Eskom Hendrina Wet Ash Disposal Facility

Aquatic Specialist Study

Environmental Impact Assessment Phase

Ash Disposal Facility and Associated Infrastructure

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Executive Summary

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 Wet Ash Disposal Facility near Hendrina, Mpumalanga. The power station requires additional ash disposal facilities in order to continue generating electricity. The initial report (November 2011) was augmented during (August 2014) to include some variation in linear infrastructure. The main aims of the wetland and aquatic assessments were to: (1) characterise the baseline extent and condition of surface water resources potentially affected by the proposed expansion, (2) assess the risks pertaining to the identified aquatic resources and (3) to provide relevant mitigation measures for identified risks.

Study Methodology

A desktop study was undertaken to determine applicable information with regards to the greater catchment area, associated ecoregions, nature of the drainage systems and overall catchment utilisation.

The field surveys were undertaken during July 2011. Two biomonitoring sites were assessed and six wetlands consisting of 13 hydrogeomorphic (HGM) units were identified, delineated and assessed. Of the 13 HGM units three were situated within the direct footprint of the proposed development (primary study area), while other units fell within a 500 m radius of the proposed development (secondary study area). The field assessment was augmented in August 2014 to include the additional distribution line alternatives.

Two relevant instream aquatic biomonitoring sites were included within the study. These sites were located downstream of dam structures on transformed valley bottom systems and for this reason conventional instream monitoring methodologies was not applied. Rather variations of these instream methods were utilised, but without an ecological classification. The biomonitoring sites were subjected to the following assessment methodologies:

- Habitat – Invertebrate Habitat Assessment System (IHAS), and Habitat Cover Rating (HCR).
- Aquatic Macro invertebrates- number of taxa sampled and average sensitivity scores per site.
- Fish – Diversity analysis

- Diatom Assessment.

Wetlands and associated HGM units were identified, delineated and classified. The following assessment methodology was applied on wetlands:

- Present Ecological State (PES) determination as determined by *WET-Health* Level 2.
- Wetland functionality as determined by WET-EcoServices Level 2.
- Environmental Importance and Sensitivity (EIS).

Summary of Results

The points below provide a summary of the biological responses measured as well as the Present Ecological State (PES) and Ecological Importance and Sensitivity (EIS) of the wetlands located within the primary and secondary study areas.

- The biological responses measured at sites HA1 and 2 (monitoring sites) indicated that the catchment is in an impaired state:
  - A total of 6 diatom species were collected with no rare or endemic species present. Diatom result for site HA1 is suggested surface water pollution through organic enrichment while results of site HA2 was consistent with industrial and mining activities (Section 3.3).
  - Aquatic macroinvertebrate revealed that both sites consisted almost entirely of pollution tolerant taxa (Section 3.4).
  - No fish species were sampled at site HA1, however, *Barbus neefi,* which is moderately intolerant to conditions of no flow, were sampled at site HA2. *Barbus neefi* is intolerant to changes in water quality and variation in abundances or frequency of occurrences will provide a future measure for impacts associated with the proposed wet ash disposal facility (Section 3.5).
- The primary study area consisted of approximately 34% wetland. Wetlands which will directly be affected by the proposed wet ash disposal facility were ecological impaired to different degrees due to current land use activities (Section 3.6.3). Wetlands in the secondary study area were also ecologically impaired. The hydrological characteristics of the valley bottom systems have been greatly altered by additional water input and a number of impeding structures (roads and dams). Simultaneously, seep zones have been infringed on by agricultural activity, destroying habitat and disturbing hydromorphic soils. Most wetlands, in the secondary study area, were assessed as vulnerable to changes in hydrology and geomorphology in their respective catchments.

- Wetlands associated with the proposed distribution lines were either in a Modified or Seriously Modified state due to existing impacts including roads, agriculture and existing distribution lines (Section 3.6.3).
- The wetland functionality assessment revealed that wetlands, in the primary study area, mostly retain a water purification function and do not contribute notably to stream flow augmentation and flood attenuation (Section 3.7).
- The EIS assessment reflected moderate importance and sensitivity of wetlands directly affected by the placement of the wet ash disposal facility.

Impacts Assessment

Alternative E

An assessment of available alternatives identified Alternative E as the environmental least cost alternative. However, Alternative E reflected residual wetland impacts, most notably the loss of wetland functions associated with HGM units falling directly on the footprint of the proposed development. The assessment of impacts resulted in the high significance (before mitigation) of the following impacts in the construction and operational phases:

- The loss of wetland function
- Altered hydrology
- Loss of water resources downstream
- Changes in natural surface water flow patterns
- Deterioration of water quality

No-Go

A likely trajectory assessment for hydrology, geomorphology and vegetation ascertained a slight to substantial deterioration of most wetlands during the next five years. It follows that even if the No-go alternative applies wetlands within the primary and secondary study area are likely to further degrade over the next five years.

Distribution Line

Alternative 1 runs along the Northern and Southern boundaries of the proposed development and has been removed as a potential alternative. Alternative 2 will infringe on Wetland 8, whereas Alternative 4 will intersect directly through the middle of Wetland 8. Alternative 3 does not intersect Wetland 8, and is outside the boundaries of Wetlands 9, 10 and 11 and is therefore the preferred alternative.

Pipelines

The proposed development will require moving an existing raw water pipeline from Alternative E to a new proposed alignment. The pipeline is not expected to cross any wetlands, although it does come close to the boundary of Wetland 11. Environmental risk liked to aquatic ecology is thus not a concern. Even so, emphasis, during construction, should fall on soil conservation, erosion and sediment control, as these factors might negatively impact receiving drainage systems.

Mitigation and Management

Principle mitigation and management facets include: (1) Pollution prevention, minimisation of impacts, water reuse and reclamation, water treatment. (2) Effective storm water management and water monitoring. (3) Lining of the wet ash disposal facility to prevent surface and ground water contamination. Similarly, impaired wetland functionality should be considered in the design of the wet ash disposal facility and simulated as far as reasonably possible during the operational phase. Off-site mitigation is the only mitigative action for the loss of wetland functions induced by the direct footprint of the proposed development. The Moderately degraded state of wetlands within the downslope area provides ample opportunity for mitigating the unavoidable infringement of wetland habitat within the direct footprint of the proposed expansion. Concurrently, the implementation of a monitoring and biomonitoring programme will monitor the receiving environment and the effective management of the wet ash disposal facility.

Conclusion

Ash management inherently carries environmental risk, particularly to surface and ground water systems. The extent of the proposed development in relation to the extent of other uses in the water management area may add to cumulative impacts on the Klein-Olifants system. The Klein-Olifants system is compromised and any additional strain on surface water ecology should be considered in this light. Thus, the remaining ecological integrity associated with the Woes-Alleenspruit is of particular importance on a quaternary catchment scale. However, the surface water study carried out in July 2011 indicated that wetlands associated with the study area are in a Moderately to Largely modified state. In light of the PES, retained functionality, EIS and potential mitigation measures available, it is possible to accommodate the proposed expansion without significantly impacting on the downslope aquatic resources.

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List of Abbreviations

DO	Dissolved Oxygen
DD	Data Deficient
DWA	Department of Water Affairs
EC	Electrical Conductivity
EIA	Environmental Impact Assessment
EIS	Ecological Importance and Sensitivity
EX	Exotic/ Alien
GSM	Gravel-Sand-Mud
HGM	Hydrogeomorphic
IHAS	Invertebrate Habitat Assessment System
LC	Least Concern
MAP	Mean Annual Precipitation
MAPE	Mean Annual Potential Evaporation
MAT	Mean Annual Temperature
MBCP	Mpumalanga Biodiversity Conservation Plan
MFD	Mean Frost Days
NFEPA	National Freshwater Ecosystem Priority Area
NT	Near Threatened
PES	Present Ecological State
PE	Potential Evaporation
%PTV	Percentage Pollution Tolerance Valves
SIC	Stones-In-Current
TDS	Total Dissolved Solids
Temp	Temperature
TWQR	Target Water Quality Range
V	Vulnerable
VEG	Vegetation

1. Introduction

1.1. Background

Lidwala Consulting Engineers 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. The power station requires additional ash disposal facilities in order to keep generating electricity. It is expected that the power station will produce approximately 64 million m³ of ash over the next 20 years of operation. This report provides the result of the field and impact assessment following the screening and scoping assessments. The latter two assessments highlighted preferred alternatives for the placement of the wet ash disposal facility. During these preceding assessments emphasis was placed on a ranking system that considered specifics regarding the surface water systems associated with respective alternatives as well as providing a detailed plan of study for the EIA phase.

During the scoping assessment it was ascertained that the study area appears to compose numerous and diverse geo-hydromorphic units which in turn add to the functionality of the local drainage network. The preliminary desktop preference rating provided a synopsis of available literature which suggested that Alternative E would yield the lowest environmental risk considering surface water systems and associated aquatic ecological processes.

The initial report (November 2011) was augmented during (August 2014) to include some variation on the original preferred alternative and linear infrastructure. The main aims of the wetland and aquatic assessments were to: (1) characterise the baseline extent and condition of surface water resources potentially affected by the proposed expansion, (2) assess the risks pertaining to the identified aquatic resources and (3) to provide relevant mitigation measures for identified risks.

1.2. Objectives of the Report

In line with the main aims of the assessment, the main objectives are listed below:

- Ascertain the present state of biological receptors in the receiving downstream environment:
    - Assess the water quality of receiving watercourses as indicated by *In situ* variables.
    - Assess the habitat availability for aquatic macroinvertebrates.
    - Assess the available fish habitat.

    - Assess the fish community assemblages compared to expected reference conditions.
    - Analyse the Diatom communities at relevant downstream areas.
- Wetland assessment
    - Identify, delineate and classify wetlands within the direct footprint of the proposed development (also referred to as the primary study area), as well as in a 500 m radius, referred to as the secondary study area.
    - Assess the Present Ecological State (PES) of identified functional units using relevant and available assessment methodologies.
    - Assess the functionality of identified wetlands by applying relevant and available methodologies.
- Impact assessment and mitigation measures:
    - Identify impacts on wetlands resulting from the proposed placement of the wet ash disposal facility and linked infrastructure.
    - Assessing the significance of impacts using a probabilistic and severity approach.
    - Provide mitigation measures were possible.

1.3. Legislative Framework

The section below highlights some important legislation pertaining to wetlands and aquatic ecosystems in general on the property.

According to the National Water Act (Act No. 36 of 1998), a water resource is defined as:
“a watercourse, surface water, estuary, or aquifer. A watercourse in turn refers to

a) a river or spring;
b) a natural channel in which water flows regularly or intermittently;
c) a wetland, lake or dam into which, or from which, water flows; and
d) any collection of water which the Minister may, by notice in the *Gazette,* declare to be a watercourse. Reference to a watercourse includes, where relevant, its bed and banks.”

A wetland is defined as: “land which is transitional between terrestrial and aquatic systems where the water table is usually at or near the surface, or the land is periodically covered with shallow water, and which land in normal circumstances support or would support vegetation typically adapted to life in saturated soil.”

Section 21 of the National Water Act (NWA Act No. 36 of 1998) covers the following activities, which might be applicable to the conceptual layout plan for the proposed development. According to Section 21 of the NWA and in relation to the river ecosystem, the following activity is considered a use, and therefore requires a water use license:

(b) - storing water;
(c) - impeding or diverting the flow of water in a watercourse;
(g) - disposing of waste in a manner which may detrimentally impact on a water resource;
(i) - altering the bed, banks, course or characteristics of a watercourse.

According to the Department of Water Affairs (DWA) any activity that falls within the temporary zone of a wetland or the 1:100 year floodline (whichever is greater) qualifies as a Section 21(c) and/or (i) water use activity (depending on the use) and will thus require either a general authorization or Water Use License (WUL). According to the NWA, an application for a WUL should be submitted to the DWA if any of the above activities are to be undertaken.

Replacement of general authorisation in terms of section 39 of the national water act (1998) done in 2009, for schedules 1 and 2 of Government notice No. 398 (2004), in respect of section 21 (c) and (i) which under section 6 (b) requires the inclusion of wetlands within a 500 meter radius of development within the wetland assessment.

Regulation 704 of 1999 of the National water act (1998) which regulates use of water for mining and related activities aimed at protection of water resources impose a restriction on locality under section 4:

No person in control of a mine or activity may:

(a): locate or place any residue deposit, dam, reservoir, together with any associated structure or any other facility within the 1:100 year flood-line or within a horizontal distance of 100 meters from any watercourse or estuary, borehole or well, excluding boreholes or wells drilled specifically to monitor the pollution of groundwater, or on water-logged ground, or on ground likely to become water logged, undermined or cracked.

In terms of Section 19 of the NWA, a person who owns, controls, occupies or uses the land is responsible for the control and prevention of water resource pollution.

The Conservation of Agricultural Resources Act (CARA - Act No. 43 of 1983) was established for the conservation of the natural agricultural resources by the maintenance of the production potential of land, by:

- combating and preventing erosion;
- mitigating the weakening or destruction of the water sources;
- protecting natural vegetation; and
- combating of weeds and invader plants:

According to REGULATION 16: Control of weeds and invader plants:
If invasive weeds (as specified in the Act) occur on any area (also specified) the land user shall, by any of the following means, control those weeds effectively:

a) The weeds shall be uprooted, felled or cut off and shall be destroyed by burning or other suitable methods.
b) The weeds shall be treated with an appropriately registered weed killer.
c) The measures above shall be applied to the seeds, seedlings or re-growth of the weeds to prevent them from setting seed or propagating vegetatively.

1.4. Study Approach and Methodology

1.4.1. Literature Review and Desktop Study

A desktop study was undertaken to determine applicable information with regards to the greater catchment area, associated ecoregions, nature of the drainage systems and overall catchment utilisation. References from Mucina and Rutherford (2006), the National Spatial Biodiversity Assessment, or NSBA (Nel *et al.,* 2004) and DWAF (2000; 2011) were used to study the surrounding area. Information on local fish distribution, fish ecology, fish biology and frequency of occurrence was obtained by studying literature from the Rivers Database (Dallas *et al.*, 2007), Kleynhans (2007), Kleynhans *et al.,* (2007), Scott *et al.* (2006) and Skelton (2001). Present Ecological State (PES) and Ecological Importance and Sensitivity (EIS) tables from DWA were used to ascertain desktop ecological categories for the general area (DWAF, 2000; 2011).

1.4.2. Field Survey and Site Selection

The spatial orientation of Alternative E (primary study area) and a 500 m radius (secondary study area) is shown in **Figure 1-1**, represented in South African quarter degree map (1:50 000) *2629BA,* 1996. The baseline field survey was undertaken during July 2011 and composed of two separate components:

1. Assessment of biomonitoring sites ascertain the present sensitivity of biological receptors in the receiving environment and describe baseline ecological conditions in these areas. The location of biomonitoring sites in relation to Alternative E is shown in **Figure 1-2**. **Table 1-1** provides the coordinates of biomonitoring sites assessed.

The assessment and delineation of identified wetlands on the primary and secondary study areas as shown in **Figure 3-5**. The scope of the study was augmented to include two additional proposed distribution lines. The additional fieldwork was conducted during August 2014 with the scope primarily focussed on wetland identification and delineation.

Table 1-1: Coordinates of sites HA1 and 2, July 2011.

GPS Point	Position	Y	X
HA1	**North of Alternative E**	-26.0296	29.58752
HA2	**North west of Alternative E**	-26.0331	29.58105

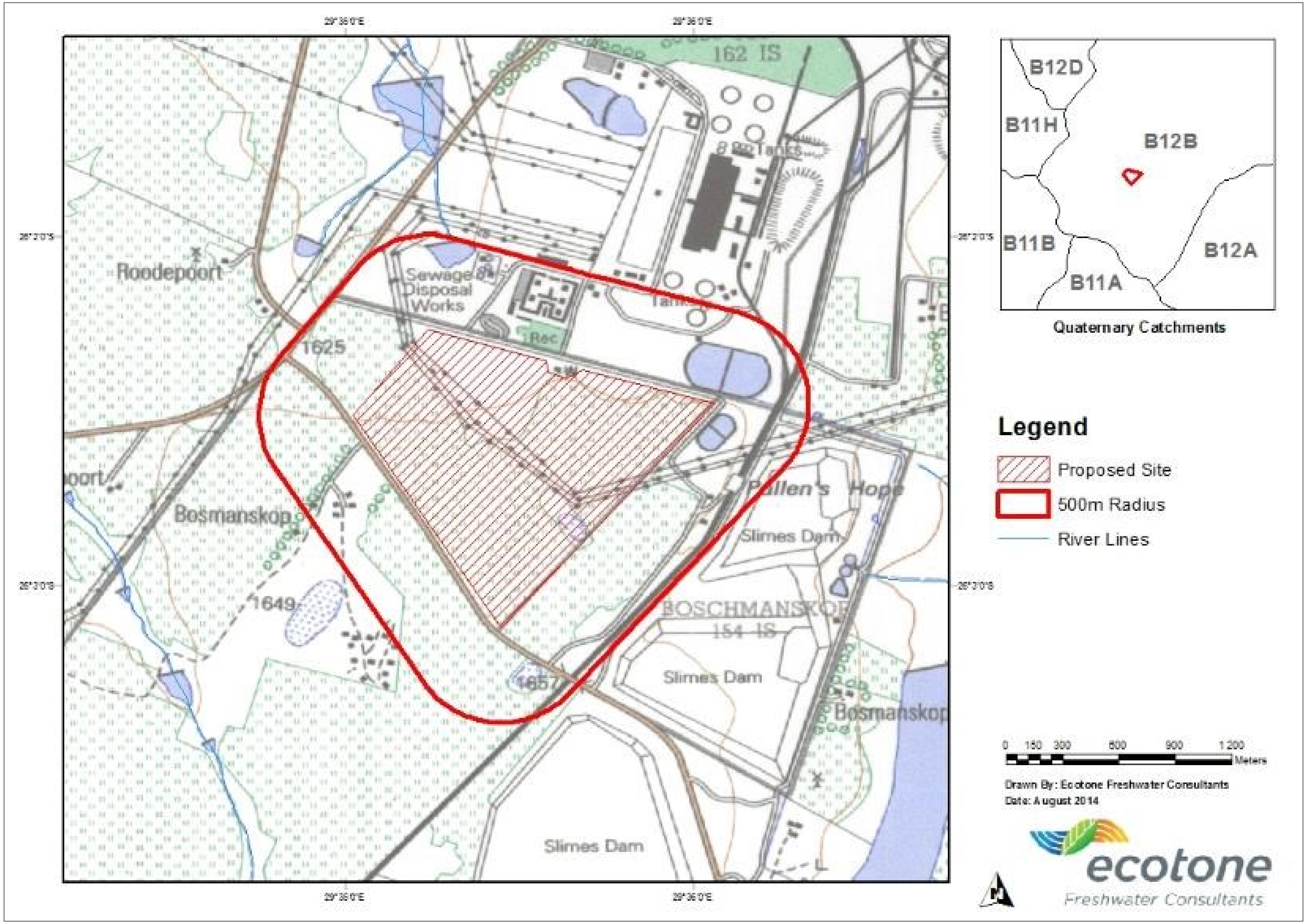


Figure 1-1: Map showing the study area on South African quarter degree map (1:50 000) *2629BA,* 1996.

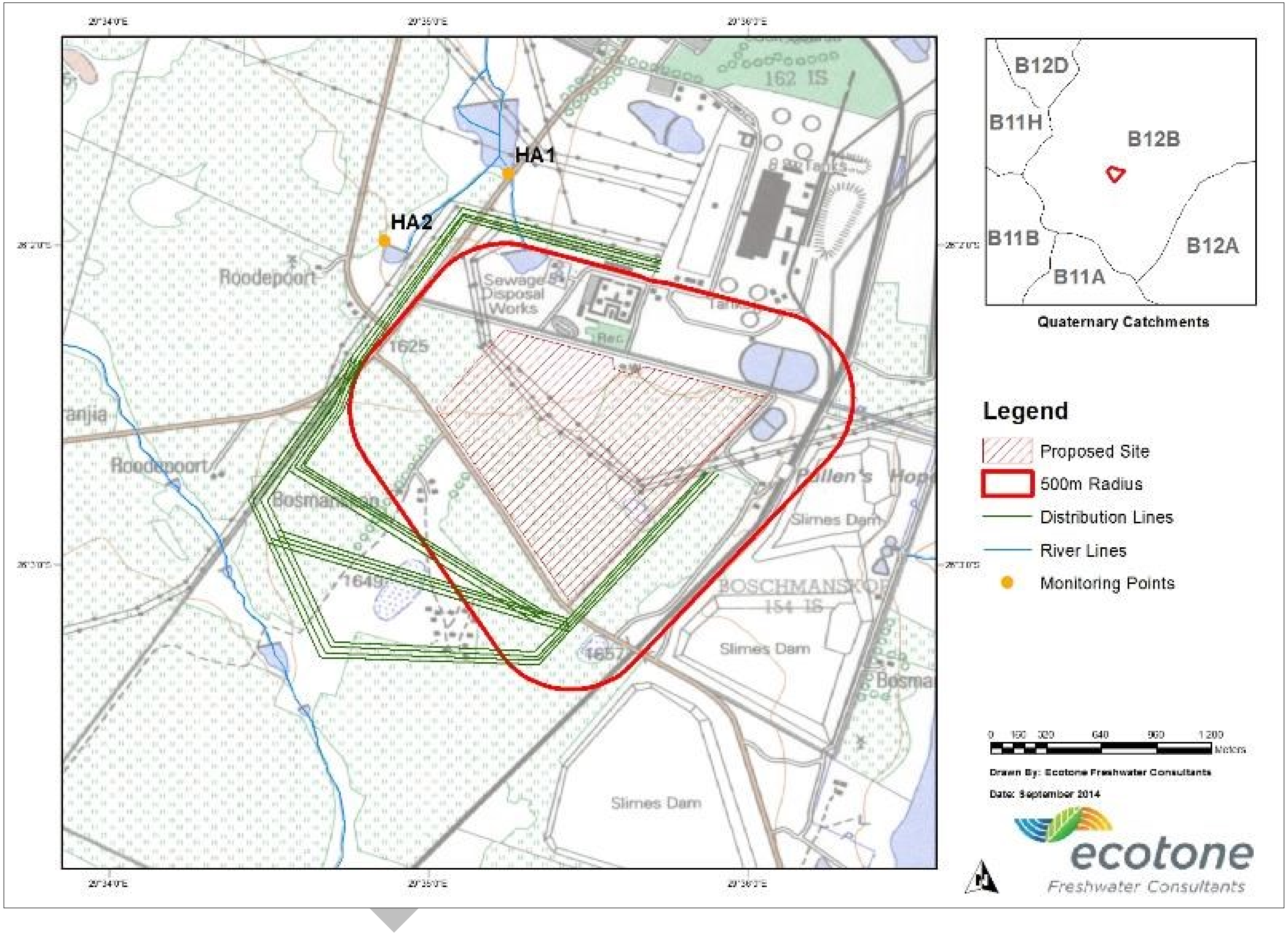


Figure 1-2: Map showing aquatic biomonitoring points assessed, associated with the study area (DWAF, 1995; Nel *et al.,* 2004; Chief Directorate – Surveys and Mapping).

1.4.3. Water Quality

In situ analysis was undertaken using a pre-calibrated Eutech PCD650 multi-parameter hand-held water quality meter (**Table 1-2**). The results obtained from the assessment of the water quality data were compared to benchmark criteria compiled by Kotze (2002) consisting of source water quality guidelines set by Rand Water (Steynberg *et al.*, 1996; Rand Water, 1998). Water quality information was represented using colour coding to indicate whether water quality variables were within guideline ranges (**Table 1-3**).

Table 1-2: *In situ* parameters measured

In situ parameters	Abbreviation	Units
pH	pH	[H¹+ ions]
Temperature	Temp	°C
Electrical Conductivity	EC	µS-cm⁻¹
Total Dissolved Solids	TDS	ppm

Table 1-3: Water quality ranges as compiled by Kotze (2002)

	Ideal	Tolerable	Intolerable	References
pH	6.5 - 8.5	5 - 6.5 and 8.5 - 9	< 5 - > 9	Steynberg *et al*. (1996); Rand Water (1998)
EC	450 µS-cm⁻¹	> 450 - 1000 µS-cm⁻¹	> 1000 µS-cm⁻¹	Steynberg *et al*. (1996)

1.4.4. Aquatic invertebrate and Fish Habitat Assessment

Only section one of IHAS was employed during the course of this project. Section one focuses on sampling biotopes and assesses the quantity and quality of the stones-in-current, vegetation and other biotopes (includes stones-out-of-current, gravel, sand and mud). The quality of each biotope, in terms of potential habitat for invertebrates, was assessed and expressed as a score. The scores for each biotope were then summed to give a total Habitat Score (**Table 1-4**).

Table 1-4: Invertebrate Habitat Assessment Score ratings and categories (McMillan, 1998)

IHAS score %	Description	Category
>80 %	Habitat is considered to be more than adequate and able to support a diverse invertebrate fauna	Good
<80>70 %	Habitat is considered to be adequate and able to support invertebrate fauna	Adequate
<70 %	Habitat is considered to be limited and unable to support adverse invertebrate fauna	Poor

The fish habitat assessment refers to the assessment of fish habitat that provides suitable conditions for a particular fish species to inhabit (Kleynhans, 2007). The assessment was site specific, and took into consideration the diversity of velocity-depth classes, and the occurrence of various cover types at each velocity-depth class (**Table 1-5**).

Table 1-5: Fish habitat assessment where scores are rated as follows: 0 = none; 1= rare; 2= sparse; 3= common; 4= abundant; 5= very abundant (Kleynhans, 2007)

Slow Deep	Slow Shallow	Fast Deep	Fast Shallow
Overhanging vegetation	Overhanging vegetation	Overhanging vegetation	Overhanging vegetation
Undercut banks & root wads	Undercut banks & root wads	Undercut banks & root wads	Undercut banks & root wads
Substrate	Substrate	Substrate	Substrate
Aquatic macrophytes	Aquatic macrophytes	Aquatic macrophytes	Aquatic macrophytes
Water column	Water column	Water column	Water column

1.4.5. Diatom Assessment

Diatoms are microscopic, unicellular algae that are used as indicators of water quality as they respond rapidly to specific physico-chemical conditions, from this ecological water quality conditions may be inferred, over a period of time. Diatom field methodology was carried out according to the methodology described by Taylor *et al.* (2005). Van Dam ecological scores for trophic status and Percentage of Pollution Tolerant Valves (%PTV) were also applied in this study (**Table 1-6**). For the purposes of this study 400 diatom frustules were counted for ecological analysis (Prygiel *et al.*, 2002). Suggested rules for counting diatoms according to CEN (2004) were followed. The taxonomic guide by Taylor *et al.* (2007) was consulted for identification purposes in this study. Where necessary, Krammer & Lange-Bertalot (1986; 1988; 1991a & 1991b) were used for identification and for confirmation of species identification.

