BUFFER ZONE GUIDELINES FOR WETLANDS, RIVERS AND ESTUARIES

Douglas Macfarlane and Ian Bredin

PART 2: PRACTICAL GUIDE

Buffer Zone Guidelines for Wetlands, Rivers and Estuaries

Part 2: Practical Guide

Douglas Macfarlane

Eco-Pulse Environmental Consulting Services

Ian Bredin

Institute of Natural Resources

Report to the

Water Research Commission

by

Eco-Pulse Environmental Consulting Services

Institute of Natural Resources

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eco-pulse
environmental consulting services

Obtainable from

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Private Bag X03

Gezina 0031

orders@wrc.org.za or download from www.wrc.org.za

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DISCLAIMER

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Front Cover: Mountain stream

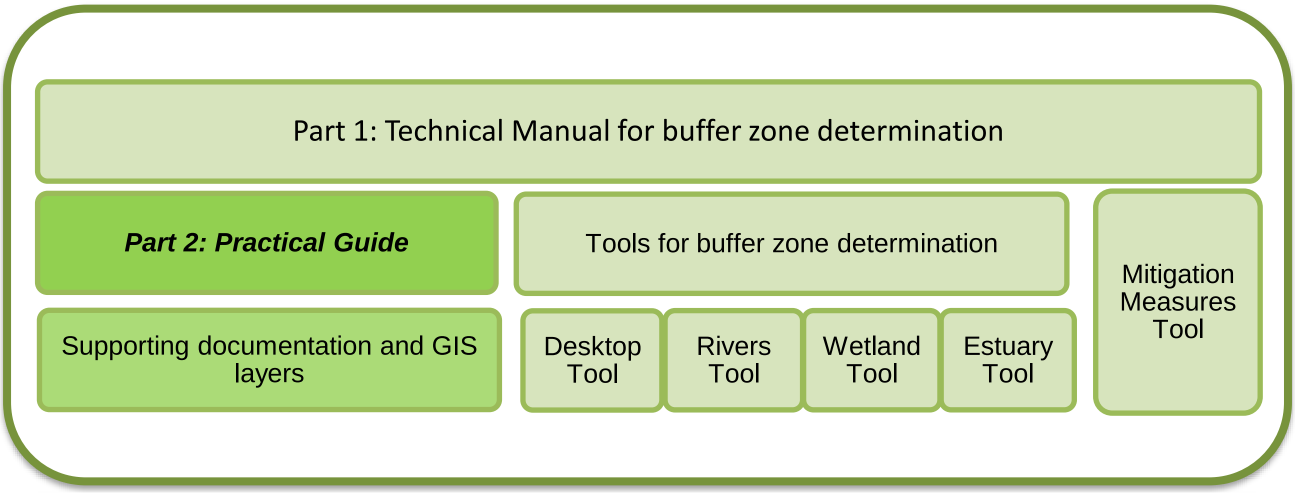
Insets: Allendale wetland, mountain stream, and Ntafufu estuary

Photographs: Douglas Macfarlane, Ian Bredin and Duncan Hay

OVERVIEW OF PROJECT OUTPUTS

This Practical Guide is one of the key outputs of a research project funded by the Department of Water and Sanitation, through the Water Research Commission. This report is designed to be used together with a range of accompanying outputs produced as part of this project. A brief summary of each product is outlined and the relationship between them is shown diagrammatically below:

- **Part 1: Technical Manual:** This report documents the step-wise assessment procedure developed to determine appropriate buffer zones for rivers, wetlands and estuaries. This includes the rationale for the approach taken, together with important supporting technical information used as a basis for developing the tools for buffer zone determination.
- **Part 2: Practical Guide:** The Practical Guide was developed to assist users with the practical application of the Buffer Zone Tools. It includes field sheets and practical guidance for collecting and interpreting relevant desktop and field information. Supporting information required to assess selected criteria has also been compiled, and includes a range of spatial datasets (shapefile or Keyhole Mark-up Language (KML) format).
- **Tools for Buffer Zone Determination:** A range of spreadsheet-based tools has been developed to help users determine suitable buffer zone requirements. These include a rapid desktop tool for determining potential aquatic impact buffer zone requirements, as well as three site-based tools for determining buffer zone requirements for rivers, wetlands and estuaries. Once completed, the outcomes of the site-based assessments can be exported as a formal record of the buffer zone assessment process.
- **Mitigation Measures Tool:** This tool is essentially a consolidation of supplementary mitigation measures from a wide range of reference material. It is designed as a quick access point for users with a broader interest in impact mitigation or those who advise on measures to mitigate impacts on water resources.



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ACRONYMS USED IN THIS REPORT

WRC	Water Research Commission
MAP	Mean Annual Precipitation
KML	Keyhole Mark-up Language
HGM	Hydrogeomorphic
GIS	Geographic Information System
SCS-SA	Soil Conservation Services method for South Africa
ARC-ISCW	Agricultural Research Council – Institute for Soil, Climate and Water
DWAF	Department of Water Affairs and Forestry
NBA	National Biodiversity Assessment
AMSL	Above Mean Sea Level
SANBI BGIS	South African National Biodiversity Institute Biodiversity Geographic Information System
NSBA	National Spatial Biodiversity Assessment
EMP	Environmental Management Plan

1. INTRODUCTION

This report stems from the work undertaken for the "Preliminary guideline for the determination of buffer zones for rivers, wetlands and estuaries" (Macfarlane et al., 2014). The Water Research Commission (WRC) project K5/2463 provided an opportunity to test the preliminary guideline at a series of national training and development workshops, and to update and finalise the report and supporting Buffer Zone Tools. A key outcome from the workshops was a clear need for a Technical Manual and a separate Practical Guide to help guide users through the process of determining an appropriate buffer zone.

The Technical Manual details the technical aspects of the eight-step assessment procedure and acts as the primary reference point for anyone wishing to determine an appropriate buffer zone around a river, wetland or estuary. This Practical Guide includes relevant information to assist users when selecting appropriate options for each of the criteria that needs to be considered when populating the accompanying site-based Buffer Zone Tools. It is therefore important to note that the Practical Guide should be used in conjunction with the Technical Manual.

The primary focus of this document is providing practical guidance on the method to be followed when rating key elements that are considered when determining an appropriate aquatic impact buffer zone for a water resource (Step 4). These elements include (Figure 1):

- Threats posed by land use/activities on the water resource.
- Climatic factors.
- The sensitivity of the water resource (such as a river, wetland or estuary).
- Buffer zone attributes.

