environmental affairs

Department:
Environmental Affairs
REPUBLIC OF SOUTH AFRICA

DETAILS OF SPECIALIST AND DECLARATION OF INTEREST

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Application for integrated environmental authorisation and waste management licence in terms of the-

(1) National Environmental Management Act, 1998 (Act No. 107 of 1998), as amended and the Environmental Impact Assessment Regulations, 2010; and

(2) National Environmental Management Act: Waste Act, 2008 (Act No. 59 of 2008) and Government Notice 718, 2009

PROJECT TITLE

Proposed 30-year Ash Disposal Facility at Kendal Power Station, Mpumalanga

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4.2 The specialist appointed in terms of the Regulations_

I, Warren Aken, declare that --

General declaration:

I act as the independent specialist in this application;
I will perform the work relating to the application in an objective manner, even if this results in views and findings that are not favourable to the applicant;
I declare that there are no circumstances that may compromise my objectivity in performing such work;
I have expertise in conducting the specialist report relevant to this application, including knowledge of the Act, Regulations and any guidelines that have relevance to the proposed activity;
I will comply with the Act, Regulations and all other applicable legislation;
I have no, and will not engage in, conflicting interests in the undertaking of the activity;
I undertake to disclose to the applicant and the competent authority all material information in my possession that reasonably has or may have the potential of influencing - any decision to be taken with respect to the application by the competent authority; and - the objectivity of any report, plan or document to be prepared by myself for submission to the competent authority;
all the particulars furnished by me in this form are true and correct; and
I realise that a false declaration is an offence in terms of regulation 71 and is punishable in terms of section 24F of the Act.

Signature of the specialist:

Golder Associates Africa (Pty)

Name of company (if applicable):

23/05/2016

Date:

REPORT

July 2016

ZITHOLELE CONSULTING (PTY) LTD

Aquatic Impact Assessment for the Kendal 30 Year Ash Disposal Facility Project

Submitted to:
Zitholele Consulting (Pty) Ltd

Report Number. 13615277-12384-1

Distribution:

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Golder Associates

Executive Summary

Golder Associates Africa (Pty) Ltd (Golder) was commissioned by Zitholele Consulting (Pty) Ltd (Zitholele) to conduct an aquatic and impact assessment for the Environmental Impact Assessment (EIA) for the proposed Kendal 30 year ash disposal facility which entails four different site alternatives.

The dry season survey was conducted in August/September 2013. A specialist workshop was held on 2nd of September 2013 where the impact assessment was due in October 2013. For this reason, a wet season survey (follow-up survey) was not conducted. The impact assessment was subsequently postponed due to awaiting final engineering designs. Upon finalisation, the impact assessment was finalised two years later. Following the client review of the Aquatic Baseline and Impact Assessment Report in March 2016, it was requested that a wet season survey be conducted for only site alternative H. This was the only feasible alternative site as it was the only area within a 10 km radius of the Kendal Power Station large enough which is not earmarked for mining. Consequently, a wet season survey was conducted in May 2016 where five (5) of the 19 previously surveyed sites were assessed as these sites may be directly affected by the proposed ADF on site alternative H. This report has subsequently been updated with these wet season results.

The following results were identified:

- *In situ* water quality was a limiting factor to aquatic biota at the time of the dry season, primarily due to low dissolved oxygen concentrations and percentage saturations. Both of these parameters were below the TWQR guideline at the majority of the sites in the tributaries of the Wilge River, including two of the upper sites on the Wilge River. The low values may be attributed to the large amount of decaying organic matter on the stream beds and limited flow conditions at the time of the survey. Furthermore, it was noted that the alkaline pH values on the upper Wilge River exceeded those values recorded during previous surveys conducted further downstream on the river. The turbidity levels were relatively low due to the time of year, with the exception of four sites in the tributaries of the Wilge River which demonstrated high turbidity levels. The rest of the water quality parameters were within the guideline values and thus not considered to be a limiting factor to the aquatic ecosystem. During the follow-up survey, the water quality was adequate at the selected sites monitored however, the turbidity levels remained high in the study area;

- A general description of the habitat integrity showed that the VEG and GSM were the dominant habitat elements in the Wilge River and adjoining tributaries draining the Kendal project area during both surveys. The limited habitat availability observed was largely due to a lack of the stones biotope and limited flow velocities at the time of the surveys;

- Based on the assessment of the aquatic macroinvertebrate communities, the biotic integrity in the tributaries in the project area ranged from unmodified to seriously modified (Class A to E) during the dry season and seriously modified at the four sites surveyed during the follow up survey;

- During the dry season (2013), the fish biotic integrity in the project area ranged from Largely to Critically Modified (PES Class D to F). The exotic and invasive fish species *Gambusia affinis* and *Cyprinus carpio* were recorded in the lower reaches of the Leeufontein and consequently at site two sites in the Wilge River downstream from the Leeufontein. Some fish species in the Wilge River showed signs of external parasites, a sign of increased physiological stress. Owing to low fish diversity recorded during the follow-up survey, the biotic integrity was critically modified. The low biotic integrity recorded in the tributaries was primarily attributed to limited habitat availability and low flow conditions;

- The current study area (3 km radius) encompasses an existing ash storage facility, Leeufontein Coal Mine, Lakeside Colliery, Kendal Power Station as well as significant agricultural (Maize) activities. All of these activities *are currently* placing increased stress on the receiving aquatic environment in the Wilge River, Leeufontein and adjoining tributaries;

- An assessment of site sensitivity was conducted for each proposed site alternative. Based on this assessment, site alternative C was considered highly sensitive as the proposed conveyor belt will cross two river crossings. Furthermore, this site will impact a longer stretch of river reach compared to the rest of the other site alternatives as it further up in the catchment adjacent to the upper Wilge River. Site alternative H is considered highly sensitive as well. This is primarily attributed to the sight being located on top of a pan visited by many aquatic avifauna including Flamingos. The importance of pans extends far beyond their value as wildlife sanctuaries, yet they are highly vulnerable. Pan systems in and around towns and cities are mostly under threat (Davies and Day, 1998). However, this site was selected as it was the only feasible site out of all the site alternatives as it is the only area within a 10 km radius of the Kendal Power Station large enough which is not earmarked for mining. Conversely, site alternative F was considered to have very low site sensitivity as the location of this site is already in an impacted state, with being located adjacent to existing open cast coal mining, waste dumps and an informal settlement. Therefore, site alternative F was identified as the preferred alternative; and
- Impacts emanating from Kendal's site alternative F for the proposed 30 year ash disposal facility will be assessed in terms of its magnitude, duration, spatial scale, probability and direction of impact in the next phase of the project.

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1.0 INTRODUCTION

Golder Associates Africa (Pty) Ltd (Golder) was commissioned by Zitholele Consulting (Pty) Ltd to conduct an aquatic baseline and impact assessment for the Environmental Impact Assessment (EIA) for the proposed Kendal 30 year ash disposal facility (ADF). The assessment entails four different site alternatives (site alternative B, C, F and H). The proposed development is located near to Ogies in the Mpumalanga Highveld. The Kendal study area is situated within quaternary drainage regions B20E and 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 (Mucina & Rutherford, 2006).

The dry season survey was conducted in August/September 2013 of which the results are presented in this report. Following the survey, a specialist workshop was held on 2nd of September 2013 where it was confirmed that the due date for the Baseline and Impact Assessment Reports was the end of September and October 2013 respectively. Owing to this reason, a wet season survey was not conducted at the time. The impact assessment was subsequently postponed due to awaiting final engineering designs and water studies which resulted in the compilation of the impact assessment which was conducted in February 2016, two years following the survey and the Baseline Report compilation. Following the client review of the Aquatic Baseline and Impact Assessment Report in March 2016, it was requested that a wet season survey/follow-up survey be conducted for only site alternative H. Since the submission of the report, it was confirmed that site alternative H was the only feasible site out of all the site alternatives as it was the only area within a 10 km radius of the Kendal Power Station large enough which is not earmarked for mining. Consequently, a follow-up survey was conducted on 5 May 2016 where five (5) of the 19 previously surveyed sites were assessed as these sites may be directly affected by the proposed ADF on site alternative H. This report has subsequently been updated with these wet season results.

Included is an assessment of the *in situ* water quality, habitat availability for aquatic macroinvertebrates, aquatic macroinvertebrate and ichthyofauna diversity within the aquatic ecosystems associated with proposed Eskom's Kendal 30 year ADF.

1.1 Description of the Proposed Ash Disposal Facilities

The ADF will be designed with a liner system which will essentially eliminate seepage from the facilities. The liner will have an underdrain system which will collect the seepage from the base of the facility and deliver the seepage to the storm water management system for management in the power station circuits. The storm water management system has been designed to meet Regulation 704 and spill into the river system on average once in 50 years. The ADF is essentially isolated from the catchment area and will contribute very little water to the surface water environment. The catchment isolated by the facilities will no longer contribute runoff or recharge to the groundwater system. The facilities will therefore reduce the volume of water reaching the surface water streams.

The ADF progression is proposed to be taken forward as set out in Table 1 for the period 2025 to 2055.

Table 1: ADF progression

Period	Ash body
2025 - 2030	1.) 96.6 hectares of first 5 years liner to be constructed including removal and stockpiling of topsoil to designated area.
2030 - 2035	1.) 96.6 hectares of first 5 years liner to be ashed on. 2.) 74 hectares of second 5 years liner to be constructed including removal and stockpiling of topsoil to designated area.
2035 - 2040	1.) 74 hectares of second 5 years liner to be ashed on. 2.) 58.6 hectares of third 5 years liner to be constructed including removal and stockpiling of topsoil to designated area. 3.) 96.6 hectares of first 5 years open ash area to be topsoiled and grassed.

Period	Ash body
2040 - 2045	1.) 58.6 hectares of third 5 years liner to be ashed on. 2.) 60 hectares of fourth 5 years liner to be constructed including removal and stockpiling of topsoil to designated area. 3.) 74 hectares of second 5 years open ash area to be topsoiled and grassed.
2045 - 2052	1.) 60 hectares of fourth 5 years liner to be ashed on. 2.) 115.5 hectares of fifth 5 years liner to be constructed including removal and stockpiling of topsoil to designated area. 3.) 58.6 hectares of third 5 years open ash area to be topsoiled and grassed.
2052 - 2055	1.) 115.5 hectares of fourth 5 years liner to be ashed on. 2.) 60 hectares of fourth 5 years open ash area to be topsoiled and grassed.

The catchment areas of the ADF options and the potentially impacted quaternary catchments are listed in Table 2. The percentages of the areas of the ADF options of the total of quaternary catchment areas are also given in Table 2. The percentages are relatively low ranging from 0.54% to 1.49%.

Table 2: Areas of ADF Options and quaternary catchments

Catchment/ADF Option	Area (km^2)	% ash storage facility of B20F and B20E
Site B	11.37	1.01
Site C	9.50	1.5
Site F	15.32	1.49
Site H	6.09	0.54
Quaternary B20E	620.0	-
Quaternary B20F	505.0	-
Quaternary B20G	522.0	-
Wilge River Catchment	4 277.0	-

1.2 Objectives

The objectives of this assessment included the following:

- Characterization of the biotic integrity of aquatic ecosystems in the project area as per the scope of work;
- Assessment of impacts emanating from the proposed Kendal ash disposal facility, taking into account the surrounding land uses on the biotic ecosystem in the catchment area;
- Evaluation of the extent of site-related effects in terms of selected ecological indicators;
- 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
- Identification of potential impacts and recommendation of suitable mitigation measures.

2.0 APPROACH

In order to enable adequate descriptions of the aquatic environment, it is recommended that 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 & USEPA) and are as follows:

2.1 Stressor Indicators

- *In situ* water quality parameters:
  - Electrical Conductivity (EC), Total Dissolved Salts (TDS), pH, Dissolved Oxygen (DO), percentage saturation (DO%), water temperature and turbidity.

2.2 Habitat Indicators

- General habitat assessment; and
- Integrated Habitat Assessment System (IHAS, *Version 2*).

2.3 Response Indicators

- Aquatic macroinvertebrates (South African Scoring System, *Version 5*); and
- Ichthyofauna (Fish Assemblage Integrity Index, FAII).

3.0 STUDY AREA

The main drainage feature of the Kendal study area is the Wilge River which flows northwards to the west of the Kendal Power Station and proposed ash dump facilities. The Leeufontein and another un-named tributary, drain in a north westerly direction from the ash disposal facilities towards and into the Wilge River.

The topography of the region is a gently undulating to moderately undulating landscape of the Highveld plateau. Some small scattered wetlands and pans occur in the area, rocky outcrops and ridges also form part of significant landscape features in the wider area. The altitude ranges between 1 260 – 1 620 m above mean sea level (Zitholele Scoping Report, 12810, 2010).

The soils in the region form a typical Highveld plinthic catena with shallow soils on the crests of slopes, deeper sandy apedal soils on the slopes and soils with some plinthic clay layers in the foot slopes. In the valleys the clays accumulate and in some cases harden into ferricrete (hardpan/ouklip) (Zitholele Scoping Report, 12810, 2010).

3.1 Sampling Points

A total of 18 sites were monitored within the watercourses associated with the Kendal 30 year ash disposal facility. The sites have been selected to represent the receiving environment associated with the proposed development, as well as potential impacts on the larger Wilge River.

The GPS co-ordinates of sampling sites were determined using a Garmin GPS 60CSx and are listed in Table 3 along 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 A.

Please note that as Alternative H was included into the project scope in January 2014, a pan, located within the centre of the proposed alternative was not sampled at the time of the survey conducted in August/ September 2013. Nonetheless, Golder has monitored this pan for the last several years and thus has historical water quality data for this pan, which will be included into this report.

Table 3: Descriptions and locations of aquatic monitoring sites

Site	River	Latitude	Longitude	Farm Portion	Location and Description	Dry Season Survey (Aug/Sep' 13)	Wet Season Survey (May' 16)
K_WIL1	Wilge River	-26.141800°	28.877233°	Welgelegen 221	This site is located in the upper Wilge River Catchment, upstream from the proposed ash disposal facility site alternatives and accounts for any additional impacts entering the system, i.e. agricultural activities amongst others from the south. In this reach of the Wilge River, erosion of the channel has resulted in typically steep/collapsed banks with a deep muddy channel. A permanent farm bridge provides a variation in flow velocity and substrate with supporting rock and concrete in place.	√	X
K_WIL2	Wilge River	-26.098717°	28.858500°	Welgelegen 221	This site is located in the upper Wilge River Catchment, upstream from the proposed ash disposal facility site alternatives and accounts for any additional impacts entering into the system, i.e. agricultural activities amongst others from the south, as well as from the tributary which enters the Wilge River from the west. At this site the Wilge River passes beneath a farmer's road bridge. The water depth was shallow at the time of the survey and the substrate dominated by mud.	√	X
K_TRI11	Unnamed tributary of the Wilge River	-26.102062°	28.851163°	Schoongezicht	This site is located on the western side of the Wilge River, although it is considered a wetland opposed to a tributary. It takes into account any additional impacts entering the system from the south-west.	√	X

Site	River	Latitude	Longitude	Farm Portion	Location and Description	Dry Season Survey (Aug/Sep' 13)	Wet Season Survey (May' 16)
					The channeled valley-bottom wetland is dominated by recently cut *Phragmites spp.* with a muddy substrate.		
K_TRI1	Unnamed tributary of the Wilge River	-26.082733°	28.835883°	Bospoort	This site is located on the western side of the Wilge River in an unknown tributary, and account for any additional impacts entering the system from the south-west. A large gravel road runs over the site which is used primarily by farmers and large coal trucks. Near the road bridge, deposition of sediment has resulted in deep mud banks, although further upstream, the river becomes shallow.	√	X
K_WIL3	Wilge River	-26.078100°	28.859133°	Bospoort	The third site on the Wilge River is located adjacent to the proposed ash disposal facility site alternative C and takes into account the impacts entering the system from site K_TRI11, as well as further upstream of the Wilge River. At this site, the Wilge River passes beneath a farmer's road bridge. The water levels upstream from the bridge are shallow compared to some parts of the river reach downstream of the bridge which is semi dry or pooled. The substrate is predominately mud with scattered cobbles and stones.	√	X
K_TRI2	Unnamed tributary of the Leeufontein	-26.092133°	28.914250°	Vlakvarkfontein 213	This site is located in an unknown tributary of the Leeufontein, adjacent to the proposed ash disposal facility site alternative C. This drainage line at this site is considered a wetland.	√	X

Site	River	Latitude	Longitude	Farm Portion	Location and Description	Dry Season Survey (Aug/Sep’ 13)	Wet Season Survey (May’ 16)
K_TRI3	Leeufontein	-26.084691°	28.920815°	Vlakvarkfontein 213	This site is located upstream from the proposed ash disposal facility site alternative C in the Leeufontein, which enters the Wilge River from the south east. Upstream and around the road bridge, deposition of sediment has resulted in deep mud banks. Due to the bridge the water has also 'dammed' up and is deeper. *Phragmites* dominated the mud banks below the bridge. Further downstream the river becomes shallow.	√	√
K_TRI4	Leeufontein	-26.078735°	28.911531°	Mooimeisiefontein	This site is located between the proposed ash disposal facility site alternative B and C in the Leeufontein and thus takes into account impacts entering the system from both proposed sites, coupled with impacts entering from further upstream. The site is characterized by a deep channel dominated by a muddy substrate. The riparian zone of the stream is subjugated by *Phragmites spp*., although was recently cut back by the local resident farmers. The farmer’s bridge/road crossing is made out of cobbles and rocks which slow the flow velocity down of this river reach, resulting in a narrow and shallow channel downstream.	√	√

Site	River	Latitude	Longitude	Farm Portion	Location and Description	Dry Season Survey (Aug/Sep' 13)	Wet Season Survey (May' 16)
K_TRI10	Leeufontein	-26.064916°	28.870633°	Vlakvarkfontein 213	This site is located just downstream of the proposed ash disposal facility site alternative B and C in the Leeufontein and thus takes into account impacts entering the system from both proposed sites, coupled with impacts entering from further upstream . The site is characterized by a channel which varies from deep to shallow with a muddy substrate. A recent veld fire passed along this river reach.	√	X
K_WIL4	Wilge River	-26.04485	28.86745	Vlakvarkfontein 213	This site is located in the upper Wilge River Catchment, where the R545 and rail crosses the Wilge River. At this site the Wilge River passes under a rail and a road (R555) bridge. In this reach the substrate is a mix of boulders, shale and deposited mud banks. Water depth is also shallower than upstream and the bridge structures provide a mix of velocities.	√	X
K_TRI8	Unnamed tributary of a secondary tributary of the Wilge River	-26.059560°	28.960769°	Heuvelfontein 215	This site is located adjacent to the Kendal Power Station and to the south western side of the proposed ash disposal facility site alternative F. The site was dry at the time of the survey. Upstream of the road a section covered in *Phragmites* is present, while downstream a bit of a channel has formed due to the road culverts. The stream would have typically been a non-channelled valley bottom wetland.	√	X

