, these objectives will have to be reached through institutional controls. However, technical measures must be commissioned to achieve continual improvement subject to the following secondary short term ST), medium term (MT) and long term (LT) objectives:

- Minimize contaminant concentration at source (ST).
- Minimize contaminant infiltration at source (ST).
- Cut of migration of contaminated ground water as close as feasible to source, to prevent the movement of contaminated ground water across boundaries - legal or arbitrary compliance boundaries (ST).
- Manipulate pollution plume migration to protect pre-defined areas (MT).
- Improve ground water quality to agreed/negotiated water quality standards (LT).

6.1.4.5 Measures

The following **technical measures** are recommended toward decommissioning of Dams 1 - 4:

- Empty dam water to the process system for treatment and recycling
- Clean up the dam footprint and remove to a suitable disposal area
- Provide for the treatment of dam sludges as may be required
- Make the footprint free draining by effective landscaping and shaping
- Shape the dam walls back into the dam basin
- Topsoil and vegetate the dam footprint
- Construct water management structures over the area
- Remove of structures, pump stations, trenches and pipelnes
- Remediate the area west of dam 4 up to the boundary

Measures comprise two main categories:

- Institutional Measures
- Technical Measures

Institutional measures must be motivated in terms of technical impracticability.

<u>Institutional measures:</u>

The aquifer(s) impacted on by Dams 1 to 4, cannot be remediated to acceptable risk levels through technical measures over the short and medium terms. Such measures will require flushing of the aquifers with "clean" water and will in any event take several decades to improve the situation significantly. They are therefore considered impracticable to achieve risk compliance over the short and medium term.

Re-zone area within IVS perimeter for ground water usage. This implies that abstraction and application control must be institutionalised within the current ground water impacted area, to such a level that the current ground water quality is within compliance, subject to demonstration of continual improvement over the long term.

Technical measures:

The following measures will address the situation at source, as well as in the aquifers receiving weter from the source. Their intention is to improve the situation over the short, medium end long term.

- Whilst the dams contain water, optimise water quality to as low as possible concentrations.
- Whilst the dams contain water, minimize infiltration by keeping the water level as low as possible until it is emptied.
- Control any leachate at the toe of the dams to prevent contaminated surface run-off and soil contamination.
- Empty and rehabilitate the dams.
- Install dreinage gallery to intercept contaminated ground water migration through the perched aquifer away from the dam towards the west. This trench must be commissioned as an extension of the trench along the northern toe of the existing dump, and must intercept seepage up to depths ranging between 4 and 6 meters.

Alternative Measures Considered:

- Line the dams (to be decommissioned)
- Empty the dams and rehabilitate (**preferred option**)
- Seepege drain/drainage gallery (**preferred option**)
- Slurry wall (does not facilitate abstraction)
- Sheet piling (not technically feasible)
- Reactive barriers (not applicable to chemistry)
- Pump and Treat (not indicated as necessary)
- Pump and Flush (not indicated as necessary - source of flush water a problem)

6.1.4.6 Monitoring

Monitoring is required to indicate the effectiveness of the recommended and implemented measures and achieving the proposed objectives.

Monitoring must be performed to verify the efficiency of the proposed measures in attaining the stated objectives.

Current ground water quality and level monitoring borehole pairs (shallow and deep) dedicated to Dams 1 - 4 and immediate surrounding areas include IVB-19, IVB-42, IVB- 70, IVB- 80, IVB-81 and IVB-93.

Additional ground water quality and level monitoring boreholes will be commissioned during implementation of the proposed measures, to monitor measure efficiency and overall compliance with objectives.

6.1.4.7 Regulatory Authorizations

The following legal authorization processes may be required for ground water:

- Registration of monitoring wells.
- Water license for ground water use.

6.1.5 Maturation Ponds

6.1.5.1 Activity Description

The three unlined maturation ponds were built to contain as a storage facility excess organic process water. The total area is 38.3 ha and the holding capacity is 700 000 m^3. The facility obtains it water from the coke ovens and bio-treatment plant when the latter is not operational. There are no spillways in the ponds. The Maturation Ponds are situated within the CRMF, in the Western catchment of the Works. The ponds have not been registered with the DWAF dam safety office. The ponds are planned to be decommissioned and the area rehabilitated.

6.1.5.2 Impacts

The Maturation Ponds are mostly underlain by the Silverton Shale Formation, but also the Daspoort and Strubenkop quartzite in the eastern section. The ponds are bounded by two regional geological structures, namely the fault to the south, and the dolerite dyke to the north.

Two aquifer types are present in the area, namely the perched aquifer and the shallow weathered zone aquifer. The thickness of the unsaturated zone is impacted by infiltration from the ponds (mounding), and measures some 1 to 2 meters deep further away. The saturated thickness for the perched aquifer is some 2 to 3 meters, whilst the shallow weathered zone aquifer is saturated up to a thickness of some 22 meters.

Three lateral aquifer boundaries are present within the area, namely the -

- dolerite dyke to the north,
- fault to the south, and
- regional surface water/ground water divides to the east.

Borehole yields in the area vary from low to medium. The aquifer hydraulic parameters (storativity and permeability) are low, whilst porosities vary from moderate to high, suggesting slow ground water flow, and restricted volumes. Piezometric levels in the two aquifer zones do not differ significantly and no conclusive statements can be made in terms of inter-aquifer gradients. Natural recharge from rainfall is estimated at 2% to 3% of MAP.

The regional ground water flow direction for this area is from east to west. Despite the presence of mounding underneath the pond, the extent thereof is insufficient to alter the regional ground water flow pattern. It is important to note that these ponds are located in close proximity to the regional surface water and ground water divide in the area. Using the observed hydraulic parameter values for the area, together with the average hydraulic gradient, the ground water flow velocity is in the order of 10 to 12 meters per year.

The Maturation Ponds are entirely located within the IVS works perimeter and no ground water abstraction occurs for any application.

The aquifer(s) underlying the area are both classified as ***Minor Aquifer Systems***, whilst their vulnerability is classified as ***medium***. Aquifer susceptibility is classified as ***medium***, resulting in an overall aquifer protection classification of a ***medium protection level***.

The geological contacts to the east of the Maturation Ponds generically represent a ground water fatal flaw with respect to waste management. However, drilling and sampling investigations along the contacts have indicated no preferential contaminant migration along these zones, to date.

With reference to the activity description, the ground water impact mechanism associated with the Maturation Ponds relates to infiltration of water (rain and process water) as water percolates downward through the footprints of the ponds, entering the ground water system as seepage/infiltration into the underlying perched aquifer. Infiltration into the shallow weathered zone aquifer is limited due to the relatively small hydraulic gradient from the ponds and the perched aquifer zone, towards the shallow weathered aquifer zone.

The downward migration of water through the footprints of the ponds, is governed by a combination of

- the pressure head distribution in the ponds,
- the hydraulic parameters of the infiltration interface (footprints and unsaturated zone),
- the hydraulic parameters of the underlying aquifers (permeability, porosity), as well as
- the piezometric pressure distribution within the two aquifer zones.

Ground water chemistry obtained from the boreholes in this area, confirm elevated concentrations for Ca, Mg, Na, K, Cl, SO_4, NO_3, F, Fe and Mn within the perched aquifer, and elevated concentrations for Na, Cl, SO_4, NO_3, F, Fe and Mn within the shallow weathered zone aquifer. However, the degree of contamination is less for the shallow weathered zone aquifer. These concentrations were observed in only one borehole within the shallow weathered aquifer zone, namely IVB-D3 located to the south west of the Maturation Ponds. In borehole IVB-D20 located to the east, an elevated NO_3 concentration was observed.

Inorganic micro contaminants differed from the other dam waters in that cyanide was present in maturation ponds up to 18 parts per million and fluorides up to 85 ppm in waters. Ground chemistry for inorganics from boreholes was therefore generally in agreement with those from the dams except that cyanide was not observed. This phenomenon cannot be explained at this stage. Considering that cyanide was also not observed in the sediments of these ponds, an explanation could be that this contaminant is being oxidised in the dam waters and therefore not available for ground water contamination. Such an explanation would not be out of the ordinary, considering that cyanide is not a very stable compound, specifically under oxidising conditions.

Organic ground water chemistry observed in the boreholes indicated no organic contamination within the perched aquifer. The presence of moderate to high concentrations of dissolved phase organics was observed in the shallow weathered zone aquifer boreholes.

Similar to inorganics, do the organic contaminant profile of pond waters differ largely from those in evaporation dams. Pond waters are contaminated to high concentrations of almost all semi-volatiles whilst pond waters also contain appreciable concentrations of phenol and its derivatives. Contamination of borehole water by organics as observed by ground water chemistry, may therefore originate from the waters in the ponds.

The extent of the inorganic contamination in both the perched and shallow weathered zone aquifers includes the entire footprints of the ponds, as well as a small area to the west and south west of the ponds. The concentration distribution within the plumes differs with higher concentrations observed in the perched aquifer zone. In other directions from the ponds, the lateral extent of the contamination is restricted due to the ground water flow pattern.

The extent of the organic contamination in the shallow weathered aquifer zone is restricted to a small area to the west. The conclusion has been drawn from the investigations on the sediments in the Maturation Ponds, that the dissolved phase observed in the boreholes originates from these sediments.

However, inorganic contaminants in sediments indicate only aluminium, chromium, iron, fluoride and manganese to be mobile for potential contamination of ground water. Only one of all sediment samples indicated limited mobility for calcium, other macro contaminants being immobile. Should inorganic ground water contamination therefore eminate from the maturation ponds, then it may be from the presence of these contaminants in the waters and not in the sediments. With regard to cyanides present in waters, was it observed that this compound was not present in sediments, which strengthen the hypothesis of the oxidation of cyanide in the waters.

The Maturation Ponds result in reduced catchment runoff to the Rietkuilspruit, and contamination of clean run-off water and rainfall by the water stored in the impoundments. The process water system needs to accommodate this water in order to empty the dam.

6.1.5.3 Risks

The risk to human health represents the risk through the ground water pathway for drinking water application (adult of 60 kg drinking 2 litres of water/day). The risk to the environment represents the risk through the aquatic ecosystems pathway. The area for which both these risks is unacceptable, relates to the entire footprint of the Maturation Ponds, as well as a small area to the west of the ponds. For the perched aquifer zone, the risk of organics to human health is caused by elevated concentrations of Ca, Mg, SO_4, Cl, Na, F, Fe and Mn, whilst the risk to the environment relates to elevated concentrations of Ca, Mg, SO_4, Cl, Na, K, NO_3, F, Fe and Mn. The risk to both human health and the environment for the shallow weathered aquifer zone, relates to elevated inorganic concentrations for Ca, Mg, SO_4, Cl, Na, Fe and Mn.

The risk to human health and the environment relates to several organic components observed in boreholes to the west, east and south west of the Maturation Ponds.

The potential risk of inorganics in the waters in these ponds, and more specifically manganese, cyanide and fluorides, could result in potential unacceptable risks of up to 100%, i.e. a mortality rate of 100% in the aquatic environment. Margins of safety for humans are also exceeded by several thousand percent, according to the potential estimated concentrations these three compounds could achieve under worst case scenarios in ground water. The potential risk by organics in the waters, portray a similar picture, being of the same order of magnitude than inorganics.

6.1.5.4 Management Objectives

Due to the technical impracticability of remediating the observed ground water pollution at this site to a level of risk acceptable to Human Health and the Environment, institutional controls will be needed to achieve the required objectives. However, technical measures will also need to be commissioned in order to achieve continual improvement subject to the following secondary short term (ST), medium term (MT) and long term (LT) objectives:

- Minimize contaminant concentration at source in the short term.
- Minimize infiltration of contaminants at source in the short to long term.

6.1.5.5 Measures

The aquifer(s) impacted on by the Maturation Ponds, cannot be remediated to acceptable risk levels through technical measures over the short and medium terms. Such measures would require flushing of the aquifers with "clean" water and would, in any event, take several decades to improve the situation significantly. It is therefore considered impracticable to achieve risk compliance in this area over the short and medium term.

Institutional measures: will be necessary to achieve effective and meaningful mitigation of the impacts.

Re-zone the area within IVS perimeter for controlled ground water usage. This implies that abstraction and application control must be institutionalised within the current ground water impacted area, to such a level that the risk of ground water use falls within acceptable levels, subject to demonstration of continual improvement over the long term.

The following **technical** measures could address the situation at source, as well as in the aquifers receiving water from the source. Their intention is to improve the situation over the short, medium and long term.

- Whilst the ponds contain water, optimise water quality to as low as possible concentrations of contaminants.
- Whilst the ponds contain water, minimize infiltration by keeping the water level as low as possible until the ponds are emptied.
- Control leachate at the toe of the ponds to prevent contaminated surface run-off and soil contamination.
- Empty the ponds: treat the water for reuse as process water and treat the sludges as required for disposal, and capping.
- Rehabilitate the footprint by enveloping the earthen walls back into the cleaned ponds to be free-draining, topsoil and vegetate.
- Construct adequate runoff control measures and remove defunct reticulation infrastructure.
- Clean and rehabilitate the adjacent areas.

Various other **alternative measures** have been considered:

- Line the ponds (to be decommissioned)
- Empty the ponds and rehabilitate (**preferred option**)
- Seepage drain/drainage gallery (not indicated as necessary)
- Slurry wall (does not facilitate abstraction)
- Sheet piling (not technically feasible)
- Reactive barriers (not applicable to chemistry)
- Pump and Treat (not indicated as necessary)
- Pump and Flush (not indicated as necessary - source of flush water a problem).

6.1.5.6 Monitoring

Monitoring is needed to verify the effectiveness of the recommended measures in achieving the suggested secondary objectives.

Current ground water quality and level monitoring borehole pairs (shallow and deep) dedicated to the Maturation Ponds and adjacent area include IVB-3, IVB-17, IVB- 18, IVB- 20, IVB-61 and IVB-124.

Additional ground water quality and level monitoring boreholes are recommended to be commissioned during implementation of the recommended measures to monitor and measure efficiency and overall compliance with objectives.

6.1.5.7 Regulatory Authorizations

Register:

- the ponds (may need to be registered) with the DWAF dam safety office depending on the decommissioning program,
- the monitoring wells.

6.1.6 Raw Materials Stockpiles Area

6.1.6.1 Activity Description

The two facilities that manage the raw material stockpiles within the CRMF area are the coal stock and blending yard and the sinter plant feed preparation pad. In total they cover 26 ha, and are situated immediately east of Dam 10. The raw materials stockpiles area falls within the western catchment and drains towards the Rietkuilspruit.

The coal is blended to achieve a consistent feed to the coke ovens. For this coal-blending operation, a coal crushing and screening station, and a coal stacking area and stacker reclaimer form the bulk of the plant and stockpile area. The coal stacking area has a sub-surface drainage system, however this system discharges the collected leachate water into the Hattingh canal for discharge towards the TETP and Rietspruit canal and is semi-bunded.

The sinter bed requires a mixture of fine ore, fine coal and other ingredients needed for the production of sinter. A sinter mixing bed and stacker reclaimer serves this purpose. This area is also serviced by an access tar road into the CRMF and the Hattingh canal.

Three environmental components form the focus of a description of this area, namely ground water, surface water and air quality.

6.1.6.2 Impacts

The entire Raw Materials Stockpiles area is underlain by Silverton Shale Formation. Two aquifer types occur in the area namely the perched aquifer and shallow weathered zone aquifer. The thickness of the unsaturated zone is impacted by insufficient free surface water drainage, which causes surface water to accumulate and dam up in the area and infiltrate into the ground water. The thickness of the unsaturated zone varies between 1 and 2 meters. Saturated thicknesses for the perched aquifer is some 0,5 to 2 meters, whilst the shallow weathered zone aquifer is saturated up to a thickness of some 9 meters.

No lateral aquifer boundaries are active within the area.

Borehole yields in the area vary from low to medium. The aquifer hydraulic parameters (storativity and permeability) are low, whilst porosities vary from moderate to high, suggesting slow ground water flow and restricted volumes. Piezometric levels in the two aquifer zones differ with a positive gradient from the deeper to the perched aquifer. Natural recharge from rainfall is estimated at 2% to 3% of MAP.

The regional ground water flow direction for this area is from east to west. Despite the presence of mounding underneath the existing waste dump and Dam 10 to the north and west respectively of these areas, the extent of the mounding is insufficient to alter the regional ground water flow pattern. Using the observed hydraulic parameter values for the area, together with the average hydraulic gradient, the ground water flow velocity is in the order of 10 to 15 meters per year.

The Raw materials Stockpile Area is entirely located within the IVS works perimeter and no ground water abstraction occurs for any application.

The aquifer(s) underlying the area are both classified as ***Minor Aquifer Systems***, whilst their vulnerability is classified as ***medium***. Aquifer susceptibility is classified as *medium*, resulting in an overall aquifer protection classification of a ***medium protection level***.

No ground water fatal flaws with respect to waste management are present within the area.

With reference to the activity description, the ground water impact mechanism associated with the Raw Material Stockpile areas relates to infiltration of rain and surface water due to insufficient surface drainage. Rainwater also percolates through the stockpile material and generates leachate as the water percolates downward through the raw materials, which enters the ground water system as seepage/infiltration through the footprint of the stockpiles into the underlying perched aquifer. Infiltration into the shallow weathered zone aquifer could be limited due to the positive hydraulic gradient from this zone towards the upper zone. However, this gradient could be compromised in certain areas and therefore contamination of the deeper aquifer will most probably also occur.

The downward migration of water/leachate leaving the footprints of the stockpiles, is governed by a combination of:

- the pressure head distribution in the stockpiles,
- the hydraulic parameters of the infiltration interface (footprint and unsaturated zone),
- the hydraulic parameters of the underlying aquifers (permeability, porosity), as well as
- the piezometric pressure distribution within the two aquifer zones.

Ground water chemistry obtained from the boreholes in this area confirm elevated concentrations for Ca, Mg, SO_4, Cl, Na, NO_3, K, F, Fe and Mn within the perched aquifer zone. For the shallow weathered aquifer zone elevated concentrations for Mg, Cl, F, Fe and Mn were observed. However the degree of concentration elevation is less for the shallow weathered zone aquifer.

No organic contamination of the ground water within the perched aquifer zone was observed from samples taken from any of the boreholes in this area. One shallow weathered zone aquifer borehole indicated low organic concentrations (IVB-D7).

The extent of the inorganic contamination in the perched and shallow weathered zone aquifers includes the entire footprint of the stockpile areas. The concentration distribution within the plumes differs with higher concentrations observed in the perched aquifer zone. The lateral extent of both aquifer zone plumes beyond the footprints is difficult to delineate as the plumes mix with plumes originating from neighbouring sources such as the existing waste dump, Dam 11, sludge dams as well as the old/former maturation ponds.

The area east of the Hattingh canal drains into the canal, while the western area drains into Dam 10. Poor quality leachate emanating from the two areas either side of the canal impacts negatively on the quality surface water run-off in canal.

While the dust fall-out within the raw material handling area as measured over a year is just below 0.9 gram/m^2/day, which is normal within heavy industry and in particular mass raw material transfer, the monitors at the CRMF perimeter confirmed no significant impact.

Leachates under dry weather flow conditions indicated manganese and the macro inorganics to leach from the sinter mix bed area, whilst higher concentrations of manganese and lead leached from the coal stocking area. The old CETP sludge dams indicated similar leachates contaminants, whilst in addition also indicated cyanide in the leachates under dry flow conditions. Leachates from the current CETP sludge dams indicated similar inorganic contaminants, however several semi-volatile organics were also observed. These results indicated the possibility for potential contamination of ground waters in the raw material stockpile area, in agreement with ground chemistry observed from boreholes in this area.

6.1.6.3 Risks

For the perched aquifer zone the risk to human health relates to elevated inorganic concentrations for Ca, Mg, SO_4, Cl, Na, F, Fe and Mn, whilst the risk to the environment relates to elevated concentrations for Ca, Mg, SO_4, Cl, Na, K, NO_3, F, Fe and Mn. The risk to human health for the shallow weathered aquifer zone relates to elevated inorganic concentrations for Mg and Fe, whilst only Mn presents a risk to the environment.

Lead, manganese and most of the macro contaminants in leachates indicated a potential unacceptable risk to both humans and the environment, generally in agreement with unacceptable risks observed in borehole water.

Organic contamination does not pose a threat of risk to human health or the environment in the Raw Material Stockpiles Area. However, phenanthrene, which was observed in leachates from the CETP sludge dams, did indicate a very marginal potential risk to humans, being of an acceptable risk to the environment.

There is no risk caused by dust generated from this area beyond the site perimeter as confirmed by fall-out buckets.

6.1.6.4 Management Objectives

Due to the technical impracticability to remediate the observed ground water pollution at this site to levels, which will represent objectives of acceptable risk to human health and the environment, these objectives will have to be reached through institutional controls. However, technical measures must be commissioned to achieve continual improvement subject to the following secondary short term (ST), medium term (MT) and long term (LT) objectives:

- Minimize the infiltration of contaminants from leachates at source (ST).
- Reduce wind blown dust as far as is practical, and in the short term implement steps to improve dust evolution.

6.1.6.5 Measures

As described above, the recommended measures comprise two main categories:

- Institutional Measures
- Technical Measures

Institutional measures must be motivated in terms of technical impracticability.

The aquifer(s) impacted on by the Raw Materials Stockpiles as indicated by ground water chemistry and leachates cannot be remediated to acceptable risk levels through technical measures over the short and medium terms. Such measures would require flushing of the aquifers with "clean" water and would in any event take several decades to improve the situation significantly. They are therefore considered impracticable to achieve risk compliance over the short and medium term.

The recommended **institutional measure** would be to **re-zone** the area within the IVS perimeter for ground water usage. This implies that abstraction and application control must be institutionalised within the current ground water impacted area, to such a level that the current risk of ground water use falls within acceptable limits, subject to demonstration of continual improvement over the long term.

The following technical measures are intended to address the situation at source, as well as to limit the aquifers receiving contaminated water from the source. The intention of the measures is to improve the situation over the short, medium and long term for both surface and ground water and air quality.

- Whilst the stockpiles are operational, minimize infiltration by keeping the piles as small as possible - consolidate and minimize total footprint.
- Control and collect leachate at the perimeters of the stockpiles and divert to a sump to prevent contaminated surface run-off and soil contamination.
- Pipe the contaminated water to the CETP.
- Seepage collection system and upgrade the central sump system.
- Bund the open areas to limit surface water contamination
- Relocate stockpiles to new prepared, lined facilities and rehabilitate

the footprints.
- New facilities must have liners and leachate collection systems.
- Fence the stockpiles areas.
- Evaluate dust control systems.

Alternative Measures Considered:

- Line the facilities – (to be relocated)
- Seepage drain/drainage gallery (not indicated as necessary)
- Slurry wall (does not facilitate abstraction)
- Sheet piling (not technically feasible)
- Reactive barriers (not applicable to chemistry)
- Pump and Treat (not indicated as necessary)
- Pump and Flush (not indicated as necessary - source of flush water a problem)

6.1.6.6 Monitoring

Monitoring must be performed to verify the efficiency of the recommended measures in attaining the suggested secondary objectives.

The current ground water quality and level monitoring borehole pairs (shallow and deep) dedicated to the Raw Materials Stockpiles and the adjacent area include IVB-4, IVB-5, IVB- 6 and IVB- 7.

Additional ground water quality and level monitoring boreholes should be commissioned during implementation of the proposed measures to monitor measure efficiency and overall compliance with the objectives.

The existing air quality monitoring should be maintained and the results audited bi-annually.

6.1.6.7 Regulatory Authorizations

The following regulatory authorisations may be required:

- Registration of monitoring wells.
- Permit for new site - CRMF.
- EIA for new site - CRMF.

6.1.7 Processed Materials Stockpile Areas

6.1.7.1 Activity Description

Various materials are stored for re-use or sale at points within the CRMF in a Management Area commonly referred to as the "Processed Materials Stockpile Areas". These areas are all located within the western catchment of the Works. The most prominent activities include:

- Coke storage north of the coal stockyard: 17.3 ha.

- Mill scale storage of different grades is situated between the maturation ponds and the existing CRMF: 15.6 ha.
- Blast furnace slag for crushing as road aggregate at the northern end of the existing CRMF.
- BOF sludge, constituting an area of about 5.9 ha.

Neither of the areas are lined or have any surface or ground water associated management systems. The areas are also not bunded.

6.1.7.2 Impacts

The Processed Materials Stockpiles are underlain by the Silverton Shale Formation. This management area is bounded by two regional geological structures namely the fault to the south and the dolerite dyke to the north.

Two aquifer types are present in the area namely the perched aquifer and shallow weathered zone aquifer. The thickness of the unsaturated zone is impacted by insufficient free surface water drainage. Due to this effect, surface water tends to accumulate and dam up in the area, causing increased infiltration into the ground water. The thickness of the unsaturated zone varies between 1 to 2 meters within this area. Saturated thicknesses for the perched aquifer is some 3 to 4 meters, whilst the shallow weathered zone aquifer is saturated up to a thickness of some 19 meters.

Due to the fact that ground water flow directions in this area are essentially parallel to the dyke and the fault, these features are not deemed to represent active lateral aquifer boundaries.

Borehole yields in the area vary from low to medium. The aquifer hydraulic parameters of storativity and permeability are low, whilst porosities vary from moderate to high, suggesting slow ground water flow, and restricted volumes. Piezometric levels in the two aquifer zones differ slightly with no conclusive positive gradient from the deeper to the perched aquifer, or vice versa. Natural recharge from rainfall is estimated at 2% to 3% of MAP.

The regional ground water flow direction for this area is from east to west. Despite the presence of mounding underneath the Existing Waste Dump, Dams 1-4 and Maturation Ponds to the west, north-east and east respectively, the extent of the mounding is insufficient to alter the regional ground water flow pattern. Using the observed hydraulic parameter values for the area, together with the average hydraulic gradient, the ground water flow velocity is in the order of 10 to 12 meters per year.

The Processed Materials Stockpiles Area is entirely located within the IVS works perimeter and no ground water abstraction occurs for any application.

