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REPORT ON

Aquatic Specialist Study for the Proposed Kuka Ropeway

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REPORT

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Golder Associates

Executive Summary

The Ecology Division of Golder Associates Africa (Pty) Ltd was commissioned by Golder's Environmental Services Division to conduct an aquatic assessment for input into the Kuka Ropeway Baseline and Environmental Impact Assessment (EIA). The proposed ropeway route is situated near Lydenburg in the Mpumalanga Eastern Bankenveld. The proposed ropeway route is situated in the Olifants Water Management Area (WMA 4).

It should be noted that this report is based on a single sampling survey, which took place after heavy rains fell within the area. Site selection was conducted at a desktop level and access to sites was limited due to the survey team's inability to gain permission from landowners, despite several attempts.

This document presents the results of the November 2009 survey of aquatic ecosystems associated with the aforementioned project. This survey is comprised of an assessment of the rivers, and includes in situ water quality, habitat assessment, aquatic macroinvertebrates and ichthyofaunal assessment.

The project objectives included an assessment of impacts, which will:

- Characterize the biotic integrity of aquatic ecosystems at selected crossing points;
- Evaluation of the extent of site-related effects in terms of selected ecological indicators;
- Identify potential problems and recommend suitable mitigation measures;
- Identify listed aquatic biota based on the latest IUCN rankings, or other pertinent conservation ranking bodies;
- Identify sensitive or unique aquatic habitats which could suffer irreplaceable loss; and

Based on *in situ* water quality analysis, pH values in the project area are naturally alkaline. *In situ* water quality should continue to be monitoring before, during and after construction of the proposed ropeway.

Based on the Invertebrate Habitat Assessment System (IHAS) results, habitat availability was not a limiting factor for aquatic macroinvertebrate diversity, with habitat availability ranging from adequate to good. In the upper reaches of the catchment, the abundance of Stones-In-Current habitat and alteration in flow velocity contributed to the good habitat availability.

Based on the SASS5 results biotic integrity ranged from slightly to severely impaired. Biotic integrity at site DOR1 was rated as severely impaired. This site is situated downstream from several anthropogenic impacts that may have contributed to the impaired state. These impacts include the Lydenburg sewerage works and Xstrata Lydenburg Smelter. Biotic integrity at site DWA3 was considerably impaired. The site is situated downstream of the Thorncliffe platinum and chrome mines.

It should however be noted that results are based on a single survey and may therefore not be truly representative of the biotic integrity of these sites. Additionally heavy rainfall in the catchment in the weeks prior to the survey may have negatively influenced the PES results at the time of the survey. Flooding within these small tributaries will lead to catastrophic drift, which results in aquatic macroinvertebrate species being washed downstream. It is recommended that additional surveys be conducted in order to obtain a more representative baseline of the sites associated with the proposed ropeway.

Due to the location of the sampling sites within the upper reaches of the rivers fish diversity was not expected to be high. Natural obstructions (*waterfalls*) and gradients in these areas are a limiting factor for certain species of fish. *Barbus motebensis cf Ohrigstad*, an undescribed barb was recorded at site ROO1 (Engelbrecht, *pers.com.*, 2010). Although not yet fully described *(Barbus motebensis cf Ohrigstad)*, the status of this species should be considered the same as *B. motebensis* which is Vulnerable.

The impacts associated with the construction of the proposed ropeway, are low if recommended mitigation measures are put into place. This is due to the fact that the ropeway passes over the rivers and is not being built directly within the rivers. However, it is important that a contingency plan for aquatic ecosystems be drafted, so that in the case of an accidental spillage of chrome ore, the correct parties can be notified and measures put in place to mitigate the impacts immediately.

It is recommended that additional monitoring be conducted before, during and after construction of the proposed ropeway. These studies should be more specific in terms of site selection and should include Present Ecological State (PES), Ecological Importance and Sensitivity (EIS) and Fish Response Assessment Index (FRAI).

It is also recommended that Chromium concentrations in fish tissue be analysed so as to determine a baseline value for future comparison.

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1.0 INTRODUCTION

The Ecology Division of Golder Associates Africa (Pty) Ltd. (Golder) was commissioned by Golder's Environmental Services Division to conduct an aquatic assessment for input into the Kuka Ropeway Baseline and Environmental Impact Assessment (EIA). The proposed ropeway is situated near to Lydenburg in the Mpumalanga province within tertiary drainage regions B41 and B42 (Olifants Water Management Area WMA4). The study area falls within the Eastern Bankenveld (9) – Lower Level 1 Ecoregion and the Mixed Bushveld Savanna and North-Eastern Mountain Grassland Biomes (Low and Rebelo, 1996 and Dallas, 2007).

This document presents the results of the November 2009 survey of aquatic ecosystems associated with the aforementioned project. This survey is comprised of an assessment of the rivers, and includes in situ water quality, habitat assessment, aquatic macroinvertebrates and ichthyofaunal assessments.

1.1 Project Description

The proposed ropeway is intended to transport chrome ore, in buckets, throughout the project life which will be a minimum of a 25-years or until Thorncliffe mine implement their closure plan. Current plans are to construct a double rope system; the buckets will be suspended on a thicker top rope, with a thinner lower rope pulling the buckets. A Central Control Room will monitor and co-ordinate material flow and attend to contingencies within the system.

Buckets will be spaced approximately 150m apart along the length of the ropeway. The dimensions of the buckets will be 1.5m x 1.5m, having a two ton carrying capacity. Buckets will be closed in order to (a) prevent dust escaping and (b) moisture from entering because the chrome ore needs to be kept as dry as possible.

The minimum above ground height of the buckets will be 3m; limited tree felling will be required along certain portions of the route. There are places, such as road crossing, where the minimum clearance must be approx. 5.2m. This demonstrates that there will be some variation in clearance height along the route depending mostly on land use.

The ropeway will be made up of four/five straight running units; each with a maximum length of 15 kilometres. The units will be connected by angle stations and, at certain locations, transfer stations as well. Directional changes of the ropeway will take place at angle stations only. The drive wheel for the first and last ropeway unit will be at the mine and individual smelters.

The loading terminal is the interface of an aerial ropeway with its external environment where material is transferred onto the system. A central action performed at this point is setting the buckets in motion; a motor drives a traction wheel. The rope connects to the traction wheel and the buckets are moved along the rope.

The off-loading terminal is the destination point of the ropeway and is normally a fairly scaled-down installation, compared to the loading terminal, as its main function is simply to offload the material. There will be strategic ore stockpiles at each end of the ropeway with a 10 to 14-day capacity.

The construction methodology will be similar to that used for the erection of power- line pylons and cables. On the proposed ropeway, tower height will be between 12 meters and 22 meters, and pylons will be spaced at distances between 200 and 350 meter.

The power cable for the ropeway will run parallel to the ropeway cables, either above or next to them. I.e. no additional power lines and pylons will be constructed.

1.2 Objectives

The projects objectives included:

- Characterization of the biotic integrity of aquatic ecosystems at selected crossing sites associated with the proposed ropeway as per the scope of work;

- Evaluation of the extent of site-related effects in terms of selected ecological indicators as per the scope of work;
- Identification of potential problems and recommendation of suitable mitigation measures;
- Identification of listed aquatic biota based on the latest IUCN rankings, or other pertinent conservation ranking bodies;
- Identification of sensitive or unique aquatic habitats which could suffer irreplaceable loss; and
- Recommendation of mitigation measures against any identified impacts.

1.3 Limitations

The following limitations were experienced during the November 2009 survey:

- This report is based on a single survey only and may therefore not be truly representative of the biotic integrity in these rivers;
- Prior to conducting the November 2009 survey, heavy rains fell in the study area. Flooding within these small tributaries will lead to catastrophic drift, which results in aquatic macroinvertebrate species being washed downstream;
- Access to sites was limited due to inability to obtain permission from landowners to access properties despite extensive efforts on behalf of the specialist teams ; and
- Site selection had to be conducted at a desktop level with the available information at the time of sampling preparation.

2.0 APPROACH

In order to enable adequate description of the aquatic environment it is recommended that at least two, or preferably three, indicators be selected to represent each of the stressor, habitat and response components involved in the aquatic environment. Broad methodologies to characterise these components are described below. These proposed methodologies are generally applied and accepted (DWA and USEPA) and are as follows:

2.1 Stressor Indicators

- *In situ* water parameters.

2.2 Habitat Indicators

- General habitat assessment; and
- Invertebrate Habitat Assessment System (IHAS, v*ersion 2*).

2.3 Response Indicators

- Aquatic macroinvertebrates (SASS, *version 5*); and
- Ichthyofaunal assessment.

3.0 STUDY AREA

The proposed ropeway will be constructed from Lydenburg, Mpumalanga Province to the south of Kennedys Vale, Limpopo Province. It will link the Thorncliffe chrome mine, located in the Steelpoort Valley, to the Xstrata Lion smelter located south of Kennedy's Vale, also in the Steelpoort Valley. It will also link the Thorncliffe chrome mine to the Xstrata Consolidated Metallurgical Industries (CMI) smelter located north of Lydenburg.

Nine sites were originally selected at a desktop level in accordance with the proposed ropeway alignment. Sites were selected at points where the proposed ropeway intersected perennial drainage lines. Once on site, three of the sites had to be refined due to accessibility and permissions. Co-ordinates of the sampling sites were determined using a Garmin GPS 60CSx and are listed in Table 1 with a brief description of each site. A map of the study area showing the location of aquatic sampling sites is presented in Figure 1. Photographs of sampling sites are presented in Appendix B.