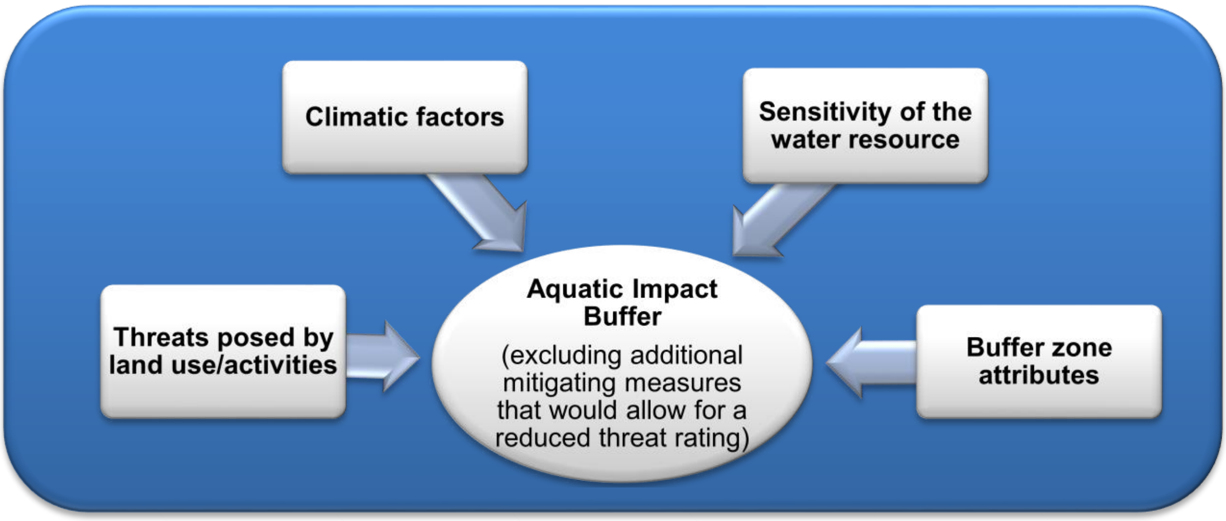


Figure 1 *– Primary characteristics considered when determining an appropriate aquatic impact buffer zone*

This Practical Guide differentiates between criteria that can be assessed at desktop level and those that need to be assessed or verified at site level. Guidance is provided on which method should be followed when evaluating each criterion, together with supplementary illustrations where necessary to assist users in undertaking the assessment process. In many instances, the assessor needs to refer to supplementary data to complete the assessment. Relevant information, including a wide range of spatial datasets, has therefore been consolidated and is available to users on the following designated website: https://sites.google.com/site/bufferzonehub/.

This document also includes basic guidance on how to complete the remaining components of the Buffer Zone Tool. This includes identifying and selecting additional complementary mitigation measures and guidance on completing the supplementary questions relating to biodiversity protection (Step 5), demarcating setback areas (Step 6), managing buffer zones (Step 7) and monitoring considerations (Step 8) that need to be addressed as part of the assessment.

Desktop and field data capture sheets are provided in Annexure 1 for wetlands, Annexure 2 for rivers, and Annexure 3 for estuaries. The Practical Guide and the data capture sheets are provided to assist users in scoring/assessing the relevant criteria used to populate the Buffer Zone Tools. The Excel™-based Buffer Zone Tools are ultimately the primary products used to determine buffer zone requirements for a particular development. It is recommended that a copy of the populated Buffer Zone Tool is included as an annexure to the relevant specialist report each time this approach is used to determine a buffer zone.

> ***Note:*** *In the event of there being more than one water resource (or a group of similar water resources) within the study area, each water resource should be assessed using a separate spreadsheet.*

2. ASSESSING THREATS POSED BY LAND USE/ACTIVITIES

An evaluation of the level of threat posed by proposed land uses/activities is used, together with an assessment of the sensitivity of the water resource to determine the risk posed to water resources. Buffer zone requirements are then established for each threat type based on generic rule curves as outlined in the Technical Manual.

The Buffer Zone Tools provide the user with an opportunity to amend the 'desktop rating' by including a 'specialist threat rating'. However, amendments should only be made if clear justification can be presented to warrant a change in the desktop threat rating (Section 2.1). Further adjustments to threat ratings can be included at a later stage to account for additional supplementary mitigation measures proposed (Section 2.2).

2.1. Specialist Threat Ratings

As an initial step, the assessor is required to select the 'sector' and 'sub-sector' that best reflect the proposed development/activity being assessed in the relevant Buffer Zone Tool[1]. The model auto-populates the spreadsheet with the starting desktop threat ratings. Threat ratings should be refined through specialist input if (i) the sub-sector and associated threats do not adequately cater for the specific case, or (ii) a clear and substantiated case can be made for refining the ratings. This is done by inputting a specialist threat rating for the specific threat that needs to be refined. Clear justification for any changes must be provided so it is easy for anyone to interpret the reason for amending the threat rating[2]. A hypothetical example is provided in (Table 1).

[1] Buffer zones need to be assessed for each land use/activity being considered. In the case of large development projects with a range of planned land uses, separate buffer zone requirements must be assessed for each land use. The final buffer zone should then be based on the maximum buffer distance calculated.

[2] Refined threat ratings should be based on standard accepted management and operational practices.

***Table 1** – Hypothetical example of how threat ratings can be changed in the Buffer Zone Tools*

Proposed development/ activity	**Sector**	Agriculture		Agricultural-based land use activities that range from large-scale commercial production of crops and timber to small-scale subsistence crop farming and livestock rearing. May be associated with rural and/or urban contexts.
	Sub-sector	Forestry/timber		Includes the planting and harvesting of various species of non-indigenous trees (pine, wattle and gum) but also includes intensive planting and harvesting of indigenous species.
Threat posed by the proposed land use/activity		**Desktop threat rating**	**Specialist threat rating**	**Justification for changes in threat ratings**
Operational Phase	1. Alteration to flow volumes	VH	VH	
	2. Alteration of patterns of flows (increased flood peaks)	M	M	
	3. Increased sediment inputs and turbidity	H	M	**Hypothetical example of justification:** Based on the findings of a recent study (Author, Date) there is sufficient evidence to indicate that there is only a moderate level of sedimentation during the operational phase of a typical timber harvesting operations along the Zululand Coastal Plain. This is linked to the generally low topographic relief and course texture of soils that make them less prone to erosion.
	4. Increased nutrient inputs	L	L	
	5. Inputs of toxic organic contaminants	VL	VL	
	6. Inputs of toxic heavy metal contaminants	L	L	
	7. Alteration of acidity (pH)	L	L	
	8. Increased inputs of salts (salinization)	VL	VL	
	9. Change (elevation) of water temperature	M	M	
	10. Pathogen inputs (such as disease-causing organisms)	VL	VL	

2.2. Refining Threat Ratings to Account for Supplementary Mitigation Measures

A further opportunity is provided in the Buffer Zone Tools to allocate a 'refined threat class' based on identified additional supplementary mitigation measures. This new threat score replaces any previous threat ratings and is used to further refine buffer zone requirements. In practice, additional mitigation measures are designed to target key risk areas highlighted in the Buffer Zone Tools as these typically drive buffer zone requirements. For most industrial developments, an increase in sedimentation and turbidity is a key threat due to the intense nature of earthworks during platform establishment. A range of practical mitigation measures[3] such as using sediment basins, cut-off berms, sediment fences and hay bales could be considered to reduce the threat of erosion and sediment runoff during the construction phase. Once selected, these additional mitigation measures should be defined in the accompanying specialist report and used as a basis for justifying changes to specialist threat ratings.

