ESKOM HENDRINA ASH DUMP

HENDRINA, MPUMALANGA

FRESHWATER ECOLOGY SCOPING STUDY

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1. Introduction

Lidwala Consulting Engineers have requested that Ecotone Freshwater Consultants CC undertake the freshwater ecology specialist component of the Environmental Impact Assessment (EIA) and Waste License for the proposed Hendrina Power Station Ash Dump near Hendrina, Mpumalanga. This report provides scoping input and regional context for the purpose of highlighting preferred alternative sites for the placement of ash dam six. Emphasis is placed on a ranking system that considers specifics regarding the surface water systems associated with respective alternatives as well as providing a detailed plan of study for the EIA phase.

2. Scope and Limitations

The Scope of Work encompassed an initial desktop study focussing on the surface water systems linked to the proposed alternatives, in order to determine the possible implications of the proposed development for the associated aquatic systems.

The scope of the work encompassed a baseline desktop aquatic biodiversity survey that incorporates the following:

- A desktop delineation of surface water systems and their associated buffer zones.
- The creation of a criterion to rank and rate alternative sites with specific emphasis on sustaining aquatic ecological integrity, the methodology of which will include the consideration of potential, issues, impacts and risks.
- Desktop aquatic ecology baseline data collection (referring to potentially occurring aquatic macroinvertebrates and fish species).
- Presentation of a detailed plan of study for the EIA phase regarding the aquatic ecological assessment.

The aquatic ecological scoping assessment is subject to the following assumptions and limitations:

- The spatial and temporal extent of Ecotone's services is described in the proposal, and is subject to restrictions and limitations. A total assessment of all probable scenarios or circumstances that may exist for each alternative was not undertaken. No assumptions should be made unless opinions are

specifically indicated and provided. Data presented in this document may not elucidate all possible conditions that may exist given the limited nature of the enquiry.

- The study was desktop based and relied heavily on GIS for determining low lying areas were surface water flow was better articulated. It thus follows that certain types of wetlands (i.e. seepage zones) might not be reflected on the surface water map. The presence of these wetlands will have to be confirmed during the EIA phase.
- Compiling reference lists for expected fish and aquatic macroinvertebrates species was particularly complicated as historical data (prior to large scale hydrological alteration induced by surrounding catchment utilisation) is scarce. The expected list provided in this report is a compilation of distributions as set out in the IUCN Red Data List database (IUCN, 2011), Skelton (2001) and Frequency of Occurrence (Kleynhans *et al.*, 2007) and the Rivers Database (Dallas *et al.*, 2007).
- The legal summary excludes an extensive review of the legal implications for development in relation to affected surface water systems. A professional legal opinion on this aspect of the development should be sought out.

3. Methodology

3.1. Desktop Assessment

3.1.1. Literature Research on General Study Area

A literature survey and desktop study was carried out using available information from reference works (Nel *et al*., 2004; Mucina and Rutherford, 2006; DWAF, 2000). Main rivers associated with the proposed development were identified and a river characterisation was done on those stretches located on, or nearest to each alternative. General area characteristics such as biome identification, landscape features, annual precipitation rates and temperature variation were obtained using reference work form Mucina and Rutherford, 2006.

3.1.2. Expected Macroinvertebrates and Fish

Potential fish species and their respective conservation status and habitat preferences were identified using expert opinion and reference works from the Rivers database (Dallas *et al*., 2007), Skelton (2001), Kleynhans (2007), Kleynhans, Louw & Moolman (2007) and IUCN (2011). A potential aquatic macroinvertebrate species list was compiled using the Rivers database (Dallas *et al*., 2007), Gerber and Gabriel (2002) and Thirion (2007).

3.1.3. Riparian Vegetation

Reference work from Mucina and Rutherford (2006) were utilised to assess on a desktop level the expected riparian vegetation compositions associated with the systems present. Expected composition of metrics such as woody, non-woody, cover and abundances were used for the purpose of this scoping assessment.

3.2. Criteria used to rank Sites

3.2.1. Wetland Infringement

The main consideration for the wetland infringement criteria was, “do the alternative sites infringe on wetlands and associated buffer zones?” The rationale being that the greater the infringement of the alternative site on the receiving aquatic environment, the less favorable the site is. Arial imagery was used to ascertain the total surface area (permanently and temporally wet areas) affected by the placement of the alternative site. It is important to note that alternative sites should be compared to each other. This subsequently forces the use of a proportional or relative criterion.

