Econ@uj

UNIVERSITY OF JOHANNESBURG

a consortium of ecological scientists

Basic Assessment of the Potential Impact of Coal Mining Activities on the Klein Olifants River and associated aquatic resources near Hendrina, Mpumalanga, South Africa – Final report

Econ@uj Report Nr. EUJ10-002

Prepared for:

Magdalena Von Ronge

GCS

63 Wessel Road Woodmead after Johannesburg South Africa

T· +27(11) 803-5726

magdalena@gcs-sa.biz

Prepared by:

Wynand Malherbe ______________________________

Martin Ferreira ______________________________

Zoology Department University of Johannesburg
C/O Kingsway and University Road Auckland Park 2006
Tel: +27 (0) 11 559 3820 Email: econ@uj.ac.za

UNIVERSITY OF JOHANNESBURG

Table of Contents

List of Tables 2

List of Figures 3

1. Introduction 4

2. Study Area 5

3. Site Selection 5

4. Material and methods 10

    4.1 Water quality assessment 11

        4.1.1 Surface Water Sample Collection 11

        4.1.2 In situ analysis 12

    4.2 Habitat quality assessment 12

    4.3 Aquatic macroinvertebrate assessment 13

    4.4 Fish community assessment 14

    4.5 Impact Assessment and Mitigation 16

5. Results and Discussion 17

    5.1 Water Quality Assessment 17

    5.2 Habitat Quality Assessment 22

    5.3 Aquatic Macroinvertebrate Assessment 24

    5.4 Fish Community Assessment 26

    5.5 Impact Assessment and Mitigation 28

6. Conclusion and Recommendations 35

7. References 38

List of Tables

Table 1: Ecological categories, categories, key colours and category descriptions presented within the biotic assessment.. 11
Table 2: The macroinvertebrate scoring system (SASS 5) results and the method applied in assigning ecological classes in this study.. 14
Table 3: Water quality results for June 2010 of selected sites associated with the proposed De Wittekrans Coal mine. Sites are situated on the KOR and a tributary. 19
Table 4: Water quality results for July 2010 of selected sites associated with the proposed De Wittekrans Coal mine. Sites are situated on the KOR and a tributary. 20
Table 5: Water quality results for August 2010 of selected sites associated with the proposed De Wittekrans Coal mine. Sites are situated on the KOR and a tributary. 21
Table 6: Water quality results for all sampling occasions of selected sites associated with the proposed De Wittekrans Coal mine. Sites are situated on the KOR and a tributary............. 22
Table 7: Final scores and the ecological classes obtained for the in-stream habitat of the selected sites. 23
Table 8: Results of the diversity of the invertebrates sampled at the various sites along with the SASS 5 results. 24
Table 9: Fish result from the July 2010 survey on the aquatic ecosystems associated with the proposed De Wittekrans mine. Reference values refer to the reference frequency of occurrence for the fish species in the reach (Kleynhans et al., 2007). 26
Table 10: FRAI results of the July 2010 survey on the Klein Olifants and its tributaries associated with the proposed De Wittekrans mine. 27

List of Figures

Figure 1: Map showing the position of the various sites 6
Figure 2: Photographs of Mashala 1 (A) upstream and (B) downstream. 7
Figure 3: Photographs of Mashala 2 (A) upstream and (B) downstream showing the abundant aquatic macrophytes. 7
Figure 4: Photographs of Mashala 3 (A) Downstream and (B) upstream showing the typical wetland habitat…... 8
Figure 5: Photographs of Mashala 4 (A) upstream and (B) downstream. 9
Figure 6: Photographs of Mashala 5 (A) upstream and (B) downstream 9
Figure 7: The Scoring system, classes and class description of the IHAS and HQI habitat indices implemented in this survey... 12

1. Introduction

Econ@uj, a consortium of environmental specialists based in the Zoology Department of the University of Johannesburg, was requested to carry out a basic assessment of the aquatic environment for the Environmental Impact Assessment (EIA) of the proposed coal mining activities near Hendrina, Mpumalanga, South Africa. The Klein Olifants River (KOR) is located near the proposed activities. The river is a tributary of the Olifants River and may have potential impacts on the Olifants River.

The report presents the results of the baseline assessment as well as an impact assessment of the potential impacts on aquatic environments in the area. The aims of the study was to characterise the present ecological integrity and assess the ecological importance of the KOR to determine the impacts that open cast mining will have on aquatic river and to propose management and mitigation measures for impacts on aquatic ecosystems

Econ@uj is a multi-disciplinary consortium of environmental specialists based at the University of Johannesburg (UJ). The consortium, formerly known as RAUEcon, has been offering environmental consultancy in the Aquatic Health, Aquatic Toxicology and Ecotoxicology fields since 1998. **Econ@uj** offers technical and specialist services, to both the government and private sectors, in a number of fields related to Integrated Water Resource Management in southern Africa. Our core activities relate to freshwater and more recently estuarine environments. These studies incorporate the assessments of aquatic fauna, aquatic and riparian vegetation, physico-chemical assessment of water and sediment, laboratory-based toxicology and ecotoxicology. In the form of RAUEcon, **Econ@uj** has a proven track record with numerous completed projects and successful collaborations with government institutions such as the Department of Water Affairs and Forestry, the Water Research Commission, the South African Institute of Aquatic Biodiversity, and private partners representing the mining, agricultural and industrial sectors. **Econ@uj** is committed to capacity building as well as postgraduate students from UJ are offered the opportunity to carry out practical aspects of projects, in order to gain experience in the fields of Aquatic Health and Ecotoxicology.

2. Study Area

The major aquatic ecosystem associated with the proposed mining activities is the Klein Olifants River (KOR) and various hillslope seeps. There is also a small valley bottom type wetland on one of the tributaries of the KOR.

The KOR falls within the upper Olifants Water Management Area (WMA). The geology of the area consists mainly of hard rock formations. The most prominent feature of the entire catchment is the occurrence of the Bushveld Igneous Complex. The eastern limb of this formation cuts through the northern part of the WMA. The sand stones and shale within the area contain rich coal deposits which occur in the Upper Olifants Sub-area in the vicinity of Witbank and Middelburg. The topography consists of typical flat grassland areas and the climate is cool. Rainfall varies between 600 – 800 mm per annum. The rainfall is, however, highly seasonal and most rain fall during characteristic thunderstorms. The KOR ultimately flows into the Olifants River which in turn flows through the very well known conservation area: the Kruger National Park.

3. Site Selection

Five sites were selected for the purpose of the study. The first site (Mashala 1) is situated above any of the potential impacts. The second and third sites are situated on a tributary of the KOR on the farm Boschmanshoek. The sites were selected above and below the proposed site for the processing plant. The fourth site (Mashala 4) was selected downstream of the proposed open cast pits, while the fifth site (Mashala 5) is situated below all the proposed activities next to the N11 highway.

Mashala 1

Mashala 1 was located upstream of any of the potential impacts. The site is located below a dam that has been constructed on the KOR. The in-stream habitat consists of gravel, sand and mud as substrate with many different aquatic macrophytes also present at the site. The flow within the river is very slow and two large pooled areas have formed below the dam and below a dirt road that intersects the river. A drainage pipe has been placed in the river to ensure flow under this road (Figure 2 A and B). Although there is minimal flow, erosion of the stream banks is already visible.

