September 2009

AQUATIC SPECIALIST STUDY FOR THE PROPOSED CONSTRUCTION OF THE

Kusile Rail Project

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REPORT

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Executive Summary

Golder Associates Africa (Pty) Ltd (Golder) was commissioned by Zitholele Consulting to conduct an assessment of the aquatic ecosystems associated with the proposed railway alternatives for the proposed transport of sorbent from the existing Pretori-Emalahleni railway to the Kusile Power Station. The proposed rail routes are situated near Emalahleni in the Mpumalanga Highveld. All three of the proposed alternatives fall within quaternary catchment B20F in the Olifants Water Management Area.

This document presents the results of the September 2009 survey of aquatic ecosystems associated with three rail alternatives associated with 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 in the project area;
- 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
- Identify the best alternative route for the rail to follow based on the assessment of aquatic ecosystem.

During the September 2009 survey it was noted that there were increased turbidity levels in the Kilpfonteinspruit (RKUS1 and RKUS3). The Klipfonteinspruit drains from the Kusile Power Station construction site, which is the likely cause of the increased sediment load. Increased turbidity may interfere with the feeding mechanisms of filter-feeding organisms such as certain macroinvertebrates, and the gill functioning, foraging efficiency (due to visual disturbances) and growth of fish.

An assessment of i*n situ* water quality showed that site RKUS5 had high pH as well as low dissolved oxygen concentrations.

An assessment of the habitat showed that habitat availability could be considered a limiting factor for aquatic macroinvertebrate diversity at sites RKUS1, RKUS3 and RKUS5. The absence of adequate Stones-In-Current habitat, incised channels and turbidity contributed to the poor habitat availability at these sites.

Based on SASS5 results obtained during the September 2009 survey, biotic integrity within the project area ranged from **slightly impaired** (PES Class B) at sites RKUS4 to **severely impaired** (PES Class E) at sites RKUS5.

Based on the Fish Assemblage Integrity Index (FAII) results biotic integrity in the project area ranged from **seriously modified** (PES Class E) at sites RKUS4 to **critically modified** (PES Class F) at sites RKUS1 and RKUS3, no rare or endangered fish species were recorded on site. It should be noted that this data is based on a single low-flow survey, and that in the high-flow season additional species are likely to move into the tributaries for breeding proposes, thus protecting the in-stream habitat and maintaining the integrity of the rivers is of utmost importance.

- The impact of rail alternative 1 was classified as LOW;
- The impact of rail alternative 2 was classified as MODERATE; and
- The impact of rail alternative 3 was classified as LOW.

As a result of this study it is recommended that an **erosion control specialist** inspect and monitor all construction processes for the proposed railway. In addition to an aquatic monitoring program, it is recommended that a **monitoring program** for turbidity and suspended solids be implemented as part of the surface water monitoring programme.

Alternatives 1 or 3 should be considered as they pose the least impact on the associated aquatic ecosystems. Site RKUS4 should be **preserved** by limiting disturbance as this site proved to be in a fairly good state. In conjunction with this a monitoring program for the receiving catchment of the Wilge River should be implemented to assess the cumulative impacts of the Kusile Power Station construction site and the construction of the Kusile railway on the downstream catchment.

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1.0 INTRODUCTION

Golder Associates Africa (Pty) Ltd (Golder) was commissioned by Zitholele Consulting to conduct an assessment of the aquatic ecosystems associated with the proposed Kusile railway for the transportation of sorbent from the existing Pretoria-Emalahleni railway to the Kusile Power Station. The proposed development is situated near to Emalahleni in the Mpumalanga Highveld, within the quaternary drainage region B20F in the Wilge River catchment in the Olifants Water Management Area (WMA4). The study area falls within the Highveld (11) – Lower Level 1 Ecoregion and the Grassland Biome (Low and Rebelo, 1996 and Dallas, 2007).

This document presents the results of a single dry-season survey conducted in September 2009 of the aquatic ecosystems associated with the proposed Kusile railway project. This survey was comprised of an assessment of the identified river crossings and included an assessment of in situ water quality, general habitat parameters, invertebrate habitat availability, aquatic macroinvertebrate diversity and ichthyofaunal diversity.

1.1 Objectives

The projects objectives included:

- Characterization of the biotic integrity of aquatic ecosystems at selected crossing sites associated with the proposed rail options 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;
- Identification of the best alternative route for the rail to follow based on the assessment of aquatic ecosystem; and
- Provision of mitigation to any identified impacts.

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 (DWAF 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
- Ichthyofauna (FAII).

3.0 STUDY AREA

Five sites were selected in accordance with the three proposed rail alternatives. Sites were selected at points where the proposed routes crossed drainage lines.

Co-ordinates of sampling sites were determined using a Garmin GPS 60CSx and are listed in Table 1 with descriptions of the sites. 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 biomonitoring sites.

Site	Description	Latitude	Longitude
RKUS1	This site is located in the Klipfonteinspruit where Rail - Alternative 2 crosses above the small dam. It is located below the overhead power line servitude.	-25.92513	28.88321
RKUS2	This site is located in an unnamed tributary of the Klipfonteinspruit just below the dam, which is situated below site RKUS1. Rail alternative 2 passes through on its way to site RKUS1.	-25.91965	28.88716
RKUS3	Site RKUS3 is located in the Klipfonteinspruit just before the confluence with the Wilge River. It is situated downstream of the reminisce of an old dam wall. This is the last site, before rail Alternative 2 joints the other two alternative routes.	-25.88678	28.86391
RKUS4	Site RKUS4 is located north of the Klipfonteinspruit in an unnamed tributary, situated before the confluence with the Wilge River. This is a broad site as all three rail alternatives pass through this area.	-25.87880	28.86971
RKUS5	Site RKUS5 is situated in an unnamed tributary just north of the N4 highway. All three rail alternatives pass through this section.	-25.84894	28.87875