The aquifers underlying the area are both classified as ***Minor Aquifer Systems***, whilst their vulnerability is classified as ***medium***. Aquifer susceptibility is classified as ***medium***, resulting in an overall aquifer protection classification of a ***medium protection level***.

No ground water fatal flaws with respect to waste management are present within the area.

With reference to the activity description, the ground water impact mechanism associated with the Processed Materials Stockpiles areas, relates to infiltration of rain and surface water due to insufficient surface drainage. Rainwater also percolates through the stockpile material and generates leachate, which then enters the ground water system as seepage/ infiltrating through the footprint of the stockpiles into the underlying perched aquifer. Infiltration into the shallow weathered zone aquifer will most probably also occur, as a well defined positive gradient does not exist from the deeper to the perched aquifer zone.

The downward migration of leachate leaving the footprints of the stockpiles is governed by a combination of the pressure head distribution in the stockpiles, the hydraulic parameters of the infiltration interface (footprint and unsaturated zone), the hydraulic parameters of the underlying aquifers (permeability, porosity), as well as the piezometric pressure distribution within the two aquifer zones.

Ground water chemistry obtained from the boreholes in this area confirms elevated concentrations of SO_4, Cl, Na, Fe and Mn within the perched aquifer zone. Elevated concentrations of SO_4, Fe and Mn were observed in the shallow weathered aquifer zone. However the degree of concentration elevation is less for the shallow weathered zone aquifer.

No organic contamination of the ground water within the perched aquifer zone was observed from samples taken from any of the boreholes in this area. One shallow weathered aquifer borehole (IVB-D153) indicated low organic concentrations for Naphthalene.

The extent of the inorganic contamination in the perched and shallow weathered zone aquifers includes the footprint of the stockpiles. The concentration distribution within the plumes differs with higher concentrations observed in the perched aquifer zone. The lateral extent of both aquifer zone plumes beyond the footprints is difficult to delineate as the plumes mix with plumes originating from neighbouring sources such as the Existing Waste Dump, Dams 1-4 and the Maturation Ponds.

As in the case at raw materials handling, the dust fall-out in the immediate vicinity of the processed materials area was elevated as would be expected for such activity. At the CRMF site perimeter it reduced to about half the level of the residential land use guideline.

6.1.7.3 Risks

For both the aquifer zones, the risk to human health relates to elevated inorganic concentrations of SO_4 and Fe, whilst only Mn present a risk to the environment for both the aquifer zones.

No unacceptable risk to human health and the environment for organic contamination exist within this area, whilst no potential unacceptable risk to human health or the environment due to air pollution was identified.

6.1.7.4 Management Objectives

Due to the technical impracticability to remediate the observed ground water pollution at this site to levels, which will represent acceptable risk to human health and the environment, these objectives will have to be reached through institutional controls. However, technical measures must be commissioned to achieve continual improvement subject to the following secondary short term (ST), medium term (MT) and long term (LT) objectives:

- Minimize contaminant infiltration at source (ST).

6.1.7.5 Measures

The aquifers impacted on by the Processed Materials Stockpiles, cannot be remediated to acceptable risk levels through technical measures over the short and medium terms. Such measures will require flushing of the aquifers with "clean" water and will in any event take several decades to improve the situation significantly. They are therefore considered impracticable to achieve risk compliance over the short and medium term.

The recommended **institutional measure** would be to **re-zone** the area within the perimeter of IVS for restricted ground water usage. This would imply that abstraction and application control would need to be institutionalised within the current ground water impacted area, to such a level that the current risk of ground water use falls within acceptable compliance limits, subject to demonstration of continual improvement over the long term.

The following general technical measures would address the situation at source, as well as in the aquifers receiving contaminated water from the source. The intention of the measures is to improve the situation over the short, medium and long term.

- Whilst the stockpiles are operational, minimize infiltration by keeping the areas as small as possible - consolidate and minimize total footprints.
- Control any leachate at the perimeters of the stockpiles to prevent contaminated surface run-off and soil contamination.

- Relocate stockpiles to new properly prepared, lined facilities and rehabilitate the footprints.
- New facilities should have liners and leachate collection systems.

More area-specific technical measures are listed below for the three main Process Materials Stockpiled Areas:

Mill scale Storage

- Prepare a footprint for a new Mill scale storage area; including bunding.
- Design and construct surface and sub-surface water management infrastructure including sump, pump station and pipes to process water treatment system.
- Relocate railway lines and access roads to accommodate the new prepared storage footprints.
- Measure and control mill scale tonnages

BOF sludge storage

- Prepare the footprint for a new BOF sludge storage area, including bunding and surface and sub-surface water collection system.
- Commission a sump and pump station and pipe the water for treatment and recycling.
- Upgrade the access roads.

Coke stockpile area

- Clean and rehabilitate the coke stockpile area footprint
- Relocate coke stockpile area to the consolidated plant area

Other **alternative measures** have been considered and are listed below:

- Line the facilities – (to be relocated)
- Decommission sites, rehabilitate and relocate to prepared (lined) footprints **(preferred option)**
- Seepage drain/drainage gallery (not indicated as necessary)
- Slurry wall (does not facilitate abstraction)
- Sheet piling (not technically feasible)
- Reactive barriers (not applicable to chemistry)
- Pump and Treat (not indicated as necessary)
- Pump and Flush (not indicated as necessary - source of flush water a problem)

6.1.7.6 Monitoring

Monitoring is necessary to verify the efficiency of the proposed measures in attaining the proposed secondary objectives.

The current ground water quality and level monitoring borehole pairs (shallow and deep) dedicated to the Processed Materials Stockpiles Areas and immediate surrounding area include IVB-18 and IVB-153.

Additional ground water quality and level monitoring boreholes should be commissioned during implementation of the proposed measures, to monitor measure efficiency and overall compliance with objectives.

6.1.7.7 Regulatory Authorizations

Authorisation processes may be required for:

- Registration of monitoring wells.
- Permit for new site - CRMF.
- EIA for new site - CRMF.

6.1.8 CETP Sludge Dams

6.1.8.1 Activity Description

The CETP Sludge Dams are situated in the western catchment of the Works, within the CRMF, and comprise two areas where sludge underflow from the CETP has been dumped, namely the old Maturation Ponds which are no longer in operation, and the current CETP Sludge Dams

The **old Maturation Ponds** area Is situated to the north of the CETP, and consists of three non-equally sized cells (cell 1 = 3.7 ha; cell 2 = 6.0 ha; cell 3 = 9.9 ha). These sludge dams are unlined and were previously used for the disposal of sludge underflow from the CETP. The estimated average depth of the dams is = 3 m. Sludge was settled out in the sludge dams and the excess and seepage water flows into the Hattingh canal.

The currently operational **CETP Sludge Dams** area is situated immediately east of Dam 10, and comprises seven equally sized and unlined cells, with areas of approximately 12.5 ha and divided by earthen walls. Sludge settles out in the sludge dams and the water is evaporated. The water is of the same quality as that which is discharged from the clarifiers at the CETP.

6.1.8.2 Impacts

The Sludge Dams are entirely underlain by geologically by the Silverton Shale Formation. Two aquifer types are present in the area namely a perched aquifer and a shallow weathered zone aquifer. The thickness of the unsaturated zone measures some 0,5 to 3 meters. Saturated thicknesses for the perched aquifer is some 2 to 4,5 m, whilst the shallow weathered zone aquifer is saturated up to a thickness of some 22 meters.

No lateral aquifer boundaries are present within the area.

Borehole yields in the area vary from low to medium. The aquifer hydraulic parameters storativity and permeability are low, whilst porosities vary from moderate to high, suggesting slow ground water flow, and restricted volumes. Piezometric levels in the two aquifer zones do not differ significantly and no conclusive statement can be made in terms of the gradient from the deeper to the perched aquifer. Natural recharge from rainfall is estimated at 2% to 3% of MAP.

The regional ground water flow direction for this area is from east to west by southwest. Using the observed hydraulic parameter values for the area, together with the average hydraulic gradient, the ground water flow velocity is in the order of 8 to 10 meters per year.

The CETP Sludge Dams are entirely located within the IVS works perimeter and no ground water abstraction occurs for any application.

The aquifer(s) underlying the area are both classified as ***Minor Aquifer Systems***, whilst their vulnerability is classified as ***medium***. Aquifer susceptibility is classified as ***medium***, resulting in an overall aquifer protection classification of a ***medium protection level***.

No ground water fatal flaws with respect to waste management exist within this management area.

With reference to the activity description, the ground water impact mechanism associated with the dams relates to infiltration of water (rain and process water) downward through the dams footprints, entering the ground water system as seepage/infiltration into the underlying perched aquifer. Infiltration into the shallow weathered zone aquifer will be limited due to the small hydraulic gradient from the dams.

The downward migration of water through the footprints of the dams, is governed by a combination of the pressure head distribution in these facilities:

- the hydraulic parameters of the infiltration interface (footprints and unsaturated zone),
- the hydraulic parameters of the underlying aquifers (permeability, porosity), as well as
- the piezometric pressure distribution within the two aquifer zones.

Ground water chemistry obtained from the boreholes in this area, confirms elevated concentrations for Ca, Mg, Cl, SO_4, F, Fe and Mn within the perched aquifer, and elevated concentrations for Ca, Mg, Na, Cl, SO_4, F, Fe and Mn within the shallow weathered zone aquifer. The degree of contamination is less in some of the shallow weathered zone aquifer boreholes. However, the inverse situation is also present within the area.

Organic ground water chemistry observed in the boreholes indicates no organic contamination within the perched aquifer. The presence of low to high concentrations of the dissolved phase in the shallow weathered zone boreholes was observed. The high concentration for organics was observed in one borehole directly down gradient from the CETP sludge dams. This is generally in agreement with organics indicated by leachates under dry weather flow conditions from these dams.

The extent of the contamination in both the perched and shallow weathered zone aquifers includes the entire footprints of the different dams. The concentration distribution within the plumes differs with slight concentrations observed in the perched and shallow weathered aquifer zones. The concentration distribution within the shallow and deeper plumes does not differ significantly. The lateral extent of both aquifer zone plumes beyond the footprints is difficult to delineate as the plumes mix with plumes originating from neighbouring sources such as the Raw Material Stockpiles.

The extent of the organic contamination is restricted to the shallow weathered aquifer zone in borehole IVB-D125.

6.1.8.3 Risks

The risk to human health represents the risk through the ground water pathway for drinking water application (adult of 60 *k*g drinking 2 litres of water/day). The risk to the environment represents the risk through the aquatic ecosystems pathway. For the perched aquifer zone, the risk to both human health and the environment, relates to elevated inorganic concentrations for Ca, Mg, Cl, SO_4, and Fe, whilst Na, F and Mn only have an environmental risk. For the shallow weathered zone aquifer, the risk to both human health and the environment relates to elevated inorganic concentrations for Ca, Mg, Cl, SO_4, F, Fe and Mn.

Risk to human health and the environment exist in terms of organic compounds (PAH) observed in only one borehole directly south of the CETP Sludge Dams. Such marginal potential risk was also indicated by phenanthrene observed in leachates.

If the surface water in these dams is discharged into the receiving environment, there could be an unacceptable risk to human health and the environment.

6.1.8.4 Management Objectives

Due to the technical impracticability to remediate the observed ground water pollution at the sludge dams to levels, which would represent an acceptable risk to human health and the environment, these objectives will have to be reached through institutional controls. However, technical measures must be commissioned to achieve continual improvement subject to the following secondary short term (ST), medium term (MT) and long term (LT) objectives:

- Minimize contaminant infiltration at source (ST).

6.1.8.5 Measures

The proposed measures for the sludge dams are similar to those proposed for the Dam 10 area. Refer also to the overall CRMF area.

Institutional measures must be motivated in terms of impracticability of technical measures. The aquifer(s) impacted on by the sludge dams, cannot be remediated to acceptable level of risk through technical measures over the short and medium terms. Such measures would require flushing of the aquifers with "clean" water and would in any event, take several decades to improve the situation significantly. They are therefore considered impracticable to achieve risk compliance over the short and medium term.

The recommended **institutional** measure is to re-zone the affected area within the IVS perimeter for controlled and restricted ground water usage. This implies that abstraction and application control must be institutionalised within the current ground water impacted area to such a level that the current risk of ground water use is within acceptable risk levels, subject to demonstration of continual improvement over the long term.

The following **technical** measures have been recommended to address the situation at source, as well as to limit the aquifers receiving controlled water from the source. The intention of the measures is to improve the situation over the short, medium and long term for both the ground water and surface water components of the old and current sludge dams.

- Dewater the sludge dams, the contaminated water to be treated for reuse.
- Optimise shaping, capping (with 500mm BOF slag topsoil) and re-vegetation (rehabilitation) of the old sludge dams to minimize rainfall infiltration. The surface would be strengthened with the installation of a "Tensar" system.
- Control leachate at the toe of the rehabilitated dams with a subsoil drainage system and ponds to prevent contaminated surface run-off and soil contamination.
- Construct a surface water management system around the area.

As a general technical measure, the area between the Sinter Blending Yard and CEPT Sludge Dams will also need to be cleared of sources of contaminants and landscaped to be free-draining.

Various other **alternative** measures were considered and have been listed below:

- Line the facility (impracticable)
- Decommission and rehabilitate (**preferred option**)
- Seepage drain/drainage gallery (not indicated as necessary)
- Slurry wall (does not facilitate abstraction)
- Sheet piling (not technically feasible)
- Reactive barriers (not applicable to chemistry)
- Pump and Treat (not indicated as necessary)
- Pump and Flush (not indicated as necessary - source of flush water a problem)

6.1.8.6 Monitoring

Refer to section 6.1.1.6 describing the monitoring protocol for the overall CRMF area.

Monitoring must be performed to verify the effectiveness of the recommended measures in attaining the suggested secondary objectives.

Current ground water quality and level monitoring borehole pairs (shallow and deep) dedicated to the sludge dams and immediate surrounding area include IVB-2, IVB-45, IVB-46, IVB-71, IVB-72 and IVB-125.

Additional ground water quality and level monitoring boreholes will be commissioned during implementation of the proposed measures, to monitor measure efficiency and overall compliance with objectives.

6.1.8.7 Regulatory Authorizations

Registration of monitoring wells may be required.

6.1.9 Redundant blast furnace sludge dams

6.1.9.1 Activity Description

These dams were historically used as a dumping site for sludge generated as a waste product at the Blast Furnaces. The dams are no longer in use and have been covered with soil. The redundant Blast Furnace Sludge Dams are situated within the CRMF near the western boundary of the CRMF, directly northwest of Dam 10 and adjacent to (south of) the existing waste dump. The area consists several unlined excavations into which sludge from the blast furnace had previously been dumped. The area affected by the dams is not known. The average depth of the sludge in the dams is unknown at present. As surface water runoff is no longer affected by these dams, the focus of this section is on ground water.

6.1.9.2 Impacts

The Redundant Blast Furnace Sludge Dams area is entirely underlain by the Silverton Shale Formation. The perched aquifer and shallow waathered zone aquifer ara found in this area. The thickness of the unsaturated zone measures some 1 to 4 meters. Saturated thicknesses for the perched aquifer is some 1 to 4 meters, whilst the shallow weathered zone aquifer is saturated up to a thickness of some 18 meters.

No lateral aquifer boundaries are present within the area.

Borehole yields in the area vary from low to moderate. The aquifer hydraulic parameters of storativity and permeability are low, whilst porosities vary from moderate to high, suggesting slow ground water flow and restricted volumes. Piezometric levels in the two aquifer zones differ with a positive gradient from tha deeper weathered zone aquifer to the perched aquifer. Natural recharge from rainfall is estimated at 2% to 3% of MAP.

The regional ground water flow direction for this area is from east to west. Using the observed hydraulic parameter values for the area, together with the average hydraulic gradient, the ground water flow velocity is in the order of 10 to 15 meters per year.

The Redundant Blast Furnace Sludge Dams is entirely located within the IVS works perimeter and no ground water abstraction occurs for any application.

The aquifer(s) underlying the area are both classified as ***Minor Aquifer Systems***, whilst their vulnerability is classified as ***medium***. Aquifer susceptibility is classified as ***medium***, resulting in an overall aquifer protection classification of a ***medium protection level***.

No ground water fatal flaws with respect to waste management exist within this management area.

With reference to the activity description, the primary ground water **impact** mechanism of concern relates to downward migration of free phase DNAPL (coal tar) into the underlying aquifer(s). Infiltration of DNAPL into these aquifer(s) will not be significantly baing limited due to the positive upward hydraulic gradients.

The downward migration of DNAPL through the footprint of the Redundant Blast Furnace Sludge Dams is governed by a combination of

- the DNAPL density and thickness,
- the physical and hydraulic parameters of the infiltration interface (footprint and unsaturated zone), as well as
- the physical and hydraulic parameters of the underlying aquifers (permaability, porosity).

With respect to inorganic contamination, the descriptions given for the Existing Waste Dump, Dam 10 and Dam 11, are also applicable to this area, as the Blast Furnace Sludge Dams most probably contributed to the inorganic contamination observed. Ground water chemistry obtained from the boreholes in these areas confirm elevated concentrations for:

- the perched aquifer: Ca, Mg, Cl, SO_4, Na, F, Fe and Mn
- the shallow weathered zone aquifer: Ca, Mg, Na, Cl, SO_4, K, F, Fe and Mn.

Organic ground water chemistry observed in the boreholes associated with the Blast Furnace Sludge Dams indicates the presence, in some instances, of both free phase and dissolved phase NAPL's.

The extent of the inorganic contamination in both the perched and shallow weathered aquifers includes the entire footprint of these sludge dams, as well as an area to the west, extending beyond the western IVS perimeter. In other directions from the Blast Furnace Sludge Dams, the lateral extent of the contamination is restricted due to the ground water flow pattern.

The extent of the organic contamination in both the perched and shallow weathered aquifers include the area to the west of the Blast Furnace Sludge Dams also extending beyond the IVS perimeter. As the exact extent of free phase DNAPL at the source is currently inadequately known, additional investigative work is required. From the analysis of the sediments found in Dam 10 one may conclude that the dissolved phase observed in the boreholes could originate from the sediments and contribute to the concentrations observed. However, contribution to the dissolved phase from residual DNAPL pools observed in the area is more likely. DNAPL free phase pools were observed in six of the twelve boreholes within the area. The lateral extent of the secondary DNAPL pool at depth is well defined, as is the extent of the dissolved phase plume extending beyond the perimeter of the Works.

The impacts, risks and mitigation thereof extending beyond the IVS western perimeter have been addressed in the Receiving Environment Management Area 7. Apart from this, no other Management Area boundary has been compromised by the ground water contamination in this Management Area.

Both areas reduce the catchment area of the Rietkuilspruit, and thus the hydrological yield. Contaminated surface water infiltrates the ground, compromising the ground water quality. Rain falling on the Sludge Dams is affected in terms of quality, and this water enters the Hattingh Canal in a contaminated state.

6.1.9.3 Risks

The area for which health and environmental risks is unacceptable, relates to the entire footprint of the directly affected area extending beyond the western IVS perimeter. The risk assessment for the area beyond the perimeter has been addressed in Management Area 7. The risk to human health relates to elevated concentrations for Ca, Mg, SO_4, Cl, Na and Fe, whilst the risk to the environment relates to elevated concentrations for Ca, Mg, SO_4, Cl, Na, F, Fe and Mn.

The risk to human health and the environment by organic compounds relates to the entire free phase DNAPL, as well as several components of the dissolved phase observed in the monitoring boreholes.

6.1.9.4 Management Objectives

Due to the technical impracticability of remediating the observed ground water pollution at the redundant Blast Furnace Sludge Dams to a level of risk acceptable to human health and the environment, institutional controls will rather need to be implemented to achieve the desired primary objectives. However, technical measures will also need to be commissioned to achieve continual improvement subject to the following recommended secondary short term (ST), medium term (MT) and long term (LT) objectives:

- Minimize infiltration of the contaminant at source (ST).
- Cut off migration of contaminated ground water as close as feasible to the source in order to prevent the movement of contaminated ground water across boundaries - legal or prescribed compliance boundaries (ST).
- Manipulate migration of the pollution plume to protect pre-defined areas (MT).
- Improve ground water quality to meet sustainable water quality standards (LT).

6.1.9.5 Measures

The aquifer(s) impacted on by the redundant Blast Furnace Sludge dams cannot be remediated to acceptable risk levels through technical measures over the short and medium terms. Such measures would require flushing of the aquifers with "clean" water and/or steam and would, in any event, take several decades to improve the situation significantly. They are therefore considered impracticable to achieve acceptable compliance with risk levels over the short and medium term.

The recommended **institutional** measure would be to **re-zone** the area within IVS perimeter for the restricted and controlled usage of ground water.

This implies that abstraction and application control must be institutionalised within the current ground water impacted area, to such a level that the current risk of ground water use to man and the environment is within acceptable compliance limits, subject to the demonstration of continual improvement over the long term.

In addition to the above, the following **technical** measures have been recommended to address the situation at source, as well as to limit in the aquifers receiving contaminated water from the source. The intention of the measure is to mitigate the situation over the short, medium and long term for both the surface and ground water components.

- Delineate the extent of the DNAPL source at the surface through detailed geotechnical investigations.
- Remove any free phase DNAPL, treat as may be necessary, and dispose of at a permitted waste disposal facility.
- Optimise shaping and capping by topsoiling and re-vegetation (rehabilitation) of the area with adequate run-off control structures to prevent erosion and to minimize rainfall infiltration.
- Install a drainage gallery to intercept inorganic and dissolved phase organic contaminated ground water migrating through the perched aquifer away from the Sludge Dams towards the west. This trench should be excavated and constructed along the western toe of the Sludge Dams, and must intercept seepage up to depths ranging between 4 and 6 meters (this trench is the same as the one proposed for the Existing Waste Dump and Dam 10 to be effective).
- Install abstraction wells into the shallow weathered zone aquifer between the western toe of the dam and the IVS western perimeter to intercept inorganic and dissolved phase organic contaminated ground water migrating through the shallow weathered zone aquifer and moving across the western IVS perimeter. The intention of these wells is secondly to manipulate the plume migration patterns to establish a reversed ground water gradient. This would form a local reversal of ground water flow from the west back towards the IVS perimeter. In the long run, this could also cause an improvement in ground water quality (inorganic and dissolved phase organics) in the areas to the west of the borehole abstraction line.
- In addition to the above the following should be considered:
- An infiltration gallery of clean water to the west of the dissolved phase organic plume may be required to force the dissolved phase back eastwards towards the IVS perimeter as well as to improve ground water quality in this area.
- Removal of the residual DNAPL pools at depth through a combination of (provisionally) steam injection, pumping, flushing and soil vapour extraction.

The **alternative measures considered** have been listed below:

- Line the facility (impracticable)
- Remove source and rehabilitate (**preferred option**)
- Seepage drain/drainage gallery (**preferred option**)
- Slurry wall (does not facilitate abstraction)
- Sheet piling (not technically feasible)
- Reactive barriers (not applicable to chemistry)

- Pump and Treat (**preferred option**)
- Pump and Flush (to be considered - source of flush water a problem)
- Infiltration gallery (to be considered - source of flush water a problem)
- Steam Injection (to be considered - very expensive)
- Solvent Injection (not preferred due to too many side effects)
- Soil Vapour Extraction (to be considered - perhaps not indicated)

6.1.9.6 Monitoring

Monitoring is needed to verify the efficacy of the recommended measures in achieving in the proposed secondary objectives.

Current ground water quality and level monitoring borehole pairs (shallow and deep) dedicated to the redundant Blast Furnace Sludge Dams and immediate surrounding area include IVB-54, IVB-55, IVB-58, IVB-59, IVB-65, IVB-66 and IVB-150.
Additional ground water quality and level monitoring boreholes should be commissioned during implementation of the proposed measures to monitor and measure efficiency and overall compliance with the objectives.

6.1.9.7 Regulatory Authorizations

- Registration of abstraction and monitoring wells may be required.
- Water use license for ground water abstraction and infiltration.
- DNAPL removal - EIA.

6.1.10 Dam 11 (Candidate Landfill Site)

6.1.10.1 Activity

Dam 11 occurs within the CRMF in the western catchment of the Works and is situated north of Dam 10, and south of the existing dump. The area is covered by an unlined dam and is no longer in use. Water accumulates behind the railway embankment separating it from Dam 10. The source of water in this area is predominantly storm water runoff. This dam has no spillway, and if it were to overtop the water would flow into Dam 10. The area has been selected as the preferred candidate site for metalliferous residue from the Works during an area and site identification and selection process. The measures for remediation have thus been applied to cater for the Minimum Requirements for Waste Management.

6.1.10.2 Impacts

The entire Dam 11 area is underlain by the Silverton Shale Formation. No monitoring boreholes have been drilled within the area. The impact description has been based on observations made in the neighbouring areas, namely:

- the existing waste dump to the north and west,
- the raw material stockpile area to the east,
- Dam 10 to the south, and
- the CETP sludge dams to the south-east.

Two aquifer types occur in the area, namely the perched aquifer and shallow weathered zone aquifer. The thickness of the unsaturated zone is impacted by infiltration from *inter alia* Dam 11 (mounding) and insufficient free surface water drainage. This thickness measures some 0,5 to 1 meters around the dam. The saturated thickness of the perched aquifer is some 4 to 4,5 meters, whilst the shallow weathered zone aquifer is saturated up to a thickness of some 9 meters.

No lateral aquifer boundaries are active within the area.

Borehole yields in the area vary from low to medium. The aquifer hydraulic parameters (storativity and permeability) are low, whilst porosities vary from moderate to high, suggesting slow ground water flow, and restricted volumes. Piezometric levels in the two aquifer zones differ with a positive gradient from the deeper to the perched aquifer. Natural recharge from rainfall is estimated at 2% to 3% of MAP.

The regional ground water flow direction for this area is from east to west. Due to the presence of mounding underneath Dam 11, Dam 10 and the existing waste dump, localized ground water flow is from west to east. The extent of the mounding is insufficient to alter the regional ground water flow pattern. Using the observed hydraulic parameter values for the area together with the average hydraulic gradient, the ground water flow velocity is estimated to be in the order of 10 to 15 meters per year.