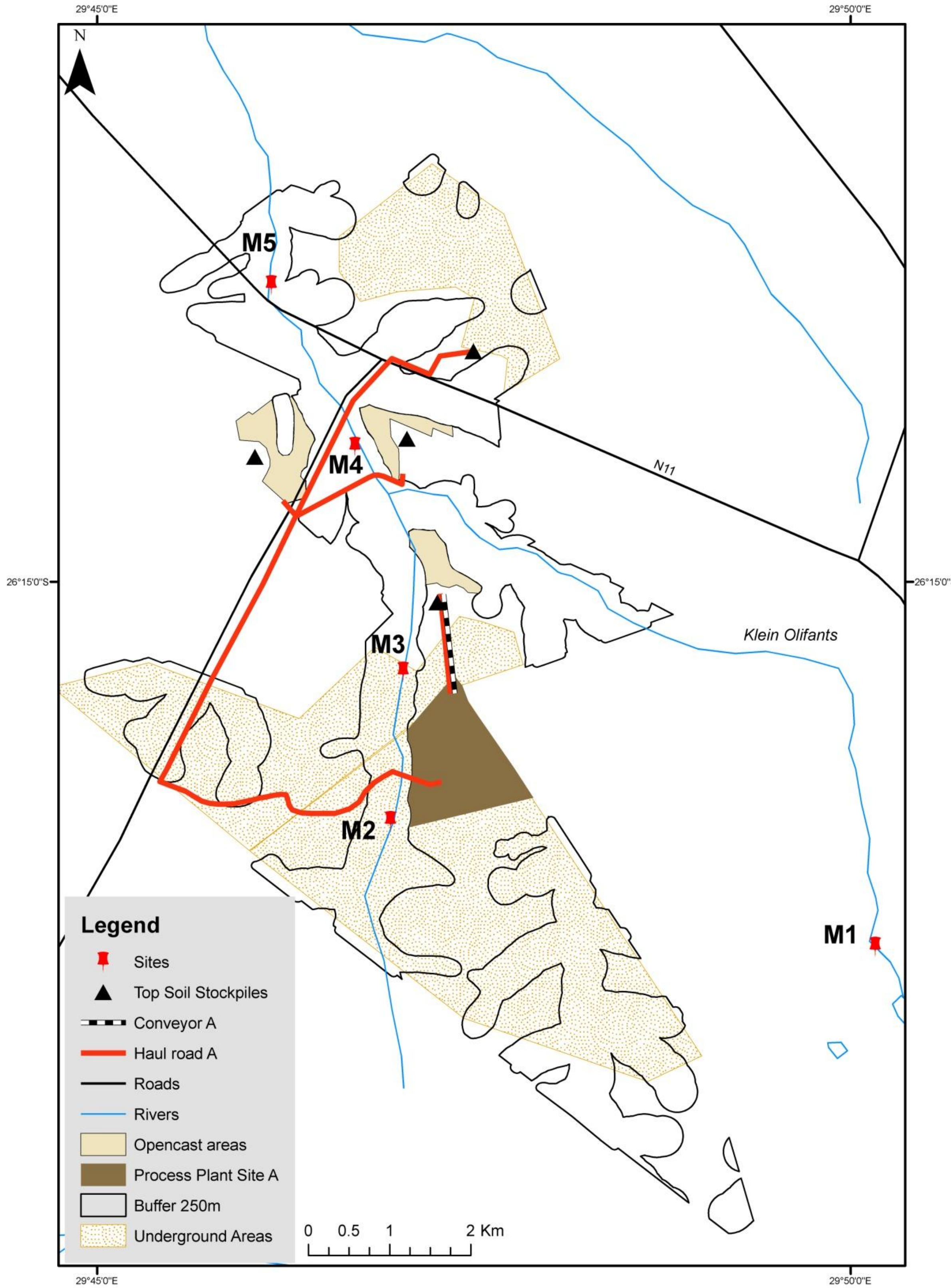

Figure 1: Map showing the position of the various sites

A B

Figure 2: Photographs of Mashala 1 (A) upstream and (B) downstream.

Mashala 2

This site is located on a tributary of the KOR upstream of the proposed site for the processing plant. A low level bridge and road intersects the river at the site. A large dam has also been constructed upstream of the site. As a result the flow within the river has been altered and there is minimal flow. The river consists largely of pooled areas. This provides excellent habitat for a variety of aquatic macrophytes. The aquatic macrophytes at this site have become so abundant that minimal open water habitat is available for the aquatic biota. The substrate consists largely of sand and mud with the only stones available being in the form of the material used to construct the river crossing. Despite minimal flow, both banks show signs of heavy erosion.

A B

Figure 3: Photographs of Mashala 2 (A) upstream and (B) downstream showing the abundant aquatic macrophytes.

Mashala 3

Mashala 3 was located downstream of the proposed site for the processing plant. The tributary of the KOR at this points form a small valley bottom – type wetland. The habitat is typical of such a wetland. The water is shallow with an abundance of sand and mud. This provides excellent habitat for a variety of submerged and emergent aquatic macrophytes. The wetland appears to be performing natural hydrological and hydrochemical functions such as water retention, purification and sediment trapping. The wetland appears to have formed in this are due to steep slopes and a flat valley. This is an important consideration for surface water runoff from the proposed processing plant.

A B

Figure 4: Photographs of Mashala 3 (A) Downstream and (B) upstream showing the typical wetland habitat.

Mashala 4

Mashala 4 is positioned directly below the proposed open cast mining activities. The site is the only site in the study where the substrate consisted of sand and mud as well as of stones. The stone habitat was in the form of large bedrock areas. The flow at this site also varies between pooled areas and faster flowing areas. Algae were present on the rocks, but marginal and in-stream vegetation was scares. Both banks show signs of heavy erosion, especially downstream of a road that intersects the river at the site.

A B


Figure 5: Photographs of Mashala 4 (A) upstream and (B) downstream.

Mashala 5

Mashal 5 was located on the KOR downstream of all the potential activities. Flow at this site is relatively uniform with slow flowing areas intersected by deeper pooled areas. The substrate in the river consists largely of fine sediment. Both banks are near vertical due to erosion and the siltation at this site is of serious concern. The silt layer at the site is more than 50 cm in depth and all other substrate has been covered. Due to the erosion of the stream banks minimal marginal vegetation is present, but the sedimentation provides substrate for the growth of in-stream aquatic macrophytes. The N11 highway intersects the river at this point.

A B


Figure 6: Photographs of Mashala 5 (A) upstream and (B) downstream

4. Material and methods

More than a century ago, people recognised that human activities produced pollution harmful to the biota. They therefore made an effort to track the extent of biological degradation; biological degradation was even considered an indicator for the presence of human activities. So began biological monitoring (Karr and Chu, 2000). In the past water quality monitoring focused on physical and chemical measurements. It has however, become recognised that by using other indicators in addition to traditional water quality measurements it can, to a great extent, enhance the assessment and management of water resources (Hohls, 1996). Biomonitoring can thus be defined as the use of living organisms as biological indicators of ecosystem or environmental health. It is further stated that animals and plants can provide a long – term integrated reflection of water quality, quantity, habitat quality and other environmental conditions.

For each ecological component at each river site, an assessment was undertaken of the reference, or natural, conditions. This field monitoring survey determined the Present Ecological State (PES) for the ecological response groups (aquatic invertebrates and fish) for each site. These methods are based on the River Health Programmes models for each main ecosystem component as follows:

Responses:

- **SASS5:** South African Scoring System version 5 (Dickens and Graham, 2002).
- **FRAI:** Fish Response Assessment Index (Kleynhans, 2007).

Driver baseline conditions for habitat and water quality (for surface water) was determined and was used to enrich and validate responder data.

Drivers:

- **IHAS v.2**: Integrated Habitat Assessment Index version 2 (McMillan, 1998).
- **HQI**: Habitat Quality Index
- **Water Quality analysis:** Surface water sampling and analysis undertaken by an accredited laboratory in accordance with methods prescribed by the SABS (Standards Act No 30 of 1982).

The results of the response models for fish, macroinvertebrates, and habitat components are provided as Ecological Categories (ECs) ranging from Natural (A) to Critically Modified (F)

(Table 1). The varying driver and responder components and indices are discussed in more detail in the following section.

Table 1: Ecological categories, categories, key colours and category descriptions presented within the biotic assessment

Class	Ecological Category	Description
A	Natural	Unmodified state - un-impacted state, conditions natural.
B	Good	Largely natural - few modifications, mostly natural.
C	Fair	Moderately modified - Community modifications, some impairment of river health.
D	Poor	Largely modified - Distinct impairment of river health, impacted state.
E	Seriously modified	Seriously modified - most community characteristics modified, seriously impacted state.
F	Critically modified	Critically modified - extremely low species diversity and abundance, unacceptable modified state.

4.1 Water quality assessment

4.1.1 Surface Water Sample Collection

The samples were taken directly below the water surface with a clean scoop bucket, transferred to a set of bottles and transported to the laboratory in a cool box. Two litres of water were taken for general analysis in pre-washed plastic bottles. All water quality analysis was carried out by Inspectorate M & L laboratory. They are a SANAS accredited laboratory. The water analysis included nutrients, salts, and selected metals. Results were compared to the South African Water Quality Guidelines where Target Water Quality Requirements are available for aquatic ecosystems (DWAF, 1996a). Water samples were taken at 4 sites associated with the proposed mine to assess the present condition of the water in the catchment. The variables were selected so that a baseline of the area can be set against which the mine will be able to manage the water quality of the systems during construction as well as during operation.

4.1.2 In situ analysis

The *in situ* physico-chemical variables that were sampled during the current survey included temperature, pH, dissolved oxygen concentration ([DO]) and saturation (DO%), and electrical conductivity (EC). *In situ* analysis was undertaken using a pre-calibrated WTW 340i multi-parameter hand-held water quality meter.

4.2 Habitat quality assessment

Habitat availability and diversity are major determinants in the overall community structure of aquatic macro-invertebrates, therefore it is of the utmost importance to evaluate habitat quality when applying biomonitoring methodologies and assessing river health. The habitat quality and diversity were assessed by means of the Habitat Quality Index (HQI) and the Integrated Habitat Assessment System (IHAS) (McMillan, 1998). They were implemented by taking note of various observations on a provided score sheet. The values of the indices were then calculated as a percentage. A rating system for each index then described the habitat quality of the given site. The classification system used to classify the habitat integrity of the sites in the study is shown in Figure 7. These indices were not applied at Mashala 3 as the indices were developed for the assessment of riverine habitat integrity and the river at this point forms a wetland.