Additionally, differentiation was made based on the nature, number and size of water courses which require crossing. Table 5 shows the respective ratings for this metric.

3.2.2. Water course crossings

Different ratings associated with the "water course crossing" criteria are reflected in Table 5. The main consideration here is: "does additional infrastructure development require the crossing of a water course/wetland in order to reach alternative sites?" The intrinsic risk with pipeline failure during operational phase as well as the environmental impacts incurred during the construction phase is higher when water course/s require crossing. The highest rating was given to the alternative with the greatest width (sum total of wetland/water courses) that requires spanning.

3.2.3. Desktop PES

The desktop Present Ecological State (PES) categories were obtained from DWAF (2000) and from the National Spatial Biodiversity Assessment (Nel *et al.*, 2004). In places where different categories were assigned to the same river signature the highest category was selected. This was done largely as part of a precautionary approach. Systems with a higher PES were assigned a higher factor rating, while systems that already reflect an impairment PES, scored a lower factor rating. Table 1 shows the respective categories and descriptions for the Desktop PES, while the Table 5 reflects the factor ratings of these categories in the rating system for alternative site selection.

Table 1: Present Ecological State Categories applied to the ranking system.

Category	Category	Description
A	Very good	Unmodified state- no impacts, conditions natural.
B	Good	Largely natural- Small changes in community characteristics, most aspects natural.
C	Moderate	Moderately modified- Clear community modifications, some impairment of health evident.
D	Poor	Largely modified- Impairment of health clearly evident. Unacceptably impacted state.
E	Very poor	Seriously modified- Most community characteristics seriously modified, unacceptable state.
F	Critical	Critically modified- Extremely low species diversity- Unacceptable state.

3.2.4. Desktop EIS

Table 2 shows the score sheet for determining the Ecological Importance and Sensitivity (EIS), while Table 3 reflects the interpretation of scores obtained as well as the different EIS categories. The factor ratings for the various EIS categories, in turn, are shown in Table 5. Higher factor rating scores were assigned to alternative sites with lower EIS scores. At alternative sites where more than one watercourse was present the highest EIS scores obtained were considered when rating the EIS factor.

Table 2: Score sheet for determining the Ecological Importance and Sensitivity category for associated water courses in each wetland.

Determinant	Score (0-4)
ECOLOGICAL IMPORTANCE	
1. Rare and endangered species (Red Data etc)	
2. Populations of unique species	
3. Vegetation species richness	
4. Diversity of HGM wetland types	
5. Migration/breeding and feeding site for wetland species	
6. Conservation Status	
FUNCTIONAL IMPORTANCE	
7 Sensitivity of HGM unit to flow changes in the catchment	
8. Sensitivity to water quality changes (e.g. closed and nutrient poor systems have higher sensitivity)	
9. Flood storage/attenuation/flow regulation	
10. Particulate/nutrient removal – water quality improvement	
11. Wetland type rarity (particularly relevant to cumulative loss issues)	
SOCIAL IMPORTANCE	
12. Direct dependence on the wetland for basic human needs (water, reeds, medicinal plants, fishing)	
13. Cultural values	

Table 3: Ecological Importance and Sensitivity categories, and the interpretation of median scores for biota and habitat determinants (Adopted from Kleynhans 1999).

EIS categories	Range of Median
Very high Wetlands that are considered ecologically important and sensitive on a **national or even international** level. The biodiversity of these systems is usually very sensitive to flow and habitat modifications. They play a major role in moderating the quantity and quality of water of major rivers.	>3 and <=4
High Wetlands that are considered to be ecologically important and sensitive. The biodiversity of these systems may be sensitive to flow and habitat modifications. They play a role in moderating the quantity and quality of water of major rivers.	>2 and <=3
Moderate Wetlands that are considered to be ecologically important and sensitive on a provincial or local scale. The biodiversity of these systems is not usually sensitive to flow and habitat modifications. They play a small role in moderating the quantity and quality of water of major rivers.	>1 and <=2
Low/marginal Wetlands that are not ecologically important and sensitive at any scale. The biodiversity of these systems is ubiquitous and not sensitive to flow and habitat modifications. They play an insignificant role in moderating the quantity and quality of water of major rivers.	>0 and <=1

3.2.5. Factor Weightings

Factors considered in the rating system were assigned different weights in the overall calculation. The "wetland infringement and crossing" factors was assigned the highest weight contribution (Table 5) followed by the desktop PES and EIS factors. Respective weights assigned to the different factors were largely due to the perceived environmental risk associated with each.