Table 1: Location and description of aquatic monitoring sites

Site	Latitude	Longitude	Description
Original Points			
DOR1	-25.06467	30.44171	This site is located in the Dorps River downstream of the Lydenburg sewerage plant and Xstrata Lydenburg Smelter.
DWA1	-25.04084	30.15686	This site is located in the Dwars River on Anglo De Brochen's property.
DWA2	-25.02802	30.15107	This site is located in the Dwars River on Anglo De Brochen's property.
DWA3	-24.95393	30.12611	This site is located in the Dwars River downstream of the Thorncliffe access road and the Thorncliffe platinum and chrome mines.
GRO1	-24.99906	30.13173	This site is located on the Groot-Dwars at the corner of the Thorncliffe and Anglo De Brochen's property.
LOO1	-25.06265	30.33083	Inaccessible, site relocated after speaking with land owner.
MAR1	-25.06529	30.42083	This site is located west of the R37, downstream of Lydenburg. It is located in the Lydenburg nature reserve in the Marambane River.
ROO1	-25.06123	30.27917	This site is located on an unpaved road in the Diepgeset Farm, where the Rooiwalshoek River runs alongside the road.
WAT1	-25.05192	30.21414	Site shifted due to access constraints
Replacement Points			
LOO1	-25.097345	30.297845	This site is located in the headwaters of the Rooiwalshoek River on the Beetgestraal Farm.
DWA1/2	-24.995017	30.143744	This site is located downstream of the Anglo De Brochen's property, where the Dwars River exits the property.
WAT1	-25.037413	30.218605	This site was moved north onto the Modderspruit farm and is accessed from the Tar road leading from Lydenburg to Thorncliffe.

WGS_84 Datum co-ordinate system represented in decimal degrees

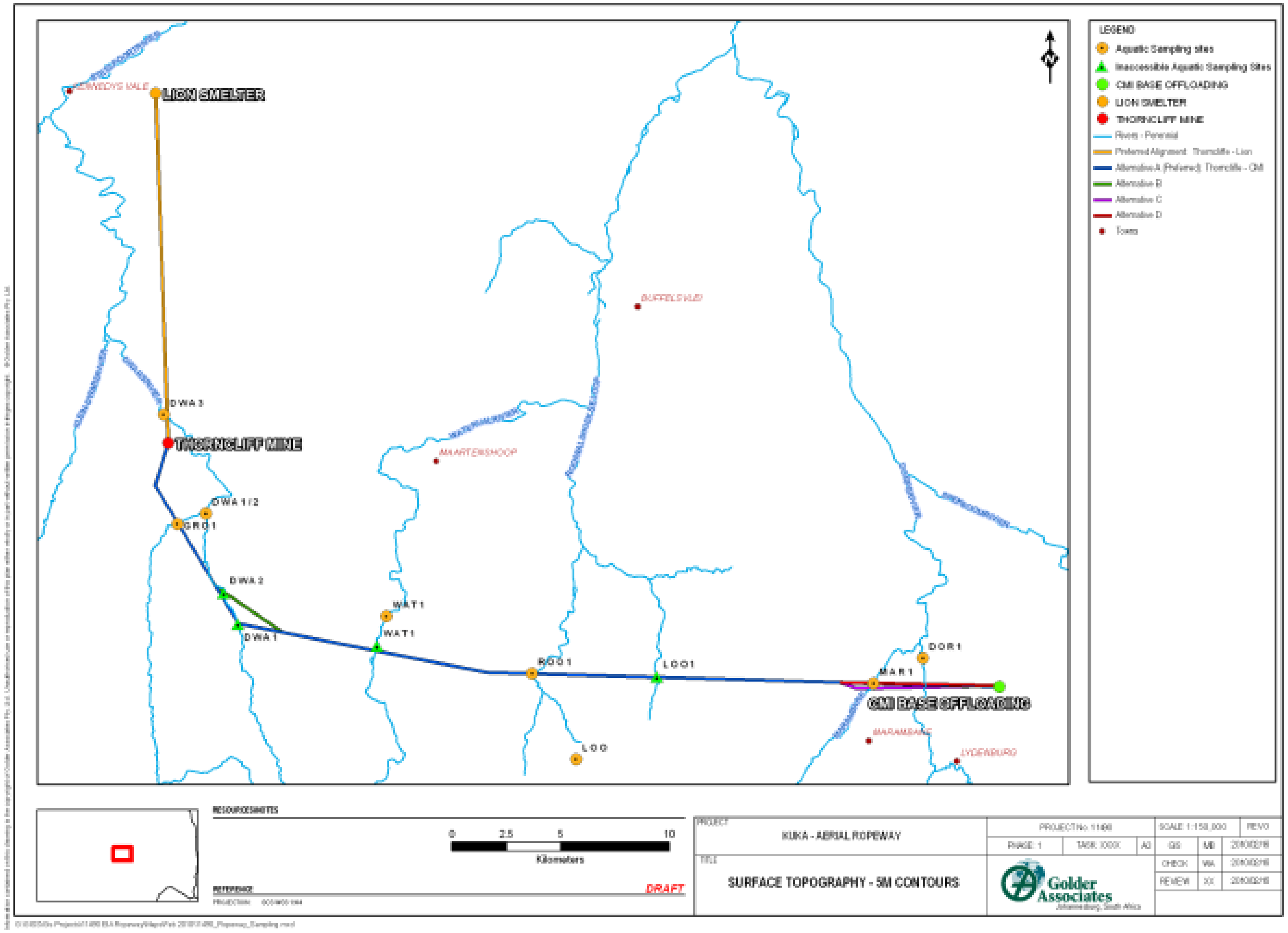

Figure 1: Map showing location of aquatic monitoring sites in relation to the proposed ropeway

4.0 METHODOLOGY

4.1 *In situ* water quality

During the survey, compact field instruments were used to measure the following parameters:

- pH (Eutech pH Tester);
- Electrical Conductivity (EC) (Eutech ECTester11 Dual Range);
- Dissolved Oxygen (DO) (Eutech CyberScan DO110); and
- Temperature (Eutech CyberScan DO110).

Water quality has a direct influence on aquatic life forms. Although these measurements only provide a "snapshot", they can provide valuable insight into the characteristics and interpretation of a specific sample site at the time of the survey.

4.2 Habitat Assessment

Habitat assessment can be defined as the evaluation of the structure of the surrounding physical habitat that influences the quality of the water resource and the condition of the resident aquatic community (Barbour *et al*., 1996). Habitat quality and availability plays a critical role in the occurrence of aquatic biota. For this reason habitat evaluation is conducted simultaneously with biological evaluations in order to facilitate the interpretation of results.

4.2.1 Invertebrate Habitat Assessment System (IHAS, *Version 2*)

The Invertebrate Habitat Assessment System (IHAS, *version 2*) was applied at each of the sampling sites in order to assess the availability of habitat biotopes for macroinvertebrates. The IHAS was developed specifically for use with the SASS5 index and rapid biological assessment protocols in South Africa (McMillan, 1998). It is presently thought that a total IHAS score of over 65% represents good habitat conditions, a score over 55% indicates adequate/fair habitat conditions (McMillan, 2002) (Table 2).

Table 2: Invertebrate Habitat Assessment System Scoring Guidelines (*version 2*)

IHAS Score	Description
> 65%	Good
55-65%	Adequate/Fair
< 55%	Poor

4.3 Aquatic macroinvertebrates

The monitoring of benthic macroinvertebrates forms an integral part of the monitoring of the health of an aquatic ecosystem as they are relatively sedentary and enable the detection of localised disturbances. Their relatively long life histories (±1 year) allow for the integration of pollution effects over time.

Field sampling is easy and since the communities are heterogeneous and several phyla are usually represented, response to environmental impacts is normally detectable in terms of the community as a whole (Hellawell, 1977).

Aquatic macroinvertebrates were sampled using the qualitative kick sampling method called SASS5 (South African Scoring System, *version 5*) (Dickens and Graham, 2001). The SASS5 protocol is a biotic index of the condition of a river or stream, based on the resident macroinvertebrate community, whereby each taxon is allocated a score according to its level of tolerance to river health degradation (Dallas, 1997). This method relies on churning up the substrate with your feet and sweeping a finely meshed SASS net (pore size of 1000 micron), over the churned up area. In the Stones-In-Current (SIC) biotope the net is rested on the substrate and the area immediately upstream of the net disturbed by kicking the stones over and against each other to dislodge benthic invertebrates. The net is also swept under the edge of marginal and aquatic vegetation. Kick samples are collected from areas with gravel, sand and mud (GSM) substrates. Identification of the organisms is made to family level (Thirion *et al*., 1995; Davies & Day, 1998; Dickens & Graham, 2001; Gerber & Gabriel, 2002).

The endpoint of any biological or ecosystem assessment is a value expressed either in the form of measurements (data collected) or in a more meaningful format by summarising these measurements into one or several index values (Cyrus *et al*., 2000). The indices used for this study were, SASS5 Total Score and Average Score per Taxon (ASPT).

4.3.1 Biotic integrity based on SASS5 results

Reference conditions reflect the best conditions that can be expected in rivers and streams within a specific area and also reflect natural variation over time. These reference conditions are used as a benchmark against which field data can be compared. Modelled reference conditions for the Eastern Bankenveld Ecoregion were obtained from Dallas (2007) (Table 3).