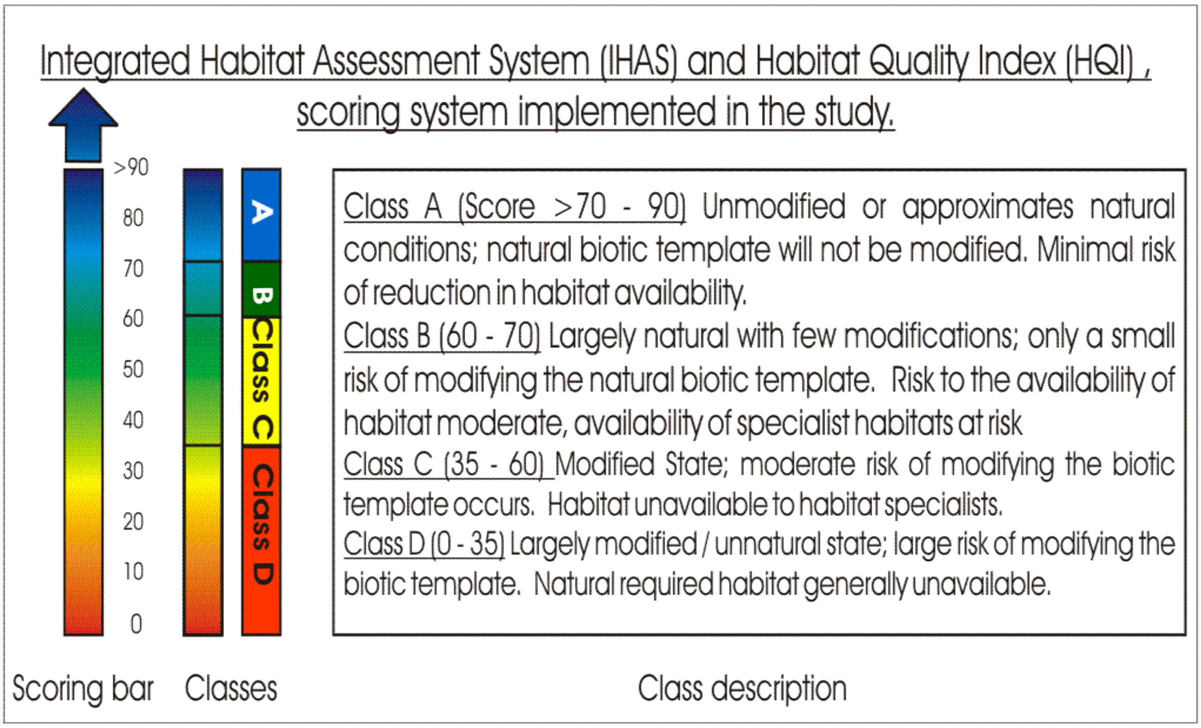

Figure 7: The Scoring system, classes and class description of the IHAS and HQI habitat indices implemented in this survey

4.3 Aquatic macroinvertebrate assessment

The current index, being used to assess the status of riverine macroinvertebrates in South Africa, is the South African Scoring System (SASS). The index is based on the presence of aquatic macroinvertebrate families and the perceived sensitivity to water quality changes of these families. Different families show different sensitivities to pollution, these sensitivities range from highly tolerant families (e.g. Muscidae and Psychodidae) to highly sensitive families (e.g. Oligoneuridae). The index has gone through several upgrades and version 5 is currently in use. SASS is an accredited protocol that has been tested and widely used in South Africa as a biological index of water quality. SASS results are expressed both as an index score (SASS score) and the average score per recorded taxon (ASPT value). From this data it is possible to establish the integrity or health of a river.

The standard SASS-5 protocol (Dickens and Graham, 2002) was followed to collect macroinvertebrate samples and various biotopes in which macroinvertebrates may occur were sampled. Three biotopes were sampled including: stones (in current, out of current and bedrock), vegetation (marginal and aquatic) and gravel, sand and mud (GSM). After sampling each biotope, using the standard SASS net (1 mm mesh and dimensions of 30 x 30 x 30 cm), the samples were placed in an identification tray and the macroinvertebrates were identified. Identification took place on site for the set period of 15 minutes. If no new taxon was identified for 5 minutes, identification was stopped. The SASS5 index was not applied at Mashala 3 as the river at this point forms a wetland and the index was developed for wadable rivers.

SASS5 results are often analysed based on the biological bands method developed by Dallas (2007). These methods are, however, still under development and SASS5 results were thus analysed according to Table 2. It should be noted that SASS5 complies with international accreditation protocols and a SASS5-accredited practitioner from Econ@uj undertook the SASS5 assessments on the monitoring trip. For a high confidence assessment, results must be obtained for various seasons. This is because aquatic macroinvertebrate communities may often display seasonal variation in community structure (Dallas, 2004). Identification of the organisms are made to family level (Dickens and Graham, 2002; Gerber and Gabriel, 2002).

Table 2: The macroinvertebrate scoring system (SASS 5) results and the method applied in assigning ecological classes in this study

SASS 5 Score	ASPT	Condition	Class
> 140	>7	Natural	A
100 – 140	5 – 7	Good	B
60 – 100	3 – 5	Fair	C
30 – 60	2 – 3	Poor	D
<30	<2	Seriously modified	E/F

4.4 Fish community assessment

The use of fish communities in the monitoring of aquatic ecosystems have been widely used to determine the overall condition of aquatic ecosystems. Fish communities have certain advantages when used as indicators of ecosystem integrity namely (Kotze, 2002):

- Fish are present in most aquatic ecosystems except when the system is highly degraded.
- Fish can be easily identified and then returned to the aquatic ecosystem.
- Most fish species have background information available in terms of life-history and environmental response information.
- Fish are mobile and can integrate contaminant exposure or habitat degradation over a river reach.
- Fish are generally long-lived and as such can provide long term information regarding environmental stress.
- Fish communities are composed of various trophic levels and can indicate stressor responses at many trophic levels.
- Fishes often exhibit physiological, morphological, or behavioral responses to stresses, which have been grouped into chemical stressors, physical stressors, and perceived stressors.
- Due to the importance relating to the safe consumption of fish and the recreational, subsistence and commercial fishing activities, the public is likely to relate to information concerning fish communities rather than other biotic communities.

It is important to consider some disadvantages relating to the use of fish as bioindicators. Some disadvantages include:

- The select nature of sampling techniques and equipment for certain species, sizes and habitats of fishes.

- Sampling bias due to the seasonal migration and/or movement of fishes.
- A large sampling effort is often required to adequately characterize fish assemblages.
- Some fish species may be influenced by the sampling techniques.
- Being mobile, fish can avoid local disturbances and not be exposed to environmental impacts.
- Due to fishes often representing higher trophic levels, lower level organisms may provide an earlier indication of water quality pollution.

The RHP (Mangold, 2001) and FRAI (Kleynhans, 2007) sampling methodologies were used to assess the fish populations of the KOR and a small tributary of the river. The technique used to sample was electroshocking (Meador *et al.*, 1993; Barbour *et al.*, 1999). A Samus battery operated electroshocking apparatus was used to sample fish in the available habitat at each site. The electroshocking technique was implemented for between 20 to 30 min depending on the site and habitat availability. All the fish caught were identified and returned. When the fish could not be identified on site it was preserved in 10% formalin for identification in the laboratory.

The current index of choice to determine the fish community integrity for the RHP and Reserve determinations is the Fish Response Assessment Index (FRAI) (Kleynhans, 2007) as developed within the EcoClassification methodology (Kleynhans and Louw 2007). EcoClassification is a rule-based method that aims to integrate the biophysical components of a river to provide a realistic and reproducible result of the EcoStatus of a river (Kleynhans and Louw, 2007). FRAI is based on the responses of fish species and the fish community to various stressors within the ecosystem. These stressors can vary from the lack of natural environmental requirements of the fish or the effects of driver changes to the habitat conditions within the ecosystem. The ecological category for the fish community is determined by comparing the environmental requirements and the response to modified habitat conditions of the observed (in some cases derived) fish community to a reference fish community (Kleynhans, 2007).

The FRAI index makes uses of the rating, ranking and weighting procedure adopted by the EcoStatus approach (Kleynhans and Louw, 2007). The drivers and responders within an ecosystem do not have the same ecological importance or sensitivity in a specific river. In effect this means that a specific metric may be modified but the effect within the ecosystem will be low if the metric has a low ecological importance or sensitivity. The specific importance and sensitivity of each metric could potentially change from river to river or from ecoregion to ecoregion depending on the importance and sensitivity. Thus, the ranking and weighting approach was incorporated to help deal with this inert variability of rivers (Kleynhans, 2007). The FRAI index has different metrics and sub-metrics to calculate the ecological category. The approach of using various metrics help to develop a more consistent index of the fish community and it helps with the mathematical integration of the metrics.

The FRAI index relies on the use of a reference fish species list as well as a fish frequency of occurrence within the system. This information is available in the Reference Fish Frequency of Occurence (FFROC) (Kleynhans et al., 2007). If no data is available from this source, previous studies and literature should be used to derive the frequency of occurrences and reference species list for the site and system. The reference list and frequency of occurrences are entered into the FRAI index together with the sampled fish species and their frequency of occurrence. The index then calculates an automated FRAI index value based on the relative intolerances, reference frequency of occurrence and current frequency of occurrence of the reference fish species. This value can be adjusted for each metric within the FRAI index due to changes in habitat conditions observed at the site or expert opinion to provide a more accurate FRAI index value. The FRAI index value is given in terms of an ecological category from A – F according to Table 1.