Table 4: Respective weights assigned to different factors used in the ranking system.

Weighting Percentage (%)	
Wetland infringement	100
Wetland/water course crossing required	100
Desktop PES	80
Desktop EIS	80

3.2.6. Rating Calculation

The following equation was applied to the alternative site rating system:

{Σ (factor ratings: wetland infringement, water course crossings} X 100/100} + {Σ (factor ratings: PES, EIS) X 80/100} = Preference rating/18 X 100

Overall scores obtained are classed into the following preference classes the different values of which are reflected by Table 6 in Section 2.3:

- Preferred site
- Acceptable site
- Less preferred site
- Unacceptable site

Table 5: Ranking system and factors considered for alternative site selection associated with the Hendrina Ash dam placement.

Ranking		Wetland Infringement	Water Course Crossings	Desktop PES (DWAF 2000)	Desktop EIS (Adopted from Kleynhans 1999,)
5	**very high importance and contributing factor**	Proposed alternative infringes on relatively large permanent wet areas.	Relatively large perennial lotic system or multiple smaller perennial lotic systems require spanning.	A Category: Unmodified state- no impacts, conditions natural	Wetlands that are considered ecologically important and sensitive on a national or even international level. The biodiversity of these systems is usually very sensitive to flow and habitat modifications. They play a major role in moderating the quantity and quality of water of major rivers.
4	**high importance and contributing factor**	Proposed alternative infringes on relatively small permanent wet areas, or relatively large seasonal and temporary wet areas.	A relatively small perennial lotic system or relatively large lentic system or multiple smaller lentic systems require spanning.	B Category: Largely natural- Small changes in community characteristics, most aspects natural	
3	**moderate importance and contributing factor**	Proposed alternative infringes on relatively small seasonal and temporary wet areas, or relatively large allocated buffer area.	A single relatively small lentic system requires spanning, or multiple non perennial systems.	C Category: Moderately modified- Clear community modifications, some impairment of health evident.	Wetlands that are considered to be ecologically important and sensitive. The biodiversity of these systems may be sensitive to flow and habitat modifications. They play a role in moderating the quantity and quality of water of major rivers.
2	**low importance and contributing factor**	Proposed alternative infringes only on a relatively small area falling in the allocated buffer zone.	Single non-perennial system requires spanning.	D Category: Largely modified- Impairment of health clearly evident. Unacceptably impacted state.	Wetlands that are considered to be ecologically important and sensitive on a provincial or local scale. The biodiversity of these systems is not usually sensitive to flow and habitat modifications. They play a small role in moderating the quantity and quality of water of major rivers.
1	**very low importance and contributing factor**			E Category: Seriously modified- Most community characteristics seriously modified, unacceptable state.	
0	**no importance**	Proposed alternative falls completely beyond the boundaries of the allocated buffer zone.	No water course crossing required.	F Category: Critically modified- Extremely low species diversity- Unacceptable state.	Wetlands that are not ecologically important and sensitive at any scale. The biodiversity of these systems is ubiquitous and not sensitive to flow and habitat modifications. They play an insignificant role in moderating the quantity and quality of water of major rivers.

3.3. Site Preference Rating (SPR)

Criteria description and site preference ratings for the freshwater ecology component are reflected in Table 6.

Table 6: Site Preference Ratings for the proposed Sites, respective descriptions of criteria and specialist score categories.