Table 3: Modelled reference conditions for the Eastern Bankenveld Ecoregion (9) based on SASS5 and ASPT scores

SASS Score	ASPT	Class	Description
>188	>6.7	**A**	Unimpaired. High diversity of taxa with numerous sensitive taxa.
140-188	5.9-6.7	**B**	Slightly impaired. High diversity of taxa, but with fewer sensitive taxa.
120-140	5.6-5.9	**C**	Moderately impaired. Moderate diversity of taxa.
91-120	5.2-5.6	**D**	Considerably impaired. Mostly tolerant taxa present.
<91	Variable <5.2	**E / F**	Severely impaired to Critically impaired. Only a few tolerant taxa present.

4.4 Ichthyofaunal Assessment

Whereas invertebrate communities are good indicators of localised conditions in a river over the short-term, fish being relatively long-lived and mobile:

- Are good indicators of long-term influences;
- Are good indicators of general habitat conditions;
- Integrate effects of lower trophic levels; and
- Are consumed by humans (Uys *et al*., 1996).

Fish samples were collected using a battery operated electro-fishing device (Smith-Root LR24). This method relies on an immersed anode and cathode to temporarily stun fish in the water column; the stunned fish can then be scooped out of the water with a net for identification. The responses of fish to electricity are determined largely by the type of electrical current and its wave form. These responses include avoidance, electrotaxis (forced swimming), electrotetanus (muscle contraction), electronarcosis (muscle relaxation or stunning) and death (USGS, 2004). Electrofishing is regarded as the most effective single method for sampling fish communities in wadeable streams (Plafkin et al., 1989). All fish were identified in the field using the guide Freshwater Fishes of Southern Africa (Skelton, 2001) and released back into the river at the point of capture.

4.4.1 Presence of Red Data species

In order to assess the Red Data status of the expected fish species in the sample area, the IUCN Red List of Threatened Species was consulted (IUCN, 2009).

5.0 ASSESSMENT OF POTENTIAL IMPACTS

In order to assess the impacts of the proposed project on the aquatic ecosystems, the following components were included:

- The identification of the main areas of impact associated with the proposed project, i.e. ropeway and aquatic crossings;
- The assessment of the impacts of the proposed project on the aquatic ecosystems;
- The recommendation of mitigation and management measures to deal with significant impacts; and
- The identification of aspects which may require further study.

In order to successfully assess the impacts, it is necessary to evaluate the following:

- The current South African legislation;
- The development of mitigation measures; and
- The significance of the impacts.

5.1 The current South African legislation

As indicated at the outset of the report, this EIR is informed and influenced by the following key pieces of legislation:

- The National Water Act, 1998 (Act 36 of 1998);

- The National Environmental Management Act, 1998 (Act 107 of 1998); and
- The National Environmental Management Biodiversity Act, 2004 (Act 10 of 2004).

5.2 Environmental impact significance

The impacts of the proposed project were assessed in terms of impact significance and recommended mitigation measures. The determination of significant impacts relates to the degree of change in the environmental resource measured against some standard or threshold (DEAT, 2002). This requires a definition of the magnitude, prevalence, duration, frequency and likelihood of potential change (DEAT, 2002). The following criteria have been proposed by the Department of Environmental Affairs for the description of the magnitude and significance of impacts (DEAT, 2002):

The consequence of impacts can be derived by considering the following criteria:

- Extent or spatial scale of the impact;
- Intensity or severity of the impact;
- Duration of the impact;
- Potential for Mitigation;
- Acceptability;
- Degree of certainty/Probability;
- Status of the impact; and
- Legal Requirements.

Describing the potential impact in terms of the above criteria provides a consistent and systematic basis for the comparison and application of judgments (DEAT, 2002).

The significance of the impact is calculated as:

Significance of Impact = Consequence (magnitude + duration + spatial scale) x Probability

Magnitude relates to how severe the impact is. Duration relates to how long the impact may be prevalent for and the spatial scale relates to the physical area that would be affected by the impact. Having ranked the severity, duration and spatial scale using the criteria outlined in Table 4, the overall consequence of impact can be determined by adding the individual scores assigned in the severity, duration and spatial scale. Overall probability of the impacts must then be determined. Probability refers to how likely it is that the impact may occur.

Table 4: Consequence and probability ranking of impacts

Magnitude/Severity	Duration	Spatial Scale	Probability
10 - Very high/don't know	5 - Permanent	5 - International	5 - Definite/don't know
8 – High	4 - Long-term (impact ceases after operational life)	4 - National	4 - Highly probable
6 – Moderate	3 - Medium-term (5-15 years)	3 - Regional	3 - Medium probability
4 – Low	2 - Short-term (0-5 years)	2 - Local	2 - Low probability
2 – Minor	1 - Immediate	1- Site only	1 - Improbable
0 – None	0 - None	0 - None	0 - None

The maximum value, which can be obtained, is 100 significance points (SP). Environmental effects are rated as either of High, Moderate, Low or No Impact significance on the following basis:

- SP > 75 Indicates high environmental significance;
- SP 50 – 75 Indicates moderate environmental significance;
- SP < 50 Indicates low environmental significance; and
- SP = 0 Indicates no environmental significance.

The descriptors for the ratings are provided in (Table 5) (DEAT, 2002).

Table 5: Categories for the rating of impact magnitude and significance

Category	Description
High	Of the highest order possible within the bounds of impacts that could occur, There is no possible mitigation that could offset the impact, or mitigation is difficult.
Moderate	Impact is real, but not substantial in relation to other impacts that might take effect within the bounds of those that could occur. Mitigation is both feasible and fairly easily possible.
Low	Impact is of a low order and therefore likely to have little real effect. Mitigation is either easily achieved or little mitigation is required, or both.
No Impact	Zero Impact

5.3 Development of mitigation measures

The quantitative accuracy and precision of impact predictions is particularly important for prescribing mitigation measures (DEAT, 2002). This is especially important for those impacts, pollutants or resources that require the setting of a site-specific discharge limit or need to be within legislated standards (DEAT, 2002). A common approach to describing mitigation measures for critical impacts is to specify a range of targets with predetermined acceptable range and an associated monitoring and evaluation plan (DEAT, 2002). To ensure successful implementation, mitigation measures should be unambiguous statements of actions and requirements that are practical to execute (DEAT, 2002). The following sections summarise the different approaches to prescribing and designing mitigation measures.

5.3.1 Avoidance

Mitigation by not carrying out the proposed action on the specific site, but rather on a more suitable site.

5.3.2 Minimisation

Mitigation by scaling down the magnitude of a development, reorienting the layout of the project or employing technology to limit the undesirable environmental impact.

5.3.3 Rectification

Mitigation through the restoration of environments affected by the action.

5.3.4 Reduction

Mitigation by taking maintenance steps during the course of the action.

5.3.5 Compensation

Mitigation through the creation, enhancement or acquisition of similar environments to those affected by the action.

6.0 RESULTS AND DISCUSSION

6.1 *In situ* water quality

In situ water quality measurements were recorded during the field surveys using portable field instruments. This information assists in the interpretation of biological results because of the direct influence water quality has on aquatic life forms.

Table 6: *In situ* water quality recorded during the November 2009 survey

Site	November 2009				
	pH	DO (mg/l)	EC (^{m}S/cm)	TDS (mg/l)	Temp (˚C)
DOR1	8.3	8.50	0.25	162.5	24.2
DWA1/2	9.3	11.30	0.36	234.0	30.1
DWA3	9.5	10.50	0.27	175.5	25.3
GRO1	9.1	8.7	0.25	162.5	22.5
LOO	8.8	10.2	0.07	45.5	22.5
MAR1	8.3	11.0	0.18	117.0	25.0
ROO1	8.9	12.4	0.16	104.0	22.6
WAT1	8.7	7.4	0.16	104.0	20.4

DO *Dissolved Oxygen*

EC *Electrical Conductivity*

TDS *Total Dissolved Salts*

6.1.1 pH

Most fresh waters are usually relatively well buffered and more or less neutral, with a pH range from 6.5 to 8.5, and most are slightly alkaline due to the presence of bicarbonates of the alkali and alkaline earth metals (Bath, 1989). The pH of natural waters is determined by geological influences and biotic activities. The pH target for fish health is presented as ranging between 6.5 and 9.0, as most species will tolerate and reproduce successfully within this pH range (Alabaster & Lloyd, 1982).

During the November 2009 survey, pH values were alkaline and ranged from 8.3 at sites DOR1 and MAR1 to 9.5 at site DWA3 (Figure 2). The pH of natural waters is determined by geological influences and biotic activities. Naturally high pH values within a system may be attributed to either the geology of the catchment or the biotic activities within.