4.5 Impact Assessment and Mitigation

In order to assess the risks and the potential efficacy of suggested mitigated measures, the following ranking scales were used (the terminology is from the DEAT guideline document on EIA Regulations, April 1998):

Occurrence

- probability of occurrence (how likely it is that the impact may occur?); and
- duration of occurrence (how long it may last?).

Severity

- magnitude (severity) of impact (will the impact be of high, moderate or low severity?);
- scale/extent of impact (will the impact affect the national, regional or local environment or only that of the site?).

Probability:=P	Duration:=D
Probability:=P 5 – Definite/don't know 4 – Highly probable 3 – Medium probability 2 – Low probability 1 – Improbable 0 – None	*Duration:=D* 5 – Permanent 4 - Long-term (ceases with the operational life) 3 - Medium-term (5-15 years) 2 - Short-term (0-5 years) 1 – Immediate
Scale:=S 5 – International 4 – National 3 – Regional 2 – Local 1 – Site only 0 – None	*Magnitude:=M* 10 - Very high/don't know 8 – High 6 – Moderate 4 – Low 2 – Minor

Figure 8: Diagram indicating the various variables and their rankings used to assess the risk of an impact occurring.

Once the above factors had been ranked for each potential impact identified, the environmental significance of each was assessed using the following formula:

SP = (magnitude + duration + scale) x probability

The maximum value is 100 significance points (SP). Environmental effects were rated as either of high, moderate or low significance on the following basis:

- More than 60 significance points indicated high (H) environmental significance.
- Between 30 and 60 significance points indicated moderate (M) environmental significance.
- Less than 30 significance points indicated low (L) environmental significance.

5. Results and Discussion

5.1 Water Quality Assessment

The results for the baseline water quality assessment of surface water on the aquatic ecosystems associated with the proposed De Wittekrans Coal mine are presented in Tables 3 – 6. The water quality variables are compared with the Target Water Quality Requirement (TWQR) for the protection of aquatic ecosystems (DWAF, 1996) presented in Table 6.

The results of the June sampling are presented in Table 3. The pH, conductivity, temperature and oxygen were all within the recommended guidelines of DWAF (1996). The conductivity and pH are some of the variables that could change should mining activities start. Generally, conductivity increases due to increased salt loads from mining runoff while pH could decrease due to AMD. A change in these variables will result in a loss of some aquatic species from the system. A decrease in pH can also allow various metal levels to increase and become bioavailable to aquatic organism which in turn could cause ecological effects.

The salt concentrations were similar for all sites during June to August 2010 at the selected sites. No TWQR for aquatic ecosystems are available at present but salt concentrations (Ca, Mg, Na, K) should remain at the levels identified in this study as any changes in these concentrations could cause effects on the aquatic ecosystem. The concentrations of inorganic nitrogen during the June survey were within the acceptable limit of less than 0.25 mg/l at Mashala 2, Mashala 4 and Mashala 5. The levels at Mashala 1 were above the limit indicating that the water is in an eutrophic condition due to increased nutrients. The levels during July 2010 were all below the detection limit and the TWQR for aquatic ecosystems. The increased nutrients are due to the farming in the area and livestock using the rivers for drinking water. The concentrations for sulphate were also similar at all sites during June to August 2010. However, the concentrations are elevated, but no TWQR exist for this variable. The chemical oxygen demand (COD) concentrations were similar during all the samples from June to August 2010. The COD values were slightly elevated. Phosphate levels were also slightly elevated.

The metal concentrations measured at all sites during June to August 2010 were either below the detection limits or below the TWQR set for the specific variable. However, the aluminium and copper concentrations were higher than the TWQR. This however is possibly due to natural levels found at the site rather than due to some pollution source. Metal concentrations could increase due to mining activities as dust, sedimentation and polluted water may carry metals into the aquatic ecosystem. Once in the aquatic ecosystem these metals can either have an effect on the aquatic biota or sink out into the sediment. The sediment metals could pose a potential problem in the future as changes in environmental conditions can cause them to dissolve into the water and cause effects on the aquatic biota. The metal concentrations measured here should not increase significantly as the levels from this study are baseline values.

Table 3: Water quality results for June 2010 of selected sites associated with the proposed De Wittekrans Coal mine. Sites are situated on the KOR and a tributary.

Parameter		Sites				
	Unit	Mashala 1	Mashala 2	Mashala 3	Mashala 4	Mashala 5
Conductivity	µS/cm	454	392	-	413	400
Temperature	°C	11.3	8.7	-	10.7	8.3
pH	-	8.49	7.83	-	7.99	8.07
Oxygen saturation	%	128.4	105.6	-	95.6	91.4
Oxygen content	mg/l	11.5	9.92	-	8.79	8.83
Calcium,Ca	mg/l	29	28	-	26	27
Magnesium, Mg	mg/l	29	19.3	-	19.8	20
Sodium,Na	mg/l	28	30	-	31	32
Potassium,K	mg/l	2.9	4.3	-	3.6	3.6
Free and Saline Ammonia as NH_4	mg/l	<0.1	<0.1	-	<0.1	<0.1
Sulfate, SO_4	mg/l	43	37	-	34	38
Nitrate, NO_3	mg/l	34	3.8	-	<0.1	1.2
Nitrate as N	mg/l	7.7	0.9	-	<0.1	0.3
Nitrite as N	mg/l	<0.1	<0.1	-	<0.1	<0.1
Chemical Oxygen Demand, O_2	mg/l	42	50	-	50	42
Arsenic, As	mg/l	<0.02	<0.02	-	<0.02	<0.02
Selenium, Se	mg/l	<0.03	<0.03	-	<0.03	<0.03
Aluminium, Al	mg/l	0.015	0.13	-	0.01	0.01
Nickel, Ni	mg/l	<0.003	0.003	-	<0.003	<0.003
Manganese, Mn	mg/l	<0.001	0.002	-	0.002	<0.001
Iron, Fe	mg/l	0.11	0.15	-	0.048	0.13
Zinc, Zn	mg/l	<0.005	<0.005	-	0.032	<0.005
Lead, Pb	mg/l	<0.01	<0.01	-	<0.01	<0.01
Cobalt, Co	mg/l	<0.001	0.006	-	<0.001	<0.001
Copper, Cu	mg/l	0.015	0.01	-	0.007	0.017
Total Chromium, Cr	mg/l	0.003	0.006	-	0.004	<0.003
Cadmium, Cd	mg/l	<0.001	<0.001	-	<0.001	<0.001
Uranium, U	mg/l	<0.004	<0.004	-	<0.004	0.004

Table 4: Water quality results for July 2010 of selected sites associated with the proposed De Wittekrans Coal mine. Sites are situated on the KOR and a tributary.

Parameter		Sites				
	Unit	Mashala 1	Mashala 2	Mashala 3	Mashala 4	Mashala 5
Conductivity	µS/cm	491	439	430	441	429
Temperature	°C	8.1	12.5	16	14.9	11.5
pH	-	8.03	8.05	7.71	8.48	8.2
Oxygen saturation	%	75.1	125.3	74.2	137.8	122.1
Oxygen content	mg/l	7.18	11.05	6	11.44	11.5
Calcium,Ca	mg/l	22	22	-	26	23
Magnesium, Mg	mg/l	25	15	-	19	16.1
Sodium,Na	mg/l	23	24	-	29	30
Potassium,K	mg/l	2.1	3.2	-	2.8	3.4
Free and Saline Ammonia as NH_4	mg/l	<0.1	<0.1	-	<0.1	<0.1
Sulfate, SO_4	mg/l	47	44	-	33	33
Nitrate, NO_3	mg/l	<0.1	<0.1	-	<0.1	<0.1
Nitrate as N	mg/l	<0.1	<0.1	-	<0.1	<0.1
Nitrite as N	mg/l	<0.1	<0.1	-	<0.1	<0.1
Chemical Oxygen Demand, O_2	mg/l	35	43	-	35	43
Arsenic, As	mg/l	<0.02	<0.02	-	<0.02	<0.02
Selenium, Se	mg/l	0.05	0.1	-	0.05	0.06
Aluminium, Al	mg/l	0.012	0.076	-	<0.009	<0.009
Nickel, Ni	mg/l	<0.003	<0.003	-	<0.003	<0.003
Manganese, Mn	mg/l	0.002	0.014	-	0.03	0.04
Iron, Fe	mg/l	<0.001	<0.001	-	<0.001	<0.001
Zinc, Zn	mg/l	0.078	0.17	-	0.057	0.061
Lead, Pb	mg/l	0.01	0.04	-	<0.01	<0.01
Cobalt, Co	mg/l	0.009	0.006	-	<0.001	0.008
Copper, Cu	mg/l	<0.002	<0.002	-	0.002	0.009
Total Chromium, Cr	mg/l	<0.003	<0.003	-	<0.003	0.003
Cadmium, Cd	mg/l	<0.001	<0.001	-	0.001	<0.001
Uranium, U	mg/l	<0.004	<0.004	-	0.004	<0.004
Phosphate	mg/l	<0.12	0.17	-	0.23	0.3

Table 5: Water quality results for August 2010 of selected sites associated with the proposed De Wittekrans Coal mine. Sites are situated on the KOR and a tributary.