3. CLIMATIC FACTORS

While potential impacts to water resources are driven primarily by threats associated with different land uses/activities, surface runoff and associated contamination risk are also influenced by climatic factors. This is discussed in detail in the Technical Manual. In summary, the frequency and intensity of surface overland flow will be higher in areas of higher mean annual precipitation (MAP), characterised by more intense rainfall events than in areas characterised by low rainfall and less intensive rainfall events.

3.1. MAP

At desktop level, determine the MAP zone that characterises the catchment where the land use/activity is located (Figure 2). For ease of use, the MAP is provided in both shapefile and Keyhole Mark-up Language (KML) format (https://sites.google.com/site/bufferzonehub/). Select the appropriate MAP zone in the relevant Buffer Zone Tool. The corresponding modifier score is automatically entered into the calculation for determining an appropriate aquatic impact buffer zone (Table 2). This process allows for the aquatic impact buffer zone to be adjusted to account for the basic climatic factor.

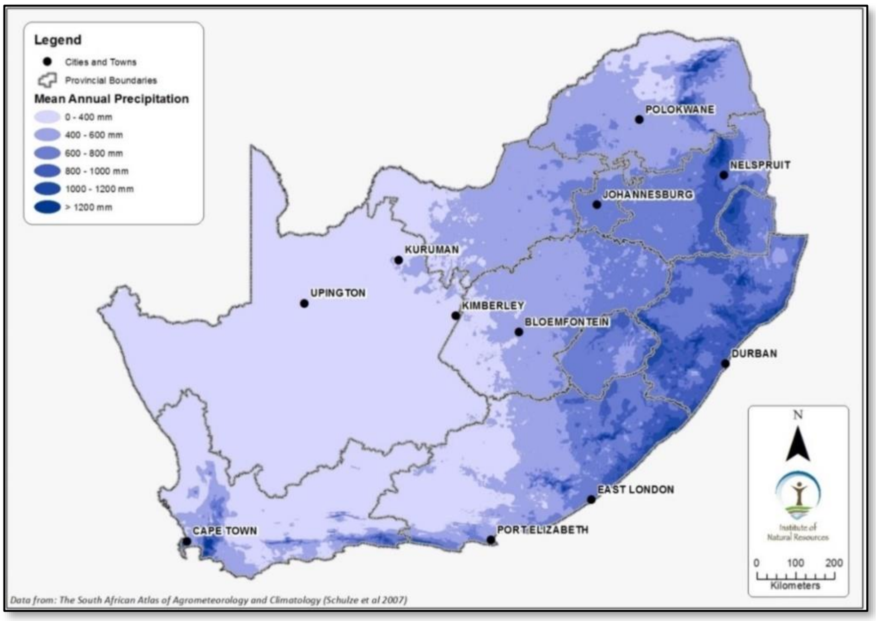


Figure 2 *– MAP (adapted from Schulze, 2007)*

[3] Further ideas for practical mitigation measures can be sourced from the Mitigation Measures Tool.

__Table 2__ – MAP classes and corresponding sensitivity scores

Criterion	Sensitivity Classes					
MAP	0-400 mm	401-600 mm	601-800 mm	801-1000 mm	*1001-1200 mm*	> 1201 mm

3.2. Rainfall Intensity

At desktop level, determine the rainfall intensity zone that characterises the catchment where the land use/activity is located (Figure 3). For ease of use, rainfall intensity is provided in both shapefile and KML format (https://sites.google.com/site/bufferzonehub/). Select the appropriate rainfall intensity zone in the relevant Buffer Zone Tool. The corresponding modifier score is automatically entered into the calculation for determining an appropriate aquatic impact buffer zone (Table 3). This process allows for the aquatic impact buffer zone to be adjusted to account for the basic climatic factors.

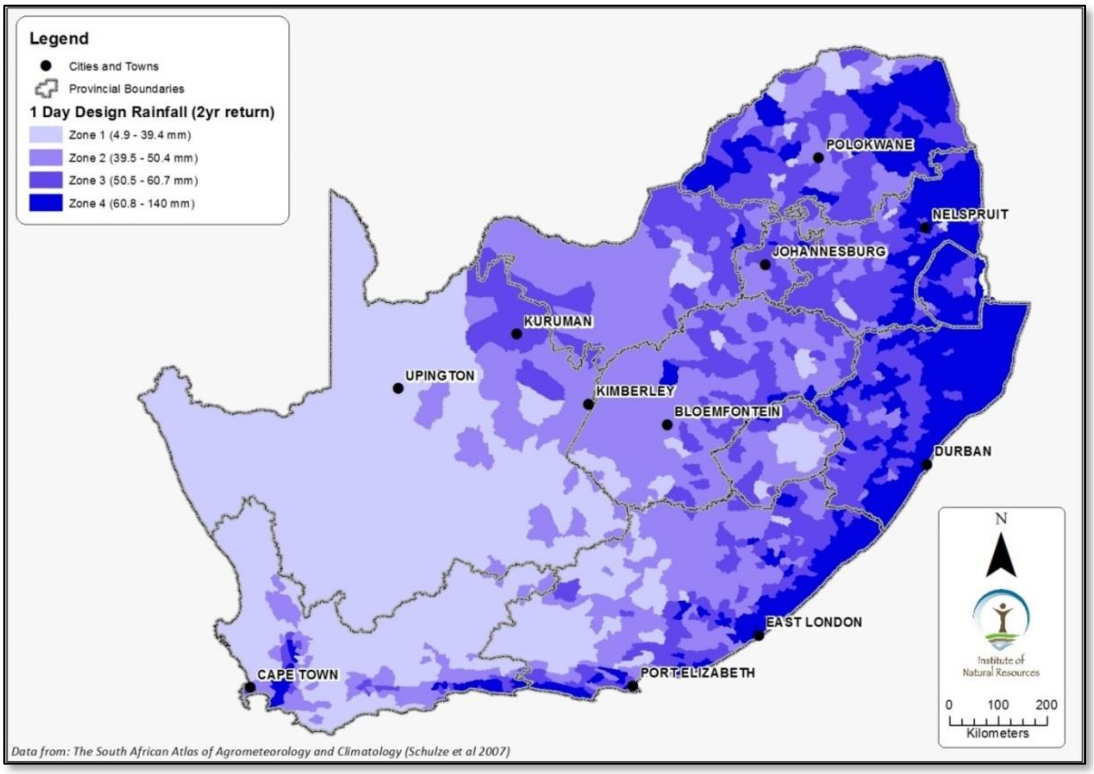


__Figure 3__ – Rainfall intensity zones based on one day design rainfall over a two-year return (adapted from Schulze, 2007)

__Table 3__ – Rainfall intensity classes and corresponding sensitivity scores

Criterion	Sensitivity Scores			
Rainfall Intensity Zone	Zone 4: Very High	*Zone 3: High*	Zone 2: Moderate	Zone 1: Low

4. ASSESSING THE SENSITIVITY OF WATER RESOURCES

The focus of this assessment is specifically on evaluating the sensitivity of water resources to lateral impacts. The information collected is integrated as part of the risk assessment, which is used to define aquatic impact buffer zone requirements. This assessment essentially requires the assessor to rate a range of easily measurable attributes that can help to distinguish between sensitive and non-sensitive systems[4]. Separate criteria have been identified for rivers, wetlands and estuaries as detailed in this section of the report. To help streamline the assessment process, criteria have been separated into those that can be assessed at desktop level and those that are better assessed as part of an in-field assessment. Data capture sheets have been developed to assist users in capturing the relevant information which must then be transferred to the relevant Buffer Zone Tool. These data capture sheets are included as annexures to this report.