** WGS_84 Datum co-ordinate system represented in decimal degrees*

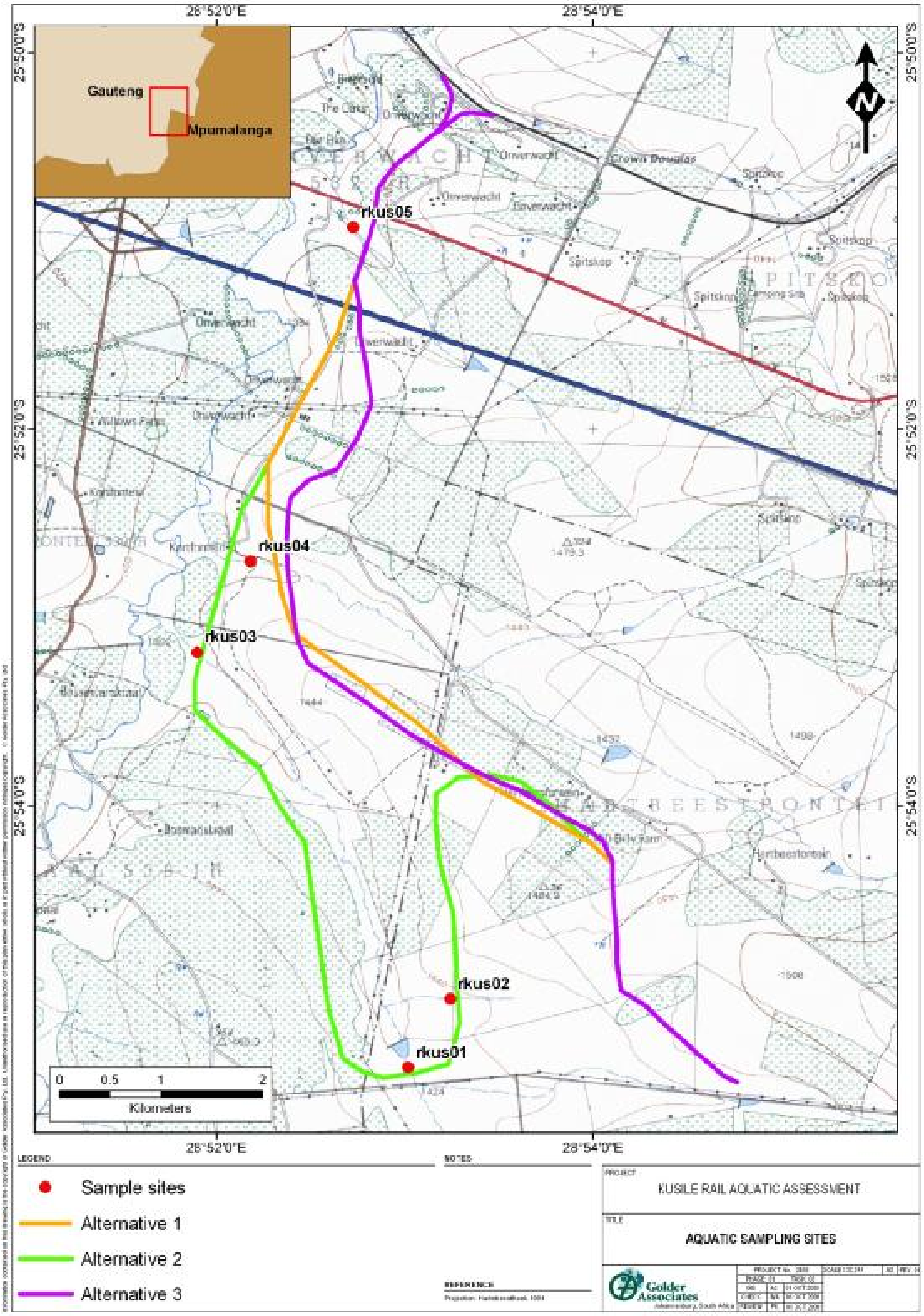

Figure 1: Map showing location of aquatic biomonitoring sites.

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);
- Temperature (Eutech CyberScan DO110); and
- Turbidity (Secchi Disk).

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 Highveld Ecoregion were obtained from Dallas (2007) (Table 3).

Table 3: Modelled reference conditions for the Highveld Ecoregion (11) based on SASS5 and ASPT scores.

SASS Score	ASPT	Class	Description
>124	>5.6	A	Unimpaired. High diversity of taxa with numerous sensitive taxa.
83-124	4.8-5.6	B	Slightly impaired. High diversity of taxa, but with fewer sensitive taxa.
60-82	4.6-4.8	C	Moderately impaired. Moderate diversity of taxa.
52-59	4.2-4.6	D	Considerably impaired. Mostly tolerant taxa present.
30-51	Variable <4.2	E	Severely impaired. Only tolerant taxa present.
<30	Variable	F	Critically impaired. 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).

4.4.2 Biotic integrity based on the Fish Assemblage Integrity Index (FAII) results

Procedures used in the application of the FAII are described below:

Species Intolerance Ratings:

Intolerance refers to the degree to which an indigenous species is unable to withstand changes in the environmental conditions at which it occurs (Kleynhans, 1999). Four components were considered in estimating the intolerance of fish species, i.e. habitat preferences and specialization (HS), food preferences and specialisation (TS), requirement for flowing water during different life stages (FW) and association with habitats with unmodified water quality (WQ). Each of these aspects was scored for a species according to low requirements/specialization (rating = 1), moderate requirement/specialization (rating = 3) and high requirement/specialization (rating = 5). The total intolerance (IT) of fish species is estimated as follows:

$IT = (HS + TS + FW + WQ)/4$

Frequency of Occurrence

For each species expected to be present in a fish habitat segment, the expected frequency of occurrence was estimated and the observed frequency of occurrence calculated:

- Occurrence at <34% of sites in a segment, score = 1 (infrequent occurrence)
- Occurrence at 34% to 67% of sites in a segment, score = 3 (frequent occurrence)
- Occurrence at >67% of sites in a segment, scores = 5 (widespread occurrence)

The same procedure was applied in the assessment of the expected frequency of occurrence of indigenous fish species at each of the sites sampled, taking into account habitat types actually present at a specific site and species' habitat preferences.

Fish Health Assessment

The assessment is conducted in such a way as to derive numeric values, which reflect the status of fish health. The percentage of fish with externally evident disease or other anomalies was used in the scoring of this metric (Kleynhans, 1999; Kilian *et al*., 1997). The following procedures were followed to score the health of individual species at site:

- Frequency of affected fish >5%. Score = 1
- Frequency of affected fish 2 – 5%. Score = 3
- Frequency of affected fish < 2%. Score = 5

This approach is based in the principle that, even under unimpaired conditions, a small percentage of individuals can be expected to exhibit some anomalies (Kleynhans, 1999).