Table 1-6: Diatom indices implemented in the Hendrina Wet Ash Disposal facility assessment

Diatom Index	Abbreviation
Percentage Pollution Tolerant Valves (Kelly & Whitton, 1995)	**%PTV**
Van Dam Ecological Scores for pH (Van Dam, 1994)	**-**

1.4.6. Macroinvertebrate Sampling and Field Identification

Aquatic macroinvertebrates were collected using the sampling protocol of the South African Scoring System version 5 or SASS5 (Dickens & Graham, 2002). The protocol is divided between three biotopes, namely Vegetation (VEG), Stones-In-Current (SIC) and Gravel-Sand-Mud (GSM). Samples were collected in an invertebrate net with a pore size of 1000 microns on a 30cm x 30cm frame by kick sampling of SIC and GSM, and sweeping of VEG for a standardised time or area. Macroinvertebrates were identified to family level in the field according to the SASS5 protocol and using relative reference guides (Dickens & Graham, 2002; Gerber & Gabriel, 2002). Please refer to Section 1.5 for details on the limitation of applying this methodology in the context of this assessment.

1.4.7. Fish Assessment

Fish survey methodology was undertaken according to Kleynhans (2007). Fish were sampled at respective sites by means of electro-narcosis (electro-shocking). Each segment was subjected to no less than 60 minutes of electro-shocking. Notes were made of velocity depth classes sampled and conclusions where made within these flow limitations.

1.4.8. Wetland Delineation and Classification

Field surveys were conducted during July 2011 and August 2014 whereby a 1:10 000 desktop delineation was verified. Verification efforts were concentrated on wetlands within the primary study area, directly affected by the placement of the wet ash disposal facility and associated infrastructure. The delineation was in line with the wetland and riparian delineation guideline set forth by DWAF (2005) in: "*A practical Guideline Procedure for the Identification and Delineation of Wetlands and Riparian Zones*".

The wetland delineation procedure identified the outer edge of the temporary zone of identified wetlands, which marks the boundary between the wetland and adjacent terrestrial areas. Please refer to Section 1.5 for limitations associated with wetland delineation. According to the GDACE (2008) requirements for wetland assessments, the temporary zone is that part of the wetland that remains flooded or saturated close to the soil surface for only a few weeks in the year, but long enough to develop anaerobic conditions and determine the nature of the plants growing in the soil.

The desktop delineation was verified during the field assessment in the following manner:

- The outer edge of each wetland was determined and sporadic verification determined the periphery of each wetland.
- The assessment made particular reference to indicators of prolonged saturation by water, namely wetland plants (hydrophytes) and wetland soils (hydromorphic soils), while soil wetness was also noted.
- Terrain unit indicators were used to ascertain likely areas of wetness.

The wetland areas identified were classified according to a classification system developed by Ollis, *et al.,* (2013) (**Table 1-7**). The Hydrogeomorphic (HGM) classification system uses the morphology and hydrological features of wetlands to classify them into units (**Table 1-7**). The features that are assessed relate to the way in which water behaves in the wetland system.

Table 1-7: Wetland classification system (Adapted from Ollis, *et al.,* 2013)

Landscape Unit	
Valley Floor	The base of a valley, situated between two distinct valley side slopes, where alluvial or fluvial processes typically dominate.
Slope	An inclined stretch of ground typically located on the side of a mountain, hill or valley floor. Includes scarp slopes, mid-slopes and foot-slopes.
Plain	An extensive area of low relief. These areas are generally characterised by relatively level, gently undulating or uniform sloping land with very gently gradient that is not located within a valley. Gradient is typically lest than 0.01.
Bench	A relatively discrete area of mostly level or nearly level high ground, including hilltops, saddles and shelves. Benches are significantly less extensive than plains, typically being less than 50 ha in area.

Hydrogeomorphic (HGM) Unit		**Hydrological Regime**
River	A linear landform with clearly discernible bed and banks, which permanently or periodically carries concentrated flow of water. A river is taken to include both the active channel and the riparian zone as a unit.	**Perenniality**
Floodplain wetland	A wetland area on the mostly flat or gently-sloping land adjacent to and formed by an alluvial river channel, und its present climate and sediment load, which is subject to periodic inundation by over-topping of the channel bank.	**Period and depth of inundation** **Period of saturation**
Channelled valley-bottom wetland	Located on a mostly flat wetland area located along a valley floor, with a river channel running through it. Often connected to an upstream or adjoining river channel.	
Unchannelled valley-bottom wetland	Located on a mostly flat wetland area located along a valley floor, without a river channel running through it. Often connected to an upstream or adjoining river channel.	
Depression	A wetland or aquatic ecosystem with closed (or near-closed) elevation contours, which increases in depth from the perimeter to a central area of greatest depth and within which water typically accumulates.	
Seep	A wetland area located on gently to steeply sloping land and dominated by colluvial, unidirectional movement of water and material down-slope.	
Wetland flat	A level or near-level wetland area that is not fed by water from a river channel, and which is typically situated on a plain or a bench.	

Table 1-8: Descriptor classification for salinity and pH (Ollis *et al.,* 2013)

	Salinity	
	TDS (ppm)	EC (µS/cm)
Fresh	<3000	<5000
Brackish	3000-18000	5000-30000
Saline	18000-48000	30000-80000
Hypersaline	>48000	>80000
	pH	
Acid	< 6	
Circum-neutral	6-8	
Alkaline	>8	

1.4.9. *WET- Health*

A *WET-Health* assessment was undertaken to ascertain the PES (**Table 1-9**) of the wetland systems located within a 500 m boundary of Alternative E and the proposed power distribution lines, according to the methodology set out by Macfarlane *et al*. (2009). Wetland health is defined as “a measure of the similarity of a wetland to a natural of reference condition” (Macfarlane *et al*., 2009).

The *WET-Health* index considers the state of the 3 main functional aspects of the wetland units, namely hydrology, geomorphology and vegetation. A Level 2 assessment was carried out for Wetlands 1, 2, 6, 7, 8, 9, and 10 respectively, with a Level 1 assessment carried out for Wetlands 3, 4, 5, 11 and 12 respectively. Briefly discussed below:

Level 1 assessment	- primarily a desktop level evaluation with limited field verification.
Level 2 assessment	- encompasses structured data collection with regards to the wetland and its catchment.

Table 1-9: Health categories used by *WET-Health* for describing the hydrological integrity of wetlands (Adapted from Macfarlane *et al.*, 2009)

Description	Impact Score Range	PES Category
No discernible modifications or the modifications are of such a nature that they have no impact on the hydrological integrity.	0-0.9	A
Although identifiable, the impacts of the modifications on the hydrological integrity are small.	1-1.9	B
The impact of the modifications on the hydrological integrity is clearly identifiable, but limited.	2-3.9	C
The impact of the modifications is clearly detrimental to the hydrological integrity. Approximately 50% of the hydrological integrity has been lost.	4-5.9	D
Modifications clearly have an adverse effect on the hydrological integrity. 51% to 79% of the hydrological integrity has been lost.	6-7.9	E
Modifications are so great that the hydrological functioning has been drastically altered. 80% or more of the hydrological integrity has been lost.	8 - 10	F

1.4.10. Wet EcoServices

A *WET-EcoServices* assessment was used to assess the "ecological goods and services" provided by each particular HGM wetland unit. This tool provides information on the importance of a wetland in delivering different ecosystem services under a number of different categories (Kotze, *et al.*, 2009). A Level 2 assessment was carried out for Wetlands 1, 2, 6, 7, 8, 9, and 10 respectively,

1.4.11. Ecological Importance and Sensitivity

Ecological Importance and Sensitivity scores were calculated using the RDM (Kleynhans, 1999) methods. Information from the baseline biodiversity assessment, *WET health* and *WET EcoServices* were taken into account when populating the EIS scores. Scoring guidelines are shown in **Table 1-10**, and categories are noted in **Table 1-11**.

Table 1-10: Scoring guidelines for each attribute considered in determining the EIS (Kleynhans, 1999)

EIS Score	
Very high	4
High	3
Moderate	2
Marginal/low	1
None	0
Confidence Score	
Very high confidence	4
High confidence	3
Moderate confidence	2
Marginal/low confidence	1

Table 1-11: Ecological Importance and Sensitivity categories and the interpretation of scores for biota and habitat determinants (Kleynhans, 1999)

Ecological Importance and Sensitivity 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

1.4.12. Impact Assessment

The impact assessment, in the context of this assessment, was viewed as a probabilistic potential for loss of ecological functioning of associated surface water systems. The impact assessment format was standardised between specialists for consistency in data. It utilised severity and incidence approach, where severity consists of magnitude and probability, while incidence considers duration and extent.

1.5. Assumptions and Limitations

1.5.1. General

This report is limited to the spatial and temporal extents as indicated and described in the proposal. A total assessment of all probable scenarios or circumstances that may exist on the study site 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.

1.5.2. Alternative Labelling

The augmentation of the scope of work included the removal of distribution line Alternative 1, and remaining alternatives were therefore numbered from 2 onwards.

1.5.3. SASS5 Methodology

According to the SASS5 protocol (Dickens and Graham, 2002), SASS5 methodology should only be carried out in wadeable rivers and stream. Due to the nature of the sites assessed, the SASS5 methodology could not be implemented. Subsequent SASS5 results should be interpreted with caution. In the context of this assessment a relative measure of ecological intactness between monitoring sites and between monitoring intervals may be inferred. No ecological classification was done based on the invertebrate response metric as this was deemed inappropriate. Similarly the invertebrate habitat assessment does not provide an ecological category and does not provide a measure for anthropogenic disturbances. It simply provides a measure to gauge available invertebrate habitat and provides a platform for comparison between monitoring sites.

1.5.4. Fish Assessment

The fish assessment is based on a review of available information and a once-off field survey at two strategically placed sites in the local study area. Spot surveys provide limited data and are likely to exclude species due to time restraints. Fish assemblages are dynamic and highly complex, a more reliable assessment of the current integrity of fish assemblages associated with the area of study would require seasonal sampling. However, this is not considered necessary for the purpose of the study.

1.5.5. Wetland Delineation

The following limitations are associated with the delineation of wetlands within the study area:

- Desktop wetland delineation was done on a 1:10 000 scale. Where access allowed wetlands were verified, however, not all wetland boundaries were walked.
- Large parts of the area have been transformed in terms of soil profile and morphology, which to a large extent influenced the effective use of hydromorphic indicators to determine the wetland boundaries.
- Portions of the study area have been disturbed by soil removal, dumping and infilling associated with a numerous anthropogenic activities. Affected areas form continuous patches of landscape, which is expected to obscure the presence of hydromorphic features in these areas.
- Wetland plants were not used as indicators of prolonged saturation during the August 2014 field assessment due to winter dieback and recent fires.

2. Description of the Project

Hendrina Power Station is a coal fired power station which Eskom is currently operating as part of its power generating fleet. Wet ashing is employed by the power station as a means of disposing the generated ash. Two of the ash dams have presently reached their capacity, while the third remaining ash dam is believed to reach its capacity within the next five years due to stability concerns. In order to continue ashing, Hendrina Power Station intends to extend the footprint of its ashing facility in order to accommodate the ashing requirements of the plant for the remainder of its life, during which it is expected to produce approximately 44.8 million m^3 of ash,

The proposed development has the following specifications:

- Capacity of air space: 173 633 14 m^3.
- Ground footprint: 100 Ha.
- The proposed ash disposal facility should be able to accommodate the ashing requirements of the power station for the next 20 years.

3. Description of the Affected Environment

3.1. Study Area Description

3.1.1. Ecoregion Characteristics

The study area is located in the western parts of Mpumalanga province within the Olifants Water Management Area (WMA), and falls predominantly within the Eastern Highveld grassland with isolated patches consisting of Eastern Temperate Freshwater wetlands (**Table 3-1**). The desktop review indicated that surface water systems are located in quaternary catchment B12B (**Figure 3-1**). Landscape features for the Eastern grassland biome includes slight 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 3-1**). 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 °C for Eastern Highveld grassland and 14.9 °C 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 3-1**).

Table 3-1: 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
Quaternary Catchment	**B12B**	
MAP	726 mm	704 mm
MAT	14.7 °C	14.9 °C
MFD	32 d	38 d
MAPE	1950 mm	1953 d
MASR	0.0563 m	0.0563 m
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

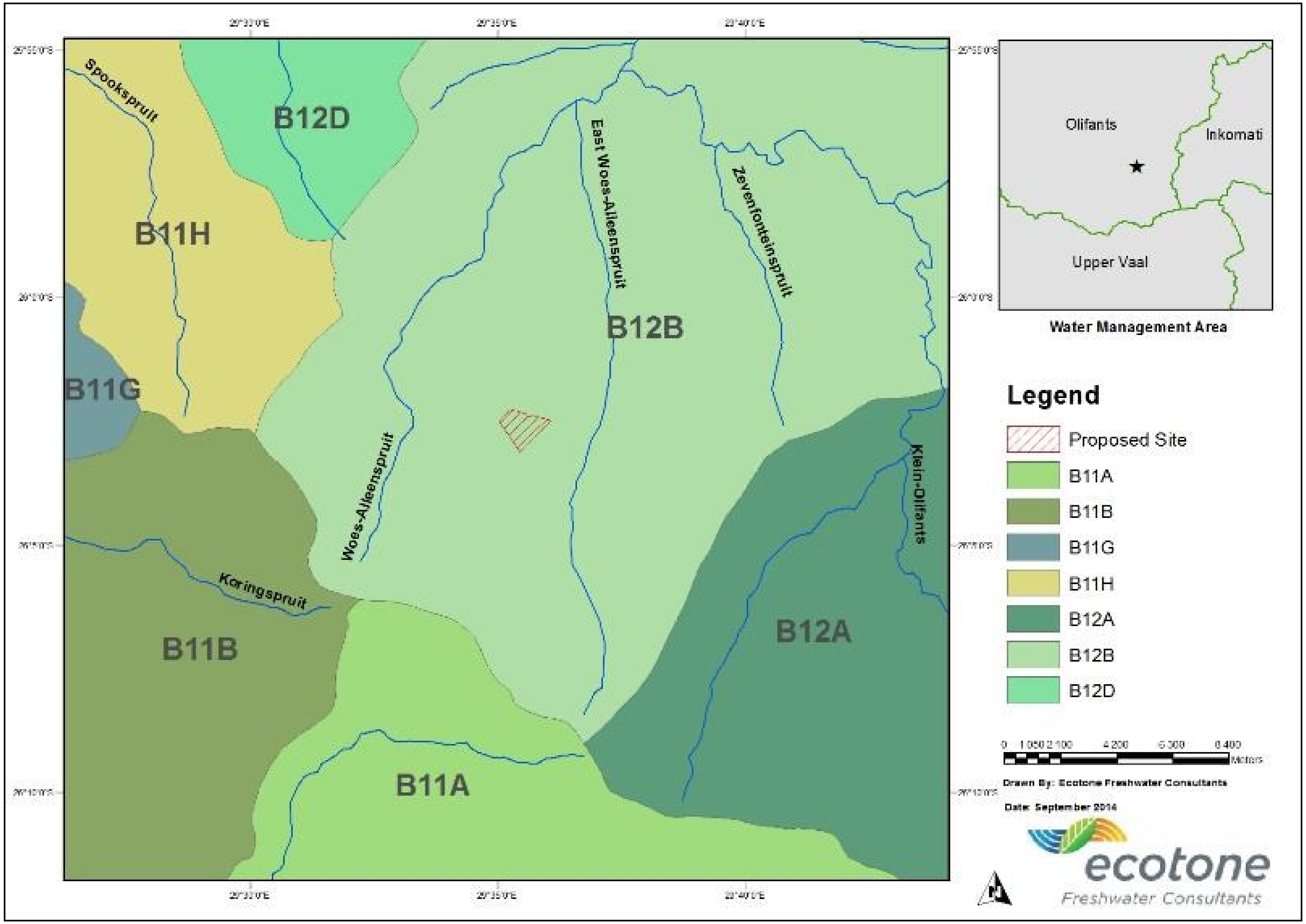


Figure 3-1: Map showing the study area and main rivers in relation with associated quaternary catchments (DWAF, 1995; DWAF, 2004c; Nel *et al.,* 2004; Chief Directorate – Surveys and Mapping).

3.1.2. Watercourse Characterisation

A characterisation of watercourses in the study area reveals that the receiving Klein-Olifants River is an order three river (**Table 3-2**). 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 Woes-Alleen systems according to the NSBA (Nel *et al*., 2004) fall within a D-category. This relates to a largely transformed ecosystem state (**Table 3-2**). 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 for the sub-quaternary catchments from DWA (2011), the Klein Olifants, Woes-Alleen and East Woes-Alleen rivers in quaternary catchment B12B fall in a D and E ecological categories, relating to largely and critically modified ecosystems clear community modifications and serious impairment of health evident. The quaternary 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 EI (Ecological Importance) and ES (Ecological Sensitivity) (DWA, 2011) is considered *moderate* and *low* for all rivers, however ES for the Woes-Alleenspruit is considered *high* due to the intolerance of fish, macroinvertebrates and riparian vegetation to changes in water quality and hydrology (DWA, 2011).

The Conservation Management Plan for Mpumalanga (Lötter & Ferrar, 2007) shows the proposed development falls within a sub-catchment considered to be highly significant in its contribution towards aquatic biodiversity. Factors considered in the assessment significance assessment include: migration, species richness and refuge. Most of the surface water systems are perennial systems. Nel *et al.* (2004) lists an ecosystem threat status of critically endangered for all the river signatures associated with the study area. The ascribed river signatures indicate 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).

The NFEPA wetland data indicated that the wetland flats, channelled valley bottoms, unchannelled valley bottom, depressions, seeps and valley head seeps associated with the Mesic Highveld Grassland Group 4 carries a treatment status of C*ritically Endangered* (**Table 3-2**; **Figure 3-3**). However, none of the wetlands associated with the study area are considered to be NFEPA wetlands. It should be noted that the NFEPA wetland data set is inconsistent with the results from the field assessment, both in wetland extent and HGM classification.

Table 3-2: Desktop river characterisation of the Klein-Olifants and Woes-Alleen and East Woes-Alleen system (DWA, 2000; Nel *et al.*, 2004)

	Klein-Olifants River	Woes-Alleen System	East- Woes-Alleen System
River Order	3	1	1
Quaternary Catchment	B12B	B12B	B12B
Sub-Quaternary Catchment	B12B-01217	B12B-01223	B12B-01233
Class	Perennial	Perennial	Perennial
PES (NSBA)	**D**	**D**	**D**
PES (DWAF, 2000)	**C**	**C**	**C**
EIS (DWAF, 2000)	**Moderate**	**Moderate**	**Moderate**
PES (DWA, 2011)	**D**	**E**	**E**
EI (DWA, 2011)	**Moderate**	**Moderate**	**Low**
ES (DWA, 2011)	**Moderate**	**High**	**Moderate**
Conservation Status (NSBA)	Critically Endangered	Critically Endangered	Critically Endangered
NFEPA wetland (Nel *et al.*, 2011)	Critically Endangered	Critically Endangered	Critically Endangered

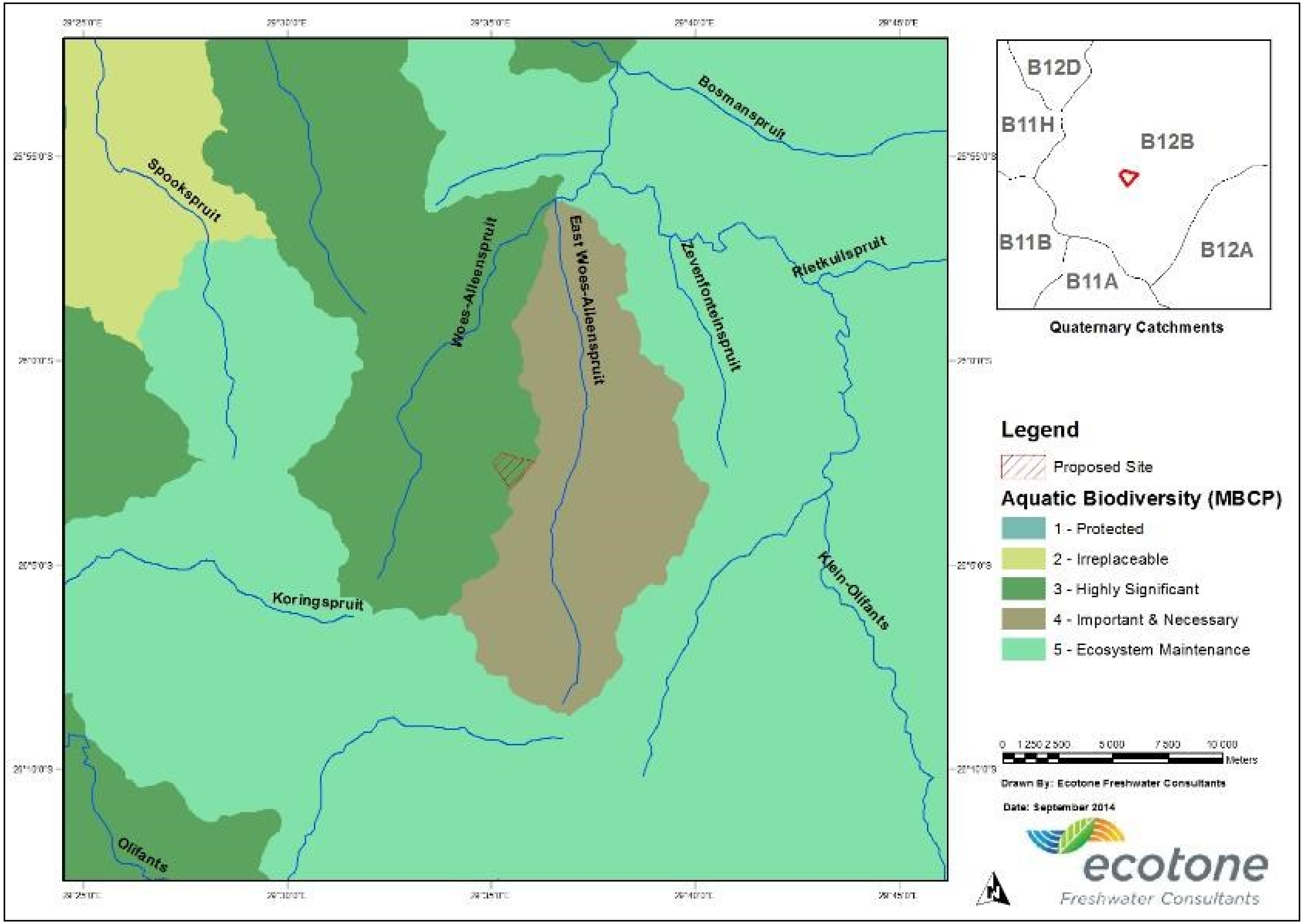


Figure 3-2: Map indicating the study area in relation to the MBCP (DWAF, 1995; Nel *et al.*, 2004; Ferrar & Lötter, 2007).

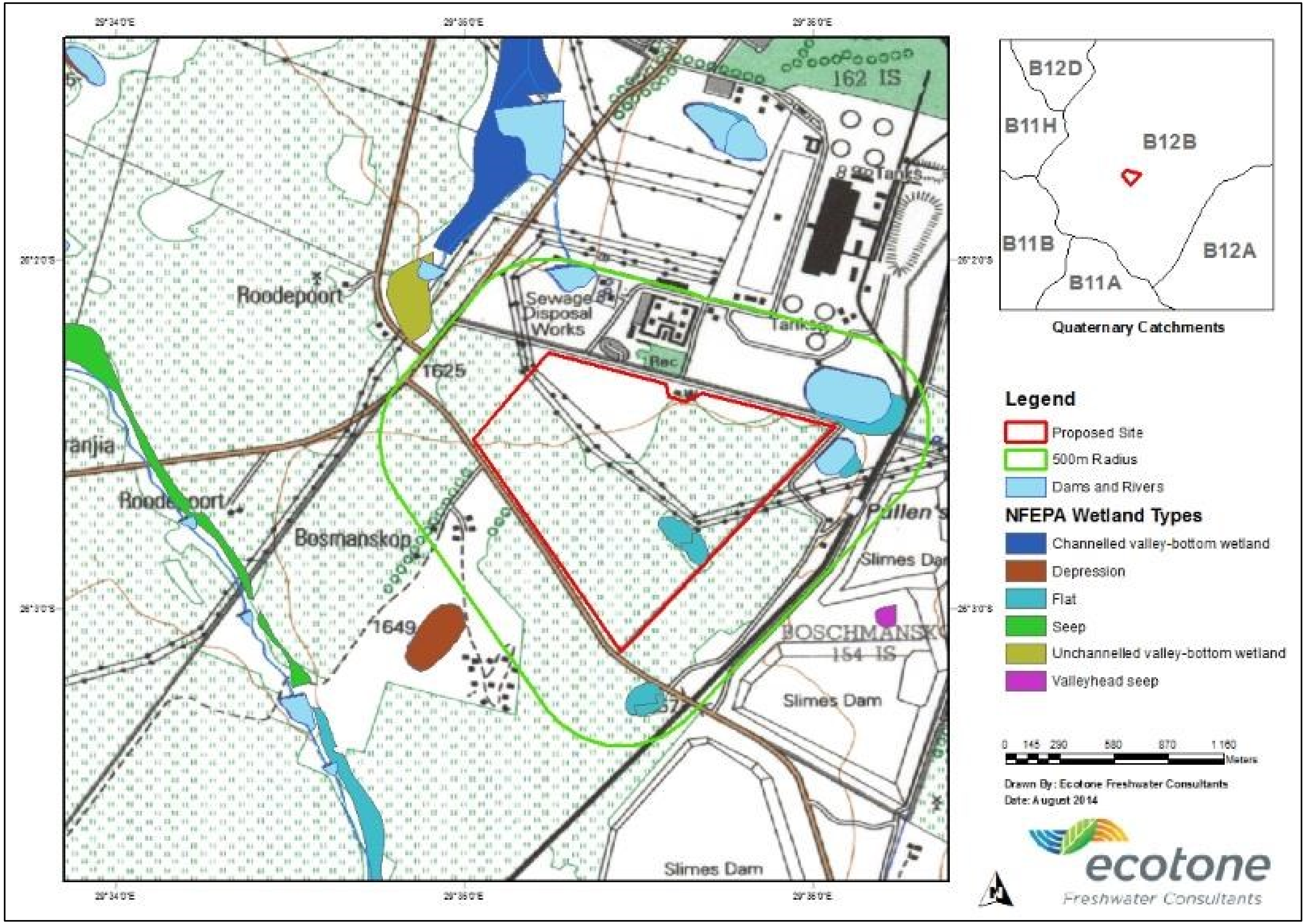


Figure 3-3: Map indicating the study area in relation to the NFEPA wetland types (Nel *et al*., 2004; Nel *et al.,* 2011).

3.1.3. Catchment 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 will grow in the near future therefore increasing the water requirement in the Sub-Area (**Table 3-3**). 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, 2004a).

Table 3-3: Reconciliation of water requirements and availability (million m³/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

3.2. Field Survey

3.2.1. Water Quality

In situ values measured for the two instream aquatic monitoring points were compared to benchmark criteria as set out by Kotze 2002 (**Table 3-4**). Both the pH and EC values fell within the ideal range for the protection of aquatic ecosystems (**Table 3-4**). However spatial variation in conductivity suggests different ionic composition associated with the two wetland systems and possibly different sources. Dissolved oxygen levels were below the Ideal level for both sites assessed, with Intolerably low levels measured at site HA2.

