Proposed Continuous Ash Disposal Facility at the Tutuka Power Station

Aquatic Specialist Study

Environmental Impact Assessment

Reference: Lidwala_Tutuka_Dry_Ash_Disposal_Facility_EIA_Final_May_2014

Date: May 2014

Version: Final

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The spatial and temporal extents of Ecotone's services are described in the proposal, and are subject to restrictions and limitations. Only a single survey was carried out and therefore 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.

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Executive Summary

Introduction

Lidwala Consulting Engineers appointed Ecotone Freshwater Consultants to undertake the freshwater ecology specialist component for the Environmental Impact Assessment (EIA) of the proposed continuous dry ashing facilities at the Tutuka Power Station located north-east of the town of Standerton, Mpumalanga. The power station requires additional dry ash disposal facilities in order to continue generating electricity until the planned life of the station. This report provides the result of the specialist assessment and an impact assessment related to the proposed activities.

Study Approach and 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. Information on local fish distribution, fish ecology, fish biology and frequency of occurrence was obtained by studying relevant literature.

The field assessment was undertaken during March 2013 where wetlands located within the three alternatives (primary study area) were identified, delineated and assessed. Wetlands located within a 500 m radius (secondary study area) were delineated at a desktop level with *in situ* water quality variables recorded during the field survey. The field assessment was augmented in May 2014 to include the extension/adjustment to Alternative A.

Water quality monitoring comprised of *in situ* components which included pH, Electrical Conductivity (EC), Total Dissolved Solids (TDS) and Temperature. The results obtained from the assessment of the water quality data were compared to Target Water Quality Ranges (TWQRs) for aquatic ecosystems. Diatoms were sampled and assessed at wetland systems located with the primary study area.

The Present Ecological State (PES) and Ecological Importance and Sensitivity (EIS) for the wetlands located in the primary study area were determined using Wet-EcoServices (Kotze *et al*., 2009) and Wet-Health (MacFarlane *et al*., 2009) methodology.

A risk based impact assessment was applied to highlight the significance of perceived impacts associated with the proposed continuous dry ashing at the Tutuka Power Station and assist in determining which alternative possess the least threat to the receiving aquatic environment.

Summary of Findings

A summary of the PES observed for aquatic drivers and responses measured in the affected systems are listed in Table 0-1 to Table 0-3. Main findings are summarised accordingly:

- Alternative A occupied the largest wetland extent.
- Alternative B retained more functional integrity that Alternatives A and C.
- Alternative B consisted of more sub-catchment drainage directions than Alternatives A and C. Alternative A is drained by only one catchment.
- The receiving watercourse linked to Alternative A is more impaired than the receiving watercourses linked to Alternative B and C.
- Water quality, as indicated by *in situ* variables and the diatom assessment, showed that Wetland 6 on Alternative A consisted of contaminated water. Wetlands on Alternative B reflected the best water quality, while that of Alternative C was considered moderate to good.
- The main retained ecosystems services include streamflow regulation and water purification. Special reference should be made to the important role in pollution control played by Wetland 6 on Alternative A.
- All three alternatives scored similar Ecological Importance and Sensitivity (EIS) scores. The total EIS score for Alternative A was marginally higher. This was due the large number of dams in its secondary study area, which provide habitat for migratory birds.

Table 0-1: Summary of PES main findings for Alternative A

Alternative A	Wetland 5	Wetland 6	Wetland 10
Total wetland size (ha)	24.4	97.66	6.04
% wetland on Alternative		13%	
Hectare Equivalents		51.69	
PES of wetlands	C	E	D
PES of receiving watercourses	E	E	E
Water Quality	Good	Poor	Moderate
Eco-Services Score (Average)	2.21	2.16	1.86
EIS (Median)		Moderate	

Table 0-2: Summary of main findings Alternative B

Alternative B	Wetland 7	Wetland 8	Wetland 9	Wetland 11	Wetland 12
Total wetland size (ha)	9.83	0.76	2.57	11.8	50.9
% wetland on Alternative	3 %				
Hectare Equivalents	52.44 (ha)				
PES of wetlands	B	C	C	C	C
PES of receiving watercourses	C	C	C	C	C
Water Quality	Good	Good	Good	Very Good	Moderate
Eco-Services Score (Average)	2.15	2.32	2.32	1.98	2.26
EIS (Median)	Medium				

Table 0-3: Summary of main findings for Alternative C

Alternative C	Wetland 1	Wetland 2	Wetland 3	Wetland 4
Total wetland size (ha)	4.76	25.11	21.14	27.2
% wetland on Alternative	4 %			
Hectare Equivalents	47 ha			
PES of wetlands	C	C	C	D
PES of receiving watercourses	E	C	C	C
Water Quality	Moderate	Good	Moderate	Moderate
Eco-Services Score (Average)	2.12	2.27	2.26	2.07
EIS (Median)	Medium			

Main Impacts

Main anticipated impacts include the following:

1. Impacts on hydrology;
2. Impacts on surface water quality;
3. Impacts related to erosion and sedimentation;
4. Impacts on wetland vegetation and disturbance of wetland habitat;
5. Impact related to increase alien/pioneer vegetation in disturbed areas;
6. Impacts on residual wetland ecosystem services.

The impact assessment ascertained that all three alternatives will be subjected to similar impacts. The main differences were the extent and the magnitude, as some alternatives occupy larger wetland areas, while others were considered more sensitive. The greater part of the proposed footprint associated with Alternative A is drained by one catchment, which is already impaired in terms of the functional integrity of associated wetlands. Considering the extent of wetlands per Alternative, their PES, Hectare Equivalents, catchment size and PES of receiving watercourses, the overall aquatic risks were considered less for Alternative A than for the other two Alternatives. Conversely, Alternative B was considered as more sensitive and as such is the less preferred site.

Recommendations

General mitigation measures are provided in the report for different impacts and phases of operation. Some residual impact will persist if Alternative A is selected which may be further mitigated by avoiding as much wetland habitat as is reasonably possible. A possible consideration might be to combine parts of Alternative A and C. It is however, recommended that ashing footprint be kept within the catchment of Wetland 6.

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List of Abbreviations

AEV	Acute Effect values
BDI	Biological Diatom Index
CEV	Chronic Effect values
D	Duration
DS	Downstream
DWA	Department of Water Affairs
E	Extent
EC	Electrical Conductivity
EIA	Environmental Impact Assessment
EIS	Ecological Importance and Sensitivity
EX	Exotic
GIS	Geographic Information System
HCl	Hydrochloric Acid
HGM	Hydro-geomorphic
I	Intensity / Severity
MAP	Mean Annual Precipitation
MAPE	Mean Annual Potential Evaporation
MAR	Mean Annual Run-off
MAT	Mean Annual Temperature
Max	Maximum
MBCP	Mpumalanga Biodiversity Conservation Plan
MFD	Mean Frost Days
NFEPA	National Freshwater Ecosystem Priority Areas
Min	Minimum
NSBA	National Spatial Biodiversity Assessment
%PTV	Percentage Pollution Tolerance Valves
P	Probability
PES	Present Ecological State
S	Significance Weighting
SANBI	South African National Biodiversity Institute
SPI	Specific-Pollution Sensitivity Index
TDS	Total Dissolved Solids
TWQR	Target Water Quality Range
US	Upstream
WMA	Water Management Area

1. Introduction

1.1. Background

Lidwala Consulting Engineers appointed Ecotone Freshwater Consultants to undertake the freshwater and wetland ecology specialist component for the Environmental Impact Assessment (EIA) of the proposed continuous dry ashing at the Tutuka Power Station located north-east of the town of Standerton, Mpumalanga. The power station requires adequate dry ash disposal facilities in order to continue generating electricity until the end of the life of the station. This report provides the result of the specialist assessment and an impact assessment related to the proposed activities.

1.2. Objectives

A specialist wetland and aquatic assessment was undertaken in order to ascertain the baseline condition of the receiving environment via the implementation of the following methodological approach:

- The present state of biological receptors in the receiving environment was ascertained by:
    - Description of the instream response metrics where applicable.
    - Measurement of *in situ* water quality of wetlands and wetland systems located within a 500 m radius of the proposed alternatives.
    - Diatom analyses at wetlands located within the alternative boundaries.
- The wetland assessment included:
    - Representation of wetland boundaries within the primary and secondary study area and 100 m buffer zone on wetland boundaries.
    - Representation of the hydrogeomorphic classification of wetlands.
    - Assessment of the Present Ecological State (PES) of these units.
    - Assessment of the vulnerability of wetlands expressed in the relationship between wetland slope and wetland size.
    - Assessment of the functionality of wetlands and calculation of the geographical extent of retained wetland functionality by making reference to Hectare Equivalents.
    - Assessment of the Ecological Importance and Sensitivity (EIS) of wetlands
- Impact assessment and mitigation measures:
    - Assessment of the perceived impacts on wetlands resulting from the proposed placement of the dry ash disposal facility and infrastructure.
    - Provision of mitigation measures for impacts where 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 water course 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 activities are considered water uses, and therefore require a water use license:

a) taking water from a water resource;
b) storing water;
c) impeding or diverting the flow of water in a watercourse;
f) discharge water or water containing waste into a water resource through a pipe, sewer, sea outfall or other conduit;
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;
j) removing, discharging or disposing of water found underground if it is necessary for the efficient continuation of an activity or for the safety of people;

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 proposed development.

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 imposes 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 on the General Study Area

A literature survey and desktop study on the general study area was carried out using available information from reference works (DWAF, 2002; Nel *et al*., 2004; Mucina & Rutherford, 2006; DWAF, 2007) and previous specialist studies, namely:

- Assessment for the proposed construction and operation of an evaporation pond at New Denmark Colliery (Golder & Associates, 2010);
- Proposed extension of the existing general waste disposal site at the Tutuka Power Station (Zitholele Consulting, 2010);
- An aquatic study associated with the proposed New Denmark Colliery weirs in the Leeuspruit (Golder & Associates, 2011); and
- Proposed brine and groundwater treatment works (Aurecon, 2010) and proposed brine evaporation expansion process (Aurecon, 2011) at Tutuka Power Station.

Main rivers associated with the proposed development were identified and relevant stretches were characterised. Wetland systems located within the study area were identified at a desktop level with the use of shapefiles obtained from the South African National Biodiversity Institute (SANBI, 2010). General area characteristics were obtained using reference work from Mucina & Rutherford (2006).

A potential aquatic macroinvertebrate species list was compiled using the Rivers database (Dallas *et al*., 2007), Gerber & Gabriel (2002) and expert opinion (Mrs. Christa Thirion, *Pers. Comm.*, 2012). Potential fish species and their respective conservation status and habitat preferences were identified using expert opinion and reference works from the Rivers database (Dallas *et al*., 2007), Skelton (2001), Kleynhans (2007), Kleynhans *et al*. (2007a) and the IUCN database (IUCN, 2012).

1.4.2. Field Survey and Site Selection

The field assessment was undertaken during March 2013 where wetlands located within the three alternatives (primary study area) were identified, delineated and assessed (Table 1-1; Figure 1-1). Wetlands located within a 500 m radius (secondary study area) were delineated at a desktop level with *in situ* water quality variables recorded during the field survey.

Table 1-1: Coordinates of diatom and *in situ water* quality points in relation to alternative areas

Point	Alternative	500m Radius of Alternative	Water Quality	Diatoms	Y	X
WQ1	**B**		**X**	**X**	-26.749235	29.408878
WQ2		**B**	**X**		-26.740037	29.410214
WQ3		**B**	**X**		-26.748070	29.386498
WQ4		**B**	**X**		-26.757852	29.420721
WQ5		**B**	**X**	**X**	-26.756193	29.412219
WQ6		**B**	**X**	**X**	-26.763388	29.400302
WQ7	**A**		**X**	**X**	-26.774974	29.420398
WQ8		**A**	**X**		-26.794245	29.417163
WQ9	**A**		**X**		-26.786851	29.412794
WQ10		**A**	**X**	**X**	-26.785128	29.414817
WQ11	**A**		**X**	**X**	-26.780967	29.408747
WQ12	**A**		**X**	**X**	-26.785657	29.406780
WQ13	**A**		**X**		-26.778666	29.398874
WQ14		**A**	**X**		-26.798302	29.400569
WQ15		**C**	**X**		-26.796486	29.368550
WQ16		**C**	**X**		-26.803824	29.387726
WQ17	**C**		**X**		-26.793004	29.395723
WQ18	**C**		**X**	**X**	-26.786272	29.379498
WQ19	**C**		**X**	**X**	-26.785638	29.375481
WQ20		**C**	**X**		-26.785286	29.367483
WQ21		**B**	**X**		-26.755610	29.382221
WQ22	**B**		**X**	**X**	-26.760755	29.384590
WQ23	**A**		**X**		-26.786710	29.419740

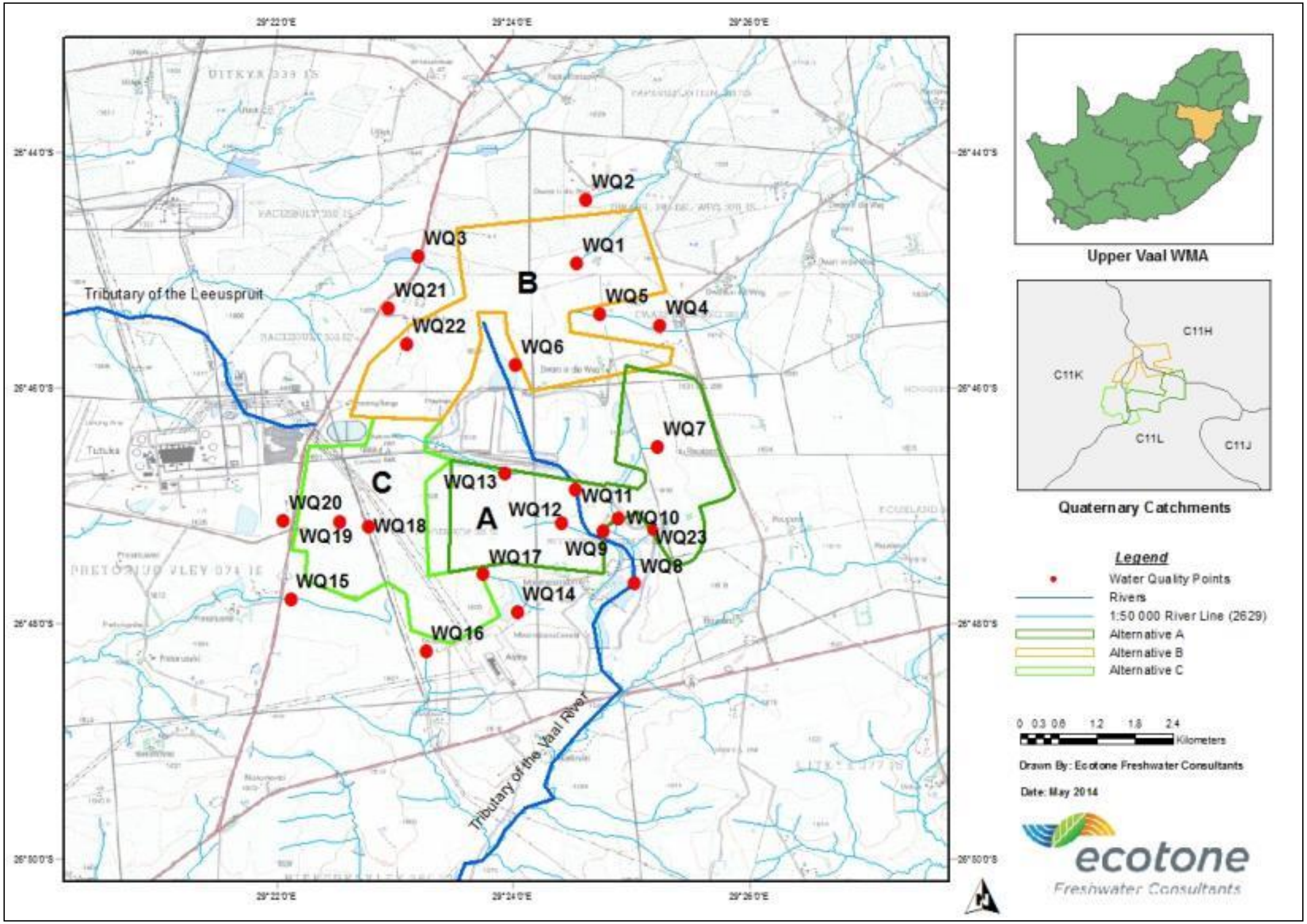


Figure 1-1: Map showing the three proposed alternatives associated with the proposed Dry Ash Disposal Facility and water quality sites (DWAF, 1995; DWAF, 2004; Nel *et al.,* 2004; SANBI, 2010; Chief Directorate – Surveys and Mapping).

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	[H^1+ 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 or > 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. Diatom Assessment

Epiphytic diatoms (attached to macrophytic plants) were sampled and collected according to the protocol of Taylor *et al.* (2005). The samples were preserved with isopropyl alcohol. Diatom samples were prepared for microscopy by using the hot hydrochloric acid and potassium permanganate method as recommended by and described in Taylor *et al.* (2005). A total of 400 diatom valves were identified and counted to produce semi-quantitative data from which ecological conclusions could be drawn (Prygiel *et al*., 2002). Suggested rules for counting diatoms according to Comité Européen de Normalisation (CEN, 2004) were followed. The taxonomic guide by Taylor *et al.* (2007) was consulted for identification purposes. Where necessary, Krammer & Lange-Bertalot (1986, 1988, 1991a, b) were used for identification and confirmation of species identification.

Research is still ongoing to construct a diatom index for the assessment of wetlands. Therefore, the environmental preferences and tolerances of the diatoms found were used to infer ecological conditions. The percentage of Pollution Tolerant Valves (%PTV; Kelly & Whitton, 1995) was calculated using OMNIDIA software (Lecointe *et al*., 1993) to indicate possible impacts of organic pollution. The %PTV has a maximum score of 100, where a score above 0 indicates no organic pollution and a score of 100 indicates definite and severe organic pollution.

1.4.5. Wetland Assessment

Desktop Delineation

A desktop study was undertaken prior to field work to pinpoint areas of interest in terms of wetland habitat. Historic (1960 and 1991) and recent aerial images were used to produce ortho-rectified digital based maps at a 1:10 000 scale onto which perceived wetland boundaries were delineated using ArcGIS 10. Perceived wetlands were verified in the field survey in March and April 2013.

Field Survey

A field survey was conducted during March and April 2013 whereby a 1:10 000 desktop delineation was verified. A further field survey was conducted in May 2014 for the additional augmentation of Alternative A. Historical aerial images and a wetness index based on 5 m contour data assisted in the desktop delineation. The field 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 wetlands, which marks the boundary between the wetland and adjacent terrestrial areas. Please refer to Section 1.5.2 for limitations associated with the wetland delineation. According to the GDACE (2008) requirements or 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 with random verification for the determination of the periphery of each wetland.
- The assessment made particular reference to indicators of prolonged saturation by water, namely: wetland plants (see classification of wetland plant types -Table 1-4) and wetland soils (hydromorphic soils), while soil wetness was also noted.
- Terrain unit indicators were used to ascertain likely areas of wetness.

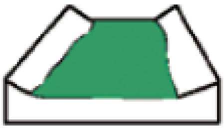
Table 1-4: Classification of wetland plant types (Van Ginkel *et al.,* 2011)

Type	Description
Obligate Wetland Species	Plant species that occur for > 99 % of the time in a wetland / water saturated areas.
Facultative Positive Species	Plant species that occur for between 67 – 99 % of the time in a wetland / water saturated areas.
Facultative Wetland Species	Plant species that occur 50 % of the time in a wetland / water saturated areas.
Facultative Negative Species	Plant species that occur for < 25 % of the time in a wetland / water saturated areas.
Opportunist Wetland Species	Plant species that opportunistically occur in a wetland / water saturated areas.

Wetland Classification

The wetland areas identified were classified according to a classification system developed by Brinson (1993). The Hydro-geomorphic (HGM) classification system uses the morphology and hydrological features of wetlands to classify them into units (Table 1-5). The features that are assessed relate to the way in which water behaves in the wetland system.

Table 1-5: Wetland HGM types associated with the study area (Brinson, 1993; Kotze *et al.*, 2009)

Wetland Type		Description
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.
Hillslope Seep (isolated)		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 or through diffuse sub-surface and/or surface flow but with no direct surface water connection to a stream channel.
Hillslope Seep (linked with a stream channel)		Slopes on hillsides, which are characterized by the colluvial (transported by gravity) movement of materials. Water inputs are mainly from sub-surface flow and outflow is usually via a well-defined stream channel connecting the area directly 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.

WET-Health (PES Determination)

A *WET-Health* level 2 assessment was undertaken to ascertain the PES of the wetland system according to the methodology by Macfarlane *et al*. (2009). The WET-Health index considers the state of the three main functional aspects of the wetland units, namely: hydrology, geomorphology and vegetation. The overall score is integrated and expressed as a PES category (Table 1-6).

Table 1-6: Health categories used by WET-Health for describing the hydrological integrity of wetlands (Adapted from Macfarlane *et al.*, 2009)

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

WET EcoServices

A *WET-EcoServices* level 2 assessment was used to assess the “ecological goods and services” provided by each particular HGM wetland unit. The tool provides information on the importance of a wetland in delivering different ecosystem services under a number of different categories (Kotze *et al*., 2009).

Ecological Importance and Sensitivity

Ecological Importance and Sensitivity (EIS) scores were calculated using the RDM (Kleynhans, 1999) methods. Information from the baseline biodiversity assessment was taken into account when populating the EIS scores. Scoring guidelines are shown in Table 1-7, and categories are noted in Table 1-8.

Table 1-7: 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 1-8: Ecological Importance and Sensitivity categories and the interpretation of median scores for biota and habitat determinants (adapted from Kleynhans, 1999)

Ecological Importance and Sensitivity categories	Range of EIS score
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**

1.4.6. 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.

The significance of each potential impact was calculated as follows: Significance = (E+D+M)*P, where: E = Extent, D = Duration, M = Magnitude, P = Probability. The Significance Rating was calculated by multiplying the Severity Rating with the Probability Rating. The significance rating should influence the development project as described below (Table 1-9).

Table 1-9: Significance rating categories showing values for Low, Medium and High significance

Significance	Rating
Low Environmental Significance	**0 - 30**
Medium Environmental Significance	**31 – 60**
High Environmental Significance	**61 -100**

1.5. Limitations of the Study

1.5.1. General

The spatial and temporal extents of Ecotone's services are described in the proposal, and are subject to restrictions and limitations. Only a single survey was carried out and therefore 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. Wetland Delineation

Historical and present agricultural activities along with the existing ash disposal facility have infringed and disturbed a number of wetland areas, which along with the occurrence of vertic soil in some areas have lowered the confidence in the wetland delineation. In these instances, more emphasis was placed on landscape features. It is unlikely that any significant wetland systems have not been identified, delineated and assessed.

The slope calculations and catchment sizes were modelled from available 5 meter contours and as such include an intrinsic error margin. This margin is deemed sufficient for the ecological assessment of wetland conditions, but is not suitable for engineering, construction or geotechnical purposes.

Given the extent and the nature of wetlands, some of the assessment methodologies have been modified. An initial assessment of each HGM unit was cumbersome. Mapping individual catchments for each HGM was not feasible and this notion did not compliment the overarching aim of alternative selection. Subdividing the catchments associated with each Alternative and then grouping connected wetlands sharing that catchment made it more efficient in defining general trends in wetlands between alternatives.

1.5.3. Biological Response Metrics

Conventional River Health response and driver methodology could not be applied in the primary study area or within a 500 m buffer as surface water systems in the study area were not suitable for the application of SASS5, FRAI and VEGRAI. These models were designed for rivers and streams and the study area is associated with wetland systems. A diatom assessment was incorporated into the study as this provides a more suitable biological response metric.

1.5.4. Legal Framework and Buffer Zones

This report does not provide a comprehensive review of legal matters pertaining to the proposed development and associated wetlands. It is recommended that a specialist legal opinion be obtained if and where required.

Buffer zone allocation is often ambiguous and might differ pending the PES, EIS and functionality of wetlands identified. However, the most conservative buffer distance, as stipulated by Regulation 704 of 1999 in terms of the National Water Act, is a 100m horizontal distance between infrastructure and surface water systems. Buffer zones allocated and illustrated in the context of this assessment were thus limited to the application of a 100m buffer zone. This allocation should be viewed as an absolute minimum and might exceed 100m in the case of environmentally sensitive and important wetlands.

It should also be noted that wetland identification and delineation was limited to the boundaries of the study area provided. In an attempt to consider cumulative impacts on surface water systems DWA requires the identification, delineation and assessment of all wetlands within a 500m radius of a proposed development.

1.6. Declaration of Independence

I, Michiel Jonker, as duly authorised representative of Ecotone Freshwater Consultants CC, hereby confirm my independence (as well as that of Ecotone Freshwater Consultants CC) as a specialist and declare that neither I nor Ecotone Freshwater Consultants CC have any interest, be it business, financial, personal or other, in any activity or application associated with the continuous dry ashing at Tutuka Power Station other than fair remuneration for work performed.

____

Full Name: Michiel Jonker
Title / Position: Aquatic Ecologist and Partner
Qualification(s): M.Sc. (Aquatic Health) M.Sc. (Environmental Management)
Registration: *Pri. Sci. Nat.* (400192/10)

2. Description of the Project

The project involves the proposed continuous ashing at the existing ash disposal facility at the Tutuka Power Station in the Mpumalanga Province. The Tutuka Power Station utilises a dry ashing disposal method where the waste product is deposited onto the disposal site by means of a stacker, which handles some 85% of the total ash whilst the remaining 15% is placed by a standby spreader system.

Currently, the ash disposal progresses from west to east. In the event that the existing ash disposal facility continues, the two extendible conveyors will be extended to its final lengths of 4 000 m each. The ash disposal facility is built out in two layers. The front stack is deposited by the stacker and spreader to a height of approximately 45 m. The ash is bulldozed out to a slope of 1:3 for dust suppression and rehabilitation purposes.

As the ash disposal advances, the topsoil is stripped ahead of the activities and is taken by truck and placed on top of the final disposal facility. Grass is then planted in this top soil. The proposed continuous development is an ash disposal facility with the following specifications:

- Capacity of airspace of 353.1 million m^3 (Existing and remaining).
- Ground footprint of 2 500 ha (Existing & Remaining ash disposal facility & pollution control canals).

3. Description of the Affected Environment

3.1. Ecoregion Characteristics

Tutuka Power Station is located near Standerton, Mpumalanga, and falls within the Mesic Highveld Grassland Bioregion, and Soweto Highveld Grassland vegetation type (Table 3-1). Landscape features for the Soweto Highveld Grassland include gently to moderately undulating plains, small scattered wetlands, narrow stream alluvium, pans and occasional ridges or rocky outcrops interrupt the continuous grassland cover (Table 3-1). The geology mainly consists of shale, sandstone or mudstone of the Madzaringwe Formation or the intrusive Karoo Suite dolerites, which feature prominently in the area (Mucina & Rutherford, 2006). The soils are deep and reddish on flat plains. The conservation status of the Soweto Highveld Grassland is classed as Endangered (Mucina & Rutherford, 2006).

Table 3-1: Environmental variables and geomorphologic description of the study area (Mucina & Rutherford, 2006)

Bioregion	Mesic Highveld Grassland
Vegetation Type	Soweto Highveld Grassland
Landscape features	Gently to moderately undulating landscape; in places not disturbed: scattered small wetlands, narrow stream alluvia, pans and occasional ridges or rocky outcrops.
Geology and soils	Shale, sandstone or mudstone. Soils are deep and reddish on flat plains.
MAP	662 mm
MAT	14.8 ^{o}C
MFD	41 d
MAPE	2060 mm
Status	Endangered

MAP: Mean Annual Precipitation; **MAT:** Mean Annual Temperature; **MFD:** Mean Frost Days; **MAPE:** Mean Annual Potential Evaporation

The Mean Annual Precipitation (MAP) is 662 mm per annum, frequently in the form of summer storms. The Mean Annual Temperature (MAT) in the study area is 14.8 ^{o}C with 41 annual Mean Frost Days (MFD). The Mean Annual Potential Evaporation rate (MAPE) exceeds the MAP in the area, thus a net loss in precipitation is experienced (Table 4-1). The average monthly and annual precipitation from 1998 to 2009 measured at the Tutuka Power Station is provided in Figure 3-1. The low rainfall period is during April to September and the highest annual rainfall was recorded for 2009.

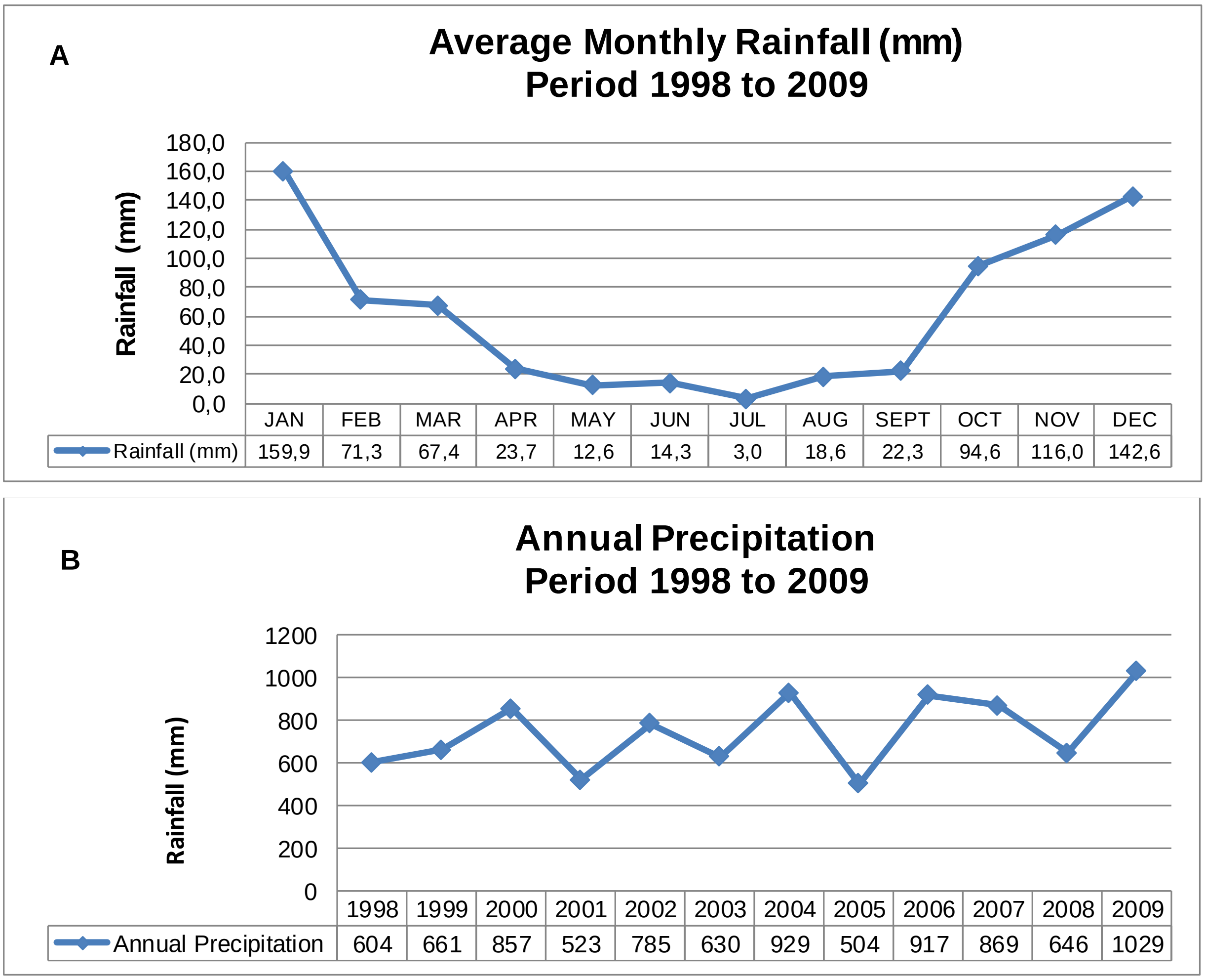


Figure 3-1: (A) Monthly and (B) annual precipitation at the Tutuka Power Station during 1998 to 2009.

3.2. River and Catchment Characterisation

The study area considered during the EIA phase encompasses three alternative areas around the current infrastructure, and falls over three quaternary catchments in the Upper Vaal Water Management Area (WMA), with the Tutuka Power Station located in the C11K quaternary catchment, draining southwards towards the Grootdraai Dam via the Leeuspruit (Figure 3-2). The study area is located in an Upstream Management Catchment (NFEPA – Nel et al., 2011) (Figure 3-3). The wetland NFEPA spatial data do not indicate the presence of NFEPA wetlands. Neither the vegetation unit (Mesic Highveld grassland group 3) nor the wetland types (seeps, depressions, valley bottoms and floodplains) are listed as threatened ecosystems (Figure 3-4). According to the MBCP (Ferrar & Lötter, 2007) the study area is located in an 'Ecosystem Maintenance' sub-catchment (Figure 3-5).

The main rivers associated with the alternatives include the tributaries of the Leeuspruit and Vaal River, which are both 1st Order rivers (Table 3-2). Numerous smaller streams are shown in the 1:50 000 river coverage. The Leeuspruit and its tributary are classified as perennial rivers (with a Highveld 4 river signature), with the tributary of the Vaal River being non-perennial (Highveld 3 river signature).