Calculation of FAII Score:

The FAII is consists of the calculation of an expected value, which serve as the baseline or reference, the calculation of an observed value and the comparison of the expected and observed scores that provide a relative FAII score. The expected FAII rating for a fish habitat segment is calculated as follows (Kleynhans, 1999):

FAII value (Exp) = ∑IT x ((F + H)/2)

Where:

- Exp = expected for a fish segment
- IT = Intolerance rating for individual species expected to be present in a fish habitat segment and in habitats that were sampled
- H = Expected health rating for a species expected to be present.

The observed observation is calculated on a similar basis, but is based on information collected during the survey:

FAII value (Obs) = ∑IT x ((F + H)/2)

Where:

- Obs: = observed for a fish habitat segment

The relative FAII score is calculated by:

Relative FAII score = FAII value (Obs)/FAII value (exp) x 100

Interpretation of the FAII score

Interpretation of the relative FAII values is based on the habitat integrity classes of Kleynhans (1996) (Table 4).

Table 4: FAII Assessment Classes (Kleynhans, 1996; 1999).

FAII score (% of total)	PES Class	Description of generally expected conditions for integrity classes
90-100	A	Unmodified or approximate natural conditions closely.
80-89	B	Largely natural with few modifications. A change in community characteristics may have taken place but species richness and presence of intolerant species indicate little modification
60-79	C	Moderately modified. A lower than expected species richness and presence of most intolerant species. Some impairment of health may be evident at the lower limit of this class
40-59	D	Largely modified. A clearly lower than expected species richness and presence of most intolerant species. Some impairment of health may be evident at the lower limit of this class
20-39	E	Seriously modified. A strikingly lower than expected species richness and general absence of intolerant and moderately intolerant species. Impairment of health may become evident.
0-19	F	Critically modified. Extremely lowered species richness and an absence of intolerant and moderately intolerant species. Only tolerant species may be present with a complete loss of species at the lower limit of the class. Impairment of health generally very evident.

5.0 IMPACT ASSESSMENT

In order to ensure uniformity, a standard impact assessment methodology has been utilised so that a wide range of impacts can be compared. The impact assessment methodology makes provision for the assessment of impacts against the following criteria:

- Significance;
- Spatial scale;
- Temporal scale;
- Probability; and
- Degree of certainty.

A combined quantitative and qualitative methodology was used to describe impacts for each of the aforementioned assessment criteria. A summary of each of the qualitative descriptors along with the equivalent quantitative rating scale for each of the aforementioned criteria is given in Table 5.

Table 5: Quantitative rating and equivalent descriptors for the impact assessment criteria.

RATING	SIGNIFICANCE	EXTENT SCALE	TEMPORAL SCALE
1	VERY LOW	*Isolated route / proposed route*	Incidental
2	LOW	*Study area*	Short-term
3	MODERATE	*Local*	Medium-term
4	HIGH	*Regional / Provincial*	Long-term
5	VERY HIGH	*Global / National*	Permanent

A more detailed description of each of the assessment criteria is given in the following sections.

5.1 Significance Assessment

Significance rating (importance) of the associated impacts embraces the notion of extent and magnitude, but does not always clearly define these since their importance in the rating scale is very relative. For example, the magnitude (i.e. the size) of area affected by atmospheric pollution may be extremely large (1000 km^2) but the significance of this effect is dependent on the concentration or level of pollution. If the concentration is great, the significance of the impact would be HIGH or VERY HIGH, but if it is diluted it would be VERY LOW or LOW. Similarly, if 60 ha of a grassland type are destroyed the impact would be VERY HIGH if only 100 ha of that grassland type were known. The impact would be VERY LOW if the grassland type was common. A more detailed description of the impact significance rating scale is given in Table 6 below.

Table 6: Description of the significance rating scale.

RATING		DESCRIPTION
5	VERY HIGH	Of the highest order possible within the bounds of impacts which could occur. In the case of adverse impacts: there is no possible mitigation and/or remedial activity which could offset the impact. In the case of beneficial impacts, there is no real alternative to achieving this benefit.
4	HIGH	Impact is of substantial order within the bounds of impacts, which could occur. In the case of adverse impacts: mitigation and/or remedial activity is feasible but difficult, expensive, time-consuming or some combination of these. In the case of beneficial impacts, other means of achieving this benefit are feasible but they are more difficult, expensive, time-consuming or some combination of these.
3	MODERATE	Impact is real but not substantial in relation to other impacts, which might take effect within the bounds of those which could occur. In the case of adverse impacts: mitigation and/or remedial activity are both feasible and fairly easily possible. In the case of beneficial impacts: other means of achieving this benefit are about equal in time, cost, effort, etc.
2	LOW	Impact is of a low order and therefore likely to have little real effect. In the case of adverse impacts: mitigation and/or remedial activity is either easily achieved or little will be required, or both. In the case of beneficial impacts, alternative means for achieving this benefit are likely to be easier, cheaper, more effective, less time consuming, or some combination of these.
1	VERY LOW	Impact is negligible within the bounds of impacts which could occur. In the case of adverse impacts, almost no mitigation and/or remedial activity is needed, and any minor steps which might be needed are easy, cheap, and simple. In the case of beneficial impacts, alternative means are almost all likely to be better, in one or a number of ways, than this means of achieving the benefit. Three additional categories must also be used where relevant. They are in addition to the category represented on the scale, and if used, will replace the scale.
0	NO IMPACT	There is no impact at all - not even a very low impact on a party or system.

5.2 Spatial Scale

The spatial scale refers to the extent of the impact i.e. will the impact be felt at the local, regional, or global scale. The spatial assessment scale is described in more detail in Table 7.

Table 7: Description of the significance rating scale.

RATING		DESCRIPTION
5	Global/National	The maximum extent of any impact.
4	Regional/Provincial	The spatial scale is moderate within the bounds of impacts possible, and will be felt at a regional scale (District Municipality to Provincial Level).
3	Local	The impact will affect an area up to 5 km from the proposed route corridor.
2	Study Area	The impact will affect a route corridor not exceeding the Boundary of the corridor.
1	Isolated Sites / proposed site	The impact will affect an area no bigger than the route site.