The entire Dam 11 area is located within the IVS works perimeter and no ground water abstraction occurs for any application.
The aquifer(s) underlying the area are classified as ***Minor Aquifer Systems***, whilst their vulnerability is classified as ***medium***. Aquifer susceptibility is classified as ***medium***, resulting in an overall aquifer protection classification of a ***medium protection level***.

No fatal flaws with respect to waste management have been identified present within the Dam 11 area.

With reference to the activity description, the ground water impact mechanism associated with Dam 11 relates to infiltration of water downward through the dam footprint, entering the ground water system as infiltration of seepage into the underlying perched aquifer. Infiltration into the shallow weathered zone aquifer is limited due to the positive hydraulic gradient from this zone towards the upper zone. However, this gradient could be compromised in certain areas (e.g. directly under the dam) and therefore contamination of the deeper aquifer will most probably also occur.

The downward migration of water leaving the dam, is governed by a combination of

- the pressure head distribution in the dam (varying water level in the dam),
- the hydraulic parameters of the infiltration interface (footprint and unsaturated zone),
- the hydraulic parameters of the underlying aquifers (permeability, porosity), as well as
- the piezometric pressure distribution within the two aquifer zones and interaction with neighbouring areas.

Ground water chemistry obtained from the boreholes in this area (essentially in the area between the dam and the western IVS perimeter) confirm elevated concentrations for Ca, Mg, SO_4, Cl, Na, NO_3, F, Fe and Mn within both the perched and shallow weathered zone aquifers. However the degree of concentration elevation is less for the shallow weathered zone aquifer.

No organic contamination was observed in the monitoring boreholes to the east of Dam 11. The organic contamination observed in the neighbouring areas is related to other sources.

The extent of the contamination in both the perched and shallow weathered zone aquifers includes the entire footprint of the dam, as well as an area to the west, north, east and south of the dam. The concentration distribution within the plumes differs with higher concentrations observed in the perched zone. In other directions from the dam the lateral extent of the contamination is restricted due to the ground water flow pattern. The lateral extent of both aquifer zone plumes beyond the footprints is difficult to delineate as the plumes mix with plumes originating from neighbouring sources mentioned above.

Apart from this, no other Management Area boundary has been compromised by the ground water contamination in this Management Area.

6.1.10.3 Risks

For the perched aquifer zone, the risk to human health is caused by elevated inorganic concentrations of Ca, Mg, SO_4, Cl, Na, F, Fe and Mn. The risk to the environment relates to elevated concentrations of Ca, Mg, SO_4, Cl, Na, F, Fe, Mn and NO3. The risk to human health from the shallow weathered zone aquifer zone relates to elevated inorganic concentrations for Mg and Fe, whilst Mg, Fe and Mn present a potential risk to the environment in this aquifer zone.

No risk exists to either human health or the environment with regard to the observed organic concentrations in either of the aquifer zones in the Dam 11 area.

6.1.10.4 Management Objectives

Due to the technical impracticability of remediating the observed ground water pollution at this site to levels that will represent acceptable level of risk to human health and the environment, these objectives will have to be achieved by the implementation of institutional controls. However, technical measures will also be required and should be commissioned to achieve continual improvement subject to the following suggested secondary short term (ST), medium term (MT) and long term (LT) objectives:

- Minimize contaminant concentration at source (ST).
- Minimize infiltration of the contaminant at source (ST).
- Cut off migration of contaminated ground water as close as feasible to source in order to prevent the movement of contaminated ground water across boundaries - legal or arbitrary compliance boundaries (ST).
- Manipulate migration of the pollution plume to protect pre-defined areas (MT).
- Improve ground water quality to meet sustainable water quality standards (LT).

6.1.10.5 Measures

Institutional measures must be motivated in terms of technical impracticability. The aquifer(s) impacted on by Dam 11 are the same as those impacted on by the Existing Waste Dump and Dam 10 and cannot be remediated to acceptable risk levels through technical measures over the short and medium terms. Such measures would require flushing of the aquifers with "clean" water and could in any event take several decades to improve the situation significantly. They are therefore considered impracticable to achieve risk compliance over the short and medium term. The recommended **institutional** measures would include **re-zoning** the area to limit and control ground water abstraction.

This implies that abstraction and application control must be institutionalised within the area impacted on by ground water to such a level that the current use of ground water is at acceptable risk levels and is also subject to the demonstration of continual improvement over the long term.

The following **technical** measures are designed to address the situation at source, as well as in the aquifers receiving contaminated water from the source. Their intention is to improve the situation over the short, medium and long term for both surface and ground water.

- Optimise water quality to as low as possible concentrations whilst there is water in the dam.
- Whilst the dam contains water, minimize infiltration by keaping the water level as low as possible until it is emptied.
- Control any leachate at the toe of the dam to pravent contaminated surface run-off and soil contamination.
- Empty the dam and treat the water for reuse.
- Install a drainage system towards the point in the south with a surface collection sump and pump adjacent to the future waste toe.
- Clear and remove all contaminated materials to the dump.
- Fill the excavations with BOF slag to form a stable platform area.
- Install a liner system, with a drainage system over the shaped area, together with a toe-drain.
- Construct the BOF slag stockpile as per the design of the new landfill.
- Shape the top of the dump at closure drainage and runoff control, including chutes.
- Topsoil, cap and vegetate tha top of the dump with berms and runoff control structures.
- Install drainage gallery to intercept contaminated ground water migration through the perched aquifer away from the dam towards the west. Tha trench proposed along the western toes of the Existing Waste Dump and Dam 10 would also cater for Dam 11, and should intercept seepaga up to depths ranging between 4 and 6 metars.
- Install abstraction wells into the shallow weathered zone aquifar between Dam 11 and the IVS western perimeter to intercept contaminated ground water migration across the western IVS perimeter through the shallow waathered zone aquifer. The wells proposed for the Existing Waste Dump and Dam 10, would also cater for Dam 11. Tha intention of these wells would also be to manipulate the plume migration to reverse the ground water gradient, thus forming a local reversal of ground water flow from the west towards the IVS perimeter. In the long run, this could also cause an improvement in ground watar quality (inorganic and dissolved phase organics) in the areas to the west of the borehole abstraction line.

Other **alternative measures** considered include:

- Line the dam (Dam 11 is to be decommissioned)
- Empty the dam and rehabilitate (**preferred option**)
- Seepage drain/drainage gallery (**preferred option**)
- Slurry wall (does not facilitate abstraction)
- Sheet piling (not technically feasible)
- Reactive barriers (not applicable to chamistry)
- Pump and Treat (**preferred option**)
- Pump and Flush (not indicated as necessary - source of flush water a problem)

6.1.10.6 Monitoring

Monitoring is needed to verify the efficacy of the proposed measures in achieving the suggested secondary objectives.

Current ground water quality and level monitoring borehole pairs (shallow and deep) dedicated to Dam 11 and the immediate surrounding area includes IVB-4, IVB-5 and IVB-6.

Additional ground water quality and level monitoring boreholes should be commissioned during implementation of the proposed measures to monitor measure efficiency and overall compliance with objectives.

6.1.10.7 Regulatory Authorizations

The following legal authorization processes may be required for the Dam 11 area:

- Registration of abstraction and monitoring wells - same as for Existing Dump and Dam 10.
- Water licence for ground water use/abstraction - same as for Existing Dump and Dam 10.

6.2 Management Area 2: Consolidated Plant Area (CPA)

6.2.1 Activity Description

A Consolidated Plant Area (CPA) has been proposed as a compound, integrated Management Area comprising several modules, each to have its own distinct but similar environmental management plans. The CPA forms the heart of the steel-making operation. The total area of the CPA is approximately 875 ha and it is separated into the older South Works and newer North Works. Construction at the South Works started in 1943 for the Coke, Iron and steel production plants and mills. The North Works was constructed during the 1970's and is a newer and cleaner operation than the South Works. Various secondary industries are included within this area.

Within the South Works there are fourteen surface water drains. Thirteen of these drain to the western catchment, while one drains to the eastern catchment (this water is transferred to the western catchment by pumping from the Leeuwspruit Sump). There is no separate system for clean and dirty water in the South Works area. The area has been covered and is thus largely impervious, promoting high runoff volumes and low infiltration of water.

Within the North Works area there is a separate system for clean and dirty water, which consists of four surface water drains. Three of these drain to the eastern catchment (clean), while one drains to the western catchment (dirty water). Low flows from the eastern catchment are also transferred to the western catchment from the Leeuwspruit Sump. The area is largely impervious, thus promoting high runoff volumes and low infiltration.

The CPA is made up of all the steel manufacturing processes and associated operations to produce saleable steel sheet products. It *inter alia* the main it consists of:

- Direct reduction plant ("DR" Plant)
- Sinter plant
- Coke ovens
- Coke ovens gas work-up
- Coke gas by-products
- Blast furnaces including ore stockpile
- Electric arc furnaces ("EAF")
- Basic oxygen furnaces ("BOF")
- Slab casting at oxygen and arc furnaces
- Hot and cold mills
- Sheet finishing
- Sheet coating including tinning, electro - and hot dip galvanising and painting
- Scrap cutting and lancing
- Spent pickle liquor recovery and ferrite plant
- Support services including high-pressure boiler, gas holders, foundry, paint mixing, flares etc.

Reference is made to the Business Units as tabularised under Section 5.2.

6.2.2 Impacts

Soils (where available) in the Consolidated Plant Area are only slightly impacted on when compared to those in the CRMF. The exception is soils from BU SM04 where the Electric Arc Furnace is situated. Surface soils in this area recorded one of the highest manganese concentrations, i.e. 8.81 ppm mobile manganese.

Elevated concentrations of mobile aluminium and titanium were also recorded in soils within the CPA. The highest concentration of manganese was recorded on the perimeter of the CPA and the South Eastern slag area resulting in an estimated environmental concentration of 1338 ppb. No organic contaminants were found in any of the soil samples of this area.

The CPA area is almost entirely underlain by the Silverton Shale Formation of the Pretoria Group of the Transvaal Sequence. A small part of the northern boundary of the North Works Plant is underlain by

Daspoort and Strubenkop Formation quartzite, due to the fact that a regional fault *(left lateral strike slip fault)* transects the North Works area, with a horizontal displacement of greater than 2 km.

It is important to note that an area within the CPA, right along the western IVS boundary, namely the TETP/MTP area, has been addressed under section 6.5, as a separate Management Area.

Two aquifer types are present in the area, namely the perched aquifer and shallow weathered zone aquifer. The thickness of the unsaturated zone measures some 2 to 3 meters. Saturated thicknesses for the perched aquifer is some 2 to 3 meters, whilst the shallow weathered zone aquifer is saturated up to a thickness of some 14 meters.

The lateral aquifer boundaries that are active within the CPA area are the fault zone and the regional surface water divides. This divide also represents a regional ground water flow divide along a north-south line across the IVS works. This divide is a hydraulic boundary and acts as a no flow boundary, dividing the CPA in half, into two catchments (west and east). The fault zone was extensively investigated and concluded not to be a hydraulic or physical boundary of significance.

Borehole yields in the area vary from low to medium. The aquifer hydraulic parameters (storativity and permeability) are low, whilst porosities vary from moderate to high, suggesting slow ground water flow, and restricted ground water volumes. Piezometric levels in the two aquifer zones differ with a positive gradient from the deeper to the perched aquifer. Natural recharge from rainfall is estimated at 2% to 3% of MAP.

The regional ground water flow directions for the CPA area are complex. From the ground water divide, ground water flow directions are from this line to the west and east. In the south, the ground water flow is towards the CPA from Vanderbijlpark, in a northerly, and then in a north-westerly and north-easterly direction as the ground water divide starts to influence the northerly flow.

No ground water abstraction occurs for any application within the CPA.

The aquifer(s) underlying the area are classified as ***Minor Aquifer Systems***, whilst their vulnerability is classified as ***medium***. Aquifer susceptibility is classified as ***medium***, resulting in an overall aquifer protection classification of a ***medium protection level***.

With respect to waste and ground water management, the fault zone in the north can be identified as a potential fatal flaw. However, investigations performed have indicated no preferential contaminant migration along this feature to date - see section 6.1.2.

With reference to the activity description, the ground water impact mechanism associated with the CPA relates to infiltration-induced mobilization of contaminants through the base of the area, resulting in contamination of the underlying perched and/or shallow weathered zone aquifers, with the subsequent lateral migration of these contaminants as ground water contaminant plumes. Infiltration of inorganic contaminants and LNAPLs into the shallow weathered zone aquifer will be limited due to the general positive hydraulic gradient from this zone towards the upper zone.

However, this gradient could be compromised in certain areas and therefore contamination of the deeper aquifer will most probably also occur. For DNAPL's, the upward hydraulic gradient could retard vertical migration somewhat, but will not be effective in preventing it from occurring.

The downward migration of water is govemed by a combination of the hydraulic parameters of the infiltration interface (ground surface, paved areas, etc.), the unsaturated zone), the hydraulic parameters of the underlying aquifers (permeability, porosity), as well as the piezometric pressure distribution within the two aquifer zones. The density and chemical reactivity of contaminants also play a role.

Ground water chemistry obtained from the boreholes in this area confirmed elevated concentrations of Ca, Mg, SO_4, Cl, Na, K, NO_3, F, Fe and Mn within both the perched and shallow weathered zone aquifers. However the degree of concentration elevation is generally less for the shallow weathered zone aquifer.

Organic ground water chemistry observed in the boreholes indicates the presence of both free phase and dissolved phase DNAPL (coal tar) in several of the boreholes within the CPA (18 from 44 boreholes), primarily in the areas of Suprachem and the Coke Ovens.

The extent of the contamination in both the perched and shallow weathered zone aquifers includes the footprints of all the sources/source areas, as well as areas beyond these footprints. Main areas of significant contamination include the areas in the west of the CPA, such as the Direct Reduction Plant area, Suprachem, Coke Ovens, Blast Furnace and the Sinter Plant area. To the east, Area CP01 (Lurgi, Paint Line, Open Veld Area) and the Suprachem Storage Area have both been impacted. The lateral migration of contamination plumes is largely a function of the observed regional ground water flow patterns. The lateral extent of both aquifer zone plumes beyond the footprints is difficult to delineate as the plumes mix with plumes originating from neighbouring sources such as Dam 10, CETP Sludge Dams and Raw Material Stockpiles (north of the DR Plant, Suprachem and the Coke Ovens).

The extent of the organic contamination in both the perched and shallow weathered zone aquifers includes localized areas within the CPA and areas up to, and beyond, the IVS perimeter. Contribution to the dissolved phase from residual DNAPL pools observed also occurs. DNAPL pools observed in monitoring boreholes, indicated them to be very localized and mainly within the Suprachem and Coke Ovens areas. These pools are deemed as mainly residual pools, originating from past spillages.

The situation in the TETP/MTP area (represents the western most portion of the CPA) will be discussed in Section 6.5. Apart from this, no other Management Area boundary is compromised by the ground water contamination in this Management Area.

The potential impacts from air pollution can be from coarse (fall-out) dusts, fine (respirable) particulates and from gases, which emanate from practically all the activities within the CPA.

While the 36 fall-out monitors, operated over a full year, identified a number of points within the plant where improvement is desirable in order to reduce potential leaching to surface or ground water. The monitors on the perimeter on the site confirmed no significant impact on either human health or the environment.

A comprehensive air emission inventory used in atmospheric dispersion modelling has not identified any significant impacts on human health or the environment. The predicted ambient concentrations of sulphur dioxide beyond the southern plant perimeter was however close to the RSA Air Quality Standard, and the hydrogen sulphide concentrations may from time to time exceed the odour threshold beyond the plant perimeter.

Rain falling on the CPA will become contaminated surface water due to the dissolving of solid waste or dust fallout, or by the mixing of the water with effluent waters, the surface water runoff volumes from this area are high due to the predominantly impermeable nature of the land use. All discharge surface water (storm water and effluent) not within the WQO's for the site must be treated – this has an impact on the process water system, which must accommodate these volumes.

6.2.3 Risks

The areas for which health and environmental risks is generally unacceptable, relates to the footprints of the process facilities/sources within the CPA.

The risk to human health generally relates to elevated concentrations of Ca, Mg, SO_4, Cl, Na, K, F, and Fe, whilst the risk to the environment in general relates to elevated concentrations of Ca, Mg, SO_4, Cl, Na, K, NO_3, F, Fe and Mn within the perched aquifer zone. For the shallow weathered aquifer zone, the risk to human health generally relates to elevated inorganic concentrations for Ca, Mg, SO_4, Cl, Na, K, F, and Fe, whilst the risk to the environment generally relates to Ca, Mg, SO_4, Cl, Na, K, NO_3, F, Fe and Mn. The risk associated with NO_3, was observed in two different boreholes, one in the perched aquifer zone and one in the shallow weathered aquifer zone.

Elevated concentrations of mobile inorganic contaminants resulted in potential unacceptable risk to the environment and health. Most of the soils indicated a potential unacceptable risk of manganese to the environment, whilst manganese, aluminium and titanium were of an unacceptable potential risk to humans, ground water being the pathway.

The risk to human health and the environment for organics, relates to the entire observed free phase DNAPL pool(s), as well as several organic components observed in dissolved phase in some boreholes within the CPA.

Mobility of the contaminants in the impacted CPA soils indicated a potentially unacceptable risk of Manganese only to the environment, whilst a potential unacceptable risk of Aluminium, Iron and Titanium was indicated with regard to human health.

The surface water discharged into the receiving environment could have an unacceptable risk to human health and the environment, depending on the extent of contamination by surface soils.

No significant risk as result of air pollution could be identified, based on the assumption that all installed abatement equipment remains functional. Some minor emissions, involving mainly fugitive dusts, were identified for further improvement.

In addition, the coke oven gas project will completely remove the present large source of hydrogen sulphide, and together with the sinter project, it will also further reduce the emissions of sulphur dioxide, oxides of nitrogen and fine particulates.

6.2.4 Management Objectives

Due to the technical impracticability to remediate the observed ground water pollution within the CPA to levels, which will represent acceptable risk to human health and the environment, these objectives will have to be reached through institutional controls. However, technical measures must be considered to achieve continual improvement subject to the following secondary short term (ST), medium term (MT) and long term (LT) objectives:

- Minimize contaminant concentration at source (ST) - not deemed practical or applicable to CPA.
- Minimize contaminant infiltration at source (ST) - **preferred option for CPA**.
- Cut off migration of contaminated ground water as close as feasible to source, to prevent the movement of contaminated ground water

across boundaries - legal or arbitrary compliance boundaries (ST) - measures to prevent any migration of CPA related ground water contamination across the IVS perimeter, will be addressed in neighbouring management areas, e.g. CRMF (Dam 10) and TETP/MTP. Removal of contaminants at source within the CPA is deemed impracticable.

- Manipulate pollution plume migration to protect pre-defined areas (MT) - will be addressed in neighbouring management areas to protect IVS perimeter.
- Improve ground water quality to agreed/negotiated water quality standards (LT) - deemed impracticable within the CPA area.

The objectives for the management of air quality are proposed as follows:

- Maintain existing abatement equipment (short term)
- Address identified fugitive emissions (short term)
- Progress coke oven gas project
- Progress sinter plant project
- Refurbish the Coke ovens off-gas and water cleaning plant (medium term)
- Commission and maintain the air abatement equipment (medium term)

6.2.5 Measures

The aquifer(s) impacted on by the activities within the CPA cannot be remediated to acceptable risk levels through technical measures, over the short and medium terms. Such measures will require flushing of the aquifers with "clean" water and/or steam, and will in any event take several decades to improve the situation significantly. They are therefore considered impracticable to achieve risk compliance for large areas within the CPA over the short and medium term.

The institutional measure recommended to manage the risk within the CPA is to **re-zone** the area within the IVS perimeter (specifically also the entire CPA) for restricted ground water usage. This implies that abstraction and application control would need to be institutionalised within the current ground water impacted area, to such a level that the risk of ground water use falls within acceptable limits, subject to demonstration of continual improvement over the long term.

The following **technical measures** should be applied to address the situation at the ground water pollution sources within the CPA, as well as in the aquifers receiving contaminated water from the pollution sources. The intention of the measures is to improve the situation over the short, medium and long term. Such measures would include:

- Optimise waste and process water streams in terms of contaminant load, volumes, handling, temporary storage and reticulation/transport.

- Optimise the management of spillages to minimize footprints and incidents.
- All sumps must be lined and storage facilities bunded.

The measures designed to mitigate surface water impacts are listed below:

New Coke Stockpile area

- Prepare footprint of Coke storage area
- Construct bunding of Coke storage area
- Install surface and sub-surface water management infrastructure at new stockpile area
- Construct sump and pump system to process
- Relocate railway lines - if required
- Upgrade access road into new storage area
- Weigh bridge as required

Plant area

- Install process water pipelines
- Construct new process water holding dam North-east of CETP
- Bunding of process areas, lining of floors, installation of sumps and pipelines to make process areas Zero Effluent Discharge facilities
- Monitoring equipment to ensure that plant adheres to ZED principles
- Upgrade CETP to manage alternative sludge removal system
- Design & construct waste treatment plant for new waste dump optimisation
- Commission Environmental Awareness training program
- Upgrade of water management control system with additional infrastructure and upgraded Water Control Centre
- Upgrade Laboratory infrastructure & systems to comply with monitoring requirements

Alternative Measures Considered for the CPA

Alternative considered have been mentioned below:

- Waste/process water minimization - **preferred option**
- Spillage control - **preferred option**
- Commission new facilities - not indicated
- Seepage drains/drainage galleries - not indicated
- Slurry walls - not indicated
- Sheet piling - not indicated
- Reactive barriers - not indicated
- Pump and Treat - impracticable
- Pump and Flush - impracticable
- Infiltration galleries - not indicated
- Steam Injection - not indicated
- Solvent Injection - not indicated

- Soil Vapour Extraction - not indicated
- The two large projects, which will influence air pollution emissions from the site significantly, namely the coke oven gas project and the sinter plant project, have already been approved and are going ahead. A number of minor items, some being more of a household nature, have been identified for attention.

6.2.6 Monitoring

Monitoring must be performed to verify the efficiency of the proposed measures in attaining the stated objectives.

Current ground water quality and level monitoring borehole pairs (S-shallow and D-deep) within, and on the perimeter of the CPA include IVB-1; IVB-11; IVB-12; IVB-13; IVB-14; IVB-15; IVB-16; IVB-29; IVB-30; IVB-31; IVB-32; IVB-33; IVB-34; IVB-35; IVB-36; IVB-37; IVB-38; IVB-39; IVB-40; IVB-41; IVB-44; IVB-48; IVB-49; IVB-50; IVB-51; IVB-73; IVB-76; IVB-84; IVB-86; IVB-89; IVB-100; IVB-110; IVB-111; IVB-112; IVB-113; IVB-114; IVB-138; IVB-142; IVB-143; IVB-144; IVB-145; IVB-146; IVB-148 and IVB-149.

Additional ground water quality and level monitoring boreholes, if in fact required, will be commissioned during implementation of the proposed measures, to monitor measure efficiency and overall compliance with objectives for the CPA.

The existing monitoring programme for dust fall-out and the caravan monitoring for gases and the fine particulates should be maintained and audited bi-annually. In addition the process emission inventory should be maintained and updated so that dispersion modelling may be done.

6.2.7 Regulatory authorizations

The following legal authorization processes may be required for ground water:

- Registration of monitoring wells.
- Registration of off-gas and water cleaning projects
- Registration of scheduled processes.

6.3 Management Area 3: South-eastern Slag and Open Veld Area (SESOVA)

6.3.1 Activity Description

The South-eastern Slag and Open Veld Area consists of the Steelserv area, Heckitts South area and an open veld area, which drains into the Leeuwspruit at the Frikkie Meyer Weir.

This area falls within the eastern catchment of the site, and the Frikkie

Meyer Weir constitutes the eastern outlet point of the Works area. Existing water management structures form three lines of defence of pollution control:

1. The Steelserv surface water and shallow ground water cut-off trench and the Steelserv Sump;
2. The south-eastern boundary flow diversion wall, attenuation facilities and the Leeuwspruit Sump;
3. The Frikkie Meyer Weir and return pump house.

This area has in the past been used to store scrap metal for re-use. It also houses the scull yard and the metal recovery from the Basic Oxygen Furnace slag, by crushing and screening. In addition, Boeredienste previously blended fertiliser in the south-eastern part adjacent to the open veld area.

The Steelserv sump serves an area of approximately 54.6 ha. The activities in this area are primarily metal recovery, scrap metal storage, slag stockpiles and cooling pits. The area is not lined.

The Hecketts South area comprises approximately 19.5 ha in size. This area has been utilised predominantly for the storage of scrap metal and slags for the Steelserv processes. This area is not lined, and has however, been partially cleared on the eastern side. This cleared and rehabilitated area has been made free-draining and topsoil has been placed on the surface in order to minimise infiltration and maximise runoff.

The Open Veld Area, which previously belonged to Ferroland, now falls under IVS. The southern portion of this area is an open veld area adjacent to the old Boeredienste premises. An artificial wetland has formed and drains into the Leeuwspruit via a weir under the Frikkie Meyer Boulevard.

6.3.2 Impacts

The entire SESOVA is underlain by the Silverton Shale Formation.

Two aquifer types are present in the area namely the perched aquifer and shallow weathered zone aquifer. The thickness of the unsaturated zone varies between 1 to 4 meters. The saturated thickness of the perched aquifer varies between 1 to 4 meters, whilst the shallow weathered zone aquifer is saturated up to a thickness of some 16 meters.

No physical lateral aquifer boundaries occur within the area. The Leeuwspruit is a hydraulic aquifer boundary and acts as a ground water discharge zone.

Borehole yields in the area vary from low to medium. The aquifer hydraulic parameters (storativity and permeability) are low, whilst porosities vary from moderate to high, suggesting slow ground water flow, and restricted ground water volumes. Piezometric levels in the two aquifer zones differ with a positive gradient from the deeper to the perched aquifer. Natural recharge from rainfall is estimated at 2% to 3% of MAP.