Table 3-2: Desktop characterisation of the main rivers associated with the study area

River	Tributary of the Leeuspruit	Tributary of the Vaal River
River Order	1	1
Hydrological Class	Perennial	Non-perennial
River Signature	Highveld 4	Highveld 3
Conservation Status (Nel *et al.,* 2004)	Critically Endangered	
PES (Nel *et al.,* 2004)	**C**	**E/F**
Water Management Area	Upper Vaal	
Aquatic Ecoregion	Highveld	
Quaternary Catchment	C11K	C11L
PES	**D***	**E/F#**
EIS	Moderate*	

PES: Present Ecological State; **EIS**: Ecological Importance and Sensitivity; * = DWAF (2007); # = DWAF (2000)

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

Six attributes were used to obtain the Present Ecological State (PES) on desktop quaternary catchment level by the National Spatial Biodiversity Assessment (NSBA - Nel *et al*., 2004). These attributes predominantly include habitat integrity of in-stream and riparian habitat. With this in mind, the receiving Leeuspruit systems and the tributary of the Vaal River fall within a C (Moderately Modified ecosystem state) and E/F (Serious to Critical Modified ecosystem state) [according to the NSBA (Nel *et al*., 2004)], respectively.

According to the desktop PES categories from DWAF (2007), the rivers in quaternary catchment C11K fall in a D ecological category, indicating a Largely Modified ecosystem with an impairment of health evident. No current PES categories could be obtained for the Vaal River tributary (C11L) and therefore the PES categories from DWAF (2000) were consulted. The tributary of the Vaal River falls in an unacceptable ecosystem state (DWAF, 2000), with most community characteristics either Seriously Modified or having extremely low species diversity. The rivers in quaternary catchment C11K at present are affected by sedimentation (farming and grazing), introduction of Carp and exotics such as Willow trees, erosion and agricultural run-off (DWAF, 2000). The Ecological Importance and Sensitivity (EIS - DWAF, 2007) for both quaternary catchments is considered moderately sensitive.

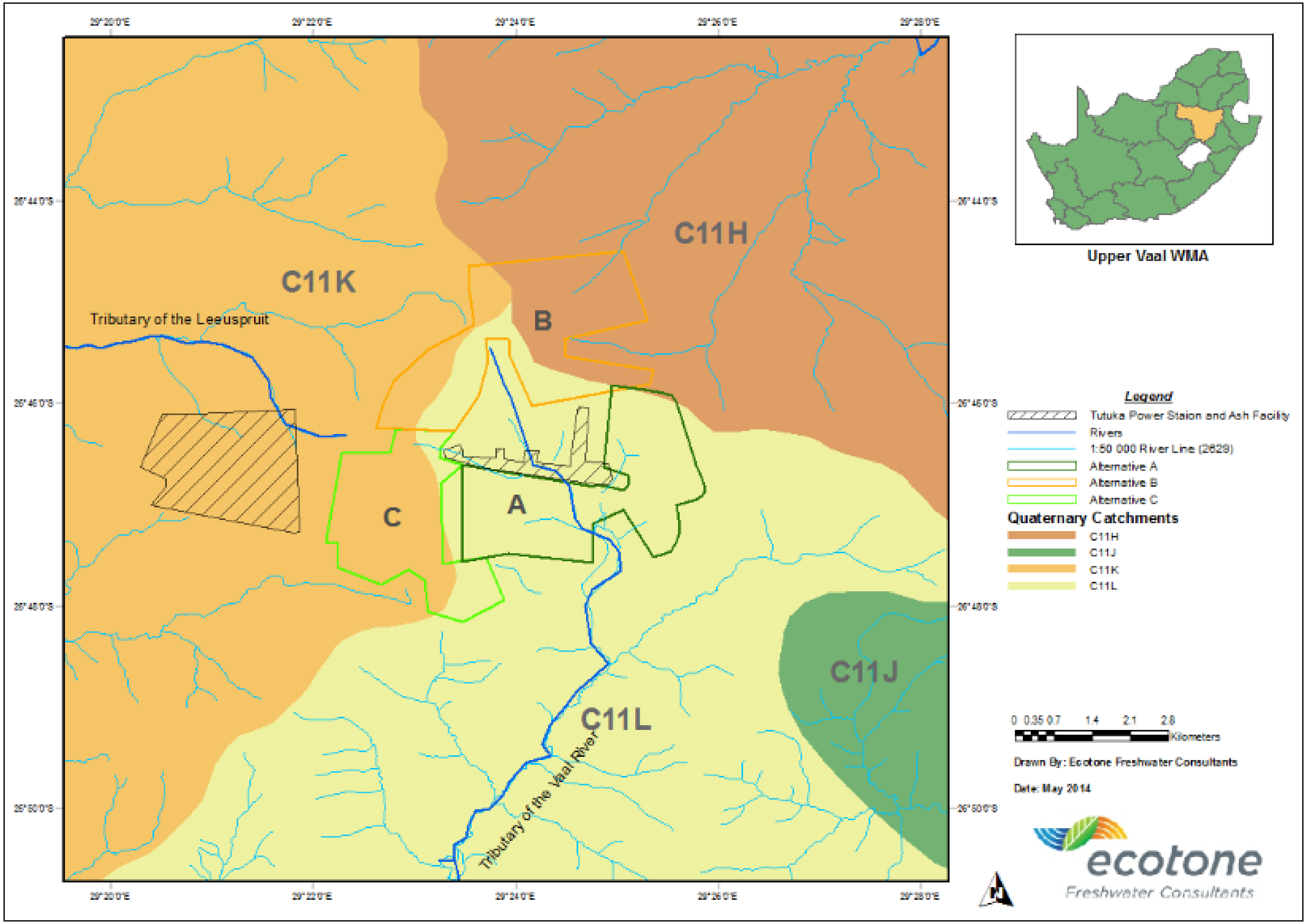


Figure 3-2: Map indicating the study area in relation to quaternary catchments (DWAF, 1995; DWAF, 2004; Nel *et al.,* 2004; SANBI, 2010; Chief Directorate – Surveys and Mapping).

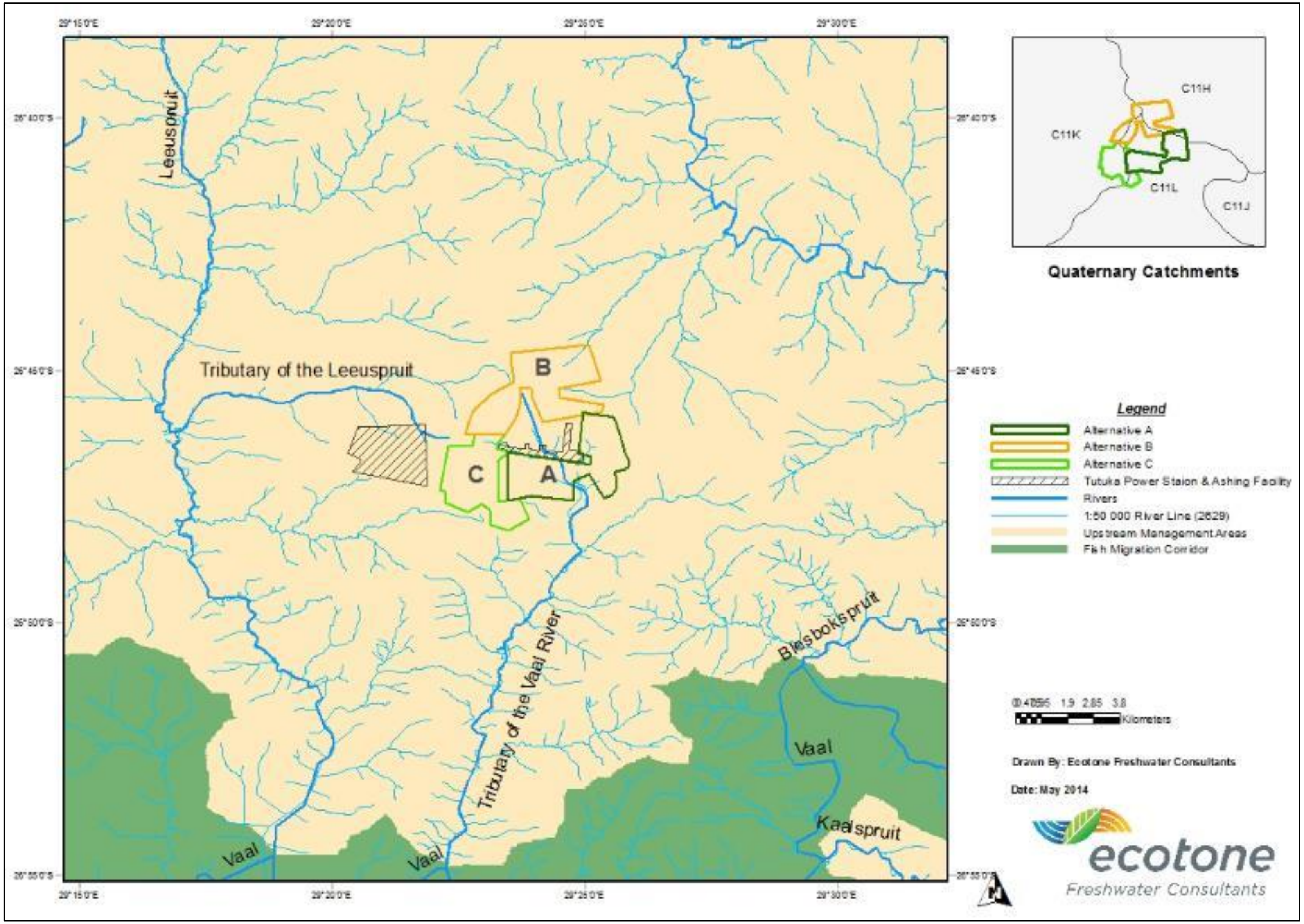


Figure 3-3: Map indicating the study area in relation to the river NFEPAs (DWAF, 1995; Nel *et al.,* 2004; Nel *et al.,* 2011, Chief Directorate – Surveys and Mapping).

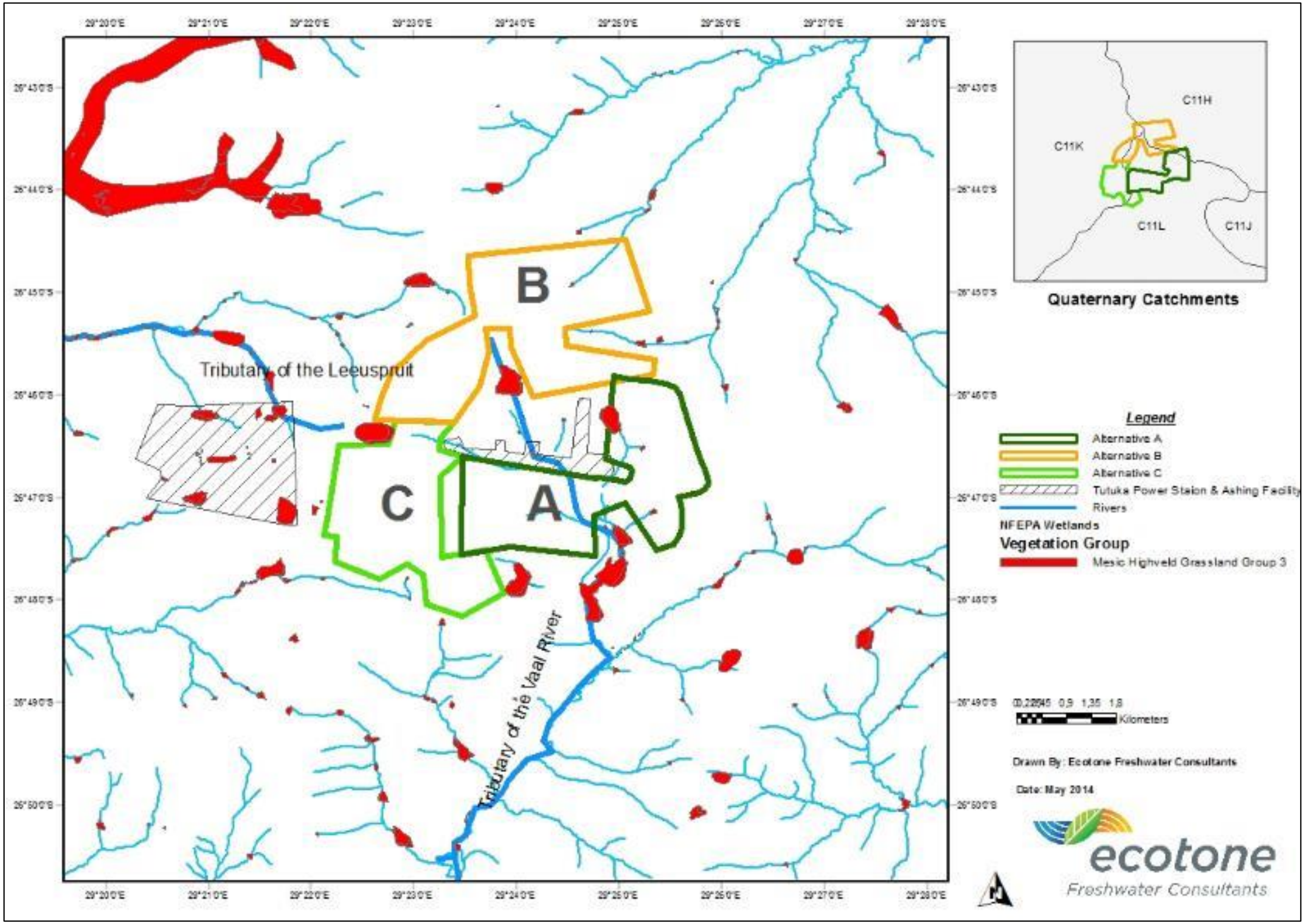


Figure 3-4: Map indicating the study area in relation to the NFEPA wetlands (Nel *et al.*, 2004; Nel *et al.,* 2011)

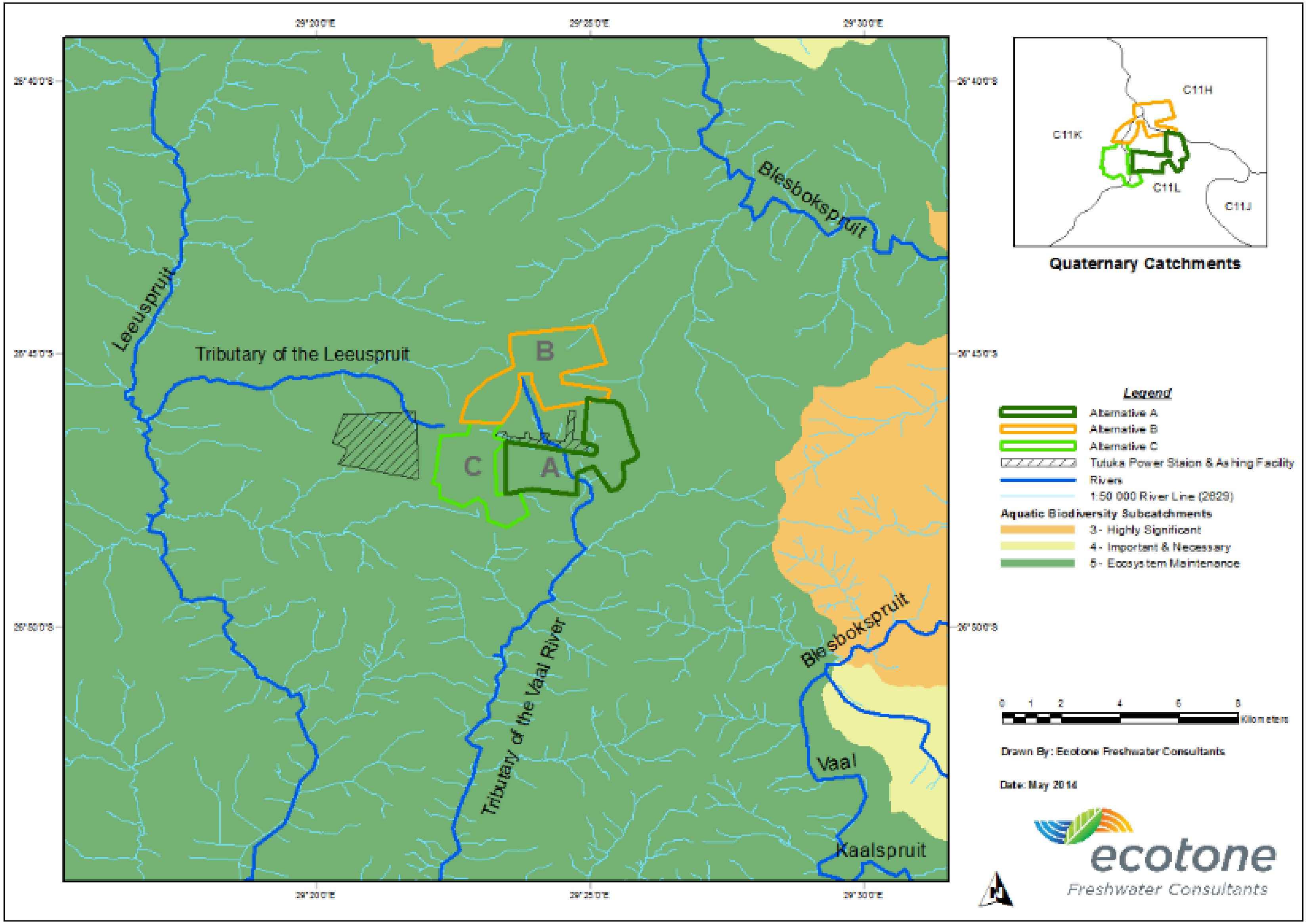


Figure 3-5: Map indicating the study area in relation to the MBCP (DWAF, 1995; Nel *et al.,* 2004; Ferrar & Lötter, 2007).

3.3. Freshwater Species Diversity and Species of Conservation Concern

3.3.1. Expected Macroinvertebrate Species

A list of macroinvertebrates expected to occur in tributaries receiving runoff from the study area, was determined for the major drainage lines (Table 3-3; Figure 3-6). Each taxon was allocated a rating score of either 1, 3 or 5, where a rating of 5 indicates that the specific taxon has been sampled within that sub-quaternary (SQ) reach and is likely to be sampled; a rating of 3 indicates that the taxon has not been sampled in the SQ reach but has been sampled in a similar SQ reach and the probability of occurrence has been extrapolated; a rating of 1 indicates that the taxon has not been sampled in the SQ reach or any other similar SQ reach but is thought to be potentially present taking into account the available habitat, water quality and associated land use activities. Only one relatively sensitive taxon is expected to occur within the study area, namely Leptophlebiidae, which has a sensitivity score of 9 out of a possible 15 (Gerber & Gabriel, 2002), representing a taxon that is moderately intolerant to alterations in water quality (pollution).

Table 3-3: Macroinvertebrate species expected to occur, or indicating the possibility of occurrence, in the different sub-quaternary reaches located within the study area. Taxa in red are considered sensitive taxa

Taxa	SS	SQ1	SQ2
		Tributary of Leeuspruit	Tributary of Vaal River
Turbellaria	3	1	1
Oligochaeta	1	1	1
Hirudinea	3	1	1
Potamonautidae	3	1	1
Atyidae	8	1	1
Hydracarina	8	1	1
Baetidae > 2 Sp.	12	1	1
Caenidae	6	1	1
Leptophlebiidae	9	1	1
Coenagrionidae	4	1	1
Aeshnidae	8	1	1
Gomphidae	6	1	1
Libellulidae	4	1	1
Belostomatidae	3	1	1
Corixidae	3	1	1
Gerridae	5	1	1
Hydrometridae	6	1	1

Taxa	**SS**	**SQ1**	**SQ2**
		Tributary of Leeuspruit	**Tributary of Vaal River**
Naucoridae	7	1	1
Nepidae	3	1	1
Notonectidae	3	1	1
Pleidae	4	1	1
Veliidae/Mesoveliidae	5	1	1
Hydropsychidae 1 Sp.	4	1	1
Hydroptilidae	6	1	1
Leptoceridae	6	1	1
Dytiscidae	5	1	1
Elmidae/Dryopidae	8	1	1
Gyrinidae	5	1	1
Hydrophilidae	5	1	1
Ceratopogonidae	5	1	1
Chironomidae	2	1	1
Culicidae	1	1	1
Muscidae	1	1	1
Simuliidae	5	1	1
Tabanidae	5	1	1
Ancylidae	6	1	1
Physidae	3	1	1
Planorbinae	3	1	1
Corbiculidae	5	1	1
Sphaeriidae	3	1	1

SS = Sensitivity Score (Dickens & Graham, 2001); **SQ** = sub-quaternary

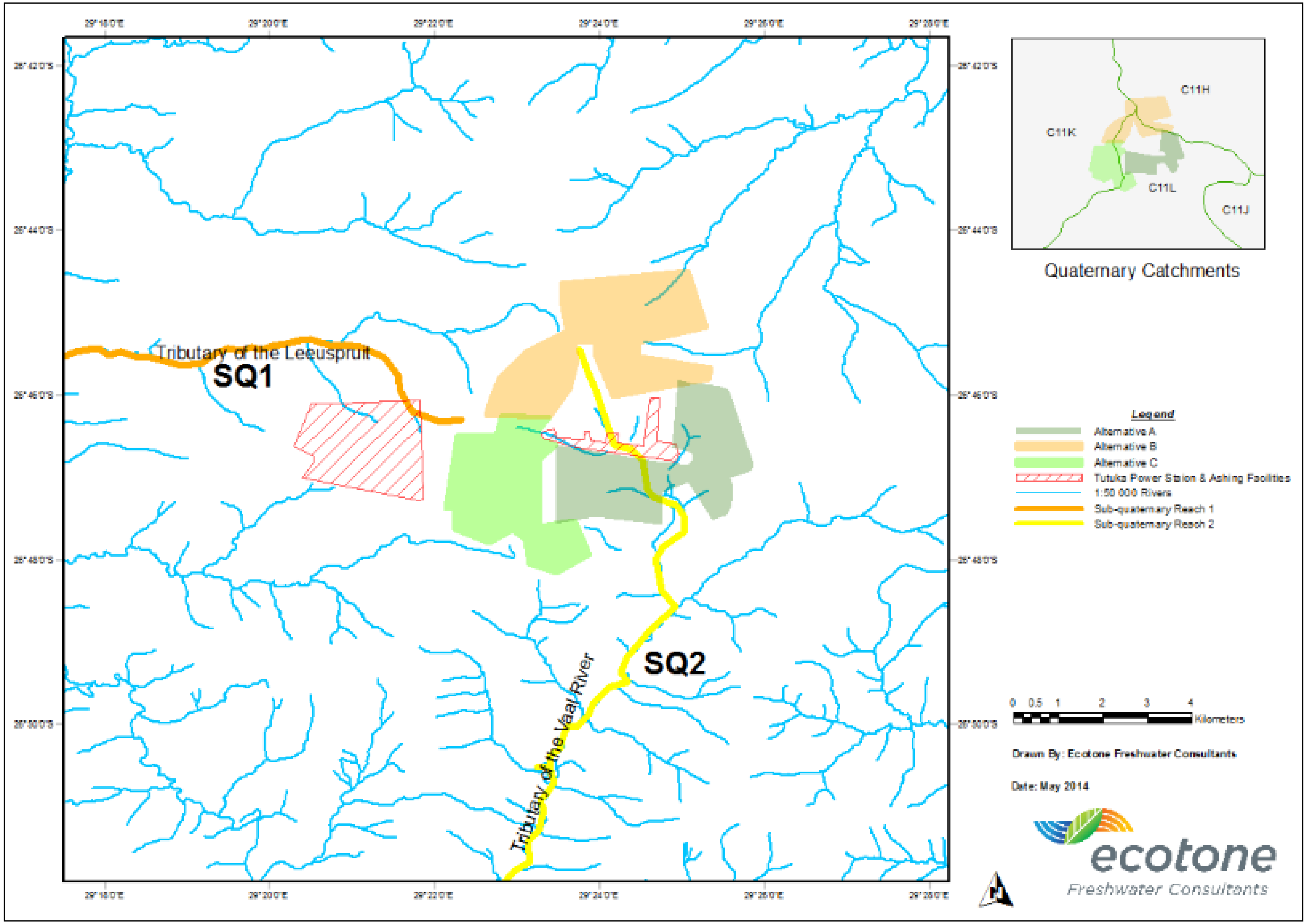


Figure 3-6: Sub-quaternary catchments related to the expected macroinvertebrate species list (Chief Directorate – Surveys and Mapping, 2629; *Pers.Comm.* Mrs. Christa Thirion, 2012).

3.3.2. Expected Fish Species

Tributaries receiving runoff from the study area provide potential refuge for four fish families represented by approximately 12 species (Table 3-4 - Kleynhans *et al.,* 2007; IUCN, 2012), none of which have conservation status and are listed as Least Concern (LC) by the IUCN (2012). *Barbus neefi* (Kleynhans *et al.,* 2007) and *Barbus pallidus* (IUCN, 2012) are expected to occur in downstream receiving systems and both species are moderately intolerant to alterations in water quality making them good indicators of ecosystem health.

Table 3-4: Fish species expected to occur, or indicating the possibility of occurrence, in the river systems located in the surrounding catchments

Family	Genus and Species	Common Name	IUCN Status
Austroglaniidae	*Austroglanis sclateri*	Rock Catfish	LC
Cyprinidae	*Barbus anoplus*	Chubbyhead Barb	LC
	Barbus neefi	Sidespot Barb	LC
	Barbus pallidus	Goldie Barb	LC
	Barbus paludinosus	Straightfin Barb	LC
Clariidae	*Clarias gariepinus*	Sharptooth Catfish	LC
Cyprinidae	*Cyprinus carpio*	Common Carp	EX
	Labeobarbus aeneus	Smallmouth Yellowfish	LC
	Labeo capensis	Orange River Labeo	LC
	Labeo umbratus	Moggel	LC
Cichlidae	*Pseudocrenilabrus philander*	Southern Mouthbrooder	LC
	Tilapia sparrmanii	Banded Tilapia	LC

LC: Least Concern; **EX:** Exotic

3.3.3. Expected Odonata (dragonflies) Species

Approximately 60 Odonata species are expected to occur in the surrounding catchments from Tutuka Power Station. All species are listed as LC according to the IUCN database (IUCN, 2012).

3.3.4. Expected Mollusca (snails, limpets) Species

A total of 10 mollusc species are expected to occur in the study area, of which nine species are listed as LC. Only one species, namely *Burnupia caffra,* is listed as Data Deficient (DD) due to taxonomic uncertainty. *Burnupia caffra* are frequently unobserved during sampling surveys due to their extremely small size (2 - 4 mm). The genus *Burnupia* needs taxonomic revision as the numbers of species are extremely uncertain (Appleton *et al.*, 2010).

3.4. *In situ* Water Quality

In situ variables measured at surface water sites located on Alternative A, reflected elevated pH and EC value (Figure 3-7; APPENDIX A - *In situ* Water Quality). The high salt loads associated with these sites suggest contamination which will impede aquatic ecological integrity. The elevated salt loads in conjunction with high pH values suggest an increase in Calcium and Magnesium Carbonates. These ions, in a reduced state, readily oxidise to form bicarbonate complexes, which will influence the pH in an upward direction.

In situ constituents for alternatives B and C were mostly within threshold values and reflected circum neutral pH values with relatively low salt loads (Figure 3-8; Figure 3-9; APPENDIX A - *In situ* Water Quality). An interesting observation relates to sites WQ18, 19 and 20, located on Alternative C and draining towards the power station, which were the only sites with marginally acid pH values.

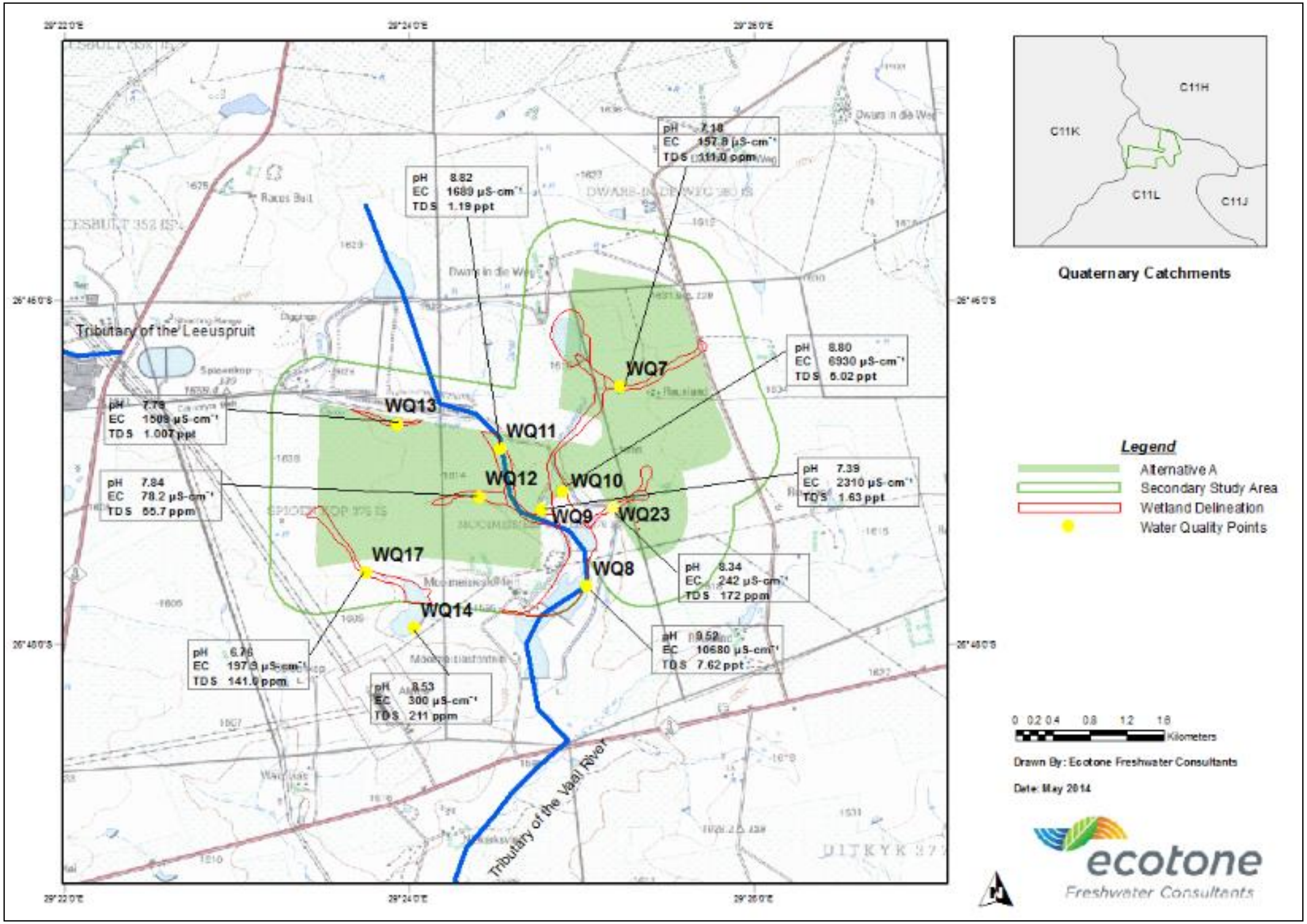


Figure 3-7: Map indicating *in situ* water quality variables measured at water quality point associated with Alternative A.

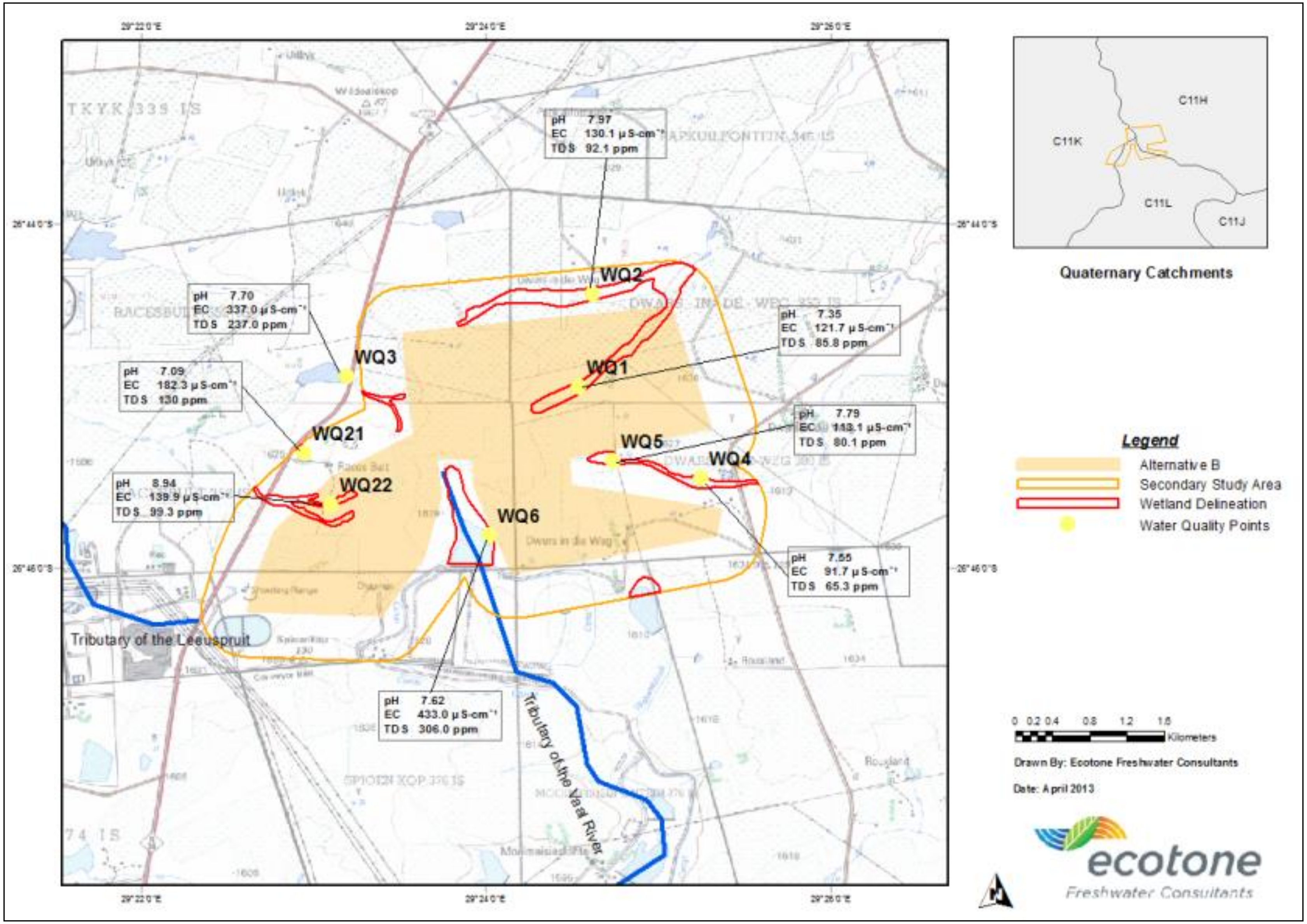


Figure 3-8: Map indicating *in situ* water quality variables measured at water quality point associated with Alternative B.