Site	River	Latitude	Longitude	Farm Portion	Location and Description	Dry Season Survey (Aug/Sep' 13)	Wet Season Survey (May' 16)
K_TRI9	Unnamed tributary of the Wilge River	-26.049550°	28.942083°	Heuvelfontein 215	This site is located on an unnamed tributary of the Wilge River and takes into account the impacts entering the system directly from the proposed ash disposal facility site alternative F. This site has been reduced to a seep. There are no appropriate culverts at the farmer's road crossing for the water to flow through, resulting in the drainage to be considered a wetland.	√	√
K-TRI13	Unnamed tributary of the Wilge River	-26.03770	28.88959	Van Dyksput 214	This site is located on an unnamed tributary of the Wilge River and takes into account the impacts entering the system directly from the proposed ash disposal facility site alternative F. It is characterized by a narrow meandering shallow stream dominated by a muddy substrate coupled with cobbles and rock.	√	√
K_WIL5	Wilge River	-26.014727°	28.868792°	Dwaalfontein 565	This site is the most downstream site on the Wilge River in the study area and thus takes into account all the impacts entering the system within the study area and in particular, from the unnamed tributary which enters the Wilge River from the east, approximately 2 km upstream. At this site the Wilge River passes beneath a farmer's road bridge with well-designed culverts which provides a variation in flow velocity and substrate with supporting rock and concrete in place.	√	X

Site	River	Latitude	Longitude	Farm Portion	Location and Description	Dry Season Survey (Aug/Sep' 13)	Wet Season Survey (May' 16)
					The substrate is dominated by mud, cobbles and boulders.		
K_TRI7	Unnamed tributary of the Saalboomspruit	-26.019494°	28.984667°	Bankfontein 216	This site is located downstream of the ash disposal facility site alternative F and which enters into the Saalboomspruit. This site can be considered as a wetland.	√	X
K_TRI6	Unnamed tributary of the Saalboomspruit	-26.019626°	29.027276°	Trichardtsfontein 1	This site is located near the informal residential area, Phola. Drainage line enters into the Saalboomspruit. The stream has been reduced to a seep, and the drainage line is considered a wetland. At the time of the survey, cows were grazing within the wetland and a raw sewage smell was noted.	√	X
K_TRI6A	Saalboomspruit	-26.018410°	29.011140°	Bankfontein 216	This site is located on the Saalboomspruit downstream of the proposed ash disposal facility site alternative F and further located near the informal residential area Phola. The stream is confined to a narrow channel that is shallow although gets deep in some sections due to the substrate being dominated by soft mud. Upstream of this site, the stream disperses out forming a channelled valley-bottom wetland.	√	X
K_TRI5	Saalboomspruit	-26.005487°	29.025831°	Phinshop 2	The site is located within the informal residential area, Phola, downstream from the proposed ash disposal facility site alternative F.	√	X

Site	River	Latitude	Longitude	Farm Portion	Location and Description	Dry Season Survey (Aug/Sep' 13)	Wet Season Survey (May' 16)
					The stream is a narrow channel of which flows through a forest of *Poplar spp*. Downstream from the monitoring site. The channel is deep with a muddy substrate coupled with in stream vegetation.		
K_PAN1	Pan	-26.07671	28.94663	Heuvelfontein 215 Schoongezicht 218 Vlakvarkfontein 213	This site is located in the centre of the proposed alternative H for the Kendal 30 year ash disposal facility. Pans are considered to be important and unique aquatic ecosystems. The pan is surrounded by maize fields.	√	√
WGS_84 Datum co-ordinate system represented in decimal degrees							

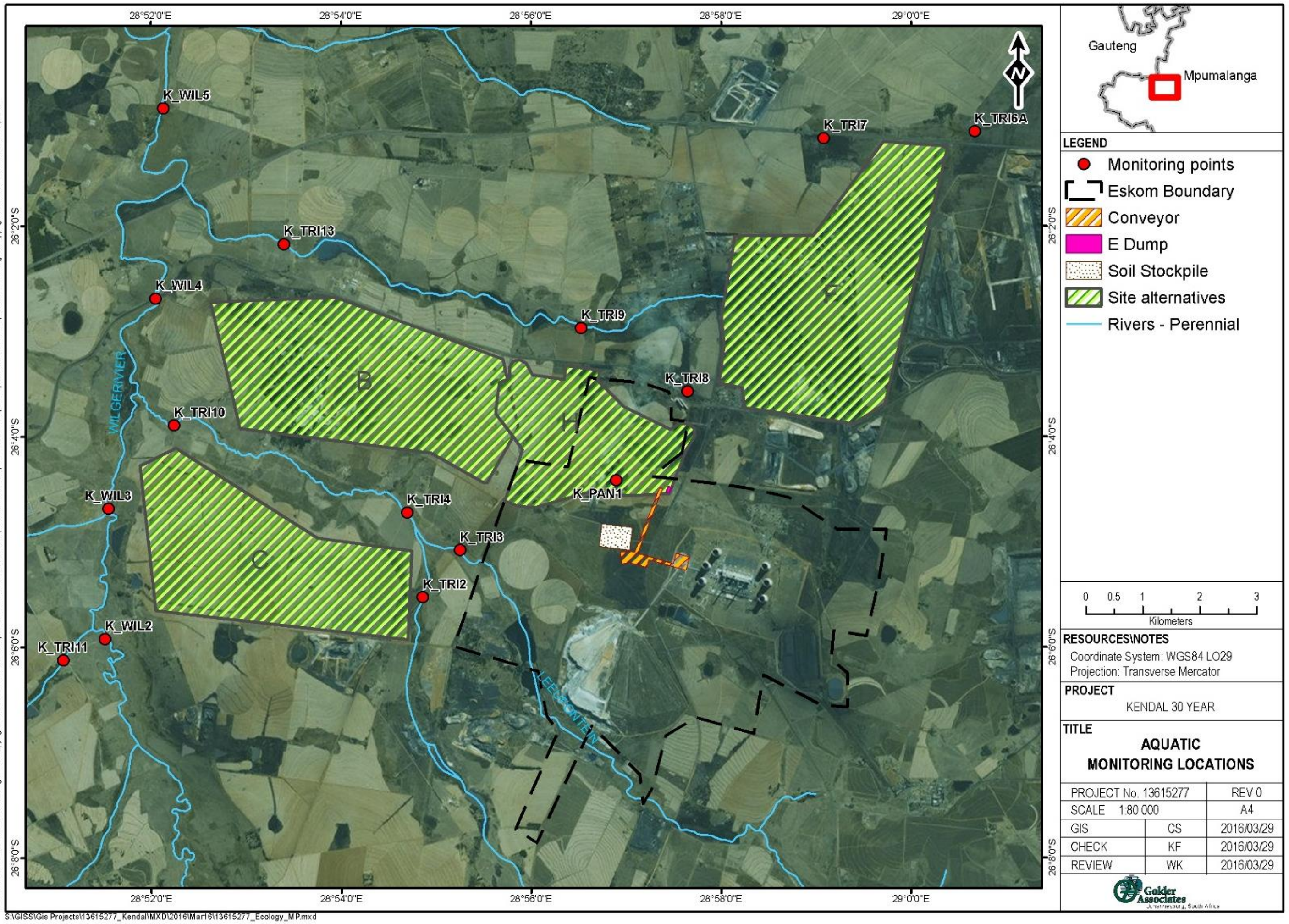


Figure 1: Map of aquatic monitoring sites as well as site alternatives and associated conveyor corridors

4.0 METHODS AND MATERIALS

4.1 *In Situ* Water Quality

During the dry season (September 2013) and the follow-up survey/wet season (May 2016) surveys, 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 DO300);
- Temperature (Eutech CyberScan DO300); and
- Clarity (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. It should be noted that this does not constitute the general water quality state of the sites or streams and does not include chemical water quality analysis, metal or organic contaminants, nutrient analysis or pesticide analysis.

In 1996 the Department of Water Affairs and Forestry (DWAF) published the South African Water Quality Guidelines for Aquatic Ecosystems (Volume 7). These guidelines provide target ranges in terms of water quality for the protection of aquatic ecosystems. All measured parameters for the sites should be within the target water quality range (TWQR). It is these benchmarks that are used to assess the present condition of the river systems and the extent of degradations. Dissolved Oxygen (DO) however is measured against the guideline provided from Kempster *et al.* 1980.

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 Integrated Habitat Assessment System

The Integrated Habitat Assessment System (IHAS, V*ersion 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). The index considers sampling habitat and stream characteristics. The sampling habitat is broken down into categories, these being stones-in-current, vegetation and other habitat/general. All of these add up to a possible 100 points (or percentage). 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 and anything below 55% is poor (McMillan, 2002) (Table 4).

Table 4: Integrated Habitat Assessment System Scoring Guidelines (Version 2)

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

4.3 Aquatic Macroinvertebrates

Biological monitoring, or commonly known as “biomonitoring” is the use of biological responses to assess changes in the environment, commonly resulting from anthropogenic sources (Plafkin *et al.,* 1989, Dickens & Graham, 2002). In general biomonitoring involves the use of indicators in the form of individuals, species or communities. Fish, aquatic macroinvertebrates, diatoms and algae are some of the indicators used, although aquatic macroinvertebrates have the longest history of use in biomonitoring programs and the application in South African streams has been well documented (Plafkin *et al.,* 1989; Dickens & Graham, 2002).

Aquatic macroinvertebrates are organisms that are small, but large enough to be seen by the naked eye. Different types of aquatic macroinvertebrate assemblages are made up of a broad range of species from different trophic levels and tolerances, thus providing information for interpreting localized disturbances, environmental conditions, as well as cumulative effects (Barbour *et al.,* 1999). Furthermore, as there are a large number of species, different stresses produce different macroinvertebrate communities (Barbour *et al.,* 1999). Depending on the different taxa found in a stream, predictions regarding water quality can be made. Different types of aquatic macroinvertebrates include *inter alia*, Ephemeroptera (mayflies), Trichoptera (caddisflies and cased caddisflies), Coleoptera (beetles), Hemiptera (bugs), Diptera (flies), Mollusca (snails) and crustaceans. These different and randomly selected assemblages and communities reflect overall stream condition as they integrate different environmental preferences such as water quality, flow and habitat. As a result, the responding community will provide insight into the presence of pollution in a river system, the amount/intensity of the exposure, and thus provide an indication of the health and integrity of the river system (O’Keeffe and Dickens, 2000). Therefore, aquatic macroinvertebrates form an essential component in assessing riverine ecosystems as they indicate the overall ecological condition (O’Keeffe and Dickens, 2000, Weber *et al.,* 2004).

The benefits of using aquatic macroinvertebrates as indicator species in biomonitoring programs, is that they are abundant in most aquatic habitats and are relatively sedentary, with limited mobility or sessile. Their relatively long life histories (approximately 1 year) allow for the integration of pollution effects over time.

Sampling of aquatic macroinvertebrates under a rapid assessment protocol is relatively easy and requires few people and minimal equipment. Sampling has limited to no detrimental effects on the resident biota or habitat. The identification process to family level is easy and many "intolerant" taxa can be identified to lower taxonomic levels with ease.

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 5).

Table 5: Modelled reference conditions for the Highveld Ecoregion (11) based on SASS5 and ASPT scores (adapted from (Dallas, 2007), (Kleynhans, 1999) and (Kleynhans, *et al.,* 2005)

SASS Score	ASPT	Class	Description
>124	>5.6	A	Unmodified; community structures and functions comparable to the best situation to be expected. Optimum community structure for stream size and habitat quality.
83 - 124	4.8 - 5.6	B	Largely natural with few modifications; A small change in community structure may have taken place but ecosystem functions are essentially unchanged.
60 - 82	4.6 - 4.8	C	Moderately modified; community structure and function less than the reference condition. Community composition lower than expected due to loss of some sensitive forms. Basic ecosystem functions are still predominantly unchanged.

SASS Score	ASPT	Class	Description
52 - 59	4.2 - 4.6	D	Largely modified; fewer families present than expected, due to loss of most intolerant forms. An extensive loss of basic ecosystem function has occurred.
30 - 51	Variable <4.2	E	Seriously modified; few aquatic families present, due to loss of most intolerant forms.
<30	Variable	F	Critically or extremely modified; An extensive loss of basic ecosystem function has occurred.

4.4 Ichthyofauna

Fish are used as indicators of river condition as they are relatively long-lived and mobile, and indicate long-term influences and 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). Reference specimens were preserved for laboratory confirmation of field identifications and the remainder of the fish released at the point of capture.

Expected fish species list

Based on a desktop review of available literature an expected species list was compiled for the Kendal ash disposal facility (Kleynhans *et al.,* 2007).

Based on this assessment, a total of eight (8) indigenous fish species are expected to occur within the area (Table 6). In addition the introduced species *Cyprinus carpio (Carp), Gambusia affinis* (Mosquito fish) and *Micropterus salmoides* (Largemouth Bass) are also expected to occur in the area (Table 6).

Table 6: Fish species expected to occur in the Kendal ash disposal facility project area (IUCN, 2013 and Kleynhans, 1999).

Species	Common Name	Habitat Preference		IUCN Status	Intolerance Rating
Barbus anoplus	Chubbyhead barb	SD/SS	Wide variety of habitats	Least Concern	2.6
Barbus paludinosus	Straightfin barb	SD/SS	Wide variety of habitats	Least Concern	1.8
**Cyprinus carpio*	Carp (Exotic)	SD	Wide variety of habitats	Vulnerable	1.4
Chiloglanis pretoriae	Shortspine Suckermouth	FS	Flowing water over cobbles and in shoots	Least Concern	4.6
Clarias gariepinus	Sharptooth catfish	SD	Wide variety of habitats	Unlisted	1.2
**Gambusia affinis*	Mosquito fish (Exotic)	SD	Wide variety of habitats	Unlisted	2.0
Labeobarbus marequensis	Lowveld Largescale yellow	FS/SD	Flowing water of larger rivers	Least Concern	2.6
Labeobarbus polylepis	Bushveld Smallscale yellowfish	FS/SD	Flowing water of larger rivers	Least Concern	3.1
**Micropterus salmoides*	Largemouth Bass (Exotic)	SD	Clear standing or slow flowing water	Unlisted	2.2
Pseudocrenilabrus philander	Southern mouthbrooder	SS	Wide variety of habitats	Unlisted	1.3
Tilapia sparrmanii	Banded tilapia	SS	Wide variety of habitats	Least Concern	1.3

**Red highlighted species are those that are classed as exotic in South Africa.*

SS: slow shallow, SD: slow, deep, FS: fast shallow

Presence of Red Data species

In order to assess the Red Data Book status of the expected fish assemblage, the IUCN Red List of Threatened Species was consulted (IUCN, 2013). The result of the IUCN Red List assessment is presented in Table 6.

Of the 11 fish species expected to occur in the sampling area:

- Four (4) are currently unlisted on the IUCN Red List of which two of them are exotic in South Africa;
- Six (6) are currently listed as Least Concern (LC) on the IUCN Red List. Species in this category are considered to be widespread and abundant (IUCN, 2013); and
- One (1) is Vulnerable (V) on the IUCN Red List although *Cyprinus carpio* is classed as an exotic species in South Africa.

Based on the IUCN Red List no rare threatened or endangered fish species are expected to occur in the project area.

Fish Assemblage Integrity Index (FAII)

The Fish Assemblage Integrity Index (FAII) was applied to sites associated with the Kendal ash disposal facility site alternatives. The FAII index uses the diversity and composition of fish populations, their relative tolerance/intolerance to disturbance, frequency of occurrence and health, to assess biotic integrity. This index measures the current integrity of the fish community relative to what is derived to have been present under natural/unimpaired conditions. The integrity of the fish assemblages is considered to provide a perspective on the broad biological integrity status of a river/stream.

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) (Table 7). The total intolerance (IT) of fish species is estimated as follows:

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

Table 7: Species intolerance ratings

Score	Class
1 - 1.9	Tolerant
>2 - 2.9	Moderately Tolerant
>3 - 3.9	Moderately Intolerant
>4 - 5.0	Intolerant

The expected fish species were ranked into classes based on their intolerance rating (Table 7). Based on that assessment one intolerant species, *Chiloglanis pretoriae* may potentially occur within the project area (Table 6).

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; and
- 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 consists of the calculation of an expected value, which serves 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) = ΣIT 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; and
- 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) = ΣIT 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 8).

Table 8: FAII Assessment Classes (Kleynhans, 1996; 1999)

Class	Description of generally expected conditions for integrity classes	FAII score (% of total)
A	Unmodified, or approximate natural conditions closely.	90 - 100
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.	80 - 89
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.	60 - 79
D	Largely modified. 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.	40 - 59
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.	20 - 39
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.	0 - 19

4.4.1 Fish Health

The fish health assessment was confined to external examination of the skin, fins, eyes, gills, opercula (the hard, bony flap covering the gill slits) and the presence of ectoparasites. This approach ensured the minimization of stress due to handling and allowed the fish to be released unharmed. 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).

4.5 Impact assessment methodology

The impact assessment is conducted by determining how the proposed activity will affect the state of the environment previously described. Specific requirements are:

- Undertake a comparative assessment to identify and quantify the environmental and/or social aspects of the various activities associated with the proposed project;
- Assess the impacts that may accrue and the significance of those impacts using the methodology as described below; and
- Identify and assess cumulative impacts utilising the same rating system.

The impacts have been rated according to the methodology described below. Where possible, mitigation measures must be provided to manage impacts. In order to ensure uniformity, a standard impact assessment methodology was utilised so that a wide range of impacts can be compared with each other. The impact assessment methodology makes provision for the assessment of impacts against the following criteria:

- Significance assessment;
- Spatial scale;
- Duration or temporal scale;
- Degree of probability; and

- Degree of certainty.

A combined quantitative and qualitative methodology is 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 9.

Table 9: Quantitative rating and equivalent descriptors for the impact assessment criteria

Rating	Significance	Extent Scale	Temporal Scale
1	VERY LOW	*Proposed site*	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 sections to follow.

4.5.1 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 (1 000 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 detailed description of the impact significance rating scale is given in Table 10.

Table 10: 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 are 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.

Rating		Description
		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.

4.5.2 Spatial scale

The spatial scale refers to the extent of the impact. In other words the impact is at a local, regional or global scale. The spatial assessment scale is described in more detail in Table 11.

Table 11: Description of the spatial 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 10 km from the proposed site.
2	Study Site	The impact will affect an area not exceeding the Eskom property.
1	Proposed site	The impact will affect an area no bigger than the ash disposal site.

4.5.3 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 12.

Table 12: 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 facility.
4	Long term	The environmental impact identified will operate beyond the life of operation.
5	Permanent	The environmental impact will be permanent.

4.5.4 Degree of probability

Probability or likelihood of an impact occurring is described in Table 13.

Table 13: Description of the degree of probability of an impact occurring

Rating	Description
1	Practically impossible
2	Unlikely
3	Could happen
4	Very likely
5	It’s going to happen/has occurred

4.5.5 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 set out in Table 14. 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 14: Description of the degree of certainty rating scale

	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.
Don’t know	The consultant cannot, or is unwilling, to make an assessment given available information.

4.5.6 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:

***Impact Risk* = ((SIGNIFICANCE + *Spatial* + Temporal) ÷ 3) X (Probability ÷ 5)**

The impact risk is classified according to five classes described in Table 15.

Table 15: 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**

4.5.7 Cumulative Impacts

It is a requirement that the impact assessments take cognisance of cumulative impacts. In fulfilment of this requirement the impact assessment will take cognisance of any existing impact sustained by the operations, any mitigation already in place, any additional impact to environment through continued and proposed future activities, and the residual impact after mitigation.

It is important to note that cumulative impacts at the national or provincial level will not be considered in this assessment, as the total quantification of external companies on resources is not possible at the project level due to the lack of information and research documenting the effects of existing activities. Such cumulative impacts that may occur across industry boundaries can also only be effectively addressed at Provincial and National Government levels.