4.1. Wetland Ecosystems

Because of the inherent variability of wetland systems, many criteria have been included in the sensitivity assessment relative to other water resources. These include ten criteria that are assessed at desktop level, and eight criteria that are best assessed during a site visit. A summary of the criteria, indicating how they relate to different threat types, is provided in Table 4. Guidance on how to complete the desktop and field-based assessments is also provided.

Table 4 *– List of criteria and their relevance to determine the sensitivity of wetlands to common threats posed by lateral land use impacts*

Criteria		Wetland Sensitivities from Lateral Inputs								
		Changes in water quantity	Changes in patterns of flow	Changes in sediment inputs and turbidity	Increased inputs of nutrients	Increases in toxic contaminants	Changes in acidity (pH)	Changes in concentration of salts	Changes in water temperature	Changes in pathogens
Desktop Assessment	Overall size	✓	✓	✓	✓	✓	✓	✓	✓	✓
	Size of the wetland relative to its catchment	✓	✓							
	Average slope of the wetland's catchment		✓							
	The inherent runoff potential of catchment soils		✓							

[4] Note that sensitivity criteria have only a moderate bearing on the final buffer recommendation. Although users should apply their minds to this assessment, it needs to be undertaken at a rapid level without overly complicating the rating procedure. Detail on the rationale for criteria selection and associated scoring is included in the Technical Manual.

Criteria		Wetland Sensitivities from Lateral Inputs								
		Changes in water quantity	Changes in patterns of flow	Changes in sediment inputs and turbidity	Increased inputs of nutrients	Increases in toxic contaminants	Changes in acidity (pH)	Changes in concentration of salts	Changes in water temperature	Changes in pathogens
	The extent to which the hydrogeomorphic (HGM) setting is characterised by subsurface-surface water input	✓	✓							
	Perimeter-to-area ratio			✓	✓	✓	✓	✓	✓	✓
	Vulnerability of the HGM type to sediment accumulation			✓						
	Vulnerability of the wetland to erosion given the wetland's slope and size			✓						
	Inherent level of nutrients in the landscape				✓					
	MAP	✓		✓	✓	✓	✓	✓		✓
	Natural salinity levels							✓		
In-field Assessment Required	Extent of open water in relation to the extent of the HGM unit			✓					✓	
In-field Assessment Required	Peat/high organic content versus mineral soils			✓						
In-field Assessment Required	Sensitivity of the vegetation to burial under sediment			✓						
In-field Assessment Required	Sensitivity of the vegetation to increased availability of nutrients				✓					
In-field Assessment Required	Sensitivity of the vegetation to toxic inputs, changes in acidity and salinity					✓	✓	✓		
In-field Assessment Required	Natural wetness regimes						✓			
In-field Assessment Required	Level of domestic, livestock and contact recreational use									✓

4.1.1. Desktop assessment

The desktop assessment should ideally be undertaken in the office and then be refined where necessary based on field investigations. This task involves mapping and interpreting a range of spatial datasets. It therefore requires the user to have experience in geographic information systems (GIS) or Google Maps™. A description of the method to be followed when assessing each criterion is provided here. Users are encouraged to print out the data capture sheet included in Annexure 1, and to populate this as they assess each criterion. Once captured, the information can be used to populate the Wetland Buffer Zone Tool.

4.1.1.1. Overall size

Determine the approximate area of the wetland (HGM unit) being assessed using available tools (for example GIS, Google Earth Pro™) (Figure 4). Select the corresponding class from the dropdown menu provided in the Wetland Buffer Tool (Table 5). The corresponding sensitivity modifier score is automatically entered into the calculation for determining an appropriate aquatic impact buffer zone.

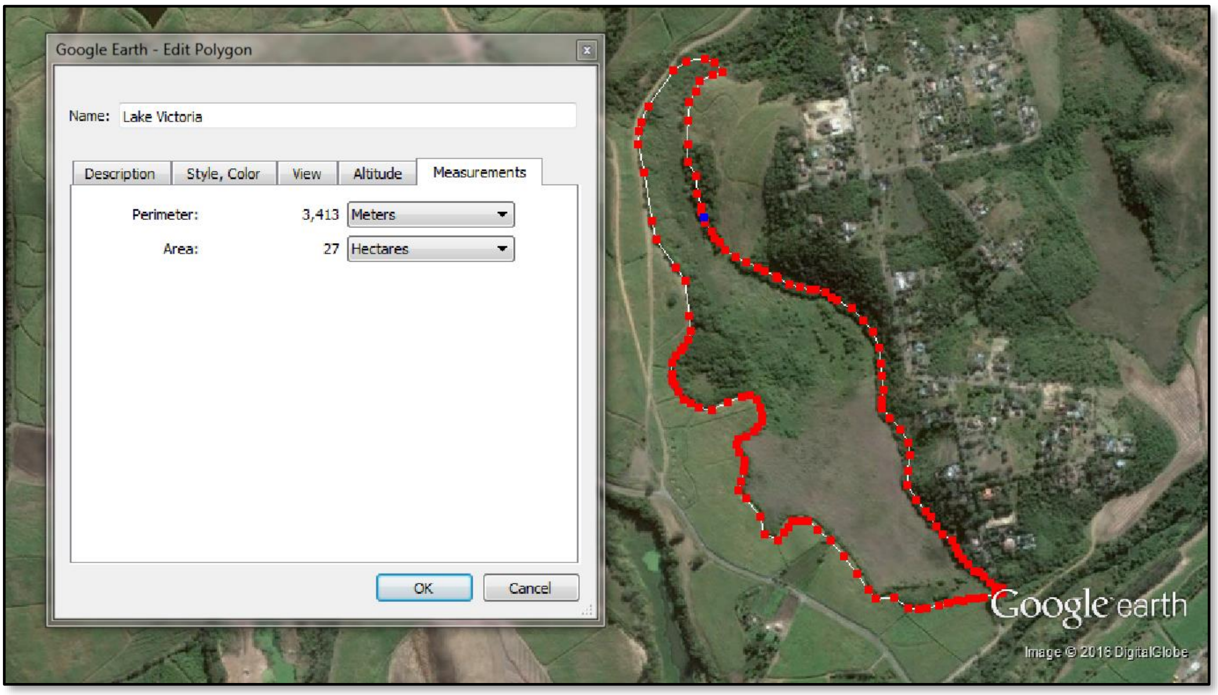


Figure 4 *– Example of determining overall size using Google Earth Pro™ (Google Earth, 2016)*

Table 5 *– Sensitivity classes for assessing overall wetland size*

Criterion	**Sensitivity Classes**				
Overall size	Small (< 0.5 ha)	0.5-5 ha	*Intermediate* *(6-50 ha)*	(51-300 ha)	Large (> 300 ha)

4.1.1.2. Size of the wetland relative to its catchment

This assessment requires the extent of the catchment of the HGM unit to be roughly estimated. This is typically done by mapping the extent of the wetlands catchment in GIS or using Google Maps™. Once estimated, the relative extent of the wetland is compared with that of the catchment and expressed as a percentage. A sensitivity class is then assigned with reference to Figure 5 and the classes provided in Table 6.