Table 3-4: *In situ* water quality values for sites HA1 and 2 respectively, July 2011

Variable	Unit	HA1	HA2
pH	[H^{1}+ ions]	7.48	7.02
EC	µS-cm^{-1}	394.2	437.0
TDS	ppm	311.7	345.8
Temp.	°C	8.13	8.62
DO	mg/l	**5.23**	**3.39**
DO (%)	%	64.7	41.2

🟨 **Ideal** (Kotze, 2002)
🟧 **Tolerable** (Kotze, 2002)
🟫 **Intolerable** (Kotze, 2002)

The descriptor classification for salinity and pH by Ollis *et al*., 2013 was used to classify and compare between wetlands based on *in situ* variables measured (please refer to **Table 1-8**). The *in situ* water quality indicators measured in the wetlands assessed during the August 2014 field assessment are shown in **Table 3-5** and **Figure 3-4**. According to Ollis et al., 2013 all of the assessed sites indicated a brackish salinity with circum-neutral pH values, with site WQ6 having the lowest salt loads and TDS values, and site WQ5 having the highest salt loads and TDS values. Site WQ5 is located directly downstream of WQ6. However, site WQ6 was measured in a large dam, and dilution factors need to be considered. The downstream improvement in salt loads observed in WQ4 and WQ3 highlighted the effectiveness of the EcoServices provided by the system in question (**Figure 3-4**).

Table 3-5: *In situ* water quality values for wetland assessed, August 2014

Abb.	Unit	WQ1	WQ2	WQ3	WQ4	WQ5	WQ6	WQ7	WQ8
pH	[H^1+ ions]	7.54	7.38	7.42	7.29	7.34	7.72	7.49	7.05
EC	µS-m^{-1}	1106	1020	812	972	1404	390	456	1352
TDS	ppm	769	719	578	690	1001	277	320	956
Temp.	°C	20.0	20.4	21.2	20.7	20.3	16.8	20.5	14.7

EC = Electrical Conductivity, TDS = Total Dissolved Solids

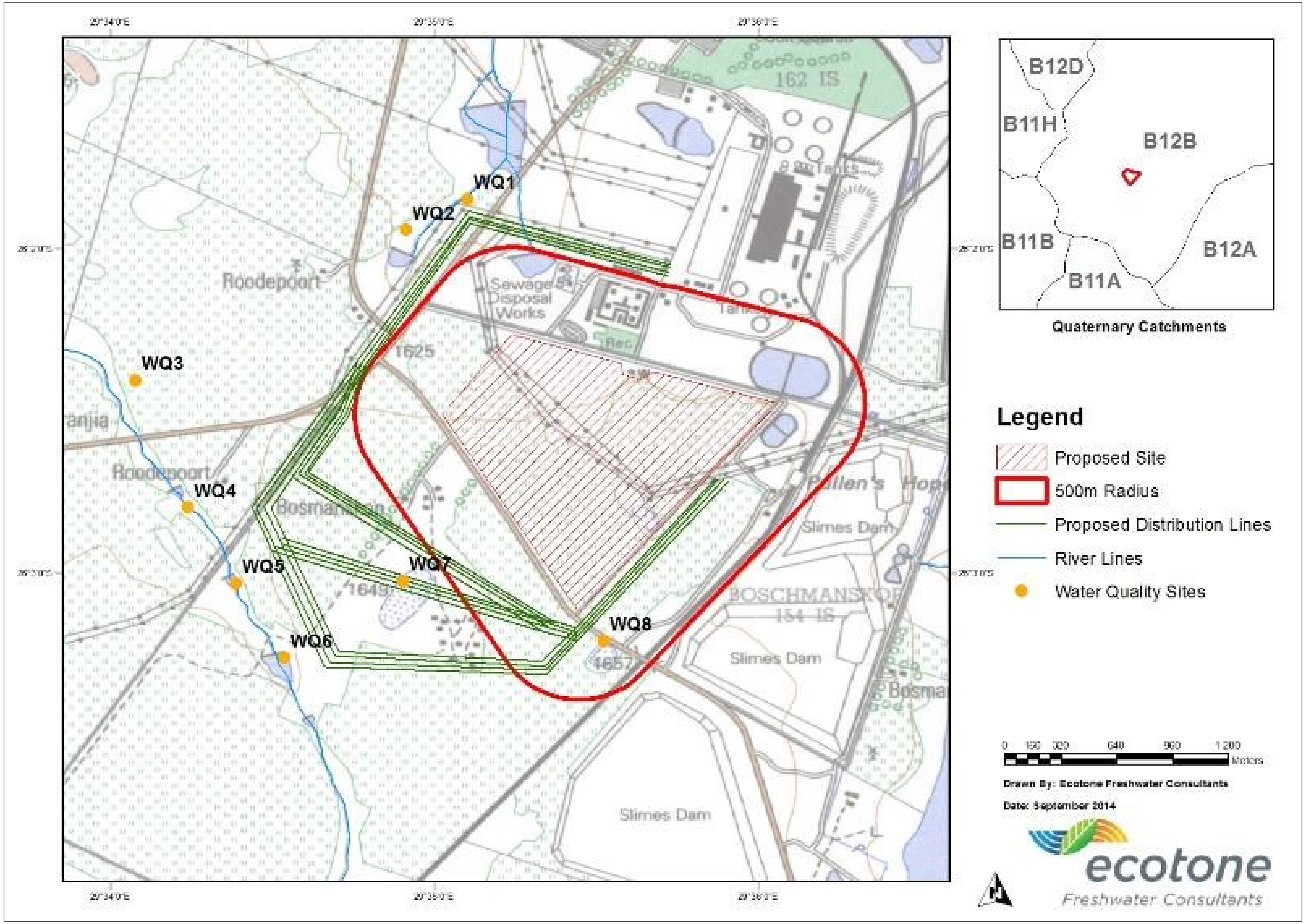


Figure 3-4: Map showing the proposed alternative and associated water quality sites (DWAF, 1995; DWAF, 2004; Nel *et al.,* 2004;; Chief Directorate – Surveys and Mapping).

3.2.2. Habitat Assessment

Invertebrate Habitat Assessment Score

Habitat availability is a major determinant of the overall aquatic macroinvertebrate community structure. The application of IHAS, in the context of this survey, provides a measure of habitat availability for macroinvertebrate colonisation at both sites respectively. The results obtained from the Invertebrate Habitat Assessment are shown in **Table 3-6**.

The results obtained from the IHAS assessment indicated that the habitat availability at both sites HA1 and 2 were poor, reflecting IHAS scores of 28.38 and 56.76 % respectively. Site HA1 lacked stones both in and out of current, as well as gravel habitat which resulted in the low IHAS score. Site HA2 also classed as "poor" but did obtain a higher IHAS score than site HA1. The construction of the dam at site HA2 has resulted in the formation of riffles habitat directly downstream of the dam (**Figure 9-3 B**) providing more habitat for macroinvertebrate colonisation.

Table 3-6: Invertebrate Habitat Assessment version 2 (IHAS v.2) score for sites during the July 2011 survey

	HA1	**HA2**
Stones in Current	0	17
Vegetation	11	14
Other Habitat	**10**	**11**
Total IHAS (%)	**28.38**	**56.76**
Class	**Poor**	**Poor**

Fish Habitat Assessment

The dominant fish habitat type linked with site HA1 included overhanging vegetation and water column, associated almost entirely with a slow deep velocity class (**Table 3-7**). Aquatic vegetation was absent at site HA1 at the time of sampling. Similar to that noted at site HA1, the dominant habitat type at site HA2 was overhanging vegetation and water column, however, aquatic vegetation was present at site HA2 providing potential fish habitat. On the contrary, site HA2 was dominated by both fast deep and fast shallow velocity depth classes (**Table 3-7**).

Table 3-7: Fish habitat and cover ratings noted for sites HA1 and 2

Habitat and velocity type	HA1	HA2
Dominant Habitat Type:		
Overhanging vegetation	35.29	23.73
Undercut banks and root wads	11.76	15.25
Substrate	17.65	13.56
Aquatic macrophytes	0.00	23.73
Water column	35.29	23.73
Velocity Depth Class %:		
Slow Deep	82.35	33.90
Slow Shallow	17.65	13.56
Fast Deep	0.00	30.51
Fast Shallow	0.00	22.03
🟩	Dominant type	

3.3. Diatom Assessment

A total of 62 diatom species were sampled in the July 2011 survey. No rare or endemic species were noted. Species richness for sites HA1 and HA2 was 34 and 47 species respectively (**Table 3-8**). According to the Van Dam ecological index, both sites were in a eutrophic state. Site HA1 comprised mostly of nitrogen autotrophic taxa which tolerate elevated concentrations of organically bound nitrogen, where site HA2 comprised of nitrogen heterotrophic taxa which require periodically elevated concentrations of organically bound nitrogen (Van Dam, 1994).

Table 3-8: Diatom index scores for Hendrina study sites showing %PTV and Van Dam scores

Site	No. species	Nitrogen uptake	Trophic State	%PTV
HA1	34	Nitrogen autotrophic taxa	Eutrophic	65%
HA2	47	Nitrogen-heterotrophic taxa	Eutrophic	43.85%

PTV = Pollution Tolerant Valves

Site HA1 showed a species composition that is characterised by pollution tolerant species that are associated with circum-neutral; eutrophic waters with low oxygen content (**Table 3-8**). Overall the water quality is poor with a high %PTV of 65% indicating that the system is impacted by organic material. As shown in **Table 3-9**, the site is dominated by the *Nitzschia* group which indicates that the system is in an impacted and degraded state (Krammer and Horst Lange-Bertalot, 2000). More specifically the dominant *Nitzschia palea*, a species found in extremely polluted waters with elevated electrolytes, nutrients and organics verifies that the system is disturbed. The presence of dominant *Nitzschia archibaldii*, and less dominant *Nitzschia nana* and *Nitzschia pura* may however suggest that pollution levels at this site tend to be more moderate, as these species are known to tolerate only moderately polluted waters.

Site HA2 comprised of diatoms that indicate a poor water quality with moderate organic content (43.8 % PTV). The diatom community is indicative of circum-neutral, low oxygenated waters with eutrophic conditions (**Table 3-8**). The presence of *Fragilaria fasciculata* and *Fragilaria pulchella* has been reported from critically polluted industrial and mining wastewaters. Other taxa recorded at this site are all extremely pollution tolerant species such *Sellaphora seminulum*, *Eolimna minima*, *Nitzschia palea, Nitzschia paleacea* and *Gomphonema parvulum*, and strongly imply that this site is severely impacted primarily from elevated electrolytes and nutrients.

Table 3-9: Dominant diatom species identified for study sites

Taxa	HA1	HA2
Achnanthidium (including *A. minutissimum*) F.T. Kützing	7	5
Achnanthes J.B.M. Bory de St. Vincent	0	17
Achnanthidium exiguum (Grunow) Czarnecki	0	5
Asterionella formosa Hassall	1	0
Aulacoseira granulata (Ehr.) Simonsen var.*angustissima*	3	1
Aulacoseira granulata (Ehr.) Simonsen	1	1
Caloneis bacillum (Grunow) Cleve	1	0
Craticula halophila (Grunow ex Van Heurck) Mann	0	1
Cyclotella meneghiniana Kützing	0	6
Cocconeis C.G. Ehrenberg	0	2
Cocconeis placentula Ehrenberg var. placentula	1	1
Diatoma vulgaris Bory	1	0
Encyonema minutum (Hilse in Rabh.) D.G. Mann	2	0
Eolimna minima(Grunow) Lange-Bertalot	9	19
Fragilaria biceps (Kützing) Lange-Bertalot	0	1
Fragilaria capucina Desmazieres var.*capucina*	9	26
Fragilaria capucina Desmazieres var. *rumpens* (Kützing)	12	41
Fragilaria fasciculata (C.A. Agardh) Lange-Bertalot sensu lato	0	1
Fragilaria nanana Lange-Bertalot	1	0
Fragilaria pulchella (Ralfs ex Kütz.) Lange-Bertalot (Ctenophora)	0	4
Fragilaria H.C. Lyngbye	11	3
Fragilaria tenera (W.Smith) Lange-Bertalot	3	0
Fragilaria ulna (Nitzsch.)Lange-Bertalot var.acus (Kütz.) Lange-Berta	1	1
Fragilaria ulna (Nitzsch.) Lange-Bertalot var. ulna	0	5
Gomphonema acuminatum Ehrenberg	0	4
Gomphonema affine Kützing	0	1
Gomphonema C.G. Ehrenberg	0	4
Gomphonema parvulum (Kützing) Kützing var. *parvulum* f. *parvulum*	5	20
Gomphonema pseudoaugur Lange-Bertalot	0	6
Lemnicola hungarica (Grunow) Round & Basson	0	1
Mayamaea atomus var. *permitis* (Hustedt) Lange-Bertalot	2	1
Melosira varians Agardh	0	6
Nitzschia acicularis(Kützing) W.M.Smith	1	0
Navicula antonii Lange-Bertalot	0	5

Taxa	HA1	HA2
Navicula J.B.M. Bory de St. Vincent	2	8
Nitzschia capitellata Hustedt in A.Schmidt & al.	0	12
Navicula capitatoradiata Germain	0	3
Nitzschia dissipata(Kützing)Grunow var.dissipata	0	4
Nitzschia draveillensis Coste & Ricard	▨ 39	2
Nitzschia filiformis (W.M.Smith) Van Heurck var. *filiformis*	0	7
Nitzschia fonticola Grunow in Cleve et Möller	0	5
Nitzschia archibaldii Lange-Bertalot	▨ 63	0
Nitzschia pura Hustedt	▨ 23	0
Nitzschia A.H. Hassall	▨ 71	▨ 40
Nitzschia linearis(Agardh) W.M.Smith var.*linearis*	5	2
Nitzschia linearis(Agardh) W.M.Smith var.*subtilis*(Grunow) Hustedt	1	0
Nitzschia nana Grunow in Van Heurck	19	0
Nitzschia paleacea (Grunow) Grunow in van Heurck	▨ 4	▨ 25
Nitzschia palea (Kützing) W.Smith	▨ 77	▨ 43
Nitzschia perspicua Cholnoky	14	0
Navicula radiosa Kützing	0	2
Navicula recens (Lange-Bertalot) Lange-Bertalot	1	0
Navicula riediana Lange-Bertalot & Rumrich	0	1
Navicula rostellata Kützing	0	5
Navicula trivialis Lange-Bertalot var. *trivialis*	2	4
Navicula veneta Kützing	6	4
Navicula zanoni Hustedt	0	3
Pinnularia C.G. Ehrenberg	1	0
Planothidium frequentissimum(Lange-Bertalot)Lange-Bertalot	0	1
Rhopalodia gibba (Ehr.) O.Muller var.gibba	0	2
Sellaphora seminulum (Grunow) D.G. Mann	0	▨ 39
Stenopterobia delicatissima (Lewis) Brebisson ex Van Heurck	1	0

▨ Dominant diatom species

3.4. Aquatic Macroinvertebrates Assemblage

The taxa that were sampled at site HA1 and 2 are reflected in **Table 3-10**. The invertebrate communities at both sites consisted mainly of highly tolerant taxa, with only a single moderately tolerant taxa sampled at both sites respectively (**Table 3-10**). Only four taxa were sampled at site HA1 compared to the nine sampled at site HA2. A distinction between habitat induced variation or possible pollution between sites, cannot conclusively be made, but the additional flow and substrate habitat available at site HA2 probably explains the measured differences.

A total of nine taxa were sampled at site HA2. The Diptera order was most represented, with three families sampled (Ceratopogonidae, Chironomidae and Simuliidae). High abundances (between 101 - 1000) of pollution tolerant Chironomidae and Simuliidae sampled also suggest contamination of surface water.

Both sites reflected low ASPT scores of 3.40 and 3.8 respectively as no sensitive taxa were sampled. This data will provide baseline information and may be used as comparison for future monitoring.

Table 3-10: Aquatic macroinvertebrate taxa, sensitivities and estimated abundances sampled, July 2011 survey (1 = 1 individual; A = 2 – 10; B = 11 – 100; C = 101 – 1000). * = air breathers

Order	Taxon	Sensitivity Score (Max 15)	HA1	HA2
ANNELIDA	Oligochaeta	1	A	B
	Hirudinea	3	-	B
DIPTERA	Ceratopogonidae	5	-	A
	Chironomidae	2	A	C
	Simuliidae	5	-	C
EPHEMEROPTERA	Baetidae 1sp	4	-	A
GASTROPODA	Physidae*	3	1	🟥
HEMIPTERA	Corixidae*	3	B	A
ACARINA	Hydracarina	8	A	A
	Turbellaria	3	-	1
No. of Taxa			**5**	**9**
ASPT			**3.4**	**3.8**

🟥	High tolerance to pollution
🟩	Moderate tolerance to pollution
🟦	Low tolerance to pollution

3.5. Fish Assessment

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 five families were expected to utilise surface water systems associated with the secondary study area (

Table 3-11). 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 but are not expected to occur in the study area (Kleynhans *et al.*, 2007) due to the lack of suitable habitat

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** 3-11).

Table 3-11: Fish species expected to utilise the river systems associated with the study area, in and around the quaternary catchment (B12A, B12B and B12C) (Kleynhans, *et al.*, 2007). Alien species are shown in orange while sensitive species are indicated in green. LC = Least Concern; DD = Data Deficient; EX = Exotic. Conservation status according to IUCN, 2011

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
EX	Poeciliidae	*Gambusia affinis*	Mosquito fish
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
EX	Centrarchidae	*Micropterus salmoides*	Largemouth bass
LC	Cichlidae	*Pseudocrenilabrus philander*	Southern mouthbrooder
LC	Cichlidae	*Tilapia sparrmanii*	Banded tilapia

🟧 Exotic / introduced
🟦 Data Deficient
🟩 Sensitive species

Of the two biomonitoring sites assessed only site HA2 yielded fish (**Table 3-12**). A large population of *Barbus neefi* was sampled at this site. *Barbus neefi* has preference for slow flowing water associated with overhanging vegetation and suitable substrate. This fish is also moderately intolerant to conditions of no flow, thus testifying to the perennial nature and constant discharge linked to site HA2. *Barbus neefi* is intolerant to changes in water quality and variation in abundances or frequency of occurrences of *B. neefi* will provide a future measure for potential impacts associated with the proposed wet ash disposal facility.

Barbus neefi has a divided distribution range, with some populations occurring in the upper Zambezi and Southern Zaire, as well as south occurring populations in tributaries of the Olifants and Limpopo systems (Skelton, 2001). The divided nature of the distribution as well as the limited southern distribution of this species ascribes a conservation importance. Minnows are also, usually, characterised by extensive genetic variation between populations, but a study done by Engelbrecht *et al.* (2002) confirmed that *B. neefi* populations in headwater streams have less genetic diversity than populations further downstream. This leaves headwater populations prone to genetic drift and inbreeding. Thus, if unidirectional genetic flow is important to maintain the genetic diversity from populations situated lower down in the river-system, it illustrates the importance of conserving headstream populations as they may provide novel alleles that will increase genetic diversity of downstream populations (Engelbrecht, *et al.,* 2002).

The absence of fish, despite suitable habitat, at site HA1 possibly indicated water quality, flow or migration impacts.

Table 3-12: Fish species sampled at sites HA1 and 2 respectively, July 2011

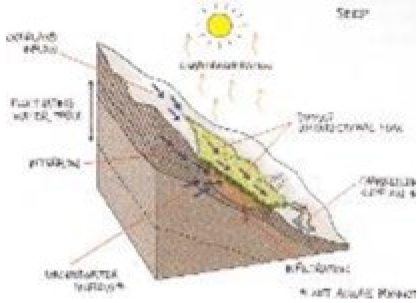
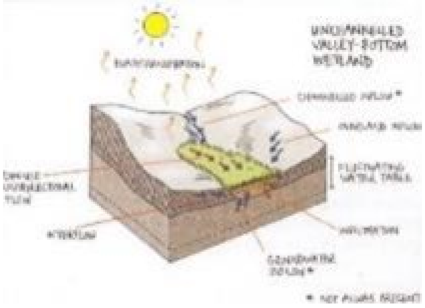
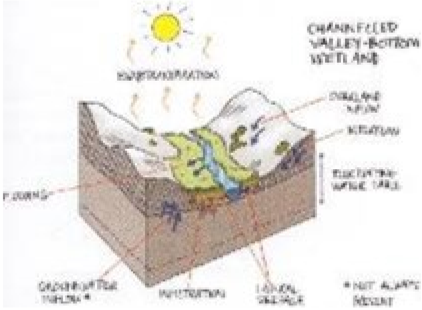
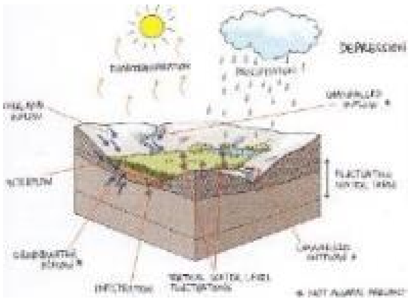
Species	**Common name**	**HA1**	**HA2**
Barbus neefi	Sidespot Barb	-	58

3.6. Wetland Classification and Delineation

3.6.1. Wetland Classification

The wetlands were delineated and assessed based on their HGM units. Four characteristic wetland types were identified within the primary and secondary study areas. The level four classification of these HGM units, in line with Ollis *et al.* (2013) included Channelled Valley Bottoms (CVBs), Unchannelled Valley Bottoms (UCVB), seeps and depressions (**Table 3-13**). Altogether, 12 wetlands were identified and 21 separate HGM units (**Figure 3-5** and **Figure 3-6**).

Table 3-13: Wetland HGM types associated with the study area (Ollis *et al.,* 2013)

Wetland Type		Description
Hillslope Seep (isolated or linked to a stream channel)		Slopes on hillsides, which are characterized by the colluvial (transported by gravity) movement of materials. Water inputs mainly from sub-surface flow and outflow either very limited, through diffuse sub-surface and/or surface flow, or with a direct surface water connection to a stream channel.
Un-channelled valley bottom		Valley bottom areas with no clearly defined stream channel usually gently sloped and characterized by alluvial sediment deposition, generally leading to a net accumulation of sediment. Water inputs mainly from channel entering the wetland and also from adjacent slopes.
Channelled valley bottom		Valley bottom areas with a well-defined stream channel but lacking characteristic floodplain features. May be gently sloped and characterized by the net accumulation of alluvial deposits or may have steeper slopes and be characterized by the net loss of sediment. Water inputs from main channel (when channel banks overspill) and from adjacent slopes.
Depression (includes Pans)		A basin shaped area with a closed elevation contour that allows for the accumulation of surface water (i.e. it is inward draining). It may also receive sub-surface water. An outlet is usually absent.

3.6.2. Soils

The study area consists of moderately deep, yellow brown to red, light to medium textured soils, with no significant degree of structure. Shallower soils with ferricrete outcrop also occurred within the study area (Patterson & Seabi, 2011). Within HGM 1 of Wetland 1, and in Wetland 3, 4, 5, 7 and 11, soils were characterised by Tukulu form, while Wetland 2, 6, 8 and 9 are characterised by Katspruit form. Wetland 10 was characterised by Longlands soil types. Seasonal zones were generally represented by Avalon forms. However for almost all of the wetlands, the temporary and much of the seasonal zone have been lost due to agricultural ploughing. The dominance of Plinthic soil in the primary study area is indicative of fluctuating perch water associated with the seasonal nature of the study area. The hydrological conductivity of the soil is relatively high; water thus drains easily to less permeable underlying geology, from where it flows as perched water. Perched water is expressed as surface wetness in the lower lying areas and seasonal wetness upslope of permanent/semi-permanent areas identified.

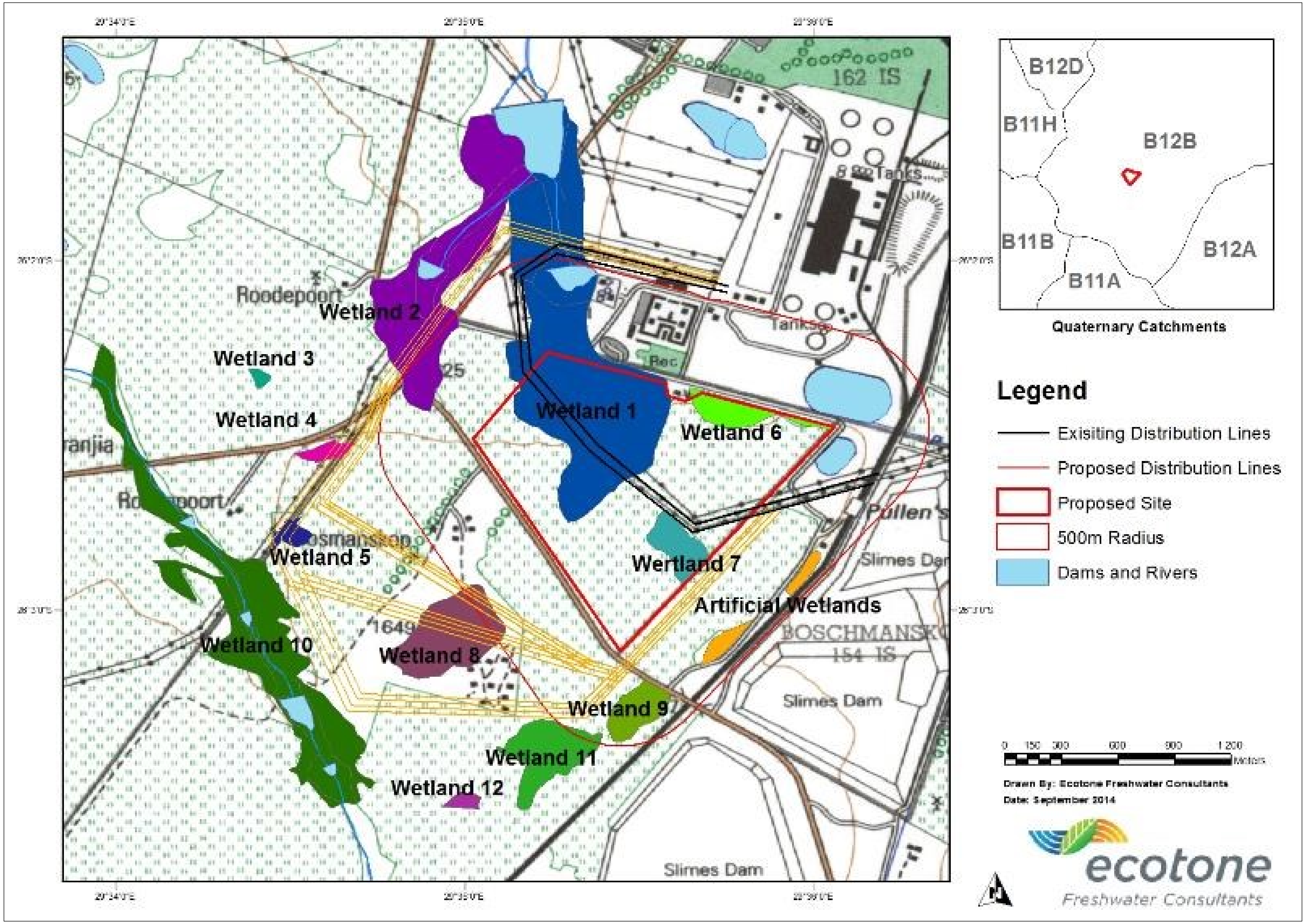


Figure 3-5: Map showing the different wetlands associated with the study area.