Results for the August water quality is still pending

Parameter		Sites			
	Unit	Mashala 1	Mashala 2	Mashala 4	Mashala 5
Conductivity	µS/cm	526	465	508	510
Temperature	°C	10.5	9.6	10.2	7.7
pH	-	8.25	9.07	8.34	8.24
Oxygen saturation	%	82.4	97	110	103.4
Oxygen content	mg/l	7.5	9.17	10.17	10.1
Calcium,Ca	mg/l				
Magnesium, Mg	mg/l				
Sodium,Na	mg/l				
Potassium,K	mg/l				
Free and Saline Ammonia as NH_4	mg/l				
Sulfate, SO_4	mg/l				
Nitrate, NO_3	mg/l				
Nitrate as N	mg/l				
Nitrite as N	mg/l				
Chemical Oxygen Demand, O_2	mg/l				
Arsenic, As	mg/l				
Selenium, Se	mg/l				
Aluminium, Al	mg/l				
Nickel, Ni	mg/l				
Manganese, Mn	mg/l				
Iron, Fe	mg/l				
Zinc, Zn	mg/l				
Lead, Pb	mg/l				
Cobalt, Co	mg/l				
Copper, Cu	mg/l				
Total Chromium, Cr	mg/l				
Cadmium, Cd	mg/l				
Uranium, U	mg/l				

Table 6: Water quality results for all sampling occasions of selected sites associated with the proposed De Wittekrans Coal mine. Sites are situated on the KOR and a tributary

Parameter		Sites				TWQR
	Unit	Mashala 1	Mashala 2	Mashala 4	Mashala 5	
Conductivity	µS/cm	490.33	432.00	454.00	446.33	-
Temperature	°C	9.97	10.27	11.93	9.17	-
pH	-	8.26	8.32	8.27	8.17	±15%
Oxygen saturation	%	95.30	109.30	114.47	105.63	80 - 120%
Oxygen content	mg/l	8.73	10.05	10.13	10.14	
Calcium,Ca	mg/l	25.5	25	26	25	NA
Magnesium, Mg	mg/l	27	17.15	19.4	18	NA
Sodium,Na	mg/l	25.5	27	30	31	NA
Potassium,K	mg/l	2.5	3.75	3.2	3.5	NA
Free and Saline Ammonia as NH_4	mg/l	<0.1	<0.1	<0.1	<0.1	
Nitrate, NO_3	mg/l	45	40.5	33.5	35.5	< 0.25
Nitrate as N	mg/l	17.03	1.925	<0.1	0.625	
Nitrite as N	mg/l	3.875	0.475	<0.1	0.175	
Sulfate, SO_4	mg/l	< 0.1	<0.1	<0.1	<0.1	NA
Chemical Oxygen Demand, O_2	mg/l	38.5	46.5	42.5	42.5	NA
Arsenic, As	mg/l	<0.02	<0.02	<0.02	<0.02	0.01
Selenium, Se	mg/l	0.033	0.058	0.033	0.075	0.002
Aluminium, Al	mg/l	0.13	0.103	0.007	0.007	0.005
Nickel, Ni	mg/l	<0.003	0.002	<0.003	<0.003	NA
Manganese, Mn	mg/l	0.001	0.008	0.016	0.041	0.18
Iron, Fe	mg/l	0.055	0.075	0.024	0.065	NA
Zinc, Zn	mg/l	0.027	0.086	0.045	0.032	< 0.002
Lead, Pb	mg/l	0.008	0.023	<0.01	<0.01	0.0002
Cobalt, Co	mg/l	0.005	0.006	<0.001	0.004	NA
Copper, Cu	mg/l	0.008	0.006	0.005	0.013	0.0003
Total Chromium, Cr	mg/l	0.003	0.004	0.003	<0.003	0.007
Cadmium, Cd	mg/l	<0.001	<0.001	<0.001	<0.001	0.15
Uranium, U	mg/l	<0.004	<0.004	<0.004	0.004	NA
Phosphate	mg/l	<0.12	0.17	0.23	0.3	NA

5.2 Habitat Quality Assessment

Habitat quality is an important part of an ecosystem as it forms the basis for the ecosystem. If the habitat quality is affected, it will have an effect on the whole systems integrity. When the habitat diversity is extensive and unimpacted, the biotic community structures tend to be good. The habitat quality and diversity were assessed by applying the HQI and the IHAS indices. These indices, as used in the RHP, are done by completing various observations on a provided score sheet in the field.

According to the State of The Rivers Report (Ballance *et al.*, 2001) the in-stream and riparian habitats in the upper Olifants WMA is in a fair to unacceptable state. The in-stream habitat of the KOR catchment is said to be in a poor state. Results of the habitat quality assessment of the current study indicates that, apart from the IHAS results for Mashala 4, the instream habitat at all the sites was in a fair to poor state.

Table 7: Final scores and the ecological classes obtained for the in-stream habitat of the selected sites.

	Mashala 1	Mashala 2	Mashala 3	Mashala 4	Mashala 5
IHAS	48	52	-	75	46
HQI	33	35	-	56	34
IHAS class	**C**	**C**	**-**	**A**	**C**
HQI class	**D**	**D**	**-**	**C**	**D**

The main reasons for the change in habitat integrity observed at all the sites were a change in in-stream flow and the resultant sedimentation. On nearly every farm through which the KOR flows, several small farm dams have been constructed. Farm dams have also been constructed on the tributary of the KOR above the proposed site for the processing plant. The flow alterations that have been caused by these dams have led to a loss in different flow types (velocities) at all the sites. As a result most of the habitat is in the form of pools or slow flowing areas. The flow alterations have also led to serious erosion and the resultant sedimentation at all of the sites. The sedimentation has directly caused the loss of riffles as a habitat at nearly all the sites apart from Mashala 4. Along with the flow alterations, land use in the form of grazing, further contributes to the heavy silt loads within the associated systems.

During the construction and operational phases of the open cats pits and the processing plant erosion and sedimentation is of serious concern. This problem is of particular concern as a valley bottom type wetland is situated directly downstream of the proposed site for the processing plant. With current silt loads being high, any additional silt loads may have a major impact on the ability of this wetland to perform is natural hydrological functions. In addition, extremely heavy silt loads are already present at Mashala 5 (downstream of the proposed open cast pits). A silt load of more than 50cm was observed during the field surveys. Removal of the vegetation and topsoil can lead to further degradation of the in-stream habitat integrity at this site. The impact of the silt loads on the biota was clearly visible when one considers the low SASS and ASPT scores observed for the macroinvertebrate communities at this site. In addition large volumes of groundwater will possibly be removed for the underground mining operations. Should the groundwater be released into the KOR, it will have a major impact on the in-stream habitat integrity.

5.3 Aquatic Macroinvertebrate Assessment

According to Ballance *et* al. (2001) the biological communities of the aquatic ecosystems within the catchment for the KOR is in a fair to unacceptable state. The results of the SASS5 index clearly indicate that the macroinvertebrate communities at most of the sites that have been included in the study appear to be in a fair state. The ecological integrity of the community at Mashala 2 was in a largely natural state. The results for the aquatic macroinvertebrate assessment correspond with data from a nearby site (Dallas, 2007; DWAF, 2007). When interpreting SASS5 results it is important to note that the SASS 5 score is often influenced by habitat alterations whereas the ASPT score is a good reflection of water quality changes. If both ASPT and SASS scores are lower, this usually indicates a problem with both drivers (water quality and habitat integrity).

Table 8: Results of the diversity of the invertebrates sampled at the various sites along with the SASS 5 results.

	Mashala 1	Mashala 2	Mashala 3	Mashala 4	Mashala 5
Aeshnidae	x				
Baetidae		x	x	x	x
Belostomatidae	x		x		
Caenidae	x	x		x	x
Ceratopogonidae			x	x	
Chironomidae	x		x	x	
Coenagrionidae	x	x	x	x	x
Corixidae	x			x	
Dixidae			x		
Dytiscidae	x		x	x	x
Gerridae		x			
Gomphidae			x	x	
Gyrinidae				x	x
Hydracarina	x				
Hydrophilidae			x		
Hydropsychidae					x
Leptoceridae				x	

Libellulidae			x		
Naucoridae				x	
Nepidae				x	
Notonectidae	x	x		x	x
Oligochaeta					
Physidae	x		x		
Planorbidae			x		
Pleidae	x	x		x	
Potamonautidae				x	
Simuliidae				x	x
Tabanidae			x		
Veliidae		x	x	x	
SASS score	49	61	-	78	38
No of taxa	11	11	-	16	8
ASPT	4.45	5.54	-	4.87	4.75
Ecological class	**C**	**B**	**-**	**C**	**C/D**

It is thus clear from the results that the alterations to the in-stream habitat integrity have also caused alterations to the ecological integrity of the invertebrate communities. The major concern in this regard is in the form of flow changes and siltation of riffle habitat. As with other studies completed in the area (DWAF, 2007), airbreathers made a large contribution to the overall diversity at the sites (Table 8). This is a clear indication of a lack in flow and the dominance of pooled areas. Should large quantities of groundwater be released into the KOR and related systems during the underground and open cast mining operations the natural community structures of the invertebrate communities will also be altered. This is due to change in the velocity types available within the river and will lead to a loss (change) in diversity. Apart from the possible in-stream habitat degradation, a change in water quality can also influence the macroinvertebrate community. There are numerous water quality changes that can take place due to the proposed mining activities. During the operation of the mine the changes of greatest concerns with regards to the macroinvertebrates is a possible increase in turbidity (due to sedimentation), pollution from heavy duty vehicles and surface runoff from spoil heaps. After mine closure the formation of Acid Mine Drainage is also of concern. Assessment of the impacts of AMD on the invertebrate communities is difficult to complete as there are no indicators that have successfully been applied in various regions and ecosystems. In rivers affected by AMD, oligochaetes, dipterans and chironomids are known to dominate the community structure. It has also been shown that the families Corixidae and Dytiscidae are often found in large numbers in streams affected by AMD (Roback and Richardson, 1969). Ephemeropterans are known to be very sensitive to AMD and are often the last group to recolonise systems after an AMD spill.