Site Preference Ranking	Criteria	Specialist Specific Score
Preferred (4)	Site falls completely or mostly beyond the boundaries of the allocated buffer zones. No or only single, relatively small non perennial watercourse crossing required. Moderately to seriously modified PES.	<35%
Acceptable (3)	Site infringes only on a relatively small area falling in the allocated buffer zone. A single relatively small lentic system requires spanning, or multiple non perennial systems. Moderately to seriously modified PES. Receiving watercourses, in direct catchment, are of limited or no importance and sensitivity.	>35-<50%
Not Preferred (2)	Site infringes on relatively small permanent wet areas, or relatively large seasonal and temporary wet areas. A relatively small perennial lotic system or relatively large lentic system or multiple smaller lentic systems require spanning. Or, PES falls in a Largely natural or moderate category. Or, receiving watercourses are considered to be ecologically important and sensitive. Their biodiversity may be sensitive to flow and habitat modifications. Functional benefits associated with receiving watercourses are likely to be present.	>50-<70%
No-Go (1)	Site infringes on relatively large permanent wet areas. A single, relatively large perennial system or multiple smaller perennial systems require spanning. Or the PES of the site is in an unmodified state. Or, receiving watercourses are considered ecologically important and sensitive on a national or even international level, with biota sensitive to flow and habitat modifications. Functional benefits associated with receiving watercourses are very likely to be present.	>70%

4. Regional Overview

4.1. Ecoregion Characteristics

The study area is located in the western parts of Mpumalanga province and falls predominantly within the Eastern Highveld grassland with isolated patches consisting of Eastern Temperate Freshwater wetlands (Table 7). The desktop review indicated that surface water systems are located in quaternary catchment B12B. Landscape features for the Eastern grassland biome includes slightly to moderately undulating plains, some low hills and pan depressions, while the Temperate Freshwater wetlands are an expression of impermeable soils or erosion resistant geological features (Table 7). Mean Annual Precipitation (MAP) ranges between 600-800 mm per annum, frequently in the form of summer storms. The annual temperature in the study area is 14.7 ℃ for Eastern Highveld grassland and 14.9 ℃ for Eastern Temperate Freshwater wetlands. The Mean Annual Potential Evaporation rate (MAPE) exceeds the MAP in the area, thus a net loss in precipitation is experienced (Table 7).

Table 7: Environmental variables and geomorphologic description of the study area (Mucina and Rutherford, 2006).

Environmental Features	Bioregion	
	Eastern Highveld grassland	**Eastern Temperate Freshwater wetland**
Landscape features	Slightly to moderately undulating plains, including some low hills and pan depressions	Flat landscapes or shallow depressions filled with (temporary) water, supporting zones systems of hygrophilous vegetation
Geology and soils	Red and yellow sandy soils found on shales and sandstones	Peat soils, ranging from Champagne to Rensburg. Vleis form on impermeable soils or erosion resistant features e.g. dolerite intrusions
MAP	726 mm	704 mm
MAT	14.7 ℃	14.9 ℃
MFD	32 d	38 d
MAPE	1926 mm	1953 d
Status	E	LC

MAP: Mean Annual Precipitation; MAT: Mean Annual Temperature; MFD: Mean Frost Days; MAPE: Mean Annual Potential Evaporation; E: endangered; LC: Least Concerned

4.2. River Characterisation

A characterisation of the rivers in the study area reveals that the receiving Klein-Olifants River is an order three river (Table 8). Six attributes were used to obtain the PES on desktop quaternary catchment level by the NSBA (Nel *et al.*, 2004). These attributes predominantly allude to habitat integrity of instream and riparian habitat. With this in mind, the receiving

Klein-Olifants River and the Woestalleen systems according to the NSBA (Nel *et al*., 2004) fall within a D-category, which relates to a largely transformed ecosystem state (Table 8). Biological communities also reflect fair to unacceptable health in these systems (RHP, 2001). The instream habitat associated with the ecoregion in the study area reflects more degradation than adjacent ecoregions (RHP, 2001).

According to the desktop PES category from DWAF (2000), the rivers in quaternary catchment B12B fall in a C ecological category, indicating a moderately modified ecosystem with clear community modifications and some impairment of health evident. The catchment at present is affected by severe erosion, sedimentation, weirs, infrastructural development in the form of power stations and mines, and translocation of species (*Labeo umbratus*). The EIS (DWAF, 2000) is considered moderately sensitive due to the expected presence of flow intolerant fish species in parts of the catchment, and the system's sensitivity to changes in flow and water quality.

Most of the surface water systems are perennial systems. Nel *et al.* (2004) lists a status of critically endangered for all the river signatures associated with the study area. The ascribed river status indicates a limited amount of intact river systems carrying the same heterogeneity signatures nationally. This implies a severe loss in aquatic ecological functioning and aquatic diversity in similar river signatures on a national scale (Nel *et al*., 2004).