The regional ground water flow directions are from the town of Vanderbijlpark located to the south, towards and through the area, in a north-easterly direction, as well as from the IVS works to the northwest, in a south-easterly to easterly direction. Using the observed hydraulic parameter values for the area, together with the average hydraulic gradient, the ground water flow velocity is estimated to be in the order of 10 to 12 meters per year. However the ground water flow velocity through the Slag Processing area is in the order of 2 to 4 meters per year.

The entire area is located within the IVS works perimeter and no ground water abstraction occurs for any application.

The aquifers underlying the area are classified as ***Minor Aquifer Systems***, whilst their vulnerability is classified as ***medium***. Aquifer susceptibility is classified as ***medium***, resulting in an overall aquifer protection classification of a ***medium protection level***.

The ground water discharge zone (Leeuwspruit) generically represents a ground water fatal flaw with respect to waste management.

With reference to the activity description, the ground water impact mechanism associated with the area relates to:

- infiltration of rain water into the subsurface,
- the generation of leachate as water percolates downward through the stockpiled/dumped material,
- seepage/infiltration through the footprint of the dump into the underlying perched aquifer.

Infiltration into the shallow weathered zone aquifer is limited due to the general hydraulic gradient from this zone towards the upper zone. However, this gradient could be compromised in certain areas and therefore contamination of the deeper aquifer will most probably also occur.

The downward migration of water/leachate is governed by a combination of:

- the pressure head distribution in the stockpiles,
- the hydraulic parameters of the infiltration interface (footprints and unsaturated zone),
- the hydraulic parameters of the underlying aquifers (permeability, porosity), as well as
- the piezometric pressure distribution within the two aquifer zones.

Ground water chemistry obtained from boreholes in this area, confirms elevated concentrations of Ca, Mg, SO_4, Cl, Na, Fe and Mn within both the perched and shallow weathered zone aquifers. However, the degree of concentration elevation is less for the shallow weathered zone aquifer.

Leachates under dry weather flow conditions from the Hecketts/Steelserve area, indicated potential contamination of surface and ground water by aluminium, fluorides, sulphates and to a lesser extent by cyanides. Soils of this area also indicated elevated concentrations of mobile manganese.

Organic ground water chemistry observed in the boreholes, indicate the presence of dissolved phase in low to high concentrations, however leachates and soils were devoid of organic contaminants.

The extent of the contamination in both the perched and shallow weathered zone aquifers, are restricted to the Southern Slag Processing Area - South East and to the southern part of the Open Veld Area, as well as an area to the east, up to, and beyond the eastern IVS perimeter. The concentration distribution within the plumes differ with higher concentrations observed in the perched zone. In other directions from this area, the lateral extent of the contamination is restricted due to the ground water flow pattern.

The extent of the organic contamination is restricted to the shallow weathered aquifer zone within this management area.

The extent of the contamination beyond the IVS eastern perimeter has been addressed in the Receiving Environment (Management Area 7). Apart from this, no other Management Area boundary is compromised by the ground water contamination in the SESOVA Management Area.

Wit reference to water that flows into the Leeuwspruit Sump, these waters include flows from the:

- South-eastern boundary surface flow diversion wall,
- North Works Runoff canal,
- Vaal Dam canal, and the
- Stormwater from South Works.

Flows under dry weather flow conditions from the Vaal Dam canal indicated contamination of lead, manganese and sulphates, whilst flows from the North works run-off canal predominantly indicated contamination by lead and fluorides.

The low flows stored in the Leeuwspruit Sump are pumped to the TETP for treatment and subsequently released into the western catchment. The Leeuwspruit Sump does have a spillway, which if overtopped flows into the open veld area and to the Frikkie Meyer Weir. The weir has level controls which, when activated, pump water back from the weir to

Leeuwspruit Sump.

The Hecketts South and Steelserv areas both have an impact on the surface water. Rainfall landing on these areas is immediately contaminated by dirty surface areas.

The central portion of the open veld area has an effect on surface water in that salts have been deposited on the surface by ground water base flow. These salts are subsequently dissolved by the surface water causing contamination.

The fall-out dust levels within the operational area was found to be high at times, but diminished rapidly towards the site perimeter.

6.3.3 Risks

The risk to human health represents the risk through the ground water pathway for drinking water application (adult of 60 kg drinking 2 litres of water/day). The risk to the environment represents the risk through the aquatic ecosystems pathway. The area for which both these risks is unacceptable, relates generally to the northern and eastern part of the Southern Slag Processing Area and generally the southern part of the Open Veld Area to the east. Within the Open Veld Area, most of the unacceptable risks were only observed in one borehole located directly east of the former Boeredienste. The risk assessment for the area beyond the IVS perimeter has been discussed in Management Area 7.

For the Southern Slag Processing Area, the risk to human health relates to elevated concentrations of Mg, SO_4, Na and Fe, whilst the risk to the environment relates to elevated concentrations of Mg, SO_4, Na, Fe and Mn in the perched aquifer. The risk to human health within the shallow weathered aquifer zone relates to Na, SO_4 and Fe whereas the risk to the environment is associated with elevated concentrations of Na, SO_4, Fe and Mn.

The risk to human health within the Open Veld Area relates to elevated concentrations of Ca, Mg, Na, K, Cl, SO_4, NO_3, F and Fe, whilst the risk to the environment can be associated with the same variables, as well as Mn. It is important to note that these risks generally can be associated with only one borehole, located immediately east of the former Boeredienste.

Unacceptable risks to both human health and the environment exist in terms of organic compounds (PAH) as observed in some of the boreholes.

The potential unacceptable risk of Manganese-contaminated soils of this area, indicate potential environmental risks of 12.7%, i.e. one mortality in a population (aquatic) of 8, compared to the acceptable risk of one mortality in a population of 300 000. The Manganese (mobile) in the soils presents a limited unacceptable risk to human health, the margin of safety being 121%.

No risk to human health or the environment as result of air pollution was identified.

6.3.4 Management objectives

Due to the technical impracticability of remediating the observed ground water pollution within the SESOVA to a level of acceptable risk to Human Health and the Environment, objectives will have to be reached through institutional controls. However, technical measures must also be commissioned to achieve continual improvement subject to the following secondary short term (ST), medium term (MT) and long term (LT) objectives:

- Minimize contaminant concentration at source (ST) - **preferred option**.
- Minimize infiltration of the contaminants at source (ST) - **preferred option**.
- Cut-off migration of contaminated ground water as close as feasible to source, to prevent the movement of contaminated ground water across boundaries - legal or arbitrary compliance boundaries (ST) - **preferred option**.
- Manipulate migration of the pollution plume migration to protect pre-defined areas (MT) - **preferred option**.
- Improve ground water quality to agreed/negotiated water quality standards (LT) - deemed impracticable within the SESOVA.

6.3.5 Measures

The aquifer(s) impacted on by the activities within the SESOVA cannot be remediated to acceptable risk levels through technical measures, over the short and medium terms. Such measures will require flushing of the aquifers with "clean" water and will in any event take several decades to improve the situation significantly. They are therefore considered impracticable to achieve risk compliance within the SESOVA over the short and medium term.

Re-zone area within IVS perimeter (specifically also the entire SESOVA), for ground water usage. This implies that abstraction and application control must be institutionalised within the current ground water impacted area, to such a level that the current ground water quality is within compliance, subject to demonstration of continual improvement over the long term.

With regard to technical measures, are the following recommended to address the situation at the ground water pollution sources within this management area, as well as in the aquifers receiving contaminated water. Their intention is to improve the situation over the short, medium and long term.

- Optimise waste streams in terms of contaminant load through waste minimization and selective placing.
- Optimise shaping, capping and re-vegetation of dumps, stockpiles and footprints to minimize rainfall infiltration.
- Whilst existing footprints cannot be lined at this stage, they should be kept as small as possible - no extension onto unlined areas.
- Control leachate at the toe of dumps and stockpiles with a sub surface drainage system to prevent contaminated surface run-off and soil contamination.
- Relocate stockpiles to new formally prepared, lined facilities with leachate collection systems and rehabilitate the footprints.
- Install a drainage gallery along the eastern flank of the south-eastern slag processing areas, to intercept contaminated ground water migrating through the perched aquifer away from this area towards the eastern IVS perimeters and surrounding receiving environment. These trenches must intercept seepage up to depths ranging between 4 and 6 metres.
- Install abstraction wells into the shallow weathered zone aquifer between the drainage gallery and the eastern IVS perimeter to intercept contaminated ground water migrating through the shallow weathered zone aquifer towards and across the eastern IVS perimeter. The intention of these wells will also be to manipulate the plume migration patterns, in that a reversed ground water gradient will be established, forming a local reversal of ground water flow from the surrounding receiving environment towards the IVS perimeter. In the long run, this could also cause an improvement in ground water quality in the areas beyond the borehole abstraction line.
- Construction of sub-surface drainage system alongside South-Eastern boundary wall
- Installation of abstraction well in South East corner
- Construction of sub-soil drainage sumps and pump leachate to process water system
- Remediation of affected areas between Works fence and Frikkie Meyer Drive
- Cleanup and remediation of selected areas within the Works area
- Cleanup and scrap removal of Southern scrap storage area
- Rehabilitation of Scrap storage area
- Removal of slags from Steelserv process area to dump or rehabilitation areas
- Preparation of footprint for continued steel separation plant
- Bunding of operational area
- Water and surface water management at operational areas
- Shaping of old slag storage area and make it free-draining
- Topsoiling of area and vegetation of rehabilitated areas

Alternative Measures Considered for the SESOVA:

- Line facilities (dumps and working areas) - impracticable
- Decommission/remove sources and rehabilitate - **preferred option**
- Commission new facilities - **preferred option**
- Seepage drains/drainage galleries - **preferred option**
- Slurry walls - do not facilitate abstraction
- Sheet piling - impracticable
- Reactive barriers - not applicable to observed contaminants
- Pump and Treat - **preferred option**
- Pump and Flush - flush water source is a problem
- Infiltration galleries - not indicated
- The slag handling process is being modified and moved to another location where dust control will be applied.

6.3.6 Monitoring

Monitoring is needed to verify the efficiency of the recommended measures in attaining the proposed secondary objectives. The current monitoring programme – especially for air and water should continue.

Current ground water quality and level monitoring borehole pairs (both shallow and deep) within, and on the perimeter of the SESOVA include IVB-64; IVB-87; IVB-88; IVB-91; IVB-92; IVB-132; IVB-133; IVB-134; IVB-135; IVB-136 and IVB-139.

Additional ground water quality and level monitoring boreholes should be commissioned during implementation of the proposed measures, to monitor and measure efficiency and overall compliance with objectives set for the SESOVA.

6.3.7 Regulatory Authorizations

The following legal authorization processes may be required for the SESOVA.

- Registration of abstraction and monitoring wells.
- Water Use License for ground water use/abstraction.
- EIA for abstraction system.

An Environmental Working Group was established for the Boipatong Township after representatives of a local environmental club had discussions with IVS as to perceived pollution of the Leeuwspruit and a community vegetable garden. This structure was supplemented by relevant local officials of the Departments of Health and Parks and Recreation. Other environmental issues (not associated with IVS) were also discussed at the meetings. The Boipatong Environmental Working Group "BEWG" intends to continue to function in future.

6.4 Management Area 4: South-western Slag Area (SWSA)

6.4.1 Activity Description

Hot slag from the Electric Arc Furnace (EAF) is cooled by a water spray and a slag-cooling pit, broken up by drop-ball and the crushed metal recovered. Parf of the metal is also reduced in size by lancing in the carousel, which contains a bag filter. EAF slags are also stockpiled and processed in this area.

Below the embankment on which this area is situated, an unlined cut-off canal with a sump is used to pump water back into the pit. A surface water berm has been constructed on the top of the embankment to prevent surface water from moving from the area in a south-westerly direction.

6.4.2 Impacts

The entire SWSPA is underlain by the Silverton Shale Formation.

Two aquifer types are present in the area namely the perched aquifer and shallow weathered zone aquifer. The thickness of the unsaturated zone varies between 2 and 3 meters. Saturated thicknesses for the perched aquifer vary between 2 and 3 meters, whilst the shallow weathered zone aquifer is saturated up to a thickness of some 12 meters.

No lateral aquifer boundaries are active within the area.

Borehole yields in the area vary from low to medium. The aquifer hydraulic parameters (storativity and permeability) are low, whilst porosities vary from moderate to high, suggesting slow ground water flow, and restricted ground water volumes. Piezometric levels in the two aquifer zones do not differ significantly in this area. Natural recharge from rainfall is estimated at 2% to 3% of MAP.

The regional ground water flow direction is from Vanderbijlpark in the south, towards and through the SWSA, in a north-westerly to westerly direction. Using the observed hydraulic parameter values for the area, together with the average hydraulic gradient, the ground water flow velocity is estimated to be in the order of 10 to 15 meters per year.

The entire area is located within the IVS works perimeter and no ground water abstraction occurs for any application.

The aquifers underlying the area are classified as ***Minor Aquifer Systems***, whilst their vulnerability is classified as ***medium***. Aquifer susceptibility is classified as ***medium***, resulting in an overall aquifer protection classification of a ***medium protection level***.

No ground water fatal flaws with respect to waste management are present within the area.

With reference to the activity description, the ground water impact mechanism associated with the SWSA relates to infiltration of water (rain and process water) downward through the slag cooling pit, then entering the ground water system as seepage/infiltration through the footprint of the slag cooling pit and into the underlying perched aquifer. Infiltration into the shallow weathered zone aquifer will most probably also occur, as a positive gradient does not exist from the deeper to the perched aquifer zone in this specific area.

The downward migration of leachate leaving the pit, is governed by a combination of:

- the pressure head distribution in the pit,
- the hydraulic parameters of the infiltration interface (footprint and unsaturated zone),
- the hydraulic parameters of the underlying aquifers (permeability, porosity), as well as
- the piezometric pressure distribution within the two aquifer zones.

Ground water chemistry obtained from the boreholes in this area confirms elevated concentrations of Ca, Mg, Na, Cl, SO_4, Fe and Mn within the perched aquifer zone, with elevated concentrations of Ca, Mg, Na, Cl, SO_4, Fe and Mn within the shallow weathered aquifer zone. The degree of contamination is less for the perched aquifer zone.

Soils in this area are contaminated by manganese

No organic contamination of the ground water could be observed from samples taken from any of the boreholes in this area, nor were the soils contaminated by organics.

The extent of the contamination in both the perched and shallow weathered zone aquifers includes the entire footprint of the pit, as well as an area to the west of the pit. The concentration distribution within the plumes differs with higher concentrations observed in the shallow weathered aquifer zone. In other directions from the dump, the lateral extent of the contamination is restricted due to the ground water flow pattern.

No other Management Area boundary is compromised by the ground water contamination in this SWSA Management Area.

Similar to the South-Eastern Slag Area, the soils of the South-western Slag Area are highly contaminated, specifically with Manganese and Calcium.

Rain falling on this area becomes contaminated surface water runoff, and when it infiltrates the ground water it causes contamination and raises the water table level. Salts are deposited on the lower lying area to the south-west of the slag processing area due to the upward movement (percolation) of groundwater. Rainwater landing on this area becomes contaminated through contact with these salts. Wind-blown dust also gives rise to contamination of the surface water problem.

At the start of the fall-out monitoring period, dust levels were high, mainly due to the roadways. Interim steps were implemented and this reduced dust loads to less than half within 6 months, to a level expected in such an industry. The fall-out however decrease rapidly with distance and impact was identified beyond the site perimeter.

6.4.3 Risks

The area for which potential risks is unacceptable, relates to the entire footprint of the slag cooling pit as well as an area to the west of the pit. For the SWSA the risk to human health relates to elevated concentrations of Mg, SO_4, Na and Fe, whilst the risk to the environment relates to elevated concentrations of Mg, SO_4, Na, Fe and Mn in the perched aquifer. The risk to human health within the shallow weathered aquifer zone relates to Ca, Mg Cl, SO_4 and Fe, whereas the risk to the environment is associated with elevated concentrations of Ca, Mg, Na, SO_4, Fe and Mn.

The mobility of manganese in these impacted soils indicates a potential risk of 5.73%, i.e. one mortality in a population (aquatic) of 17, the acceptable risk to the environment being one mortality in a population of 300 000. Risk to human health however is acceptable, with a margin of safety of 97%, the pathway being groundwater.

6.4.4 Management Objectives

Due to the technical impracticability of remediating the observed ground water pollution within the SWSA to a level of risk acceptable to human health and the environment. Institutional controls will be needed to supplement the technical measures to achieve the desired goals. Technical measures should also be commissioned to achieve continual improvement subject to the following secondary short term, medium term and long term objectives:

- Minimize contaminant concentration at source (ST) - **preferred option.**
- Minimize contaminant infiltration at source (ST) - **preferred option.**
- Cut-off migration of contaminated ground water as close as feasible to source, to prevent the movement of contaminated ground water across boundaries - legal or arbitrary compliance boundaries (ST) - not indicated.

- Manipulate pollution plume migration to protact pre-defined areas (MT) - not indicated.
- Improve ground water quality to agreed/negotiated water quality standards (LT) - deemed impracticable within the SWSA.

In order to manage the quality of air, tha genaration of dust should ba reduced, especially in the short term, by keeping the roads clean.

6.4.5 Measures

The aquifer(s) impacted on by the activities within the SWSA cannot be remediated to acceptable risk levels through technical measuras, over tha short and medium terms. Such maasures will require flushing of the aquifers with "clean" water and will in any event take several decades to improve the situation significantly. They are therefore considered impracticable to achieve risk compliance within the SWSA over the short and medium term.

The recommended institutional measure necessary for the SWSA is to **re-zone** the area within IVS perimeter (specifically also the entira SWSA), for controlled ground water usage. This implies that abstraction and application control must be institutionalised within the current ground water impacted area, to such a level that the risk of ground water use is within acceptable limits, subject to demonstration of continual improvement over the long term.

The following technical maasures are recommended to be applied to address the situation at the ground water pollution sources within the SWSA, as well as in the aquifers receiving contaminated water. The intention of the measures is to improve the situation over tha short, medium and long term.

- Optimise waste streams in terms of contaminant load, through waste minimization and selective placing.
- Whilst existing dump footprints cannot be lined at this stage, they should be kept as small as possible - no extension onto unlined areas.
- Control leachate with sub surface drainage systems at the toe of the processing areas to prevent contaminated surface run-off and soil contamination.
- Line the current slag cooling pit with a concrete liner to minimize infiltration of leachates into tha ground water system.
- Install a drainage gallery along the south-western flank of the south-western slag processing area (below the embankment), to intercept contaminated ground water migration through the perched aquifer away from this facility towards the westarn IVS perimeter and surrounding receiving environment. These trenches will need to intercept seepage down to depths of between 4 and 6 meters.

- Landscape and remediated the area west of the drain to be free-draining.

The access roads need to be kept clean to reduce the generation of dust.

The following **alternative measures** have been considered for the SWSA:

- Waste minimization - **preferred option**
- Pollution control - **preferred option**
- Line facilities - **preferred option**
- Decommission/remove sources and rehabilitate - not indicated
- Commission new facilities - not indicated
- Seepage drains/drainage galleries - **preferred option**
- Slurry walls - not indicated
- Sheet piling - not indicated
- Reactive barriers - not indicated and not applicable to observed contaminants
- Pump and Treat - not indicated
- Pump and Flush - flush water a problem
- Infiltration galleries - not indicated

6.4.6 Monitoring

Monitoring must be performed to verify the efficiency of the proposed measures in attaining the stated objectives.

Current ground water quality and level monitoring borehole pairs (shallow and deep) within, and on the perimeter of the SWSA include IVB-63 and IVB-131.

Additional ground water quality and level monitoring boreholes, if in fact required, will be commissioned during implementation of the proposed measures, to monitor and measure efficiency and overall compliance with objectives for the SWSA.

6.4.7 Regulatory Authorizations

The following legal authorization processes may be required for the SWSA:

- Registration of monitoring wells.

6.5 Management Area 5: Terminal Effluent Treatment Plant (TETP) and Main Treatment Plant (MTP) Area

6.5.1 Activity Description

This area is situated within the western catchment and on the western perimeter of the site. The main activity is storage and treatment of effluents and storm water before release to the Rietspruit canal. The treatment consists of pH adjustment and solids removal. This area is also earmarked for the new Main Treatment Plant (MTP), which will treat plant effluents to a quality that will enable re-use within the Works or as feed to the evaporator plant. All the surface water during low flow conditions passes through the TETP. All the surface water from the western catchment passes through the TETP canal during storm flow conditions. The TETP has a capacity of 86 000 m^3/day (approximately 1 m^3/s). The North and South Buffer Dams have volumes of 42 500 m^3 and 10 200 m^3 respectively. These buffer dams operate as flood attenuation facilities as well as silt traps. During high flow conditions the buffer dams fill and the water is redirected to a bypass canal which enters the TETP canal. The TETP canal has a capacity of 6 m^3/s. Should the flow into the TETP canal exceed this value, the water overtops into a flood attenuation buffer dam, situated to the northwest of the TETP. When the flow in the TETP canal recedes, the water enters this canal from the attenuation dam via non-return valves.

The Main Treatment Plant (MTP) will be integrated with the TETP and will substantially upgrade the Work's ability to treat and manage effluent water. This infrastructure will enable the site to achieve the Water Use Licence condition of Zero Effluent Discharge (ZED) by 2005.

6.5.2 Impacts

The entire TETP and MTP Area are underlain by the Silverton Shale Formation.

Two aquifer types are present in the areas namely the perched aquifer and the shallow weathered zone aquifer. The thickness of the unsaturated zone varies between 1 to 4 meters. Saturated thicknesses for the perched aquifer vary between 1 to 4 meters, whilst the shallow weathered zone aquifer is saturated up to a thickness of some 11 meters.

No physical lateral aquifer boundaries are active within the area. The Rietkuilspruit acts as a hydraulic aquifer boundary, in that it represents a ground water discharge zone.

Borehole yields in the area vary from low to medium. The aquifer hydraulic parameters (storativity and permeability) are low, whilst porosities vary from moderate to high, suggesting slow ground water flow, and restricted ground water volumes. Piezometric levels in the two aquifer zones differ with a positive gradient from the deeper to the perched aquifer. Natural recharge from rainfall is estimated at 2% to 3% of MAP.

The regional ground water flow direction is from east to westerly by north-westerly.

Despite the presence of mounding underneath the dams in this area, the extent thereof is insufficient to alter the regional ground water flow pattern. Using the observed hydraulic parameter values for the area, together with the average hydraulic gradient, the ground water flow velocity is in the order of 10 to 15 meters per year.

The entire TETP/MTP area is located within the IVS works perimeter and no ground water abstraction occurs for any application.

The aquifer(s) underlying the area are classified as ***Minor Aquifer Systems***, whilst their vulnerability is classified as ***medium***. Aquifer susceptibility is classified as ***medium***, resulting in an overall aquifer protection classification of a ***medium protection level***.

No ground water fatal flaws with respect to waste management are present within the area.

With reference to the activity description, the ground water impact mechanism associated with the area relates to infiltration of water (rain and process water) downward through the footprints of the dams entering the ground water system as seepage/infiltration through the footprints of the dams into the underlying perched aquifer. Infiltration into the shallow weathered zone aquifer is limited due to the positive hydraulic gradient from this zone towards the upper zone. However, this gradient could be compromised in certain areas and therefore contamination of the deeper aquifer will most probably also occur.

The downward migration of water leaving the footprints is governed by a combination of the pressure head distribution in the dams, the hydraulic parameters of the infiltration interface (footprint and unsaturated zone), the hydraulic parameters of the underlying aquifers (permeability, porosity), as well as the piezometric pressure distribution within the two aquifer zones.

Ground water chemistry obtained from the boreholes in this area, confirm elevated concentrations of Ca, Mg, Na, Cl, SO_4, F, Fe and Mn within the perched aquifer zone, with elevated concentrations of Ca, Mg, Na, Cl, SO_4, NO_3, F, Fe and Mn within the shallow weathered aquifer zone. The degree of contamination is less for the shallow weathered aquifer zone.

No significant organic contamination of the ground water could be observed from samples taken from any of the boreholes in this area.

The extent of the contamination in both the perched and shallow weathered zone aquifers includes the entire footprints of the dams, as well as an area to the west, extending beyond the western IVS perimeter. The concentration distribution within the plumes differs with higher concentrations observed in the perched zone. In other directions, the lateral extent of the contamination is restricted due to the ground water flow pattern. The degree of contamination observed in the boreholes in the northern part of this area can be ascribed to contributions from neighbouring sources such as Dam 10 and the Direct Reduction (DR) plant materials stockpiles.

The extent of the contamination beyond the IVS western perimeter will be discussed in the section dealing with the Receiving Environment (Management Area 7). Apart from this, no other Management Area boundary is compromised by the ground water contamination in this Management Area.

Soils in the TETP area indicate high contamination of specifically zinc.

The Rietkuilspruit emanates from the storm water system of the northern portion of the town of Vanderbijlpark. This flow passes under Delfos Road, and flows along the boundary of Iscor's site. It then passes over the TETP canal on a steel bridge and flows parallel to the Golden Highway. This stream subsequently turns ninety degrees (in a westerly direction) and follows its natural drainage path in the catchment.

The TETP removes suspended particles from the low flows emanating in IVS, thus improving the quality of surface water in the TETP canal, and ultimately the Rietkuilspruit and Rietspruit;

The various buffer dams attenuate the flows, both for dry weather and storm conditions, thus lowering the peaks of flows and attenuating floods within the deign specification that pass through the system. Thos lowers the risk of contaminated storm water leaving the property.

The buffer dams are unlined facilities, and effluent water temporarily stored in them would therefore have an influence on groundwater quality and levels;

The MTP is intended to have a major impact on the flows in the system, since no effluent water would be discharged from the site during low flow conditions, post 2005.