5.4 Fish Community Assessment

The proposed mine is situated in the upper reaches of the KOR and two tributaries. The habitat is mostly shallow slow flowing streams with some faster flowing water at especially Mashala 5. The slow flowing water is the preferred habitat of the majority of the fish species expected to occur in this reach. The exception is *Labeobarbus polylepis* which at times also prefer faster flowing water especially for spawning. Furthermore, overhanging vegetation and substrate are the most important cover characteristics of the expected fish species.

The expected fish species list (Table 9) was compiled from the Reference Fish Frequency of Occurrence report (FROC; Kleynhans et al., 2007). The list was extrapolated from a site downstream of the mining area but still representative of the habitat conditions and ecoregion of the site. Most of the fish species on the expected fish species list are fairly tolerant to decreased flow conditions and water quality. Kleynhans *et al.* (2007) also identified three exotic species that occurs in the KOR: Largemouth bass (*Micropterus salmoides*), carp (*Cyprinus carpio*) and mosquitofish (*Gambusia affinis*). These species can have significant impacts on the indigenous fish communities if allowed to dominate and take over the fish community.

Table 9: Fish result from the July 2010 survey on the aquatic ecosystems associated with the proposed De Wittekrans mine. Reference values refer to the reference frequency of occurrence for the fish species in the reach (Kleynhans et al., 2007).

Spesie	Reference (confidence)	Mashala 1	Mashala 2	Mashala 4	Mashala 5
Barbus anoplus	*5 (5)*	52	41	109	18
Barbus neefi	*5 (5)*	-	1	2	3
Barbus paludinosus	*4 (5)*	-	-	7	73
Clarias gariepinus	*2 (4)*	-	-	-	-
Labeobarbus polylepis	*5 (5)*	-	-	-	-
Pseudocrenilabrus philander	*4 (5)*	-	-	-	-
Tilapia sparrmani	*4 (4)*	-	1	10	49

The results of the sampling survey in July 2010 identified four of the seven species on the expected fish list (Table 9). The most fish species were sampled at Mashala 4 and Mashala 5 which indicated a high abundance of fish at the site. *Clarias gariepinus*, *Labeobarbus polylepis* and *Pseudocrenilabrus philander* were not sampled during this survey. The absence of especially *P. philander* and *C. gariepinus* is not of concern as all the preferred habitat conditions were present and their absence are possibly explained due to natural variation and movement in the fish community. Follow up studies and biomonitoring during construction should confirm this. The large dams within the systems couldpossibly contain these species. No exotic fish species were sampled during this survey but it is expected that they occur in the system but at a lower abundance. Their occurrence within the numerous dams in the systems is a strong possibility.

Table 10: FRAI results of the July 2010 survey on the Klein Olifants and its tributaries associated with the proposed De Wittekrans mine.

	Mashala 1 - 5
FRAI score (%)	71.1
Ecological Category	C

The results of the FRAI assessment are provided in Table 10. The KOR sites were used to determine the fish community integrity of the river ecosystems that will possibly be affected by the proposed De Wittekrans mine. The index indicated that the fish community is in a fair condition as it fell within a Category C. This indicates that the fish community is moderately modified due to changes in community structure and impairment of river health. The concern within the fish community is the possible absence or significantly decreased abundance of *Lb. polylepis* as well as *P. philander*. Their absence and decreased abundance can be explained due to natural movement as this was a once off sampling survey but the impacts within the system increases the likelihood that these species can be removed from the community. Impacts like sedimentation decreases flow conditions and silts up habitat that especially *Lb. polylepis* relies on for survival.

Furthermore, the occurrence of *Barbus neefi* is also significant as it does not occur widely in South Africa with its distribution mainly confined to smaller tributaries of the Olifants and Limpopo rivers. Research by Rashleigh *et al.* (2009) has shown that *B. neefi* can be an indicator of unimpacted sites, especially in high altitude areas of the Olifants River. If impacts occur within a site *B. anoplus* will dominate the community rather than *B. neefi*. This is indicative of the population structure identified in this study with a high abundance of *B. anoplus* as compared to *B. neefi*. This indicates that the sites are impacted as was identified by the FRAI index.

The fish community is presently in a fair condition. The RHP State of the Rivers report (Ballance *et al.* 2001) indicated that the fish communities within upper reaches of the Klein-Olifants and Olifants rivers are in a fair condition as well. However, the report also suggested that the condition of the biological communities should be managed at this level. More recently, Rashleigh *et al.* (2009) also indicated that the fish communities are in a fair condition and management of the systems should ensure that the condition remains the same or improve where possible.

5.5Impact Assessment and Mitigation

The assessment of the impacts and mitigation measures are provided in four different sections below. Each section is a summary of a range of impacts. The assessment of the impact rating is pending due to the pending water quality results.

5.5.1 Sedimentation and siltation

The habitat availability and the quality thereof, are major determinants of the aquatic community structure. Changes to the biological community in a river may be linked to changes to water quality, habitat or both. When naturally vegetated landscapes are transformed to industrial uses, physical and biological relationships with adjacent streams are affected, usually resulting in streambank erosion and increased sedimentation.

Clearance of existing vegetation will expose the upper layers of the soil horizon to soil erosion. Runoff after rain can give rise to serious pollution problems. The disturbed land or active stockpile dumps piled up near the mine is usually susceptible to erosion and silting is thus a wide spread result. A variety of other pollutants may also be transported into water courses by runoff. Sometimes stockpile dump material is piled up on the bank of the river and thus increases the suspended particulate load in the surface water. Access roads to the mining area may contribute to sedimentation, erosion and siltation. Long term toxicant input in sediment may often lead to the occurrence of contaminant levels far higher than that in the surrounding water.

The problem of particular concern in the study area is that the rivers and streams in the area already contain high sediment loads. This is due to the land use in the area causing impacts on the rivers in the proposed mining site. Any further increase in sedimentation and erosion can cause a further loss in habitat diversity and quality that will possibly affect the biological communities.

Mitigation

Silt traps can be placed down slope of where vegetation stripping will take place to minimise siltation in the pollution control dams and rivers. These silt traps need to be regularly maintained to ensure effective drainage. In order to limit the direct input of silt into the rivers via windblown sand and dust, all exposed surfaces should be stabilised once the covering vegetation has been removed.

Riparian vegetation consolidates the banks and reduces erosion, removal or degradation of this vital vegetation is the major cause of erosion and siltation in southern Africa (Branch & Branch, 1981). Riparian vegetation bordering on drainage lines and rivers should be considered environmentally sensitive. Furthermore, storm water must be managed so as to reduce the silt loads in the aquatic system. Measures must be implemented to distribute storm water as evenly as possible to avoid point sources of erosion. Storm water dams must be constructed down slope of any areas that may potentially contaminate storm water. This includes areas like the processing plan, work station, open cats pits etc. Seepage from these storm water dams must be controlled and the water must be reused during the mining operations if possible. The dams must be lined and care must be taken as to not mix contaminated and clean storm water. All access and haul roads need to be maintained and any erosion ditches forming along the road filled as soon as possible.

5.5.2 Surface water quality

Changes to the water quality could result in changes to the ecosystem structure and function as well as a potential loss biodiversity. Water quality pollution often leads to modification of the species composition where sensitive species are lost and organisms tolerant to environmental changes dominate the community structure. Various specific impacts are highlighted below:

Pollution of runoff water due to spills and oil and grease leaks during construction and operation

Workshop effluents contain high amounts of oil and grease which are released during washing of the machinery. Sometimes spillage of oil and other toxic reagents do occur in these areas which ultimately can affect the water quality. Spills and leaks can also occur from vehicles directly if not well maintained.