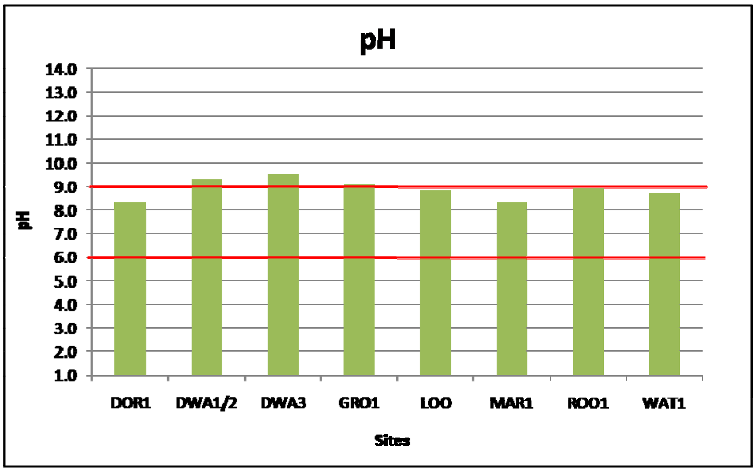

Figure 2: pH values recorded during the November 2009 survey (red lines indicate guideline values)

6.1.2 Electrical Conductivity (EC) / Total Dissolved Salts (TDS)

Electrical conductivity (EC) is a measure of the ability of water to conduct an electrical current (DWAF, 1996). This ability is a result of the presence in water of ions such as carbonate, bicarbonate, chloride, sulphate, nitrate, sodium, potassium, calcium and magnesium, all of which carry an electrical charge (DWAF, 1996). Many organic compounds dissolved in water do not dissociate into ions (ionise), and consequently they do not affect the EC (DWAF, 1996). Electrical conductivity (EC) is a rapid and useful surrogate measure of the Total Dissolved Solids (TDS) concentration of waters with a low organic content (DWAF, 1996). For the purpose of interpretation of the biological results collected during the June 2008 survey the TDS concentrations were calculated by means of the EC using the following generic equation, used throughout South Africa (DWAF, 1996):

TDS (mg/l) = EC (mS/m at 25 °C) x 6.5

If more accurate estimates of the TDS concentration from EC measurements are required then the conversion factor should be experimentally determined for each specific site and for specific runoff events (DWAF, 1996). According to Davies & Day (1998), freshwater organisms usually occur at TDS values less than 3000 mg/l. According to the South African Water Quality Guidelines for Aquatic Ecosystems (DWAF, 1996) the rate of change of the TDS concentration, and the duration of the change is more important than absolute changes in the TDS concentration. Most of the macroinvertebrate taxa that occur in streams and rivers are sensitive to salinity, with toxic effects likely to occur in sensitive species at salinities > 1000mg/ℓ (DWAF, 1996). According to the South African Water Quality Guidelines for Aquatic Ecosystems (DWAF, 1996; Volume 7) TDS concentrations in South African inland waters should not be changed by > 15%.

During the November 2009 survey Total Dissolved Solid (TDS) concentrations ranged from 45.5 mg/l at Site LOO to 234.0 mg/l at site DWA1/2 (Figure 3). TDS concentrations at well below guideline limits and would not have a limiting effect on aquatic biota.

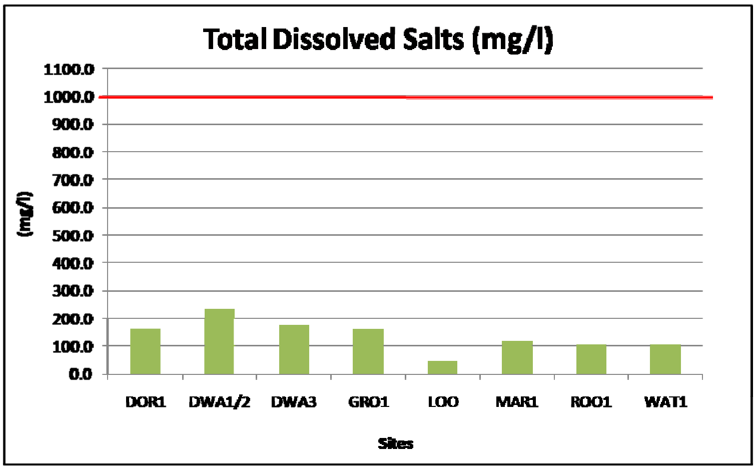

Figure 3: TDS recorded during the November 2009 survey (red line indicates guideline value)

6.1.3 Dissolved Oxygen (DO)

The maintenance of adequate Dissolved Oxygen (DO) concentrations is critical for the survival and functioning of the aquatic biota as it is required for the respiration of all aerobic organisms (DWAF, 1996). Therefore, DO concentration provides a useful measure of the health of an ecosystem (DWAF, 1996). The median guideline for DO for the protection of aquatic biota is > 5 mg/ℓ (Kempster *et al*., 1980).

During the November 2009 survey DO levels were considered adequate with all sites being recorded to be above 5 mg/l. From these results, DO is not considered to have a limiting effect on aquatic biota (Figure 4).

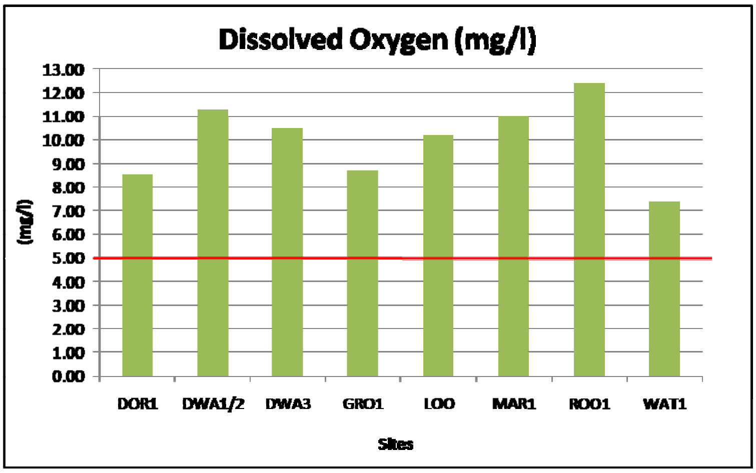

Figure 4: DO concentrations recorded during the November 2009 survey (red line indicates guideline value)

6.1.4 Temperature (˚C)

Water temperature plays an important role in aquatic ecosystems by affecting the rates of chemical reactions and therefore also the metabolic rates of organisms (DWAF, 1996). Temperature affects the rate of development, reproductive periods and emergence time of organisms (DWAF, 2005). Temperature varies with season and the life cycles of many aquatic macroinvertebrates are cued to temperature (DWAF, 2005). The temperatures of inland waters generally range from 5 to 30 degrees Celsius (˚C) (DWAF, 1996).

During the November 2009 survey water temperatures ranged from 20.4˚C at site WAT1 to 30.1 ˚C at site DWA1/2 (Figure 5). The water temperatures recorded were considered to be normal for these freshwater aquatic systems at that time of the year and would not have a limiting effect on aquatic biota.

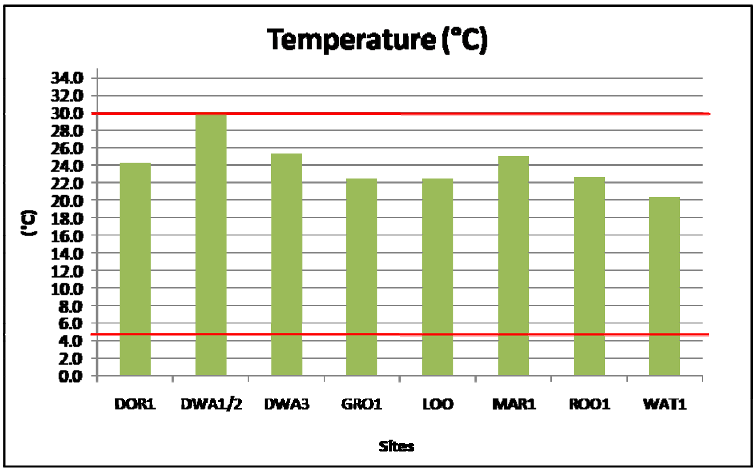

Figure 5: Temperature recorded during the November 2009 survey (red lines indicate guideline values)

6.2 Habitat Assessment

6.2.1 Invertebrate Habitat Assessment System (IHAS, *version 2*)

The Invertebrate Habitat Assessment System (IHAS, *version2*) was developed specifically for use with rapid biological assessment protocols in South Africa (McMillan, 1998) and focuses on the evaluation of the habitat suitability for aquatic macroinvertebrates. IHAS scores obtained during the November 2009 survey are presented in Table 7.

Table 7: Invertebrate Habitat Assessment System (IHAS, *version 2*) scores recorded during the November 2009 survey

Site	November 2009	
	IHAS Score	Description
DOR1	70	Good
DWA1/2	63	Adequate
DWA3	52	Adequate
GRO1	65	Good
LOO	62	Adequate
MAR1	68	Good
ROO1	88	Good
WAT1	83	Good

Based on the IHAS results habitat availability ranged from adequate to good for aquatic macroinvertebrate communities with good variation in flow and stones-in-current biotope present at all sites.

6.3 Aquatic Macroinvertebrates

Aquatic macroinvertebrates were collected using the standard SASS5 protocol described in section 4.3. A list of the aquatic macroinvertebrates collected during the November 2009 survey is provided in Appendix C and a summary is provided in Table 8.

Table 8: Aquatic macroinvertebrate data collected during November 2009 survey

Site	Total number of taxa	SASS Score	ASPT
DOR1	19	90	4.74
DWA1/2	25	142	5.68
DWA3	17	94	5.53
GRO1	18	126	7.00
LOO	31	141	4.55
MAR1	29	130	4.48
ROO1	31	162	5.23
WAT1	28	176	6.29

ASPT – Average Score Per Taxon

A total of 54 aquatic macroinvertebrate taxa were recorded in the sample area during the November 2009 survey (17 to 31 taxa per site) (Table 8). The SASS5 scores ranged from 90 at site DOR1 to 176 at site WAT1 (Table 8). The Average Score per Taxa (ASPT) values, an indication of the average tolerance / intolerance of the taxa to river health degradation, ranged from 4.48 at Site MAR1 to 7.0 at site GRO1 (Table 8).

6.3.1 Biotic integrity based on SASS5 results

The Present Ecological State (PES) classes and descriptions of each of the classes are presented in Table 9.