5.0 RESULTS AND DISCUSSION

5.1 Flow Conditions

The Ogies area normally receives about 578 mm of rain per year, with most rainfall occurring during summer and peaking in January (109 mm). Low flow conditions are experienced during June and July with no rain expected during this period (SA explorer, 2011).

At the time of the dry season survey (August/September 2013), flow conditions within the project area were considered to be normal for a dry season survey.

During the wet season survey (May 2016), flow conditions within the project area did not reflect typical wet season conditions however, this is owing to the limited rainfall of the drought currently being experienced in South Africa.

The flow conditions per site were documented, as this influences the biological results collected, and as a result the data collected should be interpreted with the prevailing flow conditions in mind (Table 16). Refer to Figure 2 for examples of the recorded conditions.

Table 16: Flow conditions during the dry and wet season surveys

Site	Flow Conditions	
	Dry Season (August/September 2016)	**Wet Season (May 2016)**
K_WIL1	Deep channel with low flow conditions	-
K_WIL2	Low flow conditions	-
K_TRI11	Wetland. No flow conditions	-
K_TRI1	Limited flow conditions	-
K_WIL3	Low to no flow conditions	-
K_TRI2	Dry	-
K_TRI3	Low to no flow conditions	Low to no flow conditions
K_TRI4	Low flow conditions	No flow conditions
K_TRI10	Low flow conditions	-
K_WIL4	Low flow conditions	-
K_TRI8	Dry, although a small water puddle in the middle of the channel	-
K_TRI9	Wetland. No flow conditions	Dry
K_TRI13	Low flow conditions	Low to no flow conditions
K_WIL5	Low to no flow conditions	-
K_TRI7	No flow conditions	-
K_TRI6	Wetland conditions	-
K_TRI6A	Low to no flow conditions	-
K_TRI5	Low flow conditions	-
K_PAN1	Pans do not have flow conditions. Stagnant waters	

Site K_WIL1: Deep channel with low flow conditions (dry season)

Site K_WIL3: Low to no flow conditions (dry season)

Site K_TRI10: Low flow conditions (dry season)

Site K_TRI8: Dry (dry season)

Site K_TRI6: Wetland conditions (dry season)

Site K_TRI13: Low to no flow conditions (wet season)

	
Site K_TRI3: Deep pool with low to no flow conditions (wet season)	Site K_TRI9: Dry (wet season)

Figure 2: Flow conditions

5.2 *In Situ* Water Quality

In situ water quality measurements were recorded using field instruments and the results presented in Table 17. This information is important in terms of the interpretation of biological results because of the direct influence water quality has on aquatic life forms. Although these measurements only provide a “snapshot”, they can provide valuable insight into the characteristics of a specific sample site at the time of the survey.

The Target Water Quality Range (TWQR) as provided by DWAF (1996) is shown for the *in situ* parameters measured. The guideline for DO was obtained from Kempster *et al.,* 1980.

Table 17: *In situ* water quality results recorded during the August/September 2013 and May 2016 survey

Site	pH		EC (mS/m)		TDS (mg/ℓ)		DO (mg/ℓ)		DO Saturation (%)		Temp (˚C)		Clarity (cm)	
	Sep'13	May'16	Sep'13	May'16	Sep'13	May'16	Sep'13	May'16	Sep'13	May'16	Sep'13	May'16	Sep'13	May'16
TWQR	6.5 – 9.0		<154		<1 000		>5.00		80 – 120		5 – 30			
K_WIL1	8.8	-	48	-	312.0	-	4.1	-	78.6	-	20.4	-	70.0	-
K_WIL2	9.1	-	54	-	351.0	-	5.3	-	103.5	-	21.1	-	52.0	-
K_TRI11	9.0	-	26	-	169.0	-	5.0	-	86.0	-	15.0	-	>3	-
K_TRI1	8.8	-	44	-	286.0	-	3.7	-	65.0	-	17.7	-	10	-
K_WIL3	8.5	-	51	-	331.5	-	2.5	-	49.6	-	22.0	-	25.0	-
K_TRI3	8.4	8.6	132	112	858.0	728.0	5.5	10.7	95.5	113.7	15.6	21.2	>28	>22
K_TRI4	8.4	8.3	73	104	474.5	676.0	4.3	10.3	83.2	112.1	21.0	21.6	35	>20
K_TRI10	8.4	-	76	-	494.0	-	4.2	-	86.5	-	23.3	-	>22	-
K_WIL4	8.9	-	92	-	598.0	-	6.3	-	95.9	-	9.9	-	>45	-
K_TRI8	8.5	-	112	-	728.0	-	1.9	-	34.0	-	16.7	-	10	-
K_TRI9	8.4	#	92	#	598.0	#	3.7	#	59.0	#	12.2	#	3	#
K_TRI13	8.4	8.6	42	37	273.0	240.5	5.8	10.8	79.7	113.1	5.8	17.6	>10	>6
K_WIL5	9.0	-	30	-	195.0	-	5.6	-	112.0	-	22.5	-	>50	-
K_TRI6	8.1	-	81	-	526.5	-	1.0	-	17.0	-	14.4	-	3	-
K_TRI6A	8.4	-	18	-	117.0	-	3.5	-	64.5	-	18.7	-	40	-
K_TRI5	8.5	-	94	-	611.0	-	5.8	-	116.9	-	22.7	-	>70	-

(Red highlighted text indicate exceedances of the guideline values detailed in the report; [1]EC - Electrical Conductivity; [2]TDS - Total Dissolved Solids; [3]DO - Dissolved Oxygen; mS/m – milliSiemens per metre; mg/l – milligrams per litre; % Sat – percentage saturation.
Clarity figures that display a ">" indicates the maximum depth of the river where the secchi disk could still be seen, and thus an accurate clarity measurement could not be recorded as the water was either too shallow or clear. #Dry

5.2.1 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 and Lloyd, 1982). In addition, pH values should not be allowed to vary from the range of historical data for a specific site and time of day, by >0.5 of a pH unit, or by >5% (whichever is the more conservative) (DWAF, 1996). The pH of natural waters is determined by geological influences and biotic activities.

During the August/September 2013 survey, the pH values in the study area were alkaline with sites along the Wilge River illustrating some of the highest pH values recorded. In particular the pH at site K_WIL2 exceeded the South African Fresh Water Quality Guidelines for Aquatic Ecosystems (DWAF, 1996, Volume 7, Table 17 and Figure 3). In accordance to previous studies conducted in the study area (Golder Report 12614437-12264-5), the pH within the middle reaches of the Wilge River are marginally lower than the upper reaches of the Wilge River as displayed in Figure 3. The pH values in the tributaries entering into the Wilge River from the east were stable with limited variation (Figure 3). During the latest survey (May 2016), the pH was adequate at the sites surveyed (Figure 3).

The pH within the pan, located in the centre of the proposed Alternative H, has mostly been alkaline and beyond the guideline values (Figure 4). This is primarily attributed to the site being an endorheic (inward draining) pan.

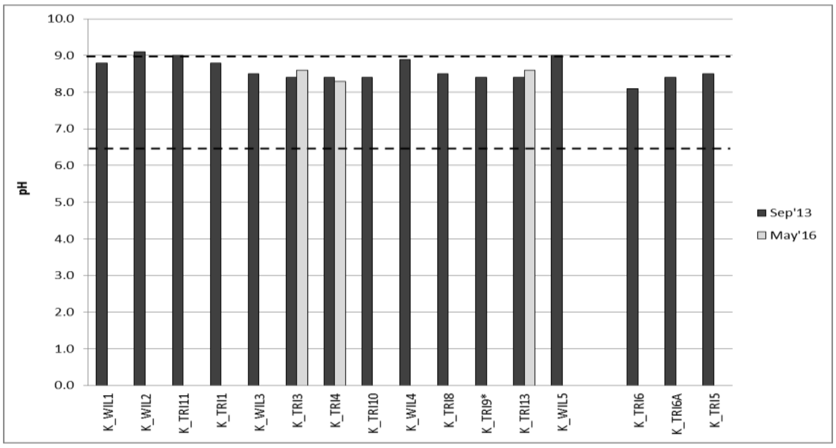


*Figure 3: pH values observed in August/September 2013 and selected points in May 2016 (dashed lines indicate guideline values, *dry during the May 2016 survey)*

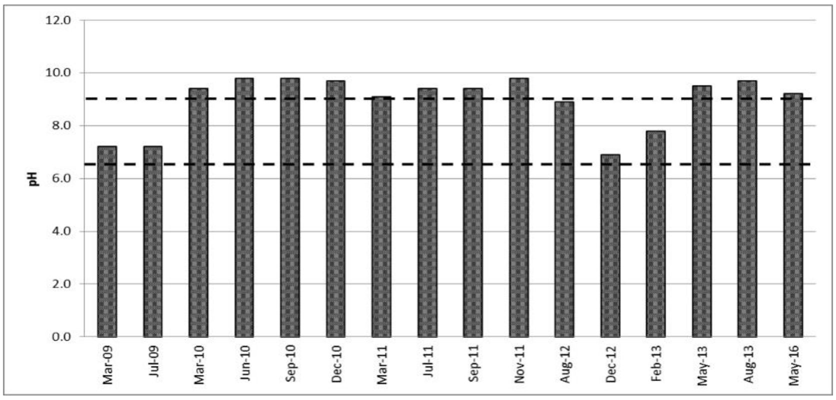


Figure 4: Historical pH values observed at site K_PAN1 from March 2009 to August 2013 and May 2016 (dashed lines indicate guideline values)

5.2.2 Total Dissolved Salts/Electrical Conductivity

The 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). The EC is a rapid and useful surrogate measure of the TDS concentration of waters with a low organic content (DWAF, 1996). For the purpose of interpretation of the biological results collected during the August 2013 and May 2016 surveys the TDS concentrations were calculated by means of the EC using the following generic equation (DWAF, 1996):

TDS (mg/ℓ) = EC (^{m}S/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 and Day (1998), freshwater organisms usually occur at TDS values less than 3 000 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 >1 000 mg/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% from the natural background values.

During the dry season, although the TDS concentrations measured within the Leeufontein and other adjoining tributaries of the Wilge River were below the guideline values, elevated concentrations were measured at sites K_TRI3, K_TRI8 and K_TRI9 (Table 17 and Figure 5). The input of the Leeufontein into the Wilge River may have contributed to this increase in the TDS concentration at site K_WIL4 in the Wilge River. However, the TDS concentrations in the subsequent tributary downstream of the Leeufontein (site K_TRI8, K_TRI9 and K_TRI13) reduced in a downstream direction towards the Wilge River, resulting in a reduced TDS concentration at the most downstream monitoring point in the Wilge River.

As the area continues to be predominantly utilised for agriculture (maize), one must consider the potential run-off from worked lands which may be contributing to the elevated TDS concentrations in the project area. Furthermore, the TDS concentrations in the tributaries associated with Kendal's existing ash dump are of concern and may be limiting to aquatic biota. During the follow-up survey, the TDS concentrations were elevated, although still below the guideline values and thus does not have a limiting effect on the aquatic biota (Figure 5).

The TDS concentrations within the pan have increased temporally (Figure 6). The elevated TDS concentration measured at this site is typical of an endorheic (inwards draining) body of water, where salts accumulate over time. However, the high TDS concentration recorded in August 2013, and which were also elevated during the follow-up survey in May 2016, was of a concern.

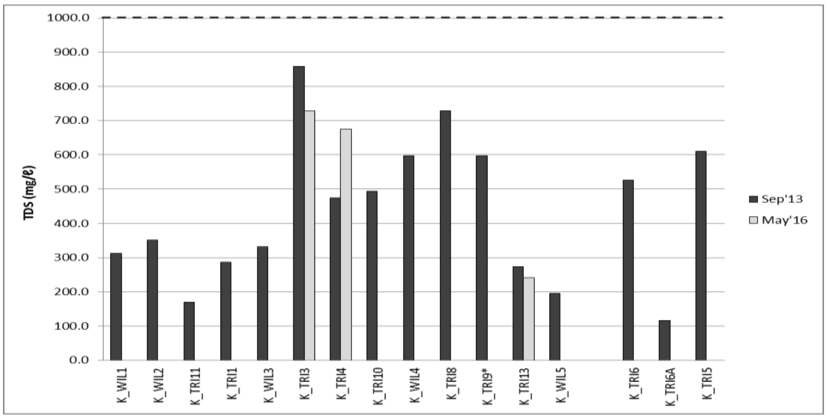


*Figure 5: Total Dissolved Salts concentrations measured in August/September 2013 and selected points in May 2016 (dashed lines indicate guideline values, * dry during the May 2016 survey)*

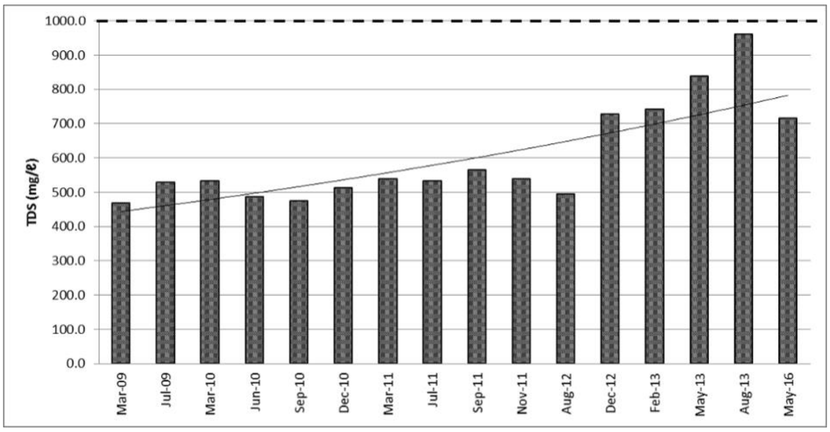


Figure 6: Historical TDS values observed at site K_PAN1 from March 2009 to August 2013 and May 2016 illustrating an exponential treadline (dashed lines indicate guideline values)

5.2.3 Dissolved Oxygen

The maintenance of adequate 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 August/September 2013 survey, the DO concentrations were below the guideline value of 5 mg/ℓ at most of the sites in the tributaries, as well as sites K_WIL1 and K_WIL3 in the Wilge River (Table 17 and Figure 7). These low DO concentrations may have been attributed to a lack of flow conditions at these sites coupled with a large amount of decaying organic matter on the stream beds at the time of the survey (Figure 7). The process of decay of organic matter consumes dissolved oxygen in the water column, resulting in hypoxic conditions (USEPA, 2012). Low DO concentrations in aquatic ecosystems may result in increased respiratory stress, changes in behaviour and consequently elevated mortality rates amongst aquatic biota (USEPA, 2012). Furthermore, DO levels fluctuate seasonally and diurnally over a 24-hour period and vary with water temperature and altitude (DWAF, 1996). There was a considerable decrease in the DO concentration between sites K_WIL2 and K_WIL3, indicating that the low DO concentration recorded at site K_TRI1, the tributary entering the Wilge River system from the west, was contributing to the low DO concentration in the Wilge River (Figure 7). A large degree of variation was noted in the DO concentrations in the tributaries of the Wilge River. The DO concentration in the Wilge River normalised downstream of site K_WIL3 and again exceeded the guideline value (Figure 7).

During the follow-up survey (May 2016), the DO concentrations displayed supersaturated conditions, likely as a result of nutrient enrichment at sites K_TRI3, K_TRI4 and K_TRI13 (Figure 7).

The DO concentration within the pan site has mostly exceeded the guideline value of 5 mg/ℓ and thus did not pose a risk to the aquatic biota during the August/September 2016 survey (Figure 8). During this latest survey in May 2016, supersaturated conditions were recorded in the pan recorded, symptomatic of the other sites during the current survey.

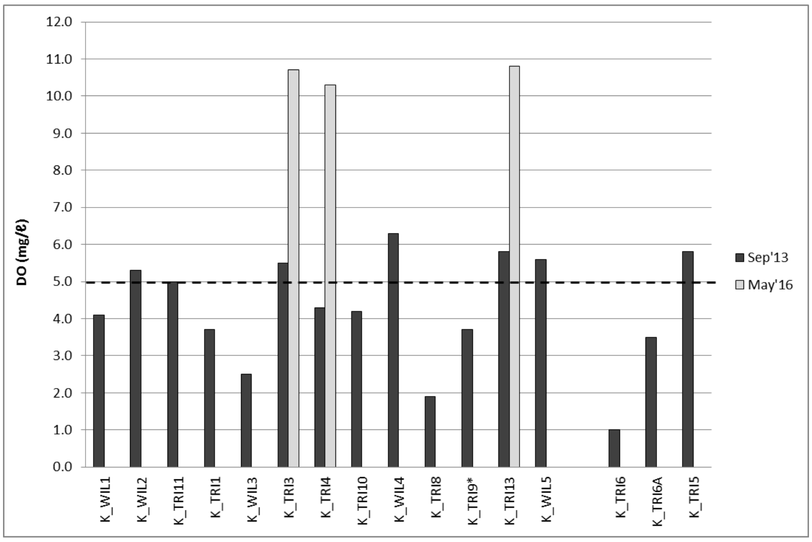


*Figure 7: Dissolved Oxygen concentrations measured during the August/September 2013 survey and selected points in May 2016 (dashed lines indicate guideline values, * dry during the May 2016 survey)*

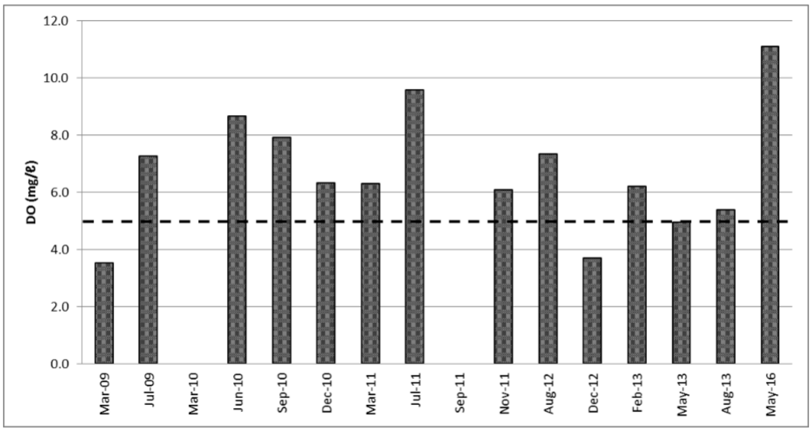


Figure 8: Historical DO concentrations observed at site K_PAN1 from March 2009 to August 2013 and May 2016 (dashed lines indicate guideline values)

5.2.4 Percentage Oxygen Saturation (DO%)

Percentage saturation (DO%) is the amount of oxygen (O_2) dissolved in a litre of water relative to the total amount of oxygen that the water can hold at that temperature. DO% levels fluctuate seasonally and diurnally over a 24-hour period and vary with water temperature and altitude (DWAF, 1996). The South African Water Quality Guidelines (1996), state that the TWQR for DO% to protect aquatic biota through most life stages is 80 - 120%, and that DO% below 40% would be lethal.

During the August/September 2013 survey, the percentage situation fell below the guideline value at several sites along the tributaries, as well as the two upper monitoring points on the Wilge River (Table 17 and Figure 9). The percentages recorded in the Leeufontein were within the guideline range, which consequently improved the saturation levels at site K_WIL4 (Figure 9). The percentage saturation at sites K_TRI8 and K_TRI6 were below the lethal limits (40%).