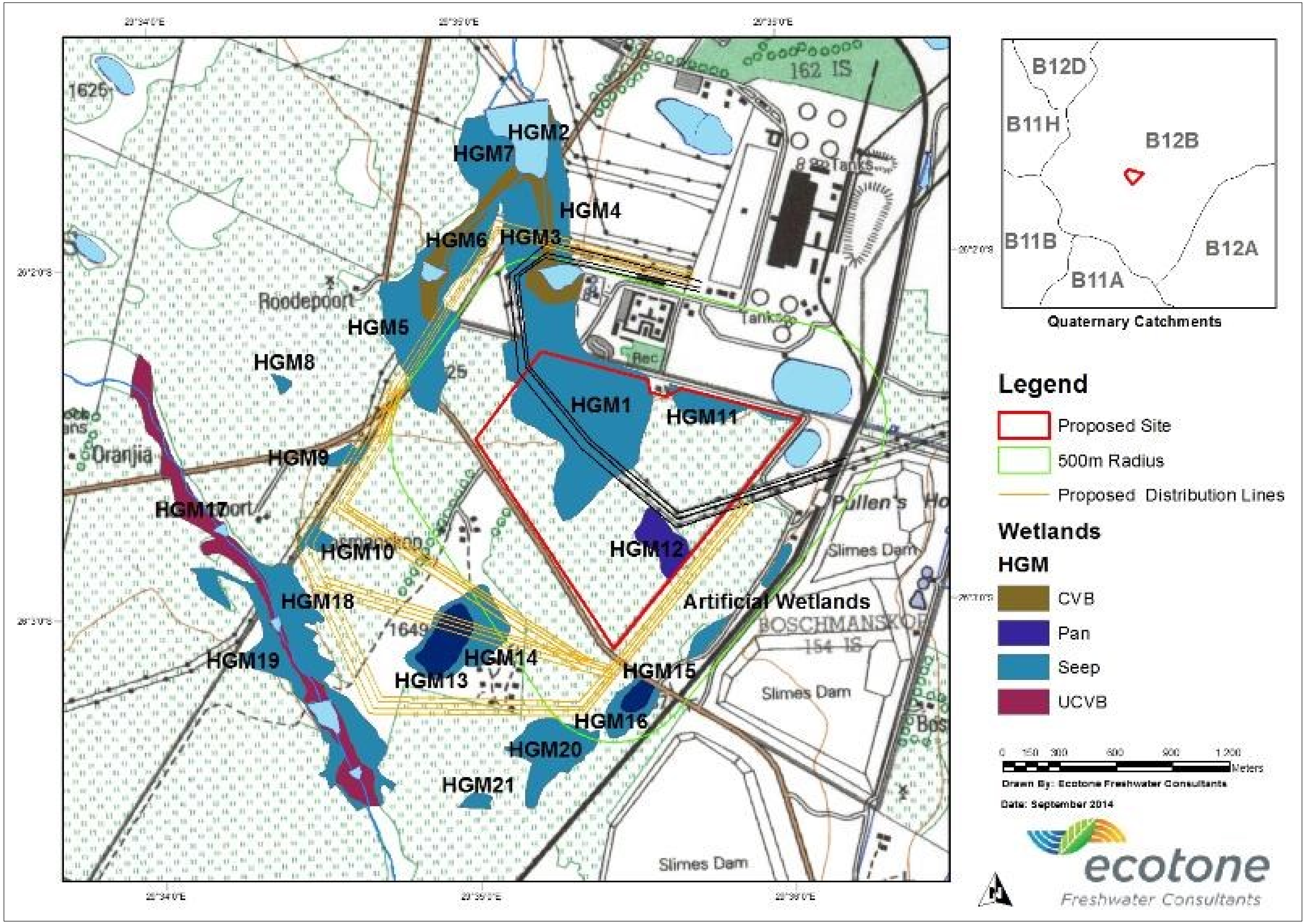


Figure 3-6: Map showing different HGM units and respective geomorphological classification.

Wetland 1 and 2 drain/or receive drainage from the North and North-western sections of the proposed footprint. These wetlands are important as they are most likely to receive runoff from the wet ash disposal facility during construction and operational phases. Clear variation in longitudinal slope associated with both wetlands warranted differentiation between higher lying seeps (with a steeper slope) abutting into channel valley bottom systems with a noted decrease in slope (**Figure 3-7** and **Figure 3-8**). Similarly both channel valley bottom systems (HGM 2 and 6) notably receive substantial lateral flows from surrounding hillslope seeps (HGM units 3, 4, 5 and 7) (**Figure 3-6**).

Wetland 1 composed of four structural units; three seeps and one channelled valley bottom system. Wetland 2 consisted of three HGM units: two seeps abutting into a channelled valley bottom system. Wetland 6, a seep, was located just east of Wetland 1 and appeared to be part of a remnant pan system, however due to access restriction during the field assessment this ambiguity remains unresolved. Wetland 7 consisted of a seasonal pan fringing on the eastern boundary of the proposed footprint. Both wetlands 8 and 9 were seasonal pan systems with associated seeps (**Figure 3-6**). Three of the HGM units were within the boundaries of the proposed ashing footprint (HGM 1, 11 and 12) (**Figure 3-6**). Of which HGM1 is considered the most important as it is the largest and drains into Wetland 1.

Both Wetlands 1 and 2 are drained by channel valley bottom systems receiving water from adjacent seeps. In both cases, the valley bottom systems were dammed extensively. Headwater seeps (HGM 1 and 5) both drain into dams, while HGM6 also has its confluence with HGM2 prior to flowing into a third dam. It is estimated that the three dams can contain approximately 70% of the mean annual runoff in their combined catchments.

Jointly, seeps make up the majority of wetlands in the study area. This is largely due to deep sandy soils (with high permeability) overlying a less permeable feature subsequently resulting in perch water with lateral movement. Hydrochemical characterisation of surface water sampled at HGM 1, associated with the proposed footprint, was compared to that of ground water sampled, but possible ground water discharge could not conclusively be eliminated (refer to hydrological report). However, the geographical setting suggests surface runoff expressed as perched water (**Figure 3-7** and **Figure 3-8**). Seeps within the study area are mostly seasonal but do express small isolated areas of permanent or mostly permanent zones. The dryer peripheries of most seeps have been cultivated in most instances, subsequently resulting in a complete loss of wetland habitat in affected areas.

Three seasonal pans have been identified in the study area; one of which falls within the primary study area, and two of which lie in close proximity, or in the direct path of the proposed power distribution line.

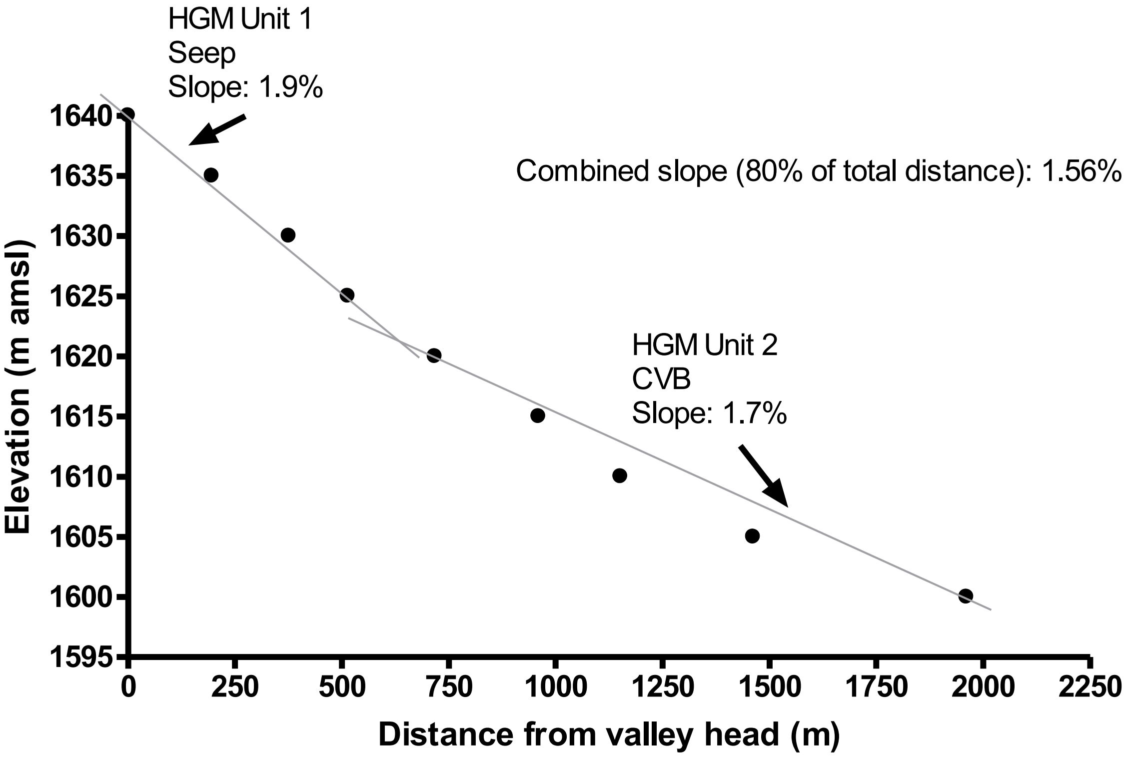


Figure 3-7: Longitudinal profile of HGM units in Wetland 1, showing different slopes between HGM1 (seep) and HGM2 (channelled valley bottom).

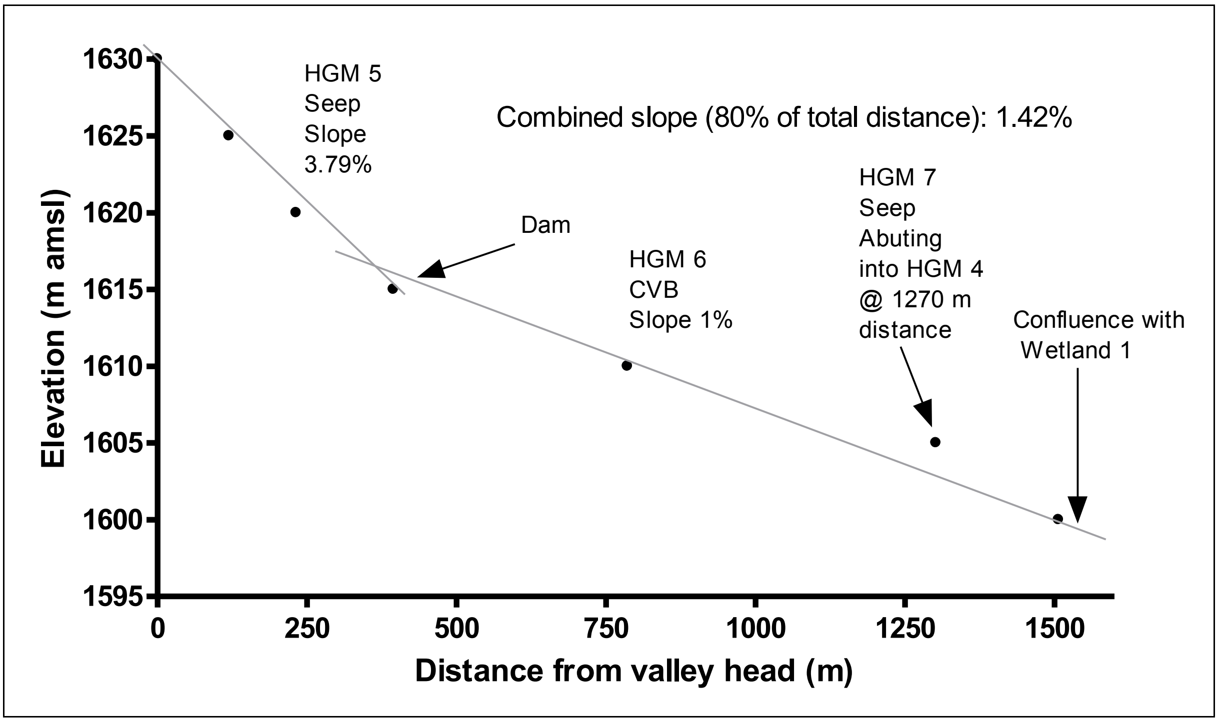


Figure 3-8: Longitudinal profile of HGM units in Wetland 2, showing different slopes for HGM5 (seep) draining into HGM6 (channel valley bottom). The abutment of HGM7 (seep) into HGM6 is also noted on the diagram.

Table 3-14 through **Table 3-16** reflects the approximate size and longitudinal slope associated with respective HGM units assessed. Respective catchment sizes are also reflected. Catchments of the two channelled valley bottom systems included those of abutting seeps. While the total catchment for Wetland 1 includes that of Wetland 2. Thus the catchment is approximately 750 hectares of which approximately 145 hectares are wetlands. Approximately 48 hectares of the proposed 140 hectare footprint is wetland.

Table 3-14: Approximate size of Wetlands 1, 2 and 9, their respective HGM units and catchments associated with the study area

	W1					W2		W6
	HGM1	**HGM2**	**HGM3**	**HGM4**	**HGM5**	**HGM6**	**HGM7**	**HGM11**
Catchment (ha)	88.30	639.20	9.70	117.30	181.80	190.30	51.80	102.30
HGM size (ha)	49.70	17.00	8.30	6.40	22.20	8.50	8.50	23.10
HGM	Seep	CVB	Seep	Seep	Seep	CVB	Seep	Seep

Table 3-15: Approximate size of Wetlands 10, 11, 12 and 13, their respective HGM units and catchments associated with the study area

	W7	W9		W8		W10		
	HGM12	**HGM15**	**HGM16**	**HGM13**	**HGM14**	**HGM17**	**HGM18**	**HGM19**
Catchment (ha)	36.80	37.00	34.70	51.10	45.00	664.00	144.00	200.00
HGM size (ha)	5.30	2.30	2.70	6.10	10.00	23.00	14.00	11.50
HGM	Pan	Pan	Seep	Pan	Seep	UCVB	Seep	Seep

Table 3-16: Approximate size of Wetlands 3, 4, 5, 11 and 12, their respective HGM units and catchments associated with the study area

	W3	W4	W5	W11	W12
	HGM8	**HGM9**	**HGM10**	**HGM20**	**HGM21**
Catchment (ha)	4.00	12.00	4.00	21.00	28.00
HGM size (ha)	0.60	2.00	2.00	12.00	1.00
HGM	Seep	Seep	Seep	Seep	Seep

3.6.3. Present Ecological State of Wetlands

Wetland health may be seen as the degree of similarity between reference conditions and the Present Ecological State (PES). The PES expressed here is a combination of alteration measured on desktop and field investigation for hydrology, vegetation and geomorphology. It should be noted that field work efforts were mostly concentrated on wetlands falling within the proposed footprint of the wet ash disposal facility, and those in the direct path of the proposed distribution lines, while other wetlands were less extensively verified.

The hydrology of wetlands in the study area have been influenced in varying degrees, by catchment utilisation and by direct wetland modification which has altered the quantity and distribution of water within each HGM unit identified. The ratio between mean annual precipitation (MAP) and potential evaporation (PE) rates provide a measure for assessing the hydrological vulnerability of wetlands to changes in water quantity. The MAP:PE ratio for the study area was calculated at 0.36, highlighting the dependence of wetlands on upstream catchment for water input. The hydrological vulnerability factor was incorporated in the PES assessment to calculate impact intensity associated with landuse activities within the respective catchments.

Similarly the vulnerability of the major HGM units identified to geomorphological alteration was ascertained by considering the variation from the equilibrium slope expected for a given size HGM and the actual slope measured (**Figure 3-9**). It follows that most of the HGM units assessed were over their equilibrium slope (green line), with the exception of HGM6 and 17, and are therefore vulnerable to erosion. HGM units 1, 5, 11 and 18 obtained the highest vulnerability scores.

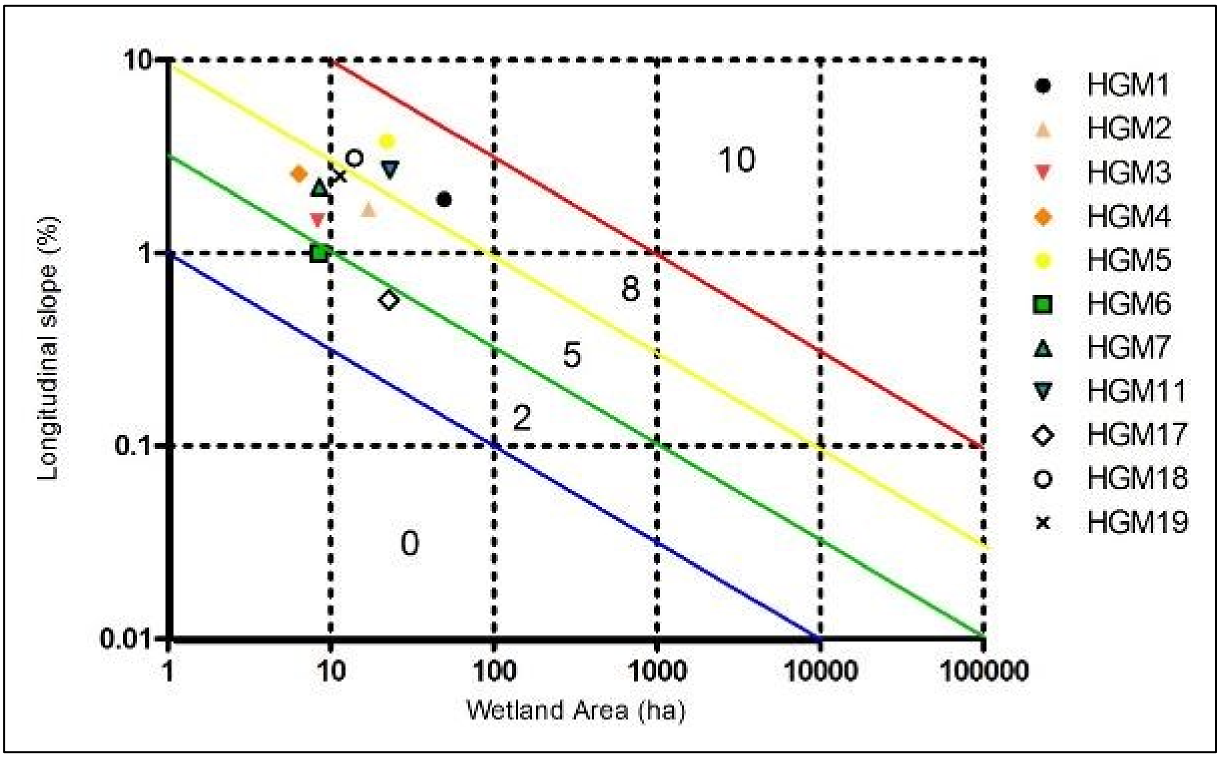


Figure 3-9: Vulnerability of major HGM units to geomorphological impacts based on the wetland size and wetland longitudinal slope. The green line between 2 and 5 approximates the equilibrium slope for a wetland of a given size.

The overall PES associated for each HGM unit is illustrated in **Figure 3-10**. Seeps associated with Wetland 1 (HGM 1, 3 and 4) and Wetland 2 (HGM 5, 7), along with the UCVB (HGM 17) of Wetland 10, and the pan of Wetland 7 fell in a C category and related to a Modified state. Receiving channelled valley bottom systems (HGM 2 and 6), along with Wetland 8, 11, 18, and 19 of Wetland 10 fell in a D-category and related to a Largely modified state. The seasonal pan system of Wetland 9 (HGM 16 and 17), and the seeps of Wetland 3, 4, 5 and 11 fell into an E category, indicating adverse modifications to the wetlands hydrological integrity. The following provides a brief summary of impacts associated with individual HGM units and their respective catchments.

- HGM 1 (**Figure 9-1 A-F**): Catchment mostly impacted on by agricultural activities, which attempted to drain the upper part of the seep (**Figure 9-1 A**). Most of the temporary zones and some seasonal areas were ploughed and have been under cultivation historically. The catchment contains a number of dirt roads and a tar road acts as an impending structure as it crosses the wetland without providing suitable hydrological continuity (**Figure 9-1 B**). This subsequently resulted in lateral extension of the HGM upstream from the tar road crossing. Power lines and linked servitude also run along most of the upper part of the seep (**Figure 9-1 C**).

- HGM 2 (**Figure 9-2 A**) have two dams at both ends, some dirt roads and a tar road crossing facilitating flow, through flumes. The upper dam (**Figure 9-2 B**) receives discharge from waste water treatment facility, while the channel between the two dams has been straightened in sections. The abutting seep on the left hill (HGM 3) (**Figure 9-2 C and D**) are mostly impacted on by road infrastructure, agricultural activity and isolated patches of alien vegetation, while the right hill seep (HGM 4) drains runoff from the power station area (**Figure 9-2 E**).
- HGM 5 is the valley head seep associated with Wetland 2 and also drains into a farm dam (**Figure 9-3 A**) which marked the start of the second valley bottom system (HGM6) (**Figure 9-3 B-E**). The unit was subjected to a number of dirt roads and a tar road crossing. The entire temporary and most of the seasonal zone was under cultivation rendering the functional wetland smaller than what is naturally expected. The diatom assessment revealed industrial pollution in the system, whilst the discharge at the breached dam wall was not consistent with the seasonal nature of the upstream catchment (**Figure 9-3 B**). The system has to deal with a notable increase in water volume.
- Thus, HGM 6 was mostly impacted on by additional discharge and agricultural infringement, with most of its seasonal zone under cultivation. Two channels have been dug diagonally across HGM 6 and along its western periphery. HGM 6 joins HGM 2 prior to flowing into another farm dam. HGM 7 is a seep abutting into a valley bottom (HGM 6) the hydrological contribution of this seep is thought to be substantial as a change in slope was measured after its confluence with HGM 6 (refer back to Figure 3-6). HGM 7 drains a small catchment, largely isolated from surrounding activities. These factors constitute the B ecological category for HGM 7.
- HGM 11, much like HGM 1, falls within the direct footprint of the proposed development. The wetland is substantially altered from natural conditions with large parts of its catchment and functional unit infringed on by industrial and agricultural activities (**Figure 9-4 A-E**). The wetland is traversed by a tar road. Low permeable fencing also restricts the movement of wetland fauna.
- HGM 12 also located on the direct footprint, was a seasonal pan system completely surrounded by agricultural activity (**Figure 9-5 A-E**).
- HGM 15 and 16 comprised of a pan and its associated seeps. The direct catchment was almost entirely under ploughed field, with most of the seasonal and temporal zones lost. The wetland is also impacted on by road and railway infrastructure, along with severe overgrazing and trampling (**Figure 9-6 A-E**)
- The catchment of HGM 13 and 14 of Wetland 8 (a larger pan and its associated seeps to the south of Alternative E), was surrounded almost completely by ploughed

fields, infrastructure, and dirt roads. The wetland itself is heavily grazed and trampled, with subsequently poor wetland vegetation cover (**Figure 9-7 A-C**).

- The catchments of Wetland 3, 4, 5, 11 and 12 were all under ploughed fields, and with major dirt roads intersecting them. The extent of soils disturbed by the agricultural ploughing has infringed on the temporal and seasonal zones of all of these wetlands, leading to a decline in hydrological integrity. In the case of Wetland 3, 4, 5, and 11, wetlands were intersected by wide dirt roads with little or no drainage, which further impeded the hydrological continuity of these wetlands (**Figure 10-1** through **Figure 10-6**).

The general state of wetlands within the study area was impaired largely due to hydrological, geomorphological and habitat alteration induced by dam and road structures, while the agricultural activities, in most instances, have infringed on wetland habitat subsequently hampering ecological and hydrological functioning.

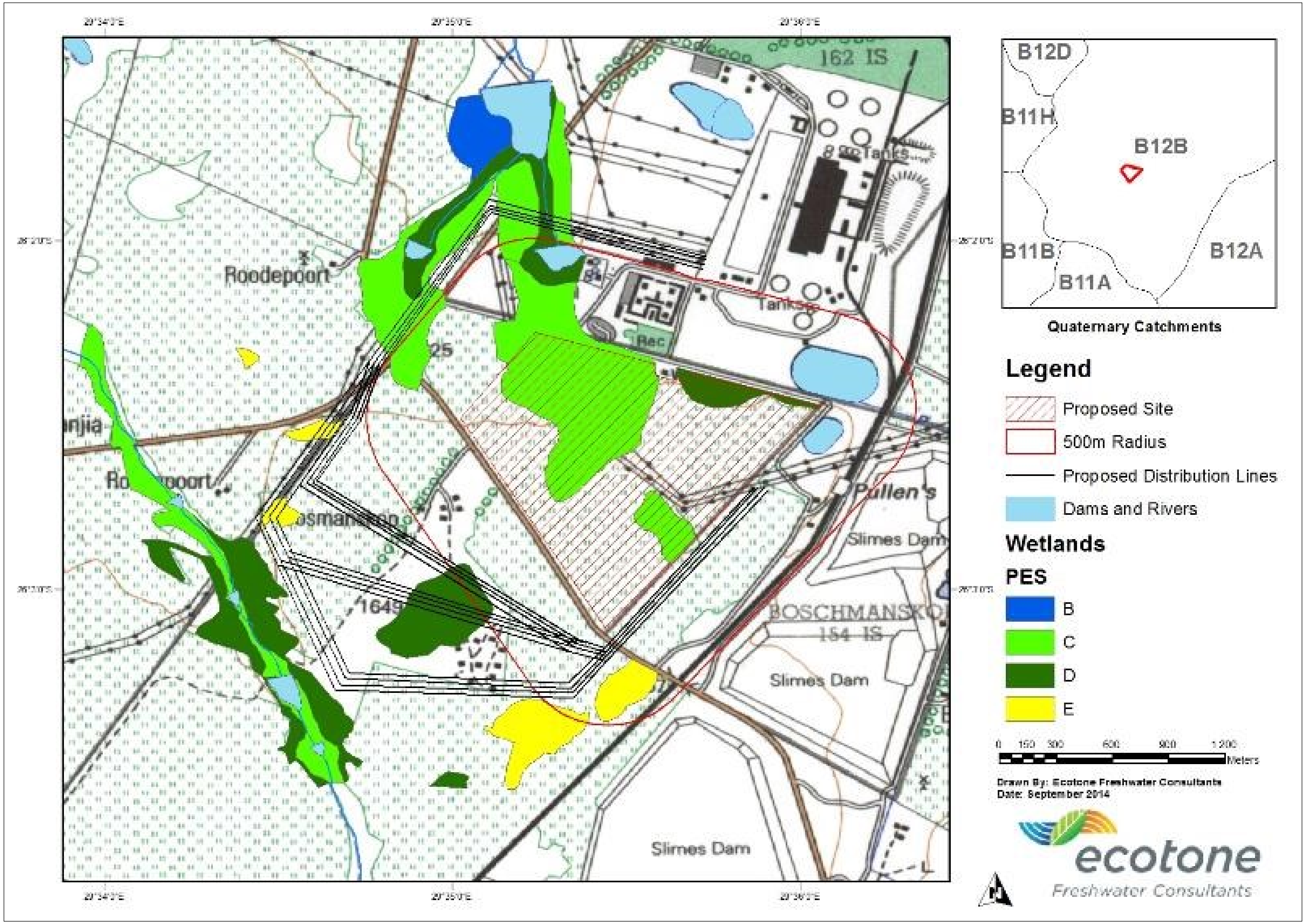


Figure 3-10: Map showing the Present Ecological State associated with respective wetlands in the study area.