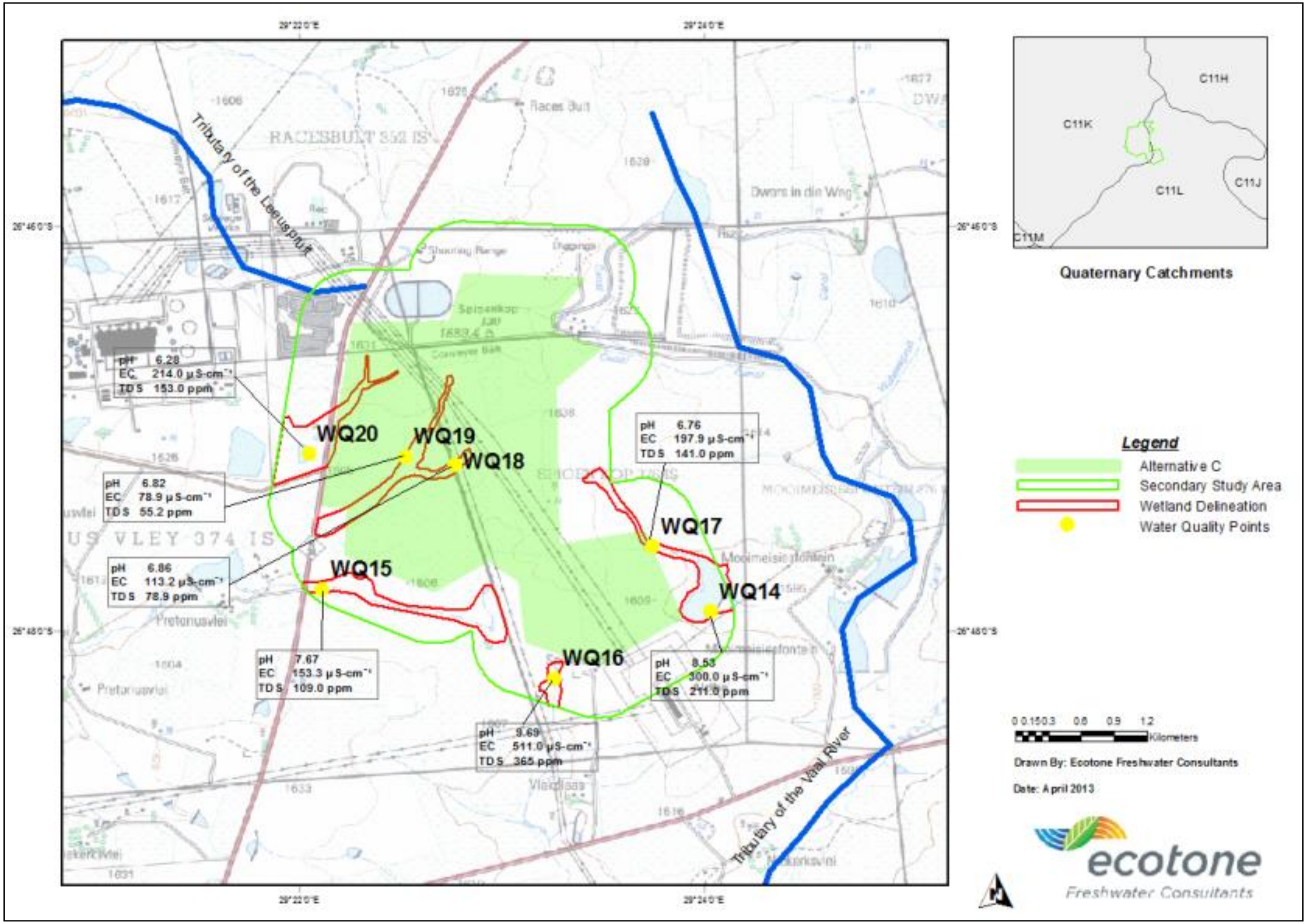


Figure 3-9: Map indicating *in situ* water quality variables measured at water quality point associated with Alternative C.

3.5. Diatom Assessment

This section provides a summary of the main findings of the diatom assessment. For details on the diatom community structures of each sites please refer to APPENDIX B - Diatom Species Sampled.

Between 10 and 24 diatom genera were recorded at the study sites. The diatom assemblages of wetlands on Alternative A were indicative of circum-neutral to alkaline pH, fresh-brackish to brackish salinity; and oligotrophic and eutrophic nutrient content. The general water quality of WQ7 and WQ12 appears to be of a higher quality compared to WQ10 and WQ11.

The diatom assemblages of wetlands in the Alternative B study area were characteristic of waters with an acidic to alkaline pH, fresh-brackish electrolyte content and oligo- to eutrophic nutrient content. The diatoms indicated that the water of WQ5 was of a good quality and that the water of WQ1, WQ6 and WQ22 was more impacted as a result of increased nutrient inputs.

The diatoms recorded for wetlands in the Alternative C study area have optimum or tolerance ranges for ambient conditions of circum-neutral pH, fresh-brackish salinity and meso- to eutrophic nutrient content. The diatom assemblages of WQ18 and WQ19 point to organic, nutrient and sediment inputs.

The diatom assemblages indicate that wetlands located on Alternative B were the least impacted and wetlands on Alternative A were the most impacted.

3.6. Wetland Classification and Delineation

The primary study areas occupied the following space:

Alternative A= 672.68 ha

Alternative B= 764.94 ha

Alternative C = 534.41 ha

The fractional representations of wetlands on each alternative were:

Alternative A= 12.0%

Alternative B= 3.0%

Alternative C= 4.0%.

The dominant wetland units were un-channelled valley bottom wetlands. The head reaches of some of the valley bottom wetlands consisted of a localised catchment on moderate to low slopes which resulted in head water seeps. In many instances dams are located immediately downstream of these areas.

The soils for nearly the entire primary study area were vertic and probably overlie Sandstone. The subsequent natures of wetlands are relatively narrow valley bottom systems with a high degree of seasonality. Areas of permanent wetness were only expressed in small isolated patches, mostly due to artificial impeding features. Low to moderate ground water interaction is expected due to the presence of vertic soils and the nature of wetlands identified.

Vegetation associated with seasonal wetlands were mostly characterised by higher abundances of complementary species including *Paspalum dilatatum, Setaria pallide-fusca, Cynodon dactylon,* and *Cyperus congestus*. Similarly areas with prolonged wetness were characterised by more obligate wetland species: *Carex glomerabilis, Juncus effuscus, Kyllinga erecta, Leersia hexandra, Schoenoplectus spp.* and *Typha capensis* (APPENDIX C – Vegetation Lists).

The topography of the study area was homogenous, characterised by gentle undulating plains with wetlands mostly in the lower parts of the landscape. Average slopes for catchments ranged from 0.7% to 6%. All three alternatives were located on local catchment water sheds and subsequently receive water from relatively small catchments of upstream areas. The largest historically continuous wetland system was located on Alternative A with an approximate catchment size 1583.41 ha. In general, wetland units ranged in size from

0.04 ha, to 97.66 ha. Slopes of wetland units were mostly moderate ranging between 0.7 % and 5.7 %.

Wetlands in the study area are mainly maintained by surfaces runoff, this is inferred from their seasonal nature. Areas of permanent wetness were nearly always associated with dam structures or localised depressions. However, the presence of perched aquifers cannot be excluded for certain and may contribute towards the hydrology of some of the wetlands.

3.6.1. Alternative A

Wetlands located in Alternative A and a 500 m buffer area included Wetland 5, 6 and 10 (Table 3-5; **Error! Reference source not found.**). Wetland 5 is located south-west in the Alternative with approximately one third occurring within the boundary. Wetland 5 consists of an unchannelled valley bottom system (AUCVB1) terminating in a large dam. Wetland 6 is the largest wetland within the study area (Table 3-5). The HGM unit associated with Wetland 6 is a channelled valley bottom system (ACVB1) with associated seeps (AS1 and AS2), unchannelled valley bottom system (AUCVB2 and AUCVB4) and 5 dams (AD1 to AD5) (Table 3-6; Figure 3-11). Wetland 10 is an unchannelled valley bottom system (AUCVB3) with an associated seep (AS3), and a very small isolated seep (AS4). Wetland 10 is located to the south east, off of the Alternative boundary, but within the secondary study area. A 100m buffer zone was placed from the edge of the temporary zones (Figure 3-12). Wetland buffer zones are automatically demarcated as ecologically sensitive as they are known to protect wetlands and facilitate migration of species between wetland units.

3.6.1. Alternative B

Wetlands 7, 8, 9, 11 and 12 were located on Alternative B (Table 3-7; Figure 3-13). This Alternative yielded the lowest extent of wetlands directly affected by the footprint of the alternative boundary (Figure 3-13). The dominant wetland units consisted of unchannelled valley bottom systems (BUCVB1-5) and associated seeps (BS1-8) (Figure 3-14). Seeps were typically located within the valley head and nearly always terminated in a dam structure (BD1-6 - Table 3-8). The alternative drains four internal catchments. The largest continuous wetland is Wetland 12, of which approximately 50% falls within the alternative boundary while the remainder resides within the secondary study area. A 100m buffer zone was placed from the edge of the temporary zones (Figure 3-15)

3.6.2. Alternative C

This Alternative is located south-east of the power station and runs parallel to the R38. Wetlands 1, 2, 3, 4 and 5 are linked to this Alternative (Table 3-9; Figure 3-16). The larger parts of Wetland 3 and 4 fall within the Alternative boundary. Alternative C drains 6 internal catchments. The three larger catchments (Wetlands 2, 3 and 4) drain in a westerly direction. As with the other Alternatives the prominent wetland unit consist of unchannelled valley bottom systems (CUCVB1-4). However, only one seep was located within the Alternative boundary (CS1). The remainder (CS2-5) were located to the south of the Alternative within the secondary study area. Two large dams (CD1 and CD4) received the runoff of Wetlands 4 and 5 (Table 3-10; Figure 3-17). A 100m buffer zone was placed from the edge of the temporary zones (Figure 3-18)

Table 3-5: The approximate sizes of wetlands and catchment areas located within the primary (Alternative A) and secondary study area

	Wetland 5	Wetland 6*							Wetland 10		
HGM unit	**AUCVB1**	**AS1**	**AS2**	**ACVB1**	**ACVB2**	**ACVB3**	**AUCVB2**	**AUCVB4**	**AUCVB3**	**AS3**	**AS4**
Size (Ha)	24.40	2.54	15.62	2.43	48.91	13.01	3.17	7.98	4	2	0.04
Slope	1.39	1.47	0.48	1.93	1.15	1.15	0.49	1.02	1.57	3.08	0.01
Total Size (Ha)	24.40	97.66							6.04		
Seeps (%)	-	14.94							43.77		
Un-channelled Valley Bottom (%)	100.00	-							66.23		
Channelled Valley Bottom (%)	-	62.11							-		
Total Catchment Size (Ha)	195.61	1583.41							49		
Catchment Slope	1.53	1.10							1.74		

* = portion of wetland is associated with Alternative B

Table 3-6: The approximate sizes of dams located within the primary (Alternative A) and secondary study area

HGM Unit	HGM size (Ha)
AD1	0.311
AD2	0.302
AD3	7.281
AD4	14.577
AD5	16.685

Table 3-7: The approximate sizes of wetlands and catchment areas located within the primary (Alternative B) and secondary study area

	Wetland 6 – continued*			Wetland 7			Wetland 8	Wetland 9	Wetland 11		Wetland 12		
HGM unit	**BS5**	**BS6**	**BUCVB5**	**BS7**	**BS8**	**BUCVB1**	**BS1**	**BUCVB2**	**BS4**	**BUCVB4**	**BS2**	**BS3**	**BUCVB3**
Size (Ha)	10.71	6.17	11.02	1.76	1.33	6.74	0.76	2.58	2.43	9.45	16.51	5.41	28.94
Slope	2.00	3.09	1.78	2.61	3.30	1.59	1.66	1.66	0.75	1.11	1.47	1.35	1.03
Total Size (Ha)	121.55			9.83			0.76	2.575	11.88		50.92		
Seeps (%)	13.89			31.47			100.00	-	20.48		43.05		
Un-channelled Valley Bottom (%)	9.06			68.53			-	100.00	79.52		56.83		
Total Catchment Size (Ha)	1583.41			73.32			7.31	2.58	285.06		396.17		
Catchment Slope	1.10			2.21			3.43	88.48	0.41		1.22		

* = portion of wetland is associated with Alternative A

Table 3-8: The approximate sizes of dams located within the primary (Alternative B) and secondary study area

HGM Unit	HGM size (Ha)
BD1	0.044
BD2	0.144
BD3	0.612
BD4	0.520
BD5	0.292
BD6	1.217
BD7	0.083
BD8	15.267

Table 3-9: The approximate sizes of wetlands and catchment areas located within the primary (Alternative C) and secondary study area

	Wetland 1		Wetland 2				Wetland 3		Wetland 4
HGM unit	**CS2**	**CUCVB3**	**CP1**	**CS3**	**CS4**	**CUCVB4**	**CS1**	**CUCVB2**	**CUCVB1**
Size (Ha)	2.80	1.97	0.24	9.73	2.88	12.50	1.39	19.75	27.20
Slope	2.66	0.87	0.26	0.81	0.78	0.90	2.17	1.24	1.37
Total Size (Ha)	4.76		25.11				21.14		27.20
Pans (%)	-		0.95				-		-
Seeps (%)	58.70		50.24				6.57		-
Un-channelled Valley Bottom (%)	41.30		49.76				93.43		100.00
Total Catchment Size (Ha)	72.89		283.36				199.42		133.74
Catchment Slope	1.76		1.45				1.68		1.62

Table 3-10: The approximate sizes of dams located within the primary (Alternative C) and secondary study area

HGM Unit	HGM size (Ha)
CD1	3.315
CD2	0.112
CD3	0.104
CD4	11.968
CD5	0.109

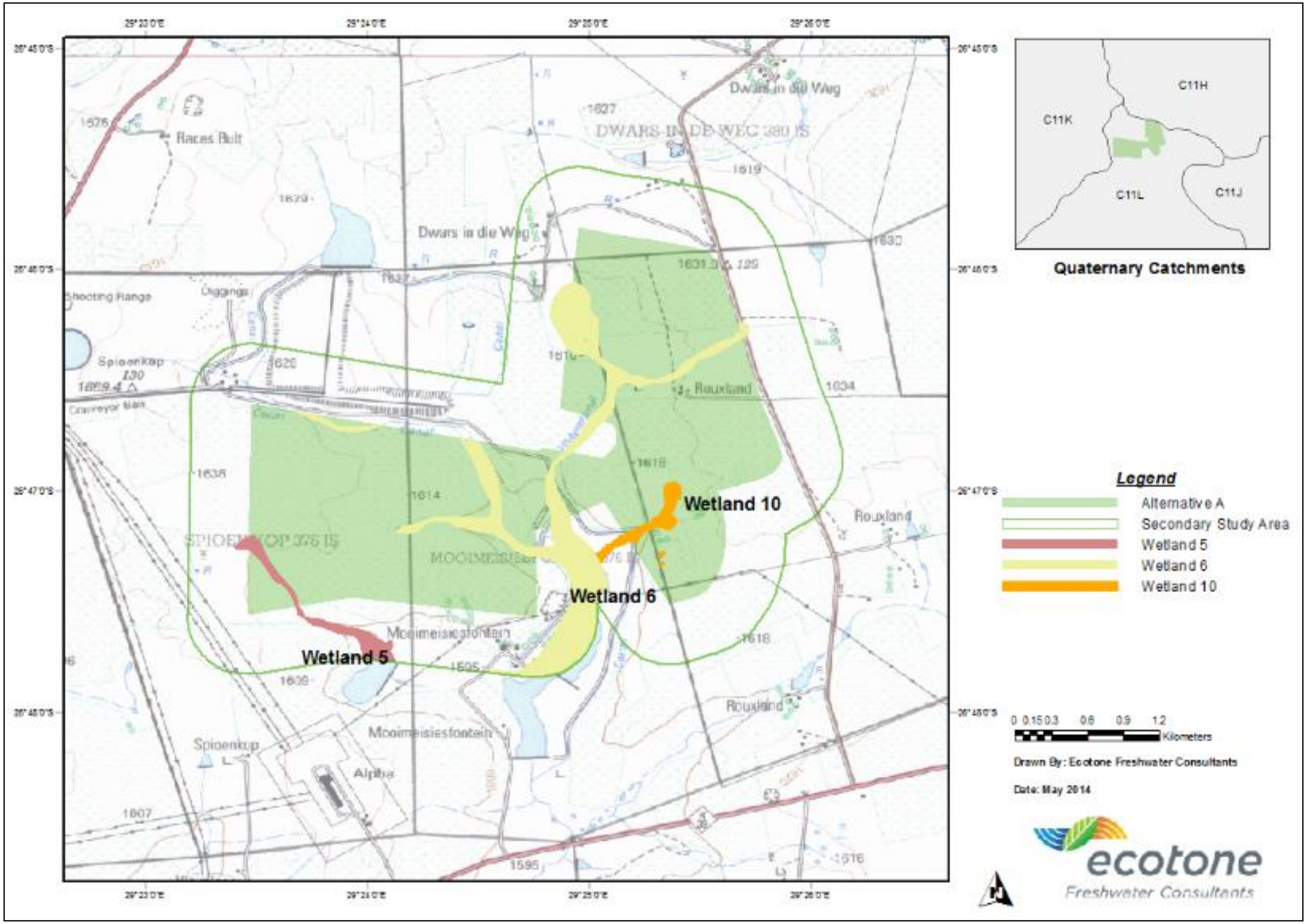


Figure 3-10: Map showing the different wetlands associated with the primary (Alternative A) and secondary study area.

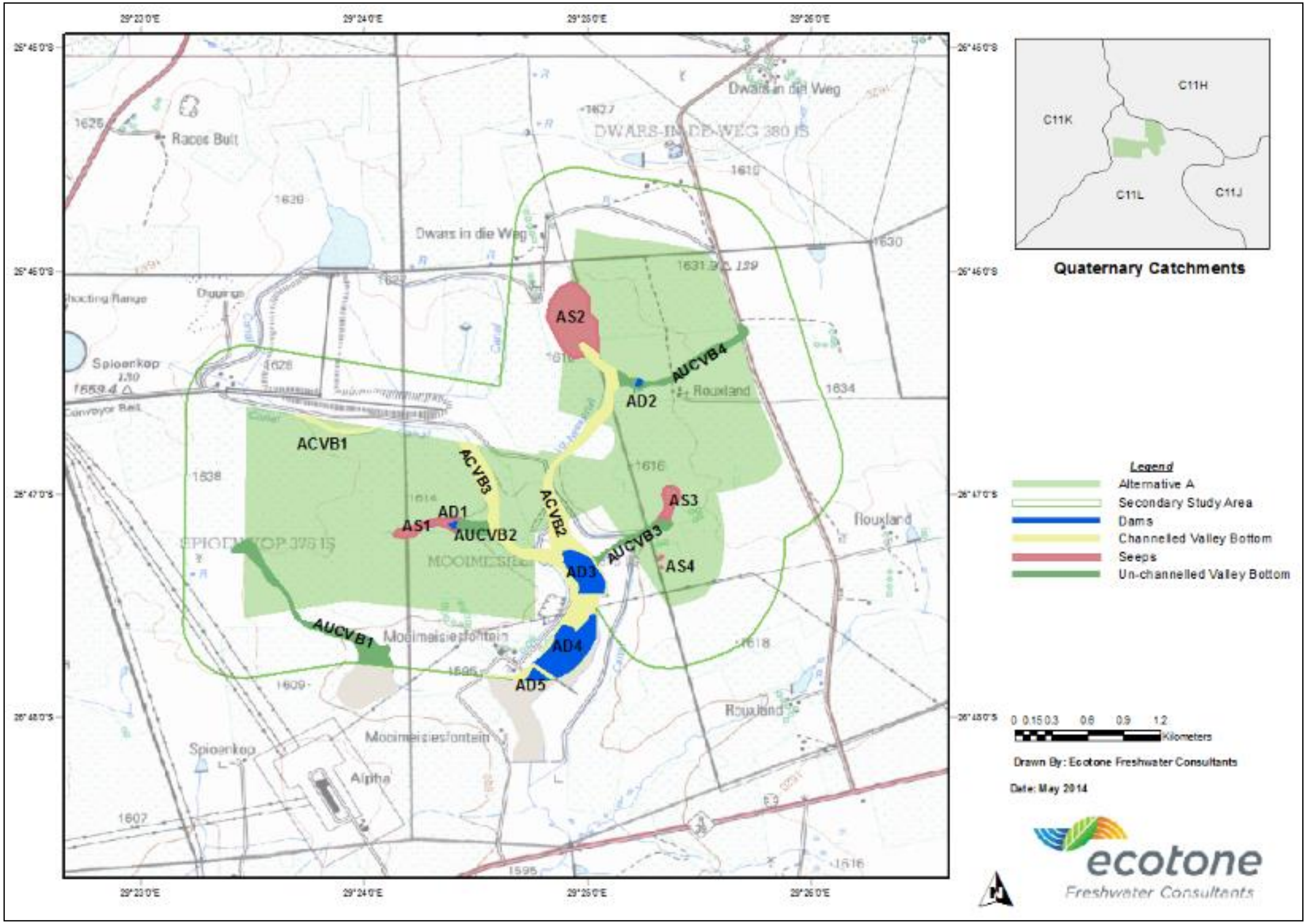


Figure 3-11: Map showing the different HGM units associated with the primary (Alternative A) and secondary study area.

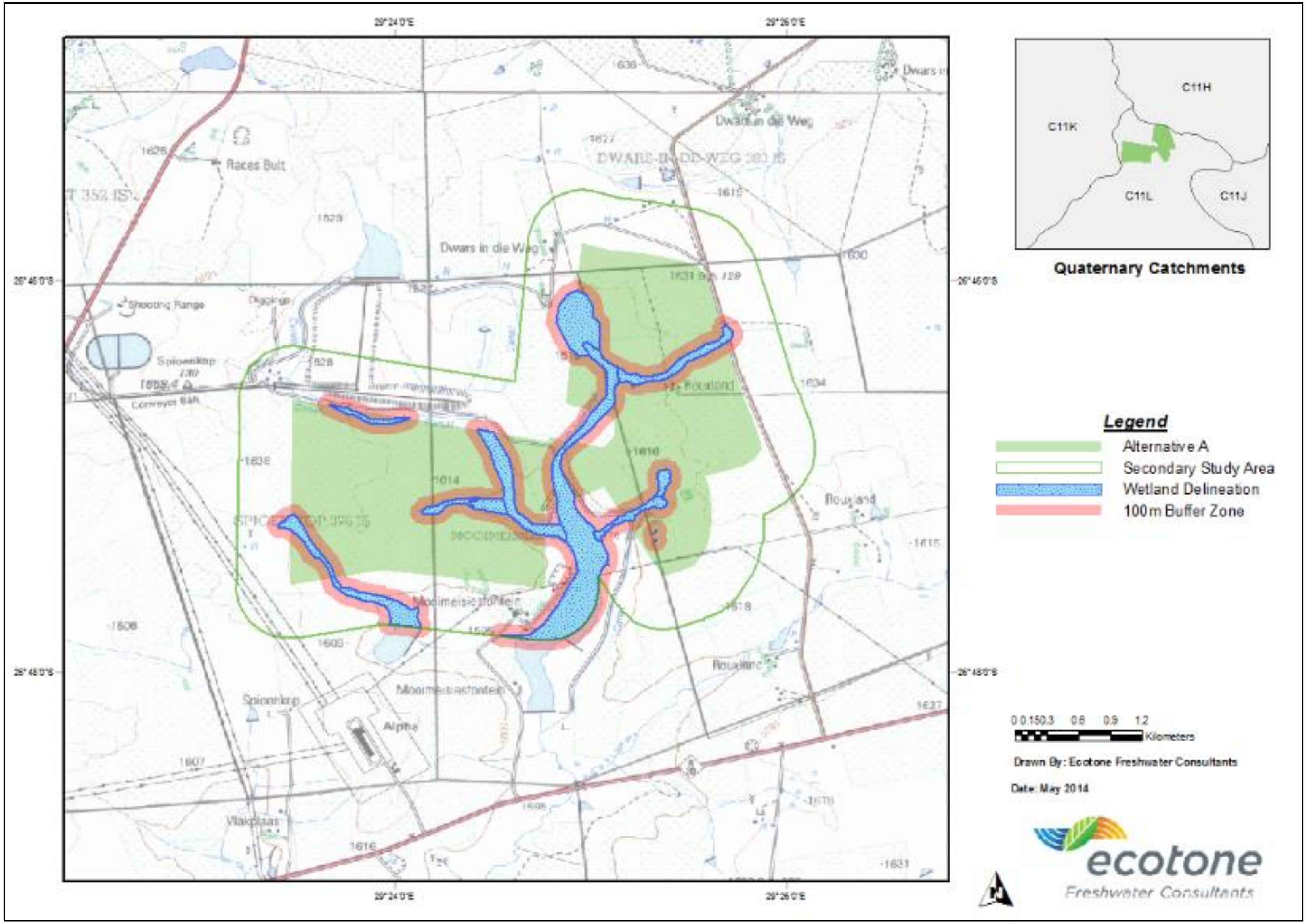


Figure 3-12: Map showing the different wetlands associated with Alternative A and the secondary study area with 100 m buffer zones.

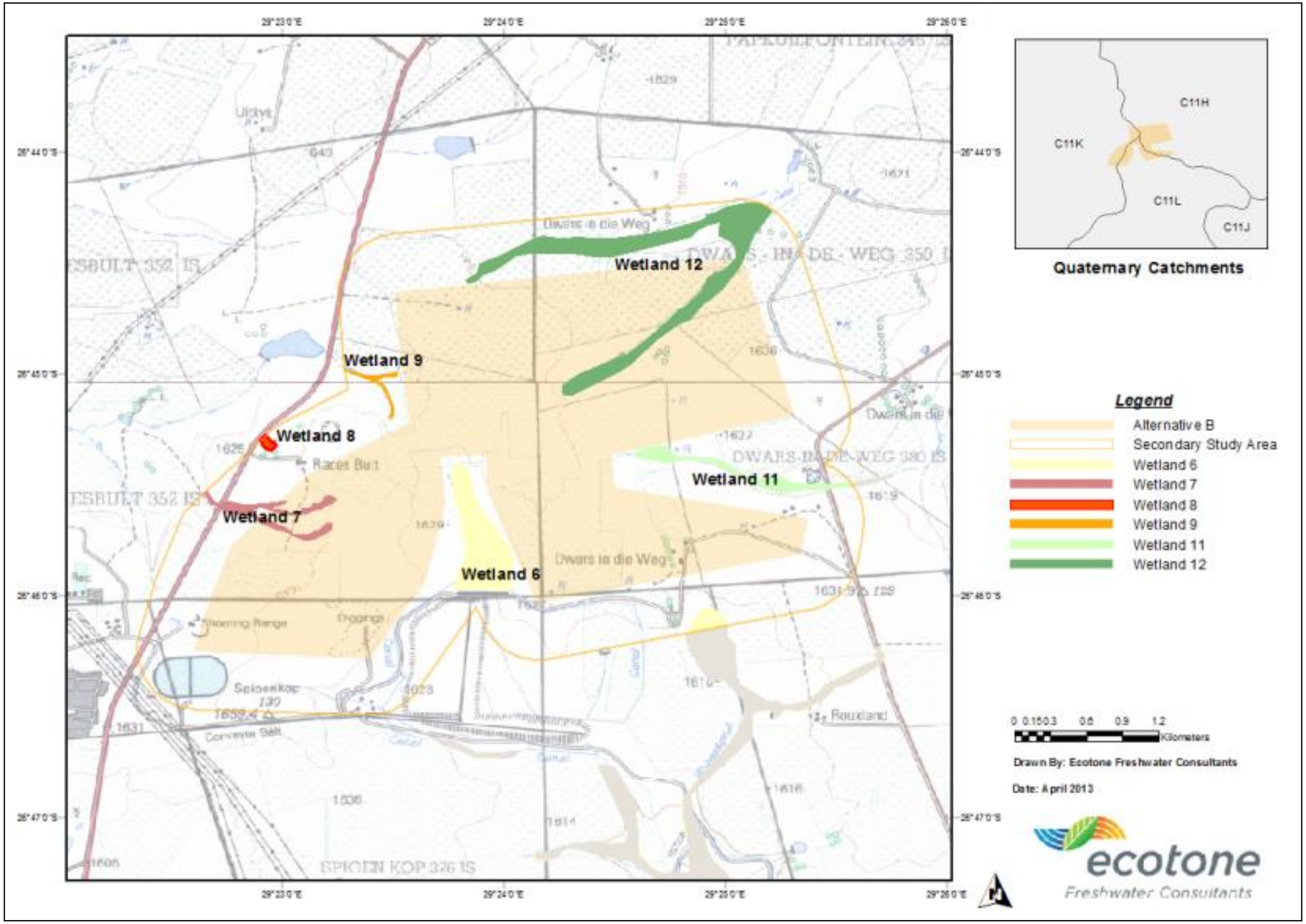


Figure 3-13: Map showing the different wetlands associated with the primary (Alternative B) and secondary study area.

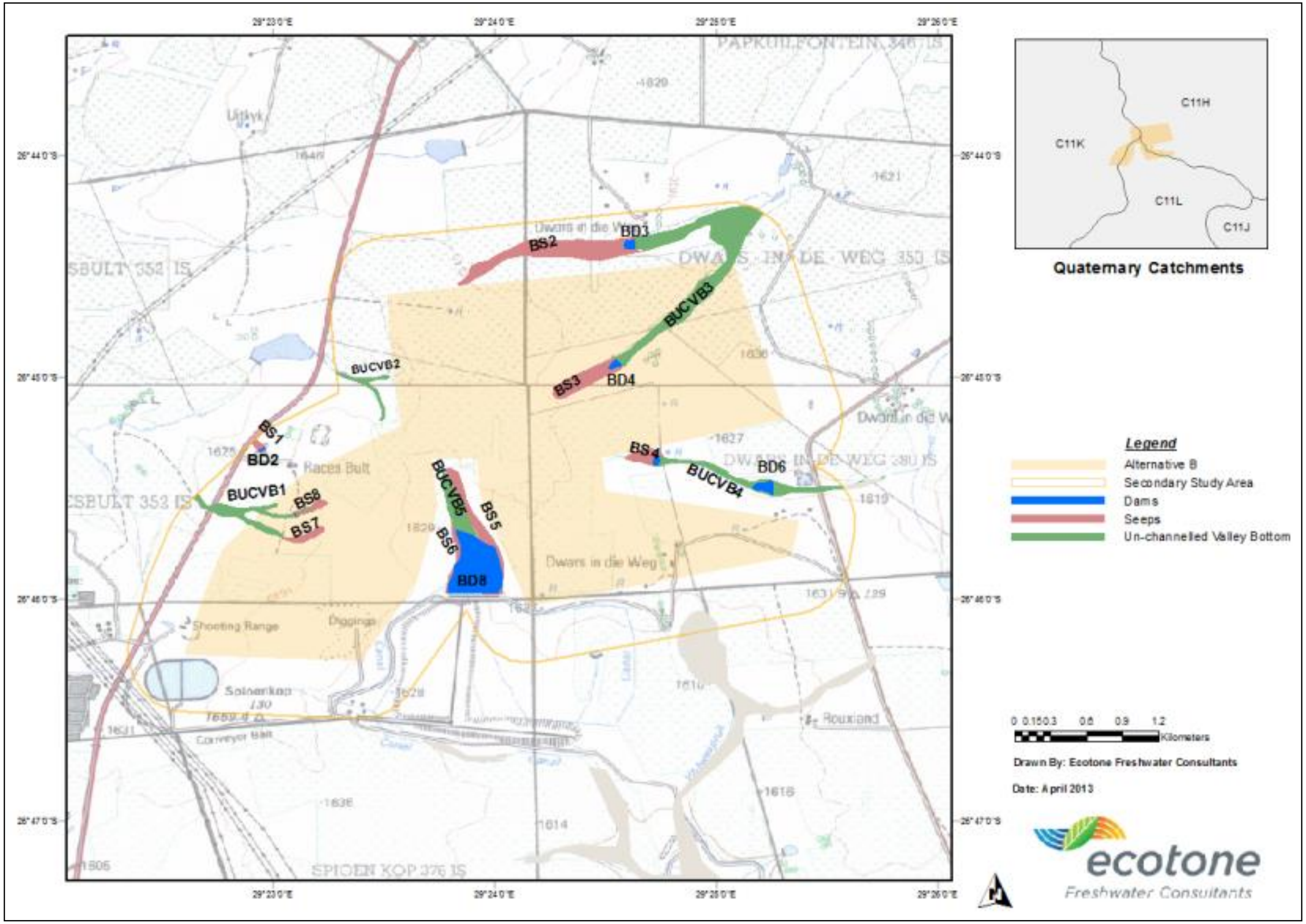


Figure 3-14: Map showing the different HGM units associated with the primary (Alternative B) and secondary study area.