This may have been attributed to the algal blooms observed at those sites at the time of the survey, a sign of eutrophication, coupled with low flow conditions and a large amount of decaying organic matter on the stream beds.

During the latest survey (May 2016) the percentage saturation was adequate and between the guideline values. Site K_TRI13 had improved since three years ago where the percentage saturation was recorded below the guideline values (Figure 9).

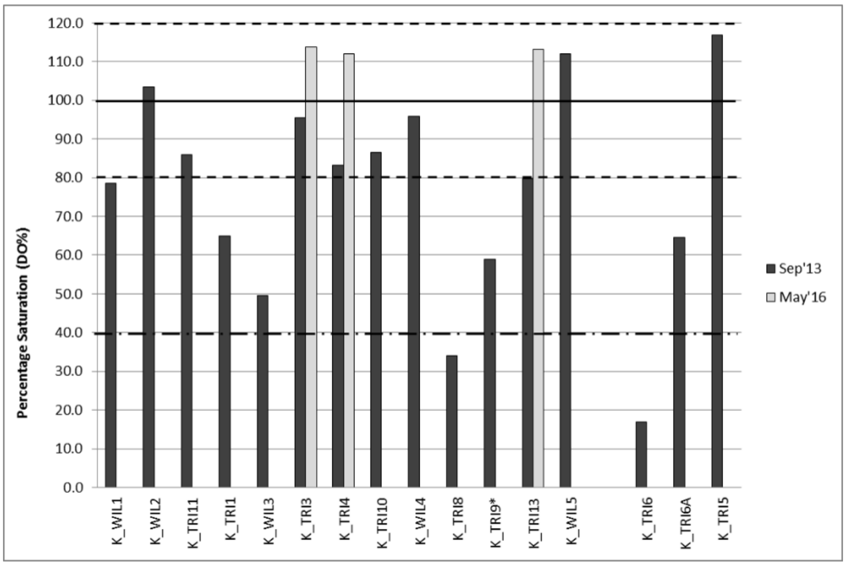


*Figure 9: Percentage saturation (DO%) recorded during the August/September 2013 survey and selected points in May 2016 (dashed lines indicates target values, solid line indicates saturation and dot-dash line indicates lethal limit, *site dry during the May 2016 survey)*

5.2.5 Water Temperature

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).

The water temperatures measured during the August/September 2013 and May 2016 surveys were considered to be normal for these systems at that time of the year and were not expected to have had a limiting effect on aquatic biota (Table 17 and Figure 10). Furthermore, the variability across the sites is primarily attributed to water depth and exposed surfaces.

The temperature within the pan site is ideal for a typical endorheic pan (Figure 11).

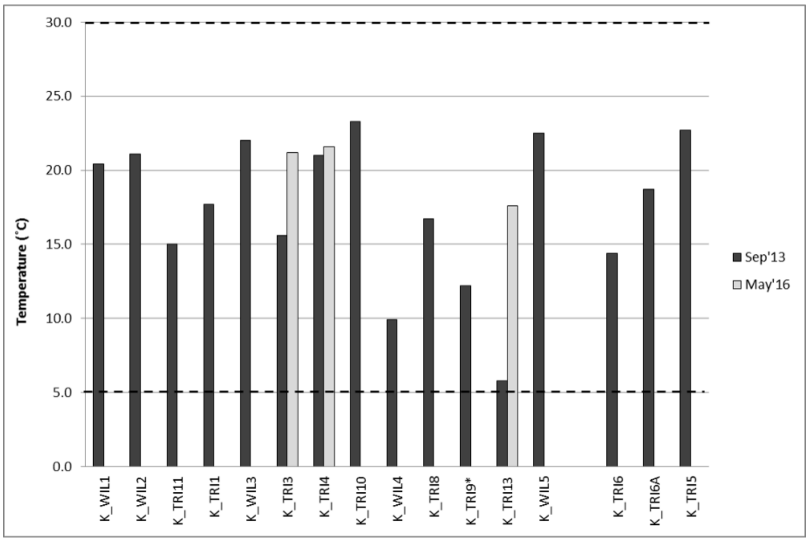


*Figure 10: Water temperatures recorded during the August/September 2013 survey and selected points in May 2016 (dashed lines indicate guideline values, * dry during the May 2016 survey)*

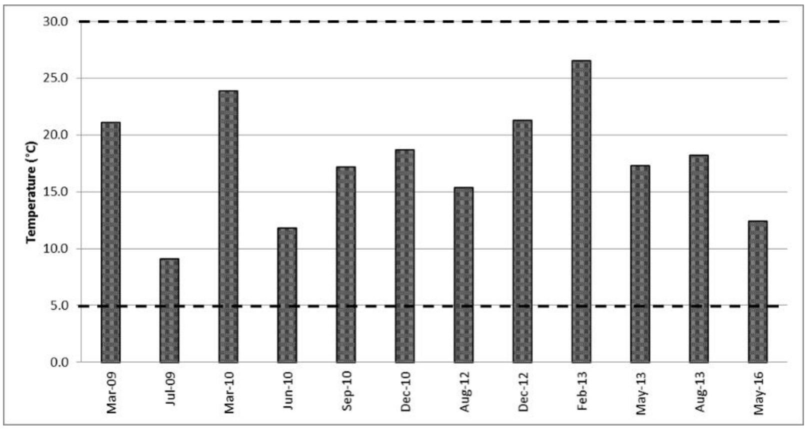


Figure 11: Historical temperature concentrations observed at site K_PAN1 from March 2009 to August 2013 and May 2016 (dashed lines indicate guideline values)

5.2.6 Turbidity

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). Suspended matter causes light to be scattered and absorbed rather than transmitted in straight lines through a water sample and may reduce light penetration, smothers in-stream habitats, interferes with the feeding mechanisms of filter-feeding organisms such as certain macroinvertebrates and reduces visibility, thus leading to a reduction in biodiversity and a system which is dominated by a few tolerant species (Davies and Day, 1998).

During both surveys, water levels at the majority of sites were comparatively low, resulting in shallow water that was low in turbidity (Figure 12). The low turbidity was attributed to a lack of run-off during the dry season in August/September 2013, coupled with limited flow deposition transferring sediment downstream. Turbidity levels at sites K_TRI1, K_TRI8, K_TRI9 and K_TRI6 were low during that survey (Figure 12). This was attributed to the sites being typical wetland sites which had been silted up, although water quality was recorded from a small remaining muddy puddle in the middle of the channel. Nonetheless, in comparison, turbidity during the wet season was typically high, with cumulative impacts within the catchment contributing to elevated suspensoids.

Historically, the turbidity levels within the pan are generally low (Figure 13). This is primarily due to the pan being relatively shallow. Furthermore, there are limited disturbance at the pan, with the exception of a farmers pipeline which occasionally pumps water into the pan.

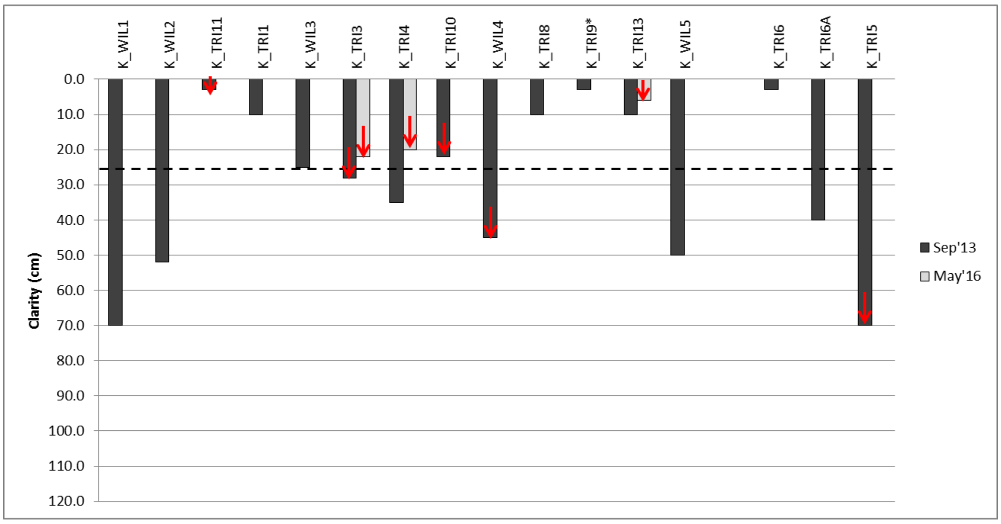


*Figure 12: Secchi Disk depths recorded during the August/September 2013 survey and selected points in May 2016 as an indication of clarity (dashed line indicates low turbidity, arrows indicate 'more than' values, *site dry during the May 201 survey)*

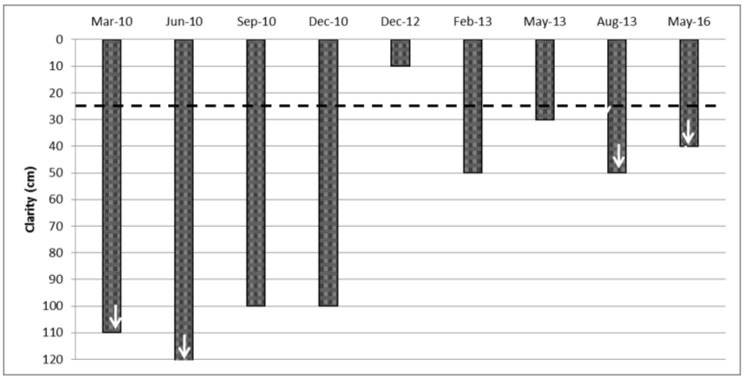


Figure 13: Historical secchi Disk Depths recorded at site K_PAN1 from March 2009 to August 2013 (dashed line indicates low turbidity, arrows indicate 'more than' values)

5.3 Habitat Assessment

5.3.1 Resource Utilization and Site Specific Impacts

Whilst on site, surrounding impacts and utilisation of resources were noted. As the study area falls within an economic hub for agricultural activities, there are a range of anthropogenic impacts on the tributaries within the study area. Impacts noted along the rivers are associated with agricultural, mining and power generation activities.

Overgrazing and trampling by cattle was evident in the vicinity of the project area. The overgrazing of the ground cover results in higher runoff velocities that transport particulates and result in erosion, increased turbidity and sedimentation (Figure 14 and Figure 15).

Figure 14: Cattle roaming around site K_TRI1 (dry season)

Figure 15: Cattle feeding within the wetland at site K_TRI6 (dry season)

A further concern is the level of nutrient input into the river systems due to the high level of agricultural activities within the project area. High levels of nutrient inputs are contributing to algal blooms at various sites, a clear sign of eutrophic conditions (Figure 16).

Site K_WIL3 (dry season)

Site K_WIL2 (dry season)

Site K_TRI3 (wet season)

Figure 16: Filamentous algal blooms indicating eutrophication condition

In addition to the agricultural activities in the project area, four (4) of the monitoring sites are further impacted by raw sewage, inadequate municipal waste water treatment works and poor waste management. This is further contributing to eutrophication (Figure 17).

Site K_TRI5 (dry season)

Dump site near site K_TRI6 (dry season)

Figure 17: Eutrophication and poor waste management near Phola adjacent to site K_TRI5

5.3.2 General Habitat Characterization

In addition to taking note of site specific impacts, habitat characteristics were documented, as species composition is largely driven by the habitat quality & availability.

The substrate of a river is defined by the biological and inorganic materials making up the river bed. The inorganics include a range of sizes, from fine silts/sands, through gravels and pebbles to boulders and bedrocks. The biological materials are dominated by leaf litter, aquatic plants and wooded debris. The velocity of the water, determined by gradient erodes and deposits the different materials to form a heterogenic substrate or habitat.

Substrate heterogeneity is an important factor in determining both abundance and diversity of biota, with more stable substrate showing higher diversity and abundances (CBD, 2012). As particle size increase, so does physical complexity, so clay or sandy substrates would be considered poor due to their instability, whereas cobbles and rocks would be more stable. A mixed substrate would obviously be the best with a variety of habitats and microflow patterns available for different biota.

Table 18 provides a summary of the habitats types present at each site that would contribute to the findings in the subsequent sections. It must be noted that habitat types vary seasonally and thus this table illustrates those for both surveys.

Table 18: Habitat descriptions

Characteristics	K_WIL1	K_WIL2	K_TRI11	K_TRI1	K_WIL3	K_TRI2	K_TRI3	K_TRI4	K_TRI10
Width (m)	>20	>20	*Wetland conditions*	1	>20	*Dry*	2	>10	>2 - 5
Depth (m)	2	2		1	½		½	2	½
Flow characteristics	Low	Low		Low	Low		Low	Low	Low
GSM	√	√		√	√		√	√	√
Vegetation	√	√		√	√		√	√	√
Stones	x	√		x	x		√	√	√
Riparian vegetation	Indigenous shrubs, grasses, and *Salix spp.*	Indigenous shrubs and grasses		Indigenous shrubs, grasses and *Phragmites spp*.	Indigenous shrub, grasses and small trees		Indigenous shrubs and grasses	Indigenous grasses and *Phragmites* spp.	Indigenous shrubs and grasses
In-stream vegetation	*Phragmites spp*. stands	None		*Phragmites spp*. stands and aquatic shrubs	None		None	*Phragmites spp*. stands	None
Algae present	√	√		√	√		√	√	√
Cattle movement	x	√		√	√		√	√	√

Characteristics	K_WIL4	K_TRI8	K_TRI9	K_TRI13	K_WIL5	K_TRI7	K_TRI6	K_TRI6A	K_TRI5
Width (m)	>10			1	>10			>2 5	>2 - 5
Depth (m)	½			½	1			1	1
Flow characteristics	Low to moderate			Low	Low			Low	Low
GSM	√			√	√			√	√
Vegetation	√			√	√			√	√
Stones	√			√	√			x	x
Riparian vegetation	Indigenous shrubs, grasses and trees	*Dry*	*Wetland conditions*	Indigenous shrubs, grasses and trees	Indigenous shrubs, grasses, and *Salix spp.*	*Wetland conditions*	*Wetland conditions*	Indigenous shrubs and grasses	Indigenous shrubs, grasses and *Populus spp.*
In-stream vegetation	*None*			None	*None*			None	*Phragmites spp*. stands and freshwater lilies
Algae present	√			√	√			√	√
Cattle movement	√			√	√			x	x

The width and depths are approximations

5.3.3 Integrated Habitat Assessment System

The IHAS was developed by McMillan (1998) for use in conjunction with the SASS5 protocol. The IHAS index considers sampling habitat and stream characteristics. The August/September 2013 IHAS results are provided in Table 19. It must be noted that neither, aquatic macroinvertebrate sampling or the IHAS was conducted for the pan site.

Based on the IHAS results obtained in August/September 2013, habitat availability ranged from **Adequate** to **Poor**. Table 19 shows the scores calculated in obtaining the final IHAS scores as well as a bar graph of the normalised percentage contribution per biotope. This allows one to breakdown the IHAS score into what biotopes were the most and least prominent as well as look between sites at what contribution the biotopes added to the final score. Results illustrate that vegetation (VEG) and gravel, sand and mud (GSM) were strong drivers for higher IHAS scores within the Kendal ash disposal facility project area (Table 19). Stream bed composition is one of the most important physical factors controlling the structure of a freshwater invertebrate community (Mackay and Eastburn, 1990). Physical stream condition and other habitats/general biotopes are also important factors to consider. The **Poor** habitat availability observed during this survey was largely attributed to the absence of the SIC habitats, the presence of incised banks and the homogenous habitats at the sampling points (Table 19). It was further attributed to the low flow conditions at the time of the survey and winter die-back of vegetation.

The habitat availability has remained poor at the sites visited during the May 2016 survey, as a result of the drivers mentioned above (Table 20).

Table 19: Integrated Habitat Assessment System Evaluation for the August/September 2013 survey

Site	Sampling Habitat				IHAS	
	Stones-in-Current	Vegetation	Other Habitat / General	Physical Stream Condition	Score	Description
K_WIL1	0	11	7	16	34	Poor
K_WIL2	0	10	17	12	39	Poor
K_TRI11	SASS5 N/A					
K_TRI1	0	13	4	14	31	Poor
K_WIL3	0	9	6	13	28	Poor
K_TRI3	12	12	8	17	49	Poor
K_TRI4	6	12	12	15	45	Poor
K_TRI10	10	13	12	23	58	Adequate
K_WIL4	13	12	13	23	61	Adequate
K_TRI8	SASS5 N/A					
K_TRI9	SASS5 N/A					
K_TRI13	7	14	9	20	50	Poor
K_WIL5	0	13	15	13	41	Poor
K_TRI6	SASS5 N/A					
K_TRI6A	0	13	7	17	37	Poor
K_TRI5	0	13	10	16	39	Poor

Table 20: Integrated Habitat Assessment System Evaluation for the May 2016 survey

Site	Sampling Habitat				IHAS	
	Stones-in-Current	Vegetation	Other Habitat / General	Physical Stream Condition	Score	Description
K_WIL1	Not assessed for site alternative H					
K_WIL2	Not assessed for site alternative H					
K_TRI11	Not assessed for site alternative H					
K_TRI1	Not assessed for site alternative H					
K_WIL3	Not assessed for site alternative H					
K_TRI3	0	8	8	12	**28**	**Poor**
K_TRI4	9	8	11	17	**45**	**Poor**
K_TRI10	Not assessed for site alternative H					
K_WIL4	Not assessed for site alternative H					
K_TRI8	Not assessed for site alternative H					
K_TRI9	Dry					
K_TRI13	0	5	9	5	**19**	**Poor**
K_WIL5	Not assessed for site alternative H					
K_TRI6	Not assessed for site alternative H					
K_TRI6A	Not assessed for site alternative H					
K_TRI5	Not assessed for site alternative H					

Bar graphs within cells indicate the normalized percentage contribution per biotope

n/a SASS5 not applicable due to site being dry or lack of flow

5.4 Aquatic Macroinvertebrates

During the dry season survey in 2013, a total of 41 aquatic macroinvertebrate taxa were recorded in the sample area (7 to 24 taxa per site) (Table 21). Refer to APPENDIX B for the detailed aquatic macroinvertebrate datasheets. The SASS5 scores ranged from 25 at site K_TRI1 to 129 at site K_WIL5 (Table 21). The Average Score per Taxa (ASPT) values ranged from 3.6 at site K_TRI1 to 5.9 at sites K_WIL4 (Table 21). The ASPT scores provide an indication of the average tolerance/intolerance of the aquatic macroinvertebrate community at each site. In this case ASPT scores indicated that the macroinvertebrate communities at most of the sites are composed primarily of tolerant (1 - 5) taxa (Dickens & Graham, 2002). However ASPT scores are considered to be unreliable when the total number of taxa at a site is low and should be interpreted with caution. Further explanations are provided below. The number of taxa, SASS5 scores and ASPT scores were variable in the tributaries, with the lowest number of taxa and SASS5 scores observed at site K_TRI1 during the 2013 survey (Figure 21 and Figure 22). The habitat at this site was poor with eroded banks and limited flow conditions. Typically, sensitive taxa populate the SIC biotope and as this site lacked this biotope/habitat, these taxa were absent resulting in a lower number of taxa and SASS5 scores. The number of taxa and SASS5 scores within the Wilge River increased in a downstream direction, with the exception of site K_WIL3 where the lowest aquatic macroinvertebrate diversity and abundance was recorded within this river reach (Figure 21 and Figure 22). This was attributed to the limiting water quality (low DO and DO%) coupled with low flow conditions. The ASPT scores fluctuated spatially during this survey with no real trend identified (Figure 22).