3.7. Wetland Functionality Assessment

Functional ecosystem services of wetlands in general include indirect services such as flood control, nutrient cycling, erosion control, toxicant removal, carbon storage, phosphate assimilation, biodiversity maintenance, and direct services such as provision of food and water, cultural services and recreation. The presence of the service is subject to the potential exposure in the catchment and the HGM type. Wetlands directly impacted by the footprint of the proposed development and in the direct path of the proposed distribution lines, were subjected to a level 2 Wet-EcoServices assessment and are discussed first, while a level 1 assessment was done on the remaining wetlands.

3.7.1. Wetlands Directly Affected by Proposed Development

The direct catchment draining into HGM 1 was largely affected by agricultural practises subsequently providing a source for nutrients and sediment. Concurrently HGM 1 retained enough functionality to provide seasonal variation in reduction potential and subsequent ion exchange (**Figure 3-11 A**). The position of HGM 1 in the landscape does not constitute a notable service in terms of flood attenuation. Similarly the stream flow regulation function provided by HGM 1 is rendered obsolete due to the presence of the dam into which HGM 1 flows. This notion is reinforced when considering the retention potential of the receiving dam in relation to the upstream catchment (approximate 80% of the mean annual runoff).

Due to the extensive agricultural practices present in the catchment of Wetland 2, potential services rendered by this wetland include water purification in the form of phosphate, nitrate and general toxicant removal (**Figure 3-11 B**). The seeps associated with Wetland 2 (HGM5 and 7), provide potential streamflow regulation, while the relatively higher vegetation cover within these seeps and the CVB (HGM6) provides a potential for sediment trapping. The decline of ecological wetland integrity results in a low potential for biodiversity maintenance. *Barbus neefi* was sampled in HGM6. *Barbus neefi* is semi-intolerant to degraded water quality, highlighting the importance of wetland functions associated with enhancement of water quality.

Wetland 6, also a seep, retains a particular function in terms of nitrate removal (**Figure 3-12 A**). The wetland is largely transformed and the direct catchment does provide the opportunity for this functional service. Unlike HGM 1, the connectivity of Wetland 6 to surface water drainage system is thought to be less. The surrounding topography suggests a possible connection to HGM 2 however this could not conclusively be verified during the field assessment. Vegetation cover signified permanent wetness, suggesting a lower functional importance for flood attenuation. Loss of vegetation cover and soil disturbance, within large parts of this wetland, has also impaired wetland services associated with wetland habitat and erosion control.

Wetland 7, the only pan in the direct footprint of the proposed ash disposal facility is relatively small and largely seasonal. Due to the isolated nature of pans they have a limited function in terms of flood attenuation and stream flow regulation particularly when considering the size of the wetland in question (5.3 ha). Similarly pans are also not considered important for sediment trapping. However the immediate catchment-use does provide sources of nutrients and Wetland 7 is expected to provide a service in terms of mineralisation and de-nitrification (**Figure 3-12 B**). The extensive grazing and trampling of Wetland 8 and 9, along with the loss of much of the temporary and seasonal zones of Wetland 9 and the isolated nature of pans, has led to an overall loss in potential EcoServices provided by these wetlands (**Figure 3-13 A and B**).

Most of the temporary and seasonal edge of HGM 18 and 19 of Wetland 10 has been ploughed, resulting in a decline in hydrological integrity and therefore the ability of Wetland 10 to provide ecosystem services (**Figure 3-14**). However, Wetland 10 may still be capable of providing valuable streamflow regulation by releasing water to the downstream environment during low-flow periods. Due to the prominent agricultural practices within the catchment of Wetland 10, the wetland further provides potential water purification through nitrate removal.

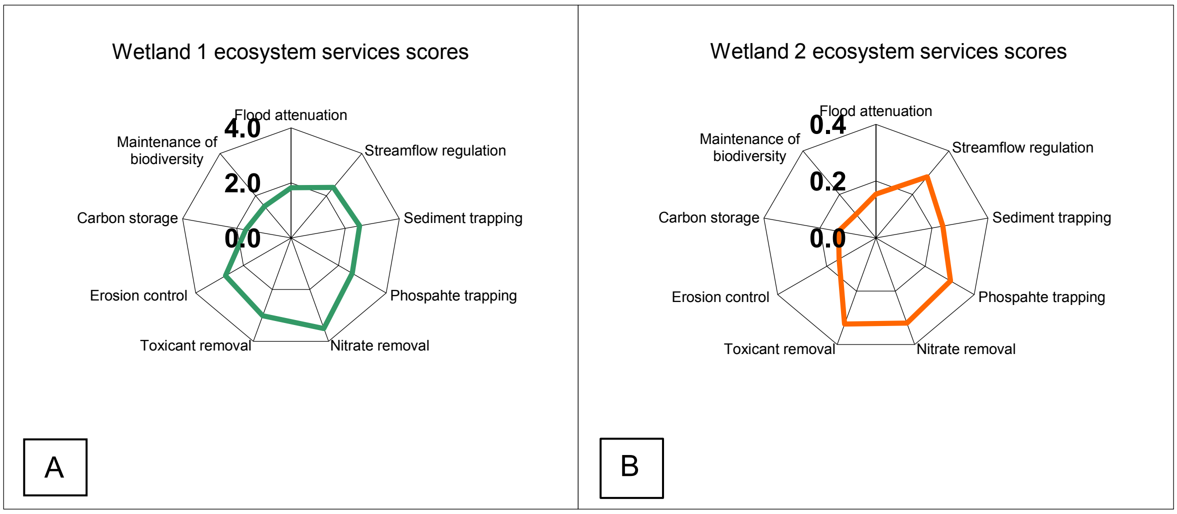


Figure 3-11: Spider diagram representing indirect services provided by A) HGM1 of Wetland 1 and B) Wetland 2.

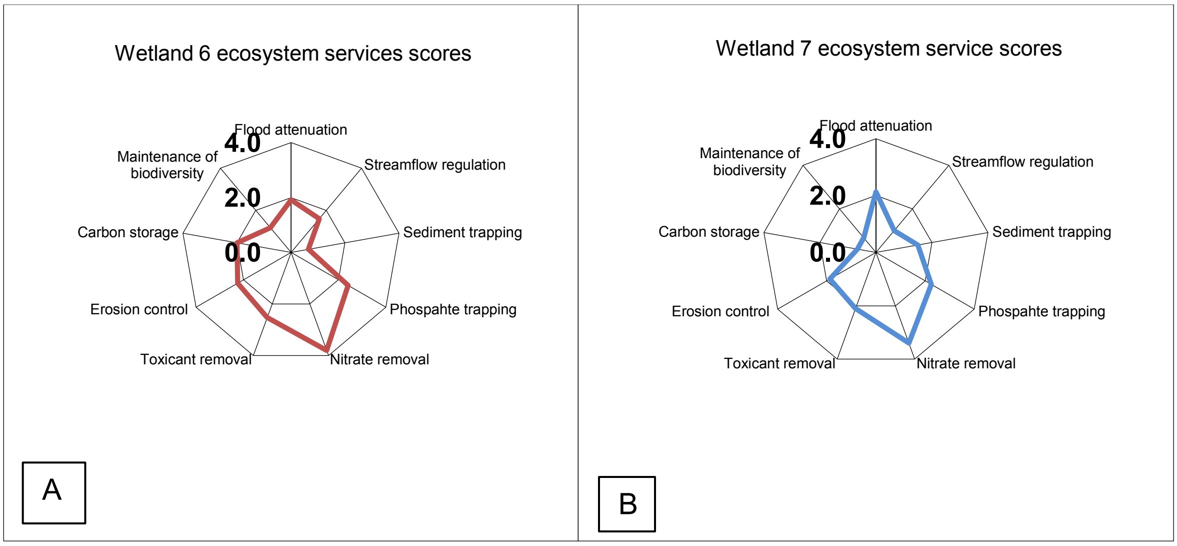


Figure 3-12: Spider diagram representing indirect services provided by A) Wetland 6 and B) Wetland 7.

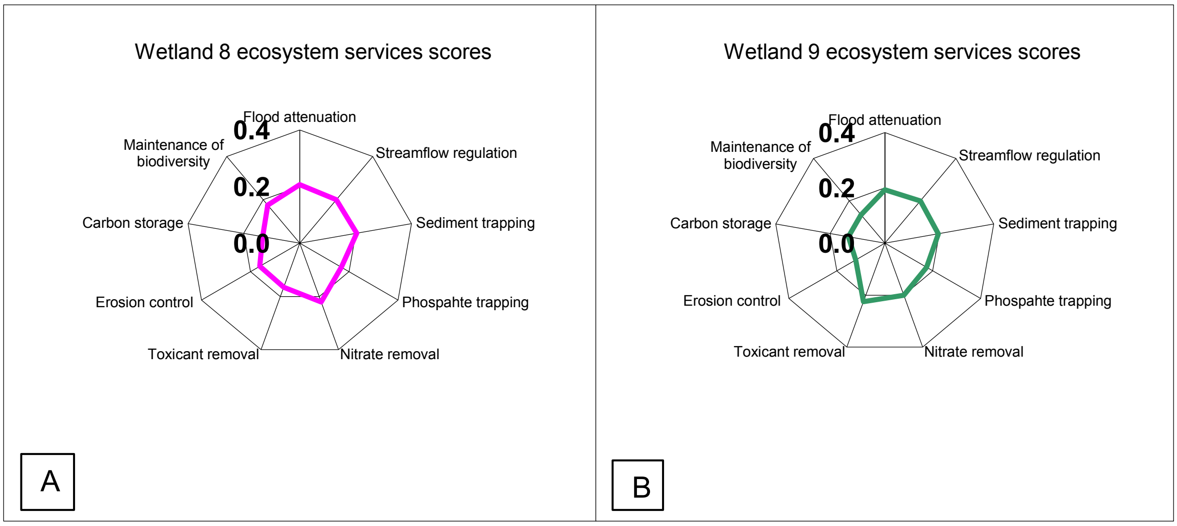


Figure 3-13: Spider diagram representing indirect services provided by A) Wetland 8 and B) Wetland 9.

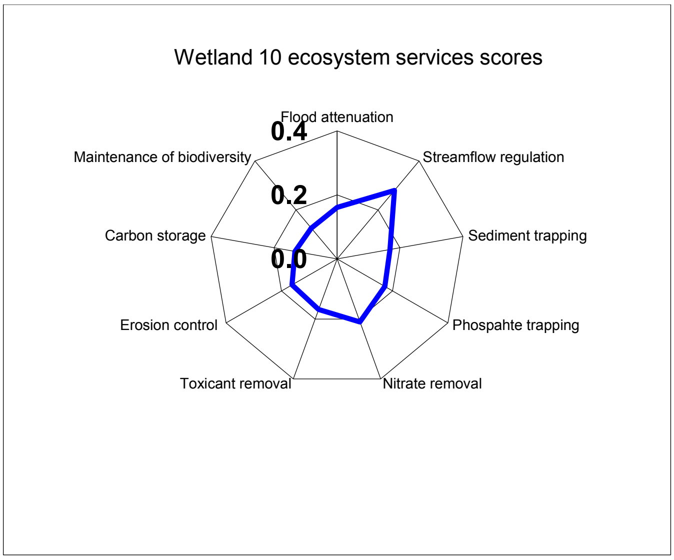


Figure 3-14: Spider diagram representing indirect services provided by Wetland 10.

3.7.2. Peripheral Wetlands

It is important to consider the functionality associated with the wetland systems outside of the direct footprint of the proposed developments, as they will be the primary receptors of upstream impacts related to the construction and operation of the proposed wet ash disposal facility and the distribution line. These wetlands include the seeps of Wetlands 3, 4, 5, 11, and 12.

Hillslope Seeps

Isolated hillslope seeps are normally associated with groundwater discharge and have a high likelihood of being capable of improving water quality by providing erosion control and excess nutrient removal, and to lesser degree flood attenuation during early wet season (**Table 3-17**). Although the hydrological integrity of Wetland 3, 4, 5, and 11 were greatly impaired, they may still be providing valuable ecosystem services, including the potential for storing water during low-flow periods, and reducing the risk of erosion where roads have little or no drainage.

Pans

Due to the isolated nature of pans, they are only capable of providing some degree of streamflow regulation and water quality enhancement through the removal of nitrates and toxicants (**Table 3-17**). In general, seasonal pans allow mineralisation, de-nitrification and volatilization in the case of high pHs (Allen *et al.,* 1995). Moreover, pans can provide suitable wetland habitat for a number of wetland species. Of particular interest is the impaired state of

Wetland 8 and 9, which provide a potential opportunity for offsite mitigation as part of rehabilitation for HGM 12, directly impacted by the placement of the proposed facility.

Table 3-17: Preliminary ratings of the hydrological benefits likely to be provided by associated wetlands

Wetland HGM	Regulatory Benefits Potentially Provided by the Wetland							
	Flood Attenuation		Stream flow regulation			Enhancement of Water Quality		
	Early wet season	Late wet season	Stream flow regulation	Erosion control	Sediment trapping	Phosphates	Nitrates	Toxicants
Hillslope seeps connected to stream channel	+	0	+	++	0	0	++	++
Pan/Depression	+	+	0	0	0	0	+	+

Rating: 0 Benefit unlikely to be provided to any significant extent; + Benefit likely to be present at least to some degree; ++ Benefit very likely to be present (and often supplied to a high level)

3.7.3. Hectare Equivalents

Hectare equivalents refer to the quantity of functional wetland area left considering the remaining integrity associated with the each unit (**Table 3-18**). Of the approximate 48 hectares of wetland directly affected by the proposed development about 30 hectares of hectare-equivalents remain, the majority of which play an important part in nitrification and detoxification of surface runoff in the catchment. It follows that the proposed placement of the ash dump will sterilise wetland services equivalent to approximately 30 ha. The impact of which is further quantified in Section 5. This provides a minimum-area framework for considering mitigation measures and for offsite mitigation plans should this be part of the rehabilitation framework. The loss of integrity downstream of the development presents an opportunity to increase services.

Table 3-18: Hectare equivalents for respective functional units in area of study

HGM unit	Size (ha)	Hectare Equivalents (ha)
HGM1	49.70	34.8
HGM2	17.00	10.7
HGM3+4**	14.7	11.8
HGM5	22.20	15.6
HGM6	8.50	4.2
HGM7	8.50	4.9
HGM 11*	5.2	2.8
HGM 12	5.30	3.18
HGM 15+16***	5.70	2.0
HGM 13+14***	16.10	9.66

***size of the section of the HGM directly on the primary study area**
****seeps on either side of HGM2**
*****Pans and linked seeps**

3.8. Ecological Importance and Sensitivity

The ecological importance of a wetland infers the degree to which biological diversity and ecological functioning is maintained on a particular spatial scale. Ecological sensitivity provides a measure of the ability of a wetland to resist disturbance. For the purpose of this assessment EIS scores are expressed for the functional HGM unit. **Table 3-19** provides EIS scores for respective HGMs.

The EIS is considered *Moderate*, and the study area contains wetlands that are considered to be ecologically important and sensitive on a provincial or local scale. The biodiversity of these systems is not usually highly sensitive to flow and habitat modifications. They play a lesser role in moderating the quantity and quality of water of major rivers. Whilst the wetlands in the study area are ecologically impaired, they still provide potential habitat for species with conservation status and serve as a corridor along the Woes-Alleenspruit system. Regardless of the impaired PES of systems in the study area, the downstream hydrological contribution of these wetlands will effectively be lost due to sterilisation of wetlands by the proposed development. The severity of the sterilisation is not considered substantial as the artificial dam receiving drainage intercepts the majority of the CVB HGMs hydrological contribution, and the presence of the existing dam renders flood attenuation and stream flow regulation functions largely obsolete. The lateral contribution of seeps together with treated waste water discharge, probably contribute a substantial volume of water, mostly maintaining the permanent nature of the valley bottom system.

Table 3-19: Table reflecting the EIS assessment scores for wetlands in the study area, confidence ratings and reasons

Determinant	Score	Confidence	Reason
PRIMARY DETERMINANTS			
1. Rare and endangered species	3	3	*Metisella meninx* (Marsh Sylph) - VU; African Grass Owl; African Marsh Harrier.-*Crinum bulbispermum* (Declining), *Nerine gracilis* (NT) and *Kniphofia typhoides* (NT)
2. Populations of unique species	2	3	Population of *Barbus neefi* sampled CVB systems.
3. Species / taxon richness	2	3	CVB and associated seeps shows a moderate bird, invertebrate and downstream fish species richness
4. Diversity of habitat types or features	3	3	Gradient of wetness in most functional units is expressed in variation in vegetation cover resulting in habitat diversity. Permanent zones in some instances are in a largely natural state.
5. Migration/breeding and feeding site for wetland species	3	2	CVB wetlands and respective seeps provide aquatic corridor for movement of aquatic invertebrates and fish. Some wetlands contain *Leersia hexandra* (feeding habitat for *M. meninx*). Numerous more common wetland species (e.g. ducks, coots, geese etc) may use wetland areas for breeding and feeding.
6. Sensitivity to changes in natural hydrological regime	2	2	A low MAP:PE ratio for the study area suggests that wetlands are depended on upstream catchment for water input. The ratio between functional unit size and slope revealed, for most HGM units, a vulnerability to geomorphological alteration in the providing catchment.
7. Sensitivity to water quality changes	3	3	Diatom response metrics in previous studies suggested an impaired state linked to organic and industrial pollution respectively, with low oxygen saturation. However, *B. neefi* is moderately intolerant to changes in water quality
8. Flood storage, energy dissipation, particulate/element removal	3	3	The predominant functions of wetlands on the site are de-nitrification and detoxification.
9. Baseflow augmentation; dilution	2	3	Dams in the immediate catchment supplement flood attenuation and surface water augmentation functions of the wetlands.
MODIFYING DETERMINANTS			
10. Protected status	1	2	SANBI conservation management plan for Mpumalanga assigned significance to the area for maintenance of aquatic diversity. The NSBA assigns a critically endangered status to the Woes-Alleenspruit.
11. Ecological importance (rarity of size/type/condition)	2	4	Local importance
TOTAL	***26***		
Average	***2.5***	2.8	
MEDIAN	**2**	3	**MODERATE**

4. Findings

The primary study area consists of approximately 34% wetland. Wetlands which will directly be affected by the proposed wet ash disposal facility are ecologically impaired to different degrees due to current land use activities. Implied wetlands mostly retain a water purification function and do not contribute notably to stream flow augmentation and flood attenuation. Although the EIS assessment reflected overall Moderate sensitivity, and the wetlands associated with the study area play a lesser role in moderating the quantity and quality of water of major rivers, they still provide potential habitat for species with conservation status and serve as a corridor along the Woes-Alleenspruit system

Wetlands in the secondary study area are also ecologically impaired. The hydrological characteristics of the valley bottom systems have been greatly altered by additional water input and a number of impeding structures (roads and dams). Simultaneously, seep zones have been infringed on by agricultural activity, destroying habitat and disturbing hydromorphic soils. Most wetlands, in the secondary study area, are vulnerable to changes in hydrology and geomorphology in their respective catchments. However, Wetland 1 is more likely to be affected the construction of the wet ash disposal facility as it receives most of the drainage of the primary study area.

Results from the aquatic biomonitoring reflected poor ecological conditions in the receiving environment, with mostly pollution tolerant species sampled. Low abundances and species richness were present at both monitoring sites for diatoms and aquatic macroinvertebrates. One monitoring site yielded a population of *B. neefi.* Results from biomonitoring provide snap shot view of baseline conditions which may be used as a platform for comparison of future monitoring effort.

4.1. Wet Ash Disposal Facility

4.1.1. Alternative 1 – Site E

Construction Phase

Functional units 1, 6 and 7 will be cleared of vegetation effectively eliminating remaining ecological integrity and functionality. Main concerns during the construction phase are erosion and sediment control.

Operation Phase

The loss of wetland functions will mostly be expressed during the operation phase. It is assumed that runoff generated by the footprint will be treated as polluted water and redirected to a pollution control facility. This will reduce the runoff received by HGM2. However this is not expected to impose a negative trajectory to this functional unit, mostly due to the dam already intercepting most of this runoff. The dam, however, will reduce in volume and this might have implications for current abstraction activities. The loss of other wetland functions, associated with HGM1, is not perceived as significant and should not contribute to ecological degradation of the downstream catchment.

Additional consideration should be given to the likelihood of surface water pollution due to runoff or malfunctioning of the pollution control system, in which case polluted water will accumulate in the dam downstream of HGM1. Biological receptors, assessed in Wetland 1, are not sensitive to changes in water quality as they already suggest chronic organic pollution. Thus, a lower severity is assigned to occasional alteration in surface water quality.

De-commissioning Phase

It is assumed that the wet ash disposal facility will be stabilised pre-decommissioning, with the aim of increasing surface roughness. Changes to the drainage system are also expected. The long term impacts of the decommissioned dam on surface water quality will rely on leachate and/or runoff quality, as well as the probability of surface water pollution.

Cumulative Impacts

The receiving catchment is in a transformed state due to mining, agriculture and residential development. Most of the East-Woes-Alleenspruit as well as the middle and lower parts of the Woes-Alleenspruit have been modified by mining activity. The upper reaches of the Woes-Alleenspruit is in a fair condition with mostly agricultural practices driving ecological change. The proposed development will pose a cumulative impact risk, particularly to the upper reaches of the receiving catchment. As mentioned earlier, no significant cumulative impact relating to aquatic biodiversity, flood attenuation or stream flow augmentation is expected. The hydrological contribution, of the area of influence to the downstream catchment is marginal.

4.1.2. Alternative 2 – No-go

A likely trajectory assessment for hydrology, geomorphology and vegetation ascertained, in most cases, a slight to substantial deterioration of most wetlands during the next five years. Factors most likely to contribute to this deterioration include:

- Ongoing agricultural practices infringing on seasonal and temporary zones.
- Active wetland draining (particularly in HGM 1).
- A likely increase in alien woody component in the catchment and within some functional units.

- Current discharge at HGM 6, impose a risk of gully formation and subsequent draining of seeps.
- Impeding road and dam structures result in the loss of functional wetland habitat and alter natural hydrology.
- In-channel excavation occurring at the tar road crossing at HGM 2 further contributes to a negative trajectory in wetland health.

It follows that even if the no-go alternative applies wetlands within the primary and secondary study area are likely to further degrade over the next 5 years. This notion supports the construction of the wet ash disposal facility on alternative E, particularly when considering the ecological constraints and risks of other alternatives (refer to aquatic screening and scoping reports). Concurrently, the anticipated negative trajectory provides an opportunity for offsite mitigation with particular emphasis on Wetlands 1, 2, 8, 9 and 10.

4.2. Distribution Lines

Existing distribution lines located on Alternative E will have to be moved to accommodate the wet ash disposal facility, and thus three alternatives have been identified as new dx-line routes (**Figure 4-1**). At the point where all three alternatives overlap they intersect Wetland 4 which is impacted by existing road infrastructure and distribution lines. All three proposed distribution line alternatives also cross through Wetland 1 and 2, and run parallel to 7.

Alternative 1 was discarded as a possible Alternative. The alignment of Alternative 2 is most accessible, requiring only minimal additional disturbance relating to the construction and maintenance phase. However, Alternative 2 will infringe on the northern section of Wetland 8, the largest pan system within the secondary study area. Wetland 8 (HGM 13 and 14) was in an Largely modified state with its immediate catchment mostly transformed. However, it is probable that the Wetland 8 provides suitable habitat for wading birds (at least in seasonal intervals) and is thus a less preferred alternative (please refer to Section 5.2.2). Alternative 4 intersects Wetland 8 which, for the same reasons as Alternative 2, makes it a less preferred alternative (please refer to Section 5.2.4). Alternative 3 does not infringe upon any additional wetland habitats, beyond Wetland 4 and 5, making it the most preferred alternative. However, Alternative 3 is least accessible and runs parallel to Wetland 10 (HGM 17, 18, and 19), which was in a Moderately modified ecological state and was deemed capable of providing valuable EcoServices. Therefore, caution should be taken during construction so as not to further impair the remaining ecological integrity of Wetland 10 (please refer to Section 5.2.3). Additionally, alternative 3 also runs parallel to Wetland 9 and 11.

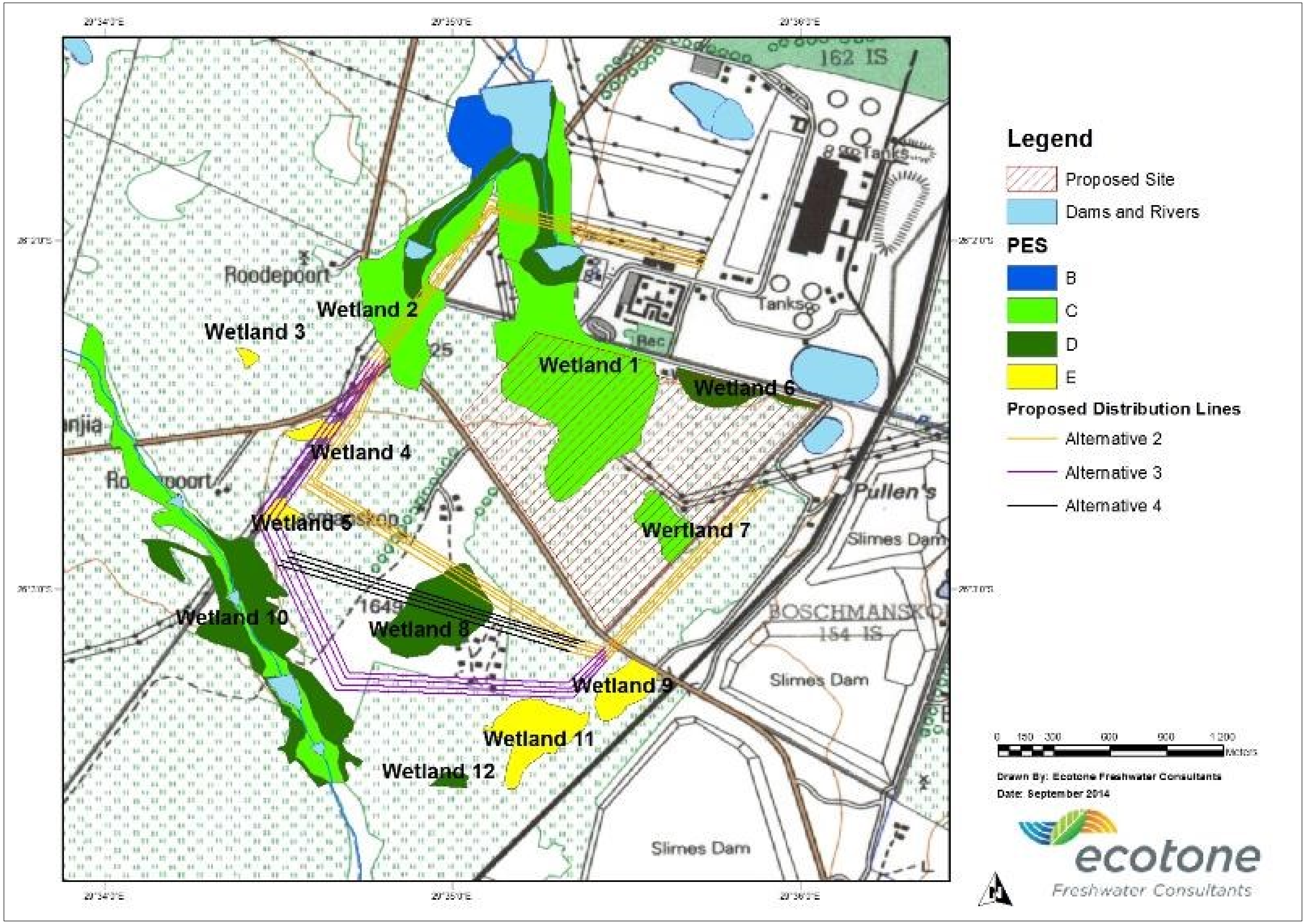


Figure 4-1: Map showing the Distribution line alternatives (Nel *et al.,* 2004; Chief Directorate – Surveys and Mapping).