Table 8: Desktop river characterisation of rivers and streams located in the study area (Nel *et al*., 2004) and DWAF (2000).

	Klein-Olifants River	Woestalleen System
River Order	3	1
Quaternary Catchment	B12B	B12B
Class	Perennial	Perennial
PES (NSBA)	**D**	**D**
PES (DWAF)	**C**	**C**
EIS (DWAF)	**Moderate**	**Moderate**
Conservation Status (NSBA)	Critically Endangered	Critically Endangered

4.3. Drivers of Ecological Change

The property falls within the Upper Olifants Sub-Area of the Olifants Water Management Area (WMA4). The Upper Olifants Sub-Area is the most urbanised of the 4 sub-areas in WMA4. The Upper Olifants covers an area of 11 464 km^2 with a mean annual runoff of 10 780 million m^3 (Midgley *et al.,* 1994). Surface runoff in this area is regulated by a number of

large dams, namely Witbank, Bronkhorstspruit and the Middleburg dams (Basson *et al*., 1997). Majority of the urban population is located in Witbank and Middelburg areas, and it is projected that the population in these urban areas is expected to grow in the near future therefore increasing the water requirement in the Sub-Area (Table 9). Extensive coal mining activities are taking place in the sub-area, both for export to other provinces and for use in the six active coal fired power stations in the sub-area. Water quality in this sub-area is therefore under threat. Mining activities in the area impact on the natural hydrological system by increasing infiltration and recharge rates of the groundwater. Approximately 62 million m^3 is predicted to decant from mining activities (post closure) every year, creating a need for water quality management plans in this Sub-Area (DWAF, 2004).

Table 9: Reconciliation of water requirements and availability (million m^3/a) for the year 2000 in the Olifants Water Management Area (DWAF, 2004b).

Sub-area	MAR	Local yield	Transfers in	Transfer out	Local requirement	Deficit
Upper Olifants	465	238	171	96	314	1
Middle Olifants	481	210	91	3	392	94
Steelpoort	396	61	0	0	95	34
Lower Olifants	698	100	1	0	104	63

4.4. Expected Fish

The expected fish species list was limited to fish that have been sampled in, and immediately around or adjacent to the quaternary catchments associated with the study area. A total of 14 indigenous species representing 5 families are expected to utilise surface water systems associated with the study area. Table 10, shows the expected species as well as their conservation status. No species with conservation status occur in the study area, however, *Barbus neefi* is Data Deficient (DD). *Barbus trimaculatus* has a status of Least Concern (LC), but some literature suggests that it is Vulnerable (V) in the Orange-system (Benade *et al*., 1995). *Amphilius uranoscopus* as well as *Chiloglanis pretoriae* both have been sampled in quaternary catchment B12C and are expected to occur in the study area (Kleynhans *et al*., 2007). Both of these fish are rheophillic; having a low tolerance for degraded water quality and a high preference for sensitive habitat, thus making them excellent indicators of ecosystem health.

The expected fish list also includes alien and introduced species. *Labeo umbratus* naturally occurs in the Vaal-system, but has been introduced into the Limpopo and Olifants systems.

Alien species that are expected in and around the study area include *Gambusia affinis* and *Micropterus salmoides* (Table 10).

Table 10: Fish species expected to utilise the river systems associated with the study area, in and around the quaternary catchment (B12A, B12B and B12C). Alien species are shown in red while sensitive species are indicated in green. LC = Least Concern; DD = Data Deficient; EX = Exotic (IUCN, 2009).