5.3 Duration Scale

In order to accurately describe the impact it is necessary to understand the duration and persistence of an impact in the environment. The temporal scale is rated according to criteria set out in Table 8.

Table 8: Description of the temporal rating scale.

RATING		DESCRIPTION
1	Incidental	The impact will be limited to isolated incidences that are expected to occur very sporadically.
2	Short-term	The environmental impact identified will operate for the duration of the construction phase or a period of less than 5 years, whichever is the greater.
3	Medium term	The environmental impact identified will operate for the duration of life of the line.
4	Long term	The environmental impact identified will operate beyond the life of operation, yet will not be permanent (could be rehabilitated).
5	Permanent	The environmental impact will be permanent, even through rehabilitation.

5.4 Degree of Probability

Probability or likelihood of an impact occurring will be described as shown in Table 9 below.

Table 9: Description of the degree of probability of an impact accruing.

RATING	DESCRIPTION
1	Practically impossible
2	Unlikely
3	Could happen
4	Very Likely
5	It's going to happen / has occurred

5.5 Degree of Certainty

As with all studies it is not possible to be 100% certain of all facts, and for this reason a standard "degree of certainty" scale is used as discussed in Table 10. The level of detail for specialist studies is determined according to the degree of certainty required for decision-making. The impacts are discussed in terms of affected parties or environmental components.

Table 10: Description of the degree of certainty rating scale.

RATING	DESCRIPTION
Definite	More than 90% sure of a particular fact.
Probable	Between 70 and 90% sure of a particular fact, or of the likelihood of that impact occurring.
Possible	Between 40 and 70% sure of a particular fact or of the likelihood of an impact occurring.
Unsure	Less than 40% sure of a particular fact or the likelihood of an impact occurring.
Can't know	The consultant believes an assessment is not possible even with additional research.

5.6 Quantitative Description of Impacts

To allow for impacts to be described in a quantitative manner in addition to the qualitative description given above, a rating scale of between 1 and 5 was used for each of the assessment criteria. Thus the total value of the impact is described as the function of significance, spatial and temporal scale as described below:

$$\textbf{\textit{Impact Risk}} = \frac{\text{SIGNIFICANCE} + \textit{Spatial} + \text{Temporal}}{3} \times \frac{\text{Probability}}{5}$$

The impact risk is classified according to 5 classes as described in the table below.

Table 11: Impact Risk Classes.

RATING	IMPACT CLASS	DESCRIPTION
0.1 – 1.0	**1**	**Very Low**
1.1 – 2.0	**2**	**Low**
2.1 – 3.0	**3**	**Moderate**
3.1 – 4.0	**4**	**High**
4.1 – 5.0	**5**	**Very High**

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. Site RKUS2, although identified as a drainage line at a desktop level, was found to be a wetland seep at the time of sampling and not a river crossing.

Table 12: Water Quality September 2009.

Site	September 2009					
	pH	DO (mg/l)	EC (^{m}S/m)	TDS (mg/l)	Temp (˚C)	Secchi Depth (cm)
RKUS1	8.7	7.08	30.0	195	13.2	3.5
RKUS2	-	-	-	-	-	-
RKUS3	8.3	7.40	31.0	202	21.4	11.5
RKUS4	8.1	8.00	15.0	98	20.3	49.0
RKUS5	9.2	2.73	39.0	254	17.3	>15.0

- *Site Dry*
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 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 July 2009 survey, pH values were alkaline and ranged from 8.1 at site RKUS4 to 9.2 at site RKUS5 (Figure 2). Alkalinity in fresh waters is usually due to bicarbonate (HCO3-) and carbonate (CO32-) ions (Davies and Day, 1998). The pH of natural waters is determined by geological influences and biotic activities. Based on the September 2009 results pH at site RKUS5 may have a limiting affect on aquatic biota, while at the remainder of the sites, pH was not considered to have a limiting effect.

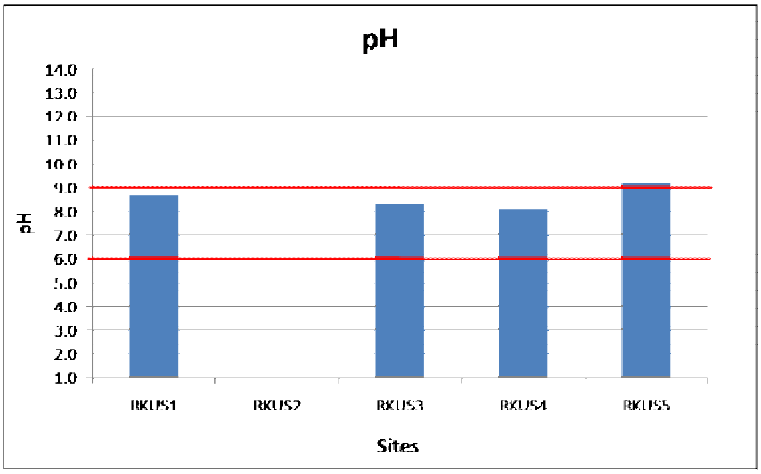

Figure 2: pH values recorded during the September 2009 survey (red lines indicate guideline values).

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 September 2009 survey Total Dissolved Solid (TDS) concentrations ranged from 98 mg/l at site RKUS4 to 254 mg/l at site RKUS5 (Figure 3). Within the observed range, TDS concentrations should not have a limiting effect on aquatic biota.

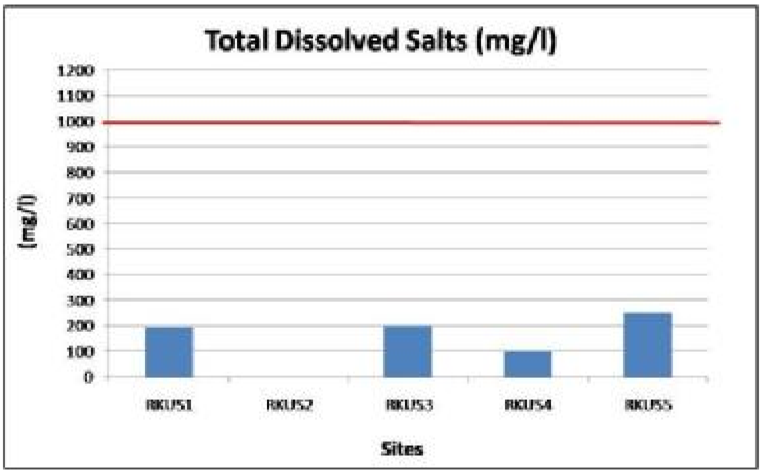

Figure 3: TDS recorded during the September 2009 survey (red line indicates guideline value).