4.3. Pipelines

The proposed development will require moving an existing raw water pipeline from Alternative E to the proposed alignment shown in **Figure 4-2**. The pipeline is not expected to cross any wetlands, although it does come close to the boundary of Wetland 8. Environmental risk linked to aquatic ecology is thus not a concern. Even so, emphasis, during construction, should fall on soil conservation, erosion and sediment control, as these factors might negatively impact receiving drainage systems.

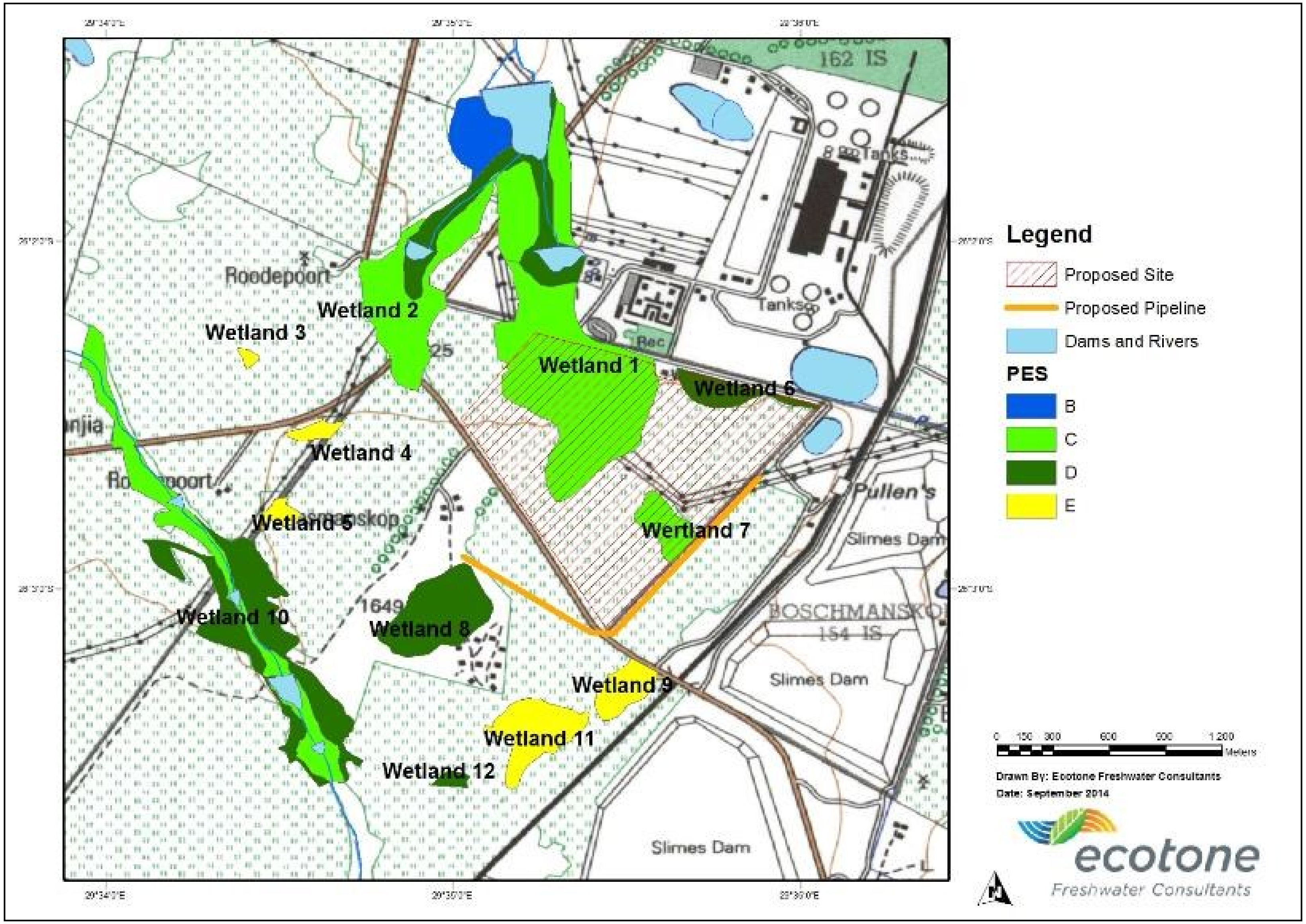


Figure 4-2: Map showing the alignment of the Pipeline infrastructure (Nel *et al.,* 2004; Chief Directorate – Surveys and Mapping).

5. Assessments of Impacts

5.1. Wet Ash Disposal Facility

5.1.1. Alternative 1 – Site E

Construction Phase

Points of concern with a “High” significance before mitigation during the construction phase of the wet ash disposal facility include: The loss of wetland function; altered hydrology and the loss of water resources downstream. The significance of all these perceived impacts can be considerably lowered (**Table 5-1**) through the implementation of the mitigation measures discussed in section 6.

Table 5-1: Impact assessment of the potential impacts of the proposed wet ash disposal facility during the construction phase.

Potential Impact	Mitigation	Extent	Duration	Magnitude	Probability	Significance		Status	Confidence
		(E)	(D)	(M)	(P)	(S=(E+D+M)*P)		(+ve or -ve)	
Loss of wetland function	**Nature of impact:**	The loss of associated wetland functions which include: Nutrient removal (particularly Nitrates); trapping of pollutants, including sediment; and to a small extent flood attenuation and stream flow augmentation as the dam located to the north of Alternative E with still provide these functions.							
	with	2	3	4	3	**27**	**Low**	-	Medium
	without	4	5	8	5	**85**	**High**	-	High
	degree to which impact can be reversed:	The associated impacts can be reversed to an extent by fulfilling the functions (as mentioned above) that have been lost by the removal of the wetland systems.							Medium
	degree of impact on irreplaceable resources:	The degree of impact can be kept low if the run-off from the wet ash disposal facility is manage adequately and prevented from leaving the wet ash disposal facility area and by ensuring that the drainage system/networks are regularly maintained.							Medium
Deterioration of water quality	**Nature of impact:**	Hydrocarbons (oil and diesel etc.), solvents and other pollutants spilling/leaking from construction machinery and equipment during the construction phase may have an impact on the receiving aquatic environment.							
	with	3	3	4	2	**20**	**Low**	-	Medium
	without	4	5	6	4	**60**	**Medium**	-	Medium
	degree to which impact can be reversed:	Reversing the impacts will be relatively difficult however if appropriate measures are carried out (Bioremediation etc.) immediately following a spill the degree and extent of the impacts can be significantly reduced. These measures are however a very costly exercise.							High
	degree of impact on irreplaceable resources:	The degree of the impact will be directly related to the extent of the spill/leak. With appropriate mitigation measures in place (refer to section 6) the probability of this impact can be reduced drastically to a low impact.							High
Increased surface run-off within the wet ash disposal facility	**Nature of impact:**	Increased run-off may contribute to the spread of pollutants, exacerbate erosion potential and lead to sedimentation.							
	with	1	2	4	2	**14**	**Low**	-	Medium
	without	3	4	6	4	**52**	**Medium**	-	Medium
	degree to which impact can be reversed:	The degree of the impact can be reversed relatively easily with the implementation of adequate mitigation measures as mentioned in section 6.							Medium

Potential Impact	**Mitigation**	**Extent**	**Duration**	**Magnitude**	**Probability**	**Significance**		**Status**	**Confidence**
		(E)	**(D)**	**(M)**	**(P)**	**(S=(E+D+M)*P)**		**(+ve or -ve)**	
	degree of impact on irreplaceable resources:	The probability of impacts resulting from surface run-off will have a low significance by implementing appropriate and adequate mitigation measures in order to manage run-off and to reduce its velocity (refer to section 6).							High
Erosion and sedimentation	**Nature of impact:**	Alter the water quality (increased turbidity) and substrate composition of receiving aquatic environments as well as altering marginal habitats due to excessive reed growth and alien vegetation encroachment as a result of the deposited sediment.							
	with	1	2	2	1	**5**	**Low**	-	High
	without	3	3	8	4	**56**	**Medium**	-	Medium
	degree to which impact can be reversed:	The degree in which these impacts can be reversed will be low if not handled appropriately, however, if appropriate mitigation is put into place and enforced throughout the construction phase the threat of this impact can be considerable lowered.							High
	degree of impact on irreplaceable resources:	The degree of the impact will be very low is erosion control measure are put into place (silt fences, berms etc.) before and throughout the construction phase and throughout the lifespan of the wet ash disposal facility.							Medium
Altered hydrology	**Nature of impact:**	The placement of the wet ash disposal facility will alter natural surface water flow paths by changing the local topography and breaking longitudinal and lateral connectivity of the drainage network. This could potentially affect surface and sub-surface flow volume by reducing base flows or augmenting stream flow.							
	with	2	3	4	3	**27**	**Low**	-	Medium
	without	3	4	8	5	**75**	**High**	-	Medium
	degree to which impact can be reversed:	This impact can be reversed to an extent if additional water can be discharged back into Wetland 1 in order to the supplement water that will no longer be accumulated in the catchment.							Medium
	degree of impact on irreplaceable resources:	The degree of the impact will be low-moderate if appropriate mitigation is implemented. It should however be taken into account that hydrology of the associated wetland system are already severely altered by several dams and water being decanted into the system.							Medium
Loss of water resources downstream	**Nature of impact:**	The construction of the wet ash disposal facility may possible result in lowered base flows which may cause the water level in the downstream dam to lower considerably due to the loss of the catchment area to the wet ash disposal facility.							
	with	3	4	4	3	**33**	**Medium**	-	Medium
	without	3	4	6	5	**65**	**High**	-	High
	degree to which impact can be reversed:	It will be almost impossible to reverse the impact as the run-off that is accumulated at alternative E will be lost once construction activities commence.							Medium
	degree of impact on irreplaceable resources:	The degree of the impact is believed to be medium as a large proportion of the dam's catchment area will be lost during the construction of the wet ash disposal facility. However, is should be noted that the dam will still receive run-off from its catchment to the east and west.							Medium

Operation Phase

Points of concern with a “High” significance before mitigation during the operational phase of the wet ash disposal facility include: the loss of water resources downstream and changes in natural surface water flow patterns (**Table 5-2**). The significance of all of these perceived impacts during operations can be considerably lowered through the implementation of the mitigation measures as discussed in section 6. The loss of water resources downstream of the proposed wet ash disposal facility reflected a “medium” significance following the implementation of mitigation due to the loss of a large proportion of the catchment area through the construction of the wet ash disposal facility.

Table 5-2: Impact assessment of the potential impacts of the proposed wet ash disposal facility during the operation phase

Potential Impact	Mitigation	Extent	Duration	Magnitude	Probability	Significance		Status	Confidence
		(E)	(D)	(M)	(P)	(S=(E+D+M)*P)		(+ve or -ve)	
Loss of water resources downstream	**Nature of impact:**	The wet ash disposal facility may result in lowered base flows which may cause the water level in the downstream dam to lower considerably due to the loss of the catchment area to the ash dam. A large percentage of the upstream dam's catchment will be sterilised due to the significant proportion of the immediate catchment that will be affected by the placement of the proposed ash facility.							
	with	3	4	4	3	**33**	**Medium**	-	Medium
	without	3	5	6	5	**70**	**High**	-	Medium
	degree to which impact can be reversed:	It will be almost impossible to reverse the impact as the run-off that is accumulated at alternative E will be lost once construction activities commence.							Medium
	degree of impact on irreplaceable resources:	The degree of the impact is believed to be medium as a large proportion of the dam’s catchment area will be lost during the construction of the wet ash disposal facility. However, is should be noted that the dam will still receive run-off from its catchment to the east and west.							Medium
Deterioration of water quality	**Nature of impact:**	If the leachate from the wet ash disposal facility is not adequately managed (via the drainage system) it could have a severe impact on the water quality of the receiving aquatic environment.							
	with	2	2	4	2	**16**	**Low**	-	High
	without	4	4	6	4	**56**	**Medium**	-	High
	degree to which impact can be reversed:	It would be extremely difficult to reverse the impacts of leachate contamination. Therefore it is vital that the design of the wet ash disposal facility drainage system in able to deal with the amount off leachate throughout the lifespan of the wet ash disposal facility and that a suitable liner in used during the construction of the wet ash disposal facility.							Medium
	degree of impact on irreplaceable resources:	Implementation of adequate mitigation measures and regular maintenance of the drainage network will keep the significance of potential impact low.							High
Storm water run-off within the wet ash disposal facility.	**Nature of impact:**	If storm water run-off is not adequate manage it could results in the transport of harmful/toxic substances into the surrounding environment.							
	with	1	4	4	2	**18**	**Low**	-	Medium
	without	4	4	6	4	**56**	**Medium**	-	Medium
	degree to which impact can be reversed:	The degree of the impacts can be reversed if adequate storm water management system is kept in place throughout the operational phase of the wet ash disposal facility.							Medium

Potential Impact	Mitigation	Extent	Duration	Magnitude	Probability	Significance		Status	Confidence
		(E)	(D)	(M)	(P)	(S=(E+D+M)*P)		(+ve or -ve)	
	degree of impact on irreplaceable resources:	The significance of impacts can be kept relatively low if adequate storm water management system is put into place. Storm water run-off will become more of an issue over time as the length of the slope increases after years of slurry deposition.							Medium
Changes in natural surface water flow patterns	**Nature of impact:**	Natural run-off patterns will be altered as storm water run-off will be diverted around the wet ash disposal facility and the loss of the catchment area to the wet ash disposal facility.							
	with	2	4	4	3	**30**	**Low**	-	Medium
	without	3	5	8	4	**64**	**High**	-	High
	degree to which impact can be reversed:	This impact cannot be reverse once the wet ash disposal facility is constructed, however the impacts can be mitigated to reduce the significance of the impacts.							Medium
	degree of impact on irreplaceable resources:	The impact can be minimised by implementation of appropriate mitigation measures and through the design of a storm water management system. It is important to note that the catchment is already in an impacted state due to the construction of several dams.							Medium

De-commissioning Phase

None of the perceived impacts during the de-commissioning phase were deemed of a “high” significance and if mitigation measures are maintained and stringently monitored the magnitude of these impacts can be considerably lowered (**Table 5-3**).

Table 5-3: Impact assessment of the potential impacts of the proposed wet ash disposal facility during the de-commissioning phase

Potential Impact	Mitigation	Extent	Duration	Magnitude	Probability	Significance		Status	Confidence
		(E)	(D)	(M)	(P)	(S=(E+D+M)*P)		(+ve or -ve)	
Deterioration of water quality	**Nature of impact:**	If the leachate from the wet ash disposal facility is not adequately managed (via the drainage system) it could have a severe impact on the water quality of the receiving aquatic environment.							
	with	2	2	4	2	**16**	**Low**	-	High
	without	3	3	8	4	**56**	**Medium**	-	High
	degree to which impact can be reversed:	The degree of the impact cannot entirely be reversed, however through regular maintenance of the mitigation measures still in place, especially the drainage network system, negative impacts on the surrounding environment can be avoided.							Medium
	degree of impact on irreplaceable resources:	Keeping and maintaining mitigation measures and regular maintenance of the drainage network etc. will keep the significance of potential impact low.							High
Storm water run-off	**Nature of impact:**	If storm water run-off is not adequate manage it could results in the transport of harmful/toxic substances into the surrounding environment.							
	with	1	4	4	2	**18**	**Low**	-	Medium
	without	4	4	4	4	**48**	**Medium**	-	Medium
	degree to which impact can be reversed:	The degree of the impacts can be reversed if adequate storm water management system is kept in place throughout the operational phase of the wet ash disposal facility.							Medium
	degree of impact on irreplaceable resources:	The significance of impacts can be kept relatively low if adequate storm water management system are kept in place beyond the operational phase and if vegetation is well established. Vegetation will provide stability and reduce the velocity of storm water run-off.							Medium

Cumulative Impacts

Cumulative impacts associated with the catchment area include: Loss of wetland function; deterioration of water quality; increased surface runoff; erosion and sedimentation. Of the mentioned perceived impacts only “loss of wetland function” and “deterioration of water quality” had a high significance before mitigation. Both impacts were deemed of a “medium” significance following mitigation (**Table 5-4**) due to the already altered nature of the surrounding catchment area (**Section 3.1.3**).

Table 5-4: Impact assessment of the potential cumulative impacts associated of the proposed wet ash disposal facility

Potential Impact	Mitigation	Extent	Duration	Magnitude	Probability	Significance		Status	Confidence
		(E)	(D)	(M)	(P)	(S=(E+D+M)*P)		(+ve or -ve)	
Loss of wetland function	**Nature of impact:**	The loss of associated wetland functions which include: Nutrient removal (particularly Nitrates); trapping of pollutants including sediment; and to a small extent flood attenuation and stream flow augmentation as the dam located to the north of alternative E with still provide these functions.							
	with	3	3	6	4	**48**	**Medium**	-	Medium
	without	4	4	8	5	**80**	**High**	-	High
	degree to which impact can be reversed:	The degree of the impact will not be easily reversed due to the severely impacted nature of the surrounding catchments. Several large dam have been constructed and severe canalisation has occurred in associated wetlands due to the altered state of the catchment.							High
	degree of impact on irreplaceable resources:	The degree of impact on irreplaceable resources is thought to be medium.							Medium
Deterioration of water quality	**Nature of impact:**	Impacts associated with surrounding industrial and agricultural activates (input of nutrients and heavy metal) as well as the Hendrina Power Station and existing wet ash disposal facility.							
	with	4	3	6	4	**52**	**Medium**	-	Medium
	without	5	4	8	5	**85**	**High**	-	High
	degree to which impact can be reversed:	It is not likely that the cumulative impacts can be easily reverse due to the altered nature of the water quality associated with the catchment (refer to section 3.3 - diatom assessment). Water quality in the catchment is impacted by nutrient enrichment (agricultural activities and WWTW) and the input of salts from industrial activities.							High
	degree of impact on irreplaceable resources:	The degree of impact on irreplaceable resources is thought to be medium due to the already altered state of the aquatic ecosystems located within the catchment.							Medium
Increased surface run-off	**Nature of impact:**								
	with	3	3	4	3	**30**	**Low**	-	Medium
	without	4	4	6	4	**56**	**Medium**	-	Medium
	degree to which impact can be reversed:	The degree of the cumulative impacts can be slightly reversed if adequate storm water management system are kept in place beyond the operational phase of the wet ash disposal facility and if the vegetation on the wet ash disposal facility is well established.							Medium
	degree of impact on irreplaceable resources:	The significance of impacts can be kept relatively low if an adequate storm water management system is put into place thereby limiting the cumulative impacts.							Medium
Erosion and sedimentation	**Nature of impact:**	The altered water quality (increased turbidity) and substrate composition of the receiving aquatic environment associated with the catchment has resulted in altered marginal habitats due to excessive reed growth and alien vegetation encroachment as a result of the sediment deposition.							
	with	2	2	4	3	**24**	**Low**	-	Medium
	without	3	4	8	4	**60**	**Medium**	-	Medium
	degree to which impact can be reversed:	Once sedimentation has occurred, reversion of the impact would be difficult, however if appropriate precautions are put into place it is likely that the risk can be almost completely avoided.							Medium
	degree of impact on irreplaceable resources:	The contribution of the wet ash disposal facility to the cumulative impacts associated with the catchment can be minimal in adequate erosion control measures are put into place before construction activities commence, and throughout the lifespan of the wet ash disposal facility.							High

5.1.2. No-go Alternative

Refer to Section 4.1.2 for a detailed discussion concerning the “no-go” and current state of the primary study area.

Table 5-5: Impact assessment of the current state of the primary study area

Potential Impact	Mitigation	Extent	Duration	Magnitude	Probability	Significance		Status	Confidence
		(E)	(D)	(M)	(P)	(S=(E+D+M)*P)		(+ve or -ve)	
Impacts associated with the surrounding catchment	**Nature of impact:**	The impacts associated with Alternative E in its current state include: agricultural and industrial impacts as well as severe hydrological alterations.							
	with	3	4	8	4	**60**	**Medium**	+	high
	without	3	4	8	4	**60**	**Medium**	+	high
	degree to which impact can be reversed:	The impacts associated with the wetlands in the primary study area will not be easily reversed due to their altered state (Refer to section 3.6.3).							Medium
	degree of impact on irreplaceable resources:	The state of the wetlands located within the primary study area is already in an impacted state as a result of anthropogenic activities taking place in the surrounding catchment (Refer to section 3.1.3).							High

5.2. Distribution Lines

5.2.1. Alternative 1

Alternative 1 was discarded as an unfeasible alternative by the client.

5.2.2. Alternative 2

Construction Phase

During the construction phase of the Alternative 2 distribution line, if all the appropriate mitigation measures referred to in section 6 are implemented, the significance of all the perceived impacts will be “low” (**Table 5-6**). No perceived impacts were identified for the operational phase of the proposed distribution lines, pending that all mitigation measures are followed in accordance with Section 6.

Table 5-6: Impact assessment of the potential impacts of proposed Distribution line alternative 2 during the construction phase

Potential Impact	Mitigation	Extent (E)	Duration (D)	Magnitude (M)	Probability (P)	Significance (S=(E+D+M)*P)		Status (+ve or -ve)	Confidence
Deterioration of water quality	**Nature of impact:**	The construction of distribution line - Alternative 2 will cross through Wetlands 1, 2, 4, and 8 and run alongside Wetlands 7 and 9 creating the possibility of water contamination by hydrocarbons (oil and diesel etc.), solvents and other pollutants spilling/leaking from construction machinery and equipment during the construction phase. The increase in sediment load due to poor erosion control will also have a negative effect on water quality and wetland health in general.							
	with	2	2	2	1	**6**	**Low**	-	Medium
	without	3	3	4	4	**40**	**Medium**	-	High
	degree to which impact can be reversed:	Reversing the impacts will be relatively difficult, however, if appropriate measures are carried out (Bioremediation etc.) immediately following a spill the degree and extent of the impacts can be significantly reduced. These measures are however a very costly exercise.							High
	degree of impact on irreplaceable resources:	The significance of the impacts can be kept low if mitigation measures are strictly enforced. The probability of further water quality deterioration at Wetlands 1 and 2 are lower due to the already altered state of these wetlands.							Medium
Vegetation removal	**Nature of impact:**	The removal of vegetation will result in a decrease in surface roughness thereby increasing the erosion potential and the potential velocity of surface runoff.							
	with	2	2	2	1	**6**	**Low**	-	Medium
	without	3	3	2	4	**32**	**Medium**	-	High
	degree to which impact can be reversed:	The impact can only be fully reversed once the vegetation is entirely re-established.							High

	degree of impact on irreplaceable resources:	If vegetation clearing is kept to a minimum and replanting of vegetation is carried out directly following construction activities the severity of the impacts can be considerably reduced to a Low significance, taking into account the already impact state of the vegetation cover in the surrounding catchment due to agricultural activities.							High
Increased surface runoff	**Nature of impact:**	Increased runoff may contribute to the spread of pollutants, exacerbate erosion potential and lead to downslope sedimentation.							
	with	1	1	2	2	**8**	**Low**		Medium
	without	3	3	2	4	**32**	**Medium**		Medium
	degree to which impact can be reversed:	The probability of impacts resulting from surface runoff can be avoided by implementing appropriate and adequate mitigation measures in order to manage runoff and to reduce its velocity (refer to section 6). Due to the distribution line crossing several wetland systems, the mismanagement surface runoff can lead to increased sedimentation within these systems.							High
	degree of impact on irreplaceable resources:	The degree of the impacts will be relatively low if appropriate mitigation measures are enforced and if the extent of the impacts are limited to the site and its immediate surroundings.							Medium

Cumulative Impacts

If mitigation measures are enforced and maintained throughout the construction of the distribution lines the significance of the cumulative impacts can be managed (**Table 5-7**).

Table 5-7: Impact assessment of the potential cumulative impacts associated with the proposed Distribution line alternative 2

Potential Impact	**Mitigation**	**Extent (E)**	**Duration (D)**	**Magnitude (M)**	**Probability (P)**	**Significance (S=(E+D+M)*P)**		**Status (+ve or -ve)**	**Confidence**
Deterioration of water quality	**Nature of impact:**	Existing water quality impacts associated with other catchment uses may likely be marginally exacerbated, Given the position of this relative to other alternatives and associated watercourses the likelihood of added deterioration of water quality is higher. The probability of the impact occurring is higher compared to Alternative 3.							
	with	2	2	2	2	**12**	**Low**	-	Medium
	without	4	3	4	4	**44**	**Medium**	-	High
	degree to which impact can be reversed:	Reversibility cumulative impacts related to alteration in water quality is low.							High
	degree of impact on irreplaceable resources:	The significance of the impacts can be kept low if mitigation measures are strictly enforced. The probability of further water quality deterioration at Wetlands 1 and 2 are lower due to the already altered state of these wetlands.							Medium
Vegetation removal	**Nature of impact:**	The removal of vegetation will result in an increase in smooth surfaces thereby increasing the erosion potential and the potential velocity of surface runoff.							

	with	2	2	2	1	**6**	**Low**	-	Medium
	without	4	3	6	3	**39**	**Medium**	-	high
	degree to which impact can be reversed:	The impact can only be fully reversed once the vegetation is entirely re-established.							High
	degree of impact on irreplaceable resources:	If vegetation clearing is kept to a minimum and replanting of vegetation is carried out directly following construction activities the severity of the impacts can be considerably reduced to a Low significance, taking into account the already impact state of the vegetation cover in the surrounding catchment due to agricultural activities.							High
Increased surface runoff	**Nature of impact:**	Increased runoff may contribute to the spread of pollutants, exacerbate erosion potential and lead to sedimentation.							
	with	2	2	2	2	**12**	**Low**		Medium
	without	4	3	6	4	**52**	**Medium**		Medium
	degree to which impact can be reversed:	The probability of impacts resulting from surface runoff can be avoided by implementing appropriate and adequate mitigation measures in order to manage runoff and to reduce its velocity (refer to section 6). Due to the distribution line crossing several wetland systems, the mismanagement surface runoff can lead to increased sedimentation within these systems.							High
	degree of impact on irreplaceable resources:	The degree of the impacts will be relatively low if appropriate mitigation measures are enforced and if the extent of the impacts are limited to the site and its immediate surroundings.							Medium

5.2.3. Alternative 3

Construction Phase

Alternative 3 misses both Wetland 8 and 10. Therefore, if all the appropriate mitigation measures referred to in section 6 and stringently implemented during the construction phase of the distribution lines in alternative corridor 3, the significance of all the perceived impacts will be "low" (**Table 5-8**). Due to the lower impact scores and the further proximity to Wetland 8 (**Figure 3-5**), Alternative 3 is suggested as the preferred alignment. No perceived impacts were identified for the operational phase of the proposed distribution lines.