Table 9: Present Ecological State (PES) classes based on SASS5 results obtained in November 2009

Site	PES Class	Description
DOR1	E	Severely Impaired
DWA1/2	B	Slightly Impaired
DWA3	D	Considerably Impaired
GRO1	B	Slightly Impaired
LOO	D	Considerably Impaired
MAR1	D	Considerably Impaired
ROO1	B	Slightly Impaired
WAT1	B	Slightly Impaired

During the November 2009 survey biotic integrity of the sites associated with the proposed ropeway ranged from slightly impaired to severely impaired (Table 9). The site located in the Dorps River (DOR1), was severely impaired. This may be attributed to anthropogenic activities upstream of the site. These include the Lydenburg sewerage works and Xstrata Lydenburg Smelter. Site DWA3 is located downstream of the Thorncliffe platinum and chrome mines and is also situated in close proximity to recent excavation activities, these disturbances and activities may have contributed to the considerably impaired state of the site.

It should however be noted that results are based on a single survey and may therefore not be truly representative of the biotic integrity of these sites. Additionally heavy rainfall in the catchment in the weeks prior to the survey may have negatively influenced the PES results at the time of the survey. It is recommended that additional surveys be conducted in order to obtain a more representative baseline of the sites that may potentially be impacted upon by the proposed ropeway.

6.4 Ichthyofaunal Assessment

6.4.1 Expected species list

An expected fish species list for the generalised sampling area was compiled based on the following sources: Skelton (2001), SAIAB (2009), Kleynhans *et al*. (2007) and Engelbrecht *pers.com.* (2010). Based on this assessment 19 fish species are expected to occur in the greater sample area. It is expected that the different sampling sites may display different species composition, however due to time constraints; the expected species list was broadly divided into four categories, these being:

- **Local Area** – as the majority of these sites are located high up in the catchment one would not expect some of the species to move that far upstream;
- **Greater Area** – these species include fish which are unlikely to move far upstream, but have been recorded within the same tertiary catchments as the sampling sites;
- **Dwars River** – These species would only be expected to be found at the Dwars River crossing; and
- **Dorps River** – These species would only be expected to be found at the Dorps River crossing and tributary.

The expected fish species list with expected distributions is provided in Table 10.

Table 10: Expected fish species list

Species	Fish code	Common Name	Distribution	Conservation Status
Amphilius uranoscopes	AURA	Stargazer (mountain catfish)	Local Area	Unlisted
Anguilla mossambica	AMOS	Longfin eel	Local Area	Unlisted

Barbus motebensis	BMOT	Marico barb	Local Area	Vulnerable
Barbus neefi	BNEE	Sidespot barb	Local Area	Unlisted
Barbus paludinosus	BPAU	Straightfin barb	Dwars River	Least concern
Barbus trimaculatus	BTRI	Threespot barb	Dwars River	Unlisted
Barbus unitaeniatus	BUNI	Longbeard barb	Dwars River	Least concern
Chiloglanis pretoriae	CPRE	Shortspine suckermouth (rock catlet)	Dwars River	Least concern
Clarias gariepinus	CGAR	Sharptooth catfish	Greater Area	Unlisted
Labeo molybdinus	LMOL	Leaden labeo	Dwars River	Least concern
Labeo cylindricus	LCYL	Redeye labeo	Dwars River	Unlisted
Labeobarbus marequensis	BMAR	Largescale yellow fish	Dwars River	Least concern
Labeobarbus polylepis	BPOL	Smallscale yellowfish	Dorps River	Least concern
*Micropterus dolomeiu**	MDOL	Smallmouth bass (ex)	Dorps River	-
*Micropterus salmoides**	MSAL	Largemouth bass (ex)	Dorps River	-
*Oncorhynchus mykiss**	OMYK	Rainbow trout (ex)	Dorps River	-
Oreochromis mossambicus	OMOS	Mozambique tilapia	Greater Area	Near threatened
Pseudocrenilabrus philander	PPHI	Southern mouthbrooder	Local Area	Unlisted
Tilapia sparrmanii	TSPA	Banded tilapia	Local Area	Unlisted

** Introduced, invasive fish species*

6.4.2 Observed species list

Ten fish species were recorded in the sample area during the November 2009 survey (Table 11).

Table 11: Observed fish species list

Species	DOR1	DWA1/2	DWA3	GRO1	LOO	MAR1	ROO1	WAT1
Amphilius uranoscopes				1				
Barbus neefi	40	9				11		
Barbus motebensis cf. Ohrigstad							21	
Chiloglanis pretoriae		3	7	9				
Clarias gariepinus	1	1						
Labeobarbus marequensis		67	30	30				
Labeo cylindricus				14				
Oncorhynchus mykiss	3							
Pseudocrenilabrus philander						7		
Tilapia sparrmanii		2						
Total spp.	**3**	**5**	**2**	**4**	**0**	**2**	**1**	**0**
Total individuals	**44**	**82**	**37**	**54**	**0**	**18**	**21**	**0**

Due to the sites being located in the upper catchments, the likelihood of many of the species occurring at the sites is reduced. This is due to gradient and natural obstacles such as waterfalls. Sites LOO and WAT1 were found to have no fish, yet were considered unexpected. Only one fish species was recorded at site ROO1, namely *Barbus motebensis cf. Ohrigstad*, yet the habitat at the sites was considered pristine with good habitat availability. The Dwars, Dorps and Marambane Rivers are all rivers which are associated with anthropogenic activities. These include the town of Lydenburg, the sewerage treatment works, Xstrata Lydenburg Smelter and the Thorncliffe mines.

Barbus motebensis cf Ohrigstad, is considered to be a lineage of *B.motebensis* (Engelbrecht, *pers.com.*, 2010). Although not yet fully described *(Barbus motebensis cf Ohrigstad)*, this species should be regarded under the same vulnerable status as *B.motebensis.* It is recommended that specimens be sent to Dr Johan Engelbrecht for verification.

It should be noted that these results are based on a single survey and may therefore not be a truly representative of the full diversity of fish species present at the sites. Furthermore the survey was conducted after a period of good rainfall in the catchment. Increased flow levels and flooding may have influenced the natural distributions of fish species with the tributaries. Additional surveys are recommended so that the full range of fish species diversity in the project area can be established.

6.4.3 Presence of Red Data species

Of the 16 expected indigenous fish species:

- Eight species are currently unlisted on the IUCN Red List;
- Six species are currently listed as Least Concern (LC). Species in this category are widespread and abundant (IUCN, 2009) (Table 10);
- One species (*Oreochromis mossambicus*- Mozambique tilapia) is currently listed as Near Threatened (NT). A species in listed as NT when it does not currently qualify for Critically Endangered, Endangered or Vulnerable status, but is close to qualifying for or is likely to qualify for a threatened category in the near future (IUCN, 2009); and
- One species (*Barbus motebensis* – Marico barb) is currently listed as Vulnerable (VU). A taxon is vulnerable when the best available evidence indicates that it is under threat, and it is therefore considered to be facing a high risk of extinction in the wild (IUCN, 2010). *B. motebensis* occurs in small streams and has a restricted distributional range. It is known from approximately ten locations most of which are threatened by water abstraction associated with agriculture. Alien *Micropterus* spp. are also a threat (IUCN, 2010 and Engelbrecht, *pers.com*., 2010).

Three of the expected species are alien and considered to be invasive.

7.0 ASSESSMENT OF POTENTIAL IMPACTS AND IDENTIFICATION OF MITIGATION MEASURES

Any development in a natural system will impact on the environment, usually with adverse effects. From a technical, conceptual or philosophical perspective the focus of impact assessment ultimately narrows down to a judgment on whether the predicted impacts are significant or not (DEAT, 2002). Alterations of the natural variation of flow by river regulation through decreasing or increasing the flows can have a profound influence upon almost every aspect of river ecological functioning (Davies and Day, 1998).

Current South African legislation, as indicated at the outset of this report, requires that the necessary study be conducted and mitigation measures assessed so as to reduce or prevent the degradation of aquatic habitat and biotic populations due to the impact that the ropeway may impact on ecosystem functioning.

7.1 Potential impacts of proposed Kuka ropeway on the aquatic ecosystems

The assessment of potential impacts of the proposed ropeway on the aquatic ecosystems is discussed according to the following:

- Impacts on water quality;

- Aquatic habitat loss and alteration impacts (*macro-channel and in-stream*); and
- Aquatic biotic impacts (aquatic macroinvertebrates, fish).

7.1.1 Water quality

Water quality at or below the watercourse crossing sites may be impacted on as a result of in-stream impacts and bank disturbances during the construction phase or from incidents during the operational and decommissioning phases. Impacts on water quality are likely to result from the following activities:

- Riparian vegetation removal, leading to increased erosion and runoff;
- Building of access roads to the site and servitudes along the ropeway routes, resulting in large quantities of topsoil removal and possible increased erosion potential;
- Oil from generators and vehicles may enter the river systems;
- Bank disturbances, resulting in increased sediment input from erosion; and
- Spills of chrome ore into the aquatic ecosystem occurring from operational incidents.

Fluctuations in the *in situ* water quality parameters (pH, Electrical Conductivity (EC), TDS, DO, and temperature) will in turn have impacts on the biotic communities and vegetation. During construction, these impacts are considered to be of moderate severity in the short-term at the site, with a low impact significance.

During the construction of the ropeway, provided that the river crossings are constructed with the least amount of disturbance, water quality changes to the downstream aquatic ecosystems will be minimal (low impact) and site specific.

Once construction has been completed, the fluctuations in water quality are likely to stabilise and reach a new equilibrium.

Impacts on the water quality of watercourses may occur during the operational phase as a result of accidental spillages (chrome ore falling out of the ropeway containers). Although this is unlikely, it is important that a contingency plan be put into plan in case of an accidental spillage. The impacts associated with regular inspection and maintenance activities are also expected to be of low significance.