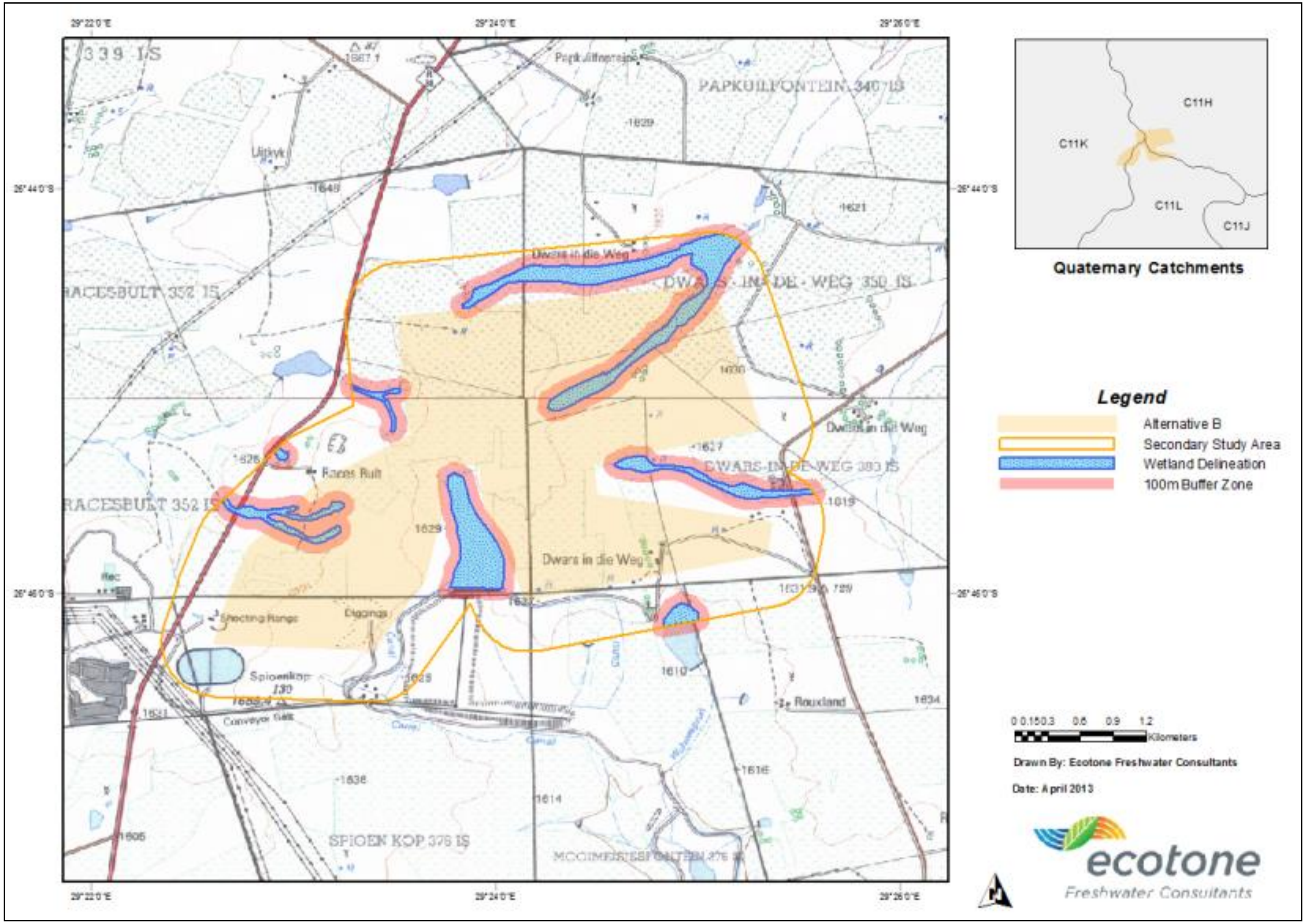


Figure 3-15: Map showing the different wetlands associated with Alternative B and the secondary study area with 100 m buffer zones.

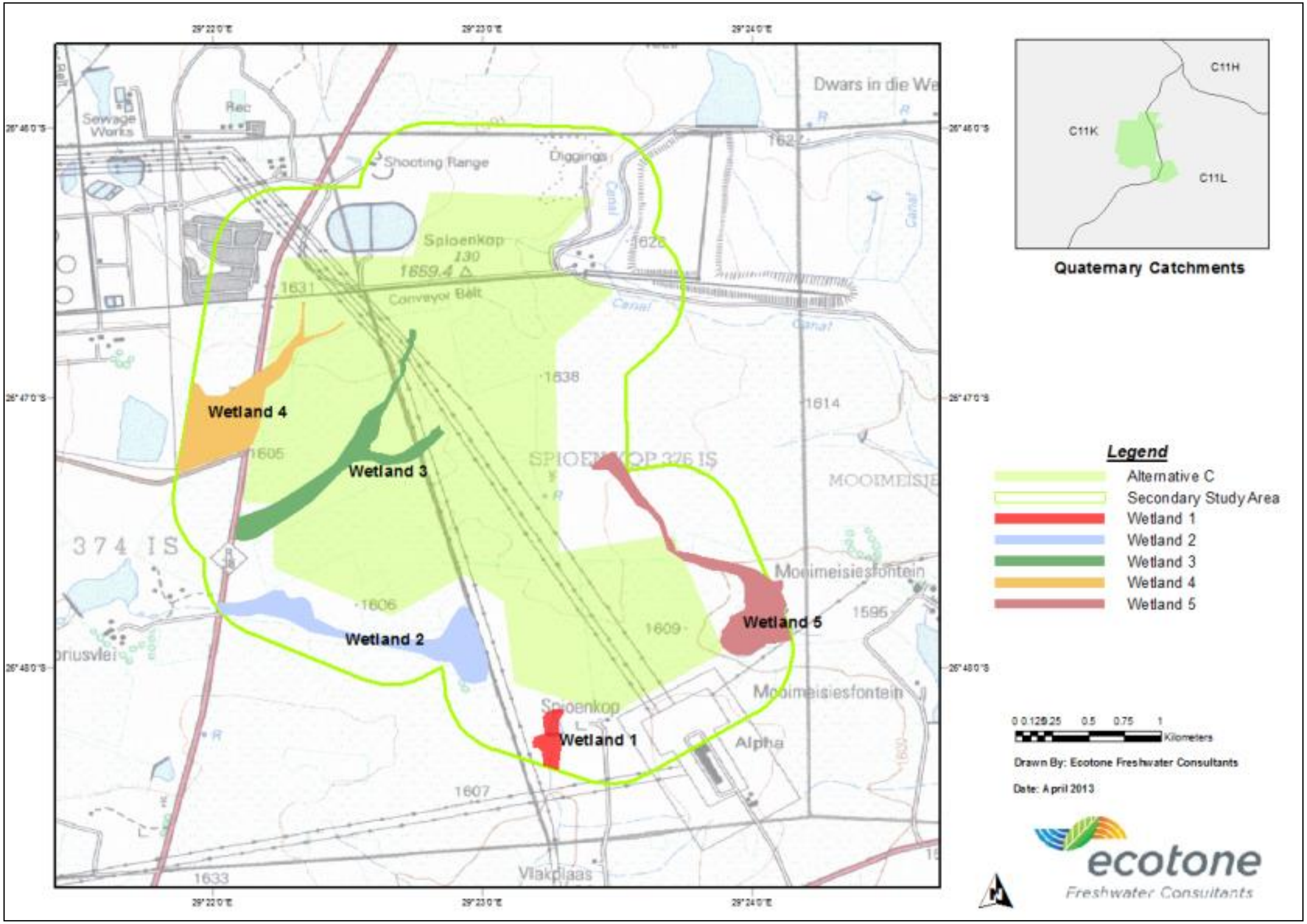


Figure 3-16: Map showing the different wetlands associated with the primary (Alternative C) and secondary study area.

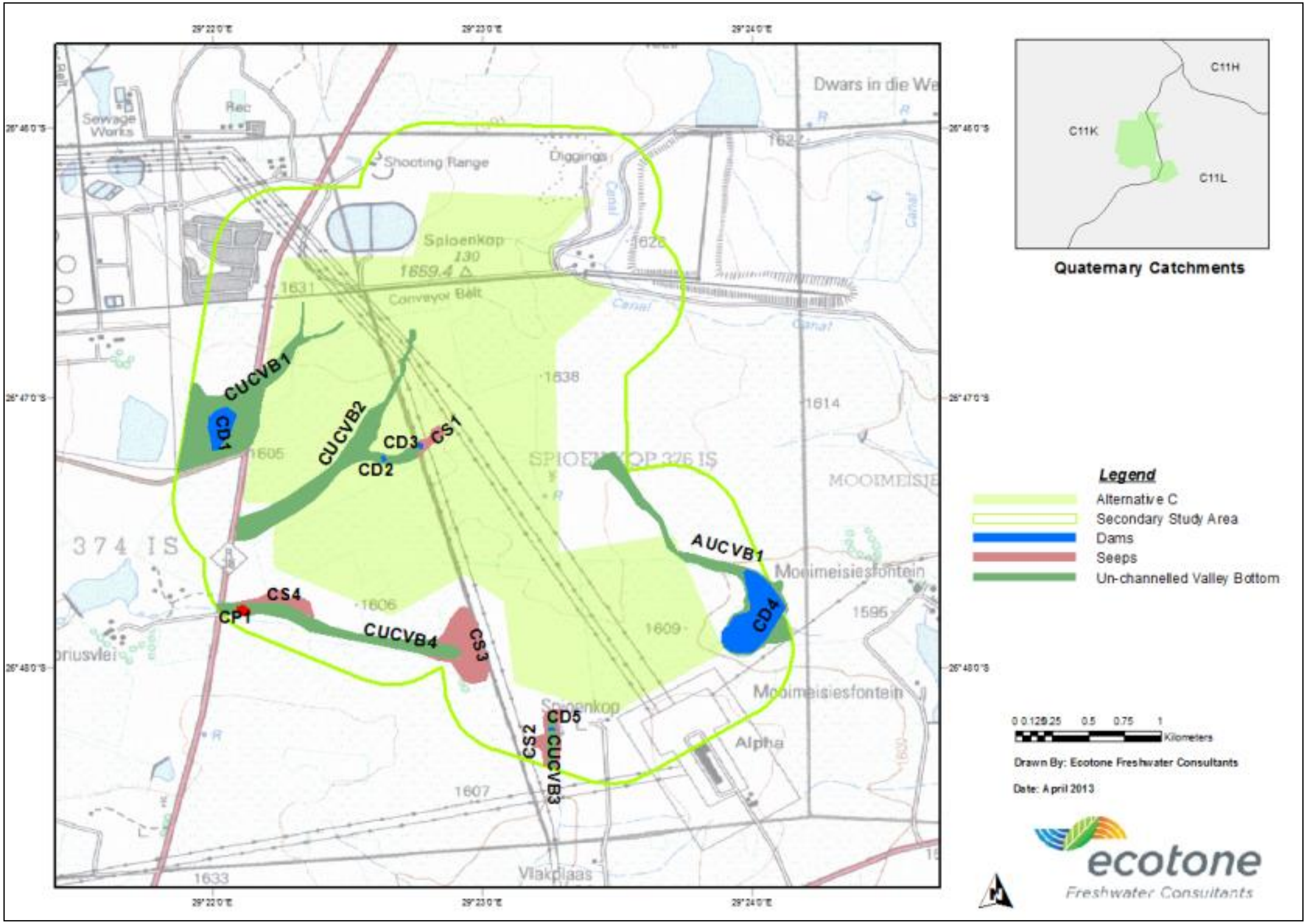


Figure 3-17: Map showing the different HGM units associated with the primary (Alternative C) and secondary study area.

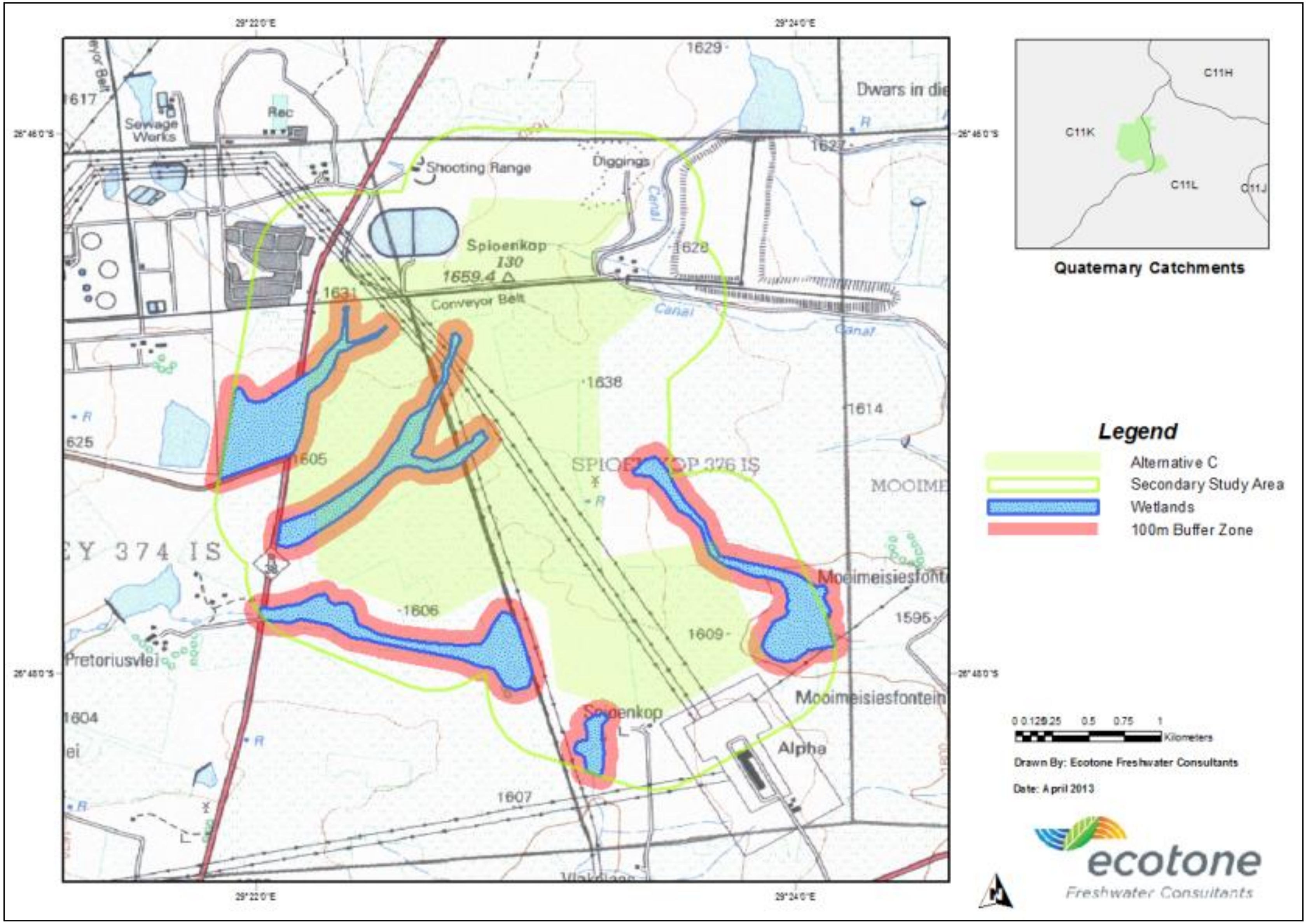


Figure 3-18: Map showing the different wetlands associated with Alternative C and the secondary study area with 100 m buffer zones.

3.7. WET-Health (PES) Determination

3.7.1. Alternative A

The Present Ecological Status (PES) assessment for Alternative A shows an overall C category for wetland 5 and a D for wetland 10, while Wetland 6 fell into an E category (Figure 3-19). The former translates into a Moderately Modified and Highly Modified state, while the latter implies a Seriously Modified state with a substantial departure from natural hydrological state. Historical aerial images reflect substantial agricultural activity pre-dating 1968. Most of the existing dams and ploughed fields were already visible in the 1968 image (Figure 3-20). The 1991 image shows the foot print of the ash disposal facility and its infringement on Wetland 6 (Figure 3-21). Two of its south-east tributaries have already been sterilised by the existing Ash Disposal Facility. A comparison with 2010 aerial image shows an infringement in the upper parts of the same wetland. This along with the following factors resulted in the PES measured (refer to Appendix D for pictures of the associated impacts):

- Possible increase in flow volumes- large dams located in the lower parts of Wetland 6 were not in existence in 1968. The capacity of these dams in relation to the local catchment yield suggests increased flows.
- An increase in hardened surfaces and subsequent increase in surface runoff characteristics.
- A decrease in surface runoff within the catchment, mostly due to monoculture and chronic soil disturbances of agricultural practices.
- Deep and shallow flooding by dams within highly seasonal systems.
- Impeding features such as inappropriate road crossings and infilling for roads and dam walls resulting in alteration of the horizontal movement of water.
- Decrease in surface roughness within the catchment and within the wetland units.
- Recent deposition of ash within wetland boundaries.
- Recent excavation and infilling, particularly in the northern parts of Wetland 6.
- Large canal structures and a number of drain features, dividing the catchment of Wetland 6.
- Cattle grazing within wetland units further resulted in soil compaction and preferential flow paths, contributing to erosion features.
- Catchment utilisation resulted in poor water quality associated with Wetland 6.

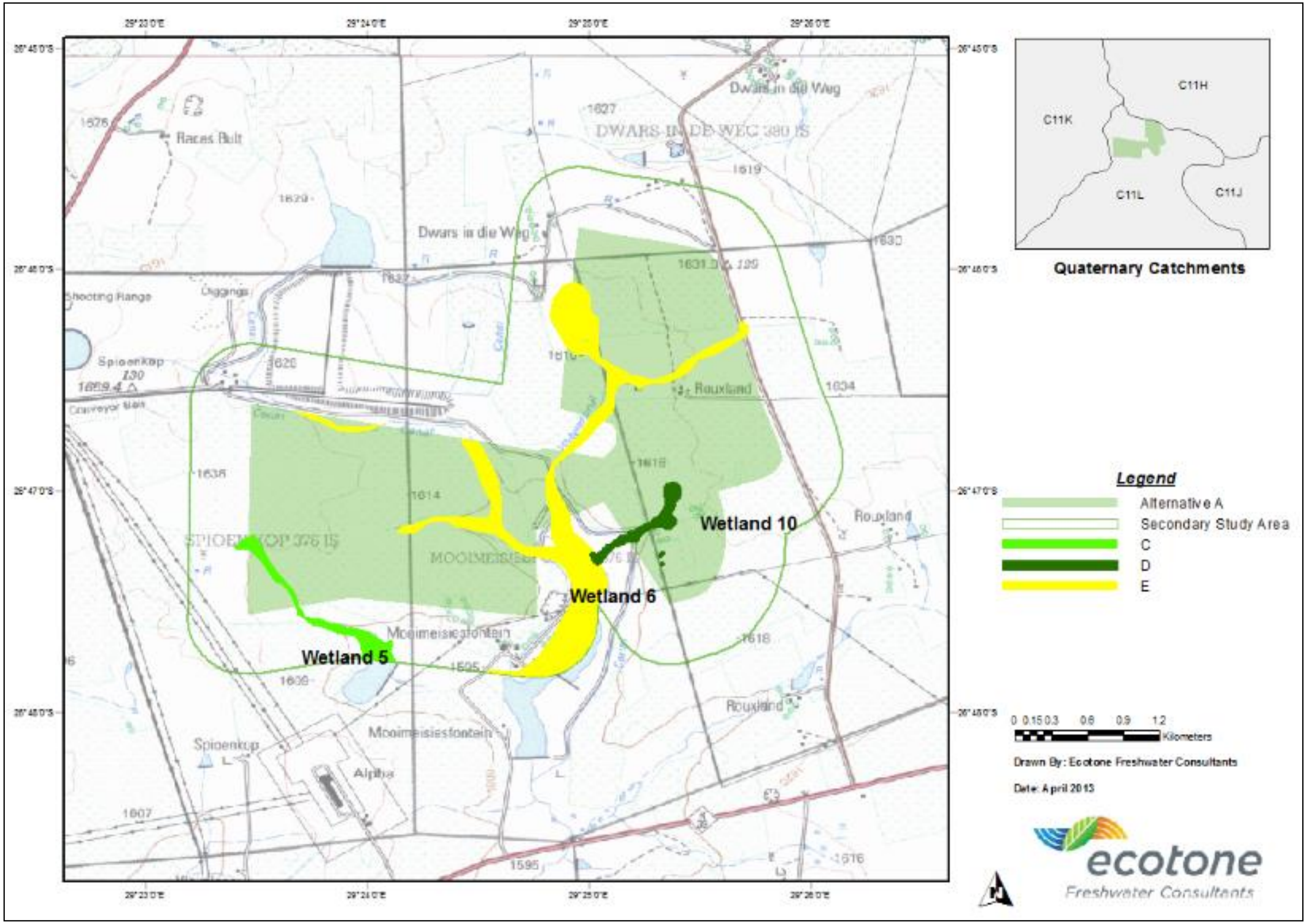


Figure 3-19: Map showing the Present Ecological State associated with wetlands located with the primary (Alternative A) and secondary study area.

Figure 3-20: Historical Aerial Image of Alternative A, 1968.

Figure 3-21: Historical Aerial Image of Alternative A, 1991.

3.7.2. Alternative B

Wetland 7 fell in a B category and is considered to retain a substantial amount of its reference hydrological integrity (Figure 3-22). Wetlands 8, 9, 11 and 12 fell in C categories and related to a Moderately Modified state (Figure 3-22) and Wetland 6 fell in an E category indicating a seriously modified ecological state. As with Alternative A, the 1968 aerial image mostly reflects agricultural activity, while the impact of the Ash disposal facility is evident in the 1991 image (Figure 3-23; Figure 3-24). Note the increased flood extent north of the ash disposal facility on one of the drainage lines linked to Wetland 6 (Figure 3-24). The modified state of Wetlands 8, 9 11 and 12 is the result of agricultural activity with some contribution of regional roads and quarries. Other reasons for the loss in hydrological integrity measured include the following:

- A decrease in surface roughness in the respective catchments and a subsequent change in runoff characteristics.
- The wetlands units itself were affected by alien trees.
- Deep and shallow flooding and road crossings.
- Some active erosion features were present in wetland 9, 11 and 12.

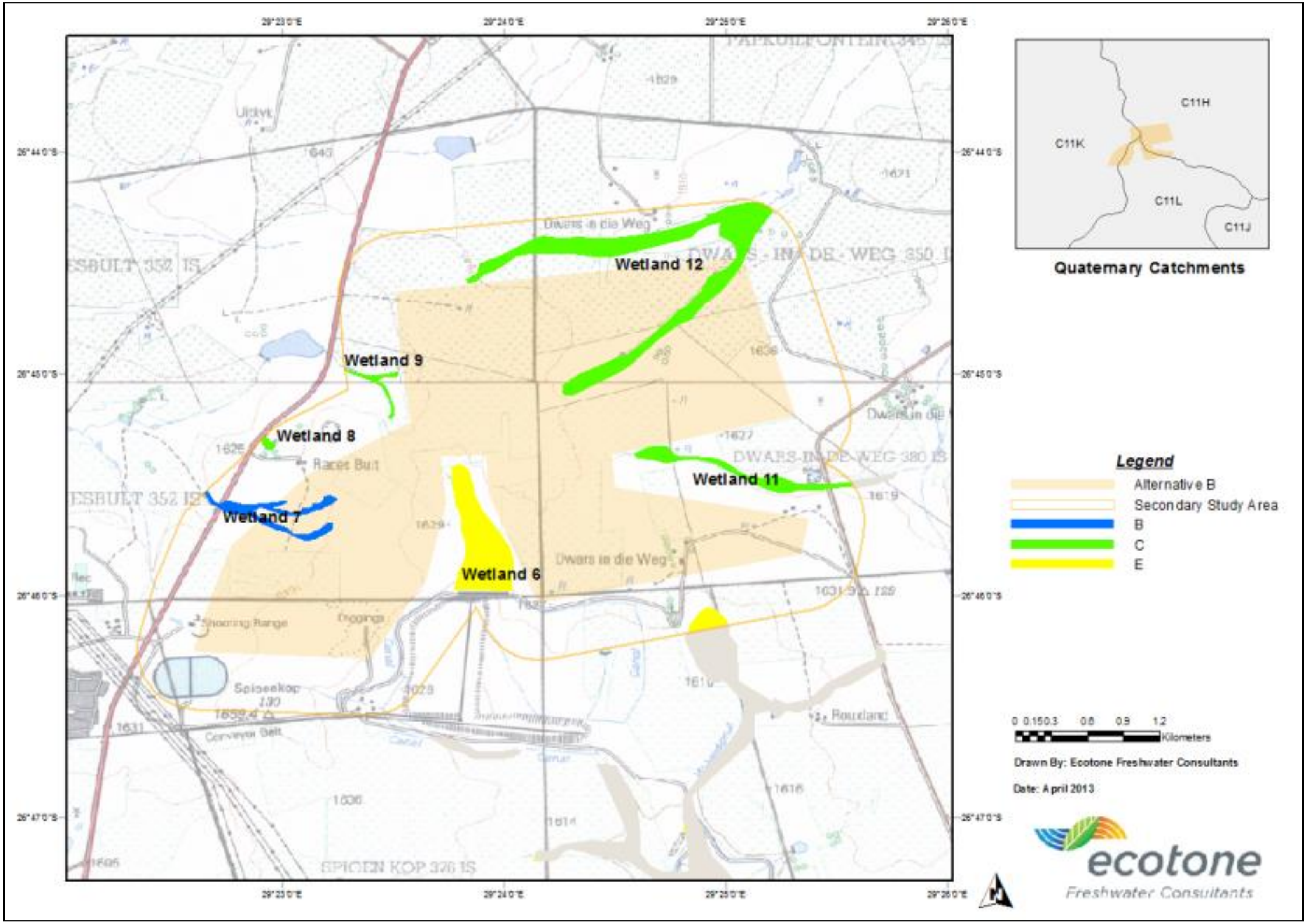


Figure 3-22: Map showing the Present Ecological State associated with wetlands located with the primary (Alternative B) and secondary study area.

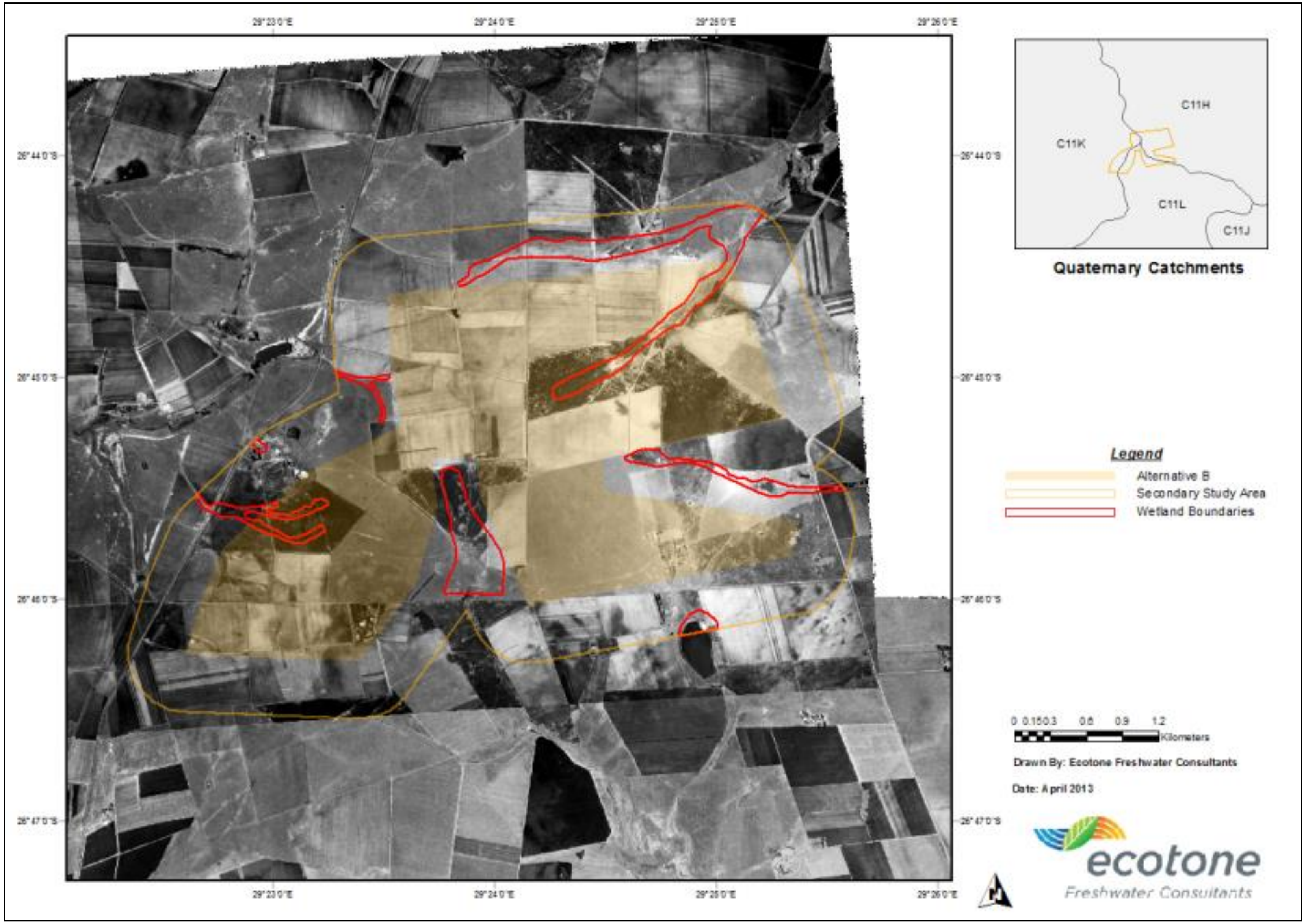


Figure 3-23: Historical Aerial Image of Alternative B, 1968.