Table 5-8: Impact assessment of the potential impacts of proposed Distribution line alternative 3 during the construction phase

Potential Impact	Mitigation	Extent	Duration	Magnitude	Probability	Significance		Status	Confidence
		(E)	(D)	(M)	(P)	(S=(E+D+M)*P)		(+ve or -ve)	
Deterioration of water quality	**Nature of impact:**	The nature of the impacts is comparable to those discussed in Table 5-6. The construction of distribution line - Alternative 3 will cross through Wetlands 1, 2, 4 and 5 and runs alongside Wetlands 7, 9, 10 and 11. The extent and magnitude of the proposed impacts is lower when compared to the other alternatives. Alternative 3 is the preferred alternative as it crosses wetlands with a lower PES and it bypasses Wetland 8, in addition to lower significance ratings.							
	with	1	2	2	1	**5**	**Low**	-	Medium
	without	3	3	2	4	**32**	**Medium**	-	High
	degree to which impact can be reversed:	Reversing the impacts will be relatively difficult, however, if appropriate measures are carried out (Bioremediation etc.) immediately following a spill the degree and extent of the impacts can be significantly reduced. These measures are however a very costly exercise.							High
	degree of impact on irreplaceable resources:	The significance of the impacts can be kept low if mitigation measures are strictly enforced. Alternative 3 crosses several wetlands, however, the probability of further water quality deterioration is lower due to the already altered state of these wetlands.							Medium
Vegetation removal	**Nature of impact:**	The nature of the impacts is comparable to those discussed in Table 5-6, however, the significance of this impact was considered lower to that of Alternatives 2 and 4.							
	with	1	2	2	1	**5**	**Low**	-	Medium
	without	3	3	2	3	**24**	**Medium**	-	High
	degree to which impact can be reversed:	The impact can only be fully reversed once the vegetation is entirely re-established.							High
	degree of impact on irreplaceable resources:	If vegetation clearing is kept to a minimum and replanting of vegetation is carried out directly following construction activities the severity of the impacts can be considerably reduced to a Low significance, taking into account the already impact state of the vegetation cover in the surrounding catchment due to agricultural activities.							High
Increased surface runoff	**Nature of impact:**	The nature of this impact is similar to those discussed in Table 5-6, with the significance of this impact considered comparable to that of Alternative 2.							
	with	1	1	2	2	**8**	**Low**		Medium
	without	3	3	2	4	**32**	**Medium**		Medium

	degree to which impact can be reversed:	The probability of impacts resulting from surface runoff can be avoided by implementing appropriate and adequate mitigation measures in order to manage runoff and to reduce its velocity (refer to section 6). Due to the distribution line crossing several wetland systems, the mismanagement surface runoff can lead to increased sedimentation within these systems. The magnitude of the impact could be higher when compared to Alternative 2, as more wetland could be affected by Alternative 4.	High
	degree of impact on irreplaceable resources:	The degree of the impacts will be relatively low if appropriate mitigation measures are enforced and if the extent of the impacts is limited to the site and its immediate surroundings.	Medium

Cumulative Impacts

If mitigation measures are enforced and maintained throughout the construction of the distribution lines the significance of the cumulative impacts will be minimal (**Table 5-9**).

Table 5-9: Impact assessment of the potential cumulative impacts associated with the proposed Distribution line alternative 3

Potential Impact	**Mitigation**	**Extent**	**Duration**	**Magnitude**	**Probability**	**Significance**		**Status**	**Confidence**
		(E)	**(D)**	**(M)**	**(P)**	**(S=(E+D+M)*P)**		**(+ve or -ve)**	
Deterioration of water quality	**Nature of impact:**	The nature of the impacts is comparable to those discussed in Table 5-7, however, the probability of this impact was considered slightly lower compared to Alternatives 2 and 4.							
	with	2	2	2	1	**6**	**Low**	-	Medium
	without	4	3	4	4	**44**	**Medium**	-	High
	degree to which impact can be reversed:	Reversing the impacts will be relatively difficult, however, if appropriate measures are carried out (Bioremediation etc.) immediately following a spill the degree and extent of the impacts can be significantly reduced. These measures are however a very costly exercise.							High
	degree of impact on irreplaceable resources:	The significance of the impacts can be kept low if mitigation measures are strictly enforced. Alternative 4 crosses several wetlands, however, the probability of further water quality deterioration is lower due to the already altered state of these wetlands.							Medium
Vegetation removal	**Nature of impact:**	The nature of the impacts is comparable to those discussed in Table 5-7, however, the probability of this impact was considered slightly lower compared to Alternatives 2 and 4.							
	with	2	2	2	1	**6**	**Low**	-	Medium
	without	4	3	4	3	**33**	**Medium**	-	High
	degree to which impact can be reversed:	The impact can only be fully reversed once the vegetation is entirely re-established.							High
	degree of impact on irreplaceable resources:	If vegetation clearing is kept to a minimum and replanting of vegetation is carried out directly following construction activities the severity of the impacts can be considerably reduced to a Low significance, taking into account the already impact state of the vegetation cover in the surrounding catchment due to agricultural activities.							High
Increased surface runoff	**Nature of impact:**	The nature of the impacts is comparable to those discussed in Table 5-7, however, the magnitude of this impact was considered slightly lower compared to Alternatives 2 and 4.							
	with	2	2	2	2	**12**	**Low**	-	Medium
	without	4	3	4	4	**44**	**Medium**	-	Medium

	degree to which impact can be reversed:	The probability of impacts resulting from surface runoff can be avoided by implementing appropriate and adequate mitigation measures in order to manage runoff and to reduce its velocity (refer to section 6). Due to the distribution line crossing several wetland systems, the mismanagement surface runoff can lead to increased sedimentation within these systems. The magnitude of the impact could be higher when compared to Alternative 2, as more wetland could be affected by Alternative 4.	High
	degree of impact on irreplaceable resources:	The degree of the impacts will be relatively low if appropriate mitigation measures are enforced and if the extent of the impacts are limited to the site and its immediate surroundings.	Medium

5.2.4. Alternative 4

Construction Phase

During the construction phase of the distribution lines in alternative corridor 4, if all the appropriate mitigation measures referred to in section 6 and stringently implemented, the significance of all the perceived impacts will be “low” (**Table 5-10**) However due to the closer proximity to Wetland 8 the probability of deterioration of water quality is “higher” and more likely when compared to alternative 2.

Table 5-10: Impact assessment of the potential impacts of proposed Distribution line alternative 4 during the construction phase

Potential Impact	**Mitigation**	**Extent (E)**	**Duration (D)**	**Magnitude (M)**	**Probability (P)**	**Significance (S=(E+D+M)*P)**		**Status (+ve or -ve)**	**Confidence**
Deterioration of water quality	**Nature of impact:**	The nature of the impacts is comparable to those discussed in Table 5-6. The construction of distribution line - Alternative 4 will cross through Wetlands 1, 2, 4, 5 and 8 and runs alongside Wetlands 7, 9, 10 and 11. Alternative 4 could potential impact on more wetland habitat when compared to Alternative 2, and is therefore the least preferred alternative.							
	with	2	2	2	2	**12**	**Low**	-	Medium
	without	3	3	6	4	**48**	**Medium**	-	High
	degree to which impact can be reversed:	Reversing the impacts will be relatively difficult, however, if appropriate measures are carried out (Bioremediation etc.) immediately following a spill the degree and extent of the impacts can be significantly reduced. These measures are however a very costly exercise.							High
	degree of impact on irreplaceable resources:	The significance of the impacts can be kept low if mitigation measures are strictly enforced. Alternative 4 crosses several wetlands, however, the probability of further water quality deterioration is lower due to the already altered state of these wetlands.							Medium
Vegetation removal	**Nature of impact:**	The nature of the impacts is comparable to those discussed in Table 5-6. Alternative 4 has a higher extent and probability rating as the alignment will bisect Wetland 8.							
	with	2	2	2	2	**12**	**Low**	-	Medium
	without	3	3	4	4	**40**	**Medium**	-	High
	degree to which impact can be reversed:	The impact can only be fully reversed once the vegetation is entirely re-established.							High

	degree of impact on irreplaceable resources:	If vegetation clearing is kept to a minimum and replanting of vegetation is carried out directly following construction activities the severity of the impacts can be considerably reduced to a Low significance, taking into account the already impact state of the vegetation cover in the surrounding catchment due to agricultural activities.							High
Increased surface runoff	**Nature of impact:**	The nature of the impacts is comparable to those discussed in Table 5-6. Alternative 4 has a higher significance rating compared to the other two alternatives, mainly due to the proposed alternative bisecting Wetland 8.							
	with	2	1	2	2	**10**	**Low**		Medium
	without	3	3	4	4	**40**	**Medium**		Medium
	degree to which impact can be reversed:	The probability of impacts resulting from surface runoff can be avoided by implementing appropriate and adequate mitigation measures in order to manage runoff and to reduce its velocity (refer to section 6). Due to the distribution line crossing several wetland systems, the mismanagement surface runoff can lead to increased sedimentation within these systems. The magnitude of the impact could be higher when compared to Alternative 2, as more wetland could be affected by Alternative 4.							High
	degree of impact on irreplaceable resources:	The degree of the impacts will be relatively low if appropriate mitigation measures are enforced and if the extent of the impacts are limited to the site and its immediate surroundings.							Medium

Cumulative Impact

If mitigation measures are enforced and maintained throughout the construction of the distribution lines the significance of the cumulative impacts will be minimal (**Table 5-11**).

Table 5-11: Impact assessment of the potential cumulative impacts associated with the proposed Distribution line alternative 4.

Potential Impact	**Mitigation**	**Extent (E)**	**Duration (D)**	**Magnitude (M)**	**Probability (P)**	**Significance (S=(E+D+M)*P)**		**Status (+ve or -ve)**	**Confidence**
Deterioration of water quality	**Nature of impact:**	The nature of the impacts is comparable to those discussed in Table 5-7, however, the probability of this impact was considered slightly lower compared to Alternative 3. Alternative 4 could potential impact on more wetland habitat when compared to the other alternatives.							
	with	2	2	2	2	**12**	**Low**	-	Medium
	without	4	3	6	4	**52**	**Medium**	-	High
	degree to which impact can be reversed:	Reversing the impacts will be relatively difficult, however, if appropriate measures are carried out (Bioremediation etc.) immediately following a spill the degree and extent of the impacts can be significantly reduced. These measures are however a very costly exercise.							High
	degree of impact on irreplaceable resources:	The significance of the impacts can be kept low if mitigation measures are strictly enforced. Alternative 4 crosses several wetlands, however, the probability of further water quality deterioration is lower due to the already altered state of these wetlands.							Medium
Vegetation removal	**Nature of impact:**	The nature of the impacts is comparable to those discussed in Table 5-7, however, the probability of this impact was considered higher compared to Alternatives 2 and 3.							
	with	2	2	2	2	**12**	**Low**	-	Medium
	without	4	3	4	4	**44**	**Medium**	-	high

	degree to which impact can be reversed:	The impact can only be fully reversed once the vegetation is entirely re-established.							High
	degree of impact on irreplaceable resources:	If vegetation clearing is kept to a minimum and replanting of vegetation is carried out directly following construction activities the severity of the impacts can be considerably reduced to a Low significance, taking into account the already impact state of the vegetation cover in the surrounding catchment due to agricultural activities.							High
Increased surface runoff	**Nature of impact:**	The nature of this impact is comparable to those discussed in Table 5-7, however, the magnitude of this impact was considered slightly higher when compared to the other alternatives.							
	with	2	2	2	2	**12**	**Low**		Medium
	without	4	3	6	4	**52**	**Medium**		Medium
	degree to which impact can be reversed:	The probability of impacts resulting from surface runoff can be avoided by implementing appropriate and adequate mitigation measures in order to manage runoff and to reduce its velocity (refer to section 6). Due to the distribution line crossing several wetland systems, the mismanagement surface runoff can lead to increased sedimentation within these systems. The magnitude of the impact could be higher when compared to Alternative 2, as more wetland could be affected by A1ternative 4.							High
	degree of impact on irreplaceable resources:	The degree of the impacts will be relatively low if appropriate mitigation measures are enforced and if the extent of the impacts are limited to the site and its immediate surroundings.							Medium

5.3. Pipeline Route

Construction Phase

Perceived impacts associated with the construction of the pipeline include: deterioration of water quality; vegetation removal; and Increased surface run-off. If all the appropriate mitigation measures referred to in section 976 are stringently implemented, the significance of all the perceived impacts will be “low” (**Table 5-12**).

Table 5-12: Impact assessment of the potential impacts of proposed pipeline route during the construction phase

Potential Impact	Mitigation	Extent	Duration	Magnitude	Probability	Significance		Status	Confidence
		(E)	(D)	(M)	(P)	(S=(E+D+M)*P)		(+ve or -ve)	
Deterioration of water quality	**Nature of impact:**	Hydrocarbons (oil and diesel etc.), solvents and other pollutants spilling/leaking from construction machinery and equipment during the construction phase may have an impact on the receiving aquatic environments.							
	with	1	1	2	1	**4**	**Low**	-	high
	without	2	2	4	3	**24**	**Low**	-	Medium
	degree to which impact can be reversed:	Reversing the impacts will be relatively difficult however if appropriate measures are carried out (Bioremediation etc.) immediately following a spill the degree and extent of the impacts can be significantly reduced. These measures are however a very costly exercise.							high
	degree of impact on irreplaceable resources:	The degree of the impact will be directly related to the extent of the spill etc. With appropriate mitigation measures in place (refer to section 6.4) the probability of this impact can be reduced drastically.							Medium
Vegetation removal	**Nature of impact:**	The removal of vegetation will result in an increase in smooth surfaces increasing the potential velocity of surface run-off thereby increasing the erosion potential.							
	with	1	2	2	1	**5**	**Low**	-	Medium
	without	3	3	6	3	**36**	**Medium**	-	high
	degree to which impact can be reversed:	The impact can only be fully reversed once the vegetation is entirely re-established.							high
	degree of impact on irreplaceable resources:	If vegetation clearing is kept to a minimum and replanting of vegetation is initiated directly following construction activities the severity of the impacts can be considerably reduced to a low significance.							high
Increased surface run-off	**Nature of impact:**	Increased run-off may contribute to the spread of pollutants, exacerbate erosion potential and lead to sedimentation.							
	with	2	2	2	2	**12**	**Low**	-	Medium
	without	3	3	6	4	**48**	**Medium**	-	Medium
	degree to which impact can be reversed:	The probability of impacts resulting from surface run-off can be avoided by implementing appropriate and adequate mitigation measures in order to manage run-off and to reduce its velocity (refer to section 6).							Medium
	degree of impact on irreplaceable resources:	The degree of the impacts will be relatively low if they are mitigated quickly and if the extent of the impacts is limited to the pipeline servitude.							Medium

Cumulative Impacts

If mitigation measures are enforced and maintained throughout the construction of the pipeline the significance of the cumulative impacts will be minimal (**Table 5-13**).

Table 5-13: Impact assessment of the potential cumulative impacts associated with the proposed pipeline route

Potential Impact	Mitigation	Extent	Duration	Magnitude	Probability	Significance		Status	Confidence
		(E)	(D)	(M)	(P)	(S=(E+D+M)*P)		(+ve or -ve)	
Deterioration of water quality	**Nature of impact:**	Hydrocarbons (oil and diesel etc.), solvents and other pollutants spilling/leaking from construction machinery and equipment during the construction phase may have an impact on the receiving aquatic environments.							
	with	1	1	2	1	4	Low	-	high
	without	2	2	4	3	24	Low	-	Medium
	degree to which impact can be reversed:	Reversing the impacts will be relatively difficult however if appropriate measures are carried out (Bioremediation etc.) immediately following a spill the degree and extent of the impacts can be significantly reduced. These measures are however a very costly exercise.							high
	degree of impact on irreplaceable resources:	The degree of the impact will be directly related to the extent of the spill etc. With appropriate mitigation measures in place (refer to section 6) the probability of this impact can be reduced drastically.							Medium
Vegetation removal	**Nature of impact:**	The removal of vegetation will result in an increase in smooth surfaces increasing the potential velocity of surface run-off thereby increasing the erosion potential.							
	with	1	2	2	1	5	Low	-	Medium
	without	3	3	6	3	36	Medium	-	high
	degree to which impact can be reversed:	The impact can only be fully reversed once the vegetation is entirely re-established.							high
	degree of impact on irreplaceable resources:	If vegetation clearing is kept to a minimum and replanting of vegetation is carried out directly following construction activities the severity of the impacts can be considerably reduced to a Low significance							high
Increased surface run-off	**Nature of impact:**	Increased run-off may contribute to the spread of pollutants, exacerbate erosion potential and lead to sedimentation.							
	with	2	2	2	2	12	Low	-	Medium
	without	3	3	6	4	48	Medium	-	Medium
	degree to which impact can be reversed:	The probability of impacts resulting from surface run-off can be avoided by implementing appropriate and adequate mitigation measures in order to manage run-off and to reduce its velocity (refer to section 6).							Medium
	degree of impact on irreplaceable resources:	The degree of the impacts will be relatively low if they are mitigated quickly and if the extents of the impacts are limited to the pipeline servitude.							Medium

6. Mitigation and Management Measures

The risks associated with future wetland impairment resulting from proposed development are subject to the efficient implementation of mitigation and management measures. In the event that construction and operation activities prevent changes to downslope sedimentations rates, erosion rates, hydrological regime and water quality, no or little loss in most ecosystem services are anticipated. This however, does not mitigate the loss of wetland habitat, which would be sterilized through the implementation of the Alternative E ashing facility.

Although the PES and EIS assessment indicated that the loss of wetland habitat and associated contributions to biodiversity linked to Alternative E is unlikely to incur significant local residual impact, the loss of further wetlands in an already altered catchment could be considered to be of cumulative importance. To compensate for the loss in wetland habitat, a possible off-site mitigation measure (adapted from Macfarlane *et al.* (2012)) may be to rehabilitate downslope impaired systems and to conserve these systems to compensate for the loss of wetland habitat induced by the proposed development.

6.1. General Recommendations

It is important to note that avoidance is the first step in the mitigation hierarchy. General recommendation mainly considers mitigating risks factors pertaining to hydrology water quality, sedimentation and erosion linked to the downslope receiving aquatic resources during the construction and operational phases.

- It is recommended that construction activity should make use of “seasonal construction window” (March to September).
- Highlight the presence, extent and sensitivity of associated watercourses, as well measures to avoid any unnecessary damage or loss to these systems during construction. Physical demarcation of wetlands, and general “wetland” awareness should be included.
- Provide a detailed course of action for accidental spills or surface water contamination and describe detailed measures to control risks related to suspended sediment and turbidity (e.g. berms, hay bales, silt curtains, river diversions, and settling ponds), damage to riparian vegetation and spillage of fuels and oils, cement and other foreign materials.
- Minimize both the area that will be exposed and the exposure time during construction (LRRB, Mn/DOT and FHWA, 2003).
- Discharge into surface water systems, should be avoided.

- Contaminated water should be isolated. Any water with a chemical signature different to that of the receiving aquatic environment should be considered contaminated and should be isolated and managed accordingly.
- Erosion control measures should be implemented as the primary means of sediment control throughout the construction and operational phase. Increased turbidity and sedimentation resulting from erosion have several adverse effects on the aquatic environment. According to DWAF (2008) an increase in sediment input into the system due to erosion is a serious issue.
- Surface water systems should be protected from contamination with volatile hydrocarbons and lubricants at all times.
- Contingency plans need to be established in case of fuel or hazardous waste spills, storm water run-off and flood events.
- No dumping of any sorts (soil, litter, organic matter or chemical substances) may occur within the associated wetlands. Dumping and temporary storage of the above should only occur at predetermined locations.
- All excavated material should be deposited and stabilised in an approved area.
- Reinstate hydrological functionality of affected systems after construction activity, as far as possible. This will require rehabilitation of disturbed downslope areas were attention is paid to increase surface roughness and energy dissipation.
- All employees should be educated regarding environmental risks and proper cause of action should such risks be presented during day to day activities.

6.2. Alternative E

During the construction and operational phase of the proposed wet ash disposal facility at Alternative E, general (**Section 6.1**) mitigation measures need to be stringently implemented and enforced in order to minimise the potential impacts. Listed below are mitigation measures concerning the construction of the proposed wet ash disposal facility:

- Construction activities need to comply with any condition set forth by applicable authorities.
- It is preferable that an impermeable liner be placed at the base of the wet ash disposal facility during construction. This will assist in mitigating the spread of pollutants/toxic substances.
- Clean water run-off channels must be constructed to divert clean water from above the construction site and divert the water around the work area (Clemens, 2010). This will be an important feature with regards to Wetland 1 (downstream of Alternative E)

as it will help prevent run-off from become sediment-laden and entering receiving wetlands.

- Vegetation clearing needs to be limited to the construction limits as it will assist in limiting erosion and reducing the velocity of run-off. In addition, clearing should only take place immediately before construction activities commence. Vegetative cover is the most effective measure to stabilise top soil and to prevent erosion, sedimentation and associated water quality impacts.
- Wetlands connected to affected HGM units in the primary study area will require monitoring during the construction phase. The results of the monitoring should feed into an adaptive management system. Specific emphasis should be placed on retaining wetland function PES.

6.3. Distribution lines

During the construction of the proposed distribution lines, general (**Section 6.1**) and mitigation measures need to be stringently implemented and enforced in order to minimise the potential impacts. Listed below are mitigation measures concerning the construction of the proposed distribution lines:

- The placement and construction of the distribution line pylons should be avoided in wetlands.
- Minimize soil compaction within wetlands during construction.
- Temporary access roads should avoid wetlands as far as possible.
- Clearing of vegetation needs to be limited to the construction limits.
- All excavated material during the construction of the pylons, should be deposited and stabilised in distinct piles within approved areas with suitable erosion control measures in place in order to minimise and reduce erosion and siltation.
- In the event of any damage to the surrounding wetlands during the construction of the distribution lines, the advice of a suitable and qualified specialist will be required in order to facilitate suitable rehabilitation of the wetland in question.

6.4. Pipeline

During the construction of the proposed pipeline route, general (**Section 6.1**) mitigation measures are also applicable. Listed below are mitigation measures concerning the construction of the proposed pipeline:

- The construction of the pipeline servitude should not infringe on the wetland areas.
- Surface and storm water must be diverted away from excavation.

- Water accumulated with the trenches (rainfall events etc.) needs to be pumped out through a water bypass system in order to filter out sediment.

6.5. Wetland Rehabilitation and Management

The alternative selection aimed at avoiding and minimising impacts on wetland imposed by the proposed development. Apart from the direct sterilisations of the wetlands within the proposed Alternative E ashing facility footprint and subsequent hydrological alteration and loss of water resources downstream, no significant residual impact could be identified as a result of the proposed activities (please refer to Section 5). It is believed that any negative effect of impacts can be averted through appropriate mitigation and management measures (please refer to Sections 6.2 through 6.4). However, in light of the high degree of catchment transformation which has occurred within the Olifants WMA, an off-site mitigation plan is suggested here to aid with the management of existing cumulative impacts.

In light of the PES and EIS of HGM units identified in the primary study area and the environmental least cost associated with Alternative E, off-site mitigation is a feasible management action. It must however be noted that off-site mitigation is not an alternative/substitute to on-site mitigation measures and that it will not reduce the magnitude and severity of the impacts associated with the proposed wet ash disposal facility construction. Off-site mitigation should be implemented in combination with the above mention mitigation measures. The impaired state of receiving wetlands in the secondary study area and the hectare equivalents provided in this report provide an opportunity and base for off-site mitigation. A wetland rehabilitation and management plan may incorporate and address possible off-site mitigation options. It a minimum such options should consider the following: 1) technical feasibility, 2) cost-effectiveness, and 3) environmental impact associated with the off-site strategy.

6.6. Monitoring

One of the main aims of this report was to establish baseline conditions of the receiving environment. The results of which thus provide a platform for future monitoring. It is recommended that constituents of this report be incorporated into a monitoring plan with quarterly intervals during construction and biannually during the operational phase of the proposed development. It is pertinent for monitoring sites and methodology to be consistent as this provides credibility and continuity in information.

Results of each monitoring report should be incorporated with that of past assessments. Particular emphasis must be placed on spatial and temporal variation in community structures as well as the absence and presence of indicator species. In the case of invertebrates and fish, seasonal average of abundances, species richness and feeding group ratios should be provided along with a standard deviation. It is always a good idea to include raw data in the form of an appendix. A record of seasonal variation in biological responses will also aid in highlighting other drivers of ecological change (i.e. mining or discharge activity), and it will help to measure the rate of recovery in the system after an unforeseen spill event. From this, target thresholds for aquatic communities may be generated, which in turn will act as a measurable environmental performance indicator.

Changes measured in biological metrics must justify an immediate correction in the process inducing the change. Biomonitoring reports should inform an adaptive management process, which ideally, should address relevant components of the process as soon as possible (prior to the following biomonitoring assessment). After a number of monitoring surveys (approximately four), a template for expected community structures may be extrapolated from the data. From this, key species or ratios between species may be highlighted which, in turn, will act as a standard in itself. These key species and or ratios between species may be used for comparison and interpretation

7. Conclusion

Ash management inherently carries environmental risk, particularly to surface and ground water systems. The extent of the proposed development in relation to the extent of other uses in the water management area may add to cumulative impacts on the Klein-Olifants system. The Klein-Olifants system is compromised and any additional strain on surface water ecology should be considered in this light. Thus, the remaining ecological integrity associated with the Woes-Alleenspruit is of particular importance on a quaternary catchment scale. However, the surface water study carried out in July 2011 indicated that wetlands associated with the study area are in a Moderately to Largely modified state. In light of the PES, retained functionality, EIS and potential mitigation measures available, it is possible to accommodate the proposed expansion without significantly impacting on the downslope aquatic resources.