Impacts during the decommissioning phase, when the the ropeway system is dismantled, the pylons are removed and impacted areas are rehabilitated, are expected to be similar to those of the construction phase.

7.1.2 Habitat changes

Macro-channel habitat and riparian vegetation loss or alteration

The most significant impact on the macro-channel and riparian vegetation is expected to occur during the construction and decommissioning phases. The following proposed activities will impact on the macro-channel and riparian vegetation during this phase:

- Riparian vegetation removal;
- Building of access roads to the site, resulting in topsoil removal and possible increased erosion potential (these access roads will however be temporary); and
- Bank disturbances;

These activities may result in possible bank destabilisation, increased erosion potential and exotic vegetation encroachment. The construction phase activities should be conducted in the dry season so as to minimise the site planning and construction effort due to wet and muddy conditions as well as the impact. Once completed, rehabilitation of the site is essential to minimising the impact. This is, however, considered to be minimal (low impact) and short-term impact for the site area.

During the operational phase, in-stream channel modifications or bank vulnerabilities are considered to be minimal (low impact), due to the fact that the ropeway will be suspended above the ground.

In-stream channel habitat loss or alteration

Due to the temporary impacts and disturbances to the riparian and marginal vegetation as well as the in-stream habitats during the construction phase, the impact will be only minimal (low impact) and on a site-specific scale during construction. Once in the operational phase, these impacts should be reduced (low impact) and the habitats should recover with suitable rehabilitation methods.

Minimal bed damage and degradation downstream of the crossings is likely to occur. Increased silt load downstream of the crossings is likely to occur. These impacts are considered to be minimal (low impact) and site-specific.

These impacts will have direct implications on the type and distribution of in-stream habitats, in particular, rocky habitats, within the downstream river channel. Siltation of cobble and gravel beds may occur as a result. This will, however, flush out with the first high flow event.

Aquatic macroinvertebrate habitat availability

Due to the above-mentioned minimal and site specific in-stream habitat alterations, it is expected that impact on the current habitat availability will be only minimal (low impact). Increased siltation may reduce the amount of stones in current (SIC) habitat, but this will be minimal and should recover during high flow events.

Ichthyofaunal habitat availability

Due to the above-mentioned minimal and site specific in-stream habitat alterations a slight decrease in marginal vegetation cover types will occur. This is considered to be minimal (low impact) and site-specific as it is expected to recover after construction.

7.1.3 Biotic changes

Aquatic macroinvertebrate diversity and abundance

During the construction phase, disturbance to the habitats within the localised area will impact on the aquatic macroinvertebrates. This will, however, be localised and temporary, and thus the aquatic macroinvertebrates should recover quickly as the habitats are rehabilitated and recolonisation takes place.

Ichthyofaunal diversity and abundance

During the construction phase, it is likely that fish species that occur at or near the sites will move away if disturbed. It is likely that this will continue for the duration of the construction phase. During the operational phase, rejuvenation of the site will result in any fish moving back into the area. As no flow modifications are expected, migration and stream connectivity will remain the same and allow for the free movement of fish species to, from and within the sites.

7.2 Mitigation measures

The mitigation measures for impacts on the aquatic are discussed collectively in the sections that follow.

7.2.1 Avoidance

In order to avoid significant (high) impacts to the aquatic ecosystems, it would be ideal to re-align the ropeway route, this however is not possible due to the fact that the rivers run perpendicular to the proposed east-west ropeway route.

7.2.2 Minimisation

In order to minimise the impacts of the proposed ropeway river crossings on the aquatic ecosystems, it is necessary to minimise the impacts on the flow, sediment input, habitat availability, and migration paths of aquatic biota. This can be accomplished by the following:

- Where possible, construct the ropeway as close to the existing road servitudes as possible;
- Construct ropeway river crossings during the dry season so as to limit the amount of impact to the sites, particularly in terms of flow diversion;
- Implement low impact construction techniques so as to minimise the impact on the river system, especially during the diverting of any water during construction;
- Where possible, keep construction activities out of the wetland buffer zone;
- Limit movement of construction vehicles within riparian area;
- Restrict vehicles to service roads;
- Put responsible construction practices in place to avoid dumping on or damage to the surrounding environment;
- Train inspection, maintenance and decommissioning crews in responsible environmental management and maintain strict discipline with respect to littering and disposal of waste materials;
- During decommissioning, preferably leave concrete structures in place, demolishing only those that must be removed for good reasons. and
- Monitor the water quality, habitat and biological responses downstream of the river crossing sites during construction on a quarterly basis, and on a bi-annual basis during the operational phase of the project. Information from this monitoring can be used to quickly implement management actions should a significant decrease in ecological integrity downstream of the crossings be experienced.

7.2.3 Reduction

- Clean up and rehabilitate any accidental spillages or impacts to the aquatic and riparian ecosystems;
- Monitor the ropeway for leaks and spills on a regular basis during the operational phase;
- Repair damaged structures immediately to avoid excessive spills;
- Contain spills to avoid degrading water quality downstream;
- Implement dust suppression on dirt roads during construction to avoid excessive dust formation;
- Maintain service roads to avoid erosion and excessive dust formation; and
- Design and implement suitable long-term water and habitat monitoring programmes as well as an ecological biomonitoring programme, for both the construction and operational phases of the project.

7.2.4 Rectification

- Implement suitable vegetation and habitat rehabilitation where construction site impacts occur. This should be done in consultation with the aquatic and wetland ecologist;
- Prevent ropeway spillages and, should any occur, clean up and rehabilitate immediately; and

- Implement corrective mitigation measures should any significant decrease in ecological integrity occur (both aquatic and riparian) within any biomonitoring period as a result of impacts associated with the ropeway.

7.2.5 Compensation

Compensation for the impacts associated with the ropeway is not foreseeable. The purpose of this study was to ensure that the impacts to the aquatic ecosystems are minimal and that the project does not remove or degrade the systems to a large degree.

7.3 Impact significance

The significance of the impacts of the ropeway river crossings on the aquatic ecosystems are discussed separately (Table 12 and Table 13) for the following impacts:

- Impacts on water quality;
- Impacts on habitat: Macro-channel and Riparian;
- Impacts on habitat: In-stream habitat; and
- Impacts on biota: Macroinvertebrates, Ichthyofauna.

Table 12: Construction

Impacts	Significance Score						Discussion	Possible mitigation measures
	Mag	D	SS	P	Total	Significance		
Impacts on water quality	SBM						If sediments and contaminants enter the in-stream environment from construction activities along the ropeway route where water crossings occur, a decrease in water quality will occur and will impact on the aquatic biota. Accidental spills, leaks and contamination from construction activities will impact the water quality and the aquatic biota.	**Avoidance:** N/A. **Minimisation:** Construct ropeway during the dry season; Implement low impact construction techniques; Where possible, keep construction activities out of the riparian buffer zone; Limit movement of construction vehicles within riparian areas; Monitor the water quality downstream of the ropeway alignment during the construction phase. **Reduction:** Clean up and rehabilitate any accidental spillages or impacts to the aquatic and riparian ecosystems; Contain spills to avoid degrading macro-habitats and vegetation downstream; Implement dust suppression on dirt roads during construction to avoid excessive dust formation. **Rectification:** Implement rehabilitation where construction site impacts occur; Prevent ropeway spillages and, should any occur, clean up and rehabilitate immediately; **Compensation:** N/A
	6	2	2	3	**30**	Low		
	SAM							
	6	2	1	2	**18**	Low		
Impacts on habitat: Macro-channel and Riparian	SBM						Removal of vegetation and changes to the channel banks and habitats will result in macro-channel instability and will impact the in-stream habitats around the ropeway crossing sites. Bank erosion, exotic vegetation and bank undercutting can occur. Trenches and river diversions at watercourse crossings are considered to be the greatest impact in terms of the habitat, yet may be avoidable.	**Avoidance:** N/A. **Minimisation:** Construct ropeway river crossings during the dry season. Implement low impact construction techniques; Where possible, keep construction activities out of the riparian buffer zone; Limit movement of construction vehicles within riparian areas; Restrict vehicles to service roads; Put construction practices in place to avoid dumping on or damage to the surrounding ecosystems; Monitor the habitat downstream of the ropeway river crossing sites. **Reduction:** Clean up and rehabilitate any accidental spillages or impacts to the aquatic and riparian ecosystems; Contain spills to avoid degrading in-stream habitats downstream; Implement dust suppression on dirt roads during construction to avoid excessive dust formation; Maintain service roads to avoid erosion and excessive dust formation. **Rectification:** Implement rehabilitation where construction site impacts occur; Prevent ropeway spillages and, should any occur, clean up and rehabilitate immediately. **Compensation:** N/A
	6	2	2	4	**40**	Low		
	SAM							
	4	2	1	3	**21**	Low		
Impacts on habitat: In-stream habitat	SBM						Increase or decrease in channel widths, removal or modification of substrates and changes in flow will impact the site and the aquatic biota. Trenches and river diversions at watercourse crossings are considered to be the greatest impact in terms of the habitat, yet may be	**Avoidance:** N/A. **Minimisation:** Construct ropeway river crossings during the dry season; Implement low impact construction techniques; Where possible, keep construction activities out of the riparian buffer zone; Limit movement of construction vehicles within riparian areas; Restrict vehicles to service roads; Put construction practices in place to avoid dumping on or damage to the surrounding ecosystems; Monitor the habitat downstream of the ropeway river crossing sites. **Reduction:** Clean up and rehabilitate any accidental spillages
	8	2	2	3	**36**	Low		