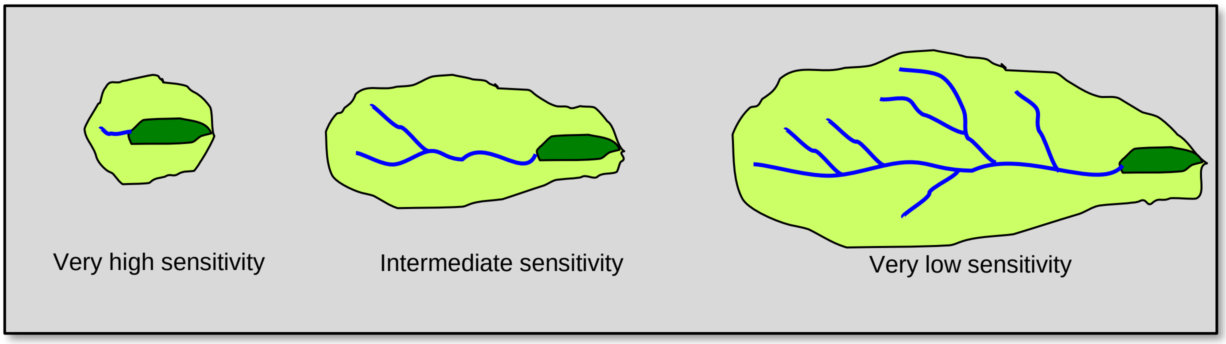


***Figure 5** – Illustration of HGM unit's sensitivity in terms of size relative to the catchment*

***Table 6** – Sensitivity classes for assessing the size of the wetland relative to its catchment*

Criterion	**Sensitivity Classes**				
Size of the wetland relative to (as a percentage of) its catchment	Large (> 20%)	10-20%	*Intermediate (6-10%)*	2-5%	Small (< 2%)

Note: *In the case of groundwater-fed systems, sensitivity should be based on the anticipated importance of lateral inflows relative to inputs from the broader groundwater system.*

4.1.1.3. Average slope of the wetland's catchment

Average slope can be roughly calculated from available topographic maps, GIS datasets or Google Maps™ information. This is done by taking elevation readings from (i) the upper-most point of the catchment and (ii) the site being assessed, and then calculating the altitudinal change. Thereafter, the distance between these points is measured and the average slope estimated by dividing the altitudinal change by the distance from the upper reaches of the catchment. A more accurate measure can be calculated in Google Earth Pro™ by drawing a line feature from the site being assessed to the top of the catchment (along the stream line) and viewing the elevation profile (Figure 6). Where significant variation in slopes occurs across the catchment, average slope should ideally be estimated from a number of sample transects.

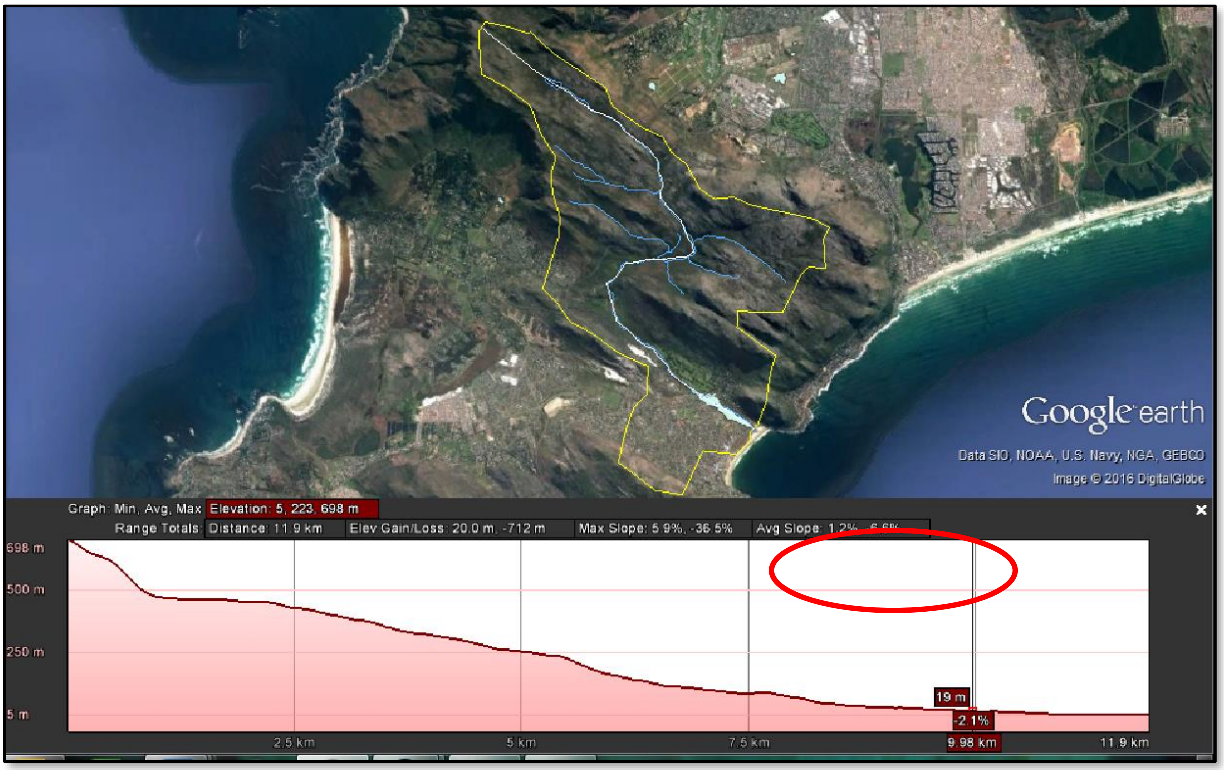


Figure 6 *– Illustration of how Google Earth is used to determine approximate average slope (Google Earth, 2016)*

Finally, a sensitivity class is selected based on the sensitivity classes in Table 7 and captured in the Wetland Buffer Tool.

Table 7 *– Sensitivity classes for assessing the average slope of the wetland's catchment*

Criterion	Sensitivity Classes				
Average slope of the wetland's catchment	< 3%	3-5%	*6-8%*	9-11%	> 11%

4.1.1.4. Inherent runoff potential of catchment soils

The Soil Conservation Services method for Southern Africa (SCS-SA) uses information on hydrologic soil properties to estimate surface runoff from a catchment (Schulze et al., 1992). Use the SCS-SA layer in either shapefile or KML format on the Buffer Zone website (https://sites.google.com/site/bufferzonehub/) (Figure 7) to determine the appropriate hydrological soil group that best defines the catchment where the change in land use/activity will occur (Table 8). Select the corresponding class from the dropdown menu provided in the Wetland Buffer Tool (Table 9). The equivalent modifier score is automatically entered into the calculation for determining an appropriate aquatic impact buffer zone.