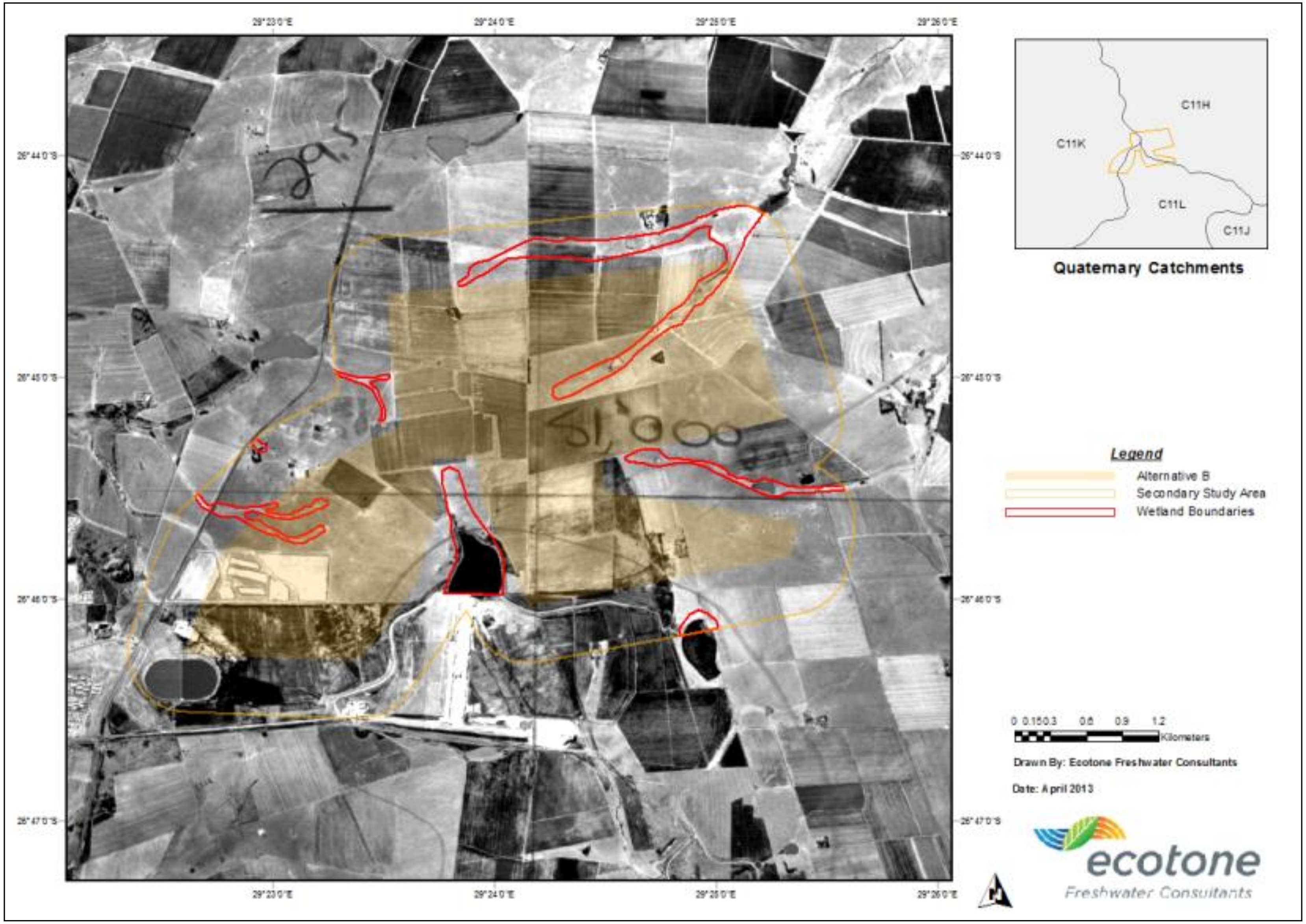


Figure 3-24: Historical Aerial Image of Alternative B, 1991

3.7.3. Alternative C

As with Alternative B most of the wetlands on Alternative C fell into a C category (Figure 3-25). However, Wetland 4 classed into a D category and reflects a Large diversion from reference conditions (Figure 3-25). The hydrological integrity of wetlands associated with this alternative was mostly affected by a change in runoff characteristics and dams. In most instances cropping and cattle grazing directly affected natural vegetation recruitment, while relatively large dams resulted in deep flooding and direct wetland habitat destruction (compare bottom half of wetland 4 in 1968 with 1991 - Figure 3-26; Figure 3-27). Other factors contributing towards the loss of wetland integrity include:

- Possible increase in surface water, particularly for Wetland 4, noted by the increased extent of inundation between 1968 and 1991. It should be noted that the water quality measured at Wetland 4 did not indicate contamination.
- Conversely the large dam structure at the terminal end of Wetland 5 pre-dated 1968.
- Both Wetland 2 and 3 reflected erosion features identified by isolated headcuts and canalisation. This is presumably due to changes in runoff patterns. The extent of the erosion features was limited and they appeared relatively stable with sloped banks and vegetation recruitment on the sides and bottom.

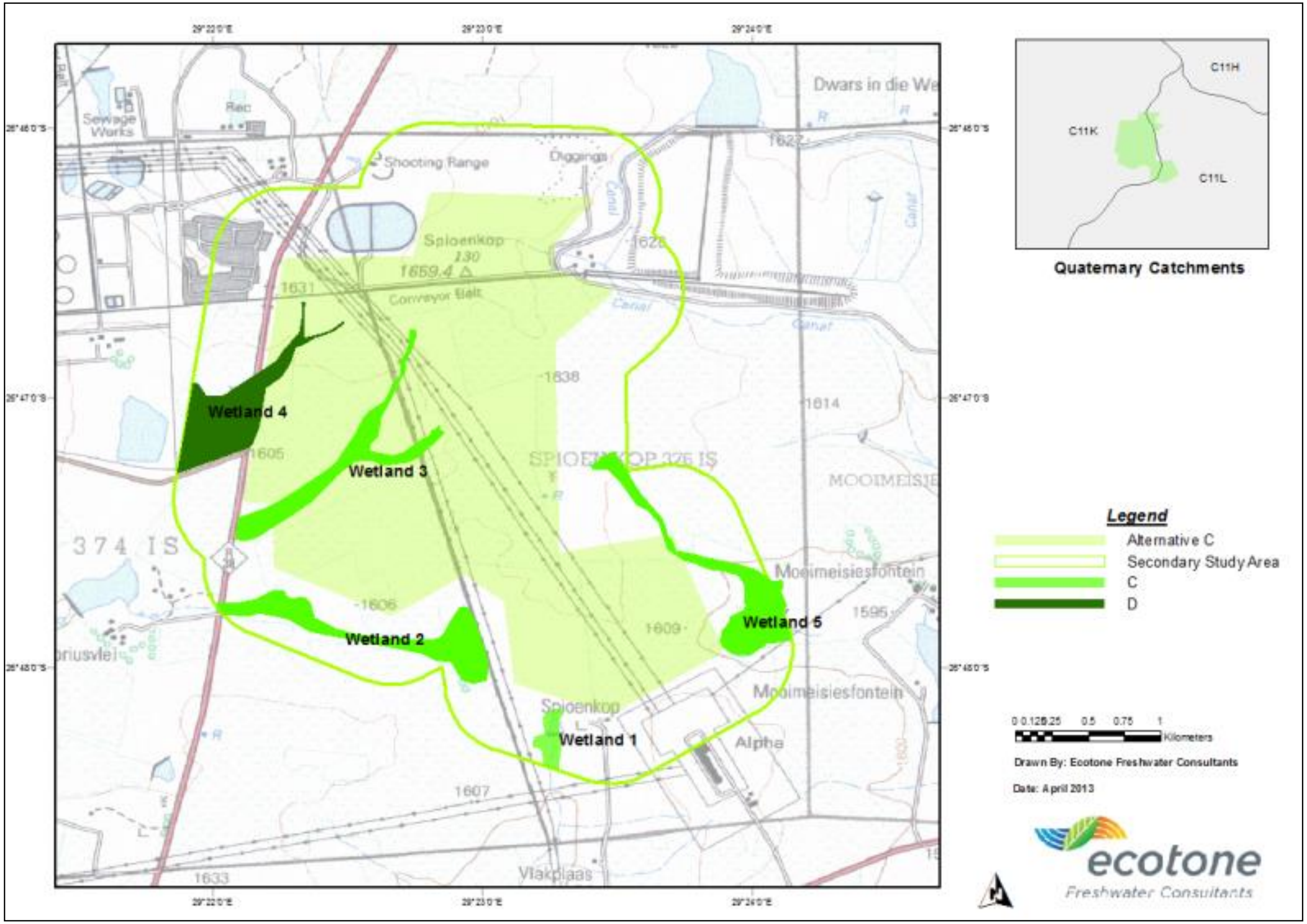


Figure 3-25: Map showing the Present Ecological State associated with wetlands located with the primary (Alternative C) and secondary study area.

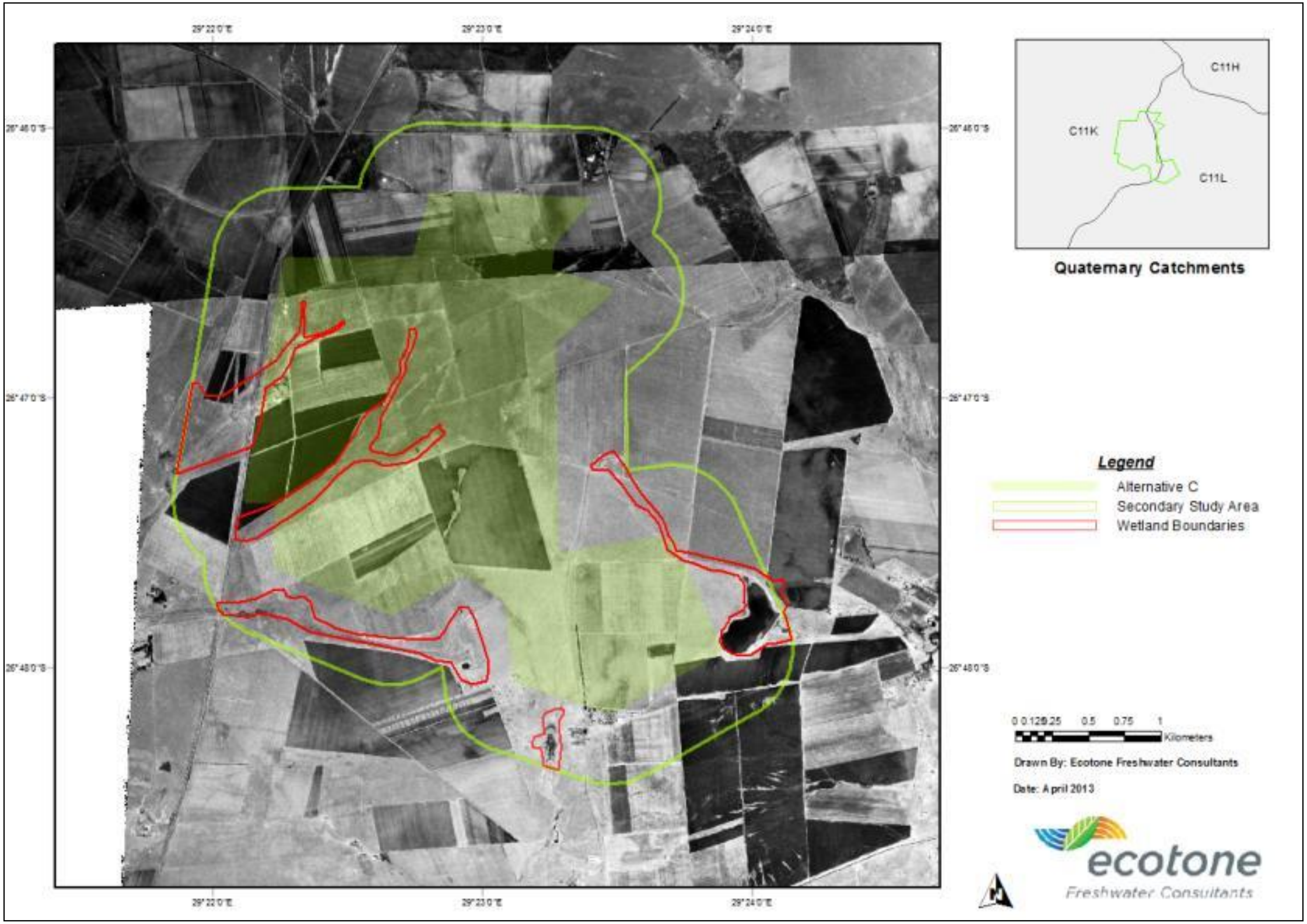


Figure 3-26: Historical Aerial Image of Alternative C, 1968.

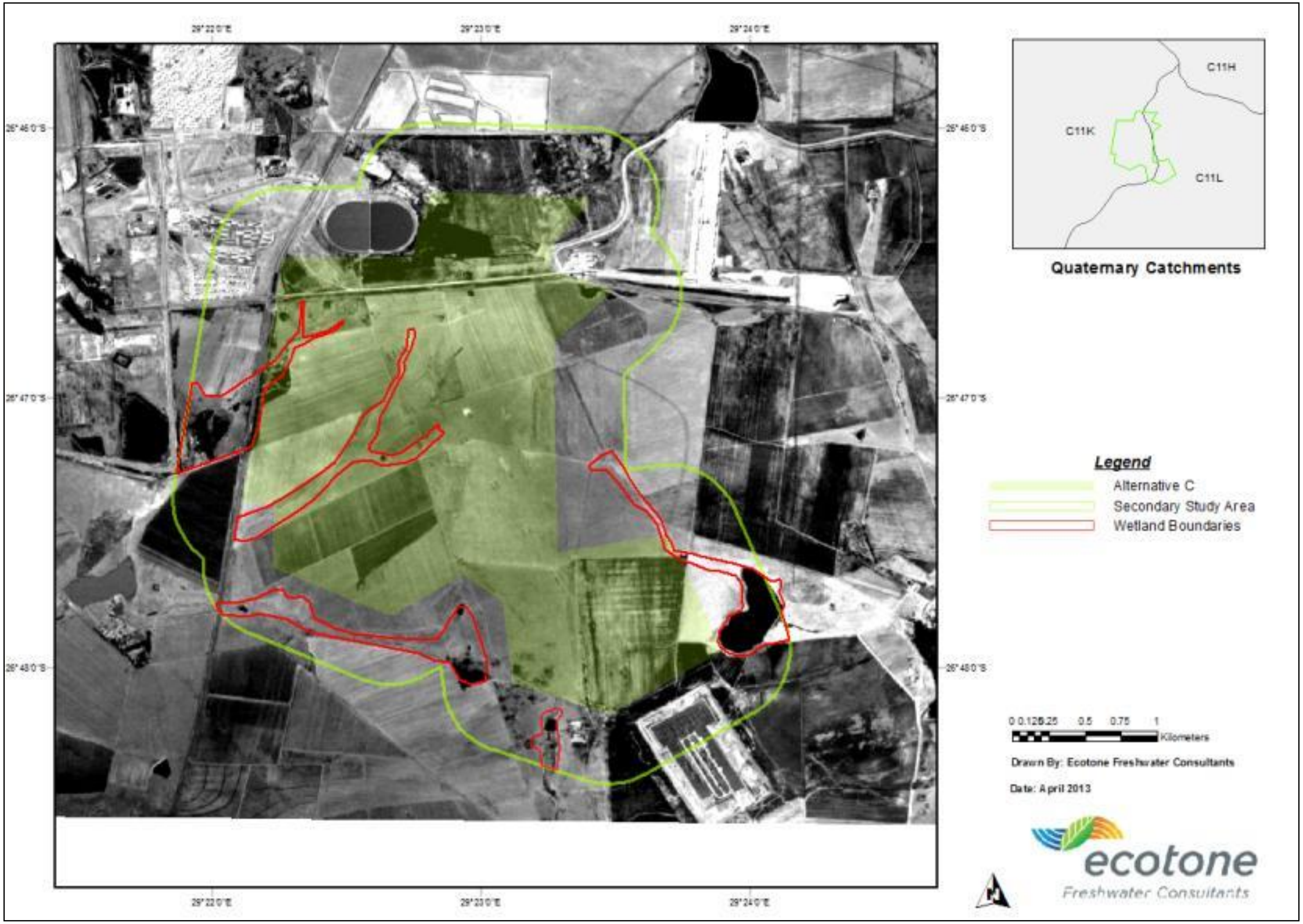


Figure 3-27: Historical Aerial Image of Alternative C, 1991.

3.8. Wetland Vulnerability

As part of the health assessment of wetland units the inherent vulnerability of wetlands should be assessed (Macfarlane, *et al.,* 2009). Erosion and the rate of headcut erosion are dependent upon many factors (such as soil type, vegetation cover and type, rainfall events etc.) but one of the most critical factors is slope. For any given discharge the steeper the slope the greater the erosion risk. It follows that the slope of a wetland unit in relation to its size provides a measure of its vulnerability. The following section illustrated this relationship for the wetlands on the different alternatives.

Wetlands on Alternative A all scored above the equilibrium slope (indicated by the green line between 2 and 5 (Figure 3-28)) and are considered to be vulnerable to catchment alteration. Wetland 10 is nearest to the equilibrium slope and is less vulnerable than Wetlands 5 and 6. Wetland 6, scored the highest and its vulnerable state is already expressed in its low PES obtained.

As with Alternative A, wetlands on Alternative B, all fall above the equilibrium slope and are considered vulnerable. However, Wetlands 7 and 12 are more vulnerable than wetlands 9 and 11 (Figure 3-29).

Wetlands on Alternative C reflects similar slope and size relationships and are all vulnerable to erosion (Figure 3-30). Wetland 1 reflected the smallest extent but also had a longitudinal slope greater than the other wetlands associated with Alternative C. Wetland 3 and 4 scored highest for wetlands in this Alternative. Their higher vulnerability scores are consistent with the extent of erosion features measured within them.

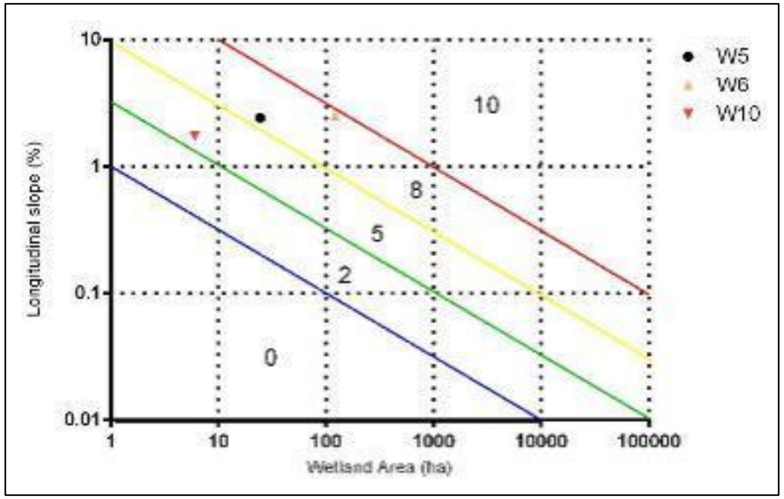


Figure 3-28: Vulnerability of wetland units to geomorphological impacts based on wetland size and slope for Alternative A.

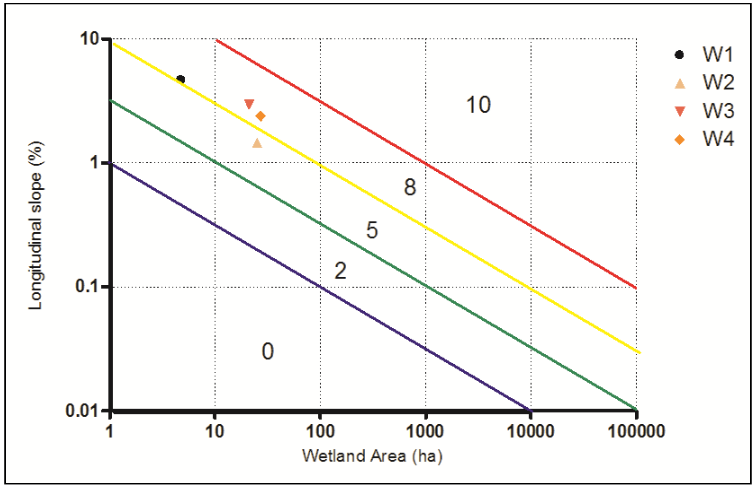


Figure 3-30: Vulnerability of wetland units to geomorphological impacts based on wetland size and slope for Alternative C.

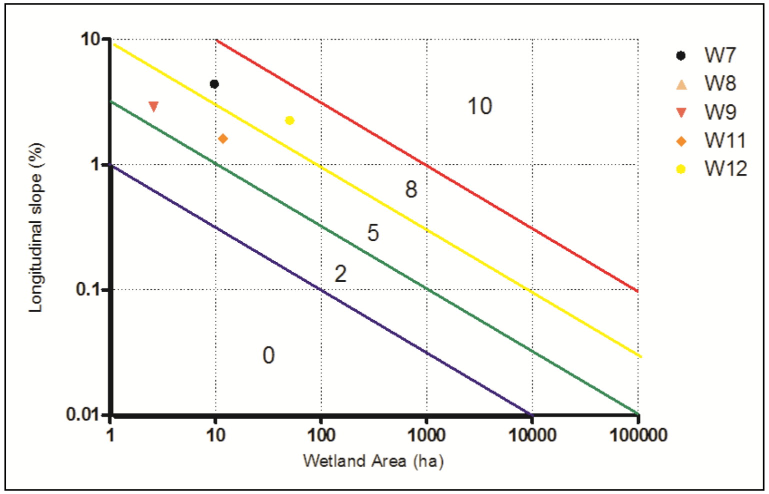


Figure 3-29: Vulnerability of wetland units to geomorphological impacts based on wetland size and slope for Alternative B.

3.9. WET EcoServices: Functional Assessment

A functional assessment for the wetlands was undertaken using the WET-EcoServices tool as developed by Kotze et al. (2007). Amongst other reasons, this methodology was designed to:

- Flag important ecosystem services that need to be considered when managing an individual wetland;
- Prioritise for the allocation of management and rehabilitation resources across a set of wetlands; and
- Plan catchment management: to determine the relative importance of individual wetlands in a catchment context.

Functional ecosystem services of wetlands in general include services such as flood control, nutrient cycling, erosion control, toxicant removal, carbon storage, phosphate assimilation, biodiversity maintenance, provision of food and water, cultural services and recreation. The presence of any service is subject to the potential exposure in the catchment and the HGM type. Wet-EcoServices methodology does not consider the size of a wetland; the larger the wetland the greater the capacity to provide a particular service.

General services associated with different wetland units are provided in Table 3-11. The dominant wetland units in the study area are unchannelled valley bottom systems which are particularly important and are likely to perform services related to flood attenuation, stream flow regulation and enhancement of water quality.

Table 3-11: Preliminary ratings of the hydrological benefits likely to be provided by wetlands located within the study area (Kotze *et al.*, 2009).

Wetland HGM	**Regulatory Benefits Potentially Provided by the Wetland**							
	Flood Attenuation		**Stream flow regulation**	**Enhancement of Water Quality**				
	Early wet season	Late wet season		Erosion control	Sediment trapping	Phosphates	Nitrates	Toxicants
Pan / Depression	+	+	0	0	0	0	+	+
Hillslope Seep (isolated)	+	0	0	++	0	0	++	+
Hillslope Seep (linked with a stream channel)	+	0	+	++	0	0	++	++
Un-channelled valley bottom	+	+	+	++	++	+	+	++
Channelled valley bottom	+	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).

On average services relating to streamflow regulation scored the highest followed by Nitrate removal and Phosphate trapping (Figure 3-31). The high score for these services are a function of the nature of the wetlands present and their current catchment utilisation. Carbon storage and maintenance of biodiversity on average scored the lowest. The more important functions are briefly discussed below:

- Streamflow regulation – Wetlands store water within their sediments and through the slowing down and spreading out of flows across the wetlands. At the start of the dry season the dry wetland sediments have a large capacity for storing water, water which is then slowly released downstream over time as well as lost to evapo-transpiration.
- Water quality maintenance and improvement – This includes the various functions of nitrate, phosphate and toxicant trapping. With the exception of Wetland 6, most wetlands on site are associated with upper reaches and provide good quality water to downstream reaches.
- Flood attenuation- Unchannelled valley bottom systems are typically less likely to provide this function to the same degree as channelled and floodplain systems. However the large number of dams and their position within the landscape generates a greater flood control function.
- Erosion control and sediment trapping – Due to the landform setting, lower slopes and generally more robust vegetation cover of wetlands, surface flows through the wetlands are generally slowed down, reducing the risk of erosion. Slower flows in the wetlands also encourage the deposition of sediments which, given the sediment sources within the area (cultivated fields and un-surfaced roads), provides an important ecosystem service in maintaining the ecological integrity of downstream aquatic ecosystems.
- Maintenance of biodiversity – Given the large changes in landuse that have occurred on the Mpumalanga Highveld due to agriculture and mining, wetlands often represent the only remaining areas of natural vegetation and thus play an important role in supporting and maintaining biodiversity within a mostly transformed landscape. Wetlands provide habitat that differs in structure and productivity from the surrounding terrestrial landscape, increasing the biodiversity support function of the landscape.

Wetland 8, 3, 9 and 12 on average scored higher and are more likely to provide the Ecosystem Services mentioned above (Figure 3-32). Wetlands 11, 10, 4 and 6 obtained low average scores and are less likely to perform similar functions with the same efficiency.

Details on particular Ecosystem Services associated with each wetland unit may be found in APPENDIX F - WET EcoServices: Functional Assessment.

When assessing wetland functionality it is important to make reference to the size of the wetland, a bigger but more degraded wetland might still provide a larger function than a smaller more intact system. The notion of hectare equivalents attempts to deal with this matter and provide a measure of the extent of remaining functionality associated with different wetland units. In this regard, special reference should be made to Wetland 6 (Alternative A) which is the largest wetland in the study area (Table 3-12). The catchment of this wetland reflects substantial alteration, the effects of which are indicated by the low PES and poor water quality measured for this wetland. The functional importance of its remaining hectare equivalents should thus be emphasised. Wetland 6, with its dams, acts as a buffer between the transformed upstream catchment and the downstream receiving environment.

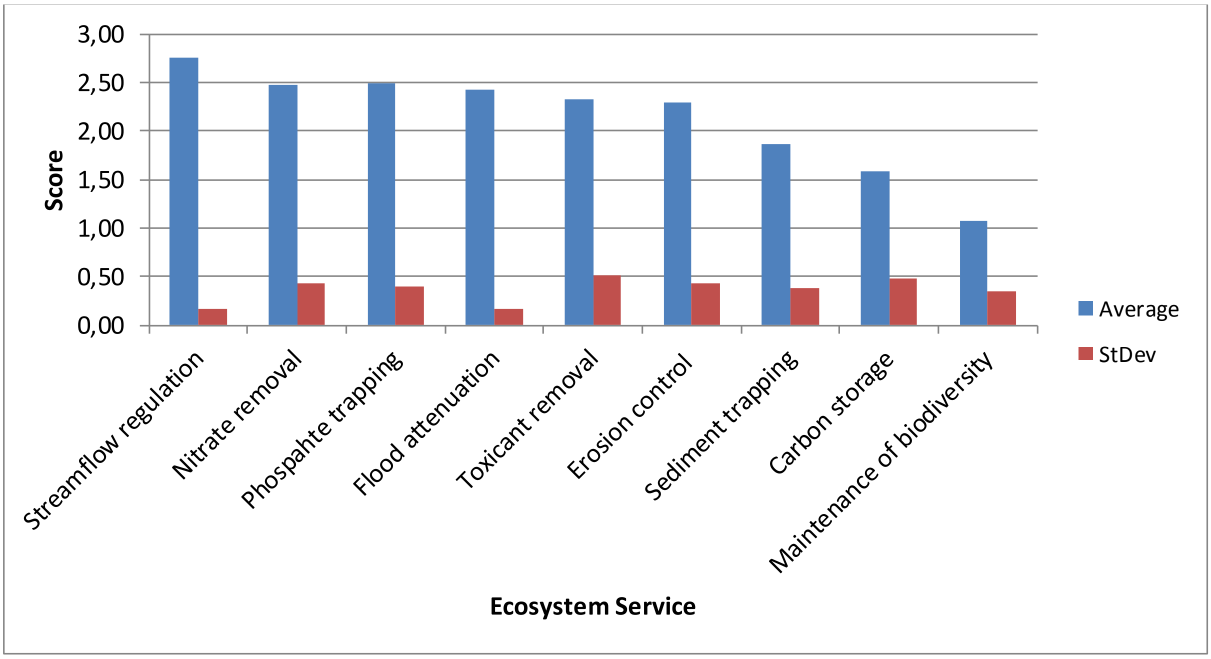


Figure 3-31: Overall average score for Ecosystem Services associated with all three Alternatives.

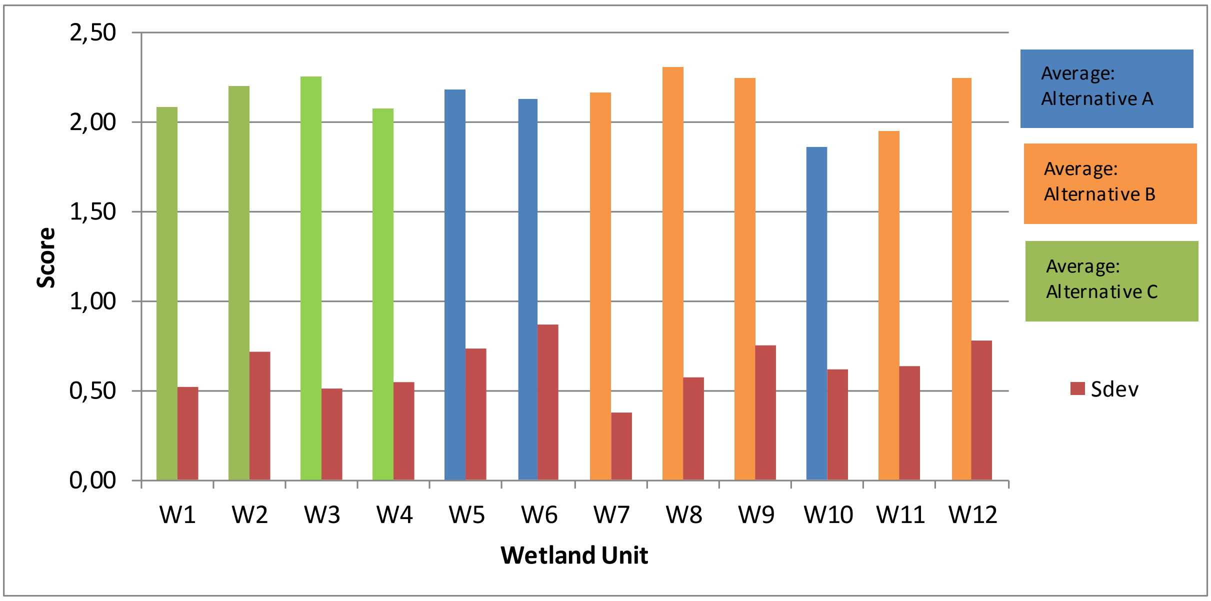


Figure 3-32: Average overall Ecosystem Service scores per wetland unit.

Table 3-12: Hectare equivalents for respective functional units in area of study.

	Size (ha)	Hectare Equivalents (ha)
	Alternative C	
Wetland 1	4.76	3.39
Wetland 2	25.11	17.72
Wetland 3	21.14	15.19
Wetland 4	27.20	11.66
	Alternative A	
Wetland 5	24.40	14.81
Wetland 6	97.66	34.04
Wetland 10	6.04	2.84
	Alternative B (includes a portion of Wetland 6)	
Wetland 7	9.83	8.71
Wetland 8	0.76	0.56
Wetland 9	2.58	1.80
Wetland 11	11.80	8.34
Wetland 12	50.92	33.03

3.10. Ecological Importance and Sensitivity

The Ecological Importance of a wetland is an expression of its importance to the maintenance of ecological diversity and functioning on local and wider scales. Ecological Sensitivity refers to the system's ability to tolerate disturbance and its capacity to recover from disturbance once it has been impacted (Kleynhans *et al*., 1998).

The EIS considers biodiversity, rarity, uniqueness and fragility of the resource. The intrinsic ecological value of the resource and its importance to the functioning of neighbouring ecosystems are the main concerns.

Only marginal differences existed between total EIS scores, while the medians remained unchanged for the different alternatives (Table 3-13). The EIS of all alternatives relate to a Moderate importance and sensitivity and are likely to be important on a local scale. Please refer to APPENDIX E – Ecological Importance and Sensitivity- for justifications of ratings allocated to the different variables assessed.

Table 3-13: Table reflecting the EIS assessment scores and confidence ratings

Determinant	**A**	**B**	**C**	**Confidence**
PRIMARY DETERMINANTS				
1. Rare and endangered species	2	2	2	3
2. Populations of unique species	2	2	2	2
3. Species / taxon richness	3	2	2	3
4. Diversity of habitat types or features	3	2	2	3
5. Migration/breeding and feeding site for wetland species	2	2	2	2
6. Sensitivity to changes in natural hydrological regime	1	2	2	3
7. Sensitivity to water quality changes	1	3	2	3
8. Flood storage, energy dissipation and particulate/element removal	3	1	3	3
Base flow augmentation; dilution	2	1	1	3
MODIFYING DETERMINANTS				
9. Protected status	3	3	3	3
10. Ecological importance (rarity of size/type/condition) – local, regional or national context	2	2	2	3
TOTAL	***24***	***22***	***23***	
Average	***2.2***	***2.0***	***2.1***	
MEDIAN	**2**	**2**	**2**	

4. Findings

As mentioned previously in Section 3.6, the primary study areas occupied the following space: Alternative A= 672.68 Ha; B= 764.94 Ha and C = 534.41 Ha. The fractional representations of wetlands were: Alternative A= 12.0%; B= 3.0% and C= 4.0%. Wetlands which will directly be affected by the proposed ash disposal facility are ecologically impaired to different degrees due to current land use activities. These wetlands mostly retain a stream flow regulation and water purification function.

Wetlands in the secondary study area are also ecologically impaired in most instances. The hydrological characteristics of the two 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 on nearly all alternatives. Most wetlands in the secondary study area are vulnerable to changes in hydrology and geomorphology in their respective catchments.

Impacts on the wetlands may be summarised under three main factors: alteration to (1) hydrology, (2) geomorphology and (3) wetland vegetation. Changes to any of these factors, due to ashing and related activities will elicit a change in the PES. The intensity of the response will be proportional to the sensitivity of the wetlands to these changes. The wetland impact assessment therefore considers six main impacts (listed below), in relation to the sensitivity of wetlands on all three Alternatives.

1. Impacts on hydrology;
2. Impacts on surface water quality;
3. Impacts related to erosion and sedimentation;
4. Impacts on wetland vegetation and disturbance of wetland habitat;
5. Impact related to increase alien/pioneer vegetation in disturbed areas;
6. Impacts on residual wetland ecosystem services.

The following section will provide a description of the above-mentioned impacts anticipated for each Alternative during three different phases: construction, operation and decommission. In addition the cumulative impacts for respective Alternatives will be described with reference to the anticipated impact on the receiving environment, current trends in PES and other land use activities.

4.1. Alternative A

Main findings from the wetland assessment considered in the impact assessment are provided in Table 4-1. Particular discussions on these findings during different life stages of the proposed development follow in subsequent sections.