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 September 2009 survey DO levels were considered adequate (> 5 mg/l) at sites RKUS1, RKUS3 and RKUS5, with concentrations ranging between 7.08 mg/ℓ and 8.00 mg/ℓ (Figure 4). Within this range, DO concentrations should not have a limiting effect on aquatic biota at the time of the survey. The DO concentration at site RKUS5 was low (2.73 mg/ℓ) and could if persistent, have a limiting affect on aquatic biota at the site (Figure 4). Oxygen levels are generally low where organic matter accumulate, this as a result of aerobic decomposition (Davies and Day, 1998). As shown in Figure 6, site RKUS5 consisted of large quantities of organic matter.

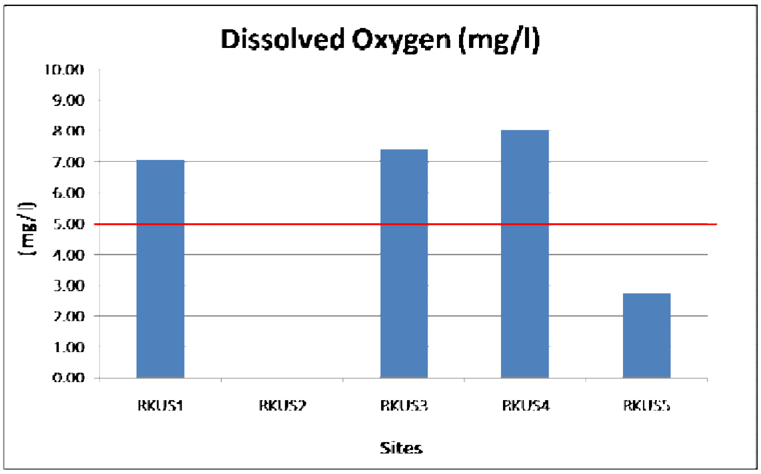

Figure 4: DO concentrations recorded during the September 2009 survey (red line indicates guideline value).

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 September 2009 survey water temperatures ranged from 13.2 ˚C at site RKUS1 to 20.3 ˚C at site RKUS4 (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.

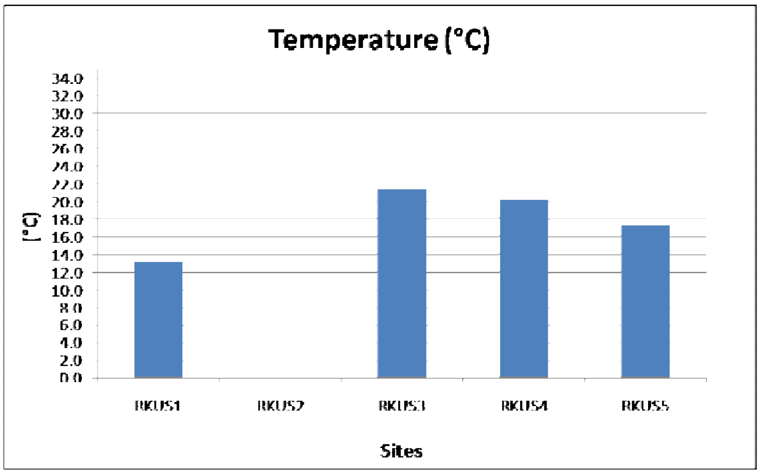

Figure 5: Temperature recorded during the September 2009 survey.

6.1.5 Turbidity

A Secchi Disk is a circular disk used to measure transparency, which in turn can be related to turbidity in aquatic ecosystems. The disk is lowered into the water on a pole until such depth that the pattern on the disk is no longer visible. This measure is taken as the transparency of the water and is referred to as the Secchi Depth.

Turbidity occurs as a result of 'suspensoids' in the water column. This suspended matter, which may include clay, silt, dissolved organic and inorganic matter, plankton and other microscopic organisms, causes the water to appear turbid (Davies and Day, 1998). This causes light to be scattered and absorbed rather than transmitted in straight lines through a water sample and may reduce light penetration, smother habitat, interfere with the feeding mechanisms of filter-feeding organisms such as certain macroinvertebrates and reduce visibility, thus leading to a reduction in biodiversity and a system which is dominated by a few tolerant species (Davies and Day, 1998).

During the September 2009 survey turbidity was considered to be high at sites RKUS1 (3.5 cm) and RKUS3 (11.5 cm). Both of these sites are located in the Klipfonteinspruit downstream of the Kusile Power station construction site. This increased turbidity may interfere with the feeding mechanisms of filter-feeding organisms such as certain macroinvertebrates, and the gill functioning, foraging efficiency (due to visual disturbances) and growth of fish and may therefore have a limiting effect on aquatic biota.

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 September 2009 survey are presented in Table 13.

Table 13: Invertebrate Habitat Assessment System (IHAS, *version 2*) scores recorded during the September 2009 survey.

Site	September 2009	
	IHAS Score	Description
RKUS1	47	Poor / Inadequate
RKUS2	-	-
RKUS3	42	Poor / Inadequate
RKUS4	64	Adequate / Fair
RKUS5	39	Poor / Inadequate

- *Site Dry*

Based on the IHAS results habitat availability was adequate at site RKUS4 with stones-in-current and a variety of habitats present. Habitat availability at the remaining sites was inadequate for diverse aquatic macroinvertebrate communities with homogenous habitat structure and no stones-in-current biotope present.

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 September 2009 survey is provided in Appendix C and a summary is provided in Table 14.

Table 14: Aquatic macroinvertebrate data collected during September 2009 survey.