During the 2016 survey, the total number of aquatic macroinvertebrates recorded were 17 at the selected monitoring sites. The ASPT values recorded all were below 5.0, indicative of tolerant taxa (Figure 21, Figure 22 and Table 21). This was expected owing to the poor habitat availability and lack of flow at the time of the survey.

Table 21: SASS5 scores recorded during the August/September 2013 and May 2016 survey

Site	Total number of taxa		SASS Score		ASPT	
	Sep'13	**May'16**	**Sep'13**	**May'16**	**Sep'13**	**May'16**
K_WIL1	15	-	76	-	5.1	-
K_WIL2	21	-	116	-	5.5	-
K_TRI11	N/A			-		
K_TRI1	7	-	25	-	3.6	-
K_WIL3	11	-	43	-	4.0	-
K_TRI3	18	7	91	28	5.1	4.0
K_TRI4	14	3	77	11	5.5	3.7
K_TRI10	18	-	87	-	4.8	-
K_WIL4	19	-	112	-	5.9	-
K_TRI8	N/A			-		
K_TRI9	N/A			Dry		
K_TRI13	22	15	113	55	5.1	3.7
K_WIL5	24	-	129	-	5.4	-
K_TRI6	N/A			-		
K_TRI6A	20	-	80	-	4.0	-
K_TRI5	19	-	87	-	4.6	-

N/A: not applicable

As habitat availability affects the structure of a freshwater invertebrate community, there was value in assessing the ASPT of each biotope sampled in isolation. In this way one could avoid bias in the results at sites with different habitat types. Some taxa, such as Plecoptera (Stoneflies) and Trichoptera (Caddisflies), are associated with SIC, while other taxa such as some Odonata (Dragonflies) and Hemiptera (Bugs) are associated with VEG (Gerber and Gabriel, 2002). This is important to note as different taxa have been assigned different tolerance scores, which are based on their susceptibility or resistance to pollution and perturbations (Dickens & Graham, 2002). As a result the biotope and ASPT scores are presented below in Figure 18.

The VEG and GSM biotopes were the most abundant biotopes sampled at all the sites during both surveys (Figure 19 and Figure 20). Although when the SIC biotope was sampled (during the 2013 survey only), the ASPT scores increased, particularly along the Wilge River (Figure 18). This can be attributed to more sensitive taxa being recorded in the SIC biotope, such as Heptageniidae (quality value (QV) score: 13) and Leptophlebiidae (QV score: 9) which prefer SIC habitats and flow conditions (Figure 18).

During the 2013 survey, the ASPT scores in the Wilge River ranged from 4.0 at site K_WIL3 to 5.9 at site K_WIL4. The low ASPT score recorded at site K_WIL3 in the Wilge River may be attributed to poor water quality namely low DO and DO% (Figure 7 and Figure 9). The GSM biotope recorded an average ASPT score of <5.0, thus this biotope primarily comprised high abundances of highly tolerant taxa such as Oligochaeta (QV score: 1), Chironomidae (QV score: 2), Simulidae (QV score: 5) and Corixidae (QV score: 3). Tolerant species with low quality value scores are typically associated with the GSM, and as the availability of this specific habitat decreases, so does the likelihood of recording these species.

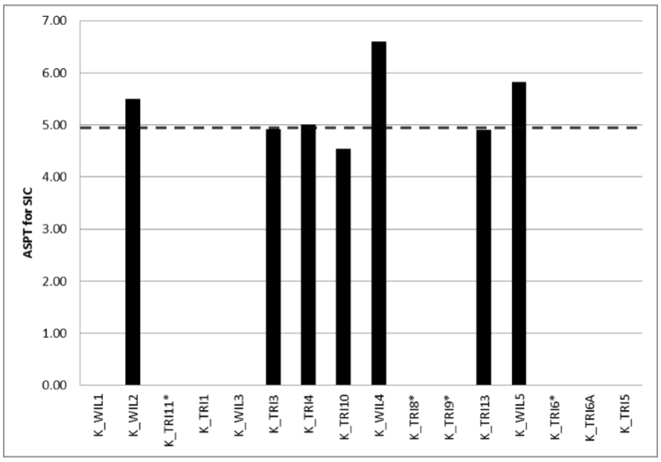


*Figure 18: ASPT score for the SIC biotope, August/September 2013 (dark bars indicate the Wilge River, dashed line indicates the reference point between biotope graphs, * represents sites that were not SASS5 applicable). No SIC were available to sample during the wet season survey (May 2016)*

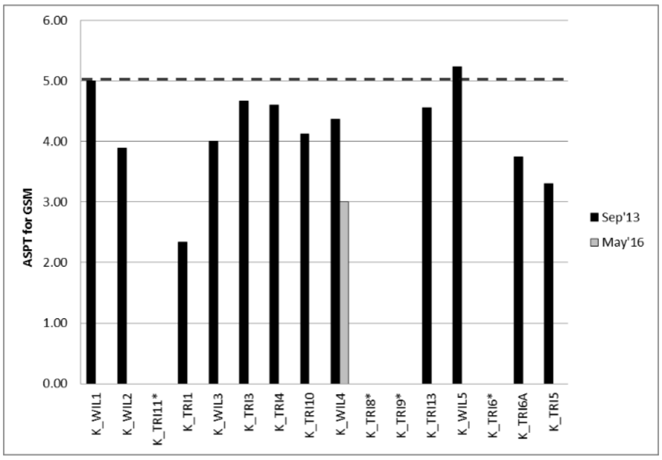


*Figure 19: ASPT score for the GSM biotope, August/September 2013 and May 2016 (dark bars indicate the Wilge River, dashed line indicates the reference point between biotope graphs, * represents sites that were not SASS5 applicable)*

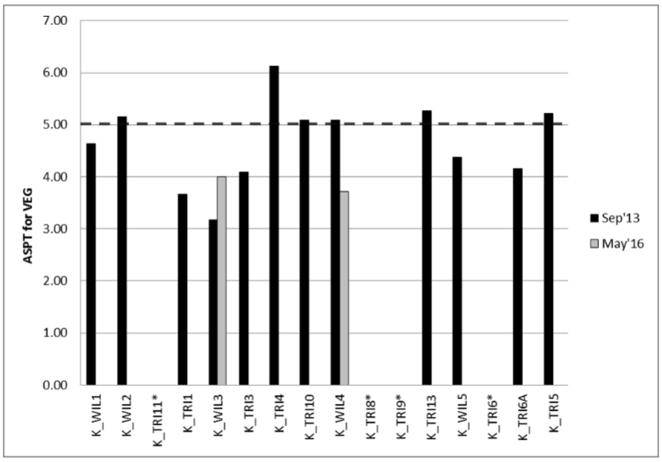


*Figure 20: ASPT score for the VEG biotope, August/September 2013 and May 2016 (dark bars indicate the Wilge River, dashed line indicates the reference point between biotope graphs, * represents sites that were not SASS5 applicable)*

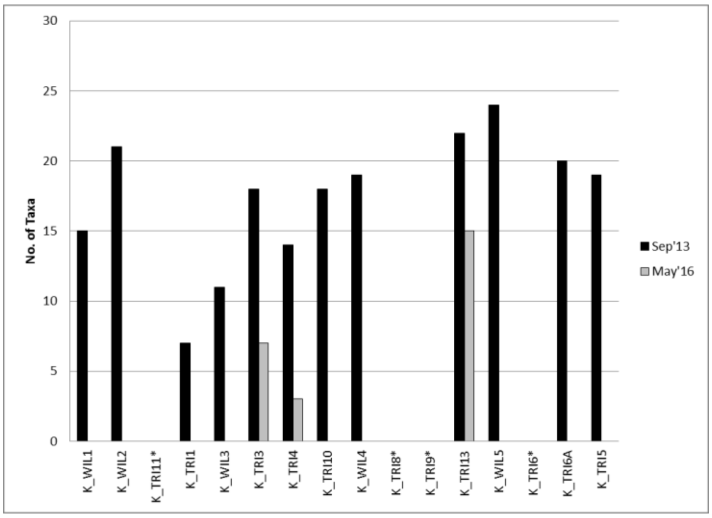


*Figure 21: Total number of Taxa recorded in the tributaries during the August/September 2013 and May 2016 surveys (dark bars indicate the Wilge River, * represents sites that were not SASS5 applicable)*

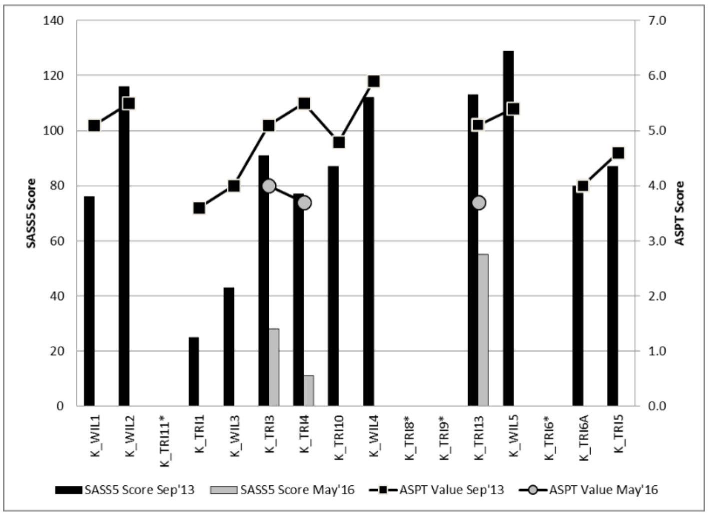


*Figure 22: SASS5 scores and ASPT score recorded in the tributaries during the August/September 2013 and May 2016 surveys (dark bars indicate the Wilge River, * represents sites that were not SASS5 applicable)*

5.4.1 Biotic Integrity based on SASS5 Results

The Present Ecological State (PES) classes and descriptions of each of the classes are presented in Table 22. Based on the August/September 2013 results, biotic integrity ranged from unmodified (PES Class A) to seriously modified (PES Class E) (Table 22). The low aquatic macroinvertebrate diversity, abundance and ASPT scores recorded at sites K_TRI1 and K_WIL3 contributed to the seriously modified state. Furthermore, this may be attributed to the sites being prevalent to agricultural activities. Following the May 2016 survey, owing to the poor aquatic macroinvertrate diversity recorded (primarily due to the poor habitat availability and lack of flow variations), the biotic integrity was seriously modified (Table 22).

Table 22: Present Ecological State (PES) classes based on SASS5 results obtained during the August/September 2013 survey

Site	Reach	PES	
		Aug/Sep'13	May'16
K_WIL1	Upper reaches of the Wilge River	B	-
K_WIL2	Upper reaches of the Wilge River	B	-
K_TRI11	Western tributary of the upper Wilge River	*SASS5 N/A*	-
K_TRI1	Western tributary of the upper Wilge River	E	-
K_WIL3	Upper reaches of the Wilge River	E	-
K_TRI3	Eastern tributary of the upper Wilge River	B	E
K_TRI4	Eastern tributary of the upper Wilge River	B	E
K_TRI10	Eastern tributary of the upper Wilge River	B	-
K_WIL4	Upper reaches of the Wilge River	A	-
K_TRI8	Eastern tributary of the upper Wilge River	*SASS5 N/A*	-
K_TRI9	Eastern tributary of the upper Wilge River	*SASS5 N/A*	*Dry*
K_TRI13	Eastern tributary of upper Wilge River	B	E
K_WIL5	Upper reaches of the Wilge River	A	-
K_TRI6	Southern tributary of the Saalboomspruit	*SASS5 N/A*	-
K_TRI6A	Unknown tributary	C	-
K_TRI5	Southern tributary of the Saalboomspruit	B	-

5.5 Ichthyofauna

5.5.1 Observed Fish Species List

During the dry season survey in 2013, 5 of the 8 expected indigenous fish species were recorded in the project area (Table 23). In addition, two exotic species *Cyprinus carpio* and *Gambusia affinis* were recorded in the lower reaches of the Leeufontein and also at sites K_WIL4 and K_WIL5 in the Wilge River (Table 23, Figure 23 and Figure 24). The highest combined fish abundance (n = 70) was recorded at site K_WIL4, which comprised four indigenous and one exotic fish species (Table 23). The low fish diversity and abundance at some sites was attributed to limited habitat.

Chiloglanis pretoriae, an indigenous fish species expected in the Wilge River in the project area was not recorded during the August/September 2013 survey. This sensitive and small rheophilic species is a good indicator of good water quality, fast flowing water (roughly >0.3 m/sec) and 'clean' substrates (interstitial areas between rocks/cobbles) (pers. comm. Kleynhans, 2012). This species has previously been recorded in the Wilge River in the project area. It is believed that the *C. pretoriae* fish population in the Wilge River represents one of the few remaining populations in the upper Olifants River catchment. It is still present in the upper Olifants and the Wilge (B2), especially the lower sections (and in the Bronkhorstspruit below the Bronkhorstspruit Dam). However, they do not generally occur in the Olifants Highveld streams, but rather the Eastern Bankenveld streams (pers. comm. Kleynhans, 2012).

During the wet season survey conducted in 2016, 2 of the 8 expected indigenous fish species were recorded (Table 24) and no exotic species. Fish were only recorded at site K_TRI13 (Table 24), with one site being dry and the other 2 sites recorded no fish at the time of the survey.

Table 23: Fish species recorded in the Kendal ash disposal facility project area during the August/September 2013 survey

Site	*Barbus anoplus*	*Cyprinus carpio*	*Clarias gariepinus*	*Gambusia affinis*	*Labeobarbus polylepis*	*Pseudocrenilabrus philander*	*Tilapia sparrmanii*		Diversity	Abundance
K_WIL1	4					1	1		**3**	**6**
K_WIL2	4					19	2		**3**	**25**
K_TRI11	*Fish N/A*									
K_TRI1	4								**1**	**4**
K_WIL3	17	1				31	4		**4**	**53**
K_TRI3	47								**1**	**47**
K_TRI4	20			5					**2**	**25**
K_TRI10	15			1		2			**3**	**18**
K_WIL4	47			9	1	11	2		**5**	**70**
K_TRI8	*Fish N/A*									
K_TRI9	*Fish N/A*									
K_TRI13	22					1	2		**3**	**25**
K_WIL5			1	6		17	18		**4**	**42**
K_TRI6	*Fish N/A*									
K_TRI6A									**0**	**0**
K_TRI5	10					1	1		**3**	**12**
Total Individuals	**190**	**1**	**1**	**21**	**1**	**83**	**30**			

Introduced species are highlighted in red

 # Site not sampled

Table 24: Fish species recorded in the Kendal ash disposal facility project area during the May 2016 survey

Site	*Pseudocrenilabrus philander*	*Tilapia sparrmanii*		Diversity	Abundance
K_TRI3				**0**	**0**
K_TRI4				**0**	**0**
K_TRI13	2	4		**2**	**6**
Total Individuals	**2**	**4**			

Figure 23: Gambusia affininis, exotic fish species recorded at sites K_TRI4, K_TRI10, K_WIL4 and K_WIL5

Figure 24: Cyprinus carpio, exotic fish species recorded at site K_WIL3

5.5.2 Presence of Red Data Species

Based on the IUCN Red List no rare, threatened or endangered fish species are expected to occur in the project area and none were recorded during the August/September 2013 survey (IUCN, 2013).

5.5.3 Fish Health Assessment

A large number of the individuals sampled during the August/September 2013 survey, showed signs of abnormalities and heavy parasite loads, a sign of increased physiological stress. The prevalence was considerably higher in *Pseudocrenilabrus philander* which showed the highest infection rates (Figure 25*)*. During the May 2016 survey, no individuals recorded any external extremities however the sample size was extremely small to conclude.

Figure 25: Trematode cysts, parasites embedded in the Pseudocrenilabrus philander's tissue

5.5.4 Fish Assemblage Integrity Index (FAII)

The interpretation of the FAII scores follows a descriptive procedure into which the FAII score is allocated into a particular class (Table 25). The PES classes for each of the sites are presented in Table 25.

Table 25: Present Ecological State (PES) Classes recorded during the August/September 2013 survey

Site	River Reach	Relative FAII Score	Class Rating	Description	Relative FAII Score	Class Rating	Description
		Aug/Sep'13			May'16		
K_WIL1	Upper reaches of the Wilge River	16	F	Critically Modified	-		
K_WIL2	Upper reaches of the Wilge River	16	F	Critically Modified	-		
K_TRI11	Western tributary of the upper Wilge River	N/A			-		
K_TRI1	Western tributary of the upper Wilge River	27	E	Seriously Modified	-		
K_WIL3	Upper reaches of the Wilge River	21	E	Seriously Modified	-		
K_TRI3	Eastern tributary of the upper Wilge River	16	F	Critically Modified	0	F	Critically Modified
K_TRI4	Eastern tributary of the upper Wilge River	16	F	Critically Modified	0	F	Critically Modified
K_TRI10	Eastern tributary of the upper Wilge River	19	F	Critically Modified	-		
K_WIL4	Upper reaches of the Wilge River	34	E	Seriously Modified	-		
K_TRI8	Eastern tributary of the upper Wilge River	N/A			-		
K_TRI9	Eastern tributary of the upper Wilge River	N/A			Dry		
K_TRI13	Eastern tributary of upper Wilge River	36	E	Seriously Modified	27	E	Seriously Modified
K_WIL5	Upper reaches of the Wilge River	23	E	Seriously Modified	-		
K_TRI6	Southern tributary of the Saalboomspruit	N/A			-		
K_TRI6A	Unknown tributary	0	F	Critically Modified	-		
K_TRI5	Southern tributary of the Saalboomspruit	49	D	Largely Modified	-		

Based on the FAII results, the biotic integrity during the 2013 survey ranged from *Largely* to *Critically Modified* (PES Class D to F) (Table 25). Six of the monitoring sites were critically modified.

The poor biotitic integrity recorded in the project area at the time of this survey may have been attributed to poor water quality, limited habitat availability and low flow conditions. During the 2016 survey, the biotic integrity did not improve at the selected sites monitored (Table 25).

6.0 SITE SENSITIVITIES FOR EACH ALTERNATIVE

Prior to the confirmation by the client that site alternative H was the preferred site, a site sensitivity for each alternative was conducted. This section in the report (written in 2013) will retain.

The proposed project area has a number of surrounding land use activities, all of which contribute to the cumulative impacts on the aquatic ecosystem. However, it is vital to identify and understand the impacts that may originate from the proposed Kendal ash disposal facility first, prior to identifying the cumulative impacts. Table 26 identifies the potential impacts on aquatic ecosystems that may originate from the proposed surrounding ash disposal facility.