6.5.3 Risks

The area for which risks are unacceptable relates to the entire footprints of the dams and an area to the west, up to, and beyond the western perimeter of IVS. For the MTP/TETP area, the risk to human health relates to elevated concentrations of Ca, Mg, Cl, SO_4, Na, F and Fe, whilst the risk to the environment relates to elevated concentrations of Ca, Mg, Cl, SO_4, Na, F, Fe and Mn, in the perched aquifer. The risk to human health within the shallow weathered aquifer zone relates to Ca, Mg Cl, SO_4, NO_3, F and Fe whereas the risk to the environment is associated with elevated concentrations of Ca, Mg Cl, SO_4, NO_3, F, Fe and Mn. It is important to note that the risks within the shallow weathered aquifer zone were generally observed in monitoring boreholes (3) in the northern part of the area.

A potential risk to groundwater exists due to zinc contamination of soils (0.256%), i.e. one mortality in a population of 389. The potential risk to human health however is acceptable.

6.5.4 Management Objectives

Due to the technical impracticability of remediating the observed ground water pollution within the TETP/MTP area to levels which will represent a level of risk acceptable to human health and the environment, these objectives will have to be reached through institutional controls. However, technical measures must be commissioned to achieve continual improvement subject to the following secondary short term (ST), medium term (MT) and long term (LT) objectives:

- Minimize contaminant concentration at source (ST) - **preferred option**.
- Minimize infiltration of contaminant at source (ST) - **preferred option**.
- Cut off migration of contaminated ground water as close as feasible to source, to prevent the movement of contaminated ground water across boundaries - legal or arbitrary compliance boundaries (ST) - **preferred option**.
- Manipulate pollution plume migration to protect pre-defined areas (MT) - not indicated.
- Improve ground water quality to agreed/negotiated water quality standards (LT) - deemed impracticable within the TETP/MTP area.

6.5.5 Measures

The aquifer(s) impacted on by the activities within the TETP/MTP area cannot be remediated to acceptable risk levels through technical measures, over the short and medium terms. Such measures will require flushing of the aquifers with "clean" water and will in any event take several decades to improve the situation significantly. They are therefore considered impracticable to achieve risk compliance within the TETP/MTP area over the short and medium term.

Recommended **institutional measures** would include the **re-zone** area within IVS perimeter (specifically also the entire TETP/MTP area), for restricted ground water usage. This implies that abstraction and application control must be institutionalised within the current ground water impacted area, to such a level that the risk of ground water use is within acceptable limits, subject to demonstration of continual improvement over the long term.

The following **technical** measures will be applied to address the situation at the various ground process and surface water pollution sources within the TETP/MTP area, as well as in the aquifers receiving contaminated water from the pollution sources. Their intention is to improve the situation over the short, medium and long term.

- Whilst dams contain water, optimise water quality to as low as possible concentrations.
- Whilst dams contain water, minimize infiltration by keeping the water level as low as possible until the dams are emptied.
- Empty existing unlined dams and line.
- Optimise process water streams in terms of contaminant load, volumes, handling, temporary storage and reticulation/transport.
- Optimise the management of spillages to minimize footprints and incidents.
- All sumps must be lined and storage facilities bunded.
- Install drainage gallery to intercept contaminated ground water migration through the perched aquifer away from the facilities towards the western IVS perimeter and surrounding receiving environment. These trenches must intercept seepage up to depths ranging between 4 and 6 meters.
- Construction of MTP plant infrastructure
- Upgrading and lining of South Buffer dam
- Upgrading and lining of MTP intake water dam
- Upgrading and cleaning of North Buffer dam
- Upgrading, cleaning and extension of flood attenuation dam
- Construction of new Southern Storm water control dam
- Construction of new Product Storage dam
- Removal and rehabilitation of existing sludge dams
- Re-routing of current storm water canals V1/V3 to outflow canal
- Installation of spillway in flood attenuation dam
- Modification of overflow bypass canal
- Modifications to controlled outlet from attenuation dam to Rietkuilspruit
- New wet weather outflow canal to Rietkuilspruit
- New sump and pump in bypass canal to process water dam
- Modifications to inlet and overflow infrastructure at North Buffer Dam inlet
- Allowance for future holding dams to West of plant at outlet

Various **alternative measures** have been considered for the TETP/MTP and these include:

- Process water minimization - **preferred option**
- Spillage control - **preferred option**
- Upgrade existing unlined facilities - **preferred option**
- Seepage drains/drainage galleries - **preferred option**
- Slurry walls - not indicated

- Sheet piling - not indicated
- Reactive barriers - not indicated
- Pump and Treat - impracticable
- Pump and Flush - impracticable
- Infiltration galleries - not indicated

6.5.6 Monitoring

Monitoring must be performed to verify the efficiency of the proposed measures in attaining the suggested secondary objectives.

Current ground water quality and level monitoring borehole pairs (shallow and deep) within, and on the perimeter of the TETP/MTP area include IVB-49, IVB-50, IVB-51, IVB-110, IVB-111, IVB-112, IVB-113 and IVB-114.

Additional ground water quality and level monitoring boreholes will be commissioned during implementation of the proposed measures to monitor and measure efficiency and overall compliance with objectives for the TETP/MTP.

Water entering the two buffer dams is monitored by means of Analysis Houses 1, 2, 3 and 5. Water leaving the site is monitored continuously by means of Analysis House 4, and daily by means of a composite grab sample at the same position. Results of the composite sample, together with the continuous flow gauge, are used for the monthly reporting to DWAF.

6.5.7 Regulatory Authorizations

The following legal authorization processes may be required for ground water:

- Registration of monitoring wells.
- Water license for ground water use/abstraction.
- EIA for abstraction system.

6.6 Management Area 6: Kiewiet Area

6.6.1 Activity Description

This open veld area was used during the 1980s to evaporate effluent process water by irrigation. The area of approximately 385 ha lies on the catchment divide and also contains a number of borrow pits.

6.6.2 Impacts

The geology within the Kiewiet Area is fairly complicated and consists mainly of Hekpoort andesite, Strubenkop shale and quartzite, the

Daspoort quartzite and shale, and the Silverton Formation shale with inter-bedded quartzite, hornfels, limestone and volcanic tuff, intruded by Transvaal diabase sills. Quaternary deposits of alluvium and gravel are also present in places.

Two major regional structures cut through the area, namely, a fault and a dolerite dyke.

Two aquifer types are present in the area, namely a perched aquifer (discontinuous) and a shallow weathered zone aquifer. The thickness of the unsaturated zone varies between 4 to 5 meters. Saturation of this perched aquifer is 1 metre deep, whilst the shallow weathered zone aquifer is saturated up to a thickness of some 13 meters.

Two types of lateral aquifer boundaries exist in the Kiewiet Area. **Physical** aquifer boundaries include the impermeable dolerite dyke and other geological discontinuities, such as where geological layers pinch out or outcrop. Secondly, **hydraulic** aquifer boundaries include the ground water divide, which acts as a no-flow boundary. The regional ground water flow divide runs along a north-south line across the Kiewiet Area. With respect to the influence of physical aquifer boundaries in the Kiewiet Area on ground water flow, the distribution of weathering depth indicates neither the dolerite dyke nor the geological contact zone to be effective physical no-flow (impermeable) boundaries.

Borehole yields in the area vary from low to high. The aquifer hydraulic parameters (storativity and permeability) are low, whilst porosities vary from moderate to high. This suggests slow to medium ground water flow and restricted ground water volumes. No significant difference in piezometric levels in the two aquifer zones could be observed. In general, the ground water level in the area is deeper than for the other areas described. Natural recharge from rainfall is estimated at 2% to 3% of MAP.

The regional ground water flow directions are towards the west (small part/area on the eastern side of the Kiewiet Area), to the north, to the east, as well as in a south-easterly direction. Using the observed hydraulic parameter values for the area, together with the average hydraulic gradient, the ground water flow velocity is in the order of 40 to 60 meters per year.

The entire area is located within the IVS Works perimeter. One borehole drilled on the dyke is currently being utilized by Ferroland for animal watering purposes.

The aquifer(s) underlying the area are classified as ***Minor Aquifer Systems***, whilst their vulnerability is classified as ***medium***. Aquifer susceptibility is classified as ***medium***, resulting in an overall aquifer protection classification of a ***medium protection level***.

Ground water fatal flaws with respect to waste management are present within the area. These include:

- an emergent ground water area (south eastern side of the Kiewiet Area),
- ground water recharge areas (fractured, rocky outcrops, topographical ridges, disturbed topographical areas),
- possible important aquifer in terms of observed yields, and
- the dolerite dyke (preferential flow path).

Extensive work (drilling, sampling, pump testing) on the dyke has indicated no preferential contaminant migration along the dyke to date.

With reference to the activity description, the ground water impact mechanism associated with the area, relates to infiltration of water (rain and irrigation) downward through the subsurface, then entering the ground water system as seepage/infiltration into the underlying aquifer(s).

The downward migration of water is governed by a combination of the hydraulic parameters of the infiltration interface (unsaturated zone), the hydraulic parameters of the underlying aquifer(s) (permeability, porosity), as well as the piezometric pressure distribution within the aquifer zones.

Ground water chemistry obtained from the boreholes in this area, confirm elevated concentrations:

- within the perched aquifer zone of Mg, Na, NO_3, Cl, SO_4, Fe and Mn,
- within the shallow weathered aquifer zone for Ca, Mg, Na, Cl, SO_4, NO_3, F, Fe and Mn.

The degree of contamination is less for the perched aquifer zone.

Low levels of organic contamination were observed in ground water samples taken from 5 boreholes in this area (total number of 21 holes). The extent of the observed organic contamination is restricted to the shallow weathered aquifer zone within the bounds of the Kiewiet Area.

The extent of the contamination in the aquifer(s) includes the entire footprint of the Kiewiet Area, as well as an area to the east, up to, and beyond the IVS perimeter. The concentration distribution within the plumes differs with higher concentrations observed in the shallow weathered aquifer zone. In other directions the lateral extent of the contamination is restricted due to the ground water flow pattern.
The extent of the contamination beyond the IVS eastern perimeter will be discussed in the Receiving Environment Management Area 7. Apart from this, no other Management Area boundary is compromised by the ground water contamination in the Kiewiet Management Area.

The soil in the Kiewiet Area is only slightly contaminated with Aluminium and Iron. Contamination by Calcium, Sulphates and Chlorides is negligible.

The area is utilised as a pastureland for game farming and is managed by Ferroland. The following types of game are farmed within this area: Black Wildebeest, Springbok, Blesbok, Red Hartebeest, Zebra and Ostriches. Both natural and planted (artificial) pastures have been established. The stocking ratio for the natural veld is one large stock animal per six hectares, while the stocking ratio for the planted pastures is one large stock animal per three hectares. The dominant soil types occurring in this area, as classified according to the Taxonomical Classification System for South Africa (Macvicar, 1991) are the Hutton, Avalon and Bainsvlei forms. The stock watering provision within this area is supplied by means of small earthen dams. The Klewiet game farming area has been joined with the Cyferpan area by a strip of land to the north of Dams 1-4 (combined area of 780 ha). This combined area is fenced with an electrified two metre high fence with 20 wires.

The Kiewiet Area is currently being rehabilitated. Several grass species have been introduced, and the area is classified as pioneer grassland. The primary rehabilitation objective is to develop the area into a game park, and red hartebeest, and ostriches had been introduced at the time of the survey. However, the area does still represent an industrially impacted area. Some 38 % of the plant species observed commonly occur in disturbed areas. This figure is significantly lower than what was observed in other areas within the IVS perimeter. The historical impact on plant life relates to disruption of the soil profile, loss of topsoil, destruction of vegetation, trampling, increased edge effect and invasion of alien species. Much of these original causes have now been addressed. For animal life the historical impacts relate to destruction of habitat, disturbance in migration patterns, loss of food sources and increase in pest species. Although some of them are being addressed, the fact that the area remains fenced will still affect the natural migration of larger mammals. The natural reintroduction of small mammals and reptiles, however, is possible and as the habitat improves, is expected to occur. No endangered, rare or vulnerable plant and animal species were recorded during the site observations. Although the site is currently being rehabilitated, it is unlikely that any of these species will occur at this stage.

- This area falls within both the eastern and western catchments of the IVS site, with surface water flowing into both catchments;
- The surface water is not controlled over this area, and overland flow occurs through the pastures;
- Surface water exits the Kiewiet Area at two points, at its south-eastern extremity (where the water passes under the Frikkie Meyer Boulevard), and near the entrance to the Northern Gate of IVS. Secondly, overland flow from Kiewiet Area flows over the western boundary of the area into the CRMF;

Clean runoff water flows into the CRMF area from the western boundary of the Kiewiet Area. This relatively clean water mixes with the dirty water from the CRMF, which has a negative effect on the quality of the surface water generated within the Kiewiet Area.

6.6.3 Risks

It is important to note that concentrations of contaminants observed, in ground water indicated risks to be unacceptable. These relate generally to individual boreholes within the Kiewiet Area, as well as an area to the east, up to, and beyond, the eastern IVS perimeter. For the Kiewiet Area the risk to human health relates to elevated concentrations for Mg, Cl, SO_4, Na, NO_3, and Fe, whilst the risk to the environment relates to elevated concentrations for Mg, Cl, SO_4, Na, NO_3, Fe and Mn in the perched aquifer. The risk to human health within the shallow weathered zone aquifer, relates to Ca, Mg, Cl, SO_4, NO_3 and Fe whereas the risk to the environment is associated with elevated concentrations of Ca, Mg, Cl, SO_4, NO_3, Fe and Mn.

Although the soil in this area shows contamination, by Aluminium and Iron, the levels are considered acceptable to the environment. However, these levels are potentially unacceptable to human life with margins of safety of 237% and 143% respectively.

There is a definite potential risk in that the "clean" water runoff from the Kiewiet Area will mix with the dirty water from the CRMF, thus increasing the volume of water that needs to be treated and/or contained within the site.

Both the plant and animal ecology has been compromised at Kiewiet Area. The area still remains disturbed, with a low to medium ecological quality and risk. As the newly established communities become established and stabilise, the risk is likely to decrease.

A consultation process was held during the selection process for a candidate landfill site, of which the Kiewiet site was the preferred option pending detailed technical investigations. The Public have thus previously been made aware of the Kiewiet Area.

6.6.4 Management Objectives

Due to the technical impracticability for remediation of the observed ground water pollution within the Kiewiet Area to levels which will represent acceptable risk to Human Health and the Environment, these objectives will have to be reached through institutional controls. However, technical measures must be commissioned to achieve continual improvement subject to the following secondary short term (ST), medium term (MT) and long term (LT) objectives:

- Construct a surface drainage canal towards the South-East
- Install a groundwater abstraction system to the East of the Kiewiet area
- Install pumps and pipelines to the process water system for treatment
- Remediate selected areas within the Kiewiet area
- Rehabilitate Old Borrow pits
- Maintain vegetation
- Minimize contaminant concentration at source (ST) - **irrigation has ceased and the site is already being rehabilitated**.
- Minimize contaminant infiltretion at source (ST) - **irrigation has ceased and the site is already being rehabilitated**.
- Cut of the migration of contaminated ground water as close as feasible to source, to prevent the movement of contaminated ground water across boundaries - legal or arbitrary compliance boundaries (ST) - **preferred option**.
- Manipulate pollution plume migration to protect pre-defined areas (MT) - **preferred option**.
- Improve ground water quality to agreed/negotiated water quality standards (LT) - not indicated.

6.6.5 Measures

The aquifer(s) impacted on by the activities within the Kiewiet Area cannot be remediated to accaptable risk levels through technical measures, over the short and medium terms. Such measures will require flushing of the aquifers with "clean" water and will in any event take several decades to improve the situation significantly. They are therefore considered impracticable to achieve risk complience within the Kiewiet Area over the short and medium term.

The recommended institutional **re-zone** the area within the perimeter of IVS (specifically also the entire Kiewiet Area), for restricted ground water usage. This implies thet abstraction and application control must be institutionalised within the current ground water impacted area, to such a level that the risk of ground water use falls within levels of acceptable risk, subject to the demonstration of continual improvement over the long term.

In addition to termination of the irrigation activities and the rehabilitation which has largely been completed, the following **technical** measures should be applied to address the situation within the Kiewiet Area, as well as in the aquifers underlying the site. Their intention is to improve the situation over the short, medium and long term.

- Install abstraction wells into the shallow weethered zone aquifer between the old irrigation areas and the eastern IVS perimeter to intercept contaminated ground water migration through the shallow weathered zone aquifer, across the IVS perimeter. The intention of these wells will also be to manipulate the plume migration pattems, in that a reversed ground water gradient will be established. This would form a local reversal of ground water flow from the surrounding receiving environment towards the IVS perimeter. In the long run, this could also cause an improvement in ground water quality in the areas beyond the borehole abstraction line.

The **alternative** measures considered for the Kiewiet Area include:

- Decommission/remove sources and rehabilitate - **completed**
- Commission new facilities - not required
- Seepage drains/drainage galleries - not indicated
- Slurry walls - not indicated
- Sheet piling - not indicated
- Reactive barriers - not indicated
- Pump and Treat - **preferred option**
- Pump and Flush - not indicated, source of flush water a problem
- Infiltration galleries - not indicated

The following options for possible management measures have been identified for plant and animal life subject to the actual activity and resulting impact within a specific area, for implementation according to the life cycle phase of the specific activity and impact.

- Identification of threatened species - short term.
- Ongoing monitoring - medium and long term.
- Selective soil stockpiling - medium and long term.
- Compile seed bank of natural species - medium and long term.
- Re-introduce natural vegetation to denuded areas - medium and long term.
- Prevent unnecessary species removal - medium and long term.
- Limit the number of roads - medium and long term.
- Control alien and invader species - medium and long term.
- Limit human access where possible- medium and long term.
- Institute a buffer zone around activities - medium and long term.
- Restrict activity area - medium and long term.
- Limit and control vehicular traffic - medium and long term.
- Control invader species - medium and long term.

6.6.6 Monitoring

Monitoring must be performed to verify the efficiency of the proposed measures in attaining the stated objectives.

Current ground water quality and level monitoring borehole pairs (shallow and deep) within, and on the perimeter of the Kiewiet Area include IVB-21; IVB-22; IVB-23; IVB-24; IVB-25; IVB-26; IVB-27; IVB-28; IVB-79; IVB-82; IVB-83; IVB-84; IVB-85; IVB-94; IVB-126; IVB-127; IVB-128; IVB-129; IVB130; IVB-154 and IVB-155.

Additional ground water quality and level monitoring boreholes are recommended to be commissioned during implementation of the proposed measures to monitor and measure efficiency and overall compliance with objectives for the Kiewiet site.

For plant and animal life, monitoring of the applicable environmental variables are necessary to prevent the degradation of the ecosystem. A floral and faunal survey should be conducted once a year, in which species lists are compiled and the abundance of each of the specific species recorded. Throughout the year, any unusual occurrences in the floral and faunal communities should be monitored.

6.6.7 Regulatory Authorizations

The following legal authorisation processes may be required for ground water.

- Registration of abstraction and monitoring wells
- Water licence for ground water use/abstraction

EIA for abstraction system

6.7 Management Area 7: Perimeter and Immediate Surrounding Areas (PISA)

6.7.1 Activity Description

The perimeter of the site is approximately 19.77 km in length. The area to the **west** of the site consists predominantly of agricultural holdings bought out by IVS. The bought-out area is managed by Ferroland as veld and pasture land for game and cattle farming. The area to the west of the R57 (main road into Vanderbijlpark from N1 highway) is utilised for the farming of cattle, while the area to the east of this road is utilised for the farming of game. This area does not have a specific zoning (undetermined). The Rietkuilspruit and TETP canal pass through this area.

The area to the **south and southwest** of the Works is classified as Industrial Area NW7, and is zoned as Industrial Type II. Portions of these areas are occupied by small to medium sized industries, while portions of this land are vacant open veld areas. Beyond this area (in a southerly direction) is the residential area of Bophelong.

The area to the **southeast** of the Works has various portions zoned as residential, municipal, agricultural and Industrial Type II. These areas include the Leeuwspruit and the residential areas of Boipatong and Vanderbijlpark CW7.

The area to the **east** of IVS is zoned predominantly as agricultural, although bands of land are zoned for SAR and Industrial Type II. The area to the **north and northeast** of IVS includes areas zoned as places of education, offices, entertainment, refreshment, dwelling units, agricultural (including Cyferpan), SAR, brick making, and manufacturing of clay products and reinforced beams. Beyond this area (in a northerly direction) is the residential area of Sebokeng.

A strip of land which surrounds the IVS premises, is characterised by a wide range of infrastructure, activities and phenomena such as:

- Smaller industries.
- Residential areas, e.g. Boipatong, Tshepiso, Bophelong, Bonanne, agricultural smallholdings.
- Abandoned agricultural smallholdings.
- Land covered with numerous koppies such as Wolwekop, Houtheuwel, Mountridge, Langeraad and Eerstekop.
- Pieces of undisturbed land.

6.7.2 Impacts

It should be stated right at the outset of this discussion, that the areas discussed here, are located outside the IVS plant perimeter, and the impacts observed, can be related to activities/sources (single or combinations) within the IVS plant perimeter. The following areas outside the IVS plant perimeter have been identified through the ground water base line study, to have been impacted:

The impact on human health and to the environment within the following areas outside the IVS perimeter:

- Area opposite TETP/MTP
- Area opposite Dam 10 and the Existing Waste Dump
- Area opposite Dams 1-4
- Area opposite the Kiewiet Area
- Area opposite the South Eastern Slag Processing and Open Veld Area (SESOVA)

Area opposite TETP/MTP

The area is located immediately to the west of the TETP/MTP and is entirely underlain by the Silverton Shale Formation.

Two aquifer types are present in the area, namely the perched aquifer zone (discontinuous) and the shallow weathered zone aquifer. The thickness of the unsaturated zone measures some 2,5 to 4 meters, whilst the saturated thicknesses for the perched aquifer measures some 1 to 2,5 meters. The shallow weathered zone aquifer is saturated up to a thickness of some 11 meters.

The only definable lateral aquifer boundary that exists in the area is the Rietkuilspruit stream. This stream represents a hydraulic boundary and manifest as a ground water discharge zone. This stream emanates from a storm water system in the northern parts of the town of Vanderbijlpark.

Borehole yields in the area vary from low to high (IVB-D96 - blow yield of 7 *l/s*). The aquifer hydraulic parameters storativity and permeability are low, whilst porosities vary from moderate to high, suggesting slow to medium ground water flow velocities and restricted volumes of ground water. Natural recharge from rainfall is estimated at 1% to 3% of MAP. No ground water abstraction for any application occurs for at least some 2,6 kilometres from the IVS western perimeter, along the Rietkuilspruit stream.

The regional ground water flow direction is towards the west. Using the observed hydraulic parameter values for the area, together with the average hydraulic gradient, the ground water flow velocity is in the order of 15 - 24 meters per year. It is important to note that this velocity can vary within localized areas.

The entire impacted area is located within IVS property.
The aquifer underlying the area are classified as ***Minor Aquifer Systems***, whilst their vulnerability, is classified as ***medium***. Aquifer susceptibility is classified as ***medium***, resulting in an overall aquifer protection classification of a ***medium protection level***.

The only ground water fatal flaw within this area with respect to ground water is the Rietkuilspruit, being a ground water discharge zone.

The ground water impact mechanism associated with the area relates to the hydraulic and hydro-chemical manifestation of contaminants at source (within IVS plant perimeter), resulting in contamination of the underlying perched aquifer zone and the shallow weathered aquifer zone, with the subsequent lateral migration of these contaminants as ground water contaminant plumes. For all contaminants in solution, for which the major migration mechanism is advection, the contaminant plume is therefore anticipated to manifest in a westerly direction along the ground water flow direction.

Only 3 boreholes are currently available in this area to assess the impact and risk with, all 3 of which could also be influenced by other source areas. Ground water chemistry obtained from the 3 boreholes in this area, confirm elevated concentrations of Ca, Mg, Cl, SO_4, Na, F, Fe and Mn within the perched aquifer zone and elevated concentrations of Ca, Mg, Cl, SO_4, F, Fe and Mn in the shallow weathered zone aquifer. The degree of contamination (observed concentrations) is generally higher for the shallow weathered zone aquifer - based on a borehole next to the stream. Additional boreholes will be required to refine this assessment.

Low levels of organic contamination of the ground water were observed from samples taken from 3 boreholes in this area. These trace concentrations of organic constituents are probably due to analytical limitations as can be expected at very low concentrations (values reported are in proximity of the detection level), and not due to any form of organic pollution. In addition could they not be related to any organic source(s) through the source - pathway - receptor principle. These concentrations are therefore equivocal and should be interpreted as such.

The inorganic contamination observed in the aquifer(s), of the 3 monitoring boreholes, extends to a distance of some 800 meters beyond the IVS perimeter - one borehole which was situated next to the Rietkuilspruit stream to the west of IVS Works below the first dam was (destroyed during 2002). As far as primary ground water contamination plume migration is concerned, the extent of inorganic contamination opposite the TETP/MTP area appears to be less than 300 meters. More boreholes are required to refine this assessment.

The extent of the observed organic contamination is restricted to the shallow weathered aquifer zone as observed in boreholes IVB-D95 and IVB-D96 - the latter hole is next to the stream. No organic related source could be linked to this observed contamination source - pathway - receptor principal, and must this phenomenon be investigated and verified through routine monitoring and additional drilling.

Area opposite Dam 10 and the Existing Waste Dump

The area is located opposite the west of Dam 10 and the Existing Waste Dump, and is entirely underlain by the Silverton Shale Formation. Two regional structures present within the area are a dolerite dyke and a geological fault. The dolerite dyke cuts through the area in the north, in an east to westerly direction. The regional geological fault zone runs underneath the dump, cutting from the south-eastern tip of the dump in a north-westerly direction, and deviates from the dump slightly east of its north-western tip.

Two aquifer types are present in the area namely the perched aquifer zone(s) and the shallow weathered aquifer zone. The thickness of the unsaturated zone measures some 3 to 5 meters, whilst the saturated thicknesses for the perched aquifer measures some 2 meters. The shallow weathered zone aquifer is generally saturated up to a thickness of some 17 meters.