Status	Family	Species	Status
LC	Amphiliidae	*Amphilius uranoscopus*	Stargazer Catfish
LC	Cyprinidae	*Barbus anoplus*	Chubbyhead barb
DD	Cyprinidae	*Barbus neefi*	Sidespot barb
LC	Cyprinidae	*Barbus paludinosus*	Straightfin barb
LC -Vulnerable in Orange*	Cyprinidae	*Barbus trimaculatus*	Threespot barb
LC	Cyprinidae	*Barbus unitaeniatus*	Longbeard barb
LC	Mochokidae	*Chiloglanis pretoriae*	Shortspine rock catlet
LC	Clariidae	*Clarias gariepinus*	Sharptooth catfish
LC	Cyprinidae	*Labeo cylindricus*	Redeye labeo
LC	Cyprinidae	*Labeo molybdinus*	Leaden labeo
Introduced	Cyprinidae	*Labeo umbratus*	Moggel
LC	Cyprinidae	*Labeobarbus marequensis*	Largescale yellowfish
LC	Cyprinidae	*Labeobarbus polylepis*	Smallscale yellowfish
LC	Cichlidae	*Pseudocrenilabrus philander*	Southern mouthbrooder
LC	Cichlidae	*Tilapia sparrmanii*	Banded tilapia
EX	Poeciliidae	*Gambusia affinis*	Mosquito fish
EX	Centrarchidae	*Micropterus salmoides*	Largemouth bass
DD: Data deficient; LC: Least Concern; EX: Exotic (alien) *: Benade *et al.*, 1995			
	Alien/Exotic/Introduced		Sensitive

4.5. Expected Aquatic Macroinvertebrates

A number of macroinvertebrate families are expected to utilise the habitat provided by the surface water systems associated with the proposed development and are shown in Table 11 (Gerber, 2002; Thirion, 2007). Also reflected by Table 11 is the respective sensitivity scores associated with each invertebrate family. The majority of expected macroinvertebrates are of low to moderate sensitivity, scoring between 3 and 8 out of a possible 15. Conversely a few relatively sensitive families are expected, these include: Heptageniidae, Leptophlebiidae, Tricorythidae and Chlorocyphidae.

Table 11: Macroinvertebrate species expected to use the non perennial systems for a part of their life cycle.

Order	Family	Common Name	SASS Score
Turbellaria	Planaria	Flatworms	3
Annelida	Oligochaeta	Aquatic earthworms	1
	Hirudinea	Leeches	3
Crustacea	Potamonautidae	Crabs	3
	Atyidae	Freshwater prawns	8
Hydracarina	Hydrachnellae	Water mites	8
Ephemeroptera	Baetidae	Small Minnow Flies	4
	Caenidae	Cain Flies	6
	Heptageniidae	Flat-headed Mayflies	13
	Leptophlebiidae	Prongill Mayflies	9
	Tricorythidae	Stout Crawlers	9
Odonata	Chlorocyphidae	Damsel flies	10
	Chlorolestidae	Sylphs	8
	Coenagrionidae	Sprites and Blues	4
	Lestidae	Emerald Damsel flies	8
	Aeshnidae	Hawkers	8
	Corduliidae	Cruisers	8
	Gomphidae	Clubtails	6
	Libellulidae	Darters	4
Hemiptera	Belostomatidae	Giant water bugs	3
	Corixidae	Water boatmen	3
	Gerridae	Pond skaters	5
	Hydrometridae	Water measurers	6
	Naucoridae	Creeping water bugs	7
	Notonectidae	Back swimmers	3
	Pleidae	Pygmy back swimmers	4
	Veliidae	Ripple bugs	5
Trichoptera	Hydropsychidae	Caseless caddis flies	4
	Hydroptilidae	Cased caddis flies	6
	Leptoceridae	Cased caddis flies	6
Coleoptera	Dytiscidae	Diving beetles	5
	Elmidae	Riffle beetles	8
	Gyrinidae	Whirligig beetles	5
	Hydrophilidae	Water scavenger beetles	5
Diptera	Ceratopogonidae	Biting midges	5
	Chironomidae	Midges	2
	Culicidae	Midges	1
	Ephydridae	Shore flies	3
	Muscidae	House flies	1
	Psychodidae	Moth flies	1
	Simuliidae	Black flies	5
	Syrphidae	Rat tailed maggots	1
	Tabanidae	Horse flies	5
	Tipulidae	Crane flies	5
Gastropoda	Ancylidae	Freshwater limpets	6
	Lymnaeidae	Pond snails	3
	Physidae	Pouch snails	3
	Planorbinae	Orb snails	3
	Thiaridae		3
	Corbiculidae		5
Pelecypoda	Sphaeriidae		3