Site	September 2009		
	Number of taxa	SASS5 Score	ASPT
RKUS1	18	80	4.4
RKUS2	-	-	-
RKUS3	10	51	5.1
RKUS4	16	92	5.8
RKUS5	9	37	4.1

- *Site Dry*
ASPT *Average Score Per Taxon*

A total of 28 aquatic macroinvertebrate taxa were recorded in the sample area during the September 2009 survey (9 to 18 taxa per site) (Table 14). The SASS5 scores ranged from 37 at site RKUS5 to 92 at site RKUS4 (Table 14). The Average Score per Taxa (ASPT) values, an indication of the average tolerance / intolerance of the taxa to river health degradation, ranged from 4.1 at site RKUS5 to 5.8 at site RKUS4 (Table 14). Site RKUS4 showed a higher diversity of taxa, while site RKUS5 showed only tolerant taxa and low diversity.

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 15.

Table 15: Present Ecological State (PES) classes based on SASS5 results obtained in September 2009.

Site	September 2009	
	PES Class	Description
RKUS1	C	Moderately Impaired
RKUS2	-	-
RKUS3	C	Moderately Impaired
RKUS4	B	Slightly Impaired
RKUS5	E	Severely Impaired

- *Site Dry*

Based on the SASS5 results biotic integrity ranged from severely impaired to slightly impaired (Table 15). Sites RKUS1 and RKUS3, in the Klipfonteinspruit were moderately impaired (PES Class C) with a moderate diversity of taxa recorded. Site RKUS4, which was shown to be slightly impaired (PES Class B), displayed not only a high diversity of taxa but with fewer sensitive taxa than an unimpaired site (Table 2). Site RKUS5 showed to be severely impaired (PES Class E), with few species and only tolerant taxa present.

6.4 Ichthyofaunal Assessment

6.4.1 Expected species list

An expected fish species list for the sample area and adjacent Wilge River was compiled based on the following sources: Skelton (2001), SAIAB (2009) and Kleynhans *et al*. (2007). Based on this assessment nine indigenous fish species are expected to occur in the sample area. The expected fish species list is provided in Table 16. This report is based on a single low-flow survey, so the likelihood of observing many of these species is lower than what would be expected in the high-flow season.

Table 16: Expected fish species list and current IUCN status.

Species	Common Name	IUCN Status
Pseudocrenilabrus philander	Southern mouthbrooder	Unlisted
Tilapia sparrmanii	Banded tilapia	Unlisted
Clarias gariepinus	Sharptooth catfish	Unlisted
Barbus anoplus	Chubbyhead barb	Least Concern*
Barbus trimaculatus	Threespot barb	Unlisted
Barbus paludinosus	Straightfin barb	Unlisted
Chiloglanis pretoriae	Shortspine Suckermouth	Least Concern*
Labeobarbus marequensis	Lowveld Largescale yellow	Least Concern*
Labeo cylindricus	Redeye labeo	Unlisted

6.4.2 Observed species list

A total of three fish species were recorded in the sample area during the September 2009 survey (1 to 3 species per site) (Table 17). All recorded fish species were expected in the area, as per the expected species list (Table 16).

Table 17: Fish species observed in September 2009.

Site	September 2009		
	B. anoplus	***L. marequensis***	***C. gariepinus***
RKUS1	4	0	0
RKUS2	-	-	-
RKUS3	14	0	0
RKUS4	4	20	2
RKUS5	*	*	*

\- *Site Dry*
* *Site not suitable for sampling*

Site RKUS1 is situated in a deep incised channel above the dam. Only *B.anoplus* was collected in the well vegetated, shallow areas. Site RKUS3 is an incised channel with limited habitat diversity availability for fish, as with site RKUS1, only *B.anoplus* was collected in the well vegetated, shallow areas. Site RKUS4 provided good habitat with alternating riffle and pool habitats. Three fish species were sampled at site RKUS4. Site RKUS5 could not be samples as water was limited to shallow surface seepage (Figure 6).

Figure 6: Site RKUS5 (September 2009).

6.4.3 Presence of Red Data species

Of the nine expected fish species:

- Six are currently unlisted on the IUCN Red List; and
- Three are currently listed as Least Concern (LC). Species in this category are widespread and abundant (IUCN, 2009) (Table 16).

Based on this assessment no rare or endangered fish species were expected to occur or were recorded in the sample area.

6.4.4 Biotic integrity based on fish results

The interpretation of the FAII scores follows a descriptive procedure into which the FAII score is allocated into a particular class known as the Present Ecological Status (PES) Class (Table 4). The PES classes for each of the sites are presented in Table 18.

Table 18: FAII Results and PES Classes recorded during the September 2009 survey.

Site	September 2009		
	FAII Score (%)	PES Class	Description
RKUS1	19	F	Critically modified
RKUS2	-	-	-
RKUS3	19	F	Critically modified
RKUS4	40	E	Seriously Modified
RKUS5	*	*	*

- *Site Dry*
* *Site not suitable for sampling*

Based on the FAII results biotic integrity in the project area ranged between critically and seriously modified (Table 18). Sites RKUS1 and RKUS3 both displayed homogeneous habitat which consisted of deep channelled areas with muddy substrate. In addition to this, increased turbidity within the Kilpfonteinspruit could have contributed to the impaired biotic integrity. Biotic integrity at site RKUS4 was classified as seriously modified, with low species richness and a lack of intolerant taxa.

The species observed are considered to be tolerant species, which can cope with low-flow conditions and high turbidity. It should be noted that in the high-flow season additional species are likely to move into the tributaries for breeding proposes, thus protecting the in-stream habitat and maintaining the integrity of the rivers is of utmost importance.

7.0 IMPACT ASSESSMENT

In consideration of the proposed rail development, the following initial impacts have been identified:

7.1 Initial impacts associated with the aquatic ecosystem.

Based on the in-field assessment, the initial impacts on present ecological status, would **probably** be considered MODERATE, with low diversity and high sediment loads present *locally*. The impacts identified will persist over the medium-term and are *presently occurring* at the sampled sites. The table below indicates the impact rating class as moderate impact.

Table 19: Initial impact assessment, aquatic ecosystem for all three alternatives.

IMPACT	SIGNIFICANCE	SPATIAL SCALE	TEMPORAL SCALE	PROBABILITY	RATING
	MODERATE	*Local*	Medium Term	*Presently occurring*	
Impact on current aquatic ecosystem	**3**	***3***	**3**	**5**	**3**

7.2 Additional impacts associated with the aquatic ecosystem.

The additional impacts of the proposed railway alternatives on the aquatic ecosystem during the construction phase include:

- Degradation of biotic integrity due to modification of water quality;
- Degradation of aquatic ecosystems due to increased sedimentation; and
- Change to natural flow regime.