Table 26: Potential impacts emanating from the ash dumps

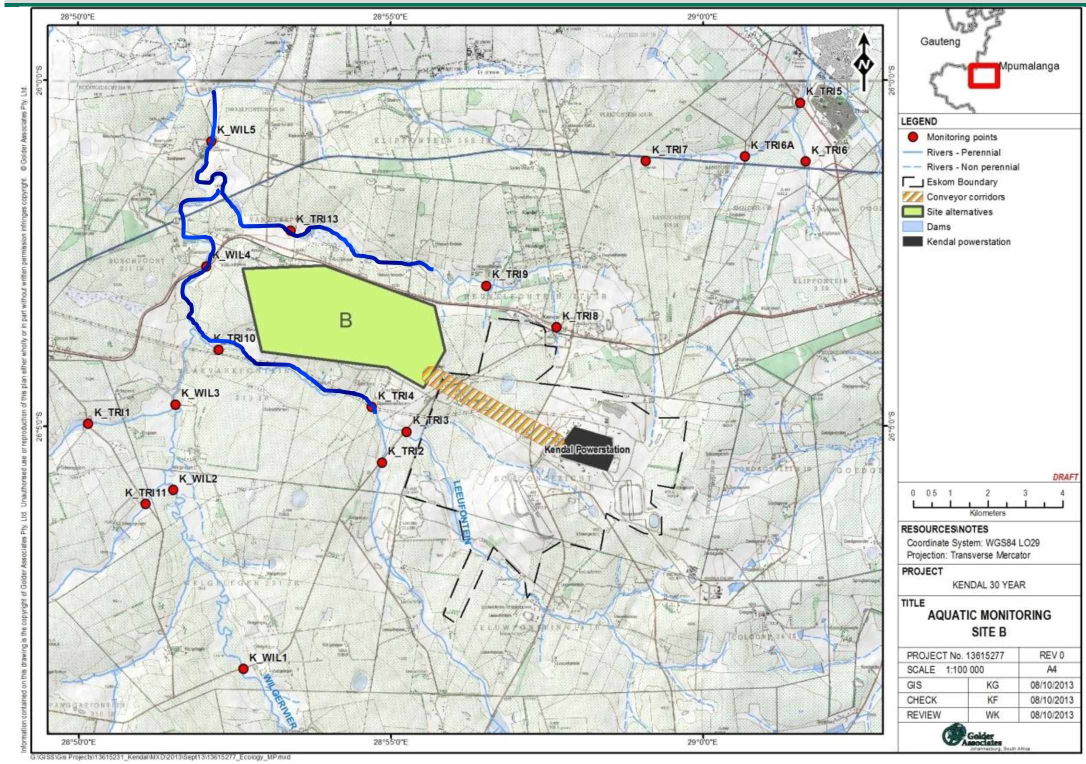
Impact	Discussion
Erosion	During the construction phase, increased run-off events will occur resulting in increased sediment loading causing habitats to become smothered leading to the loss of aquatic habitat for example vegetation and thus result in a limited amount of shade and coverage for fish species.
Surface water pollution	The toxins and chemicals from coal ash may leach into the surface water thus impacting water quality, this impact is only likely should the ash disposal facility not be appropriately lined.
Loss of indigenous species, biodiversity and overall biotic integrity	Potential run-off from the Kendal ash disposal facility may result in a decline in water quality and consequently detrimental impacts to the functioning, ecology and integrity of the surrounding water courses. *B. anoplus* and *P. philander* were both recorded at the majority of the aquatic monitoring sites for this project and although are not sensitive species, they are indigenous and expected species in the study area. Furthermore, C. *pretoria, L. marequensis and L. polylepis all occur within the study area, which are all indigenous fish species. Of particular importance is C. Pretoria which* is a sensitive fish species within the project area. *The fish species is* considered to be a useful indicator species in studies on river conservation (Skelton, 2001). The presence of the *C. pretoriae* in the Wilge River is of significance as it is an indicator of good water quality and habitat integrity. It is anticipated that the *C. pretoriae* fish population in the Wilge River represents one of the last remaining populations of this species in the upper Olifants River catchment.
Loss of water resources	The proposed location of alternative H encompasses an existing pan (Figure 26). The importance of pans extends far beyond their value as biodiversity hotspots of ecological importance for biodiversity. They therefore are highly vulnerable and require to be protected where possible. Pan systems in and around towns and cities are largely under threat and thus it is vital that they are protected (Davies and Day, 1998). Should alternative H go ahead, this pan will be completely lost. A variety of water birds including the Lesser Flamingo (*Phoenicopterus minor*) have been observed at the pan, during previous aquatic surveys.
Change in natural flow regimes	As alternative C will be crossing two rivers, the alternation of flow regime may occur. Flow modifications within a river may have several effects on the aquatic biota found within these systems. Flow is a major determinant of physical habitat, and thus a major determinant of biotic community structure. Furthermore, the invasion and success of exotic species in rivers is facilitated by the alteration of flow regimes (Poff and Ward, 1990; Bunn and Arthington, 2002).

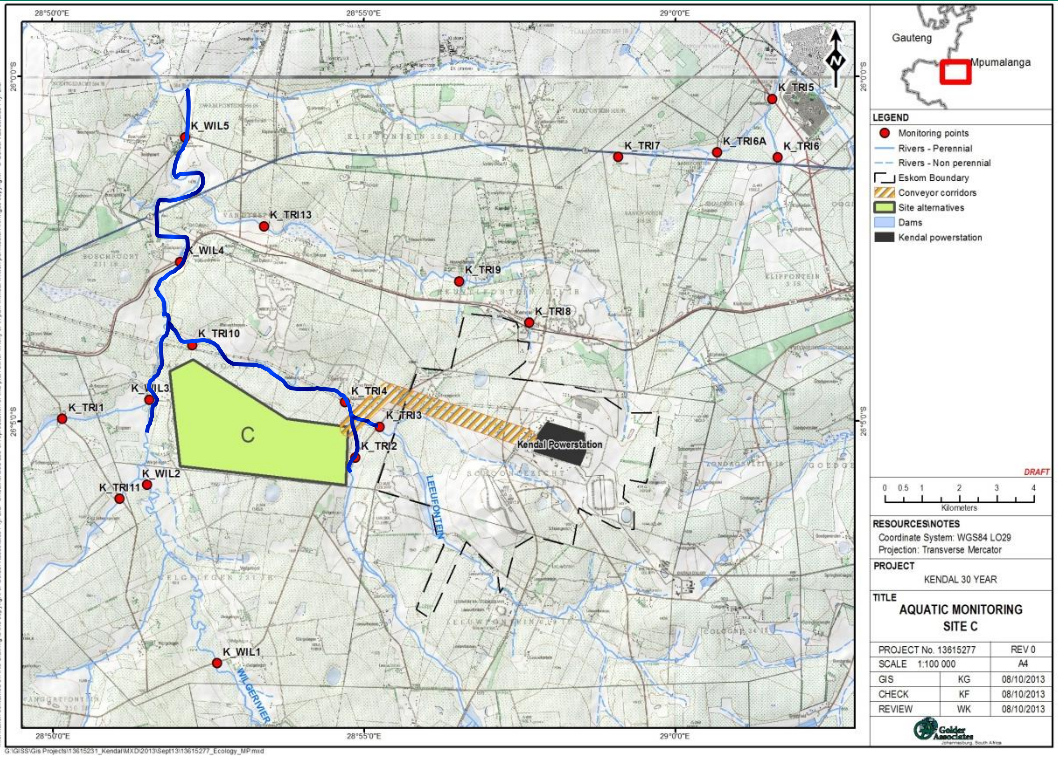
Figure 26: Site K_PAN1 where site alternative H is proposed to be located

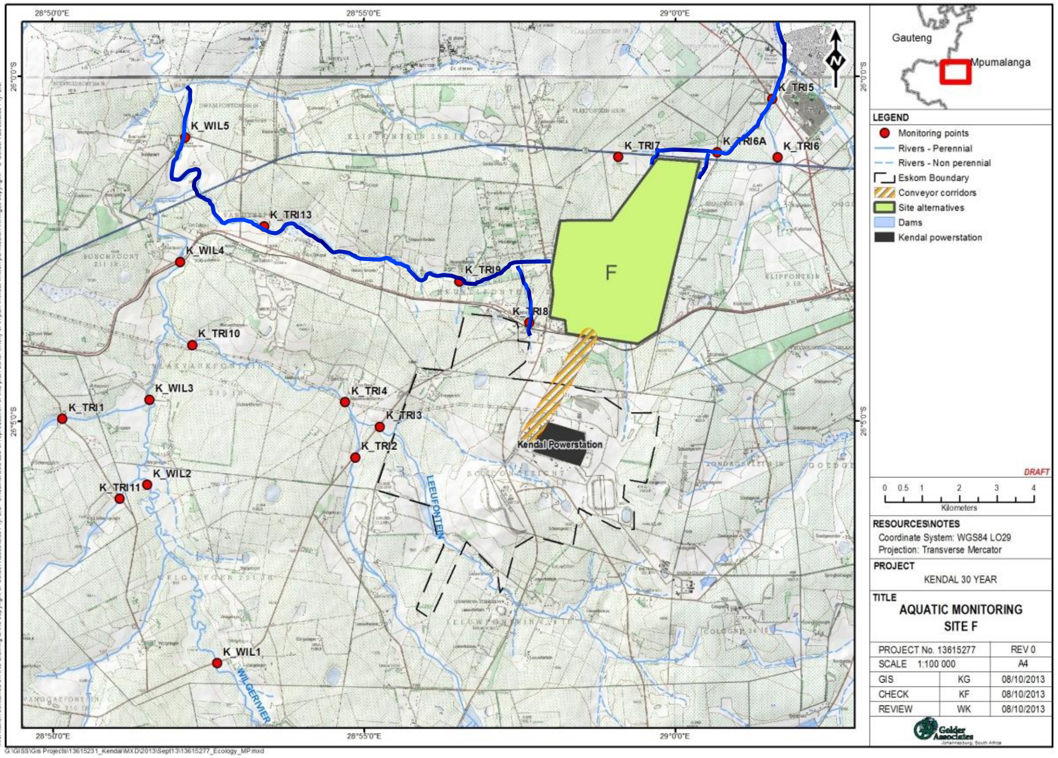
Therefore, with an understanding of the potential impacts emanating from the proposed project on the aquatic ecosystem, site sensitivities were subsequently assessed based on the *in situ* water quality, aquatic macroinvertebrate and ichthyofaunal biotic integrity results coupled with the sensitive fish species, *C. pretoriae*, which has been recorded in the Wilge River within the catchment area (Table 27). Site sensitivity was further based on the following aspects:

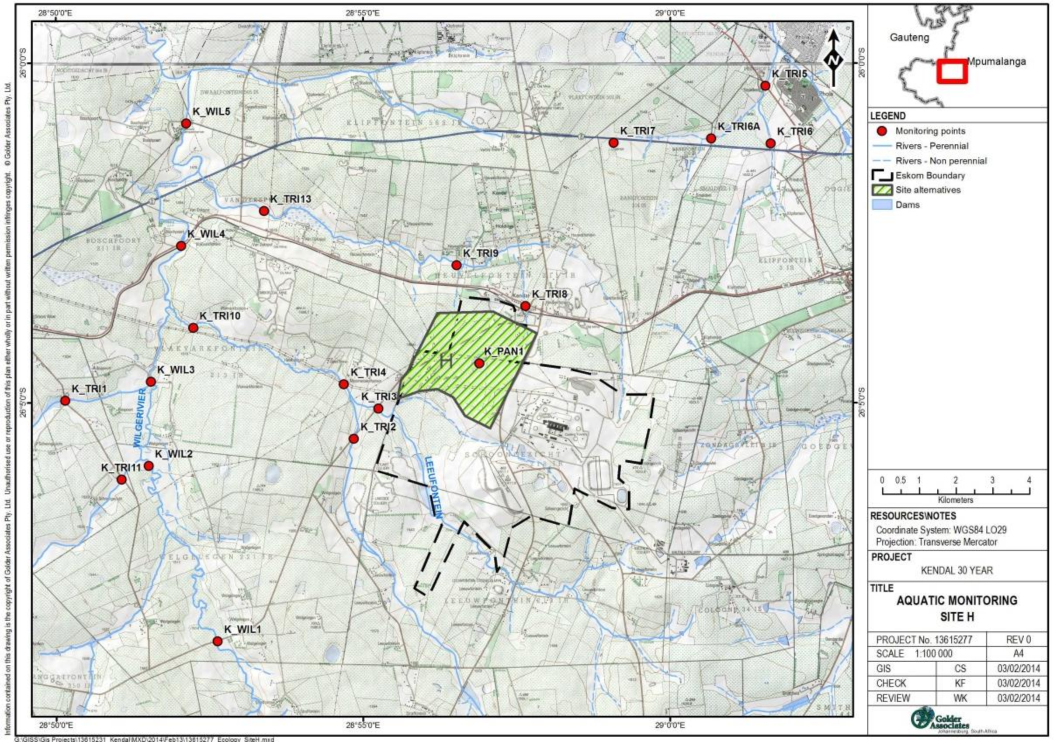
- Surrounding land use;
- Urban development;
- Expanse of river reach affected by the proposed development; and
- The conveyor belt routes and number of river reach crossings.

Table 27: Sensitivities for each ash disposal alternative

Site alternative and monitoring points associated with the site alternative	Convey routes and river crossings	Surrounding land use	Overall site sensitivity
	■ None	■ Agriculture	■ Medium

Site alternative and monitoring points associated with the site alternative	Convey routes and river crossings	Surrounding land use	Overall site sensitivity
	■ Leeufontein ■ Tributary of the Leeufontein	■ Agriculture	■ High

Site alternative and monitoring points associated with the site alternative	Convey routes and river crossings	Surrounding land use	Overall site sensitivity
	■ None	■ Agriculture; ■ Informal settlement (Phola); ■ Informal waste disposal facility; ■ Open cast coal mining; and ■ Existing waste dump.	■ Very low

Site alternative and monitoring points associated with the site alternative	Convey routes and river crossings	Surrounding land use	Overall site sensitivity
	■ The proposed ash dump boundary will encompass an existing pan.	■ Agriculture	■ High

Run-off from the Kendal ash disposal facility may result in detrimental impacts to the functioning, ecology and integrity of the surrounding water courses (Table 26). Based on this assessment, site alternative C was considered highly sensitive (Table 27). The conveyor belt transporting ash from the Kendal Power Station to the proposed site alternative C will cross two rivers. Furthermore, this site will impact a longer stretch of river reach compared to the rest of the other site alternatives as it is further upstream in the catchment adjacent to the upper Wilge River. Due to the presence of a large pan, site alternative H is also considered highly sensitive. The sensitivity of the pan (K-Pan1) is reflected in the large diversity of water birds that have been observed, including the Lesser Flamingo (*Phoenicopterus minor*) during previous surveys conducted for other industrial and mining projects in the study area. The importance of pans extends far beyond their value as biodiversity hotspots of ecological importance for biodiversity, and thus is highly vulnerable. Pan systems in and around towns and cities are largely under threat (Davies and Day, 1998). However, as site alternative H has been selected as the preferred site, this pan and its associated aquatic ecosystem will be completely lost.

Conversely, site alternative F was considered to have very low site sensitivity as the location of this site is already in an impacted state (Table 27). Open cast coal mining is located adjacent to the site as well as waste disposal facilities. As a result, there are a number of streams in this vicinity that are desiccated due to such activities in the area and thus are all a contributing factor to the low sensitivity of this site. Refer to Figure 27 and Figure 28 which illustrates a panoramic view of the land use activities in the vicinity of site alternative F, visually confirming the impacted state of this site locality.

Figure 27: Land use adjacent to the proposed site alternative F, illustrating a highly impacted site. Kendal Power Station to the right of the photo is located south west of the proposed alternative site

Figure 28: Land use to the east of the proposed site alternative F, illustrating a highly impacted site

However, site alternative H was selected as the preferred site despite the sensitive feature of the pan, the associated aquatic ecosystem and extensive utilisation for agriculture. Consequently, the impact assessment has only been conducted for this site alternative.

7.0 SITE H IMPACT ASSESSMENT

Project impact (Unmitigated)

The proposed construction activities planned for the establishment of the 30 year ADF, including the associated infrastructure, will subsequently result in various impacts to the aquatic environment. These include:

- Loss of an aquatic ecosystem namely, the pan;
- Loss of aquatic biota;
- Disturbance to streams;
- Increased erosion;
- Increased sediment transport into water resources; and
- Water quality deterioration in adjacent water resources because of sediments and spills from mechanical equipment.

The pan, which falls within the footprint of the ADF and associated infrastructure, will be completely lost, coupled with impacts downstream on the surrounding streams (Table 27). Earth works relating to the construction of these facilities will permanently destroy the water resource within the construction footprint. The importance of this pan extends far beyond their value as biodiversity hotspots of ecological importance for biodiversity. A variety of water birds including the Lesser Flamingo (*Phoenicopterus minor*) have been observed at the pan, during previous aquatic surveys. Consequently, the impact on this natural resource is very high and owing to the loss of this habitat (Table 28). A study by Wetland Consulting Services (WCS) was conducted on the pans within the proposed study area. They have developed a wetland offset strategy and identified possible target sites for this pan in question. Refer to report number WCS 2016: 1032-2013 for this detail coupled with their mitigation measures.

Loss of flow at the outlet of catchment B20F and B11F due to destruction of streams within the footprint of Site H is expected to be very low. Only the footprint required for the first 5 years of ash deposition will be cleared and prepared during the construction phase so the loss of water resources is expected to be greatest during the operational phase for the period 2030 to 2052 as indicated in Table 2.

Construction activities are likely to increase the disturbance footprint beyond the boundaries of the actual development footprint through temporary stockpiles, laydown areas, construction camps and uncontrolled driving of machinery. This will lead to increased exposed soils and thus with limited groundcover and buffering capacity, will result in increased runoff velocities, increasing the risk of erosion with sediments potentially transported down the water resources and finally deposited in the Wilge River.

During the construction phase it is possible that potential spills and leaks of hazardous substances (*inter alia* cement, hydrocarbons, sewage) may occur. Run-off from the site would therefore lead to water quality deterioration.

With respect to the pan, the combined weighted project impact will be of high significance as the pan will be completely lost. It will be affected nationally (owing to it being the maximum extent of any impact) and the degree of probability of the impact occurring will most definitely occur primarily during the first 10 years of construction (Table 28 and Table 2). A study by WCS was conducted on the pans within the proposed study area. They have developed a wetland offset strategy and identified possible target sites for this pan in question. Refer to report number WCS 2016: 1032-2013 for this detail coupled with their mitigation measures. Overall, the impact risk class is thus moderate (Table 28).The remaining potential identified impacts namely, water quality deterioration, altered flow regime, bed modification, erosion and increase in sedimentation, the extent scale will affect the *study site to local area*. The impact will act in the <u>short/medium term to permanent</u> where loss of streams occurs, and is very likely to occur. The impact risk class is thus **Low to Moderate** (Table 28).

Cumulative Impact

The Olifants River has a catchment (Water Management Area 4) of approximately 54 400 km^2 in size. The river originates in the Mpumalanga Highveld and flows through industrial, agricultural and mining areas such as eMalahleni (Witbank), Middelburg, Steelpoort and Phalaborwa on its way towards the Kruger National Park (Van Zyl *et al.,* 2001; De Villiers and Mkwelo, 2009). Flowing through these economic hubs of mining and industry, combined with extensive agricultural activity within the catchment, the Olifants River has been classified as stressed with the overall condition of the river ecosystems being regarded as Fair to Poor (DWAF, 2000; WRC, 2001). Associated with these activities are high surface run-off, water contamination and biotic community alteration. The Wilge River a tributary of the Olifants River flows roughly northwards until it is joined by its main tributary, the Bronkhorstspruit River. The river then flows in a north-easterly direction until it joins the Olifants River about 12 km upstream of the Loskop Dam.

With the existing land-use in the Wilge River catchment, agriculture, mining and Waste Water Treatment Works (WWTW's) the river is already under pressure from nutrients and sulphate inputs (De Villiers and Mkwelo, 2009). This being said, sites within the Wilge River catchment show relatively good water quality in comparison to those in the Olifants River catchment (CSIR, 2010). It is therefore important to maintain the ecological integrity of the Wilge River and strive to improve it.