Table 4-1: Total wetland size within primary and secondary study area, PES totals, indirect ecosystem service scores and EIS score for Alternative A

Alternative A	Wetland 5	Wetland 6	Wetland 10
Total wetland size	24.4 ha	97.66 ha	6.04 ha
% wetland on Alternative within primary study area		13%	
Hectare Equivalents		51.69	
PES of wetlands	**C**	**E**	**D**
PES of receiving watercourses	**E**	**E**	**E**
Water Quality	Good	Poor	Moderate
Eco-Services Score (Average)	2.21	2.16	1.86
EIS (Median)		Moderate	

Construction Phase

The construction phase on Alternative A will impact directly on parts of Wetland 5, 6 and 10 (**Error! Reference source not found.**). Main anticipated impacts during the construction hase relate to direct loss in wetland habitat and functionality for Wetlands 5 and 6, as well as changes to the hydrology, water quality and sediment loads of downstream receiving wetlands. Wetland 6 retains little hydrological integrity and mainly functions as a pollution control facility at the moment.

Operational Phase

The residual hectare extent of functional wetlands associated with the primary and secondary catchment is 51.7 ha for Alternative A (Table 4-1). This is substantially less than the fractional representation of wetlands per Alternative (Table 4-1 - Table 4-3). None-the-less, the loss of wetland functions will mostly be expressed during the operational phase. It is anticipated that runoff generated by the footprint will be treated as polluted water and redirected to a pollution control facility. This containment of runoff will greatly reduce the runoff received by Wetlands 5 and 6. Existing dams on both systems already intercept relatively large amounts of the runoff. It follows that this impact is unlikely to contribute significantly to the downstream receiving systems. These dams, however, will reduce in volume and this might have implications for current abstraction activities.

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 Wetland 5, 6 and 10. Current water quality for Wetland 5 and 10 is considered good and resultant impacts related to water quality thus scored a higher severity for these two wetlands.

De-commissioning Phase

Activities that will take place during the de-commission phase have not been disclosed. It is assumed that the dry 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 disposal facility on surface water quality will rely on leachate and/or runoff quality, as well as the probability of surface water pollution.

Cumulative Impacts

Receiving watercourses linked to the Alternative A include the GrootDraai Dam. Wetland 5 and 10 drains into the same tributary as Wetland 6 (a tributary of GrootDraai Dam), which reflects a desktop PES of an E ecological category. The PES for this wetland itself retains a Medium integrity.

4.2. Alternative B

The main findings considered in the impact assessment are provided in Table 4-2.

Table 4-2: Total wetland size within primary and secondary study areas, PES totals, indirect ecosystem service scores and EIS score for Alternative B

Alternative B	Wetland 7	Wetland 8	Wetland 9	Wetland 11	Wetland 12
Total wetland size	9.83	0.76	2.57	11.8	50.9
% wetland on Alternative within primary study area			3 %		
Hectare Equivalents			52.44 (ha)		
PES of wetlands	B	C	C	C	C
PES of receiving watercourses	C	C	C	C	C
Water Quality	Good	Good	Good	Very Good	Moderate
Service Score	2.15	2.32	2.32	1.98	2.26
EIS			Medium		

Construction Phase

Alternative B will directly impact on parts of Wetland 7 and 12 and indirectly on Wetlands 8, 9, 11 and part of Wetland 6 (Figure 3-13). Of the wetlands to be impacted on, Wetland 7 is more sensitive as it yielded a B PES and even though the system does reflect some alien vegetation its main hydrological workings are preserved. The main perceived impacts during the construction phase are similar to that of Alternative A, however the extent to which wetland habitat will directly be affected is less (Table 4-2). Loss in wetland habitat, erosion and sedimentation, hydrology and water quality is also expected during the construction phase.

Operational Phase

Alternative B drains more individual catchments than alternative A, albeit smaller catchments in size. The operational activities within these catchments will result in a decrease in the PES, and wetland services of affected wetlands. Affected wetlands are mostly in a Moderately Modified state, but retain functions relating to stream flow regulation, water purification and maintenance of biodiversity.

De-commissioning Phase

It is unlikely that the post-ashing landscape will reclaim lost wetland functions. Long term impacts relate to water quality through leachate, erosion and sedimentation of ash disposal facility. It is also possible that these impacts might increase in extent and further impair receiving watercourses over the long term. This might be expressed in a further loss of services and integrity in downstream wetlands.

Cumulative Impacts

Currently Alternative B does not drain runoff from the existing ash disposal facility and the modified state of wetlands is mostly the result of agricultural activity. Similarly the two large receiving watercourses (the Leeuspruit to the west and the Blesbokspruit to the north east) retain a Moderate PES, compared to the Seriously modified PES associated with receiving watercourse of Alternative A. The capacity for the cumulative impacts on the receiving environment is thus greater for Alternative B. The number of internal catchments draining this alternative further increases the probability of contamination.

4.3. Alternative C

A summary of the main findings considered within the impact assessment for Alternative C is provided in Table 4-3.

Table 4-3: Total wetland size within primary and secondary study areas, PES totals, indirect ecosystem service scores and EIS score for Alternative C

Alternative C	**Wetland 1**	**Wetland 2**	**Wetland 3**	**Wetland 4**
Total wetland size	4.76	25.11	21.14	27.2
% wetland on Alternative within primary study area	4 %			
Hectare Equivalents	47 ha			
PES of wetlands	**C**	**C**	**C**	**D**
PES of receiving watercourses	**E**	**C**	**C**	**C**
Water Quality	Moderate	Good	Moderate	Moderate
Service Score	2.12	2.27	2.26	2.07
EIS	Medium			

Construction Phase

Construction on Alternative C will impact directly on Wetlands 3 and 4 and indirectly on Wetlands 1, 2 and 5 (Figure 3-16). During construction, this alternative poses additional impacts related to the realignment of the current power line. As with the previous two Alternatives the expected impacts remain the same and relate to a direct loss in wetland habitat, decrease in PES and ecosystem services. Receiving wetlands will experience an alteration in hydrology, possible decline in surface water quality, erosion and sedimentation.

The extent and severity of anticipated impacts are smaller compared to that of Alternative B. Due the lower PES and EIS scores associated with this alternative.

Operational Phase

Alternative C is comparable to Alternative B in the number and type of wetlands present; however, the amount of functional wetland size is the smallest for Alternative C (Table 4-3). This suggests a lower severity for impacts during the operational phase.

De-commissioning Phase

Long term hydrological impacts for downstream watercourses are less likely than possible water quality issues. An initial hydrological adjustment is expected in receiving watercourses, but this is unlikely to carry on indefinitely. Water quality impacts linked to possible leaching and ground water contamination are the main consideration during the de-commissioning phase.

Cumulative Impacts

The majority of Alternative C drains west towards the Leeuspruit, which reflects a Moderate PES, while the rest drains into the same degraded tributary as Alternative A. At the same time wetlands on alternative C retain less integrity than wetlands on Alternative B and reflect poorer surface water conditions. It follows that the extent and intensity for cumulative impacts on this Alternative falls somewhere between that of Alternative B (more sensitive) and Alternative A (less sensitive).

4.4. No-go Alternative

A comparison between the 1968 aerial image and more recent images highlights four main points: (1) all three alternatives have been subjected to agricultural transformation pre-dating the 1960’s. (2) With the exception of Wetlands 4 and 6, the majority of other wetlands adjusted to this alteration and are unlikely to further decline in PES, (3) both Wetlands 4 and 6 reflect an increase in deep flooding due to dams constructed somewhere between 1968 and 1991, (4) the current ash disposal facility has encroached and impacted on Wetland 6 and its catchment. Residual functions linked to Wetland 6 relate to its capacity to control pollution and buffer the downstream receiving environment. It follows that if the No-go Alternative applies, the majority of the wetlands will maintain a neutral trajectory. Continuous encroachment on and contamination of Wetland 6 might result in a further loss of residual wetland integrity and functionality of this system.

5. Impact Assessment

The impacts and the phases in which they will be more prominent have been noted in the previous section. The impact assessment ascertained that all three alternatives will be subjected to similar impacts. The main differences were the extent and the magnitude, as some alternatives occupy larger wetland areas, while others were considered more sensitive. Similarly, the different phases reflect different duration scores i.e. impacts experienced during the construction phase are mostly limited to the construction period, while operational impacts are likely to last for the duration of operations. The following section provides a brief summary of impacts with a Medium and High significance after mitigation. For details on the nature, extent, duration, magnitude and probability of the impacts please refer to APPENDIX G – Impact Assessment.

5.1. Alternative A

Construction Phase

Impacts on wetland vegetation and disturbance of wetland habitat scored a Medium significance before and after mitigation. The residual wetland habitat directly linked to the proposed footprint, albeit transformed, will be lost. Mitigating factors include the seasonal nature of the system, the large number of dams, the poor PES and the way in which water is received by the downslope wetlands- mostly seasonal and dependant on overland flow.

Operational Phase

A Medium impact score for hydrological impact after mitigation was calculated. Runoff associated with the extent of the footprint will be lost during the operational phase which may impact on downslope wetlands. This impact is mitigated by the large number of downstream dams, which have the approximate capacity to contain 13% of the catchment runoff. A Medium impact score for water quality after mitigation was also noted. This impact has a high probability, but the receiving environment is less sensitive as indicated by results of diatom and *in situ* water quality.

De-commissioning Phase

No impacts of Medium or High significance are anticipated during this phase.

Cumulative Impacts

As previously mentioned the greater part of the proposed footprint associated with Alternative A is drained by one catchment. Considering the PES of the existing wetlands and that of the receiving watercourse the magnitude of cumulative impacts are considered less severe for Alternative A than for the other two Alternatives.

5.1.2. Alternative B

Construction Phase

- Medium impact on hydrology post mitigation. Direct loss of recharge areas and wetlands, on average retaining a higher PES than Alternatives A and C will result in less water available for downslope wetland maintenance.
- Medium impact of surface water quality post mitigation. Surface water quality associated with Alternative B was considered Good to Very Good and was better than surface water quality measured on Alternative A and C.
- Medium erosion and sedimentation impact post mitigation. Alternative B scored the highest average slope, for its wetlands and the respective catchments. The vulnerability of this alternative to additional catchment alteration is thus higher than for the other two Alternatives.
- An impact on residual ecosystem services. Relative to the amount of wetland habitat to be disturbed, the wetlands affected by Alternative B retain more hectare equivalents than wetlands on Alternative A and C.

Operational Phase

- High impact on surface water and soil hydrology after mitigation. Alteration in the volume and timing of water received by downslope wetlands will be impacted by the proposed ash disposal facility. Alternative B drains into a number of different directions and, compared to Alternative A, has less dams. The loss of water from its catchment due to the occupation by the ash disposal facility, will negatively impact on downstream wetlands. Less water will result in a decrease of wetland extent, possible soil instability, alien/pioneer encroachment and loss in residual ecosystem services.
- Medium impact on water quality after mitigation. *In situ* and diatom results suggest that surface water quality of Alternative B wetlands is better than that of Alternative A and C. This impact can be mitigated by means of prevention by proper design and operational considerations.

De-commissioning Phase

Medium impact to water quality is anticipated for Alternative B, following the long term possibility of leachate and perched water contamination. The main reason for the increase in risk associated with this alternative, compared to Alternative C is the nature of background water qualities.

Cumulative Impacts

Alternative B scored a Medium significance for impacts of a cumulative nature. Two main watercourses (Blesbokspruit and Leeuspruit) are connected to this Alternative, both of which retain more integrity than the receiving watercourses associated with Alternative A. The subsequent likelihood and magnitude of cumulative impacts for Alternative B were deemed higher.

5.1.3. Alternative C

Construction Phase

- Medium impact on hydrology. The present hydrological state associated with wetlands on Alternative C was more impaired than that of Alternative B but less than that of Alternative A. A residual hydrological impact will remain even after mitigation has been applied, due to wetland habitat giving way to the footprint of the ash disposal facility.
- Medium impact on surface water quality after mitigation. Currently, water quality on Alternative C is considered Moderate to Good. The diatoms indicate evidence of organic pollution and nutrients, probably associated with agricultural activity. The magnitude of this impact thus scored between that of Alternative A (worse) and Alternative B (better).
- Medium impact related to erosion and sedimentation after mitigation. Average catchment and wetlands slopes were relatively high for Alternative C, with three of its wetlands scoring relatively high in the vulnerability/slope assessment (Figure 3-30).
- Medium impact on wetland vegetation and disturbance of wetland habitat. Even though Alternative C scored the lowest EIS compared to the other two Alternatives, it still provides wetland habitat and contributes to overall habitat heterogeneity.

Operational Phase

- Medium impact on hydrology for the same reasons as for Alternative B. However the magnitude scored lower due to the relatively more impaired hydrological state of Alternative C.
- Medium impact on surface water quality after mitigation. This impact was also scored similar to that of Alternative B, however receiving systems are perceived as less sensitive in terms of water quality.

De-commissioning Phase

Medium impact to water quality is anticipated for Alternative C, following the long term possibility of leachate and perched water contamination.

Cumulative Impacts

A Medium impact score, relating to a decrease in PES of downslope receiving wetlands is anticipated for Alternative C. The majority of this Alternative drains into the Leeuspruit, while a smaller portion drains into an unknown tributary of the Vaal. The former is Moderately intact, while the latter is Largely transformed. It follows that the magnitude and probability of cumulative impacts associated with Alternative C falls between that of Alternative B and A.

5.1.4. No-go Alternative

Refer to Section 4.4.

6. Mitigation and Management Measures

6.1. General Recommendations

- It is recommended that construction activity should make use of “seasonal construction window” (March to September) wherever possible.
- Minimize both the area that will be exposed and the exposure time during construction (LRRB, Mn/DOT and FHWA, 2003).
- Pollution prevention, minimisation of impacts, water reuse and reclamation and erosion control measures should be implemented according to available best practices guidelines.
- 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 building rubble, soil, litter, organic matter or chemical substances may occur within the associated wetland. 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.

6.2. Construction Phase

6.2.1. General

During the design phase, considerations should be given to environmental least cost options for the proposed activity. The strategic placement of related infrastructure and the proper design thereof will be the first course of action in impact mitigation. Before construction is initiated, a detailed construction method statement should be provided in accordance with all the applicable authorisations, for all of the proposed activities. The method statement should address the following components related to wetlands:

- 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 biophysical description of the construction site and potentially affected wetlands (vegetation cover and biotic composition etc.);
- Provide a list of the typical types of equipment that will be used for the construction activity and for the control of water if present;
- 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;
- Provide details for environmental monitoring during the construction phase. It should provide information on what environmental aspects are to be monitored (*in situ* water quality, erosion, soil and slope stability), how it should be monitored (quantitative or qualitative), at what frequency it should be monitored (daily, weekly, monthly), who is responsible for the monitoring and how to communicate and respond to information generated by the monitoring reports. This should be addressed by the wetland monitoring and rehabilitation plan.
- Provide details of appropriate responses for monitoring results. The end of the construction phase should be marked by a clean-up and rehabilitation program for all wetlands located adjacent to the construction servitudes. The extent of which should be to the periphery of the secondary study area, as indicated in this report.

6.2.2. Hydrology

- The lateral extent of wetlands should be delineated prior to construction and the temporary access roads to cross points should be designed to minimise soil compaction, thus not impeding the horizontal movement of water through the soil;
- This can be achieved through the use of coarse aggregates and pre-fabricated mat (e.g. bog / swamp mats). An input from an engineer is recommended.
- 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.

6.2.3. Water Quality

- No dumping of any building rubble, soil, litter, organic matter or chemical substances should occur within watercourses. Dumping and temporary storage of the above should only occur at predetermined locations;
- Construction workers should not use watercourses for sanitation purposes;
- In the case of dewatering of a construction site, water should be treated and all suspended particles should be removed. Water removed from a construction site should not be released directly into a watercourse. The discharge should occur onto a well vegetated area, which will help trap sediment and residual contaminants; and
- Construction equipment should not be serviced or refuelled near watercourses.

6.2.4. Erosion and Sedimentation Impacts

- Erosion and silt control mechanisms must be in place prior to the onset of construction within any watercourse. This includes the elimination of surface flow through the construction site. Silt fences or hay bales need to be placed near the base of a slope in order to limit the amount of silt entering the watercourse;
- Similarly, the erection of silt barriers along all of the drainage lines must be undertaken to curb any sediment and silt run-off in the preparation activities of the ash disposal facility. Ideally, the amount of land that will be disturbed should be kept to an absolute minimal;
- Non-erodible materials should be used for the construction of any berms, coffer dams or any other isolation structures to be used within a flowing watercourse;
- Spoil piles should be placed above the high water mark in distinct piles and adequate erosion measures need to be implemented in order to minimise and reduce erosion and siltation into the watercourse from spoil piles;

- It is also recommended that construction activities should make use of the dry seasonal construction window where possible. This will further reduce the risk associated with erosion / siltation; and
- Erosion control measures should be inspected regularly during the course of construction and necessary repairs need to be carried out if any damage has occurred.

6.3. Operational Phase

6.3.1. General

General recommendations applicable to operational activities include the environmental education and awareness associated with the importance and value of wetlands, and wetland monitoring:

- All employees should be educated regarding environmental risks and proper cause of action should such risks be presented during day to day activities; and
- A wetland monitoring plan should be implemented for all operational activities possibly impacting on wetland systems. The monitoring plan should provide details on strategic test- and control sites, uniform and repeatable sampling efforts, response metrics to be used, data processing and dissemination of monitoring results.

6.3.2. Hydrology

The hydrological functions associated with wetlands that fall within the footprint of the preferred alternative will be lost. In most instances this impact was not considered of High significance, due to the location of the alternatives and the transformed state of wetlands within them.

6.3.3. Water Quality

- Isolate contaminated water. Any water with a chemical signature different to that of the receiving aquatic environment should be considered contaminated and should be isolated. Ashing processes and activities should make a clear distinction between clean and contaminated water and systems to deal with both should be in place;
- Follow available best practice guidelines;
- Threshold criteria for water quality should not just consider potable standards. Background concentrations of TDS, in particular, should be considered. It is pertinent

that receiving surface systems do not incur TDS variations greater than 15 % of that of background concentrations;

6.3.4. Erosion and Sedimentation Impacts

- Routine monitoring of turbidity in receiving watercourses should not yield values greater than background values;
- Wetland buffer zones should be pre-determined and placed on all of the drainage lines associated with the proposed mining development;
- Place access roads and associated infrastructure on natural topography and avoid side hill cuts and grades. Roads should be designed with natural reclamation in mind; and
- Design runoff control features to minimize soil erosion and avoid placement of infrastructure and sites on unstable slopes and consider conditions that can cause slope instability, such as groundwater aquifers, precipitation and slope angles.

6.4. De-commissioning Phase

A detailed activity description for de-commissioning phase should be provided prior to the onset of de-commissioning. Highlighted risks after decommissioning mainly relate to long term leachate and surface water contamination. This impact will be mitigated by procedures already in place during the operational phase. Lining of the ash disposal facility will be one of the main recommendations for curtailing long term, chronic impacts of this nature.

7. Site Preference Ranking

The wetland assessment ascertained Alternative A as the preferred Alternative (Table 7-1; Table 7-2). In addition to the main selection criteria provided in Table 7-1, other factors considered include the following:

- Soils- nearly the entire study area consisted of Vertic soils, which is preferred over deeper sandy soils, where soil water retention is greater.
- The number and size of catchments drained by the proposed Alternative. The greater the number of catchments the more difficult it becomes to control possible contamination.
- Average slope of catchment and wetland units. This relates to the vulnerability of wetlands to erosion due to catchment transformation.
- The area of functional wetland retained as expressed by hectare equivalents.
- Overall quality of water where it was expressed on the surface.

Table 7-1: Aquatic specialist criteria for site preference ratings

Site preference Rating	Criteria
Preferred (4)	Main wetland/s is Largely to Seriously modified from reference conditions. They reflect serious hydrological alteration and limited or no downslope wetland maintenance.
Acceptable (3)	Most of the wetlands are at least Moderately modified, with clear evidence of persistent alteration in their catchment, limited hydrological maintenance (or impaired contribution) to downslope wetlands.
Not Preferred (2)	Wetland/s on site or downslope wetlands retains a Largely Natural PES and a Moderate EIS.
No-Go (1)	Wetland/s on site or downslope connected wetlands retains a Natural or Largely Natural PES and a High EIS.

Table 7-2: Final Site Ranking Matrix

Study	Alternative A	Alterative B	Alternative C
Aquatic Ecology	4	2	3

8. Conclusion

The wetland assessment ascertained that most wetlands within the primary and secondary study area are in a Modified state. The wetland study contributions to the screening and scoping assessment assisted in the selection of the current Alternatives assessed, in which large drainage lines and areas reflected a greater probability of wetness and were avoided as far as possible. This assessment complimented the screening and scoping assessment in that the selection criteria further minimises perceived impacts on wetlands. Similarly, general and more specific mitigation measures are provided for most anticipated impacts. The most significant impacts from a wetland perspective are considered to be the loss of wetland habitat that falls within the footprints of the proposed ash disposal facility and the risk of water quality deterioration due to seepage and leakage of pollutants from the facility.

All reasonable Alternatives have been assessed and it is unlikely that these impacts will be expressed with less significance anywhere else in the direct landscape than at Alternative A. However, some residual impact will persist if Alternative A is selected which may be further mitigated by avoiding as much wetland habitat as is reasonably possible. A possible consideration might be to combine parts of Alternative A and C. It is however, recommended that ashing footprint be kept within the catchment of wetlands 6 and 10.

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10. APPENDIX A - *In situ* Water Quality

Table 10-1: Water quality values obtained at sites associated with Alternative A during the March 2013 field survey

Sites	**HGM unit**	**pH** (H^1+ ions)	**EC** (µS-cm^{-1})	**TDS** (ppm)	**Temp** °C
WQ7		7.18	157.8	111.0	17.2
WQ8		🟫 9.52	🟫 **10680**	7.62*	30.1
WQ9		7.39	🟫 **2310**	1.63*	31.8
WQ10		🟧 **8.8**	🟫 **6930**	5.02*	27.0
WQ11		🟧 **8.82**	🟫 **1689**	1.19*	29.3
WQ12		7.84	78.2	55.7	31.1
WQ13		7.79	🟫 **1509**	1.007*	31.6

🟧 Tolerable

🟫 Intolerable

* = ppt

Table 10-2: Water quality values obtained at sites associated with Alternative B during the March 2013 field survey

Sites	**HGM unit**	**pH** (H^1+ ions)	**EC** (µS-cm^{-1})	**TDS** (ppm)	**Temp** °C
WQ1		7.35	121.7	85.8	21.4
WQ2		7.97	130.1	92.1	24.3
WQ3		7.70	337.0	237.0	24.2
WQ4		7.55	91.7	65.3	24.8
WQ5		7.79	113.1	80.1	25.3
WQ6		7.62	433	306.0	27.6
WQ21		7.09	182.3	130.0	26.2
WQ22		🟧 **8.94**	139.9	99.3	27.2

🟧 Tolerable

🟫 Intolerable

Table 10-3: Water quality values obtained at sites associated with Alternative C during the March 2013 field survey

Sites	**HGM unit**	**pH** (H^1+ ions)	**EC** (µS-cm^{-1})	**TDS** (ppm)	**Temp** °C
WQ14		🟧 8.53	300.0	211.0	25.8
WQ15		7.67	153.3	109.0	25.0
WQ16		🟫 9.69	🟧 **511.0**	365.0	25.8
WQ17		6.76	197.9	141.0	24.8
WQ18		6.86	113.2	78.9	29.8
WQ19		6.82	78.9	55.2	27.9
WQ20		6.28	214.0	153.0	22.1

🟧 Tolerable

🟫 Intolerable

11. APPENDIX B - Diatom Species Sampled

11.1. Alternative A

Species belonging to 24 genera were recorded for Alternative A (Table 11-4). The diatom assemblages comprised of pollution tolerant species, which included species from the genera *Navicula*, *Sellaphora*, *Eolimna*, *Gomphonema*, *Amphora*, *Nitzschia*, *Mastogloia* and *Epithemia* (Table 11-1; Table 11-4). The diatoms have a preference or tolerance for the following ambient conditions (Table 11-1):

- circumneutral (WQ7, WQ12) and alkaline pH (WQ10, WQ11);
- fresh-brackish (WQ7, WQ12), brackish-fresh (WQ10) and brackish salinity (WQ11); and
- oligotrophic (WQ12) and eutrophic nutrient content (WQ7, WQ10, WQ11).

The %PTV scores of WQ7 and WQ11 were above 20 %, indicating some evidence of organic pollution. However, the sub-dominance of the genus *Eunotia* at WQ7 indicate that the ambient ecological conditions were better at this site compared to other sites in Alternative A, since *Eunotia* species are usually found in nutrient and electrolyte poor conditions (Van Dam *et al*., 1994; Taylor *et al*., 2007). The small motile *Navicula absoluta*, *Sellaphora seminulum* and *Eolimna minima* may point to sediment inputs to WQ7. The sub-dominance of *Pinnularia subcapitata* at WQ12 is an indication that the nutrient and electrolyte content at WQ12 was not as high as the brackish conditions found at WQ10 and WQ11 (Table 11-1). The diatom assemblages therefore indicate that the ecological conditions found at WQ10 and WQ11 were more impacted compared to WQ7 and WQ12.

Table 11-1: **Dominant diatoms found and their ecological preferences or tolerances for sites in Alternative A (Van Dam *et al.*, 1994; Taylor *et al.*, 2007)**

		pH	**Nutrients**			**Electrolyte Content**				
Site	**Dominant Taxa (descending order)**	**Alkaline**	**Oligo-trophic**	**Meso-trophic**	**Eutrophic**	**Poor**	**Moderate**	**High**	**Brackish**	**Saline**
WQ7	*Navicula absoluta*									
	Sellaphora seminulum #				X			X		
	Eolimna minima #									
	Eunotia sp.		X			X				
	Gomphonema lagenula									
WQ10	*Navicula erifuga*				X			X	X	
	Amphora veneta							X		
	Navicula symmetrica				X			X		
	Navicula veneta				X			X	X	
	Navicymbula pusilla		X	X	X		X	X		
WQ11	*Mastogloia smithii*						X	X	X	
	Epithemia adnata						X	X	X	
	Navicula veneta				X			X	X	
	Nitzschia microcephala							X		
	Nitzschia spp.									
	Nitzschia frustulum							X	X	
	Pleurosigma elongatum								X	
	Planothidium engelbrechtii							X		X
WQ12	*Gomphonema lagenula*									
	Pinnularia subcapitata		X			X				
	Nitzschia spp.									
	Navicula absoluta									

Found in a range of waters, including conditions listed in table.

11.2. Alternative B

A total of 21 diatom genera were recorded at WQ1, WQ5, WQ6 and WQ22, with the dominant taxa belonging to the genera *Gomphonema*, *Eunotia*, *Achnanthidium*, *Nitzschia*, *Navicula*, *Fragilaria* and *Thalassiosira* (Table 11-2; Table 11-4). The diatom assemblages comprised of species characteristic of waters with:

- acidic (WQ5), circumneutral (WQ1, WQ22), alkaline (WQ6) pH;
- fresh-brackish electrolyte content; and
- oligo- to eutrophic (WQ5) and eutrophic (WQ1, WQ6, WQ22) nutrient content (Table 11-2).

The %PTV score of WQ1 indicated that this site was heavily impacted by organic pollution (Table 11-4). *Gomphonema parvulum* was the pre-dominant diatom species at this site and is known to occur in a range of waters and is considered tolerant of extremely polluted conditions. *Gomphonema parvulum* has been reported to be associated with waters of relatively high conductivity (Potapova & Charles, 2003), and waters with high organic pollution (Salomoni *et al*., 2006) and low DO (Potapova & Charles, 2003). The dominance of *Gomphonema* spp. at WQ1 may point to increased sediment and nutrient inputs.

The high abundance of *Eunotia bilunaris*, a species that prefers acidic waters with low electrolyte content (Taylor *et al*., 2007), at WQ5 indicates that the water at WQ5 was of a good quality. The sub-dominance of *Gomphonema parvulum* may point to nutrient inputs to the system.

The dominance of *Achnanthidium* spp. at WQ6 and *Gomphonema angustatum* at WQ22 (Table 11-2; Table 11-4) indicate that the water of WQ6 and WQ22 was of a slightly better quality than WQ1 with regards to electrolyte and nutrient content. *Achnanthidium* is frequently found in clean waters with low nutrient levels (Taylor *et al*., 2007). However, the sensitive *Achnanthidium minutissimum*, for example, has also been found in nutrient rich waters, with higher pH (Round, 1993), thus suggesting that the genus *Achnanthidium* has a wide tolerance range. It is therefore important to be aware of the discrepancies surrounding this genus when inferring water quality based on diatom assemblages, particularly in impacted areas. *Gomphonema angustatum* is common in oligotrophic waters and found over a range of pH and electrolyte concentrations, including Ca rich waters (Taylor *et al*., 2007). The diatom assemblages indicate that WQ5 was in the best ecological state followed by (descending order) WQ6, WQ22 and WQ1.

Table 11-2: **Dominant diatoms found and their ecological preferences or tolerances for sites in Alternative B (Van Dam *et al*., 1994; Taylor *et al*., 2007)**

		pH	Nutrients			Electrolyte Content				
Site	**Dominant Taxa (descending order)**	**Alkaline**	**Oligo-trophic**	**Meso-trophic**	**Eutrophic**	**Poor**	**Moderate**	**High**	**Brackish**	**Saline**
WQ1	*Gomphonema parvulum* #									
	Gomphonema spp.									
	Gomphonema pseudoaugur			X	X					
WQ5	*Eunotia bilunaris*	Acidic				X				
	Gomphonema parvulum #									
	Gomphonema spp.									
	Eunotia sp.					X				
WQ6	*Achnanthidium* spp. #									
	Nitzschia filiformis						X	X	X	
	Navicula capitatoradiata				X			X	X	
	Thalassiosira pseudonana									
	Fragilaria capucina var. *vaucheriae* #									
WQ22	*Gomphonema angustatum* #		X							
	Gomphonema spp.									
	Gomphonema parvulum #									
	Fragilaria tenera			X	X					
	Gomphonema gracile							X		

Found in a range of waters, including conditions listed in table.

11.3. Alternative C

Species belonging to 10 genera were recorded at WQ18 and WQ19, of which species from the genera *Gomphonema*, *Nitzschia*, *Navicula* and *Diadesmis* occurred in higher abundances (Table 11-3; Table 11-4). The diatom species recorded are characteristic of the following ambient conditions:

- circumneutral pH (pH values about 7);
- fresh-brackish electrolyte content; and
- mesotrophic (WQ19) and eutrophic nutrient content (Table 11-3).

Table 11-3: **Dominant diatoms found and their ecological preferences or tolerances for sites in Alternative C (Van Dam *et al.*, 1994; Taylor *et al.*, 2007)**

		pH	Nutrients			Electrolyte Content				
Site	**Dominant Taxa (descending order)**	**Alkaline**	**Oligo-trophic**	**Meso-trophic**	**Eutrophic**	**Poor**	**Moderate**	**High**	**Brackish**	**Saline**
WQ18	*Gomphonema parvulum* #									
	Gomphonema lagenula									
	Nitzschia palea				X					
	Gomphonema spp.									
	Nitzschia spp.									
WQ19	*Navicula absoluta*									
	Nitzschia palea				X					
	Gomphonema lagenula									
	Gomphonema parvulum #									
	Diadesmis confervacea #				X			X		

Found in a range of waters, including conditions listed in table.

The %PTV scores of WQ18 and WQ19 are indicative of moderate and slight organic pollution respectively (Table 11-4). The dominant taxa found at WQ18 and WQ19 may also point to sediment inputs to these systems (Table 11-3; Table 11-4).