The following section will deal with the three proposed routes, and their individual impacts.

Access to site often includes secondary impacts, which include sedimentation, increased run-off and dust. Temporary dirt roads are required to get machinery to site, especially during the construction phase, this increased activity if not managed will have a negative impact with regard to the above mentioned.

Alternative 1

The proposed rail, Alternative 1, passes over two water crossings (sites RKUS4 and RKUS5). The additional impact on the aquatic ecosystem during the construction phase will **probably** include the above mentioned impacts as well as access to the site. Due to the tributaries flowing into the Wilge River, impacts are considered to be MODERATE and occur on a *Regional* scale. The additional impacts *will occur* in the short-term. As indicated in Table 20 below, the impact rating of rail alternative 1 is moderate.

Table 20: Alternative 1.

IMPACT	SIGNIFICANCE	SPATIAL SCALE	TEMPORAL SCALE	PROBABILITY	RATING
	MODERATE	***Regional***	**Short Term**	***Will occur***	
Impact on the aquatic ecosystems associated with rail crossings	**3**	***4***	**2**	**5**	**3.00**

Alternative 2

The proposed rail, Alternative 2, passes over all five water crossings assessed. The additional impact on the aquatic ecosystem during the construction phase will **probably** include the above mentioned impacts as well as access to the site. Due to the tributaries flowing into the Wilge River and the fact that this proposed rail alternative crosses so many watercourses, impacts are considered to be HIGH and occur on a *Regional* scale. The additional impacts *will occur* in the short-term. As indicated in Table 21 below, the impact rating of rail alternative 1 is high.

Table 21: Alternative 2.

IMPACT	SIGNIFICANCE	SPATIAL SCALE	TEMPORAL SCALE	PROBABILITY	RATING
	HIGH	***Regional***	**Short Term**	***Will occur***	
Impact on the aquatic ecosystems associated with rail crossings	**4**	***4***	**2**	**5**	**3.33**

Alternative 3

The proposed rail, Alternative 3, passes over two water crossings (sites RKUS4 and RKUS5). These crossing points are relatively similar to that of Alternative 1. The additional impact on the aquatic ecosystem during the construction phase will **probably** include the above mentioned impacts as well as access to the site. Due to the tributaries flowing into the Wilge River, impacts are considered to be MODERATE and occur on a *Regional* scale. The additional impacts *will occur* in the short-term. As indicated in Table 22 below, the impact rating of rail alternative 3 is moderate.

Table 22: Alternative 3.

IMPACT	SIGNIFICANCE	SPATIAL SCALE	TEMPORAL SCALE	PROBABILITY	RATING
	MODERATE	***Regional***	**Short Term**	***Will occur***	
Impact on the aquatic ecosystems associated with rail crossings	**3**	***4***	**3**	**5**	**3.00**

7.3 Cumulative impacts associated with the aquatic ecosystem.

The cumulative impacts of constructing the proposed railway, using any of the three alternatives, increases the initial impact (moderate), up to within a high impact class. This is due to the fact that the rivers are currently already impacted upon by the Kusile Power Station construction site and farming practices within the area.

7.4 Mitigation Measures

Degradation of biotic integrity due to modification of water quality.

- Monitoring of streams should be conducted and quality should be maintained to comply with Department of Water Affairs standards / guidelines.
- Avoid any spillage or pollution entering the system during construction phase.

Degradation of aquatic ecosystems due to increased sedimentation.

- Maintain surveillance of construction activities.
- Limit speed and traffic on dirt roads adjacent to sites;
- Construction should take place at the right time of the year to reduce runoff into streams; and
- Sediment traps should be put into place and should be maintained.

Change to natural flow regime.

- Infrastructure and design should take into account the natural flow of the current system and base flow.
- Access roads and construction should where possible avoid the streams and adjacent riparian zones and take into consideration base flow (i.e. compaction and diversion).

7.5 Residual Impacts associated with the aquatic ecosystem

Alternative 1

If the above mitigation measures are implemented and adhered to then the residual impact on the aquatic *ecosystems associated with river crossings* will **possibly** have a LOW negative impact in the short term, which *will occur* during construction. Thus the construction of rail alternative 1 will have a LOW impact on the associated aquatic ecosystems (water crossings).

Table 23: Residual impact assessment, aquatic ecosystem, Alternative 1.

IMPACT	SIGNIFICANCE	SPATIAL SCALE	TEMPORAL SCALE	PROBABILITY	RATING
	LOW	***Study Site***	**Short-Term**	***Will occur***	
Impact on the aquatic ecosystems associated aquatic ecosystem	**2**	***2***	**2**	**5**	**2.00**

Alternative 2

If the above mitigation measures are implemented and adhered to then the residual impact on the aquatic *ecosystems associated with river crossings* will **possibly** have a MODERATE negative impact in the short term, which *will occur* during the construction phase. Thus the construction of rail alternative 2 will have a MODERATE impact on the associated aquatic ecosystems (water crossings).

Table 24: Residual impact assessment, aquatic ecosystem, Alternative 2.

IMPACT	SIGNIFICANCE	SPATIAL SCALE	TEMPORAL SCALE	PROBABILITY	RATING
	MODERATE	***Study Site***	**Short-Term**	***Will occur***	
Impact on the aquatic ecosystems associated aquatic ecosystem	**3**	***2***	**2**	**5**	**2.33**

Alternative 3

If the above mitigation measures are implemented and adhered to and rail alternative 3 is constructed, then the residual impact on the aquatic *ecosystems associated with river crossings* will **possibly** have a LOW negative impact in the short term, which *will occur* during the construction phase. Thus the construction of rail alternative 3 will have a LOW impact on the associated aquatic ecosystems (water crossings).

Table 25: Residual impact assessment, aquatic ecosystem, Alternative 3.