This impact is easily managed if good operational practice is employed. All vehicles and equipment should be regularly maintained to avoid any oil leaks or spills. Furthermore, if any spill or leak does occur ensure that it is properly cleaned up as soon as possible to avoid significant effects. Store all these associated chemicals in the proper facility which is well ventilated with a concrete floor. All runoff associated with cleaning of vehicles and equipment should be treated before being discharged in the aquatic environment. Runoff from contaminated areas should be discharged into lined pollution controlled dams. The size of these dams must be determined by calculating a water and salt balance for the various mining operations. Measures should also be put in place to minimize the potential of pollution during the transport of material. This includes runoff traps from roads and covering the loads of the transport trucks.

Pollution of surface water due to seepage and runoff from waste dumps and stockpiles.

Rainfall is likely to permeate into waste heaps, dumps and ore stockpiles and may dissolve some pollutants that often contaminate the water course. The pollutants from the stockpiles will be heavy metals or salinity impacts on the aquatic ecosystem.

Runoff water from the waste dumps and stockpiles should be channelled into the pollution control dams to avoid effects on the aquatic ecosystem. These stockpiles and waste dumps should also be placed in areas where groundwater and surface water pollution can be avoided. Seepage drains should also be maintained and channelled into the pollution control dams. Storm water falling above these dumps and stockpiles should be channelled around them so as to avoid mixing clean and dirty water. The runoff should be routinely monitored for acidity and salinity as an early warning for potential increases in salinity or acidic drainage water. The water in these pollution control dams should be reused during the mining operations if possible.

Polluted runoff from mining site

Mining sites generally contain surface water on site due to runoff from the site as well as water pumped out from the mine itself. This water is often of poor quality due to exposure to various mining process and chemicals. This water often ends up in river systems due to failure of pipes transporting water, overflow from pollution control dams, accidental discharges etc. This impact can have significant impacts as the concentrations of pollutants can be high and cause acute effects in the aquatic ecosystem. Additionally, storm water from the mining site can transport pollutants to the aquatic ecosystem.

All water coming into contact with contaminated areas within the mining site should be channeled to the pollution control dams for settling and reuse. This includes any surface and storm water found within the mining site. Clean storm water should also be channeled around the contaminated mining site into the aquatic ecosystem so that it is available for downstream users. Measures must be implemented to minimize the entrance of water into the mining operations. If this clean storm water comes into contact with dirty water it must not be released into the aquatic environment. Care should also be taken to allow storm water to settle out without causing the return flow dams to break.

Pollution of surface water due to discharges and runoff from processing plants.

Surface water will also be polluted due to chemicals used in underground blasting operations and processing plants. Any mine discharges of water used during processing or blasting into settling dams may pose a risk as well as any accidental spills due to mismanagement.

The mitigation for this impact relies on good mining practice that will ensure no spills or accidental discharges occur from the processing plant. Mitigation should include proper storm water management that will reduce the probability of storm water mixing with effluent and thus spilling into the environment. All chemicals used within the processing plant should be stored in concrete floored storerooms which are well ventilated. This will ensure that if any accidental spill occurs it is maintained within the storage facility. Any accidental spills or discharges should be cleaned up immediately to avoid significant effects.

5.5.3 Change in hydrological regime

The alteration of flow regimes is often claimed to be the most serious and continuing threat to ecological sustainability of rivers and their associated floodplain wetlands (Bunn and Arthington, 2002). Flow modifications within a river may have several effects on the aquatic biota found within these systems. Firstly, flow is a major determinant of physical habitat, which in turn is a major determinant of biotic community structure; Secondly, aquatic species have evolved life history strategies primarily in direct response to the natural flow regimes; Thirdly, the invasion and success of exotic species in rivers is facilitated by the alteration of flow regimes (Poff and Ward, 1990; Bunn and Arthington, 2002). There are several impacts related to the change in the hydrological regime. These impacts include: reduced surface runoff and changes in groundwater recharge. Surface runoff is reduced as rainfall collects in collapsed areas after heavy summer rains. However, the increased speed of runoff due to impermeable structures and drains could cause extensive erosion and scouring of the aquatic ecosystems if not designed adequately. Furthermore, access roads to the mining area may also contribute to changes in the hydrological regime.

Changes in the hydrological regime can cause an increase in erosion as water will have to be diverted around structures. These diversions often cause extensive erosion as the areas are not the natural drainage lines. This erosion will then in turn cause sedimentation in the aquatic ecosystem.

Due to the nature of the activity the hydrological regime of the surrounding aquatic environments will be changed. Because open cast mining will take place very little can be done to mitigate or prevent this impact. The extent of the impact can be minimised in the immediate area surrounding the rivers and wetlands by allowing a single access road. This road needs to be maintained and any erosion ditches formed along the road filled as soon as possible. This road must also be constructed outside the boundaries of the aquatic environments. Furthermore, the extent of impacts can be minimised in the immediate area surrounding the rivers by ensuring storm water and return water is significantly slowed down to avoid further erosion and changes in the water flow patterns. The impacts will also be less severe if the natural riparian zone is kept intact and no activity is allowed within the buffer zones.

Assessment of impacts identified

Mitigation Measures

Potential Environmental Impact	Activity	ENVIRONMENTAL SIGNIFICANCE BEFORE MITIGATION						RECOMMENDED MITIGATION MEASURES/ REMARKS	ENVIRONMENTAL SIGNIFICANCE AFTER MITIGATION					
		M	D	S	P	TOTAL	SP		M	D	S	P	TOTAL	SP
Water Use/Water Quantity														
Sedimentation and siltation	Clearing, dumps, roads	8	4	3	5	75	H	Keep riparian zone intact. Revegetation. Silt traps from dumps.	6	4	2	3	36	M
Change in hydrological regime	Mining activities, construction, operation	8	5	4	5	85	H	Best practice guidelines. Keep riparian zone intact. Storm and return water attenuation.	6	5	3	4	56	M
Ground and Surface Water Pollution														
Spills, leaks	Trucks,	6	4	2	3	36	M	Best practice guidelines. Management of chemicals and vehicles	2	4	1	1	7	L
Seepage and runoff	Waste dumps, stockpiles	8	5	3	5	80	H	Pollution control dams. Best practice guidelines. No spills from return water dams or pollution control dams.	6	5	2	3	39	M
Runoff from site	Processing plant, mining site	8	4	3	5	75	H	Storm and return water management.	6	4	2	3	36	M
Discharges, runoff from plant	Processing plant	8	4	3	5	75	H	Best practice guidelines. No discharges. Treatment of contaminated water.	6	4	2	3	36	M
Drainage from site incl AMD	Mining	10	5	4	5	95	H	Best practice backfill, reduce oxygenated water contact with reactive minerals. Treatment of acidic water.	8	5	4	4	68	H

The hydrological regime may also be altered due to an increase in flow within the river itself. This increase could be due to increase surface water flows or the release of groundwater removed during underground mining. The groundwater that will be removed should alternatively be retained and not released into the river.

5.5.4 Drainage from Mining Sites Including Acid Mine Drainage and Mine Water

Mine excavation usually has a water influx, either due to rainfall or interception of ground water flows. This water is usually an unwanted feature of mining though it can sometimes be used for processing and dust suppression but the rest may have to be pumped out. It can be contaminated by particulate matters, oil and grease, unburnt explosives and other chemicals. If the coal seems contain high amount of pyrites the mine water may be acidic and thus pollute the groundwater and the nearby aquatic ecosystem after being discharged. This phenomenon is commonly known as Acid Mine Drainage (AMD). These effects can be categorised as chemical, physical, biological and ecological, although the overall impact on the community structure is the elimination of species, simplifying the food chain and so significantly reducing ecological stability. Results of a study on the effects of AMD on aquatic invertebrates showed that under conditions of constant acid mine drainage, the Odonata, Ephemeroptera and Plecoptera were completely eliminated. The Trichoptera, Megaloptera and Diptera were reduced in number of species (Roback and Richardson, 1969). AMD is a threat to several aquatic environments within the study area. The biggest concern is the fact that AMD will remain a problem long after the mining operations have stopped.

Mitigation

The impact of AMD is very difficult to predict due to the variability of discharge from the source, variation in the strength and composition of the source which varies seasonally, the effect of surface runoff from exposed areas of the mines during heavy rainfall, and the effect of the catchment discharge characteristics affecting dilution and the concentration of organic matter in the water chelating soluble metals present. Assessment is also difficult due to the complexity of the impacts, although diversity and abundance are key variables for biotic evaluation. The nature (strength) and volume of AMD can be altered by controlling generation and dilution on site. AMD and its impacts can be managed by exclusion of oxygenated water from reactive minerals or neutralisation of the acid produced. Alternatively AMD from the site can be treated, reduced to acceptable levels for safe discharge or reduced by remediation of the site (e.g. re-vegetation) to a level which can be treated prior to discharge. All reduction and remediation measures can become expensive, but need to be implemented to ensure the protection of the aquatic environments.