5. Site Specific Results

Table 12 shows the scores assigned to the factors considered in the alternative site ratings. Alternative D yielded the highest score. This was largely due to extensive wetland infringement and the probable requirement for watercourse crossings associated with infrastructure development. Alternative D and A, reflected a lower PES than the other alternative sites and was allocated a higher score for this factor. The lower PES for these sites is mostly the result of extensive bed, bank, channel and hydrological alteration of the East Woestalleenspruit. Alternative C and E yielded the lowest factor rating scores overall. It is expected that these alternatives will impose the smallest environmental risk relative to the other sites. Drainage lines linked to these sites are smaller in extent than other sites and in both cases wetland infringement is marginal. Concurrently, additional ash transporting infrastructure will probably not require water course crossings. It should however be mentioned that the catchment associated with both of these alternative sites drains into the West Woestalleenspruit which is currently largely not impacted by mining activity, for this reason these alternatives were assigned a lower PES factor score.

Table 12: Ratings for respective factors considered for each alternative.

Alternative	Wetland Infringement	Water Course Crossings	Desktop PES	Desktop EIS	Score /18	Score %
Alternative A	0	5	3	3	9.8	54.44
Alternative B	5	0	2	2	8.2	45.56
Alternative C	2	2	2	2	7.2	40.00
Alternative D	5	5	3	3	14.8	82.22
Alternative E	3	0	2	1	5.4	30.00

5.1. Site Preference Rating (SPR)

The preference ratings for respective alternative sites in relation to aquatic ecology are provided in Table 13. Alternative E is the preferred alternative, while Alternative C is considered acceptable. Both alternative A and B are not preferred, largely due to probable extensive wetland infringement. Alternative D scored falls within the “no go” criterion and is considered not suitable.

Table 13: Site Preference Ratings for the proposed sites

Alterative	Score %	Site Preference rating
Alternative A	54.44	2
Alternative B	45.56	2
Alternative C	40.00	3
Alternative D	82.22	1
Alternative E	30.00	4

6. Plan of Study for EIA

A detailed study using the rule based EcoStatus or DWAF approved River Health Programme methodology (Kleynhans, 2007; Kleynhans, Mackenzie & Louw, 2007; Thirion, 2007; RHP, 2001) is recommended during a suitable flow period. A total of 10 sites will be strategically chosen (two sites per alternative) to assess, and the following information will be generated in the form of a detailed freshwater ecology report:

1. Species of fish and macroinvertebrates and their (estimated) abundance, flow preferences, habitat preferences and sensitivities.
2. An aquatic ecological study and recommendations referring to ecological processes and system connectivity (migratory connectivity).
3. Diatom analyses will be carried out according to the methodology described by Taylor *et al.* (2005).
4. An assessment of *in situ* water quality and the PES (fish, aquatic macroinvertebrates, habitat integrity and riparian vegetation) of the relevant part of the watercourse/s associated with the proposed development based on river biomonitoring protocol.
5. An impact assessment of the proposed development in relation to the receiving aquatic environment.
6. An ecological study referring to ecological processes and connectivity.

6.1. Deliverables

The following will be deliverables from the aquatic ecological assessment:

1. A comparative analysis of habitat biotopes, macroinvertebrate community structure and fish community structure.
2. An *in situ* water quality analysis of basic water quality variables.
3. An impact assessment of the proposed development on the aquatic ecosystem associated with each alternative site.
4. A detailed report on the status of the fish, macroinvertebrate, riparian vegetation and habitat integrity associated with each alternative site, incorporating the above mentioned deliverables and recommendations for mitigation of any perceived impacts.

7. Conclusions

The ecological integrity associated with the study area is in a moderately to largely modified PES, with a moderate to low EIS. At the same time the study area appears to compose of numerous and diverse geo-hydromorphic units which intern add to the functionality of the local drainage network. In line with this notion is the hydrological contribution of the Woestalleenspruit to the larger Klein-Olifants River, the discharge of which nearly doubles after the confluence with the Woestalleenspruit. Considering this, it is pertinent for any additional development, in the Klein-Olifants catchment, to consider and manage all environmental risks posing further degradation to surface water systems. This preliminary desktop preference rating provides a synopsis of available literature which suggests that Alternative E would yield the lowest environmental risk considering surface water systems and associated aquatic ecological processes. The detailed aquatic ecological impact assessment will quantify the significance of possible impacts associated with each alternative site which, in turn will verify the findings of this scoping assessment and will also provide resolution and additional context.

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