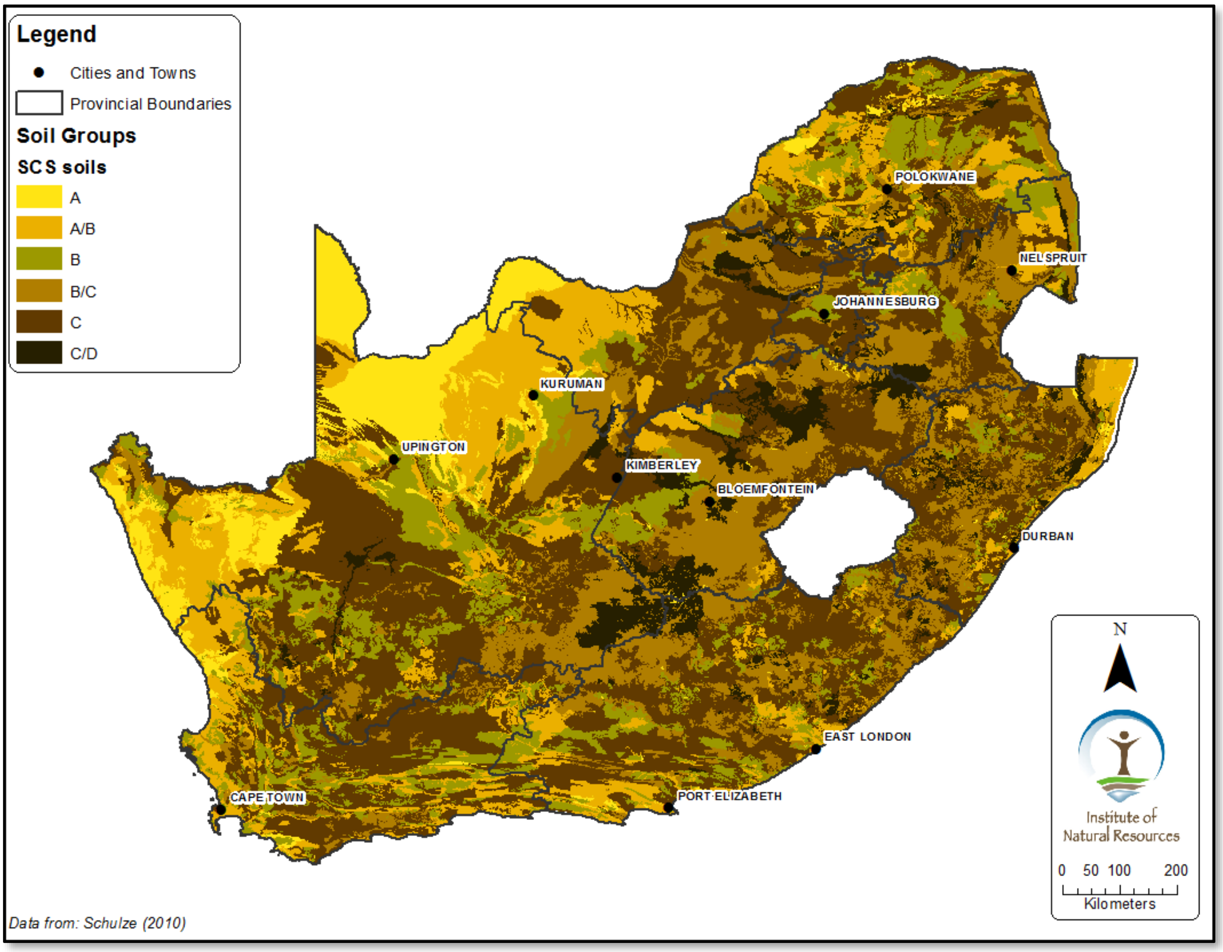


Figure 7 *– Distribution of SCS Soil Groups A to D over South Africa at a spatial resolution of land type polygons (Schulze, 2010)*

Table 8 *– Runoff potential classes (after Schulze et al., 1992)*

Low Runoff Potential	**Moderately Low Runoff Potential**	**Moderately High Runoff Potential**	**High Runoff Potential**
Soil Group A: Infiltration is high and permeability is rapid. Overall drainage is excessive to well drained.	**Soil Group B:** Moderate infiltration rates, effective depth and drainage. Permeability slightly restricted.	**Soil Group C:** Infiltration rate is slow or deteriorates rapidly. Permeability is restricted.	**Soil Group D:** Very slow infiltration and severely restricted permeability. Includes soils with high shrink-swell potential.

Table 9 *– Sensitivity classes for assessing the inherent runoff potential of catchment soils*

Criterion	**Sensitivity Classes**				
Inherent runoff potential of catchment soils	Low (A and A/B)	Moderately low (B)	*Moderate (B/C)*	Moderately high (C)	High (C/D)

4.1.1.5. *The extent to which the HGM setting is characterised by subsurface water input*

At a rapid level, it is assumed that hillslope seepages are characterised by high levels of lateral input and floodplains by low levels while the other HGM types are characterised by intermediate inputs from subsurface water sources. A sensitivity score should therefore be based initially on the HGM type of the wetland being assessed (Table 10). Where site assessments are undertaken, or further detailed information is available, this assumption should be verified and sensitivity scores adjusted where required based on field observations.

Table 10 *– Sensitivity classes for assessing the extent to which the wetland (HGM) setting is generally characterised by subsurface water input*

Criterion	Sensitivity Classes				
The extent to which the wetland (HGM) setting is generally characterised by subsurface water input	High (Hillslope seepage)	Moderately high	*Intermediate (Remaining HGM types)*	Moderately low	Low (Floodplain)

4.1.1.6. *Perimeter-to-area ratio*

Determine both the area (ha) and approximate perimeter (m) of the wetland being assessed using GIS or Google Earth Pro™. The perimeter is then divided by the area (ha) to obtain a perimeter-to-area ratio. Use this to place the wetland into one of the classes indicated (Figure 8 and Table 11).

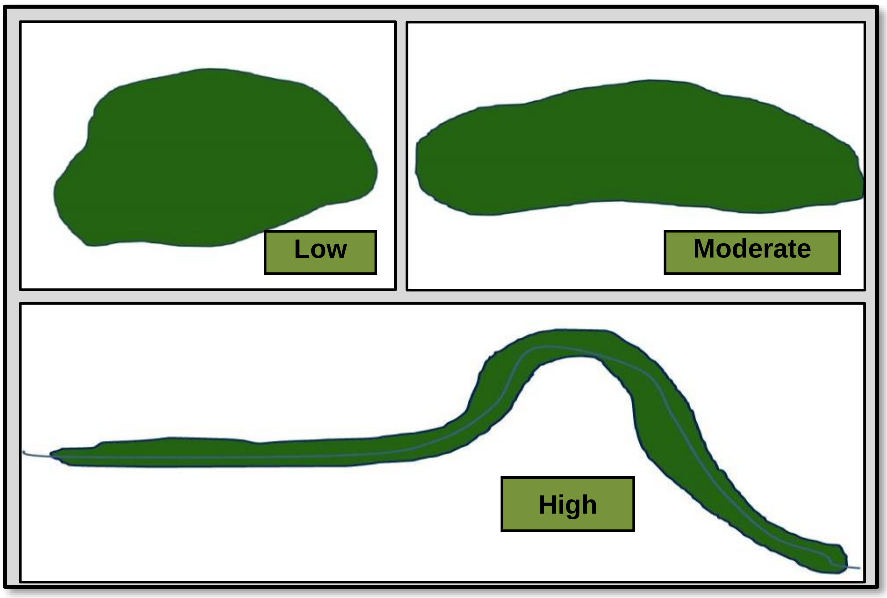


Figure 8 *– Illustration of different shaped wetlands and associated perimeter-to-area ratio sensitivity*

Table 11 *– Sensitivity classes for assessing the perimeter-to-area ratio*

Criterion	Sensitivity Classes				
Perimeter-to-area ratio	High (> 1600 m/ha)	Moderately high (1600-1201 m/ha)	*Moderate (1200-801 m/ha)*	Moderately low (800-401 m/ha)	Low (< 400 m/ha)

4.1.1.7. Vulnerability of the HGM type to sediment accumulation

Assign a sensitivity score based on the grouping of different HGM types as outlined in Table 12.