No lateral aquifer boundaries occur within the area. The fault and dolerite dyke zones were extensively investigated and was it concluded not to be hydraulic or physical boundaries, primarily due to the fact that the regional ground water flow directions run parallel to these features.

Borehole yields in the area vary from low to medium. One borehole sited and drilled on the dolerite dyke zone, had a blow yield of 6.3 *l/s*. The aquifer hydraulic parameters storativity and permeability are low, whilst porosities vary from moderate to high, suggesting slow to medium ground water flow velocities and restricted quantities of ground water. Natural recharge from rainfall is estimated at 1% to 3% of MAP.

The regional ground water flow directions are towards the northwest, west and south-west. Using the observed hydraulic parameter values for the area, together with the average hydraulic gradient, the ground water flow velocity is in the order of 10 - 15 meters per year. It is important to note that this velocity can vary within localized areas.

The entire impacted area is located within IVS property, except for three smallholdings in the Steelvalley/Linkholm area.

The aquifers underlying the area are both classified as ***Minor Aquifer Systems***, whilst their vulnerability is classified as ***medium***. Aquifer susceptibility is classified as ***medium***, resulting in an overall aquifer protection classification of a ***medium protection level***.

The only fatal flaw within this area, with respect to ground water is an inadequate buffer zone beyond the western perimeter. Buffer zones are for example separations between a registered landfill site boundary and any adjacent residential or sensitive development, on which such an activity may have a negative impact.

The ground water impact mechanism associated with the area relates to the hydraulic and hydro-chemical manifestation of contaminants at source, resulting in contamination of the underlying perched aquifer zone and the shallow weathered zone aquifer, with subsequent lateral migration of contaminants as ground water contaminant plumes in the direction of ground water flow. With reference to the organic contamination within these zones, the free phase coal tar (DNAPL) located beyond the IVS perimeter, is regarded the possible source which contributes to the dissolved phase observed in the monitoring boreholes. The ground water impact mechanism associated with this dissolved organic pollution relates to hydraulic (advection, convection, dispersion) and hydro-chemical (diffusion, solubility) mechanisms.

Ground water chemistry obtained from the boreholes in this area (27 deep and shallow holes), confirm elevated concentrations of Ca, Mg, Cl, SO_4, F, Fe and Mn within the perched aquifer zone(s) and elevated concentrations of Ca, Mg, Cl, SO_4, F, Na, NO_3, Fe, and Mn in the shallow weathered aquifer zone. The degree of contamination is higher in the shallow weathered aquifer zone. Organic ground water chemistry observed in the boreholes indicates the presence of both free phase and dissolved phases (both not necessarily present in all the boreholes).

The inorganic contamination observed in the aquifer(s), extends to a distance of some 700 meters beyond the IVS perimeter. The extent of the plume was based on the following criteria:

- Observed concentrations,
- Hydro-chemical imaging (source - pathway - receptor), and
- Statistical analysis.

The extent of the **observed** dissolved organic contamination, is restricted to the shallow weathered aquifer zone as observed in boreholes some 300 meters beyond the perimeter. The free phase is located much closer to the perimeter. The approach to delineate the organic dissolved and free phase contamination beyond the IVS perimeter was done through non-invasive (geophysical work, review of existing work) and invasive methods (sampling/observations in existing holes and drilling according to with the outside-in approach).

Area opposite Dams 1-4

The area is located immediately to the west of Dams 1-4 (Cyferpan Area) and is entirely underlain by the Silverton Formation shale. A regional dolerite dyke cuts through the area in an east to west/north-west direction underneath the dam.

Two aquifer types are present in the area, namely the perched aquifer zone(s) and the shallow weathered aquifer zone. The thickness of the unsaturated zone measures some 2 to 4,5 meters, whilst the saturated thicknesses for the perched aquifer measures some 0,5 to 3 meters. The shallow weathered zone aquifer is saturated up to a thickness of some 14 meters.

No lateral aquifer boundaries are active within the area. The dolerite dyke zone was extensively investigated and the conclusion made that it is not a hydraulic or physical boundary (ground water flow direction is from east to west and therefore parallel to the dyke).

Borehole yields in the area vary from low to medium. The aquifer hydraulic parameters storativity and permeability are low, whilst porosities vary from moderate to high, suggesting slow to medium ground water flow velocities and restricted quantities of ground water. Piezometric levels in the two aquifer zones differ slightly with no distinct positive gradient from one to the other. Natural recharge from rainfall is estimated at 2% to 3% of MAP.

One borehole is currently being utilized by Ferroland for animal drinking water consumption (IVB-D93), by means of a wind mill some 480 m west from the dams.

The regional ground water flow direction for this area is from east to west. Using the observed hydraulic parameter values for the area, together with the average hydraulic gradient, the ground water flow velocity is in the order of 10 - 12 meters per year. It is important to note that this velocity can vary within localized areas.

The entire area is located within IVS property (Cyferpan area).

The aquifers underlying the area are classified as ***Minor Aquifer Systems***, whilst their vulnerability is classified as ***medium***. Aquifer susceptibility is classified as ***medium***, resulting in an overall aquifer protection classification of a ***medium protection level***.

The dolerite dyke cutting through the area generically represents a ground water fatal flaw with respect to waste management. However, drilling, pump testing and sampling investigations along the dyke have indicated no preferential contaminant migration along the dyke to date.

The ground water impact mechanism associated with the area relates to the hydraulic and hydro-chemical manifestation of contaminants at source, resulting in contamination of the underlying perched aquifer zone and the shallow weathered zone aquifer, with subsequent lateral migration of contaminants as ground water contaminant plumes. For all contaminants in solution the major migration mechanism being advection, it is anticipated the contaminant plume to manifest in a westerly direction along the ground water flow direction.

Ground water chemistry obtained from the boreholes in this area, confirm elevated concentrations of Ca, Mg, Na, Cl, SO_4, Fe and Mn within the perched aquifer zone(s) and elevated concentrations of Ca, Mg, Na, Cl, SO_4, F, Fe and Mn in the shallow weathered aquifer zone. The degree of contamination is comparable within the two aquifer zones.

Low levels of organic contamination of ground water could be observed from samples taken from the boreholes in this area. These trace concentrations of organic constituents are probably due to analytical limitations at very low concentrations (values reported in proximity of the detection level), and not due to any form of organic pollution. In addition could they not be related any organic source(s) through the source - pathway - receptor principle. These concentrations are therefore equivocal and should be interpreted as such.

The inorganic contamination observed in the aquifer(s), extends up to a distance of some 140 meters beyond the IVS works perimeter, as indicated by one borehole.

The extent of the observed organic contamination is restricted to the shallow weathered aquifer zone as observed in boreholes IVB-D101 and IVB-D161. No organic related source could however be linked by means of the source - pathway - receptor principal.

Area opposite the Kiewiet Area

The area is located immediately to the north and east of the Kiewiet Area and is underlain by Hekpoort andesite and quartzite belonging to the Strubenkop Formation. A major regional dolerite dyke cuts through the area from east to west.

Two aquifer types are present in the area namely the perched aquifer zone(s) and the shallow weathered aquifer zone. The thickness of the unsaturated zone is highly variable (between 2 and 13 meters), whilst the saturated thicknesses for the perched aquifer measures some 3 meters. The shallow weathered zone aquifer is saturated to a thickness of some 18 meters.

With respect to the influence of physical aquifer boundaries in this area on ground water flow, the weathering depth distribution indicates neither the dolerite dyke, nor the geological contact zones, to be effective physical, no-flow (impermeable) boundaries.

Borehole yields in the area vary from low to medium. The aquifer hydraulic parameters, storativity and permeability are low, whilst porosities vary from moderate to high, suggesting slow to medium ground water flow velocities and restricted quantities of ground water. Natural recharge from rainfall is estimated at 2% to 3% of MAP.

No ground water abstraction occurs for any application, for at least some 2,6 kilometre from the IVS perimeter, in an easterly direction.

The regional ground water flow directions are towards the north-east, east and south-east. Using the observed hydraulic parameter values for the area, together with the average hydraulic gradient, the ground water flow velocity is in the order of 10 - 24 meters per year. It is important to note that this velocity can vary within localized areas.

The impacted area belongs to IVS.

The aquifers underlying the area are classified as ***Minor Aquifer Systems***, whilst their vulnerability is classified as ***medium***. Aquifer susceptibility is classified as ***medium***, resulting in an overall aquifer protection classification of a ***medium protection level***.

The dolerite dyke (preferential flow path) is the only ground water fatal flaw with respect to waste management within the area. Extensive work (drilling, sampling, pump testing) on the dyke has indicated no preferential contaminant migration along the dyke to date.

The ground water impact mechanism associated with the area relates to the hydraulic and hydro-chemical mechanisms at source, resulting in contamination of the underlying perched aquifer zone and the shallow weathered zone aquifer, with subsequent lateral migration of contaminants as ground water contaminant plumes in the direction of ground water flow. For all contaminants in solution, the major migration mechanism being advection, it is anticipated the contaminant plume to manifest in an easterly and south easterly direction.

Ground water chemistry obtained from 6 boreholes in this area, confirm elevated concantrations of Fa and Mn within the perched aquifer zone(s) and elevated concentrations of Ca, Mg, F, Cl, SO_4, NO_3, Fe and Mn in the shallow weathered aquifer zone. Due to the deep water table in this area, only two perched aquifer boreholes established water levels and could therefore be sampled. The degree of contamination is higher for the shallow weathered aquifer zone.

Low organic concentrations were observed from samples taken from the boreholes in this area. These trace concentrations of organic constituents are probably due to analytical limitations at very low concentrations, and not due to any form of organic pollution. The observed concentrations could not be related to any organic source.

The inorganic contamination observed in the aquifer(s) within the monitoring boreholes, extends up to a distance of some 670 meters beyond the eastern IVS perimeter. Additional holes are required to accurately delineate the plume beyond the IVS eastern perimeter.

The extent of the observed organic contamination is restricted to the shallow weathered aquifer zone. No organic related source can be linked to these low concentrations.

Area opposite the South Eastern Slag Processing and Open Veld Area (SESOVA)

The area is located immediately to the east of the area opposite the SESOVA area. This area is underlain by Strubenkop shale and quartzite, Daspoort quartzite and shale, and Silverton Formation shale, with inter-bedded quartzite, hornfels, limestone and volcanic tuff, all which have been intruded by Transvaal diabase sills. Localised quaternary deposits of alluvium (along the Leeuwspruit stream) and gravel are also present.

Two aquifer typas are present in the area namely perched aquifer zone(s) and shallow weathered aquifer zone. The thickness of the unsaturated zone measures some 2,5 to 4 meters, whilst the saturated thickness for the perched aquifer measures some 1 to 2,5 meters. The shallow weathered zone aquifer is saturated up to a thickness of some 20 meters.

The only definable lateral aquifer boundary that exist in the area is the Leeuwspruit stream itself. This stream represents a hydraulic boundary and manifests as a ground water discharge zone.

Borehole yields in the area vary from low to medium. The aquifer hydraulic parameters (storativity and permeability) are low, whilst porosities vary from moderate to high, suggasting slow to medium ground water flow velocities and restricted quantities of ground water. Natural recharge from rainfall is estimated at 1% to 3% of MAP.

Ground water abstraction for domestic/garden, and to the north industrial/commercial application, occurs some 340 meters to 800 meters respectively from the IVS perimeter in an easterly direction.

The regional ground water flow direction is towards the east. Using the observed hydraulic parameter values for the area, together with the average hydraulic gradient, the ground water flow velocity is in the order of 10 - 20 meters per year. It is important to note that this velocity can vary within localized areas.

The entire area is located outside IVS property.

The aquifer(s) underlying the area are classified as ***Minor Aquifer Systems***, whilst their vulnerability is classified as ***medium***. Aquifer susceptibility is classified as ***medium***, resulting in an overall aquifer protection classification of a ***medium protection level***.

The only ground water fatal flaw within this area with respect to ground water and waste management, is the Leeuwspruit stream, which represents a ground water discharge boundary/zone.

The ground water impact mechanism associated with the area, relates to hydraulic and hydro-chemical mechanisms at source, resulting in contamination of the underlying perched aquifer zone(s) and the shallow weathered zone aquifer, with subsequent lateral migration of these contaminants as ground water contaminant plume(s). For all contaminants in solution, for which the major migration mechanism is advection, the contaminant plume is anticipated to manifest in an easterly direction along the ground water flow direction.

Ground water chemistry obtained from 7 boreholes in this area, confirms elevated concentrations of Ca, Mg, Cl, SO_4, Na, F, Fe and Mn within the perched aquifer zone(s) and elevated concentrations of Ca, Mg, Na, Cl, SO_4, K, NO_3, F, Fe and Mn in the shallow weathered aquifer zone. The degree of contamination is higher for the perched aquifer zone(s), especially as observed in the alluvium next to the Leeuwspruit.

Extremely low organic concentrations were observed from samples taken from the monitoring boreholes in this area. These trace concentrations of organic constituents are probably due to analytical limitations at very low concentrations (values reported in proximity of the detection level), and not due to any form of organic pollution. The observed/reported concentrations could not be related to any organic source(s) through the source - pathway - receptor principle, and therefore these concentrations are equivocal and should be interpreted as such.

The contamination observed in the shallow weathered aquifer zone boreholes extends to a distance of some 80 meters beyond the IVS perimeter, to the east. However, most of the observed concentrations were found in only one borehole next to the Leeuwspruit stream, to the east of IVS works, below the Frikkie Meyer weir (IVB-D137). The extent of contamination within the perched aquifer zone(s) was observed some 1,2 kilometre along the Leeuwspruit stream. These monitoring boreholes were drilled into the alluvium flanking the stream, and can therefore be explained through secondary pathways and not through the primary ground water flow pathway.

The extent of the observed organic contamination is restricted to the shallow weathered aquifer zone. No organic related source could be linked through the source - pathway - receptor principle.

Within Management Zone 7, the receiving environment around the IVS works was divided into two smaller areas - the area west and north of the plant, and the area east and south of the plant. The division was mainly due to historical and current land use.

The land use, fauna and flora for the two less disturbed areas West and North of IVS Works; South and East of IVS Works, is as follows:

West and North of IVS Works

The historic and current **land use** for this area comprise (d) agricultural smallholdings, cultivated farmlands, pastures and natural grazing. Large areas formerly used for crop farming, were recently converted to pastures. However, the impact of historic agricultural practices is still clearly visible in the type and composition of **plant** species. The large number of roads servicing the area increases the edge effect. Herbaceous and weakly woody species dominate the area. A large number of **animals**, birds and reptiles are anticipated to still occur in this area. Large areas of the study area are fenced off, thus forming a barrier for the migration of larger animals. However, migration patterns for smaller animals are less affected. No endangered, rare or vulnerable plant or animal species were observed in the area, and due to its highly disturbed status, none are anticipated to occur. However, a number of invader or exotic species do occur as a result of the highly disturbed state of the area. From an ecological perspective the area is classified as disturbed, with an ecological quality varying from medium to low. Impacts varying from low to medium to high significance, associated with plant and animal life in the area, relate to disruption of the soil profile, loss of topsoil, destruction of vegetation, decrease in species richness and diversity, trampling, increased edge effect, invasion of alien species and erosion for plant life, and for animal life a decrease in species richness and diversity, destruction of habitat, disturbance in migration patterns, increase in pest species and loss of food source.

South and East of IVS Works

The historic and current **land use** for this area comprise (d) informal and formal housing for the largest part, with some light industry also present. Isolated patches of agricultural (informal) activities also occur. Herbaceous and weakly woody **plant** species dominate the area. A large number of **animals**, birds and reptiles are anticipated to still occur in this area. Large areas of the study area are fenced off, thus forming a barrier for the migration of larger animals, whilst migration patterns for smaller animals are less affected. However, the high levels of urbanization preclude much of these to exist in the area. No endangered, rare or vulnerable plant or animal species were observed in the area, and due to its highly disturbed status, none are anticipated to occur. However, a number of invader or exotic species do occur as a result of the highly disturbed state of the area. From an ecological perspective the area is classified as disturbed, with an ecological quality varying from medium to low. Impacts varying from low to medium to high significance, associated with plant and animal life in the area, relate to disruption of the soil profile, loss of topsoil, destruction of vegetation, trampling, increased edge effect, invasion of alien species and erosion for plant life, and for animal life a decrease in species richness and diversity, destruction of habitat, disturbance in migration patterns, increase in pest species and loss of food source.

On the western boundary the IVS Works has an impact on the **surface water** flows and qualities in the TETP canal, and subsequently in the Rietkuilspruit, Rietspruit and Vaal River, while on the eastern boundary, the IVS Works has an impact on the surface water flows and qualities in the Leeuwspruit. Storm flows from the eastern catchment of the Works area (including North Works) enter directly into the source of the Leeuwspruit at the Frikkie Meyer Weir. Clean overland storm flows emanate from the Kiewiet Area.

A number of measurement points were selected on or near the border of the IVS Works. At each of these points an ambient **noise** level was sampled at representative times of a 24 hour period. The main manufacturing activities of Iscor are situated along the southern and eastern borders of the property. On the western border activities can be associated with the transport and disposal of waste products. Estimates of the ambient noise climate on the border of the IVS Works area were made from this. The typical noise levels for Industrial Districts, as defined by SABS 0103, are specified as 70dBA, 65 dBA and 60 dBA. The present ambient noise levels are the highest along the southern border of the CPA. The Industrial District noise criterion is exceeded during the evening and at night time. It should however be kept in mind, that a significant buffer of land exists between the CPA border and the nearest residential areas.

There are no sources of **air pollution** in these areas but air movement has the potential of dispersing pollution from operational areas. Based on the dust fall-out monitor results and the dispersion modelling there are no significant impacts.

Outbuildings on the Rietkuil farm area may be close to 60 years old and require consideration as historical structures. Various **graveyards** are located inside the IVS farming areas on the farm Rietkuil. Potential damage to graveyards is regarded as a significant impact (Graveyards 05 and 06 have been damaged).

6.7.3 Risks

The potential risk to human health and to the environment for the:

- Area opposite TETP/MTP;
- Area opposite Dam 10 and the Existing Waste Dump;
- Area opposite Dams 1-4;
- Area opposite the Kiewiet area; and the
- Area opposite the South Eastern Slag processing and Open Veld Area (SESOVA), could be summarised as follows:

The potential risk to human health represents the risk through the ground water pathway for drinking water application (adult of 60 kg drinking 2 litres of water/day). The risk to the environment represents the risk through the aquatic ecosystems pathway.

Area opposite TETP/MTP

Within the perched aquifer zone(s) the risk to human health relates to elevated concentrations for Ca, Mg, SO_4, Cl, Na and Fe, whilst the risk to the environment relates to elevated concentrations of Ca, Mg, SO_4, Cl, Na, Fe and Mn.

The risk to human health in the shallow weathered zone aquifer relates to elevated concentrations for Ca, Mg, SO_4, Cl, Na and Fe, whilst the risk to the environment relates to elevated concentrations of Ca, Mg, SO_4, Cl, Na, NO_3, Fe and Mn. Taking cognisance of the ground water flow direction, the observed NO_3 concentration observed in IVB-69 originates from an area to the north and not the TETP/MTP area.

Area opposite Dam 10 and the existing dump site

Within the perched aquifer zone(s), the risk to human health relates to elevated concentrations of Ca, Mg, Cl and Fe, whilst the risk to the environment relates to elevated concentrations for Ca, Mg, Cl, Fe and Mn.

The risk to human health in the shallow weathered zone aquifer relates to elevated concentrations of Ca, Mg, SO_4, Cl and Fe, whilst the risk to the environment relates to elevated concentrations for Ca, Mg, SO_4, Cl, NO_3, Fe and Mn.

For organics, the risk to human health and the environment relates to several components of VOC, PAH as well as the physical free phase coal tar (DNAPL).

Area opposite Dams 1-4

Within the perched aquifer zone(s), the risk to human health and the risk to the environment relates to elevated concentrations of Fe.

No risk to human health or risk to the environment was observed in the shallow weathered zone aquifer.

Area opposite the Kiewiet Area

Within the perched aquifer zone(s), the risk to human health and the risk to the environment relates to elevated concentrations of Fe.

The risk to human health in the shallow weathered zone aquifer relates to elevated concentrations of Ca, Mg, SO_4, Cl, Na and Fe, whilst the risk to the environment relates to elevated concentrations of Ca, Mg, SO_4, Cl, Na, NO_3, and Mn.

Area opposite the south eastern slag processing and open veld area (SESOVA)

Within the perched aquifer zone(s), the risk to human health relates to elevated concentrations of Ca, Mg, SO_4, Cl, Na and Fe, whilst the risk to the environment relates to elevated concentrations of Ca, Mg, SO_4, Cl, Na, NO_3 and Mn. Taking cognisance of the geology, (alluvium flanking the Leeuwspruit stream) and ground water flow directions, the observed risks cannot be related to the primary ground water flow pathway, but resulted from flow along/through secondary pathways.

The risk to human health in the shallow weathered zone aquifer relates to elevated concentrations for Ca, Mg, SO_4 and Fe, whilst the risk to the environment relates to elevated concentrations for Ca, Mg, SO_4, NO_3, Fe and Mn. These concentrations were observed in borehole IVB-137 and subject to the ground water flow directions the observed concentrations cannot be related to the SESOVA.

IVS has a potentially unacceptable impact on the surface water of the Rietkuilspruit via the Rietspruit canal.

It is anticipated that both the **plant and animal** ecology is at risk within the receiving environment surrounding the IVS works. Especially the larger mammals, due to the unsuitable habitat, are at potential risk, whilst the smaller mammals are less at risk. The risk to the terrestrial ecology is commensurate with that to be expected within an agricultural and a highly urbanized and industrialized area. The risks assessed for this area, are endemic to the current land use distribution and cannot be related to activities within the IVS works perimeter. No endangered, rare or vulnerable plant or animal species are at risk.

The risk on the **noise** environment is characterised by the occurrence of noisy single events, such as the handling of materials, which could exceed the Industrial Districts noise criterion. The specialist opinion states however, that the noise emissions are generally in compliance with the prescribed standards. The south-eastern part of the CPA area is situated much closer to the residential area than the rest of the CPA area, although the heavy industrial activities, e.g. arc furnace plant activities, are quite a distance further away.

Various categories of significant objects in terms of the National Heritage Resources Act may be affected and require conservation / protection.

6.7.4 Management Objectives

In the final analysis all recommended measures must support these primary objectives.

For ground water purposes, five areas of significance exist where activities within the IVS Works Perimeter have caused unacceptable impacts and potential risks to both Human Health and the Environment, beyond the IVS perimeter.

- An area beyond the Western IVS perimeter, to the west from and opposite to Management Area 5 - TETP/MTP.
- An area beyond the Western IVS perimeter, to the west from and opposite to Management Area 1 - CRMF (Existing Waste Dump, Redundant Blast Furnace Sludge Dams and Dam 10).
- An area beyond the northern IVS perimeter, to the west and northwest from and opposite to Management Area 1 - CRMF (Dams 1 to 4).
- An area beyond the eastern IVS perimeter, to the east from and opposite to Management Area 6 - KIEWIET.
- An area beyond the eastern IVS perimeter, to the east from and opposite to Management Area 3 - SESOVA.

Due to the technical impracticability to remediate the observed ground water pollution within the PISA (Perimeter and Immediate Surrounding Areas) to levels which will represent acceptable risk to Human Health and the Environment over the short and medium terms, these objectives will have to be reached through **institutional controls**.

This should be seen against the background that **technical measures** are proposed for implementation within the Management Areas within the IVS perimeter, to prevent ground water pollution to continue to migrate across the IVS perimeter into the five areas listed above. These technical measures within the IVS perimeter, should be commissioned to achieve continual improvement not only within the IVS perimeter, but also in Management Zone 7 – PISA. This is both with respect to the prevention of pollution plume migration, as well as the reversal of ground water flow over the short and medium terms, and the gradual improvement in ground water quality over the long term.

Secondary objectives within the PISA, relate to technical measures required to support the primary objectives, over the short, medium and long terms, such as buy out of land, alternative water supply, compensation, etc.

The generic short tarm management objectives for **plant and animal** life within the receiving environment surrounding the IVS works relate to identification and protection of all threatened species. For the medium term, the objective should be to monitor the general health of the flora and fauna, whilst the long term objective (post rehabilitation and closure) should be to attempt to restore the vegetation and animal communities to a healthy condition with both high species richness and diversity, obviously within the bounds/limitations applicable to the current land use of the area.

The suggested management objective is to achieve compliance with the National Heritage Resources Act, following the relevant guidelines and obtaining the necessary authorisations to formalise, relocate, protect graveyards and conserve outbuildings more than 60 years old.

The air quality standards or guidelines as applicable will be used as the management objective. This should be audited annually.

The noise management objectives for this area include reduction of noise emissions, e.g. noise emissions at the materials handling division (noisy single events), to ensure compliance to the Industrial Districts Noise criterion.

6.7.5 Measures

Before any measures are implemented in this Management Area 7: PISA, with regard to ground water, additional boreholes must be drilled and sampled during the detailed feasibility stage, to accurately delineate the impact and risk zones.

Institutional measures:

The aquifer(s) located within the PISA, which were impacted on by the activities from within the IVS perimeter, can generally not be remediated to acceptable risk levels through technical measures, over the short and madium terms. Such measuras will require flushing of the aquifers with "clean" water and/or steam and will in any event take several decades to improva the situation significantly. Such maasures are therefore considered impracticable to achieve risk compliance for the five areas within tha PISA over the short and medium term.

The institutional measures required within the PISA, to support the above, relates to two zones:

- The zone(s) for which the current impact and risk is unacceptable for protection of Human Health and/or the Environment.
- Buffer zone(s) beyond the first zone(s) in which ground water abstraction must be controlled/prevented in order not to compromise the extent of the unacceptable impact and risk.

The **institutional** controls required within both these zones, relate to **re-zoning** of these areas within the PISA for ground water usage. This implies that abstraction and application control must be institutionalised within both the current ground water impacted area as well as the buffer area, to such a level that the current ground water quality is within compliance, subject to demonstration of continual improvement over the long term.