IMPACT	SIGNIFICANCE	SPATIAL SCALE	TEMPORAL SCALE	PROBABILITY	RATING
	LOW	***Study Site***	**Short-Term**	***Will occur***	
Impact on the aquatic ecosystems associated aquatic ecosystem	**2**	***2***	**2**	**5**	**2.00**

8.0 CONCLUSIONS

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

- High turbidity levels were recorded in the Kilpfonteinspruit (RKUS1 and RKUS3). These sites are located downstream of the Kusile Power Station construction site. Increased turbidity may interfere with the feeding mechanisms of filter-feeding organisms such as certain macroinvertebrates, and the gill functioning, foraging efficiency (due to visual disturbances) and growth of fish;
- Based on *In situ* water quality analysis, the pH value at site RKUS5 was high pH and Dissolved Oxygen (DO) concentrations low. This may have contributed to the severely impaired biotic integrity recorded at the site.
- Based on the IHAS results, habitat availability was a limiting factor of aquatic macroinvertebrate diversity at sites RKUS1, RKUS3 and RKUS5. The absence of adequate Stones-In-Current habitat and turbidity contributed to the poor habitat availability at these sites;
- Based on SASS5 results biotic integrity in the project area ranged from slightly impaired (PES Class B) at site RKUS4 to severely impaired (PES Class E) at site RKUS5;
- No rare or endangered fish species are expected to occur in the sample area and none were recorded;
- Based on the Fish Assemblage Integrity Index (FAII) results biotic integrity in the project area ranged from seriously modified (PES Class E) at sites RKUS4 to critically modified (PES Class F) at sites RKUS1 and RKUS3. It should be noted that this data is based on a single low-flow survey, and that in the high-flow season additional species are likely to move into the tributaries for breeding purposes, thus protecting the in-stream habitat and maintaining the integrity of the rivers is of utmost importance.
- The preferred alternative from an aquatic ecology perspective is alternative 1 and 3 (equally) followed by the least preferred alternative 2 as per the summary table below.

Table 26: Impact Summary.

	ALTERNATIVE 1	ALTERNATIVE 2	ALTERNATIVE 3
IMPACT ON AQUATIC ECOLOGY	LOW (two river crossings)	MODERATE (five river crossings)	LOW (two river crossings)
Rating	2	3	2

9.0 RECOMENDATIONS

It is recommended that:

- An erosion control specialist inspect all erosion control measures on site prior to and during the construction of the proposed railway;
- Ongoing turbidity and suspended solids should be monitored as part of the surface water monitoring programme;
- Site RKUS4 should be preserved by limiting disturbance as this site proved to be in a fairly good state, for the area;
- Alternatives 1 or 3 be considered as they pose the least impact on the associated aquatic ecosystems;
- Monitoring of the receiving catchment of the Wilge River should be conducted to assess the cumulative impacts of the Kusile construction site and railway development on the downstream catchment; and

- It is recommended that a high-flow survey be conducted as additional species are likely to move into the tributaries for breeding proposes.

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APPENDIX A

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APPENDIX B

Site Photographs

RKUS1 – Downstream

(Taken by: W.Aken. 09/09/2009)

RKUS1 – Upstream

(Taken by: W.Aken. 09/09/2009)

RKUS2 – Downstream

(Taken by: W.Aken. 09/09/2009)

RKUS2 – Upstream

(Taken by: W.Aken. 09/09/2009)

RKUS3 – Downstream

(Taken by: W.Aken. 09/09/2009)

RKUS3 – Upstream

(Taken by: W.Aken. 09/09/2009)

RKUS4 – Downstream

(Taken by: W.Aken. 09/09/2009)

RKUS4 – Upstream

(Taken by: W.Aken. 09/09/2009)

RKUS5 – Downstream

(Taken by: W.Aken. 09/09/2009)

RKUS5 – Upstream

(Taken by: W.Aken. 09/09/2009)

APPENDIX C

Aquatic Macroinvertebrate Data

	September 2009				
Aquatic macroinvertebrate	RKUS1	RKUS2	RKUS3	RKUS4	RKUS5
ANNELIDA					
Oligochaeta (Earthworms)	A		A		
CRUSTACEA					
Potamonautidae* (Crabs)	1				
Atyidae (Freshwater Shrimps)				B	
HYDRACARINA (Mites)					
EPHEMEROPTERA (Mayflies)					
Baetidae > 2 sp	C		C	B	
Caenidae (Squaregills/Cainfles)	B			B	
Leptophlebiidae (Prongills)				1	
ODONATA (Dragonflies & Damselflies)					
Coenagrionidae (Sprites and blues)	B			B	A
Aeshnidae (Hawkers & Emperors)	OBS				
Gomphidae (Clubtails)	1		B		
Libellulidae (Darters/Skimmers)	A				A
HEMIPTERA (Bugs)					
Corixidae* (Water boatmen)	A		A		A
Notonectidae* (Backswimmers)				1	
Pleidae* (Pygmy backswimmers)					
Veliidae/M...veliidae* (Ripple bugs)				1	1
TRICHOPTERA (Caddisflies)					
Hydropsychidae 1 sp	B		A	A	
Cased caddis:					
Hydroptilidae	1				
Leptoceridae				A	
COLEOPTERA (Beetles)					
Dytiscidae/Noteridae* (Diving beetles)				1	
Gyrinidae* (Whirligig beetles)	A		A	A	
Hydraenidae* (Minute moss beetles)	1		1	A	1
Hydrophilidae* (Water scavenger beetles)				1	
DIPTERA (Flies)					
Ceratopogonidae (Biting midges)	A		1		1
Chironomidae (Midges)	B		A	B	A
Simuliidae (Blackflies)	B		B	C	
Tabanidae (Horse flies)				A	
GASTROPODA (Snails)					
Lymnaeidae* (Pond snails)					B
Physidae* (Pouch snails)	1				B
Planorbinae* (Orb snails)	B				
CLADOCERA (Water fleas)					
Daphnia (Water fleas)				OBS	
Tadpoles	OBS				
Total number of taxa	18	-	10	16	9
SASS Score	80	-	51	92	37
ASPT	4.44	-	5.10	5.75	4.11

At Golder Associates we strive to be the most respected global group of companies specialising in ground engineering and environmental services. Employee owned since our formation in 1960, we have created a unique culture with pride in ownership, resulting in long-term organisational stability. Golder professionals take the time to build an understanding of client needs and of the specific environments in which they operate. We continue to expand our technical capabilities and have experienced steady growth with employees now operating from offices located throughout Africa, Asia, Australasia, Europe, North America and South America.

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