***Table 12** – Sensitivity of wetlands to changes in sediment inputs and turbidity based on HGM type*

Criterion	Sensitivity Classes				
Vulnerability of the HGM type to sediment accumulation	Depression – endorheic, flat	Depression – exorheic	*Hillslope seep, valley head seep, unchanneled valley bottom*	Channelled valley bottom	Floodplain wetland

4.1.1.8. Vulnerability of the wetland to erosion given the wetland's slope and size

The approximate longitudinal slope of the wetland must be estimated based on available information. This may include the use of contour data available from a topographical map, more detailed contour data or by coarsely estimating slope in Google Earth Pro™. To calculate longitudinal slope, simply estimate the change in elevation from the top to the bottom of the wetland, divide this value by the length of the wetland and convert into a percentage. Measurement of the approximate area of the wetland is based upon the method outlined in Section 4.1.1.1. The vulnerability score is then derived with reference to Figure 9, which assumes that wetland area is a proxy for discharge. The vulnerability score attained is used to place the wetland into one of the five classes indicated (Table 13).

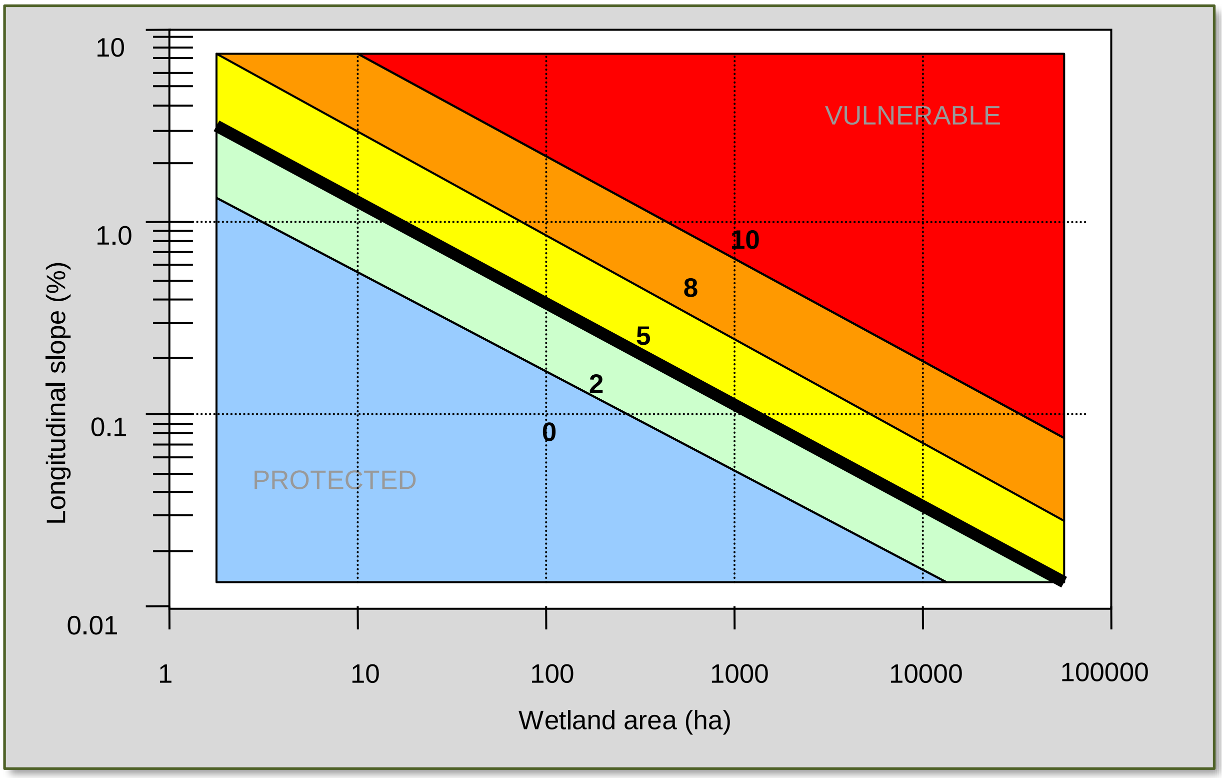


***Figure 9** – Vulnerability of HGM units to geomorphological impacts based on wetland size (a simple surrogate for mean annual runoff) and wetland longitudinal slope (Macfarlane et al., 2007)*[5]

[5] Take note that the Y-axis (longitudinal slope) uses a logarithmic scale.

Table 13 *– Sensitivity classes for assessing the vulnerability of a wetland to erosion given the wetland's slope and size*

Criterion	Sensitivity Classes				
Vulnerability of the site to erosion given the site's slope and size	High (Vulnerability score: 10)	Moderately high (Vulnerability score: 8)	*Moderate (Vulnerability score: 5)*	Moderately low (Vulnerability score: 2)	Low (Vulnerability score: 0)

4.1.1.9. Inherent level of nutrients in the landscape

The base status of natural soil fertility is used to broadly determine the inherent level of nutrients in the landscape. The natural fertility map (Turner, 2016) was derived from the original Agricultural Research Council – Institute for Soil, Climate and Water (ARC-ISCW) Soil Leaching Status map with five classes (Schoeman & Van der Walt, 2004). Based on the location of the proposed change in land use/activity, refer to the provided shapefile or KML format on the Buffer Zone website (https://sites.google.com/site/bufferzonehub/) (Figure 10) to estimate the natural fertility base status. This is then used as a basis for rating the inherent levels of nutrients in the landscape coarsely (Table 14).