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9. Appendix A – Site Photos, July 2011

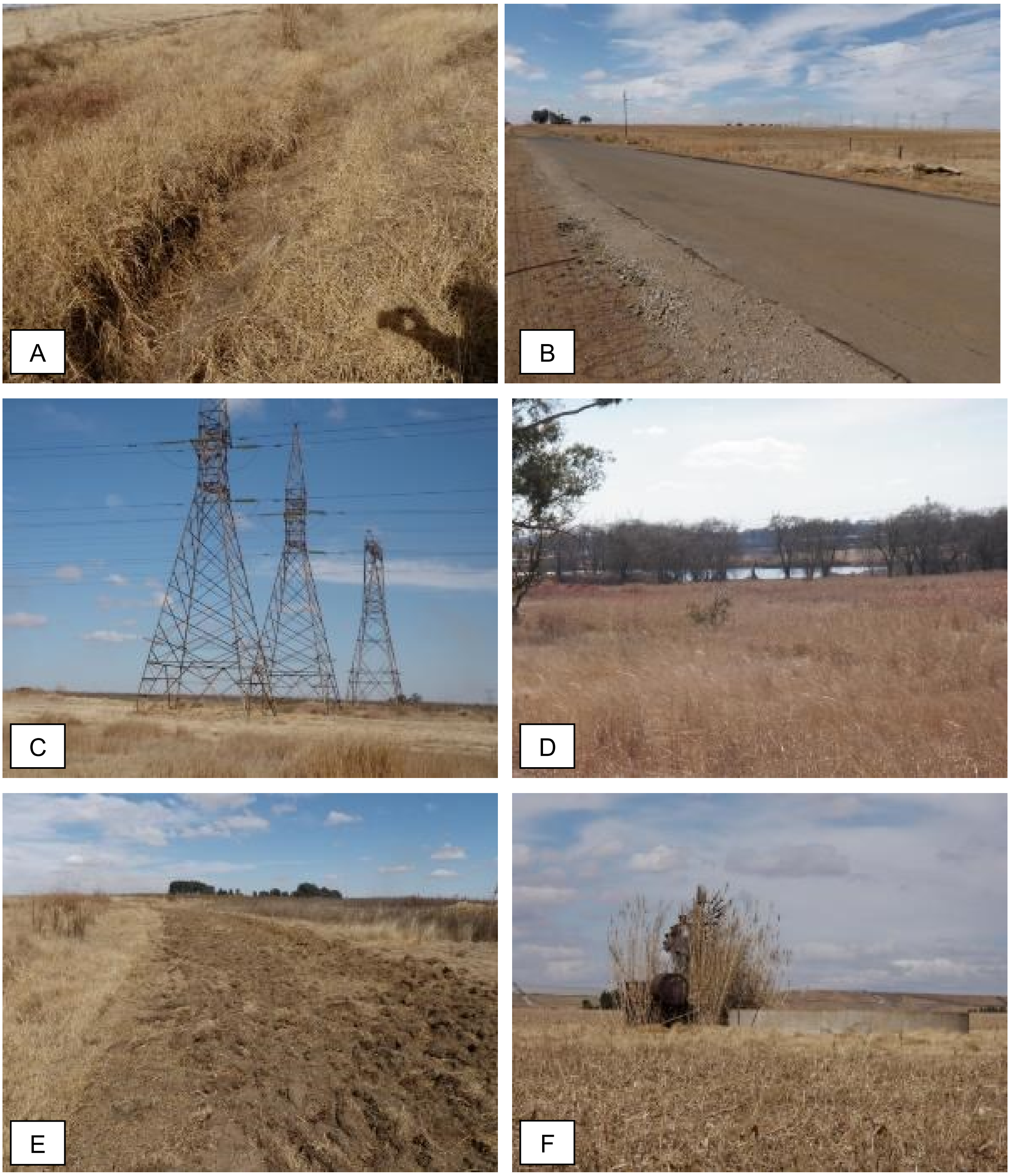

Figure 9-1: HGM1 is situated in the north-western portion of Alternative E reflecting exciting impacts which include: (A) retention dam, (B) road, (C) power line pylons, (D) furrow (E) a fire break and (F) a small dam.

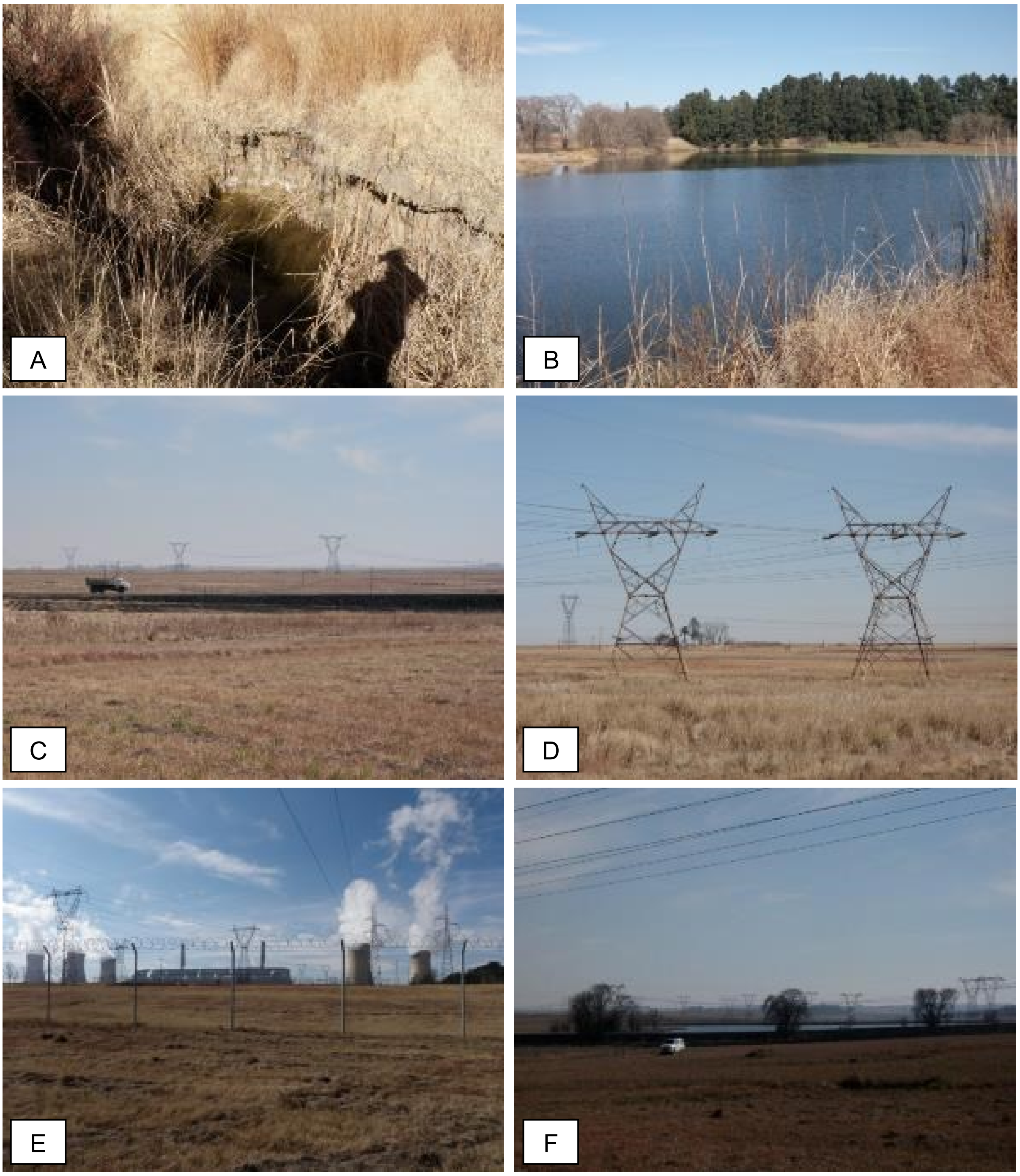

Figure 9-2: Exciting impacts associated with HGM 2, 3 and 4 include: (A) (B) large dams, (C) Hendrina Power Station, (D) severe canalisation, (E) power line pylons and (F) a road.

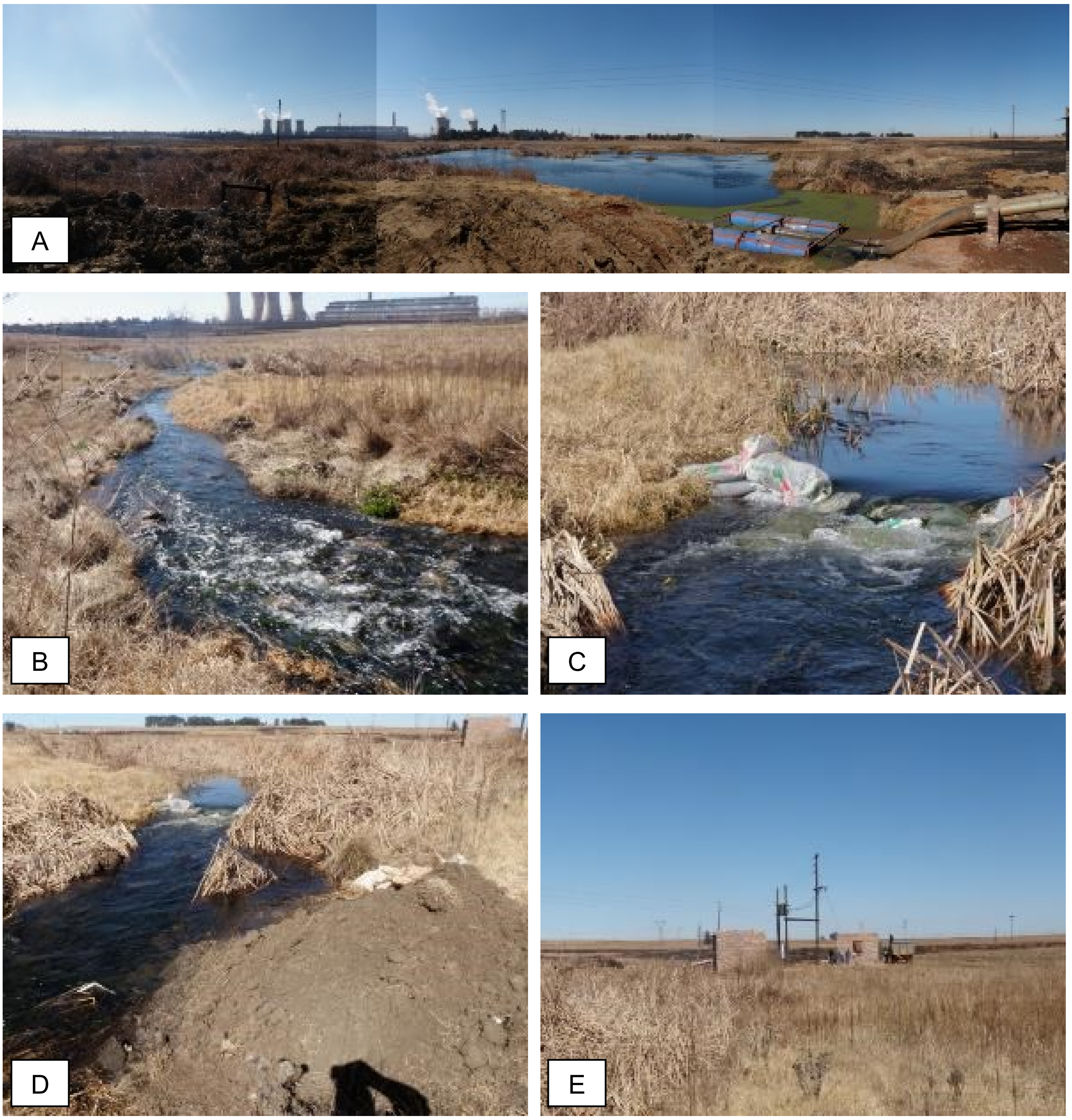

Figure 9-3: Site HA2 (monitoring site 2) is located to the north-west of Alternative E showing (A) panoramic view, (B) riffle section located downstream of the dam, (C) sand bags altering the flow, (D) loose sediment placed on the left bank, (E) construction activities.

Figure 9-4: HGM 11 is situated in the north-eastern portion of Alternative E reflecting (A) panoramic view of the wetland with exciting impacts: (B) maize fields, (C) fire breaks, (D) Hendrina Power Station and (E) a farm property.

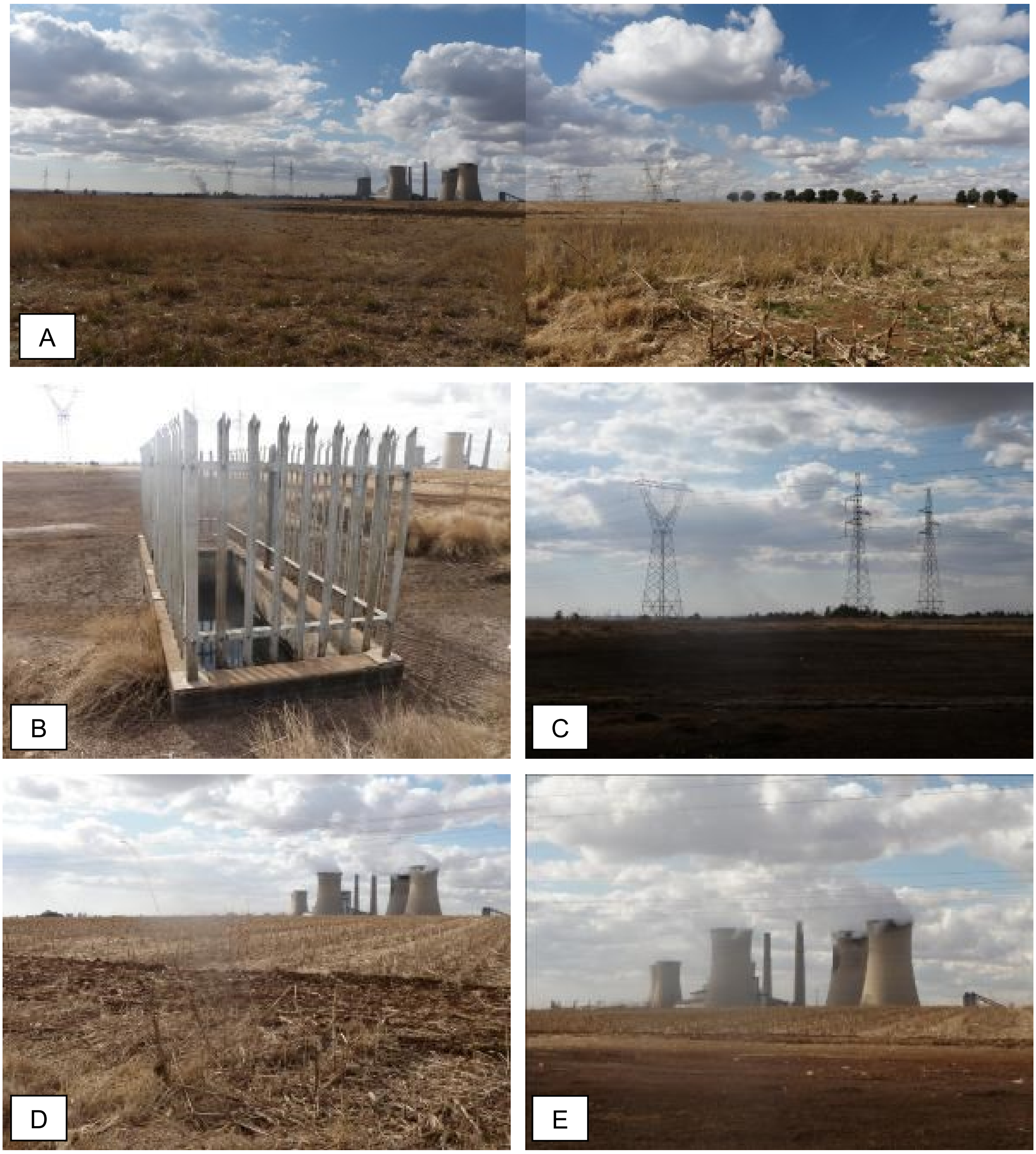

Figure 9-5: HGM 12 is situated in the south-eastern portion of Alternative E reflecting (A) a panoramic view of the wetland with exciting impacts: (B) presumably a cattle dip located within the seasonal zone, (C) power line pylons, (D) maize field with a fire break (E) and Hendrina Power Station.

Figure 9-6: HGM 15 and 16 are situated to the south of Alternative E reflecting (A) a panoramic view of the wetland with exciting impacts: (B) tar road and (C) exciting Hendrina ash disposal facility.

Figure 9-7: HGM 13 and 14 are situated to the south-west of Alternative E reflecting (A) a panoramic view of the wetland with exciting impacts: (B) farm property, (C) maize husks deposited within the seasonal zone, (D) trampling via cattle and (E) power lines.

10. Appendix B – Site Photos, August 2014

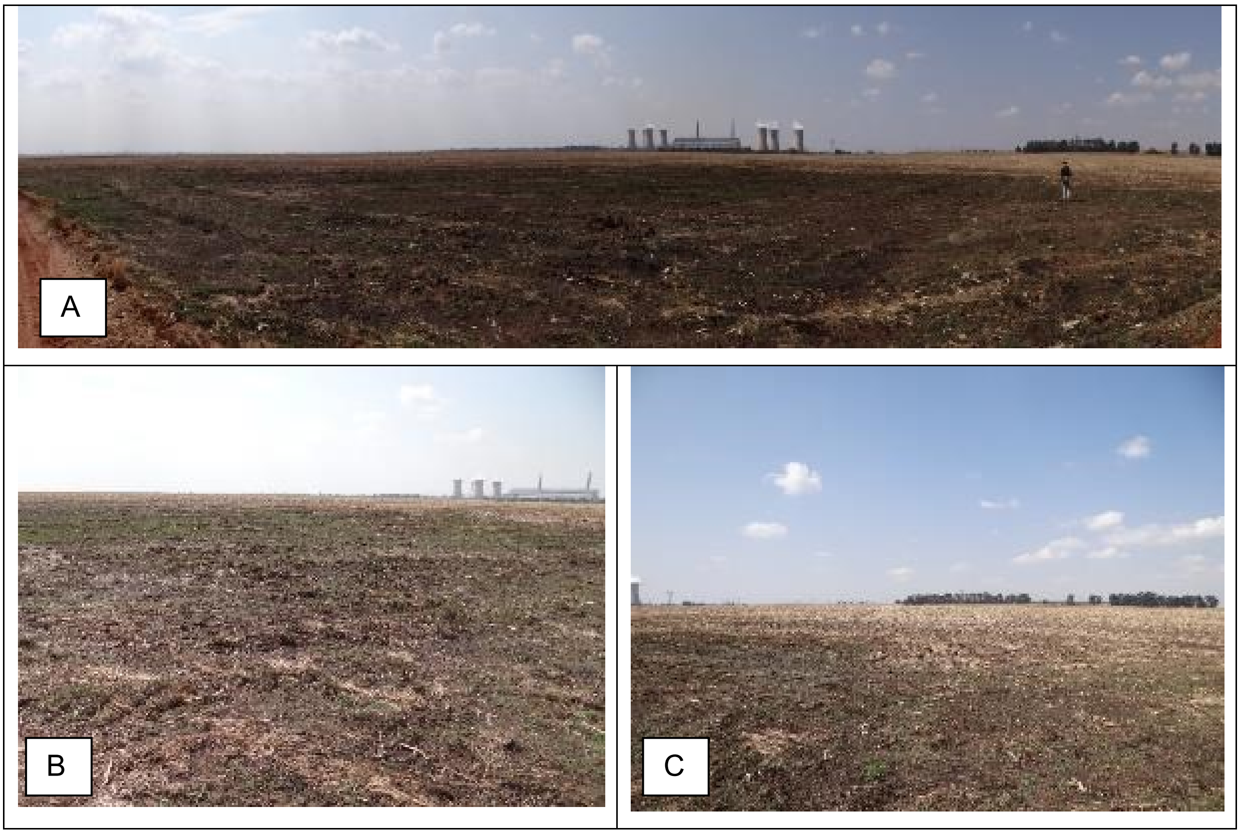

Figure 10-1: Wetland 3 (HGM8) located west of Alternative E indicating A) a panoramic view of the wetland, B) and C) surface denudation through burning and ploughing.

Figure 10-2: Wetland 4 (HGM9) located in the direct line of the proposed distribution line options A) a panoramic view of the wetland, B) hydromorphic alteration, and C) surface denudation through burning.

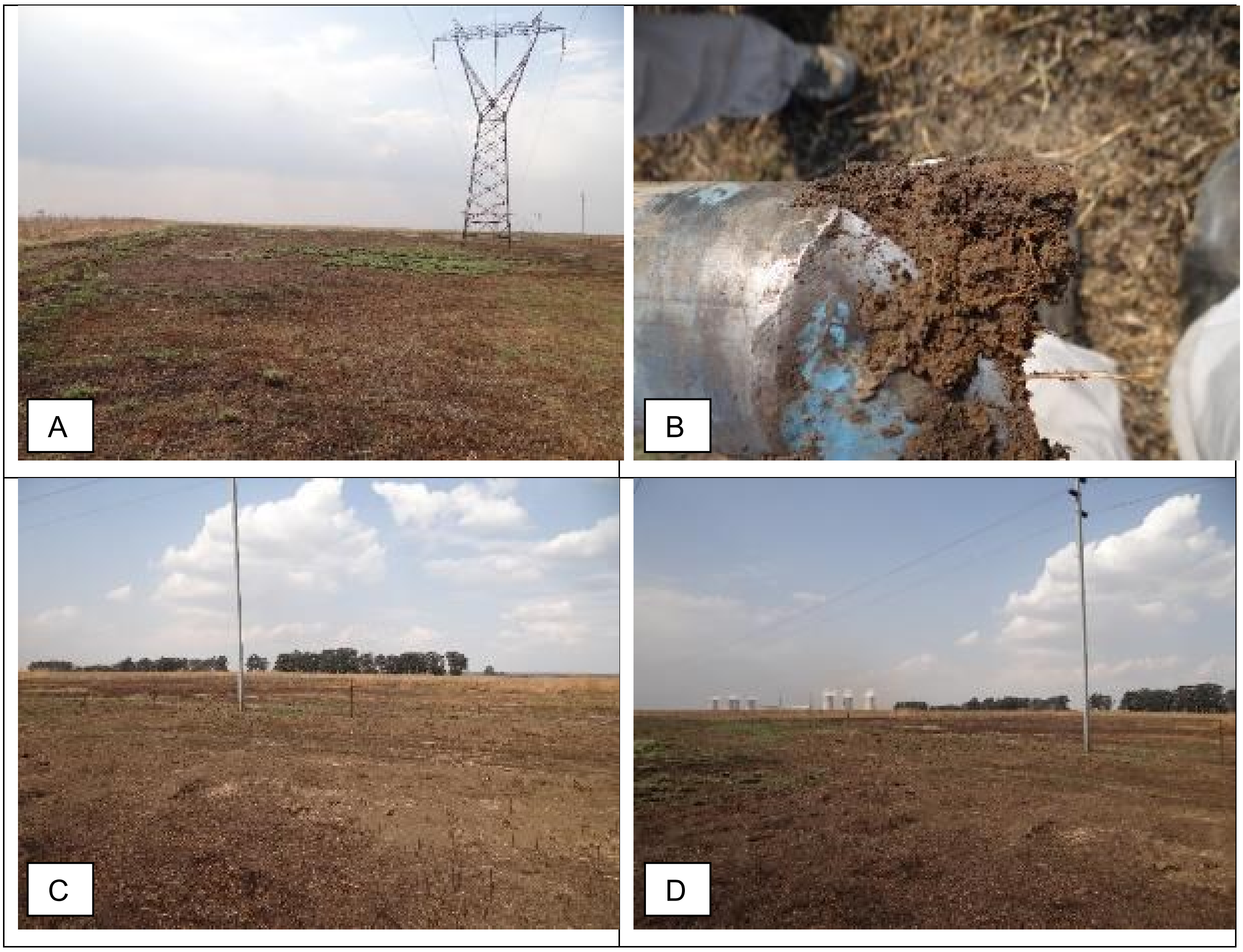

Figure 10-3: Wetland 5 (HGM10) located in the direct path of the proposed distribution lien options indicating A) existing pylon within, B) hydromorphic alteration in soils C) and D) surface denudation through burning and ploughing.

Figure 10-4: Wetland 10 (HGM 17, 18 and 19) locate south of proposed activities indicating A) panoramic view of HGM 17, B) proximity of permanent zone to ploughed fields, C) Sandy hillslope soil type from HGM 18, D) trenching within HGM17, and E) denudation and burning of HGM18.

Figure 10-5: Wetland 11 located south of proposed distribution lines indicating A) panoramic view of wetland, B) denudation through burning, and C) loss of temporal and seasonal zone through ploughing.

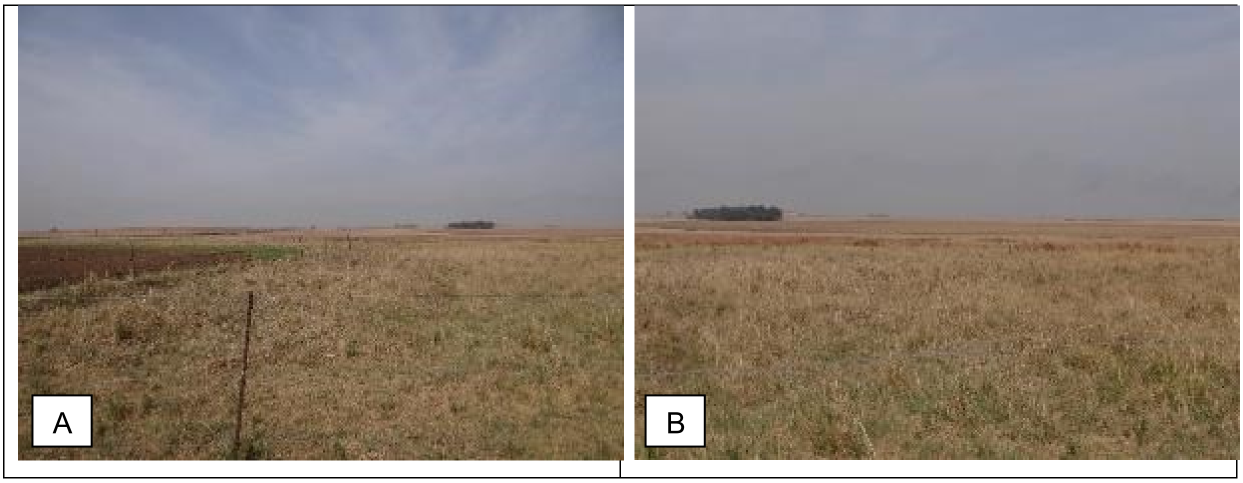

Figure 10-6: Wetland 12 located south of proposed distribution lines indicating A) encroachment of agriculture on wetland habitat, B) trampling and grazing of wetland vegetation.