Selections from, and/or combinations of, the following technical measures will be required to support the institutional controls proposed:

- Provide an alternative water supply to all ground water users within the two zones (risk and buffer zones).
- Negotiate and provide compensation for loss of ground water supply/availability.
- Buy out properties within both zones (risk and buffer zones).

The **alternative** measures considered for the PISA include:

- Re-zoning
- Alternative water supply
- Compensation
- Buy out
- Pump and Treat
- Pump and Flush
- Infiltration galleries
- Steam Injection
- Solvent Injection
- Soil Vapour Extraction

For **plant and animal** life, the following potential management measures were identified for selected from, subject to the actual activity and resulting impact within a specific area, for implementation according to the life cycle phase of the specific activity and impact.

- Identification of threatened species - short term.
- Ongoing monitoring - medium and long term.
- Selective soil stockpiling - medium and long term.
- Establish seed bank of natural species - medium and long term.

- Re-introduce natural vegetation to denuded areas - medium and long term.
- Prevent unnecessary species removal - medium and long term.
- Limit the number of roads and limit and control vehicular traffic - medium and long term.
- Control alien and invader species - medium and long term.
- Limit human access where possible- medium and long term.
- Institute a buffer zone around activities - medium and long term.
- Restrict activities in the area - medium and long term.

The Steelserv area is the most critical area in terms of noise emissions, especially single noise events. IVS indicated that this operational area would be relocated in the medium to long term, which will reduce noise from the area.

Protect and conserve graveyards and outbuildings older than 60 years: **short term**.
Incorporate graveyards into development schemes: **medium term**
Relocate graveyards and graves: **medium term**.
Obtain permits through SAHRA, through consultation with national, provincial and local governmental departments: **long term.**

6.7.6 Monitoring

Monitoring must be performed to indicate the performance and effectiveness of the recommended measures, which have been implemented.

The boreholes within the following areas outside the IVS perimeter are dedicated to monitor and verify the ground water status (flow and quality) within the PISA:

- Area opposite TETP/MTP
- Area opposite Dam 10 and the Existing Waste Dump
- Area opposite Dams 1-4
- Area opposite the Kiewiet area
- Area opposite the South Eastern Slag Processing and Open Veld
- Area (SESOVA)

Area opposite TETP/MTP

Current ground water quality and level monitoring borehole pairs (shallow and deep) dedicated to monitor the area opposite TETP/MTP and immediate surrounding area include IVB-69, IVB-95 and IVB- 96.

Area opposite Dam 10 and the Existing Waste Dump

Current ground water quality and level monitoring borehole pairs (shallow and deep) dedicated to monitor the area opposite Dam 10 and the Existing Waste Dump within the immediate surrounding erea, include IVB-68, IVB-89, IVB-97, IVB- 98, IVB-99, IVB-102, IVB-103, IVB-107, IVB-108, IVB-109, IVB-116, IVB-117, IVB-118, IVB-119, IVB-120, IVB-121, IVB-122, IVB-123, IVB-156, IVB-157, IVB-159, IVB-171, IVB-172, IVB-173, IVB-175, IVB-176 and IVB-177.

Area opposite Dams 1-4

Current ground water quality and level monitoring borehole pairs (shallow and deep) dedicated to monitor the area opposite Dams 1-4 to the west include IVB-81, IVB-93, IVB-101 and IVB-161.

Area opposite the Kiewiet Area

Current ground water quality and level monitoring borehole pairs (shallow and deep) dedicated to monitor the aree opposite Kiewiet Area within the immediate surrounding receiving environment, include IVB-147, IVB-160, IVB-163, IVB-165, IVB-166 and IVB-167.

Area opposite the SESOVA area

Current ground water quality and level monitoring borehole pairs (S-shallow and D-deep) dedicated to monitor the area opposite SESOVA within the immediate surrounding receiving environment, include IVB-88, IVB-106, IVB-136, IVB-137, IVB-140, IVB-141 and IVB-169.

Additional ground water quality and level monitoring boreholes will be commissioned during implementation of the proposed measures, to monitor measure efficiency and overall compliance with objectives for the PISA.

For **plant and animal** life, monitoring of the applicable environmental variables are necessary to prevent the degradation of the ecosystem. A floral and faunal survey must be conducted once a year, in which species lists are compiled and the abundance of each of the specific species recorded. Throughout the year, any unusual occurrences in the floral and faunal communities should be monitored.

Ongoing monitoring for noise will be required on a quarterly to six monthly basis on the southern and south-eastern boundary of the CPA. The envisaged integrated Environmental Monitoring Committee (IEMC) should meet biannually to monitor the progress and performance of the various Environmental Management Plans for the PISA.

6.7.7 Regulatory Authorizations

The following legal authorization processes may be required for the PISA:

- Registration of monitoring wells.

- Institutionalisation of a restricted groundwater use area.
- Establishment of an industrial and waste management buffer.

6.8 Management Area 8: Rietkuilspruit and Rietspruit Canal Area (RRCA)

6.8.1 Activity Description

This area is situated to the west of the IVS Works and is made up of the Louisrus (South and North) smallholdings and farms. Much of Louisrus South consists of agricultural holdings bought out by IVS. This portion of the bought-out area is managed by Ferroland as a pastureland for cattle farming. The area is divided up into fenced camps for cattle. This area does not have a specific zoning (undetermined).

The Rietkuilspruit and Rietspruit canal pass through this area. The Rietspruit canal was parallel to the Rietkuilspruit and enters the spruit some 1km upstream of the confluence between the Rietkuilspruit and the Rietspruit. The Rietkuilspruit is a stream, which originates in a storm water system in the northern areas of the town of Vanderbijlpark. Surface water run-off from IVS is not a source of surface water for this stream before the Rietspruit canal enters. Historically, water was diverted from the Rietspruit canal by means of pipes or secondary canals for the purposes of irrigating agricultural holdings in Louisrus South. The irrigation method utilised was predominantly flood irrigation.

6.8.2 Impacts

The entire Rietkuilspruit and Rietspruit Canal (RRCA) Management Area is underlain by Silverton Shale formation. The area pertaining to this discussion is located between the IVS-Rietspruit Canal in the south and the Rietkuilspruit stream to the north, from where the canal discharges into the Rietkuilspruit stream in the west, up to the earth dam, some 2 km upstream to the east.

It is anticipated that two aquifer types are present in the area namely the discontinuous perched aquifer zone(s) and a shallow weathered zone aquifer. Only the shallow weathered zone aquifer was investigated during studies for this area. The thickness of the unsaturated zone has a variance of some 5 meters. The shallow weathered zone aquifer is saturated up to a thickness of some 17 meters.

The only definable lateral aquifer boundary that exists in the area is the Rietkuilspruit stream itself. This stream acts as a hydraulic ground water discharge boundary/zone.

Borehole yields in the area vary from low to medium. The aquifer hydraulic parameters (storativity and permeability) are low, whilst porosities vary from moderate to high, suggesting slow to medium ground water flow velocities and restricted volumes of ground water in storage. Natural recharge from rainfall is estimated at 1% to 3% of MAP.

The regional ground water flow direction is towards the north-west. Using the observed hydraulic parameter values for the area, together with the average hydraulic gradient, the ground water flow velocity is in the order of 4 to 6 meters per year. It is important to note that this velocity can vary within localized areas.

The entire area is located within current IVS property.

The aquifer(s) underlying the area are classified as ***Minor Aquifer Systems***, whilst their vulnerability, is classified as ***high***. Aquifer susceptibility is classified as ***medium***, resulting in an overall aquifer protection classification of a ***medium protection level***.

The only ground water fatal flaw within this area with respect to ground water is the Rietkuilspruit, which represents a ground water discharge zone.

With reference to the historical activity description, the ground water impact mechanism associated with the area relates to infiltration of water (rain and irrigated process water/storm water from the IVS canal) downward through the subsurface, then entering the ground water system as seepage/infiltration into the underlying aquifer(s).

The downward migration of water is governed by a combination of the hydraulic parameters of the infiltration interface (unsaturated zone), the hydraulic parameters of the underlying aquifer(s) (permeability, porosity), as well as the piezometric pressure distribution within the aquifer zones.

Ground water chemistry obtained from the boreholes in this area confirms elevated concentrations of Ca, Mg, Cl, SO_4, Fe and Mn within the shallow weathered zone aquifer.

Low organic contamination (the origin of which is unknown.) of the ground water was observed from samples taken from the boreholes IVS-B12 and IVS-B18 in this area.

The extent of the contamination in aquifer(s) includes the entire footprint of the area used for flood irrigation, as well as an area to the west up to the Rietkuilspruit. The contaminated ground water in the shallow weathered zone aquifer most probably contributes to contaminated ground water base flow into the Rietkuilspruit. More investigation into the perched aquifer is required.

The extent of the observed organic contamination is restricted primarily to two boreholes in the shallow weathered zone aquifer, and does not display the same pattern as the inorganic contamination.

Apart from this, no other Management Area boundary is compromised by the ground water contamination in this Management Area.

The **historic land use** for this area comprised agricultural smallholdings. The area is currently being rehabilitated. However, the impact of historic agricultural practices is still clearly visible in the type and composition of **plant** species. The large number of roads servicing the area, increases the edge effect. Herbaceous and weakly woody species dominate the area. A large number of **animals**, birds and reptiles are anticipated to still occur in this area. Large areas of the study area are fenced off, thus forming a barrier for the migration of larger animals. However, migration patterns for smaller animals are less affected. No endangered, rare or vulnerable plant or animal species were observed in the area, and due to its highly disturbed status, none are anticipated to occur. From an ecological perspective, the area is classified as disturbed, with an ecological quality varying from medium to low. Impacts varying from low to medium to high significance, associated with plant and animal life in the area, relate to disruption of the soil profile, loss of topsoil, destruction of vegetation, decrease in species richness and diversity, trampling, increased edge effect, invasion of alien species and erosion for plant life, and for animal life a decrease in species richness and diversity, destruction of habitat, disturbance in migration patterns, increase in pest species and loss of food source.

The routine grab-sampling programme in the Rietkuilspruit has indicated deterioration in surface water quality as the water flows through the Louisrus area. After integration with the surface and ground water results, as well as the soils investigation results, it has become apparent that the historic irrigation practices increased the salt load in the groundwater. This water naturally drained from the Louisrus South area and ingressed into the Rietkuilspruit. This causes an ongoing deterioration in surface water quality as water in the stream mixes with the contaminated baseflow from the ground water aquifer.

A base line study of the aquatic ecosystems was performed for the two surface drainage features draining surface run-off away from the IVS works. The study included the Rietkuilspruit, the Rietspruit after the Rietkuilspruit confluence, all the way into the Vaal River (as well as the Leeuwspruit all the way into the Vaal River. Refer section 6.10).

It is clear from the results of this study that IVS is one of several potential impactors on the aquatic ecology within these streams. The management of these streams from an aquatic ecological perspective should therefore be a combined effort by all the role players.

With reference therefore to Aquatic Ecosystems, the recommendation is that the entire process, right through to implementation and monitoring, should be facilitated by the Catchment Management Agency (CMA). It will therefore not form part of the IVS Environmental Master Plan implementation. However, IVS should play its active role in investigations, management and monitoring.

6.8.3 Risks

It is important to note that concentrations observed for which potential environmental and health risks are unacceptable, relates generally to individual boreholes within the area and an area to the north and east up to the Rietkuilspruit stream. The risk to human health relates to elevated concentrations for Mg, Cl, SO_4, and Fe, whilst the risk to the environment relates to elevated concentrations for Mg, Cl, SO_4, Fe and Mn in the aquifer(s).

Unacceptable risks to both human health and the environment exist in terms of organic compounds (PAH) observed in two of the boreholes. No obvious source(s) for these risks could be identified.

There is a potential risk that the impact of the contaminated groundwater on the surface waters in the Rietkuilspruit could result in the water posing an unacceptable risk to both human health and the environment.

It is clear from the baseline study, that both the plant and animal ecology is at risk within this area. Especially the larger mammals, due to the unsuitable habitat, are at risk, whilst the smaller mammals are less at risk. The risk to the terrestrial ecology is commensurate with that to be expected within an agricultural small holding area. The risks assessed for this area, are endemic to the historic land use distribution and cannot be related to activities within the IVS works perimeter. No endangered, rare or vulnerable plant or animal species are at risk.

6.8.4 Management Objectives

Due to the technical impracticability to remediate the observed ground water pollution within the RRCA to levels which will represent an acceptable level of risk to Human Health and the Environment over the short and medium terms, these objectives will have to be reached through institutional controls. However, technical measures must be commissioned to achieve continual improvement subject to the following secondary short term (ST), medium term (MT) and long term (LT) objectives:

- Minimize contaminant concentration at source (ST) - irrigation has ceased, land bought out and the site already rehabilitated.
- Minimize infiltration of contaminants at source (ST) - irrigation has ceased, land bought out and the site already rehabilitated.
- Cut off migration of contaminated ground water as close as feasible to source, to prevent the movement of contaminated ground water across boundaries - legal or arbitrary compliance boundaries (ST) - **preferred option.**
- Manipulate pollution plume migration to protect pre-defined areas (MT) - **preferred option.**
- Improve ground water quality to agreed/negotiated water quality standards (LT) - currently not indicated.

The generic short term management objectives for plant and animal life within the area relate to the identification and protection of all threatened species. For the medium term, the objective should be to monitor the general health of the flora and fauna, whilst the long term objective (post rehabilitation and closure) should be to attempt to restore the vegetation and animal communities to a healthy condition with both high species richness and diversity, within the bounds applicable to the current land use of the area.

6.8.5 Measures

The aquifer(s) impacted on by the activities within the RRCA can generally not be remediated to acceptable risk levels through technical measures, over the short and medium terms. Such measures would require flushing of the aquifers with "clean" water and would in any event take several decades to improve the situation significantly. They are therefore considered impracticable to achieve risk compliance for ground water and surface water within the RRCA over the short and medium term.

The **institutional** measures required within the RRCA, to support the above, relate to two zones:

- The zone for which the current ground water impact and risk is unacceptable for protection of Human Health and/or the Environment - Louisrus South and the Rietkuilspruit.
- Buffer zone(s) beyond the first zone(s) in which ground water abstraction must be controlled/prevented in order not to compromise the extent of the unacceptable impact and risk.

The institutional controls required within both these zones, relate to **re-zoning of these areas** within the RRCA for ground water and surface water usage. This implies that ground water and surface water abstraction and application control must be institutionalised within both the ground water/surface water impacted area, as well as the buffer area, to such a level that the current ground water and surface water quality is within compliance, subject to

- demonstration of continual improvement over the long term, as well as
- abstraction from the buffer zone not compromising the extent of existing contamination.

Technical measures:

Selections from, and/or combinations of, the following measures will be required to support the institutional controls proposed, as well as to improve the situation over the short, medium and long term.

- Ensure alternative water supply to all ground water users within the two zones (risk and buffer zones) - **viable alternative option for buffer zone, in conjunction with next option.**

- Provide compensation for loss to ground water supply/availability - **see above**.
- Buy out properties/other regulatory measures as considered by Authorities within both zones (risk and buffer zones) - **risk zone already bought out, preferred option for buffer zone.**
- Install drainage galleries to intercept contaminated ground water migration through the perched aquifer away from the Louisrus South rehabilitated irrigation areas towards the Rietkuilspruit. These trenches must intercept seepage up to depths ranging between 4 and 6 meters. The system must include a sump and pipeline to return the contaminated water to the Works for treatment
- Install abstraction wells into the shallow weathered zone aquifer to intercept contaminated ground water migration through the shallow weathered zone aquifer, away from the Louisrus South rehabilitated irrigation areas, towards the Rietkuilspruit - **only necessary if drainage galleries does not perform effectively**.
- Close and rehabilitate the Rietspruit canal and remediate the surrounding, affected areas, including the stream.

Various **alternative measures** were considered for the RRCA and are listed below:

- Provide an alternative water supply - possible option for buffer zone
- Compensate for loss of ground water supply - **possible option for buffer zone**
- Buy out properties - done and preferred option also for buffer zone
- Decommission/remove sources and rehabilitate - **done**
- Install seepage drains/drainage galleries - **preferred option**
- Slurry walls - not preferred
- Sheet piling - not preferred
- Reactive barriers - not preferred, wrong chemistry
- Pump and Treat - preferred option in addition to drainage galleries
- Pump and Flush - flush water a problem
- Infiltration galleries - infiltration water a problem

For plant and animal life, the following management measures have been identifies for selection from, subject to the actual activity and resulting impact within a specific area, for implementation according to the life cycle phase of the specific activity and impact.

- Identification of threatened species - short term.
- Ongoing monitoring - medium and long term.
- Selective soil stockpiling - medium and long term.
- Compile seed bank of natural species - medium and long term.
- Re-introduce natural vegetation to denuded areas - medium and long term.
- Prevent unnecessary species removal - medium and long term.

- Limit the number of roads and vehicular traffic - medium and long term.
- Control alien and invader specias - medium and long term.
- Limit human access whera possible- medium and long term.
- Institute a buffer zone around activities - medium and long term.
- Restrict activity area - medium and long term.

6.8.6 Monitoring

Monitoring must be performed to verify the efficiency of the proposed measures in attaining the stated objectives.

Current ground water quality and level monitoring boreholes (only shallow weathered zone boreholes drilled during investigation) within the area include: IVS-5, IVS-11, IVS-12, IVS-17, IVS-18 and IVS-28.

Additional ground water quality and level monitoring boreholes will be commissioned during implementation of the proposed measures, to monitor the efficiancy of tha measures and overall compliance with objectives for the RRCA.

Monitoring of the applicable environmental variables for plant and animal life is necessary to prevent any degradation of the ecosystem passing by unnoticed. A floral and faunal survey must be conducted once a year, in which species lists are compiled and the abundance of each of the specific species recorded. Throughout the year, any unusual occurrences in the floral and faunal communities should be monitored.

6.8.7 Regulatory Authorizations

The following legal authorization processes may be required:

- Registration of abstraction and monitoring wells.
- Watar license for ground water use/abstraction/infiltration.
- EIA for abstraction system.

6.9 Management Area 9: Leeuwspruit and Vaal River Area (LVRA)

8.9.1 Activity Dascription

The Leeuwspruit catchment lies on the eastern side of IVS and flows initially in an eastarly direction, and then in a southerly direction. Land use in the Leeuwspruit catchment includes formal residential areas, informal settlements, agricultural holdings, industrial areas, a sewaga treatment works, recreational areas and a wetland. The stream flows through the community of Boipatong, and then to the north of Tshepiso and Sharpville. It subsequently flows to the west of Powerville, and finally enters the Vaal River to the east of Bedworth Park. A small dam is located in the Leeuwspruit River, just downstream of Boipatong. Outflow from the Leeukuil Dam (adjacent to Sharpeville) also enters the

Leeuwspruit River via a furrow.

The Frikkie Meyer Weir is the point of discharge from the eastern catchment of the IVS Works Area. This facility has a return pump house that pumps low-flows to the Leeuwspruit Sump. No water therefore flows over the weir during dry-weather conditions.

6.9.2 Impacts

During storm conditions, runoff water from a limited area of the eastern catchment of the IVS Works Area flows over the Frikkie Meyer Weir into the Leeuwspruit. This flow impacts on the water qualities and quantities in the Leeuwspruit system.

A base line study on aquatic ecosystems was performed for the two surface water courses draining surface run-off away from the IVS works. The study included the Rietkuilspruit, the Rietspruit after the Rietkuilspruit confluence, to the Vaal River, as well as the Leeuwspruit to the Vaal River.

It is clear from the results of the baseline study that IVS is one of several potential polluters of the aquatic ecology within these streams. Therefore, it is recommended that the management of these stream systems from an aquatic ecological perspective should be a combined effort by all relevant role players.

6.9.3 Risks

The flows that pass over the Frikkie Meyer Weir do not pose an unacceptable risk to humans or the receiving environment.

6.9.4 Management Objectives, Measures and Monitoring

The surface and ground water monitoring programme should continue as currently set for the Master Plan.

With reference therefore to Aquatic Ecosystems, the recommendation is that the entire process, right through to implementation and monitoring, should be facilitated by the Catchment Management Agency (CMA). It will therefore not form part of the IVS Environmental Master Plan implementation. However, IVS will play its active role in investigations, management and monitoring.
6.9.4 Management Objectives, Measures and Monitoring

6.9.5 Regulatory Authorizations

The IVS task team of the Rietspruit Catchment Forum should continue to focus on the required authorisation process for the IVS Works

6.10 Management Area 10: Rietspruit and Vaal River Area (RVRA)

6.10.1 Activity Description

The Rietspruit catchment includes the towns of Ennerdale, Evaton, Orange Farm, Sebokeng, the north-western portion of Vanderbijlpark, and extends to just south of Westonaria and Lenasia. The catchment includes large areas of agricultural land. The Rietspruit flows into the Vaal River at Loch Vaal, slightly upstream of the Vaal Barrage.

The Rietspruit has a catchment area of approximately 1,597 km^2 and is an important tributary of the Vaal River. The MAR of the Rietspruit catchment is about $262*10^6 m^3/a$. The longest channel in the Rietspruit is 59.5 km in length. A preliminary reserve and class determination of this catchment was performed in December 2001 by DWAF.

The flow volumes and water qualities in the Rietspruit are monitored by Rand Water at a position (RV2) in the river approximately 1.3 km north of Loch Vaal (approximately 200m below the confluence of the Rietspruit and the Klein Rietspruit). The catchment area of the Rietspruit and Klein Rietspruit above the weir is approximately 1,398 km^2 and 199 km^2 respectively. Water qualities are monitored by IVS at three positions in the Rietspruit. The flow in the Rietspruit is approximately 4.2 times larger that the flow in the Rietspruit Canal. The flow in the Vaal River is approximately 13.7 times larger that the flow in the Rietspruit.

6.10.2 Impacts

Surface water from IVS increases the salt concentration in the Rietspruit.

An aquatic ecosystems base line study was performed for the two surface drainage features draining surface run-off away from the IVS works. The study included the Rietkuilspruit, the Rietspruit after the Rietkuilspruit confluence, to the Vaal River, as well as the Leeuwspruit to the Vaal River.

It is clear from the results that IVS is one of several potential contributors to the compromised state of the aquatic ecology within these streams, and it is suggested therefore, that the management of these streams from an aquatic ecological perspective, should assume a combined effort by all the role players ("polluters").

With reference therefore to Aquatic Ecosystems, the recommendation is that the entire process, right through to implementation and monitoring, should be facilitated by the Catchment Management Agency (CMA). It should therefore not form part of the IVS Environmental Master Plan implementation. However, IVS will continue to play an active role in investigations, management and monitoring.

6.10.3 Risks

The influence of the IVS Works on the Rietspruit and Vaal Rivers does not pose an unacceptable risk to human health or the environment.

6.10.4 Management Objectives, Measures and Monitoring

The surface and ground water monitoring programme should continue as currently set for the Master Plan.

With reference therefore to Aquatic Ecosystems, the recommendation is that the entire process, right through to implementation and monitoring, should be facilitated by the Catchment Management Agency (CMA). It will therefore not form part of the IVS Environmental Master Plan implementation. However, IVS will play its active role in investigations, management and monitoring.

6.10.5 Regulatory Authorizations

The IVS task team of the Rietspruit Catchment Forum should continue to focus on the required authorisation process for the IVS Works

7. PRIORITISATION

7.1 Prioritisation matrices

The **three level prioritisation** methodology as outlined in chapter 4.10 were applied and the members of the project team conducted a two day workshop during which the 17 environmental **AREAS** were prioritised. Methodology of prioritising the **AREAS** are reproduced in Ranking Tables A, B and C, the final ranking depicted in the last column of Table C.