A concern is that the rivers, streams and the pan in the area already contain high sediment loads (turbidity). This is due to the land use in the area. Any further increases in sedimentation and erosion may cause a further loss in habitat diversity and quality that will further contribute to impacts on biological communities. Additionally the increase in development with mining (New Largo) and the new Kusile Power Station, cumulative impacts will be present. Furthermore, farm dam construction has resulted in some flow alteration.

The combined weighted project cumulative impact on the pan will be of moderate significance due to reasons stated above. The baseline remaining impacts are considered to be low and additional project impact (if no mitigation measures are implemented) will only marginally increase the significance of the existing baseline impacts, the cumulative unmitigated impact will likely be of a **Low/Moderate** impacts, affecting the *study/local area* in extent. The impact is very likely and will be short/medium term to permanent where loss of streams occurs. The impact risk class is thus **Low to Moderate** (Table 28).

Mitigation Measures

No mitigation and management measures have been implemented for the loss of the pan in this report owing to the complete loss of this aquatic feature over the next 10 year construction period. However, WCS have developed a wetland offset strategy and identified possible target sites for this pan in question. Refer to report number WCS 2016: 1032-2013 for this detail coupled with their mitigation measures.

Mitigation during construction for the surrounding water resources would be to:

- Optimise design of the ADF to minimise the size of the footprint;
- Minimise area of vegetation clearing;
- Where practically possible, undertake the clearing of vegetation during the dry season to minimise erosion;
- The storm water management plan should be in place prior to construction being initiated;
- Install and maintain sediment traps as part of the storm water management plan where necessary and especially upstream of discharge points where erosion protection measures and energy dissipaters should be in place;
- Clean spills as quickly as possible;
- Store and handle potentially polluting substances and waste in designated bunded facilities;
- Waste should be regularly removed from the construction site by suitably equipped and qualified operators and disposed of in approved facilities;

- Locate temporary waste and hazardous substance storage facilities out of the 1:100 floodlines;
- Locate temporary sanitation facilities out of the 1:100 year floodlines; and
- An aquatic biomonitoring programme should be maintained for the Wilge River and adjoining tributaries (as per the monitoring points upstream and downstream of alternative site F in this report). The monitoring programme should include the following indices monitored on a bi-annual basis during the wet and dry season:
  - *In situ* water quality;
  - Habitat availability using the IHAS;
  - Aquatic macroinvertebrates; and
  - Ichthyofauna.

Residual Impact

The residual impact of the construction of the ADF will include the permanent loss of water resources (pan), as well as a potential decline in water quality. Most of these impacts, with the exception of the pan, are expected to be restricted to the local scale; however the potential deterioration of water quality within the Wilge River will increase the extent of the impacts.

The residual impact to water resources beyond the construction phase of the project will be reduced through mitigation, except for the pan which will be lost. Following mitigation the impacts to the water resources will likely be of a **Very low to low** significance, affecting the *study site to local area* in extent. The impact *could happen and certain* cases related to water quality is *very likely.* The duration will be <u>short term</u>. The impact risk class is however **Low** (Table 28). With respect to the pan, the combined weighted project impact will be of moderate significance, as it is affected nationally (owing to it being the maximum extent of any impact) and the degree of probability of the impact occurring will most definitely occur primarily during the first 10 years of construction (Table 28).

Table 28: Pre-construction and Construction Phase Impacts

Activity	Description of Impact	Impact type	Spatial Scale	Duration	Significance	Probability	Rating	Mitigation Measures	Interpretation
Construction of dams, associated storm water drains and site access roads	Degradation of aquatic ecosystems (including reduced biotic integrity and impaired habitat availability in the surrounding tributaries owing to increased sedimentation, erosion and bed modification	Existing	2	2	3	4	1.9 - LOW	Implement an aquatic biomonitoring programme	Limited erosion occurs with the existing land use
		Cumulative	2	2	3	4	1.9 - LOW	Minimise footprint size; Stabilisation/rehabilitation of exposed areas as soon as possible; storm water management will be incorporated to limit sediment transported to the Leeufonteinspruit	The construction of the dams and associated infrastructure will not contribute significantly to the risk rating
		Residual	2	2	2	2	0.8 - VERY LOW		The impact can be mitigated to a very low risk rating by applying mitigation described
	Water quality deterioration within the surrounding tributaries owing to hydrocarbon spillages and sedimentation	Existing	3	3	3	4	2.4 - MOD	Store and handle potentially polluting substances and waste in designated bunded facilities Hydrocarbon spills must be cleaned up immediately; storm water management will be incorporated to limit contaminated water entering the Leeufonteinspruit; stay out of 1:100 floodlines; implement water quality monitoring programme	Limited pollution from the current land uses
		Cumulative	3	3	3	4	2.4 - MOD		Contamination of the site from spills from mechanical equipment may occur and impact the Leeufonteinspruit The land clearing associated with the construction of the ADF will not contribute significantly to the risk rating
		Residual	2	2	2	4	1.6 - LOW		The impact can be mitigated to a low risk rating by applying mitigation described
	Complete loss of the pan and associated aquatic biota, including the identified Lesser Flamingo (*Phoenicopterus minor)*	Existing	3	3	3	4	2.4 - MOD	WCS have developed a wetland offset strategy and identified possible target sites for this pan in question. Refer to report number WCS 2016: 1032 - 2013 for this detail coupled with their mitigation measures.	
		Cumulative	5	5	5	4	4 - HIGH		
		Residual	3	3	3	4	2.4 - MOD		

Activity	Description of Impact	Impact type	Spatial Scale	Duration	Significance	Probability	Rating	Mitigation Measures	Interpretation
Clearing of vegetation	Erosion	Existing	2	2	3	4	1.9 - LOW	Minimise footprint size by phasing; vegetation clearing only where necessary and avoid the riparian zone of surrounding rivers and streams. This must be preferably conducted during dry season; stabilisation/ rehabilitation of exposed areas as soon as possible.	Limited erosion occurs with the existing land use
		Cumulative	2	2	3	4	1.9 - LOW		The land clearing associated with the construction of the ADF will not contribute significantly to the risk rating
		Residual	2	2	2	2	0.8 - VERY LOW		The impact can be mitigated to a very low risk rating by applying mitigation described
	Impaired habitat and reduced biotic integrity	Existing	2	2	3	4	1.9 - LOW	Implement an aquatic biomonitoring programme for the surrounding water resources	Limited erosion occurs with the existing land use
		Cumulative	2	2	3	4	1.9 - LOW	Minimise footprint size by phasing; vegetation clearing only where necessary and avoid the riparian zone of surrounding rivers and streams. This must be preferably conducted during dry season	The land clearing associated with the construction of the ADF will not contribute significantly to the risk rating
		Residual	2	2	2	2	0.8 - VERY LOW		The impact can be mitigated to a very low risk rating by applying mitigation described
	Loss of streams and altered flows	Existing	1	5	1	4	1.9 - LOW	Site H is only 0.54% of the B20F and B20E quaternary catchments; a storm water management plan that will direct clean water around the site to the Leeufonteinspruit will be put in place	No major streams located on the site
		Cumulative	1	5	1	4	1.9 - LOW		The construction activities will not contribute significantly to the loss of streams/altered flow in the area
		Residual	1	5	1	4	1.9 - LOW		Limited mitigation to ensure clean water reaches steams
	Loss of the pan and associated aquatic habitat and aquatic biota.	Existing	3	3	3	4	2.4 - MOD	WCS have developed a wetland offset strategy and identified possible target sites for this pan in question. Refer to report number WCS 2016: 1032 - 2013 for this detail coupled with their mitigation measures.	
		Cumulative	5	5	5	4	4 - HIGH		

Activity	Description of Impact	Impact type	Spatial Scale	Duration	Significance	Probability	Rating	Mitigation Measures	Interpretation
	Of significance is the Lesser Flamingo identified in the pan	Residual	3	3	3	4	2.4 - MOD		
	Increased sediment transport into water resources and bed modification	Existing	3	2	2	4	1.9 - LOW	Vegetation clearing only where necessary and avoid the riparian zone of surrounding rivers and streams; Stabilisation/ rehabilitation of exposed areas as soon as possible; storm water management will be incorporated to limit sediment transported to the Leeufonteinspruit	Limited erosion occurs with the existing land use
		Cumulative	3	2	2	4	1.9 - LOW		The land clearing associated with the construction of the ADF will not contribute significantly to the risk rating
		Residual	2	2	2	3	1.2 - LOW		The impact can be mitigated to a low risk rating by applying mitigation described
	Water quality deterioration in the surrounding tributaries owing to potential hydrocarbon spills from mechanical equipment	Existing	3	3	3	4	2.4 - MOD	Store and handle potentially polluting substances and waste in designated bunded facilities; hydrocarbon spills must be cleaned up immediately; storm water management will be incorporated to limit contaminated water entering the Leeufonteinspruit; stay out of 1:100 floodlines; implement aquatic biomonitoring programme.	Limited pollution from the current land uses
		Cumulative	3	3	3	4	2.4 - MOD		Contamination of the site from spills from mechanical equipment may occur and impact the Leeufonteinspruit
		Residual	2	2	2	4	1.6 - LOW		The impact can be mitigated to a low risk rating by applying mitigation described

7.1.1 Operational Phase

The impacts from the operational phase are likely to include:

- Water quality impacts and deterioration (sedimentation and chemical contamination) from operation of the ADF;
- Erosion and increased sediment transport into water resources as the ADF construction progresses; and
- Loss of streams, aquatic habitats, aquatic biota, bed modification and altered flows as the ADF construction progress.

The combined weighted project impact to water resources (prior to mitigation) during the operational phase will be of a **Low to Moderate** significance, affecting the *site and local area*. The impact will act in the short term to permanent (where water resources such as streams will be removed and pans lost) and is *likely* to occur. The impact risk class is **Low to Moderate** (Table 29).

Cumulative impacts

Additional project impacts (if no mitigation measures are implemented) will increase the significance of the existing baseline impacts. The cumulative unmitigated impact will probably be of a Low to Moderate significance, affecting the *study/ local area* in extent. The impact *is very likely* and will be short term to permanent (where water resources such as streams and pans will be lost). The impact risk class is **Low to Moderate** (Table 29).

Mitigation Measures

As the 5 year footprint extension, mitigation during operation would be similar to the construction mitigation:

- Optimise design of ash dam to minimise size of footprint;
- Minimise area of vegetation clearing;
- Where areas need to be cleared of vegetation, the proposed project must aim to cap and revegetate as soon as possible to avoid run off and dust;
- Where practically possible, undertake the clearing of vegetation during the dry season to minimise erosion;
- Maintain sediment traps as part of the storm water management plan where necessary and especially upstream of discharge points where erosion protection measures and energy dissipaters should be in place;
- Clean spills as quickly as possible;
- Store and handle potentially polluting substances and waste in designated, bunded facilities;
- Locate waste and hazardous substance storage facilities out of the 1:100 floodlines;
- Locate sanitation facilities out of the 1: 100 year floodlines;
- Maintain infrastructure for river crossings adequately to prevent spillages; and
- An aquatic biomonitoring programme should be maintained for the Wilge River and adjoining tributaries (as per the monitoring points upstream and downstream of alternative site F in this report). The monitoring programme should include the following indices monitored on a bi-annual basis during the wet and dry season:
  - *In situ* water quality;
  - Habitat availability using the IHAS;

- Aquatic macroinvertebrates; and
- Ichthyofauna.

Residual Impact

The residual impact of the construction (as the ADF progresses over the period 2030 to 2052) and operation of the ADF will include the permanent loss of water resources, as well as a potential decline in water quality, aquatic habitat and associated aquatic biota.

Most of these impacts are expected to be mostly restricted to the local area, however the potential deterioration of water quality within the Wilge River will increase the extent of the impacts.

The residual impact to water resources of the construction (as the ADF progresses over the period 2030 to 2052) and operation of the ADF of the project will be reduced through mitigation. After mitigation the impacts to the water resources will probably be of a low to moderate significance, affecting the site/ *local area* in extent. The impact *is likely* and will be <u>short term to permanent</u> where loss of water resources occur, namely the pan. The impact risk class is likely to be reduced to **Low** (Table 29).

Table 29: Operational Phase Impact Assessment

Description of Impact	Impact type	Spatial Scale	Duration	Significance	Probability	Rating	Mitigation Measures	Interpretation
Water quality impacts to surrounding tributaries (sedimentation, chemical contamination)	Existing	2	2	3	4	1.9 - LOW	Implement an aquatic biomonitoring programme for the surrounding water resources	Construction phase will have had some negative impacts on site
	Cumulative	3	2	4	4	2.4 - MOD	Store and handle potentially polluting substances and waste in designated bunded facilities;	Operation of the ADF will have additional impacts
	Residual	3	2	3	3	1.6 - LOW	spills cleaned up immediately; storm water management will be incorporated to limit contaminated water entering the Leeufonteinspruit; stay out of 1:100 floodlines; implement water quality monitoring programme	The impact can be mitigated to a very low risk rating by applying mitigation described
Erosion and increased sediment transport into the surrounding tributaries and bed modification	Existing	2	2	3	4	1.9 - LOW	Implement an aquatic biomonitoring programme for the surrounding water resources	Construction phases will have some negative impacts on site
	Cumulative	2	2	3	4	1.9 - LOW	Vegetation clearing only where necessary	The land clearing associated with the ongoing construction of the ADF should not contribute significantly to the risk rating
	Residual	2	2	2	3	1.2 - LOW	Stabilisation/rehabilitation of exposed areas as soon as possible; storm water management will be incorporated to limit sediment transported to the Leeufonteinspruit	The impact can be mitigated to a low risk rating by applying mitigation described
Loss of streams, aquatic habitats, bed modification coupled with the loss of aquatic biota	Existing	1	5	1	4	1.9 - LOW	Site H is only 0.54% of the B20F and B20E quaternary catchments; a storm water management plan that will direct clean water around the site to the Leeufonteinspruit will be put in place and upgraded as the phases proceed	No major streams located on the site
	Cumulative	1	5	1	4	1.9 - LOW		The construction activities will not contribute significantly to the loss of streams/altered flow in the area
	Residual	1	5	1	4	1.9 - LOW		Limited mitigation to ensure clean water reaches steams
Change to natural flow regime	Existing	2	2	3	4	1.9 - LOW	Site H is only 0.54% of the B20F and B20E quaternary catchments; a storm water management plan that will direct clean water around the site to the Leeufonteinspruit will be put in place	No major streams located on the site
	Cumulative	3	2	4	4	2.4 - MOD		The construction activities will not contribute significantly to the loss of streams/altered flow in the area
	Residual	3	2	3	3	1.6 - LOW		Limited mitigation to ensure clean water reaches steams

7.1.2 Closure Phase

A number of impacts are expected to materialise as a consequence of the closure phase of the 30 year ADF and the associated infrastructure. Impacts relating to the rehabilitation of the ADF are also applicable to the operational phase of the project, as rehabilitation will take place concurrently. The decommissioning and removal of infrastructure during the closure phase is also likely to result in a number of impacts similar to the construction phase impacts:

- Stream deterioration and loss of aquatic habitat and biota;
- Increased sediment transport into water resources and further bed modification;
- Increased erosion; and
- Water quality deterioration in adjacent water resources.

Rehabilitation of the ADF will include the placement of topsoil on the side slopes and crest of the ADF and the establishment of vegetation on the ADF. Surface runoff on the steep side slopes is likely to erode the topsoil in the initial stages prior to the establishment of sufficient vegetation.

The combined weighted project impact to water resources (prior to mitigation) will be of a Low significance, affecting the *site/local area*. The impact will act in the short term and is very likely to occur. The impact risk class is thus **Low** (Table 30).

Cumulative Impact

The cumulative impacts of the operational phase activities, if not mitigated successfully, as well as impacts from other developments (mines, industrial areas and urban development) in the area are likely to impact on the water resources.

In this respect additional project impact (if no mitigation measures are implemented) will increase the significance of the existing impacts, the cumulative unmitigated impact will probably be of a low to moderate significance, affecting the *site/ local area* in extent. The impact is very likely and will be *short term to permanent* where water resources have been removed throughout the various phases of the ADF development. The impact risk class is thus **Low to Moderate** (Table 30).

Mitigation Measures

Mitigation during closure would be to:

- Maintain sediment traps as part of the storm water management plan where necessary and especially upstream of discharge points where erosion protection measures and energy dissipaters should be in place; and
- An aquatic biomonitoring programme should be maintained for the Wilge River and adjoining tributaries (as per the monitoring points upstream and downstream of alternative site F in this report). The monitoring programme should include the following indices monitored on a bi-annual basis during the wet and dry season:
  - *In situ* water quality;
  - Habitat availability using the IHAS;
  - Aquatic macroinvertebrates; and
  - Ichthyofauna.

Residual Impact

The residual impact of the closure of the ADF will include the permanent loss of water resources (flow) although this is minimum, as well as a potential decline in water quality.

Most of these impacts are expected to be restricted to the local scale, however the potential deterioration of water quality and habitat availability within the Wilge River will increase the extent of the impacts.

The residual impact to water resources beyond the closure phase of the project will be reduced through mitigation. After mitigation the impacts to the water resources will probably be of a low significance, affecting the *site/local area* in extent. The residual impact from the closure phase is likely but will be short term. The impact risk class is therefore **Low to very low** (Table 30).