	SAM						avoidable.	or impacts to the aquatic and riparian ecosystems; Contain spills to avoid degrading water quality downstream; Implement dust suppression on dirt roads during construction to avoid excessive dust formation; Maintain service roads to avoid erosion and excessive dust formation. **Rectification:** Implement rehabilitation where construction site impacts occur; Prevent ropeway spillages and, should any occur, clean up and rehabilitate immediately. **Compensation:** N/A
	6	2	1	2	**18**	Low		
Impacts on biota: Macroinvertebrates, Ichthyofauna	SBM						Aquatic biota will be impacted during the Construction Phase due to disturbance and activity at certain sites. This is however temporary and should recover during the operational phase.	**Avoidance:** N/A. **Minimisation:** Construct ropeway river crossings during the dry season. Implement low impact construction techniques; Where possible, keep construction activities out of the riparian buffer zone; Limit movement of construction vehicles within riparian areas; Restrict vehicles to service roads; Put construction practices in place to avoid dumping on or damage to the surrounding ecosystems; Monitor the biotic integrity downstream of the ropeway river crossing sites. **Reduction:** Clean up and rehabilitate any accidental spillages or impacts to the aquatic and riparian ecosystems; Contain spills to avoid degrading water quality and habitat downstream; Implement dust suppression on dirt roads during construction to avoid excessive dust formation; Maintain service roads to avoid erosion and excessive dust formation. **Rectification:** Implement rehabilitation where construction site impacts occur; Prevent ropeway spillages and, should any occur, clean up and rehabilitate immediately. **Compensation:** N/A
	8	2	2	3	**36**	Low		
	SAM							
	4	2	1	2	**14**	Low		

Table 13: Operation

Impacts	Significance Score						Discussion	Possible mitigation measures
	Mag	D	SS	P	Total	Significance		
Impacts on water quality	SBM						Any accidental spillage which occurs in or near one of the ropeway river crossings.	**Avoidance:** N/A. **Minimisation:** Implement a monitoring program to check for any changes in biotic integrity downstream; Monitor buckets on a regular basis for leeks or damage; weigh buckets on departure and arrival to make sure no chrome ore is being lost along the ropeway route. **Reduction:** Frequently maintain and inspect the ropeway and buckets for damage. **Rectification:** If any accidental spills occur, immediately implement a clean-up and rehabilitation plan. **Compensation:** N/A
	6	2	2	2	**20**	Low		
	SAM							
	4	1	1	2	**12**	Low		
Impacts on habitat: Macro-channel and Riparian	SBM						Any accidental spillage or maintenance work which occurs in or near one of the ropeway river crossings. Work requiring vehicles to access through the riparian	**Avoidance:** N/A. **Minimisation:** Implement a monitoring program to check for any changes in biotic integrity downstream; Monitor buckets on a regular basis for leeks or damage; weigh buckets on departure and arrival to make sure no chrome ore is being lost along the ropeway route. **Reduction:** Frequently
	6	2	2	2	**20**	Low		

	SAM						buffer zone.	maintain and inspect the ropeway and buckets for damage. **Rectification:** If any accidental spills occur, immediately implement a clean-up and rehabilitation plan. **Compensation:** N/A
	4	1	1	2	**12**	Low		
Impacts on habitat: In-stream habitat	SBM						Any accidental spillage which occurs in or near one of the ropeway river crossings.	**Avoidance:** N/A. **Minimisation:** Implement a monitoring program to check for any changes in biotic integrity downstream; Monitor buckets on a regular basis for leeks or damage; weigh buckets on departure and arrival to make sure no chrome ore is being lost along the ropeway route. **Reduction:** Frequently maintain and inspect the ropeway and buckets for damage. **Rectification:** If any accidental spills occur, immediately implement a clean-up and rehabilitation plan. **Compensation:** N/A
	6	2	2	2	**20**	Low		
	SAM							
	4	1	1	2	**12**	Low		
Impacts on biota: Macroinvertebrates, Ichthyofauna	SBM						Any accidental spillage or maintenance work which occurs in or near one of the ropeway river crossings.	**Avoidance:** N/A. **Minimisation:** Implement a monitoring program to check for any changes in biotic integrity downstream; Monitor buckets on a regular basis for leeks or damage; weigh buckets on departure and arrival to make sure no chrome ore is being lost along the ropeway route. **Reduction:** Frequently maintain and inspect the ropeway and buckets for damage. **Rectification:** If any accidental spills occur, immediately implement a clean-up and rehabilitation plan. **Compensation:** N/A
	6	2	2	2	**20**	Low		
	SAM							
	4	1	1	2	**12**	Low		

Table 14: Decommissioning

Impacts	Significance Score						Discussion	Possible mitigation measures
	Mag	D	SS	P	Total	Significance		
Impacts on water quality	SBM						If sediments and contaminants enter the in-stream environment from decommissioning activities along the ropeway route where water crossings occur, a decrease in water quality will occur and will impact on the aquatic biota. Accidental spills, leaks and contamination from decommissioning activities will impact the water quality and the aquatic biota.	**Avoidance:** N/A. **Minimisation:** Disassemble ropeway during the dry season; Implement low impact decommissioning techniques; Where possible, keep decommissioning activities out of the riparian buffer zone; Limit movement of decommissioning vehicles within riparian areas; Monitor the water quality downstream of the ropeway alignment during the decommissioning phase. **Reduction:** Clean up and rehabilitate any accidental spillages or impacts to the aquatic and riparian ecosystems; Contain spills to avoid degrading macro-habitats and vegetation downstream; Implement dust suppression on dirt roads during decommissioning to avoid excessive dust formation. **Rectification:** Implement rehabilitation where decommissioning site impacts occur; Prevent ropeway spillages and, should any occur, clean up and rehabilitate
	6	2	2	3	**30**	Low		
	SAM							

	6	2	1	2	**18**	Low		immediately; **Compensation:** N/A
Impacts on habitat: Macro-channel and Riparian	**SBM**						Removal of vegetation and changes to the channel banks and habitats will result in macro-channel instability and will impact the in-stream habitats around the ropeway crossing sites. Bank erosion, exotic vegetation and bank undercutting can occur. Trenches and river diversions at watercourse crossings are considered to be the greatest impact in terms of the habitat, yet may be avoidable.	**Avoidance:** N/A. **Minimisation:** Disassemble ropeway river crossings during the dry season. Implement low impact decommissioning techniques; Where possible, keep decommissioning activities out of the riparian buffer zone; Limit movement of decommissioning vehicles within riparian areas; Restrict vehicles to service roads; Put decommissioning practices in place to avoid dumping on or damage to the surrounding ecosystems; Monitor the habitat downstream of the ropeway river crossing sites. **Reduction:** Clean up and rehabilitate any accidental spillages or impacts to the aquatic and riparian ecosystems; Contain spills to avoid degrading in-stream habitats downstream; Implement dust suppression on dirt roads during decommissioning to avoid excessive dust formation; Maintain service roads to avoid erosion and excessive dust formation. **Rectification:** Implement rehabilitation where construction site impacts occur; Prevent ropeway spillages and, should any occur, clean up and rehabilitate immediately. **Compensation:** N/A
	6	2	2	4	**40**	Low		
	SAM							
	4	2	1	3	**21**	Low		
Impacts on habitat: In-stream habitat	**SBM**						Increase or decrease in channel widths, removal or modification of substrates and changes in flow will impact the site and the aquatic biota. Trenches and river diversions at watercourse crossings are considered to be the greatest impact in terms of the habitat, yet may be avoidable.	**Avoidance:** N/A. **Minimisation:** Disassemble ropeway river crossings during the dry season. Implement low impact decommissioning techniques; Where possible, keep decommissioning activities out of the riparian buffer zone; Limit movement of decommissioning vehicles within riparian areas; Restrict vehicles to service roads; Put decommissioning practices in place to avoid dumping on or damage to the surrounding ecosystems; Monitor the habitat downstream of the ropeway river crossing sites. **Reduction:** Clean up and rehabilitate any accidental spillages or impacts to the aquatic and riparian ecosystems; Contain spills to avoid degrading in-stream habitats downstream; Implement dust suppression on dirt roads during decommissioning to avoid excessive dust formation; Maintain service roads to avoid erosion and excessive dust formation. **Rectification:** Implement rehabilitation where construction site impacts occur; Prevent ropeway spillages and, should any occur, clean up and rehabilitate immediately. **Compensation:** N/A
	8	2	2	3	**36**	Low		
	SAM							
	6	2	1	2	**18**	Low		
Impacts on biota: Macroinvertebrates, Ichthyofauna	**SBM**						Aquatic biota will be impacted during the Decommissioning Phase due to disturbance and activity at certain sites. This is however temporary and should recover during the operational phase.	**Avoidance:** N/A. **Minimisation:** Disassemble ropeway river crossings during the dry season. Implement low impact decommissioning techniques; Where possible, keep decommissioning activities out of the riparian buffer zone; Limit movement of decommissioning vehicles within riparian areas; Restrict vehicles to service roads; Put decommissioning practices in place to avoid dumping on or damage to the surrounding ecosystems; Monitor the habitat downstream of the ropeway river crossing sites. **Reduction:** Clean up and rehabilitate any
	8	2	2	3	**36**	Low		

	SAM							accidental spillages or impacts to the aquatic and riparian ecosystems; Contain spills to avoid degrading in-stream habitats downstream; Implement dust suppression on dirt roads during decommissioning to avoid excessive dust formation; Maintain service roads to avoid erosion and excessive dust formation. **Rectification:** Implement rehabilitation where construction site impacts occur; Prevent ropeway spillages and, should any occur, clean up and rehabilitate immediately. **Compensation:** N/A
	4	2	1	2	**14**	**Low**		