Please refer to paragraph 4.10

PRIORITISATION TABLE

Rating Table A

	Management Area: Description		HUMAN HEALTH				ENVIRONMENT				HUMAN HEALTH RANKING				Environmental Average
			Ground water	Surface water	Land	Air	Ground water	Surface water	Land	Air	Sum	Average	Ranking A	Ranking B	
1	1.1	Management area 1: Overall CRMF		5				3			5	5	3	2	3
12	3	Management area 3: South-eastern slag and open veld area	6	2	7	3	2	2	6	3	18	5	3	6	3
2	1.2	Management area 1: Existing waste dump	5	7	3	2	6	6	3	2	17	4	2	5	4
3	1.3	Management area 1: Dam 10	3	8	2		4	10	2		13	4	2	3	5
14	5	Management area 5: TETP and MTP area	8	1	14		3	1	13		23	8	5	7	6
10	1.10	Management area 1: Dam 11	16	6	10		11	4	4		31	10	7	11	6
17	8	Management area 8: Rietkuilspruit and Rietspruit canal	2	4	9		1	5	14		15	5	3	4	7
5	1.5	Management area 1: Maturation ponds	11	10	1	7	10	11	1	7	29	7	4	10	7
11	2	Management area 2: consolidated plant area	16	3	11	1	12	7	10	1	31	8	5	11	8
4	1.4	Management area 1: Dams 1 to 4	10	9	4		7	12	5		23	8	5	7	8
13	4	Management area 4: South-western slag area	9	15	8	6	9	15	7	6	38	10	7	13	9
7	1.7	Management area 1: Processed materials stockpiles	14	13	12	5	14	8	11	5	44	11	8	14	10
6	1.8	Management area 1: Raw materials stockpiles	13	14	13	4	15	9	12	4	44	11	8	14	10
9	1.9	Management area 1: Redundant blast furnace sludge dams	4	16	6		8	16	8		26	9	6	8	11
15	6	Management area 6: Kiewiet area	7	12	15		5	14	15		34	11	8	12	11
8	1.8	Management area 1: Sludge dams	12	11	5		13	13	9		28	9	6	9	12
16	7	Management area 7: Perimeter and immediate surrounding areas	1												

PRIORITISATION TABLE

Rating Table $\boxed{B}$

	Management Area: Description		HUMAN HEALTH				ENVIRONMENT				HUMAN HEALTH RANKING				Environ-mental Average
			Ground water	Surface water	Land	Air	Ground water	Surface water	Land	Air	Sum	Average	Ranking A	Ranking B	
3	1.3	Management area 1: Dam 10	3		2		2	10			13	3	2	3	6
17	8	Management area 8: Rietkuilspruit and Rietspruit canal	2	4				5			15	3	3	4	5
5	1.5	Management area 1: Maturation ponds			1	7		11		7	29	4	4	10	9
4	1.4	Management area 1: Dams 1 to 4			4		3	12			23	4	5	7	8
6	1.6	Management area 1: Raw materials stockpiles				4		9		4	44	4	8	14	7
2	1.2	Management area 1: Existing waste dump	5	7	3	2	1	6		2	17	4	2	5	3
12	3	Management area 3: south-eastern slag & open veld area	6	2	7	3		2		3	18	5	3	6	3
8	1.8	Management area 1: Sludge dams			5			13			28	5	6	9	13
1	1.1	Management area 1: Overall CRMF		5				3			5	5	3	2	3
7	1.7	Management area 1: Processed materials stockpiles				5		8		5	44	5	8	14	7
9	1.9	Management area 1: Redundant blast furnace sludge dams	4		6		4	16			26	5	6	8	10
13	4	Management area 4: south-western slag area				8		15		6	38	6	7	13	11
10	1.10	Management area 1: Dam 11		6				4			31	8	7	11	4
15	6	Management area 6: Kiewiet area	7				5	14			34	7	8	12	10

PRIORITISATION TABLE

Ranking Table C

		Management Area: Description	HUMAN HEALTH				ENVIRONMENT				HUMAN HEALTH RANKING				Environ-mental	Ranking
			Ground water	Surface water	Land	Air	Ground water	Surface water	Land	Air	Sum	Average	Ranking A	Ranking B	Average	
16	7	Management area 7: Perimeter & immediate surrounding areas	1								1	1	8	12		1
2	1.2	Management area 1: Existing waste dump	5	7	3	2	6	6	3	2	17	4	2	5	4	2
3	1.3	Management area 1: Dam 10	3	8	2		4	10	2		13	4	2	3	5	3
12	3	Management area 3: South-eastern slag & open veld area	6	2	7	3	2	2	6	3	18	5	3	6	3	4
1	1.1	Management area 1: Overall CRMF		5				3			5	5	3	2	3	5
17	8	Management area 8: Rietkuilspruit & Rietspruit canal	2	4	9		1	5	14		15	5	3	4	7	6
5	1.5	Management area 1: Maturation ponds	11	10	1	7	10	11	1	7	29	7	4	10	7	7
14	5	Management area 5: TETP and MTP area	8	1	14		3	1	13		23	8	5	7	6	8
4	1.4	Management area 1: Dams 1 to 4	10	9	4		7	12	5		23	8	5	7	8	9
11	2	Management area 2: Consolidated plant area	16	3	11	1	12	7	10	1	31	8	5	11	8	10
9	1.9	Management area 1: Redundant blast furnace sludge dams	4	16	6		8	16	8		26	9	6	8	11	11
8	1.8	Management area 1: Sludge dams	12	11	5		13	13	9		28	9	6	9	12	12
13	4	Management area 4: south-western slag area	9	15	8	6	9	15	7	6	38	10	7	13	9	13
10	1.10	Management area 1; Dam 11	15	6	10		11	4	4		31	10	7	11	6	14
7	1.7	Management area 1: Processed materials stockpiles	14	13	12	5	14	8	11	5	44	11	8	14	10	15
6	1.6	Management area 1: Raw materials stockpiles	13	14	13	4	15	9	12	4	44	11	8	14	10	16
15	6	Management area 6: Kiewiet area	7	12	15		5	14	15		34	11	8	12	11	17

The final result of the prioritisation process is reflected in the following table:

- **Priorities already committed by IVS (A-PRIORITIES)**

Priority	Major Projects already committed
A1	MTP treatment plant to achieve ZED
A2	Coke oven gas cleaning
A3	Sinter pilot plant
A4	Sinter plant (full scale)

- **Priorities in terms of Environmental Management areas (P-PRIORITIES)**

Area No.	Management Area
P1	Perimeter and surrounding areas
P2	Existing waste dump
P3	Dam 10
P4	South eastern slag and open veld area
P5	Overall CRMF
P6	Rietkuilspruit and Rietspruit canal
P7	Maturation ponds
P8	TETP and MTP area
P9	Dams 1 to 4
P10	Consolidated Plant area (CPA)
P11	Redundant blast furnace dams (Dams 1 to 9)
P12	Sludge dams (Dams 1 to 8)
P13	South western slag area
P14	Dam 11 (New waste site area)
P15	Processed materials stockpiles
P16	Raw materials stockpiles
P17	Kiewiet area

Site Specific Measures for each **environmental management area**, were listed and prioritised. The prioritisation of the measures are reflected in tables for each management area, which is reproduced in the Appendix of the Integration report as well as in the Master Plan: Book of Plans, volume 2. A total of 206 measures (M-priorities) resulted from the Integration exercise. The nett result of this exercise – prioritisation of management areas and measures, cost estimates and proposed scheduled implementation, is reproduced in both the Appendix to this report and the Book of Plans, volume 2.

An example, of the measures as prioritised for the existing waste dump site (priority 2 area), and as reproduced in the appendix and Book of Plans referred to, is as follows:

Priority	Environmental Management Area	Measures No	Measures (M-priorities)
P2	**Existing Waste Dump**	**M1**	Relocation of railway line
		M2	Rehabilitation of railway line
		M3	Shaping of dump
		M4	Toe seepage drain N/W face
		M5	Upgrade surface water drains to Du Preez dam
		M6	Sump (seepage collection), pump station at Du Preez dam
		M7	N/W bench shaping
		M8	Drainage canals NW
		M9	Berm on top of dump
		M10	Construction of chutes N/W
		M11	Shaping in preparation of G-liner
		M12	Incremental capping of dump
		M13	G-liner system over dump
		M14	S/E bench shaping
		M15	Topsoiling of N/W area
		M16	Grassing of NW area
		M17	Rehabilitation/closure of residue transfer station
		M18	Weir/Sluice arrangement at Du Preez dam
		M19	Water quality monitoring at Du Preez dam
		M20	Drainage canal S/E face
		M21	Toe drain system S/E face
		M22	Berms on top of S/E face
		M23	Chute construction on S/E face
		M24	Topsoiling/Capping of S/E face
		M25	Vegetation of S/E face
		M26	Topsoiling and capping
		M27	Water management berms S/E
		M28	Vegetation
		M29	Rehabilitation of soil borrow area

8. COSTS

8.1 Cost Estimates

The measures proposed for the preferred options were conceptualised and these measures are reflected on a series of maps and plans.

Please refer to Master Plan: Book of Plans, Volume 2, Section III, Integration Process.

The measures were costed, believed to be of a 25% level of accuracy. The cost estimates were determined utilising the conceptual design layouts, which were executed during the Master Plan Integration process.

8.2 Accuracy levels

Costs are approximations and the measures should not be implemented by IVS without performing detailed designs. The approval of the regulatory authorities should be obtained in terms of:

- Principle acceptance of tha proposed measure(s) before detailed design should proceed
- Authorisation and permitting of the proposed measures, by following the prescribed regulatory processes.

Each measure was costed on an individual basis and all the measures (M-priorities) were summarised per environmental management area. The estimated costs are market related costs, and applicable to the construction industry in South Africa, November 2002.

8.3 Cost summary

The cost summary of all the Environmental Management Areas are:

- **Priorities/Projects already committed by IVS**

Priority	Projects already committed	TOTAL R Mil
A1	MTP treatment plant	150.0
A2	Coke oven gas cleaning	189.2
A3	Sinter pilot plant	15.0
A4	Sinter plant (full scale)	152.0
	SUB-TOTAL (A)	**R 506.2mil**

- **Master Plan cost estimates per Environmental Management Area**

Priority	Master Plan costs per Management Area	TOTAL R Mil
P1	Perimeter and surrounding areas	25.0
P2	Existing waste dump	105.4
P3	Dam 10	37.5
P4	South eastern slag and open veld area	95.3
P5	Overall CRMF	49.3
P6	Rietkuilspruit and Rietspruit Canal	8.7
P7	Maturation ponds	17.4
P8	TETP and MTP area	25.0
P9	Dams 1 to 4	4.4
P10	Consolidated Plant Area (CPA)	164.5
P11	Redundant blast furnace sludge dams	36.4
P12	Sludge dams (1 to 8)	16.0
P13	South western slag area	10.6
P14	Dam 11 (New waste site area)	128.2
P15	Processed materials stockpiles	16.2
P16	Raw materials stockpiles	4.0
P17	Kiewiet area	8.4
	Sub-Total	**782.5**
	Feasibility studies, detailed design, supervision, project management, authorisation processes (10% provision)	78.3
	Contingency allowance (10%)	78.3
	SUB-TOTAL (B)	**R 939.1 mil**

Estimated Total Cost:

• Projects already committed	**Sub-Total (A)**	**R 506.2 mil**
• Master Plan Cost Estimates	**Sub-Total (B)**	**R 939.1 mil**
	TOTAL (A+B)	**R1 445.3 mil**

8.4 Costs for Air Pollution Clean-up Priorities

A more detailed cost breakdown for the Air Pollution Clean-up Priorities are tabled below:

AIR POLLUTION CLEAN-UP PRIORITIES

	Item	Cost	
		R/kg/day	Estimated
1	Arc Furnace Hall Roof Emissions	0-10	R50 000
2	Blast Furnace C Tap Floor Filter	0-21	R200 000
2	Blast Furnace C Tap Floor	0-21	R200 000
2	Blast Furnace C Dust Chamber	0-21	R250 000
2	Blast Furnace D Dust Chamber	0-21	R250 000
6	EAF Filter Silo Discharge	0-28	R100 000
7	Steelserv North	0-42	R400 000
8	Conveyor Feeding Sinter Crush & Screen	0-84	R200 000
9	Sinter Bed Stacker	1-56	R150 000
9	BOF Raw Materials Conveyor	1-56	R150 000
11	Blast Furnace C Raw Materials	6-06	R300 000
11	Blast Furnace D Raw Materials	5-06	R300 000
13	DR Kiln Discharge Ends	5-21	R250 000
14	Sinter Prep. Crushing and Screening	6-56	R2 400 000
15	Foundry Shot Blasting	9-37	R1 000 000
18	Sinter Raw Materials Tippler Station	28-12	R300 000

The costs of measures for all the other disciplines are reflected in the detailed cost summary and timeframes, which forms part of the Appendices of the Integration Report.

8.5 Cost Saving Opportunities

8.5.1 Overview

Having regard to the high level of re-use of particularly solid residue streams already achieved, it is not likely that further lucrative opportunities for the sale or internal use of significant volumes of residue streams will be found. The accent must therefore be on the reduction of the cost of residue disposal, which has become a significant economic factor.

To this end it is logical to look at the larger residue streams. In decreasing order of magnitude, these are:

- Basic oxygen furnace slag – 510 000 tons/year
- Direct reduction raw material and separation dust – 296 600 tons/year
- Direct reduction coarse and fine Dolochar – 122 500 tons/year
- Blast furnace granulated slag – 56 200 tons/year

- Blast furnace and tap floor dusts – 33 900 tons/year
- Electric arc furnace fume – 18 000 tons/year

The six streams listed above contribute to almost 98% of the mass of residue, which has to be disposed of at present.

8.5.2 Basic Oxygen Furnace Slag

This stream makes up 48% of the present residue load. It is friable and can not be used for any purpose within the present operations being relatively low in iron (19%), high in aluminium (3,3%) and manganese 4,5%). If however it is allowed to weather in the open on a suitable pad, it may find an application as an aggregate in the building or road construction sectors.

8.5.3 Direct Reduction Dust

Making up nearly 28% of the present solids streams for disposal and having regard to it's origin and nature with 38,6% iron and low in contaminant metals, it would seem prudent to investigate the possibility of agglomerating it to a size range where it could be re-introduced into the kilns as a raw material. If such a process can be found, the cost will have to be weighed up against the cost of future disposal and the reduction of raw material cost. This must be seen as a medium to longer term project.

8.5.4 Coarse and fine Dolochar

No potential for internal use or sale can be foreseen for these streams. They are however high in alkaline content and may be a valuable resource if the inerting of other residue streams are to be undertaken. The need for inerting of residue streams depends on the future policy with regard to solid residue disposal and in particular the cost saving implication of inerting.

Using the Dolochar for inerting would however not reduce the total mass to be disposed of, although it could displace alternative alkaline material.

8.5.5 Blast Furnace Granulated Slag

The major portion of this material at present goes to the cement industry, but 56 200 tons/year remains in the basket of streams to be disposed of on-site. While only 5% of the present total, it would seem desirable to actively investigate the possibility of also routing this stream to the cement industry. If this is not feasible at present, the option of storing it separately for potential future sale would seem desirable.

8.5.6 Blast Furnace Dusts

This stream of mixed fumes and dusts of 33 900 tons/year being 3% of the total is relatively insignificant in the overall picture. It contains about 35% iron and little else in contaminant metal other than 0,75% manganese. The possibility of agglomeration and re-introduction into either the direct reduction or sinter processes would seem to warrant consideration.

8.5.7 Electric Arc Furnace Fume

At 18 000 tons/year being 1,7% of the total, it is also not significant by mass. The main components are 46% iron, 3.7% manganese and 2,6% zinc. The high iron content would make it a possible feed to the sinter plant after agglomeration to a suitable size range.

8.5.8 Reduced Residue Streams

The blast furnace scrubber sludge, at 29 300 tons/year or 2,7% of the total, contains 32% iron and is low in other metals. Potential uses after agglomeration would be as direct reduction or sinter feed.

The blast furnace raw material dust at 900 tons/year is essentially iron oxide ore. If an agglomeration process for the direct reduction dusts can be found it may well be possible to blend in this stream. The possibility of introducing it into the sinter plant raw material may also bear consideration.

The V3 concaster sludge analysed at 73% iron with almost no contaminant metals, would make it a candidate for re-use in the sinter or direct reduction plants, provided the particle size can be adjusted upwards. Assuming the same to apply to the V1 and V2 sludges, this could remove 1 090 tons/year from the streams to be disposed of to a residue facility.

The estimated 2 800 tons/year of oils and 420 tons/year of greases would place a heavy burden on any residue management facility and is likely to require a special cell for disposal. The two alternatives, which come to the fore, are re-refinement by an outside contractor or use as a fuel in the high-pressure steam boiler.

The latter possibility would depend on the composition, particularly as regards undesirable compounds like halocarbons or heavy metals.

8.5.9 Future Arisings

With the coke oven gas treatment project, the present emission of hydrogen sulphide to the atmosphere will be discontinued, as it will be converted to elemental sulphur. At a conversion rate of 95% it would produce 2 900 tons/year of saleable sulphur which would partly offset the cost of the conversion process.

Whatever abatement technology will be applied at the sinter plant main stack, it is almost certain to create an effluent, which will be very rich in potassium chloride. While it is too early to speculate on the full implications, the possibility may exist to recover KCl either as a solution or as crystals. South Africa imports all the potassium trace element requirements for the fertiliser industry.

Lastly, the MTP is likely to produce salts from the planned evaporator. At this stage it is not prudent to speculate on the composition and nature, but it may provide cost saving opportunities.

8.6 Conclusions

IVS has progressed well along the way of residue stream utilisation, whether through internal re-use or by external sale. It is however true that with each step forward, the next step becomes less rewarding and more difficult.

It is recommended that the accent be transferred from potential direct economic benefit, to an approach of cost saving on the disposal side.

No firm recommendations can be offered at this stage, but a number of potential avenues for investigation and evaluation do exist.

9. TIMEFRAMES

9.1 Pre-Master Plan Phase

A preliminary implementation programme was developed during the pre-Master Plan Phase. A gantt-chart was developed consisting of 218 activities, which included tasks and sub-tasks of all disciplines, their inter-relationships and estimated duration of each activity.

The activities were sub-divided into 3 main categories, namely:

- Short term (1 – 2 years)
- Medium term (3 – 4 years)
- Long term (5 – 12 years)

The overall proposed timeframe was scheduled over a period of 12 financial years, with a proposed commencement date of 2000/2001, and a completion date of 2011/2012.

Activities which related to short term (1 – 2 years), included short term actions for example –

- Perform comprehensive quantitative investigations
- Perform environmental monitoring and detailed risk assessments
- Refine the overall waterbalances for surface water, groundwater and process water
- Scope and determine permit and other regulatory requirements
- Implement emergency pollution control measures

- Perform feasibility study requirements for priority activities/projects

The activities, which were identified during the medium to long term, included mainly detailed design and implementation of measures, as well as the initiation of reguletory requirements e.g. permitting and licensing of measures. These listed activities were linked to a monetary velue, and the timeframe was coupled to a capital cash flow programme over a 12 year implementation programme.

The MP investigations were scheduled in phase 2, nemely the development of the MP.

9.2 Implementation Schedule developed during the Master Plan investigations

The implementation schedule of the MP were phased over 3 stages, namely:

- Pre-Master Plan study (Phase 1)
- Development of a Master Plan (Phase 2)
- Implementation of the Master Plan (Phase 3)

A main objective of phase 2 was *inter alia* to develop an implementation schedule, based on specific key criteria. These criteria could be summarised to be priorities derived from the MP process, environmental management objectives, regulatory requirements as advocated by the authorities, business plan objectives and a phased-in approach to be followed.

Subsequently, the key criteria were applied to waste management (new weste site and closure of existing facilities), pollution control of high, and medium to high, priority areas, rehabilitation in the short and long term, management of surface and process waters, air pollution abatement end soil remediation programmes.

9.2.1 Scheduled Implementetion

The pre-Master Plan implementation programme, which reflected a 12 year period of implementation, was mainly categorised in, and focussed on a short, medium and long term philosophy. Subsequently, during the MP study of 32 months, numerous short term measures identified by the pre-Master Plan study, were attended to, albeit that it was realised that such actions performed may not necessarily be the preferred option eventually identified during the MP integration exercise.

Never-the-less was information of the pre-Master Plan the premature impetus for the implementation during 2000/2001 of the IVS MP to be finalised in December 2002.

The results of the baseline study work and the MP integration process, enable the project teem in collaboration with IVS management to attach a higher level of accuracy and confidence to scheduled implementation. Subsequently a **20 year implementation programme** was developed by which comprehensive environmental management of the multi-media air, land and water at IVS were addressed:

- **Process water projects** - MTP treatment plant and associated ZED infrastructure
- **Air quality projects** – Coke Oven gas cleaning and Sinter Plant projects
- **Solid waste projects** – Rehabilitation, clean-up, pollution control and closure measures for various listed priority areas inside the CRMF area
- **Surface water related projects** – Pollution control measures inside the CRMF, on the perimeter of the IVS works, at the South-Eastern and South-Western slag areas, etc. It includes holding dam facilities, drainage facilities, cut-off trenches, pipelines and pump station facilities
- **Ground water related projects** – Abstraction borehole systems, mainly on the IVS perimeter and immediate surrounding areas
- **Institutional controls, authorizations, environmental awareness and training** – Initiation of formal and informal processes which relate to institutional measures and controls, authorizations from the regulatory authorities and to conduct environmental awareness and training programmes

The detailed implementation programme for each Environmental Management area, is presented in the Integration Report, as well as in the Master Plan: Book of Plans, Volume 2, and reproduced in the following two tables:

SCHEDULE 1: MAJOR PROJECTS ALREADY COMMITTED TIMEFRAME AND CASHFLOW PROJECTION

Priority	Major Projects Already Committed	Total R m	2002 R m	2003 R m	2004 R m	2005 R m	2006 R m	2007 R m
A1	MTP treatment plant	150.0		50.0	50.0	50.0		
A2	Coke oven gas cleaning	189.2		94.6	94.6			
A3	Sinter pilot plant	15.0		7.5	7.5			
A4	Sinter plant full scale	152.0				50.0	50.0	52.0
	TOTAL	**506.2**		**152.1**	**152.1**	**100.0**	**50.0**	**52.0**

SCHEDULE 2: IMPLEMENTATION SCHEDULE FOR MEASURES IN THE ENVIRONMENTAL MANAGEMENT AREAS TIMEFRAME AND CASHFLOW PROJECTION

Priority	Management area	Total Area Rm	Total Measures Rm	Year 1 Rm	Year 2 Rm	Year 3 Rm	Year 4 Rm	Year 5 Rm	Year 6 Rm	Year 7 Rm	Year 8 Rm	Year 9 Rm	Year 10 Rm	Year 11 Rm	Year 12 Rm	Year 13 Rm	Year 14 Rm	Year 15 Rm	Year 16 Rm	Year 17 Rm	Year 18 Rm	Year 19 Rm	Year 20 Rm
P1	Perimeter & surrounding areas	25.0	25.0	12.5	12.5																		
P2	Existing waste dump	105.6	105.6	5.0	6.0	7.7	14.6	8.8	11.3	6.4	5.5	5.5	5.5	7.5	7.5	6.1	4.2	4.3					
P3	Dam 10	37.5	37.5	0.1	1.7	3.6	7.0	10.9	8.6	5.6													
P4	S/E slag & open veld area	95.3	95.3	8.7	11.9	14.7	20.7	22.1	2.8	7.1	5.2	1.6	0.5										
P5	Overall CRMF	49.3	49.3	6.8	5.2	4.5	4.5	10.6	11.7	1.5	1.5	1.5	1.5										
P6	Rietkuilspruit & Rietspruit canal	8.9	8.9			0.3	0.8	2.3	2.0	1.5	1.0	1.0											
P7	Maturation ponds	17.6	17.6							5.5	5.8	1.5	0.3	2.2	0.7	0.1	1.5						
P8	TETP & MTP area	25.0	25.0	9.6	8.7	3.2	3.5																
P9	Dams 1-4	34.5	34.5				Opex	Opex	Opex	Opex	3.0	3.0	3.0	4.0	4.0	7.4	2.0	2.0	5.8	0.3			
P10	CPA	164.1	164.1	13.5	13.5	14.5	16.8	28.5	11.5	7.5	6.5	3.3	3.5					15.0	15.0	15.0			
P11	Dams 1-9 Redundant blast furnace sludge dam	36.4	36.4										4.0	4.0	8.0	4.0	5.1	2.5	4.0	4.8			
P12	Sludge dams 1-8	16.1	16.1					Opex	Opex	Opex	Opex	Opex	Opex	1.5	1.8	4.8	5.7	2.3					
P13	S/W slag area	10.6	10.6					0.6							5.0	5.0							
P14	Dam 11	128.3	128.3	0.1	0.1	0.3	0.5	0.6	4.2	5.2	4.9	14.2	16.5	15.7	15.7	13.7	10.7	10.7	11.6	0.9	0.9	0.9	0.9
P15	Processed materials stockpiles	16.3	16.3						3.0	4.0	5.6	1.1	1.1	1.1	0.4								
P16	Raw materials stockpiles							1.1	1.3	0.5	0.4	0.4	0.4										
P17	Kiewiet area	8.4	8.4										1.3	1.0	1.5	1.0	1.0	1.0	1.0	0.6			
	TOTAL	**783.3**	**783.3**	**56.3**	**60.0**	**48.8**	**68.4**	**85.5**	**56.4**	**44.8**	**39.4**	**33.1**	**37.6**	**37.0**	**44.6**	**42.1**	**30.2**	**37.8**	**37.4**	**21.6**	**0.9**	**0.9**	**0.9**

9.2.2 Cost and Cashflow distribution

The proposed 20 year implementation schedule is presented in terms of estimated cashflow requirements and cost distribution over a 20 year period; financial provisions for the major projects already committed over the financial years 2003 up to 2007; the relevant cost distribution between the listed P-Priorities; and proposed cost allocations to water, air and rehabilitation related projects.

The cost distribution, financial provisions and capital/cash flow schedules are graphically presented in the appendix of this Report and the Book of Plans referred to.

10. CONCLUSIONS

10.1 The **baseline study findings** resulted into a high level of confidence and understanding of the environmental status quo.

10.2 The sub-division of the IVS works area and the surrounding receiving environment emanated into **a well defined study area,** which was effectively related and integrated with the steel manufacturing processes.

10.3 Baseline study findings enabled the project team **to identify and quantify** all the key health and environmental related impacts and risks.

10.4 The impacts and risks were formulated and described in the baseline specialist reports and it was **holistically integrated** for the larger study area, the immediate surrounding areas and the environmental management areas inside the IVS works.

10.5 The MP study dealt in detail with the management practices of water air, waste and land. As for air and solid residue, extensive monitoring was conducted on water management related practices, which included ground water, surface water, process water and effluent.

It can be concluded that the MP study work resulted into well defined and optimised environmental management plans for solid residue, water and air.

10.6 The development of the **residue management plans** included the consideration of alternatives, cost benefit analysis, evaluation of best available technologies and the motivation of preferred options.

It can be concluded that special attention was given to **residue minimisation** and benchmarking against international standards.

10.7 Through a process of **integration of all the baseline study findings,** the overall objective of the MP was achieved, i.e. to structure, develop and implement an effective Environmental Management Plan for the IVS works.

The MP study unfolded into a **process of prioritisation, by the application of** primary human health and environmental criteria.

It can be concluded that a **risk based** approach was followed, by the application of site specific considerations and criteria. This approach enabled the project team to ascertain that the best practicable environmental option is pursued, taking into consideration the historical nature of activities, as well as the business objectives of continuous improvement.

10.8 The prioritisation process included the promotion of **sustainable development** and continued operations.

It included due consideration of the requirements which are enforced by the regulator.

10.9 The MP concluded by a process of detailed **cost estimation of the preferred options** and measures.

The proposed measures were prioritised and scheduled over an implementation period of 20 years. An estimated amount of R 1445.3 mil. is required. for environmental management over a 20 year period.

The **high priority measures** are scheduled for implementation during the first five financial years. An estimated amount of **R 506,2 mil.** will be required.

10.10 It can be concluded that the study adequately addressed the MP implementation phase, by applying a **life cycle approach** over a 20 year business horizon. This approach is inherently cast into typical environmental management activities such as rehabilitation, decommissioning and closure of existing facilities, which need to be replaced by new, upgraded or supplementary facilities.