6. Conclusion and Recommendations

The basic assessment of the aquatic ecosystem associated with the proposed De Wittekrans mine was completed from June to August 2010. Five sites were selected on the KOR and a tributary that will possibly be impacted upon by the mine. The assessment include macro-invertebrate, fish, water quality and habitat assessments. The in-stream habitat of the KOR catchment is said to be in a poor state. Results of the habitat quality assessment of the current study indicates that, apart from the IHAS results for Mashala 4, the instream habitat at all the sites was in a fair to poor state. The results of the SASS5 index clearly indicate that the macroinvertebrate communities at most of the sites that have been included in the study appear to be in a fair state. The ecological integrity of the community at Mashala 2 was in a largely natural state. The fish community is presently in a fair condition. The RHP State of the Rivers report (Ballance *et al.* 2001) indicated that the macroinvertebrate and fish communities within upper reaches of the Klein-Olifants and Olifants rivers are in a fair condition as well. However, the report also suggested that the condition of the biological communities should be managed at this level. More recently, Rashleigh *et al.* (2009) also indicated that the fish communities are in a fair condition and management of the systems should ensure that the condition remains the same or improve where possible. The water quality in the aquatic ecosystems was fair with some increased nutrient values a cause of concern. The metal concentrations within the system were very low.

The impacts identified on the biological communities and water quality is due to the numerous land use activities in the area. These effects are due mainly to livestock watering, agriculture and decrease flow due to dams. These effects are relatively small but if it is taken into account that this is the upper reaches of one of the biggest catchments in South Africa, the aquatic health should remain as good as possible. This will then indicate that as the system is already only in a fair condition no further degradation should be allowed to occur. Therefore all the mining impacts should be properly mitigated by using mining best practice to ensure all possible impacts are mitigated. If no mitigation occurs the aquatic ecosystem health will decrease significantly.

The table below gives an indication of the DMR and I&AP comments that were dealt with in this basic assessment.

Table 11: Comments of DMR and I&AP covered in this baseline assessment of the aquatic ecosystem associated with the proposed De Wittekrans Coal mine.

No	Directive	Page
2	Describe the potential impact on Acid Mine Drainage on the physical environment and on the interested and affected parties. Provide sustainable mitigation measures and the cost thereof.	23 - 30
6	Describe the impacts associated with decant into the Klein Olifants River, and provide possible mitigation measures and the cost thereof	23 - 30
9	Provide realistic mitigation measures to modify, contain or stop any activity, process or actions leading to environmental degradation or migration of pollution into the environment	23 - 30
12	Determine Impact of opencast on the quality of the river	23 - 30
47	What will the impact be on the Klein Olifants system from the mining activities?	23 - 30
89	No biophysical surveys where done. The buffer zone which has been recommended needs to be monitored properly during the construction and operational phase. The surface aquatic habitat integrity of the river was not determined.	1 -23
90	No baseline information is available on the surface water quality and the reports lacks information on the makro-variables and metal concentrations that are used to assess water quality by comparing the values to the Water Quality Guidelines for the natural environment published by DWAF in 1996.	15 - 17
91	No attention was given to the impact that the proposed mining activity will have on the surface water downstream of the project.	1 - 23
92	No information is provided on the diversity of aquatic organisms in the river and its tributaries. The present ecological state of surface water was not determined. Assessments on fish, aquatic invertebrates and river habitat have to be done before mining activities start. There is no baseline data that can be used to assess whether changes in the aquatic macroinvertebrates population has taken place.	1 – 23
93	No mention is made of a surface water Biomonitoring programme during the construction phase and during normal operations. A programme is needed where selected water quality variables, aquatic organism diversity and aquatic habitat assessments are used to establish water quality at predetermined	32

	intervals.	
94	The EMP refers to the monitoring of water quality after the mining operations in the Klein Olifants River but includes only pH, EC. SO4 and siltation. to do a proper water quality assessment more variables will have to be monitored (TDS, turbidity, metals that have the potential to accumulate in the surface water after disturbance of the proposed magnitude.	32

Recommendations:

The following recommendations can be made to ensure proper management of the potential mine during the construction, operation en end of life of the mine.

- Implement Best Practice Guidelines stringently to minimise impacts. Certain impacts are unavoidable due to the destructive nature of mining but other impacts will have minimal long term impacts if guidelines are followed.
- Monitoring of surface water quality should be conducted on a monthly basis during construction as well as during operation. The surface water quality variables measured during this basic assessment should be the minimum that is analysed. No values should increase by more than 5-10% for an extended period of time. Predicted cost for this would be around R1600.00 per sample at current prices excluding travel cost.
- Aquatic biomonitoring in the form of fish, macroinvertebrates (SASS5) and diatoms should be carried out bi-annual to determine any lasting effects and trends. The aim should be that no decline in these communities should be observed as they are already in a fair condition. These communities should be assessed during the construction phase as well as the operational phase of the mine. A biomonitoring assessment program would cost around R10 000.00 per site at current prices
- Holding dams and any discharges from the mining site should not be toxic to aquatic biota. These dams and discharges must be assessed for toxicity on a bi-annual basis during construction as well as operation of mine. The toxicity should include bacteria, algae, Daphnia and fish toxicity tests. These assessments should be carried out biannually to ensure the protection of the aquatic ecosystem. Toxicity test prices vary from R220.00 to R500.00 per organism depending on the organism per sample.

7. References

Ballance A, Hill L, Roux DJ, Silberbauer M and Strydom W. (2001). State of the Rivers report: Crocodile, Sabie – Sand and Olifants River systems. WRC Report No. TT 147/01. Water Research Commission, Pretoria.

Barbour MT, Gerritsen J, Snyder BD and Stribling JB (1999) *Rapid Bioassement Protocols for Use in Streams and Wadeable Rivers: Periphyton, Bentic Macroinvertebrates and Fish, Second Edition*. EPA 841-B-99-002. U.S. Environmental Protection Agency; Office of Water; Washington D.C.

Dallas HF (2004). Seasonal variability in macroinvertebrate assemblages in two regions of South Africa: implications for aquatic bioassessment. *African Journal of Aquatic Science*. Vol. 29 (2) pp 173 – 184.

Dallas HF (2007). River Health Program: South African Scoring System (SASS) interpretation guidelines. Prepared for: Institute of Natural Resources and Department of Water Affairs and Forestry pp 1-85.

Dickens CWS & Graham PM (2002). The South African Scoring System (SASS), Version 5, Rapid bioassessment method for rivers. African Journal of Aquatic Science. Vol. 27 pp 1 – 10.

DWAF. Department of Water Affairs and Forestry, South Africa (1996). *South African Water Quality Guidelines (second edition).* Volume 7: Aquatic Ecosystems, Pretoria, South Africa.

DWAF. Department of Water Affairs and Forestry, South Africa. (2004). *Olifants Water Management Area: Internal Strategic Perspective*. Prepared by GMKS, Tlou and Matji and WMB on behalf of the Directorate: National Water Resource Planning. DWAF Report No P WMA 04/000/00/0304 .

DWAF. Department of Water Affairs and Forestry, South Africa (2007). Rivers Database. Data owners: CJ Thirion, 1998

Gerber A & Gabriel MJM (2002). Aquatic macroinvertebrates of South African Rivers: Illustrations. Version 2. Institute for Water Quality Studies (IWQS). Department of Water Affairs and Forestry, Pretoria.

Hohls DR (1996). National biomonitoring program for riverine ecosystems: Framework document for the program. NBP Report series No 1. Institute for water quality studies, Department of Water Affairs and Forestry, Pretoria, South Africa.

Karr JR and Chu EW (2000). Sustaining living rivers. *Hydrobiologia*. Vol. 422/423 pp 1 – 14.

Kleynhans CJ. 2007. Module D Volume 1: Fish Response Assessment Index (FRAI) (version 2). Joint Water Research Commission and Department of Water Affairs and Forestry report. WRC Report No. TT 329/08.

Kleynhans CJ & Louw MD (2007). *Module A: EcoClassification and EcoStatus determination in River EcoClassification: Manual for EcoStatus Determination (version 2).* Joint Water Research Commission and Department of Water Affairs and Forestry report.

Kleynhans CJ, Louw MD, Moolman J (2007). Reference frequency of occurrence of fish species in South Africa. Report produced for the Department of Water Affairs and Forestry (Resource Quality Services) and the Water Research Commission.

Kotze P J (2002) *The Ecological Integrity of the Klip River (Gauteng) and the Development of a Sensitivity-Weighted Fish Index of Biotic Integrity (SIBI).* Ph.D Thesis. Rand Afrikaans University, Johannesburg.

Mangold S (2001). National Aquatic Ecosystem Biomonitoring Programme: An Implementation Manual for the River Health Programme - a hitch hiker's guide to putting the RHP into action. NAEBP Report Series No 15. Resource Quality Services, Department of Water Affairs and Forestry, Pretoria.

Meador MR, Cuffney TF and Gurtz ME (1993) *Methods for sampling fish communities as part of the natural-water quality assessment programme.* U.S Geology survey. Open-file Report 93-104. Carolina.

Rashleigh B, Hardwick D and Roux D. (2009). Fish assemblage patterns as a tool to aid conservation in the Olifants River catchment (East), South Africa. Water SA 35 (4): 517 – 524.

Roback SS and Richardson JW .(1969). The Effects of Acid Mine Drainage on Aquatic Insects. *Proceedings of the Academy of Natural Sciences of Philadelphia*. Vol. 121 pp 81-107.