Table 30: Close Phase impact assessment

Activity	Description of Impact	Impact type	Spatial Scale	Duration	Significance	Probability	Rating	Mitigation Measures	Interpretation
Infrastructure removal	Disturbance to streams (Loss of streams, aquatic habitat, bed modifications, aquatic biota and altered flows)	Existing	1	5	1	4	1.9 - LOW	Site H is only 0.54% of the B20F and B20E quaternary catchments; a storm water management plan that will direct clean water around the site to the Leeufonteinspruit will be put in place to ensure clean water flows around the site after closure	Existing impacts from and operational phase are expected to be low
		Cumulative	1	5	1	4	1.9 - LOW		Additional impacts from the closure phase are unlikely to impact significantly to the loss of streams/ altered flow in the area
		Residual	1	5	1	4	1.9 - LOW		The impact can be mitigated to a low risk rating by applying mitigation described
	Increased sediment transport into water resources and erosion	Existing	2	2	3	4	1.9 - LOW	Maintenance of the storm water management system; rehabilitation of sloped areas to minimise erosion	Existing impacts from and operational phase are expected to be low
		Cumulative	3	2	3	4	2.1 - MOD		Additional impacts from the closure phase may add additional impacts
		Residual	2	2	2	3	1.2 - LOW		The impact can be mitigated to a low risk rating by applying mitigation described
	Water quality deterioration	Existing	3	2	2	3	1.4 - LOW	Store and handle potentially polluting substances and waste in designated bunded facilities; spills cleaned up immediately; storm water management will be incorporated to limit contaminated water entering the Leeufonteinspruit; implement water quality monitoring programme	Construction phases will have some negative impacts on site
		Cumulative	3	2	2	3	1.4 - LOW		Contamination of the site from spills from mechanical equipment and removal of infrastructure may occur and impact the Leeufonteinspruit
		Residual	2	2	1	3	1 - VERY LOW		The impact can be mitigated to a low risk rating by applying mitigation described

8.0 CONCLUSIONS

The following conclusions were reached based on the results of the August/September 2013 (dry season) and May 2016 (follow-up) surveys and based on the impact assessment conducted in February 2016 following the receipt of the final engineering designs:

- *In situ* water quality was a limiting factor to aquatic biota at the time of the dry season, primarily due to low dissolved oxygen concentrations and percentage saturations. Both of these parameters were below the TWQR guideline at the majority of the sites in the tributaries of the Wilge River, including two of the upper sites on the Wilge River. The low values may be attributed to the large amount of decaying organic matter on the stream beds and limited flow conditions at the time of the survey. Furthermore, it was noted that the alkaline pH values on the upper Wilge River exceeded those values recorded during previous surveys conducted further downstream on the river. The turbidity levels were relatively low due to the time of year, with the exception of four sites in the tributaries of the Wilge River which demonstrated high turbidity levels. The rest of the water quality parameters were within the guideline values and thus not considered to be a limiting factor to the aquatic ecosystem. During the follow-up survey, the water quality was adequate at the selected sites monitored however, the turbidity levels remained high in the study area;

- A general description of the habitat integrity showed that the VEG and GSM were the dominant habitat elements in the Wilge River and adjoining tributaries draining the Kendal project area during both surveys. The limited habitat availability observed was largely due to a lack of the stones biotope and limited flow velocities at the time of the surveys;

- Based on the assessment of the aquatic macroinvertebrate communities, the biotic integrity in the tributaries in the project area ranged from unmodified to seriously modified (Class A to E) during the dry season and seriously modified at the four sites surveyed during the follow up survey;

- During the dry season (2013), the fish biotic integrity in the project area ranged from Largely to Critically Modified (PES Class D to F). The exotic and invasive fish species *Gambusia affinis* and *Cyprinus carpio* were recorded in the lower reaches of the Leeufontein and consequently at site two sites in the Wilge River downstream from the Leeufontein. Some fish species in the Wilge River showed signs of external parasites, a sign of increased physiological stress. Owing to low fish diversity recorded during the follow-up survey, the biotic integrity was critically modified. The low biotic integrity recorded in the tributaries was primarily attributed to limited habitat availability and low flow conditions;

- Overall, site alternative H was considered highly sensitive from an aquatic perspective owing to the large pan that will be lost during the first 10 years of construction. However, this site was selected as it was the only feasible site out of all the site alternatives as it is the only area within a 10 km radius of the Kendal Power Station large enough which is not earmarked for mining. Impacts emanating from the proposed project have been addressed in terms of their spatial and temporal scale, probability, degree of certainty and significance. Owing to the complete loss of the pan, this was identified to have a Very High significant impact. Not only is this aquatic ecosystem a natural feature of the landscape, it further is inhabited by the near threatened Lesser Flamingo (*Phoenicopterus minor*) (IUCN, 2015.4) which has been observed during previous surveys. A study by WCS was conducted on the pans within the proposed study area. They have developed a wetland offset strategy and identified possible target sites for this pan in question. Refer to report number WCS 2016: 1032-2013 for this detail coupled with their mitigation measures. The Wilge River catchment and adjoining tributaries is a priority area which already has existing impacts. Mitigation and management measures have been put in place in order to reduce the potential impact on this already impacted upon catchment from a water quality, habitat availability and associated aquatic biota perspective;

- As the construction, operation and closure phase of the project will be ongoing for the next 30 years, continual changes to the aquatic ecosystem will be inevitable both directly from this project and cumulatively. Therefore, the primary recommendation was that an aquatic biomonitoring programme be instituted for all three phases of the project in order to monitor the aquatic resources to adaptively manage and mitigate potential impacts to this system going forward.

This current report will function as the baseline report and thus enable one to identify the trajectory of change within the aquatic systems within the project area as a result of the mining activities;

- Furthermore, the Wilge River has been classified as a Class II river (DWA, 2013), which is defined as a river which is moderately used and the overall condition of that resource is moderately altered from its pre-development condition (DWA, 2013). It thus requires protection and maintenance in order to remain in its current ecological state. It further requires to be improved in areas where it has been severely impacted, such as the unnamed tributary flowing north of the proposed Site H; and
- In terms of the in situ water quality, habitat and biotic integrity, it is therefore important that best practise is employed when undertaking ash disposal activities.

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APPENDIX A
Site Photos

 **K_WIL1:** Upstream *(taken by K. Farrell 08/2013)*	 **K_WIL1:** Downstream *(taken by K. Farrell 08/2013)*
 **K_WIL2:** Upstream *(taken by K. Farrell 08/2013)*	 **K_WIL2:** Downstream *(taken by K. Farrell 08/2013)*
 **K_TRI11:** Upstream *(taken by K. Farrell 08/2013)*	 **K_TRI11:** Downstream *(taken by K. Farrell 08/2013)*

K_TRI1: Upstream *(taken by K. Farrell 08/2013)*

K_TRI1: Downstream *(taken by K. Farrell 08/2013)*

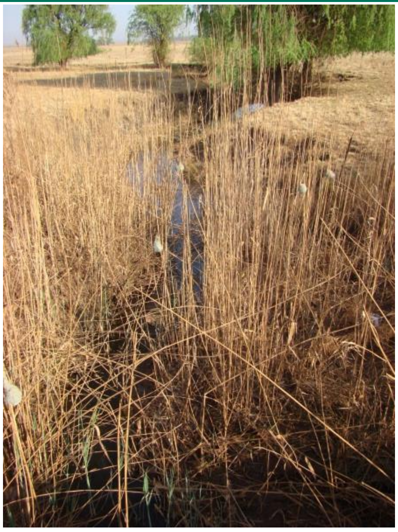
K_WIL3: Upstream *(taken by K. Farrell 08/2013)*

K_WIL3: Downstream *(taken by K. Farrell 08/2013)*

K_TRI2: Upstream *(taken by K. Farrell 08/2013)*

K_TRI2: Downstream *(taken by K. Farrell 08/2013)*

K_TRI3: Upstream *(taken by K. Farrell 08/2013)*



K_TRI3: Downstream *(taken by K. Farrell 08/2013)*

K_TRI4: Upstream *(taken by K. Farrell 08/2013)*

K_TRI4: Downstream *(taken by K. Farrell 08/2013)*

K_TRI10: Upstream *(taken by K. Farrell 08/2013)*

K_TRI10: Downstream *(taken by K. Farrell 08/2013)*

 **K_WIL4:** Upstream *(taken by K. Farrell 08/2013)*	 **K_WIL4:** Downstream *(taken by K. Farrell 08/2013)*
 **K_TRI8:** Upstream *(taken by K. Farrell 08/2013)*	 **K_TRI8:** Downstream *(taken by K. Farrell 08/2013)*
 **K_TRI9:** Upstream *(taken by K. Farrell 08/2013)*	 **K_TRI9:** Downstream *(taken by K. Farrell 08/2013)*

 **K_TRI13:** Upstream *(taken by K. Farrell 08/2013)*	 **K_TRI13:** Downstream *(taken by K. Farrell 08/2013)*
 **K_WIL5:** Upstream *(taken by K. Farrell 08/2013)*	 **K_WIL5:** Downstream *(taken by K. Farrell 08/2013)*
 **K_TRI6:** Upstream *(taken by K. Farrell 08/2013)*	 **K_TRI6:** Downstream *(taken by K. Farrell 08/2013)*

K_TRI7: Upstream *(taken by K. Farrell 08/2013)*

K_TRI6A: Upstream *(taken by K. Farrell 08/2013)*

K_TRI6A: Downstream *(taken by K. Farrell 08/2013)*

K_TRI5: Upstream *(taken by K. Farrell 08/2013)*

K_TRI5: Downstream *(taken by K. Farrell 08/2013)*

Follow up survey (May 2016)

K_PAN: ***(taken by M. Mashaba 05/2016)***

K_PAN: ***(taken by M. Mashaba 05/2016)***

K_TRI3: Upstream *(taken by M. Mashaba 05/2016)*

K_TRI3: Downstream *(taken by M. Mashaba 05/2016)*

K_TRI4: Upstream *(taken by M. Mashaba 05/2016)*

K_TRI4: Upstream *(taken by M. Mashaba 05/2016)*

K_PAN: ***(taken by M. Mashaba 05/2016)***

K_PAN: ***(taken by M. Mashaba 05/2016)***

K_TRI9: Upstream *(taken by M. Mashaba 05/2016)*

K_TRI9: Upstream *(taken by M. Mashaba 05/2016)*

K_TRI13: Upstream *(taken by M. Mashaba 05/2016)*

K_TRI13: Upstream *(taken by M. Mashaba 05/2016)*

APPENDIX B

Aquatic Macroinvertebrate Data

August 2013

Taxon	QV	K_WIL1			K_WIL2			K_TRI11			K_TRI1			K_WIL3			K_TRI3			K_TRI4		
		SIC	VEG	GSM	SIC	VEG	GSM	SIC	VEG	GSM	SIC	VEG	GSM	SIC	VEG	GSM	SIC	VEG	GSM	SIC	VEG	GSM
TURBELLARIA (Flatworms)	3												1									
ANNELIDA																						
Oligochaeta (Earthworms)	1			1	1	1	B					B	B		A	B	B	A	C			
Hirudinea (Leeches)	3											A	B			B						
CRUSTACEA																						
Potamonautidae* (Crabs)	3				A		A										A		OBS			1
HYDRACARINA (Mites)	8		B	A		A										A			1		A	B
EPHEMEROPTERA (Mayflies)																						
Baetidae 1sp	4																	A	A			
Baetidae 2 sp	6		B			B											B				A	A
Baetidae > 2 sp	12				B												B		A			
Caenidae (Squaregills/Cainfles)	6			B	A	A	B									A					1	1
Ephemeridae	15																					
Heptageniidae (Flatheaded mayflies)	13				A																	
Leptophlebiidae (Prongills)	9				A																	
ODONATA (Dragonflies & Damselflies)																						
Coenagrionidae (Sprites and blues)	4		A	B		A									A			B			B	B
Aeshnidae (Hawkers & Emperors)	8																				1	
Gomphidae (Clubtails)	6																					
Libellulidae (Darters/Skimmers)	4																					
HEMIPTERA (Bugs)																						
Belostomatidae* (Giant water bugs)	3																					
Corixidae* (Water boatmen)	3				B	A	B								A	B	B	B	B			B
Gerridae* (Pond skaters/Water striders)	5			A																		
Hydrometridae* (Water measurers)	6																					
Nepidae* (Water scorpions)	3		1																			
Notonectidae* (Backswimmers)	3														1			A	A			
Pleidae* (Pygmy backswimmers)	4		A			1																A
Veliidae/M...veliidae* (Ripple bugs)	5					1			SASS5 N/A										1			
TRICHOPTERA (Caddisflies)																						
Hydropsychidae 1 sp	4																1					
Hydropsychidae 2 sp	6				A	B																
Hydropsychidae > 2 sp	12																					
COLEOPTERA (Beetles)																						
Dytiscidae/Noteridae* (Diving beetles)	5		B	A	A	A	B					A					A	B	B		A	A
Elmidae/Dryopidae* (Riffle beetles)	8																					
Gyrinidae* (Whirligig beetles)	5																B		B			
Hydraenidae* (Minute moss beetles)	8		1			1											1			A		
Hydrophilidae* (Water scavenger beetles)	5		A				A											A				
DIPTERA (Flies)																						
Ceratopogonidae (Biting midges)	5		B				B					A				A	A	A	C			A
Chironomidae (Midges)	2		B	B	B		B									B	B	1	B	A	A	A
Culicidae* (Mosquitoes)	1		B	OBS																		
Dixidae* (Dixid midge)	10																	B			1	
Muscidae (House flies, Stable flies)	1				1																	
Simuliidae (Blackflies)	5				A	B	B								1		B			A		
Tabanidae (Horse flies)	5																					
Tipulidae (Crane flies)	5																					
GASTROPODA (Snails)																						
Ancylidae (Limpets)	6				1	1																
Lymnaeidae* (Pond snails)	3														1							
Physidae* (Pouch snails)	3											1						1				
Planorbinae* (Orb snails)	3																					
PELECYPODA (Bivalvles)																						
Corbiculidae (Clams)	5				1							A										
SASS Score		0	51	32	77	67	35				0	22	7	0	19	28	59	45	56	15	49	46
No. of Taxa		0	11	8	14	13	9				0	6	3	0	6	7	12	11	12	3	8	10
ASPT		0.00	4.64	4.00	5.50	5.15	3.89				0.00	3.67	2.33	0.00	3.17	4.00	4.92	4.09	4.67	5.00	6.13	4.60

Taxon	QV	K_TRI10			K_WIL4			K_TRI8			K_TRI9			K_TRI13			K_WIL5			K_TRI6			K_TRI6a			K_TRI5		
		SIC	VEG	GSM	SIC	VEG	GSM	SIC	VEG	GSM	SIC	VEG	GSM	SIC	VEG	GSM	SIC	VEG	GSM	SIC	VEG	GSM	SIC	VEG	GSM	SIC	VEG	GSM
TURBELLARIA (Flatworms)	3				1												A								A			
ANNELIDA																												
Oligochaeta (Earthworms)	1	A		A			A								A	A	A		B					1	A			B
Hirudinea (Leeches)	3																											
CRUSTACEA																												
Potamonautidae* (Crabs)	3	1	A											1	1										OBS		1	OBS
HYDRACARINA (Mites)	8	A			1		1										A							B	A		B	
EPHEMEROPTERA (Mayflies)																												
Baetidae 1sp	4			1														1										
Baetidae 2 sp	6	A	B		C	B										B	B		B					A				
Baetidae > 2 sp	12													B	1													
Caenidae (Squaregills/Cainfles)	6	B		B	B	A	A							B	A	B	B	A	B									A
Ephemeridae	15																											
Heptageniidae (Flatheaded mayflies)	13				B												A		1									
Leptophlebiidae (Prongills)	9				B												B											
ODONATA (Dragonflies & Damselflies)																												
Coenagrionidae (Sprites and blues)	4		B	A	1	B									B			B						B			B	A
Aeshnidae (Hawkers & Emperors)	8		1												1										OBS		A	
Gomphidae (Clubtails)	6														A				A									
Libellulidae (Darters/Skimmers)	4																							1	A			
HEMIPTERA (Bugs)																												
Belostomatidae* (Giant water bugs)	3														A		OBS										OBS	
Corixidae* (Water boatmen)	3	A	A	A		B	C							A	B	B	B	B	B						B			B
Gerridae* (Pond skaters/Water striders)	5														A			A						A	OBS		A	
Hydrometridae* (Water measurers)	6																							A				
Nepidae* (Water scorpions)	3																											1
Notonectidae* (Backswimmers)	3														A	A								A	A		A	
Pleidae* (Pygmy backswimmers)	4					1																		A			A	
Veliidae/M...veliidae* (Ripple bugs)	5	A	A						SASS5 N/A			SASS5 N/A					1		OBS		SASS5 N/A							
TRICHOPTERA (Caddisflies)																												
Hydropsychidae 1 sp	4	1												A														
Hydropsychidae 2 sp	6																											
Hydropsychidae > 2 sp	12				A												B											
COLEOPTERA (Beetles)																												
Dytiscidae/Noteridae* (Diving beetles)	5		1		B	A	B								A	B	A		B					B	1		1	A
Elmidae/Dryopidae* (Riffle beetles)	8		A	A										1														
Gyrinidae* (Whirligig beetles)	5																1											
Hydraenidae* (Minute moss beetles)	8														1		A										1	
Hydrophilidae* (Water scavenger beetles)	5						1								1												1	
DIPTERA (Flies)																												
Ceratopogonidae (Biting midges)	5	A	A	B	A	B	1							A	B	A	A		B					1	A		B	B
Chironomidae (Midges)	2	A		B	B	A	B							A	B	B	A	A	B					B	B		B	B
Culicidae* (Mosquitoes)	1																							1	A			
Dixidae* (Dixid midge)	10				1	1									A	1											A	
Muscidae (House flies, Stable flies)	1													1											1			1
Simuliidae (Blackflies)	5	1	A		A									B	A		A											
Tabanidae (Horse flies)	5	1																1							1			
Tipulidae (Crane flies)	5																		A									
GASTROPODA (Snails)																												
Ancylidae (Limpets)	6	1	1		A	A									A			B	A									
Lymnaeidae* (Pond snails)	3																											
Physidae* (Pouch snails)	3																											
Planorbinae* (Orb snails)	3		A																									
PELECYPODA (Bivalvles)																												
Corbiculidae (Clams)	5				1	1													B									
SASS Score		59	61	33	99	56	35							49	100	41	99	35	68				0	54	57	0	73	33
No. of Taxa		13	12	8	15	11	8							10	19	9	17	8	13				0	13	15	0	14	10
ASPT		4.54	5.08	4.13	6.60	5.09	4.38							4.90	5.26	4.56	5.82	4.38	5.23				0.00	4.15	3.80	0.00	5.21	3.30

	K_WIL1	K_WIL2	K_TRI11	K_TRI1	K_WIL3	K_TRI3	K_TRI4	K_TRI10	K_WIL4	K_TRI8	K_TRI9	K_TRI13	K_WIL5	K_TRI6	K_TRI6a	K_TRI5
Total SASS Score	**76**	**116**		**25**	**43**	**91**	**77**	**87**	**112**			**113**	**129**		**80**	**87**
Total No. Of Taxa	**15**	**21**		**7**	**11**	**18**	**14**	**18**	**19**			**22**	**24**		**20**	**19**
Total ASPT	**5.07**	**5.52**		**3.57**	**3.91**	**5.06**	**5.50**	**4.83**	**5.89**			**5.14**	**5.38**		**4.00**	**4.58**

May 2016

Taxon	QV	K_TRI3			K_TRI4			K_TRI13		
		SIC	VEG	GSM	SIC	VEG	GSM	SIC	VEG	GSM
ANNELIDA										
Oligochaeta (Earthworms)	1								1	
Hirudinea (Leeches)	3									A
EPHEMEROPTERA (Mayflies)										
Baetidae 1sp	4				1				A	
Baetidae 2 sp	6								A	
ODONATA (Dragonflies & Damselflies)										
Coenagrionidae (Sprites and blues)	4								B	
Aeshnidae (Hawkers & Emperors)	8		1							
Libellulidae (Darters/Skimmers)	4									1
HEMIPTERA (Bugs)										
Belostomatidae* (Giant water bugs)	3		A						A	
Corixidae* (Water boatmen)	3		A						C	C
Gerridae* (Pond skaters/Water striders)	5								A	
Notonectidae* (Backswimmers)	3		1						A	
Pleidae* (Pygmy backswimmers)	4		A							
COLEOPTERA (Beetles)										
Dytiscidae/Noteridae* (Diving beetles)	5		A		A				A	
Gyrinidae* (Whirligig beetles)	5								A	
Hydrophilidae* (Water scavenger beetles)	5								1	
DIPTERA (Flies)										
Chironomidae (Midges)	2		1		A				A	A
GASTROPODA (Snails)										
Physidae* (Pouch snails)	3								1	
Planorbinae* (Orb snails)	3								A	
SASS Score		0	28	0	11	0	0	0	52	12
No. of Taxa		0	7	0	3	0	0	0	14	4
ASPT		0.00	4.00	0.00	0.00	0.00	0.00	0.00	3.71	3.00
Total SASS Score		**28**			**11**			**55**		
Total No. Of Taxa		**7**			**3**			**15**		
Total ASPT		**4.00**			**3.67**			**3.67**		

APPENDIX C
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