Table 11-4: Diatom species, abundances and %PTV scores of samples collected during the March 2013 field survey

Taxa	Alternative A				Alternative B				Alternative C	
	WQ7	WQ10	WQ11	WQ12	WQ1	WQ5	WQ6	WQ22	WQ18	WQ19
Achnanthidium spp.	0	0	0	0	0	0	169	0	0	0
Aulacoseira granulata var. *angustissima* (O.M.) Simonsen	0	0	0	0	0	0	9	0	0	0
Aulacoseira granulata (Ehrenberg) Simonsen	0	0	0	0	0	0	13	0	0	0
Amphora veneta Kützing	0	69	1	0	0	0	0	0	0	0
Craticula ambigua (Ehrenberg) Mann	0	0	0	0	0	0	0	1	0	0
Caloneis bacillum (Grunow) Cleve	0	0	0	0	0	0	0	4	0	0
Cyclostephanos dubius (Fricke) Round	0	0	0	0	0	0	9	0	0	0
Craticula halophila (Grunow in Van Heurck) Mann	0	0	0	0	0	0	0	0	2	0
Cyclotella meneghiniana Kützing	0	11	3	0	0	0	0	2	0	0
Craticula spp.	0	0	0	1	0	0	1	0	4	2
Diadesmis confervacea Kützing	0	0	0	1	1	0	0	19	0	20
Diadesmis contenta (Grunow in Van Heurck) Mann	0	0	0	2	0	0	0	0	0	0
Epithemia adnata (Kützing) Brébisson	0	0	45	0	0	0	0	0	0	0
Eunotia bilunaris (Ehrenberg) Mills	8	0	0	0	0	217	0	0	0	7
Encyonema minutum (Hilse in Rabenhorst) D.G. Mann	0	0	0	0	1	0	8	8	0	0
Eolimna minima (Grunow) Lange-Bertalot	63	0	0	0	1	0	0	0	0	0
Eunotia rhomboidea Hustedt	0	0	0	0	0	1	0	0	0	0
Eolimna subminuscula (Manguin) Moser, Lange-Bertalot & Metzeltin	2	0	0	0	2	0	4	0	0	0
Eunotia sp.	49	0	0	0	0	39	0	0	0	1
Fragilaria capucina var. *vaucheriae* (Kützing) Lange-Bertalot	0	0	0	0	0	0	24	0	0	0
Fragilaria tenera (W. Smith) Lange-Bertalot	0	0	0	0	0	1	0	23	0	0
Fallacia tenera (Hustedt) Mann in Round	0	0	2	0	0	0	0	0	0	0
Gomphonema affine Kützing	1	0	0	0	0	0	0	0	0	0

Taxa	**Alternative A**				**Alternative B**				**Alternative C**	
	WQ7	**WQ10**	**WQ11**	**WQ12**	**WQ1**	**WQ5**	**WQ6**	**WQ22**	**WQ18**	**WQ19**
Gomphonema angustatum (Kützing) Rabenhorst	0	0	0	0	0	0	0	182	0	2
Gomphonema auritum A. Braun in Kützing	0	0	0	0	0	0	0	14	0	0
Gomphonema exilissimum (Grunow) Lange-Bertalot & Reichardt	1	0	0	0	0	2	0	1	0	0
Gomphonema gracile Ehrenberg	3	0	0	8	7	10	0	21	14	0
Gomphonema insigne Gregory	4	0	0	0	0	0	0	0	2	1
Gomphonema lagenula Kützing	37	0	0	259	19	0	0	0	97	25
Gomphonema minutum (Agardh) Agardh	0	0	0	0	0	0	0	12	0	0
Gomphonema spp.	19	0	0	7	26	47	0	50	39	3
Gomphonema parvulum (Kützing) Kützing	19	0	0	16	287	64	4	38	130	24
Gomphonema pumilum var. *rigidum* Reichardt & Lange-Bertalot	0	0	0	0	0	1	0	0	0	0
Gomphonema pseudoaugur Lange-Bertalot	0	0	0	3	23	1	1	1	3	0
Gomphonema subclavatum Grunow	0	0	0	0	0	0	0	1	0	0
Gyrosigma sp.	0	0	1	0	0	0	0	0	0	0
Hantzschia amphioxys (Ehrenberg) Grunow in Cleve & Grunow	1	0	0	0	0	0	0	0	0	0
Hippodonta capitata (Ehrenberg) Lange-Bertalot, Metzeltin & Witkowski	0	0	0	0	0	0	1	0	0	0
Lemnicola hungarica (Grunow) Round & Basson	0	0	0	0	0	0	0	1	0	0
Luticola mutica (Kützing) D.G. Mann	0	0	0	0	0	1	0	0	1	0
Mayamaea atomus (Kützing) Lange-Bertalot	1	0	0	0	0	0	0	0	0	0
Mastogloia smithii Thwaites	0	0	71	0	0	0	0	0	0	0
Navicula absoluta Hustedt	93	0	20	22	0	0	0	4	11	234
Nitzschia agnita Hustedt	0	0	0	0	0	0	0	0	1	0
Nitzschia aurariae Cholnoky	0	4	0	0	0	0	0	0	0	0
Navicula spp.	1	1	9	0	0	0	1	0	0	0
Nitzschia clausii Hantzsch	1	0	0	0	0	0	0	0	1	0
Nitzschia capitellata Hustedt in A. Schmidt et al.	0	0	0	3	0	0	0	0	0	0

Taxa	**Alternative A**				**Alternative B**				**Alternative C**	
	WQ7	**WQ10**	**WQ11**	**WQ12**	**WQ1**	**WQ5**	**WQ6**	**WQ22**	**WQ18**	**WQ19**
Navicula capitatoradiata Germain	0	0	0	0	0	0	36	0	0	0
Navicymbula pusilla Krammer	0	36	9	1	0	0	0	0	0	0
Navicula cryptocephala Kützing	0	2	2	1	0	0	3	0	0	0
Navicula cryptotenella Lange-Bertalot	0	2	0	0	0	0	2	0	0	0
Nitzschia desertorum Hustedt	0	0	1	0	0	0	0	0	0	0
Navicula erifuga Lange-Bertalot	0	125	4	0	0	0	0	0	0	0
Nitzschia filiformis (W.M. Smith) Van Heurck	0	0	0	0	0	0	40	0	0	0
Nitzschia fonticola Grunow in Cleve & Möller	0	0	0	0	0	0	2	0	0	0
Navicula gibbosa Hustedt	0	0	0	0	18	0	0	0	0	0
Nitzschia frustulum (Kützing) Grunow	0	18	35	0	0	0	0	0	0	0
Nitzschia spp.	3	10	36	30	0	1	4	0	37	10
Nitzschia linearis var. *subtilis* (Grunow) Hustedt	0	0	0	2	0	0	0	0	0	0
Navicula microcari Lange-Bertalot	0	0	3	0	0	0	2	0	0	0
Nitzschia microcephala Grunow in Cleve & Möller	0	1	38	0	0	0	0	0	0	0
Nitzschia obtusa var. *kurzii* (Rabenhorst) Grunow	0	0	4	0	0	0	0	0	0	0
Nitzschia palea (Kützing) W. Smith	2	17	5	0	0	0	12	1	49	59
Navicula rostellata Kützing	0	0	0	0	0	0	3	0	0	0
Nitzschia sigma (Kützing) W.M. Smith	0	0	0	0	0	0	0	2	0	0
Navicula small species	0	0	0	0	0	0	2	0	0	0
Navicula symmetrica Patrick	0	65	0	0	0	0	5	8	0	0
Navicula veneta Kützing	0	45	41	1	0	0	8	0	0	0
Pleurosigma elongatum W. Smith	0	0	34	0	0	0	0	0	0	0
Pinnularia gibba Ehrenberg	0	0	0	0	1	0	0	0	0	0
Pinnularia sp.	0	0	0	2	0	1	0	0	0	0

Taxa	Alternative A				Alternative B				Alternative C	
	WQ7	**WQ10**	**WQ11**	**WQ12**	**WQ1**	**WQ5**	**WQ6**	**WQ22**	**WQ18**	**WQ19**
Planothidium engelbrechtii (Cholnoky) Round & Bukhtiyarova	0	0	22	0	0	0	6	0	0	0
Planothidium rostratum (Oestrup) Lange-Bertalot	0	0	0	0	0	0	0	0	1	0
Pinnularia subbrevistriata Krammer	5	0	0	0	0	0	0	1	0	0
Pinnularia subcapitata Gregory	16	0	0	41	5	14	0	6	8	15
Rhopalodia operculata (Agardh) Håkansson	0	0	4	0	0	0	0	0	0	0
Stauroneis phoenicenteron (Nitzsch) Ehrenberg	1	0	0	0	0	0	0	0	0	0
Sellaphora pupula (Kützing) Mereschkowksy	0	0	0	0	9	0	0	0	0	0
Sellaphora seminulum (Grunow) D.G. Mann	69	0	0	0	0	0	0	0	0	4
Stauroneis anceps Ehrenberg	1	0	0	0	0	0	0	0	0	0
Tryblionella apiculata Gregory	0	0	2	0	0	0	0	0	0	0
Tabularia fasciculata (Agardh) Williams & Round	0	0	3	0	0	0	0	0	0	0
Tryblionella hungarica (Grunow) D.G. Mann	0	0	3	0	0	0	0	0	0	0
Thalassiosira pseudonana Hasle & Heimdal	0	0	0	0	0	0	32	0	0	0
Tryblionella sp.	0	0	2	0	0	0	0	0	0	0
%PTV	**39.3**	9.9	21.0	5.5	**72.8**	16.0	16.0	15.0	45.3	26.3

🟦 Dominant species

12. APPENDIX C – Vegetation Lists

Table 12-1: Vegetation species identified at Wetlands 5 and 6 with wetland vegetation highlighted

Species	Common Name	Wetland 5	Wetland 6
Asclepias sp			X
Bidens formosa	Cosmos		X
Bidens pilosa	Black jack		X
Cirsium vulgare	Scotch thistle	X	X
Conyza sp			X
Cynodon dactylon	Couch Grass		X
Cyperus congestus		X	X
Cyperus esculentus	Yellow nut sedge		X
Cyperus sp		X	X
Datura stramonium	Thorn apple		X
Eleocharis acutangula			X
Eragrostis curvula	Weeping love grass	X	X
Eragrostis sp.			X
Helichrysum sp.			X
Juncus effusus	Rushes		X
Juncus sp			X
Kyllinga erecta	White Sedge		X
Leersia hexandra	Rice grass		X
Osteospermum muricatum			X
Panicum schinzii	Sweet grass	X	X
Paspalum dilatatum	Dallis grass	X	X
Paspalum notatum	Bahia grass	X	X
Persicaria lapathifolia	Spotted knot weed		X
Phragmites australis	Common reed		X
Schkuhria pinnate	Dwarf Marigold		X
Schoenoplectus brachyceras	Water reed		X
Schoenoplectus corymbosus		X	
Schoenoplectus paludicola		X	
Schoenoplectus sp.			X
Senecio inornatus			X
Setaria pallide-fusca	Garden Bristle Grass	X	X
Setaria sp.			X
Stoebe vulgaris	Bankrupt bush		X
Tagetes minuta	Khaki Weed		X
Themeda triandra	Red grass		X
Typha capensis	Bullrush		X
Verbena bonariensis	Wild Verbena		X
Veronia sutherlandii			X

🟦	Obligate Wetland Species
🟧	Facultative Wetland Species
🟫	Facultative/Opportunist Wetland Species
🟥	Exotic / weed

Table 12-2: Vegetation species identified at Wetland 10 with wetland vegetation highlighted

Species	**Common Name**	Wetland 10
Asclepias sp		X
Berkheya zeyheri		X
Bidens pilosa	Black jack	X
Cirsium vulgare	Scotch thistle	X
Cynodon dactylon	Couch Grass	X
Cyperus congestus		X
Cyperus esculentis	Yellow Nutsedge	X
Eleocharis acutangula		X
Eragrostis sp.		X
Hibiscus trionum	Bladder weed	X
Hyparrhenia hirta	Common thatching grass	X
Juncus effusus	Rushes	X
Lagarosiphon muscoides	Fine oxygen weed	X
Leersia hexandra	Rice grass	X
Oxalis obliquifolia	Sorrel	X
Paspalum notatum	Bahia grass	X
Paspalum dilatatum	Dallis grass	X
Tagetes minuta	Khaki Weed	X
Schkuhria pinnate	Dwarf Marigold	X
Setaria sp.		X
Schoenoplectus corymbosus		X
Tagetes minuta		X
Themeda triandra	Red grass	X
Typha capensis	Bullrush	X
Verbena bonariensis	Wild Verbena	X

🟦 Obligate Wetland Species
🟧 Facultative Wetland Species
🟫 Facultative/Opportunist Wetland Species
🟥 Exotic / weed

Table 12-3: Vegetation species identified at Wetlands 7 and 12 with wetland vegetation highlighted

Species	Common Name	Wetland 7	Wetland 12
Berkheya insignis			X
Bidens pilosa	Black jack	X	X
Cirsium vulgare	Scotch thistle	X	X
Conyza sp			X
Cynodon dactylon	Couch Grass	X	
Cyperus esculentis	Yellow Nutsedge	X	X
Eragrostis sp.		X	X
Helichrysum sp.			X
Panicum schinzii	Sweet grass	X	
Paspalum dilatatum	Dallis grass		X
Persicaria lapathifolia	Spotted knot wee	X	X
Salix babylonica	Weeping willow		X
Schoenoplectus paludicola		X	
Schoenoplectus spp.	Water reed	X	X
Senecio inornatus			X
Setaria pallide-fusca	Garden Bristle Grass	X	X
Setaria sp.		X	X
Taraxacum officianale	Common dandelion		X
Themeda triandra	Red grass	X	
Typha capensis	Bullrush	X	
Verbena bonariensis	Wild Verbena		X

🟦 Obligate Wetland Species
🟫 Facultative/Opportunist Wetland Species
🟥 Exotic / weed

Table 12-4: Vegetation species identified at Wetlands 3 and 4 with wetland vegetation highlighted

Species	Common Name	Wetland 3	Wetland4
Berkheya insignis		X	
Bidens formosa	Cosmos	X	
Carex glomerabilis			X
Cirsium vulgare	Scotch thistle	X	X
Conyza sp		X	
Crepis hypochoeridea.		X	
Cynodon dactylon	Couch Grass		X
Cyperus congestus		X	
Cyperus esculentis	Yellow Nut Sedge	X	X
Eragrostis gummiflua	Gum Grass		X
Eragrostis sp.		X	X
Juncus effusus	Rushes		
Juncus sp.		X	X
Kyllinga erecta	White Sedge	X	X
Leersia hexandra	Rice grass	X	
Panicum schinzii	Sweet grass	X	
Panicum sp.		X	
Paspalum dilatatum	Dallis grass	X	X
Paspalum notatum	Bahia grass	X	X
Persicaria lapathifolia	Spotted knot wee	X	X
Schkuhria pinnate	Dwarf Marigold	X	X
Schoenoplectus spp.	Water reed	X	
Setaria pallide-fusca	Garden Bristle Grass	X	X
Solanum elaeagnifolium	Silver leaf bitter apple	X	
Tagetes minuta	Khaki Weed		X
Themeda triandra	Red grass	X	
Typha capensis	Bullrush		X
Verbena bonariensis	Wild Verbena	X	X

🟦	Obligate Wetland Species
🟧	Facultative Wetland Species
🟫	Facultative/Opportunist Wetland Species
🟥	Exotic / weed

13. APPENDIX D - Site Photos

Figure 13-1: Wetland 5 situated within Alternative A showing (A) a panoramic view of the area, (B-C) wetter areas dominated by *Imperata cylindrica*, cattle grazing activities within the wetland resulting in (D) trampling of vegetation and (E) organic input.

Figure 13-2: Site Wetland 6 upstream of the Ash Disposal Facility within Alternative A showing (A) panoramic view of the area, (B-E) extensive trenching and (F-G) clearing activities.

Figure 13-3: Wetland 6 upstream of the Ash Disposal Facility (continued) within Alternative A showing (A) clearing activities, (B) unconsolidated soil, (C-D) stockpiled soil, (E) erosion, (F-G) small dam formations and (H) dust blowing of the Ash Disposal Facility.

Figure 13-4: Wetland 6 downstream of the Ash Disposal Facility showing (A) the Ash facility cutting through the wetland system, (B) dry channel, (C) soil berm, (D-E) dirt road and associated gabion structures, (F) pipeline and (G) another dirt road located in the lower reaches.

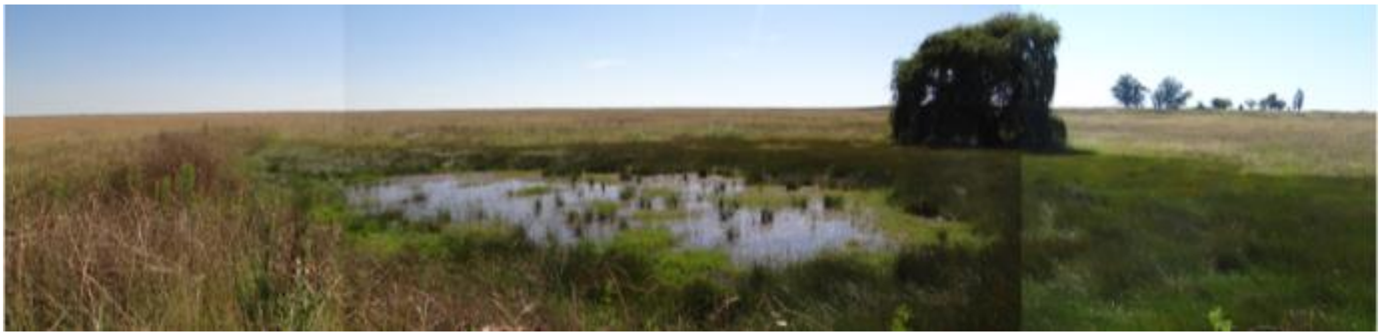

Figure 13-5: A small dam constructed on Wetland 6, east of the existing ash disposal facility

Figure 13-6: Small seeps located in the southern portion of Wetland 10.

Figure 13-7: Wetland 10 (A) located south east of Ash Disposal Facility within Alternative A showing (B) a road crossing the system, (C) with a small flume, (D) fence, (E) broken dam wall in the upper reaches, (F) small patches of exotic woody component, (G-H) and a trench surrounding the Ash Disposal Facility cutting through Wetland 10.

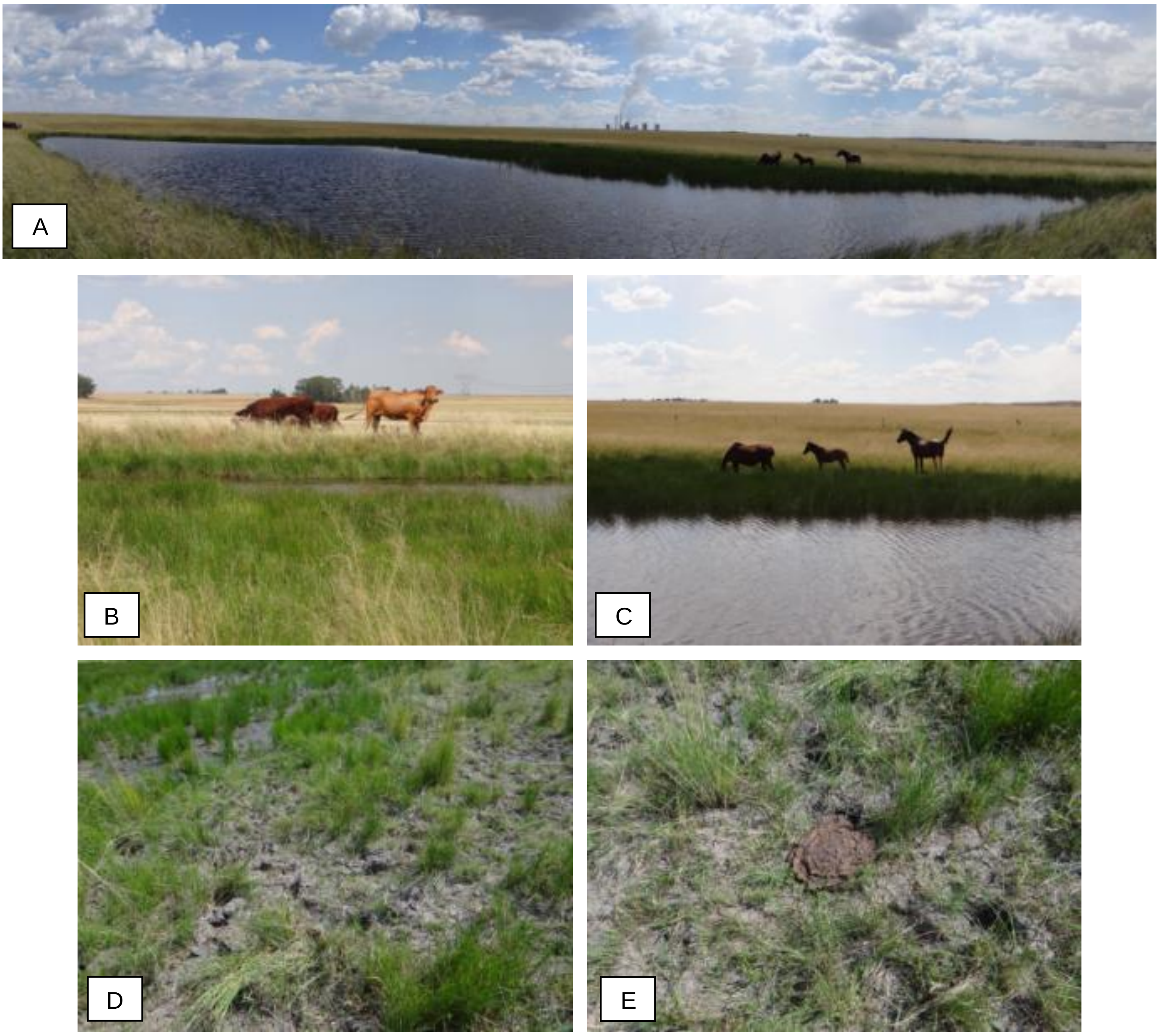

Figure 13-8: A small dam constructed in Wetland 6 situated within Alternative A showing (A) a panoramic view of the area, (B) cattle and (C) horses grazing within the wetland resulting in (D) trampling of vegetation and (E) organic input.

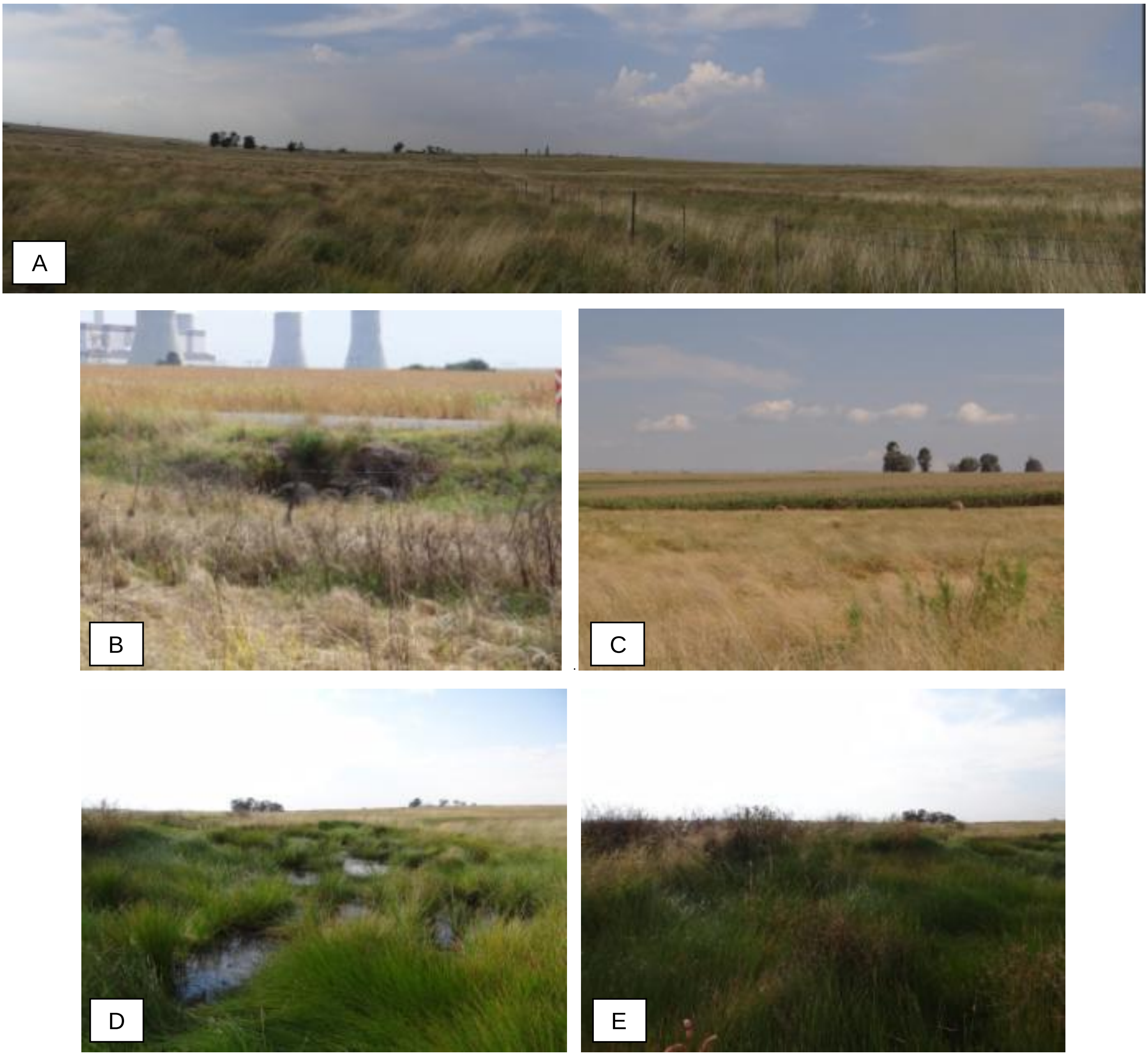

Figure 13-9: Wetland 7 located in Alternative B showing (A) a panoramic view of the area, (B) upstream road crossing, (C) agricultural activities and (D-E) a small dam present.

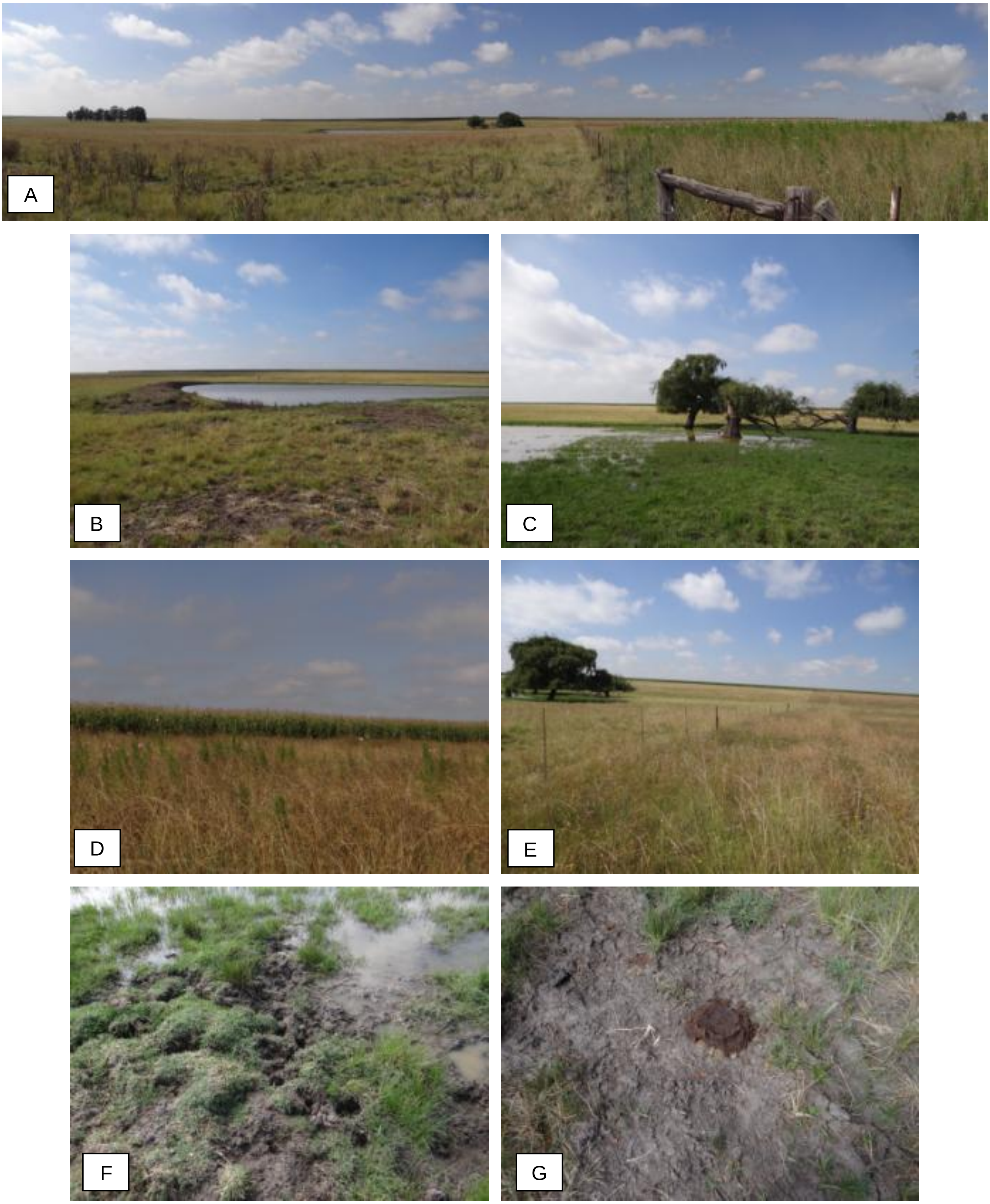

Figure 13-10: Wetland 12 situated within Alternative B showing (A) a panoramic view of the area, (B) dam constructed on the wetland, (C) small exotic woody component, (D) agricultural activities, (E) fences crossing the system, cattle grazing activities within the wetland resulting in (D) trampling of vegetation and (E) organic input.

Figure 13-11: Wetland 3 situated within Alternative C showing (A) a panoramic view of the area with two small dams present in the lower reaches, (B) agricultural activities, (C) cattle grazing resulting in (D) the trampling of vegetation and (E) organic input.

Figure 13-12: Wetland 4 situated within Alternative C showing (A) a panoramic view of the area (B) with a tar road crossing the system, (C) concrete flumes, (D) a small dry dam and (E) vegetation trampling and organic input due to cattle grazing activities.

14. APPENDIX E – Ecological Importance and Sensitivity

Table 14-1: Table reflecting the EIS assessment scores and confidence ratings for Alternative A

Determinant	Score	Confidence	Reason
PRIMARY DETERMINANTS			
1. Rare and endangered species	2	3	Protected species recorded.
2. Populations of unique species	2	2	Moderately suitable habitat for high floristic diversity.
3. Species / taxon richness	3	3	Moderately suitable habitat for high floristic diversity.
4. Diversity of habitat types or features	3	3	Largest extent of remaining natural habitat.
5. Migration/breeding and feeding site for wetland species	2	2	Interactive habitat types suitable for conservation important species. More dams provide feeding and habitat for migratory birds.
6. Sensitivity to changes in natural hydrological regime	1	3	Wetlands on site retail little ecological integrity, upslope catchment have been altered substantially.
7. Sensitivity to water quality changes	1	3	Poor water quality on site.
8. Flood storage, energy dissipation and particulate/element removal	3	3	Large numbers of dams increase the likelihood of flood storage and energy dissipation.
Base flow augmentation; dilution	2	3	Some augmentation, but water is polluted and impact on downstream sections
MODIFYING DETERMINANTS			
9. Protected status	3	3	Endangered regional ecological type
10. Ecological importance (rarity of size/type/condition) – local, regional or national context	2	3	Natural grassland habitat remaining in the area
TOTAL	***24***		
Average	***2.2***		
MEDIAN	**2**		

Table 14-2: Table reflecting the EIS assessment scores and confidence ratings for Alternative B

Determinant	Score	Confidence	Reason
PRIMARY DETERMINANTS			
1. Rare and endangered species	2	3	No protected species recorded, suitable habitat present.
2. Populations of unique species	2	2	Moderately suitable habitat for high floristic diversity.
3. Species / taxon richness	2	3	Moderately suitable habitat for high floristic diversity.
4. Diversity of habitat types or features	2	3	Relative large extent of natural grassland habitat remaining.
5. Migration/breeding and feeding site for wetland species	2	2	Moderately interactive habitat types suitable for conservation important species.
6. Sensitivity to changes in natural hydrological regime	2	3	Systems score high one vulnerability index, and retain more integrity than other those of other alternatives.
7. Sensitivity to water quality changes	3	3	Good water quality indicated by Diatoms and *in situ* constituents.
8. Flood storage, energy dissipation and particulate/element removal	1	3	Does provide these services, but not to the same extent as wetlands on Alternatives A and C.
Base flow augmentation; dilution	1	3	Small headwater catchments contribute on a local scale.
MODIFYING DETERMINANTS			
9. Protected status	3	3	Endangered regional ecological type.
10. Ecological importance (rarity of size/type/condition) – local, regional or national context	2	3	Natural grassland habitat remaining in the area.
TOTAL	***22***		
Average	***2.0***		
MEDIAN	**2**		

Table 14-3: Table reflecting the EIS assessment scores and confidence ratings for Alternative C

Determinant	Score	Confidence	Reason
PRIMARY DETERMINANTS			
1. Rare and endangered species	2	3	No protected species recorded, habitat not particularly suitable.
2. Populations of unique species	2	2	high degradation levels in this option.
3. Species / taxon richness	2	3	Remaining natural habitat of relative poor status.
4. Diversity of habitat types or features	2	3	Small portions of remaining natural habitat, homogenous topography and habitat types.
5. Migration/breeding and feeding site for wetland species	2	2	Low interactivity of habitat types, not suited for conservation important taxa. One large dam within the secondary study area provide habitat for migrating water fowl.
6. Sensitivity to changes in natural hydrological regime	2	3	Wetlands retain Moderate PES, and scored relatively high on vulnerability index.
7. Sensitivity to water quality changes	2	3	Moderate to good water quality indicated by diatoms and *in situ* water constituents.
8. Flood storage, energy dissipation and particulate/element removal	3	3	Nearly all wetlands terminate into dams, which assist flood storage and energy dissipation.
Base flow augmentation; dilution	1	3	The seasonal Nature, extent and location of wetlands is not likely to contribute notably to base flow augmentation.
MODIFYING DETERMINANTS			
9. Protected status	3	3	Endangered regional ecological type
10. Ecological importance (rarity of size/type/condition) – local, regional or national context	2	3	Natural grassland habitat remaining in the area
TOTAL	***23***		
Average	***2.1***		
MEDIAN	**2**		

15. APPENDIX F - WET EcoServices: Functional Assessment

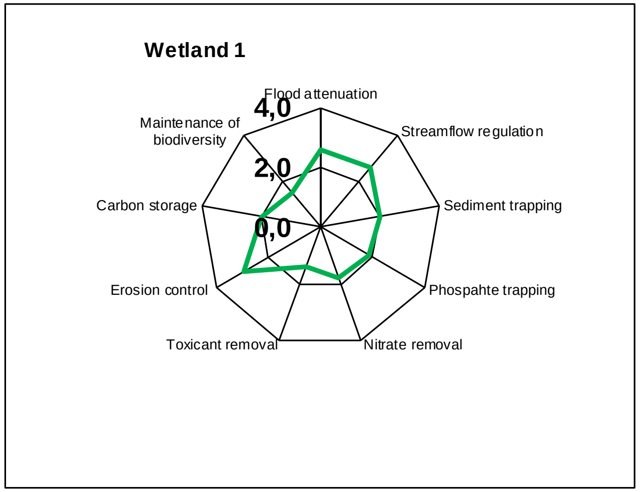

Figure 15-1: Spider diagram representing indirect services provided by Wetland 1.