8.0 CONCLUSIONS

Based on the results of the November 2009 survey the following conclusions were reached:

- The results of this report are based on a single survey only and may therefore not be truly representative of the full degree of biotic integrity in the project area;
- Based on *in situ* water quality analysis, pH values in the project area are naturally alkaline due to the geological influences in the catchment which determine the natural pH. In situ water quality should be monitored on an ongoing basis before, during and after construction of the ropeway so that changes and trends can be picked up.
- Based on the IHAS results, habitat availability was not a limiting factor for aquatic macroinvertebrate diversity, with habitat availability ranging from adequate to good. The abundance of Stones-In-Current habitat and alterations in flow velocity contributed to these results;
- Based on the SASS5 results biotic integrity ranged from slightly to severely impaired. Site DOR1 was rated as severely impaired, this site is located downstream of several anthropogenic impacts including the Lydenburg sewerage works and Xstrata Lydenburg Smelter. Biotic integrity at site DWA3 was rated as considerably impaired. Site DWA3 is situated downstream of the Thorncliffe platinum and chrome mines which may be contributing to the impaired state.
- Biotic integrity may have been influenced by heavy rainfall in the weeks preceding the survey. High flow levels and flooding will lead to catastrophic drift, which results in aquatic macroinvertebrate species being washed downstream. Several weeks may pass before the full range of aquatic biodiversity is re-established after a flood event.
- Due to the location of the sampling sites within the upper reaches of the rivers, fish species diversity was not expected to be high. Natural obstructions (*waterfalls*) and gradients in these areas are a limiting factor for certain species of fish;
- *Barbus cf motebensis Ohrigstad*, a lineage of *Tuberculed barb* was recorded at site ROO1 (Engelbrecht, *pers.com.*, 2010). Although not fully described *(Barbus cf motebensis Ohrigstad)*, this should be regarded under the same vulnerable status as *B.motebensis.*
- Predicted impacts associated with the construction of the proposed ropeway are low if recommended mitigation measures are put into place. This is due to the fact that the ropeway passes over the rivers and is not being built directly within the rivers.
- During the operational phase of the ropeway, predicted impacts are minimal under normal operation. If however a accidental spill or incident occurs and chrome ore spillage occurs, measures need to be in place so that mitigation measures can be implemented immediately to clean up and rehabilitate the affected areas;
- Chromium is a relatively scarce metal, and the occurrence and amounts thereof in aquatic ecosystems are usually very. Chromium (VI) is a highly oxidized state and occurs as the yellow dichromate salt in neutral or alkaline media, and as the orange chromate salt in acid medium. Both of these Cr (VI) salts are highly soluble at all pH values. The reduced forms, Cr (II) and Cr (III) are much less toxic and therefore less hazardous than Cr (VI). The most common ore of the metal Cr is chromite, in which Cr occurs in the trivalent state. Other minerals containing Cr do occur, but are not common. Most elevated levels of Cr in aquatic ecosystems are a consequence of industrial activity. In the aquatic environment chromous compounds tend to be oxidized to chromic forms, whilst the Cr (VI) form can be reduced to Cr (III) by heat, in the presence of organic matter and by reducing agents. Chromium exerts a toxic effect at different concentrations in different groups of aquatic organisms, with fish being the most

resistant. Invertebrates are usually at least an order of magnitude more sensitive to chromium (DWAF, 1996).

9.0 RECOMMENDATIONS

It is recommended that:

- Construction activities take into account the prescribed mitigation measures to reduce the impact on the associated aquatic environments;
- That a contingency plan for aquatic ecosystems be drafted, so that in the case of an accidental spillage of chrome ore, the correct parties can be contacted and informed immediately;
- Additional monitoring should be conducted before, during and after construction and again before, during and after decommissioning. These surveys should include:
  - Present Ecological State (PES) and Ecological Importance and Sensitivity (EIS); and
  - Fish Response Assessment Index (FRAI).
- That further investigation into the occurrence and distribution of *Barbus motebensis cf Ohrigstad* be conducted to accurately assess its status and distributional range; and
- Chromium concentrations in fish tissues should be assessed in order to establish a baseline value for future comparison.

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APPENDIX A

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APPENDIX B

Site Photographs

DOR1 – Downstream

(Taken by: W. Aken. 11/2009)

DOR1 – Upstream

(Taken by: W. Aken. 11/2009)

MAR1 – Downstream

(Taken by: W. Aken. 11/2009)

MAR1 – Upstream

(Taken by: W. Aken. 11/2009)

LOO – Downstream

(Taken by: W. Aken. 11/2009)

LOO – Upstream

(Taken by: W. Aken. 11/2009)

ROO1 – Downstream

(Taken by: W. Aken. 11/2009)

ROO1 – Upstream

(Taken by: W. Aken. 11/2009)

WAT1 – Downstream

(Taken by: W. Aken. 11/2009)

WAT1 – Upstream

(Taken by: W. Aken. 11/2009)

DWA1/2 – Downstream

(Taken by: W. Aken. 11/2009)

DWA1/2 – Upstream

(Taken by: W. Aken. 11/2009)

DWA3 – Downstream

(Taken by: W. Aken. 11/2009)

DWA3 – Upstream

(Taken by: W. Aken. 11/2009)

GRO1 – Downstream

(Taken by: W. Aken. 11/2009)

GRO1 – Upstream

(Taken by: W. Aken. 11/2009)

APPENDIX C

Aquatic Macroinvertebrate Data

	November 2009							
Aquatic macroinvertebrate	**DOR1**	**DWA1/2**	**DWA3**	**GRO1**	**LOO**	**MAR1**	**ROO1**	**WAT1**
TURBELLARIA (Flatworms)	B	1	A		1	1	1	B
ANNELIDA								
Oligochaeta (Earthworms)	A		A	A	A	1	A	A
Hirudinea (Leeches)	B				A	A		
CRUSTACEA								
Potamonautidae* (Crabs)		OBS		A	OBS	1	1	A
Atyidae (Freshwater Shrimps)			OBS					
HYDRACARINA (Mites)		B		1	A			
PLECOPTERA (Stoneflies)								
Perlidae			A	B				C
EPHEMEROPTERA (Mayflies)								
Baetidae 1sp	1	1		1	A		A	A
Baetidae 2 sp	A	A		B	B	B	B	B
Baetidae > 2 sp			A	C				C
Caenidae (Squaregills/Cainfles)		A	1	B	B	A	B	A
Heptageniidae (Flatheaded mayflies)		A		OBS				A
Leptophlebiidae (Prongills)	B	1		B		1	A	B
Prosopistomatidae (Water specs)				A				
Tricorythidae (Stout Crawlers)	1	1					1	B
ODONATA (Dragonflies & Damselflies)								
Chlorocyphidae (Jewels)								1
Coenagrionidae (Sprites and blues)	A	1	1	1	B	A	A	A
Lestidae (Emerald Damselflies/Spreadwings)					1			
Aeshnidae (Hawkers & Emperors)		1			B	1	1	OBS
Gomphidae (Clubtails)	1	A	A	B	B	1	A	B
Libellulidae (Darters/Skimmers)	1	A		1	A	1	A	1
HEMIPTERA (Bugs)								
Belostomatidae* (Giant water bugs)		1	A	1	1	1		
Corixidae* (Water boatmen)					B	1	1	1
Gerridae* (Pond skaters/Water striders)	OBS		1		OBS	C	1	
Hydrometridae* (Water measurers)					OBS	B		
Naucoridae* (Creeping water bugs)	1	A					A	A
Nepidae* (Water scorpions)					OBS			
Notonectidae* (Backswimmers)		1			B	A	A	
Veliidae/M...veliidae* (Ripple bugs)	A	A	A	A		A		1
TRICHOPTERA (Caddisflies)								
Hydropsychidae 1 sp	A	1	A		1	A	1	B
Philopotamidae							1	
Cased caddis:								

Hydroptilidae		A						
Leptoceridae					1	A	B	A
COLEOPTERA (Beetles)								
Dytiscidae/Noteridae* (Diving beetles)			1		B	1	1	A
Elmidae/Dryopidae* (Riffle beetles)			A	A	1			1
Gyrinidae* (Whirligig beetles)	OBS		A		1	A	A	A
Helodidae (Marsh beetles)							A	
Hydrophilidae* (Water scavenger beetles)		1			1	A		
Psephenidae (Water Pennies)				1				A
DIPTERA (Flies)								
Athericidae (Snipe flies)		1						
Ceratopogonidae (Biting midges)		1	1	A	1	A	1	1
Chironomidae (Midges)	B	A	A	A	B	B	A	A
Culicidae* (Mosquitoes)					1	1		
Dixidae* (Dixid midge)					1			
Muscidae (House flies, Stable flies)					1		1	
Simuliidae (Blackflies)	B					A	A	A
Tabanidae (Horse flies)		1					1	
Tipulidae (Crane flies)		1				1		1
GASTROPODA (Snails)								
Ancylidae (Limpets)	A					1	1	B
Lymnaeidae* (Pond snails)							A	
Physidae* (Pouch snails)	B				B			
Planorbinae* (Orb snails)		1				1		
PELECYPODA (Bivalvles)								
Corbiculidae (Clams)							1	
Sphaeriidae (Pill clams)					A		1	
Total number of taxa	**19**	**25**	**17**	**18**	**31**	**29**	**31**	**28**
SASS Score	**90**	**142**	**94**	**126**	**141**	**130**	**162**	**176**
ASPT	**4.74**	**5.68**	**5.53**	**7.00**	**4.55**	**4.48**	**5.23**	**6.29**

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