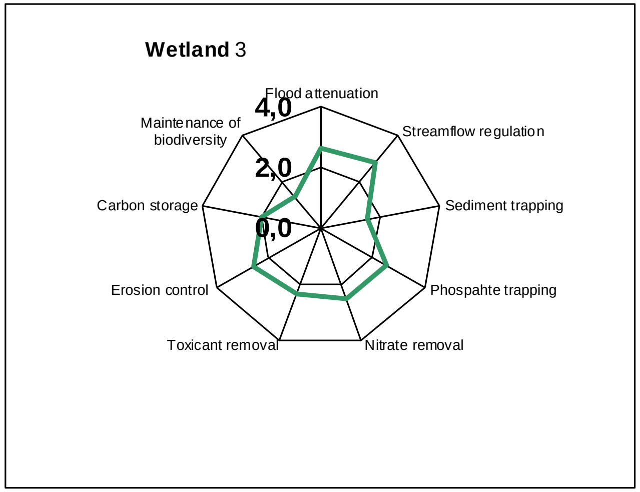

Figure 15-3: Spider diagram representing indirect services provided by Wetland 3.

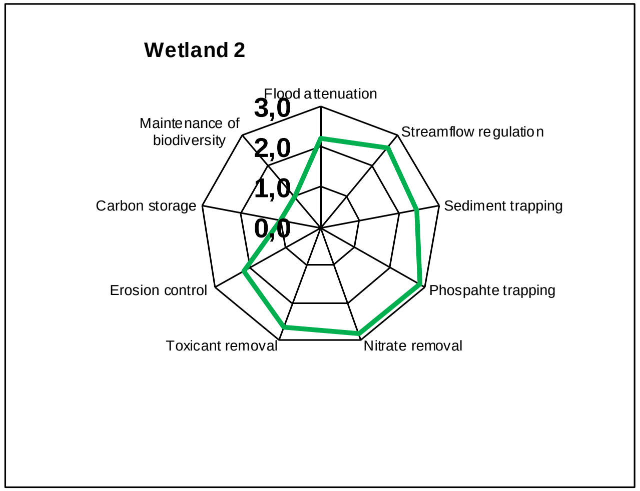

Figure 15-2: Spider diagram representing indirect services provided by Wetland 2.

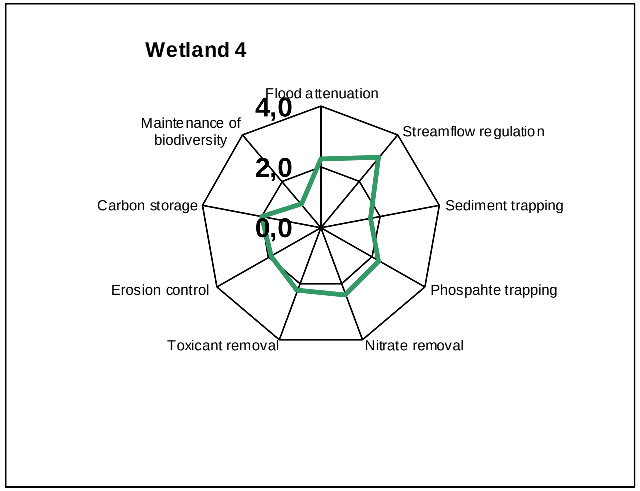

Figure 15-4: Spider diagram representing indirect services provided by Wetland 4.

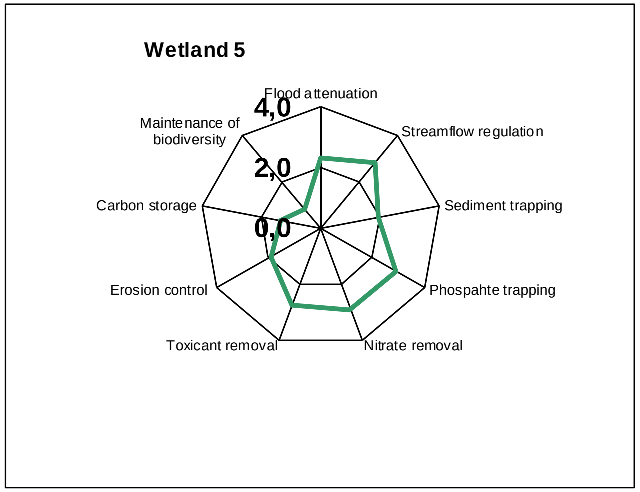

Figure 15-5: Spider diagram representing indirect services provided by Wetland 5.

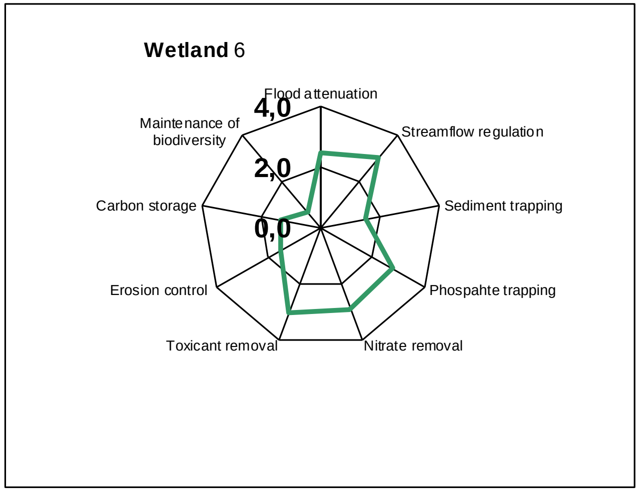

Figure 15-6: Spider diagram representing indirect services provided by Wetland 6.

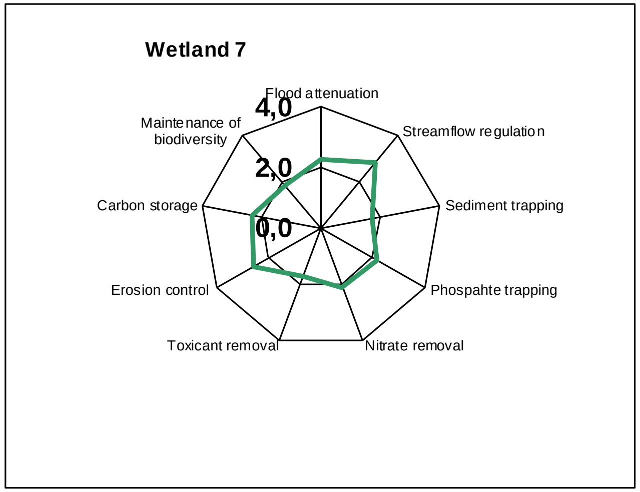

Figure 15-7: Spider diagram representing indirect services provided by Wetland 7.

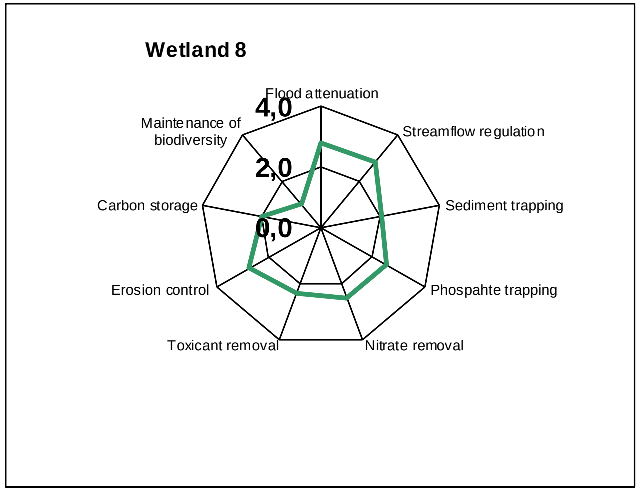

Figure 15-8: Spider diagram representing indirect services provided by Wetland 8.

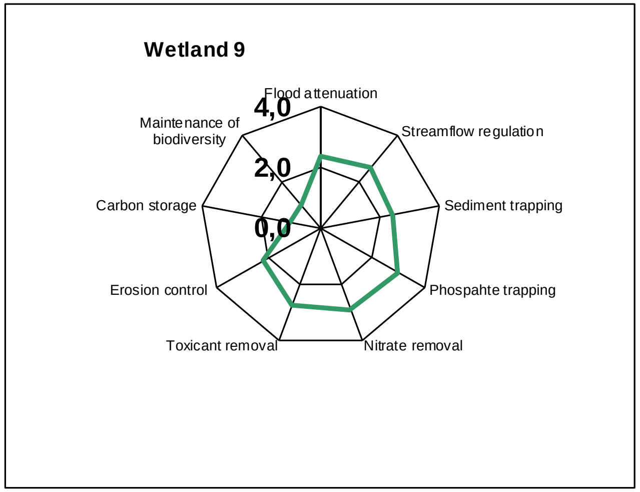

Figure 15-9: Spider diagram representing indirect services provided by Wetland 9.

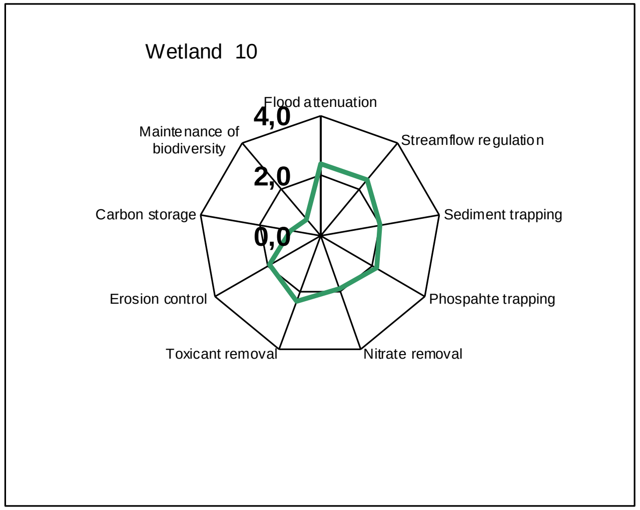

Figure 15-10: Spider diagram representing indirect services provided by Wetland 10.

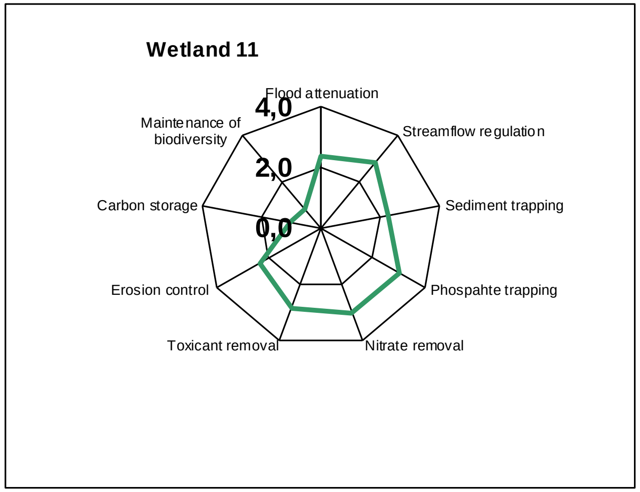

Figure 15-11: Spider diagram representing indirect services provided by Wetland 11.

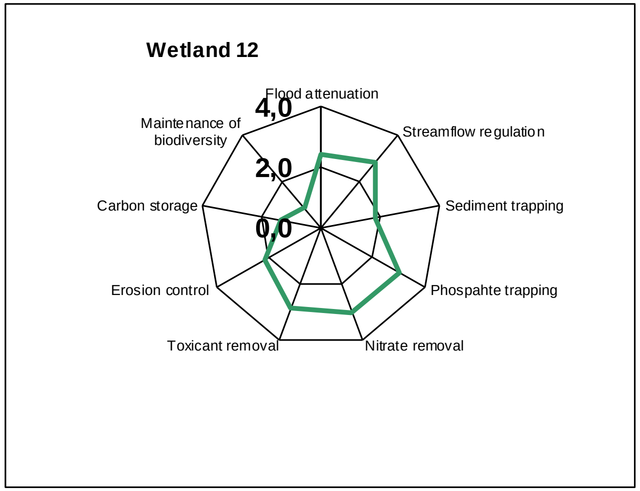

Figure 15-12: Spider diagram representing indirect services provided by Wetland 12.

16. APPENDIX G – Impact Assessment

16.1. Alternative A

Table 16-1: Impact assessment of the potential impacts of the proposed Site A, 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
Impacts on hydrology	**Nature of impact:**	Clearing of vegetation result in decrease surface roughness and change in runoff characteristics							
	without	2	2	2	5	30	Low	-	3
	with	2	2	2	3	18	Low	-	3
	degree to which impact can be reversed:	Impact is not readily reversed							3
	degree of impact on irreplaceable resources:	Low							3
Impacts on surface water quality	**Nature of impact:**	During the construction phase of the project, water quality deterioration will result as a consequence of increased sediment loads within the downslope wetlands, as well as through pollutants derived from spillage, leakage and incorrect disposal of hazardous substances on site. Incorrect waste management and disposal is also likely to contribute further to water quality deterioration.							
	without	3	2	2	4	28	Low	-	3
	with	2	2	2	3	18	Low	-	3
	degree to which impact can be reversed:	This impact is difficult to reverse at it has far reaching implications. Even once water constituents return back to background levels, subsequent biological responses might take much longer to recover.							3
	degree of impact on irreplaceable resources:	Low							3
Impacts related to erosion and sedimentation	**Nature of impact:**	Disturbance of vegetation and soil during the construction process will significantly increase the risk of erosion. The compaction of soil surfaces will increase the volumes and velocities of surface run-off, further increasing erosion risk. Use of heavy machinery on site is also likely to result in the formation of well-worn tracks and ruts that act as preferential flow paths to surface run-off. Concentrated surface run-off will lead to erosion, with gully formation likely. Removal of vegetation and the disturbance of the soil profile will expose the soils to erosion by wind (dust) and water (from surface run-off). Eroded soil is likely to enter downstream wetland areas, increasing sedimentation within these wetlands and leading to changes in vegetation composition and aquatic fauna. Erosion is likely to be highest during the summer months when high intensity storm events are likely to result in significant surface runoff. While the vertic clay soils are fairly resistant to erosion in the undisturbed state, once disturbed they will pose a significant erosion risk.							
	without	2	2	2	4	24	Low	-	3
	with	1	1	2	3	12	Low	-	3
	degree to which impact can be reversed:	Loss in direct wetland integrity and functioning due to erosion cannot be reversed easily. Loss due to downslope sedimentation might be easier to reinstate or might recover spontaneously provided sediment sources are stopped.							3
	degree of impact on irreplaceable resources:	Low							3

Potential Impact	Mitigation	Extent (E)	Duration (D)	Magnitude (M)	Probability (P)	Significance (S=(E+D+M)*P)		Status (+ve or -ve)	Confidence
Impacts on wetland vegetation and disturbance of wetland habitat	**Nature of impact:**	Destruction of the wetlands will result in the loss or displacement of biodiversity associated with the affected reach of the wetlands, while indirect negative impacts will also accrue to the downstream reaches of the affected wetlands through altered flow volumes and quality. In addition to the loss of wetland habitat, wetland habitat located immediately adjacent to the development footprints are likely to be substantially disturbed during the construction process through increased and uncontrolled movement of heavy machinery and people on site.							
	without	4	3	2	5	**45**	**Medium**	-	3
	with	4	3	2	5	**45**	**Medium**	-	3
	degree to which impact can be reversed:	Wetland loss will be permanent.							3
	degree of impact on irreplaceable resources:	Low.							3
Impact related to increase alien/pioneer vegetation in disturbed areas	**Nature of impact:**	Disturbances to the wetlands on site will provide opportunity for invasion by alien and weedy species. Species such as Bidens formosa (Cosmos) are already prevalent on site and likely to increase, to the detriment of indigenous species.							
	without	2	2	2	4	**24**	**Low**	-	3
	with	1	2	2	3	**15**	**Low**	-	3
	degree to which impact can be reversed:	Can be reversed							3
	degree of impact on irreplaceable resources:	Low							3
Impacts on residual wetland ecosystem services	**Nature of impact:**	Loss in wetland habitat, and flow maintenance will result in a decrease in ecosystem services associated with wetlands							
	without	3	2	6	4	**44**	**Medium**	-	3
	with	3	2	6	4	**44**	**Medium**	-	3
	degree to which impact can be reversed:	Without reinstating impaired/impacted wetlands- ecosystem services cannot be regained							3
	degree of impact on irreplaceable resources:	Moderate							3

Table 16-2: Impact assessment of the potential impacts of the proposed Site A, during the operational phase

Potential Impact	Mitigation	Extent (E)	Duration (D)	Magnitude (M)	Probability (P)	Significance (S=(E+D+M)*P)		Status (+ve or -ve)	Confidence
Impacts on hydrology	**Nature of impact:**	Decreased flows within the downslope wetlands will result in a decreased wetland extent and decreased vegetation vigour as wetland species are replaced by dry land species, increasing the risk of erosion especially during flood events.							
	without	3	5	2	5	**50**	**Medium**	-	3
	with	2	5	2	5	**45**	**Medium**	-	3
	degree to which impact can be reversed:	Can be reversed							3
	degree of impact on irreplaceable resources:	Low							3
Impacts on surface water quality	**Nature of impact:**	Seepage or leakage of polluted water out of the ash disposal facility and into adjacent wetlands is likely to result in a significant deterioration of water quality within the receiving water resources. Decreasing water quality within the wetlands is likely to have a deleterious effect on biodiversity supported by the wetlands, as well as making the water less fit for use for downstream water users. Downstream water users at a local scale include farmers using the water for livestock watering and irrigation, while further downstream the polluted water would enter the Leeuspruit and the Vaal River.							
	without	3	5	4	5	**60**	**Medium**		3
	with	2	5	4	4	**44**	**Medium**		3
	degree to which impact can be reversed:	Cannot be readily reversed							3
	degree of impact on irreplaceable resources:	Low							3

Table 16-3: Impact assessment of the potential impacts of the proposed Site A, during the de-commissioning phase

Potential Impact	Mitigation	Extent (E)	Duration (D)	Magnitude (M)	Probability (P)	Significance (S=(E+D+M)*P)		Status (+ve or -ve)	Confidence
Water Quality	**Nature of impact:**	The long term impacts of the decommissioned disposal facility on surface water quality will rely on leachate and/or runoff quality, as well as the probability of surface water pollution.							
	without	3	5	4	5	**60**	**Medium**	-	3
	with	2	5	2	3	**27**	**Low**	-	3
	degree to which impact can be reversed:	Not readily reversed							3
	degree of impact on irreplaceable resources:	Low							3

Table 16-4: Impact assessment of the potential cumulative impacts associated of the proposed Site A

Potential Impact	Mitigation	Extent (E)	Duration (D)	Magnitude (M)	Probability (P)	Significance (S=(E+D+M)*P)		Status (+ve or -ve)	Confidence
Decrease PES of wetland type and downstream watercourse	**Nature of impact:**	A combination of altered driver components (hydrology, sediment and vegetation cover) will result in a change in wetland integrity. The magnitude and probability of this change relates to the PES and EIS of the wetlands in question and of wetlands sharing the same catchment.							
	without	2	4	2	4	**32**	**Medium**	-	3
	with	2	2	2	4	**24**	**Low**	-	3
	degree to which impact can be reversed:	Cannot be readily reversed							3
	degree of impact on irreplaceable resources:	Low							3

16.2. Alternative B

Table 16-5: Impact assessment of the potential impacts of the proposed Site B, 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
Impacts on hydrology	**Nature of impact:**	Clearing of vegetation result in decrease surface roughness and change in runoff characteristics							
	without	2	2	8	5	60	Medium	-	3
	with	2	2	8	4	48	Medium	-	3
	degree to which impact can be reversed:	Impact is not readily reversed							3
	degree of impact on irreplaceable resources:	Low							3
Impacts on surface water quality	**Nature of impact:**	During the construction phase of the project, water quality deterioration will result as a consequence of increased sediment loads within the downslope wetlands, as well as through pollutants derived from spillage, leakage and incorrect disposal of hazardous substances on site. Incorrect waste management and disposal is also likely to contribute further to water quality deterioration.							
	without	4	2	8	5	70	High	-	3
	with	4	2	8	4	56	Medium	-	3
	degree to which impact can be reversed:	This impact is difficult to reverse at it has far reaching implications. Even once water constituents return back to background levels, subsequent biological responses might take much longer to recover.							3
	degree of impact on irreplaceable resources:	Low							3
Impacts related to erosion and sedimentation	**Nature of impact:**	Disturbance of vegetation and soil during the construction process will significantly increase the risk of erosion. The compaction of soil surfaces will increase the volumes and velocities of surface run-off, further increasing erosion risk. Use of heavy machinery on site is also likely to result in the formation of well-worn tracks and ruts that act as preferential flow paths to surface run-off. Concentrated surface run-off will lead to erosion, with gully formation likely. Removal of vegetation and the disturbance of the soil profile will expose the soils to erosion by wind (dust) and water (from surface run-off). Eroded soil is likely to enter downstream wetland areas, increasing sedimentation within these wetlands and leading to changes in vegetation composition and aquatic fauna. Erosion is likely to be highest during the summer months when high intensity storm events are likely to result in significant surface runoff. While the vertic clay soils are fairly resistant to erosion in the undisturbed state, once disturbed they will pose a significant erosion risk.							
	without	3	2	8	5	65	High	-	3
	with	2	2	8	4	48	Medium	-	3
	degree to which impact can be reversed:	Loss in direct wetland integrity and functioning due to erosion cannot be reversed easily. Loss due to downslope sedimentation might be easier to reinstate or might recover spontaneously provided sediment sources are stopped.							3
	degree of impact on irreplaceable resources:	Low							3

Impacts on wetland vegetation and disturbance of wetland habitat	**Nature of impact:**	Destruction of the wetlands will result in the loss or displacement of biodiversity associated with the affected reach of the wetlands, while indirect negative impacts will also accrue to the downstream reaches of the affected wetlands through altered flow volumes and quality. In addition to the loss of wetland habitat, wetland habitat located immediately adjacent to the development footprints are likely to be substantially disturbed during the construction process through increased and uncontrolled movement of heavy machinery and people on site.							
	without	4	2	8	5	**70**	**High**	-	3
	with	4	2	8	4	**56**	**Medium**	-	3
	degree to which impact can be reversed:	Wetland loss will be permanent.							3
	degree of impact on irreplaceable resources:	Low.							3
Impact related to increase alien/pioneer vegetation in disturbed areas	**Nature of impact:**	Disturbances to the wetlands on site will provide opportunity for invasion by alien and weedy species. Species such as Bidens formosa (Cosmos) are already prevalent on site and likely to increase, to the detriment of indigenous species.							
	without	3	2	6	4	**44**	**Medium**	-	3
	with	2	2	6	3	**30**	**Low**	-	3
	degree to which impact can be reversed:	Can be reversed							3
	degree of impact on irreplaceable resources:	Low							3
Impacts on residual wetland ecosystem services	**Nature of impact:**	Loss in wetland habitat, and flow maintenance will result in a decrease in ecosystem services associated with wetlands							
	without	4	2	8	5	**70**	**High**	-	3
	with	4	2	8	4	**56**	**Medium**	-	3
	degree to which impact can be reversed:	Without reinstating impaired/impacted wetlands- ecosystem services cannot be regained							3
	degree of impact on irreplaceable resources:	Moderate							3

Table 16-6: Impact assessment of the potential impacts of the proposed Site B, during the operational phase

Potential Impact	Mitigation	Extent (E)	Duration (D)	Magnitude (M)	Probability (P)	Significance (S=(E+D+M)*P)		Status (+ve or -ve)	Confidence
Impacts on hydrology	**Nature of impact:**	Decreased flows within the downslope wetlands will result in a decreased wetland extent and decreased vegetation vigour as wetland species are replaced by dry land species, increasing the risk of erosion especially during flood events.							
	without	2	5	6	5	65	High	-	3
	with	2	5	6	5	65	High	-	3
	degree to which impact can be reversed:	Can be reversed							3
	degree of impact on irreplaceable resources:	Low							3
Impacts on surface water quality	**Nature of impact:**	Seepage or leakage of polluted water out of the ash disposal facility and into adjacent wetlands is likely to result in a significant deterioration of water quality within the receiving water resources. Decreasing water quality within the wetlands is likely to have a deleterious effect on biodiversity supported by the wetlands, as well as making the water less fit for use for downstream water users. Downstream water users at a local scale include farmers using the water for livestock watering and irrigation, while further downstream the polluted water would enter the Leeuspruit, Blesbokspruit and the Vaal River.							
	without	3	5	6	5	70	High	-	3
	with	2	4	4	4	40	Medium	-	3
	degree to which impact can be reversed:	Cannot be readily reversed							3
	degree of impact on irreplaceable resources:	Low							3

Table 16-7: Impact assessment of the potential impacts of the proposed Site B, during the de-commissioning phase

Potential Impact	Mitigation	Extent (E)	Duration (D)	Magnitude (M)	Probability (P)	Significance (S=(E+D+M)*P)		Status (+ve or -ve)	Confidence
Water Quality	**Nature of impact:**	The long term impacts of the decommissioned disposal facility on surface water quality will rely on leachate and/or runoff quality, as well as the probability of surface water pollution.							
	without	2	5	6	5	65	High	-	3
	with	2	5	6	3	39	Medium	-	3
	degree to which impact can be reversed:	Not readily reversed							3
	degree of impact on irreplaceable resources:	Low							3

Table 16-8: Impact assessment of the potential cumulative impacts associated of the proposed Site B

Potential Impact	Mitigation	Extent (E)	Duration (D)	Magnitude (M)	Probability (P)	Significance (S=(E+D+M)*P)		Status (+ve or -ve)	Confidence
Decrease PES of wetland type and downstream watercourse	**Nature of impact:**	A combination of altered driver components (hydrology, sediment and vegetation cover) will result in a change in wetland integrity. The magnitude and probability of this change relates to the PES and EIS of the wetlands in question and of wetlands sharing the same catchment.							
	without	2	4	6	5	**60**	**Medium**	-	3
	with	2	3	6	4	**44**	**Medium**	-	3
	degree to which impact can be reversed:	Cannot be readily reversed							3
	degree of impact on irreplaceable resources:	Low							3

16.3. Alternative C

Table 16-9: Impact assessment of the potential impacts of the proposed Alternative C, 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
Impacts on hydrology	**Nature of impact:**	Clearing of vegetation result in decrease surface roughness and change in runoff characteristics							
	without	3	2	6	5	**55**	**Medium**	-	3
	with	2	2	6	4	**40**	**Medium**	-	3
	degree to which impact can be reversed:	Impact is not readily reversed							3
	degree of impact on irreplaceable resources:	Low							3
Impacts on surface water quality	**Nature of impact:**	During the construction phase of the project, water quality deterioration will result as a consequence of increased sediment loads within the downslope wetlands, as well as through pollutants derived from spillage, leakage and incorrect disposal of hazardous substances on site. Incorrect waste management and disposal is also likely to contribute further to water quality deterioration.							
	without	4	2	6	5	**60**	**Medium**	-	3
	with	3	2	6	4	**44**	**Medium**	-	3
	degree to which impact can be reversed:	This impact is difficult to reverse at it has far reaching implications. Even once water constituents return back to background levels, subsequent biological responses might take much longer to recover.							3
	degree of impact on irreplaceable resources:	Clearing of vegetation result in decrease surface roughness and change in runoff characteristics							3
Impacts related to erosion and sedimentation	**Nature of impact:**	Disturbance of vegetation and soil during the construction process will significantly increase the risk of erosion. The compaction of soil surfaces will increase the volumes and velocities of surface run-off, further increasing erosion risk. Use of heavy machinery on site is also likely to result in the formation of well-worn tracks and ruts that act as preferential flow paths to surface run-off. Concentrated surface run-off will lead to erosion, with gully formation likely. Removal of vegetation and the disturbance of the soil profile will expose the soils to erosion by wind (dust) and water (from surface run-off). Eroded soil is likely to enter downstream wetland areas, increasing sedimentation within these wetlands and leading to changes in vegetation composition and aquatic fauna. Erosion is likely to be highest during the summer months when high intensity storm events are likely to result in significant surface runoff. While the vertic clay soils are fairly resistant to erosion in the undisturbed state, once disturbed they will pose a significant erosion risk.							
	without	3	2	6	5	**55**	**Medium**	-	3
	with	3	2	6	4	**44**	**Medium**	-	3
	degree to which impact can be reversed:	Loss in direct wetland integrity and functioning due to erosion cannot be reversed easily. Loss due to downslope sedimentation might be easier to reinstate or might recover spontaneously provided sediment sources are stopped.							3
	degree of impact on irreplaceable resources:	Low							3

Impacts on wetland vegetation and disturbance of wetland habitat	**Nature of impact:**	Destruction of the wetlands will result in the loss or displacement of biodiversity associated with the affected reach of the wetlands, while indirect negative impacts will also accrue to the downstream reaches of the affected wetlands through altered flow volumes and quality. In addition to the loss of wetland habitat, wetland habitat located immediately adjacent to the development footprints are likely to be substantially disturbed during the construction process through increased and uncontrolled movement of heavy machinery and people on site.							
	without	3	2	4	4	**36**	**Medium**	-	3
	with	2	2	4	2	**16**	**Low**	-	3
	degree to which impact can be reversed:	Wetland loss will be permanent.							3
	degree of impact on irreplaceable resources:	Low.							3
Impact related to increase alien/pioneer vegetation in disturbed areas	**Nature of impact:**	Disturbances to the wetlands on site will provide opportunity for invasion by alien and weedy species. Species such as Bidens formosa (Cosmos) are already prevalent on site and likely to increase, to the detriment of indigenous species.							
	without	3	2	6	4	**44**	**Medium**	-	3
	with	2	2	6	3	**30**	**Low**	-	3
	degree to which impact can be reversed:	Can be reversed							3
	degree of impact on irreplaceable resources:	Low							3
Impacts on residual wetland ecosystem services	**Nature of impact:**	Loss in wetland habitat, and flow maintenance will result in a decrease in ecosystem services associated with wetlands							
	without	4	2	4	3	**30**	**Low**	-	3
	with	3	2	4	3	**27**	**Low**	-	3
	degree to which impact can be reversed:	Without reinstating impaired/impacted wetlands- ecosystem services cannot be regained							3
	degree of impact on irreplaceable resources:	Moderate							3

Table 16-10: Impact assessment of the potential impacts of the proposed Alternative C, during the operational phase

Potential Impact	Mitigation	Extent (E)	Duration (D)	Magnitude (M)	Probability (P)	Significance (S=(E+D+M)*P)		Status (+ve or -ve)	Confidence
Impacts on hydrology	**Nature of impact:**	Decreased flows within the downslope wetlands will result in a decreased wetland extent and decreased vegetation vigour as wetland species are replaced by dry land species, increasing the risk of erosion especially during flood events.							
	without	2	5	4	5	**55**	**Medium**	-	3
	with	2	5	4	5	**55**	**Medium**	-	3
	degree to which impact can be reversed:	Cannot be readily reversed							3
	degree of impact on irreplaceable resources:	Low							3
Impacts on surface water quality	**Nature of impact:**	Seepage or leakage of polluted water out of the ash disposal facility and into adjacent wetlands is likely to result in a significant deterioration of water quality within the receiving water resources. Decreasing water quality within the wetlands is likely to have a deleterious effect on biodiversity supported by the wetlands, as well as making the water less fit for use for downstream water users. Downstream water users at a local scale include farmers using the water for livestock watering and irrigation, while further downstream the polluted water would enter the Leeuspruit, Blesbokspruit and the Vaal River.							
	without	3	5	4	5	**60**	**Medium**		3
	with	2	4	4	4	**40**	**Medium**		3
	degree to which impact can be reversed:	Cannot be readily reversed							3
	degree of impact on irreplaceable resources:	Low							3

Table 16-11: Impact assessment of the potential impacts of the proposed Alternative C, during the de-commissioning phase

Potential Impact	Mitigation	Extent (E)	Duration (D)	Magnitude (M)	Probability (P)	Significance (S=(E+D+M)*P)		Status (+ve or -ve)	Confidence
Water Quality	**Nature of impact:**	The long term impacts of the decommissioned disposal facility on surface water quality will rely on leachate and/or runoff quality, as well as the probability of surface water pollution.							
	without	2	5	4	5	**55**	**Medium**	-	3
	with	2	5	4	3	**33**	**Medium**	-	3
	degree to which impact can be reversed:	Not readily reversed							3
	degree of impact on irreplaceable resources:	Low							3

Table 16-12: Impact assessment of the potential cumulative impacts associated of the proposed Alternative C

Potential Impact	Mitigation	Extent (E)	Duration (D)	Magnitude (M)	Probability (P)	Significance (S=(E+D+M)*P)		Status (+ve or -ve)	Confidence
Decrease PES of wetland type and downstream watercourse	**Nature of impact:**	A combination of altered driver components (hydrology, sediment and vegetation cover) will result in a change in wetland integrity. The magnitude and probability of this change relates to the PES and EIS of the wetlands in question and of wetlands sharing the same catchment.							
	without	2	4	4	4	**40**	**Medium**	-	3
	with	2	3	4	3	**27**	**Low**	-	3
	degree to which impact can be reversed:	Cannot be readily reversed							3
	degree of impact on irreplaceable resources:	Low							3