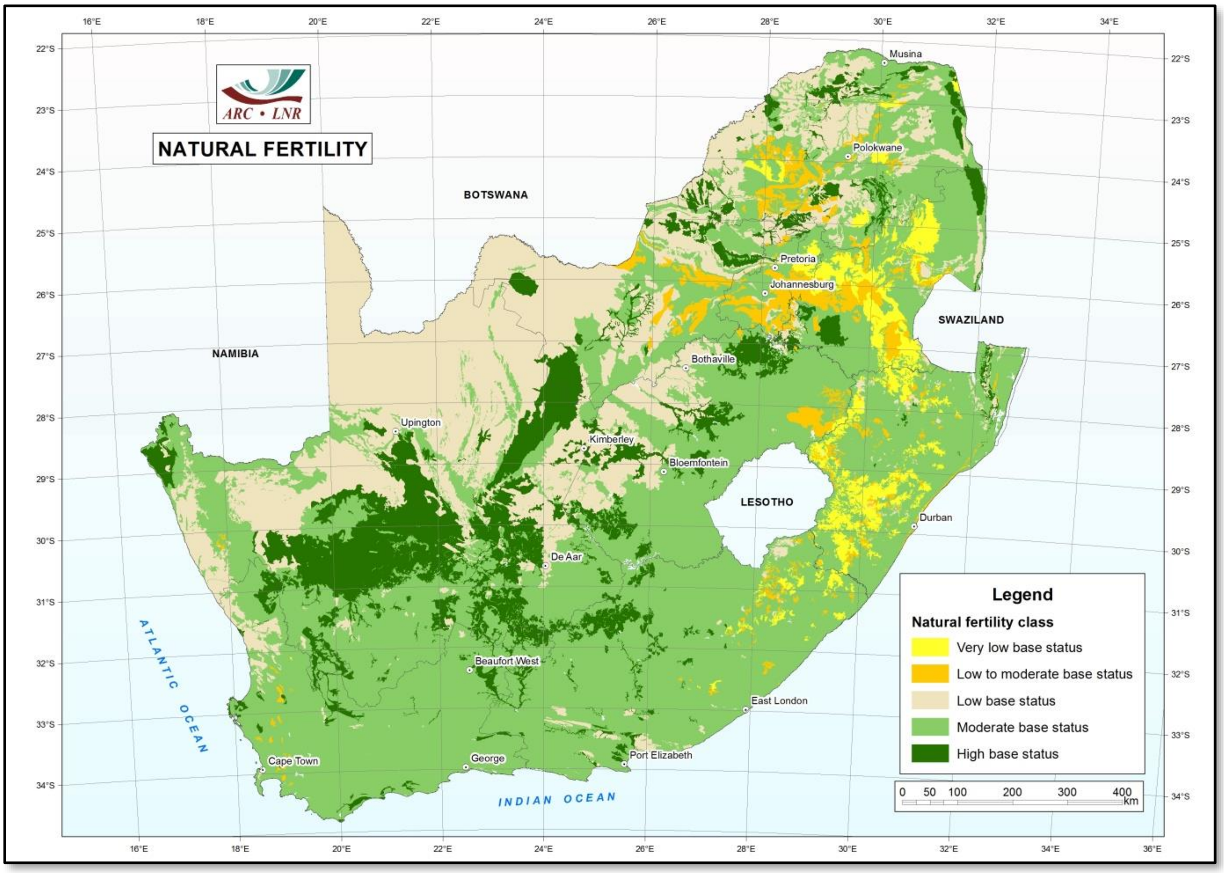


Figure 10 *– Natural soil fertility map (Turner, 2016)*

Table 14 *– Sensitivity classes for assessing the inherent level of nutrients in the landscape*

Criterion	**Sensitivity Classes**				
Inherent level of nutrients in the landscape: Is the river/stream and its catchment naturally fertile?	Very low base status	Low base status	Low to moderate base status	Moderate base status	High base status

4.1.1.10. MAP

The mean annual temperature zone is assessed for the wetland based on spatial layers provided (either in shapefile or KML format) on the Buffer Zone website (https://sites.google.com/site/bufferzonehub/) (Figure 11). A corresponding sensitivity score is then assigned based on the classes provided (Table 15).

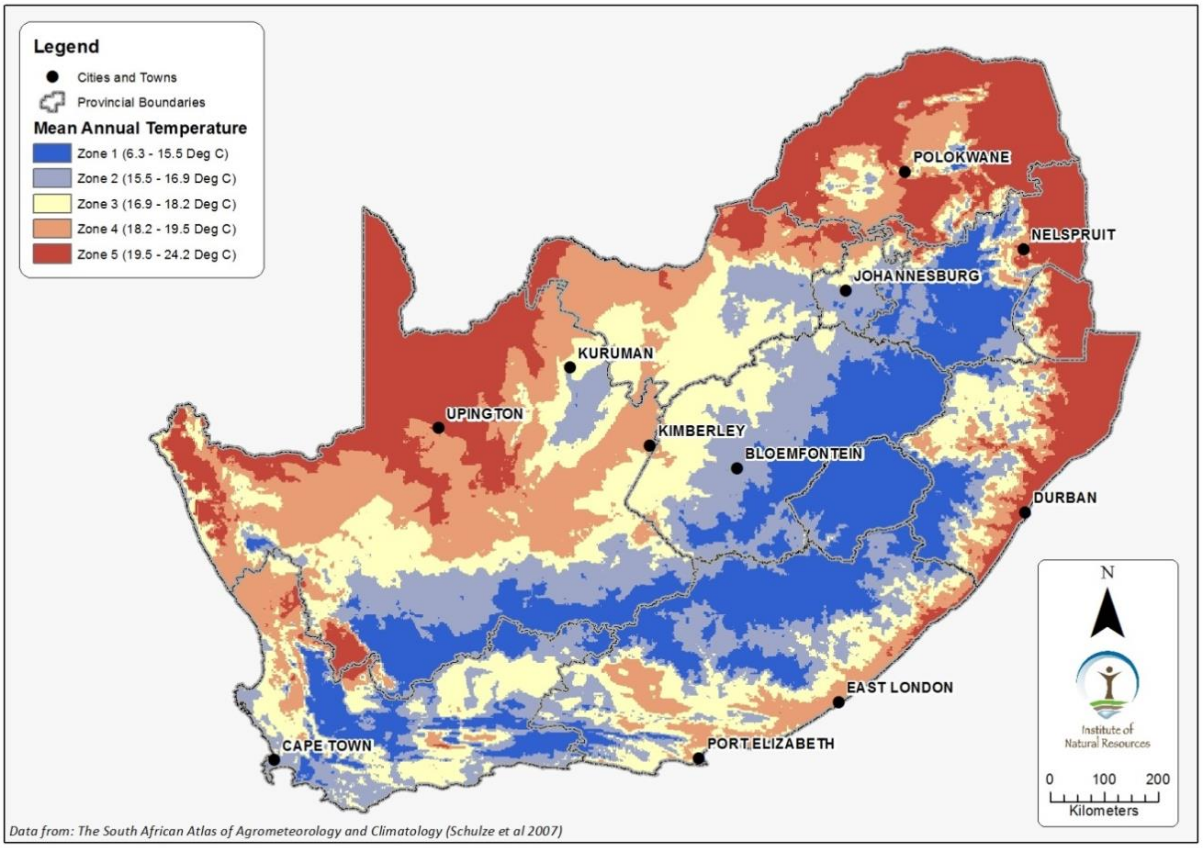


Figure 11 *– Mean annual temperature separated into five temperature zones based on five equal quantiles (data from Schulze, 2007)*

Table 15 *– Sensitivity classes based on mean annual temperature zones*

Criterion	**Sensitivity Classes**				
MAP	Zone 1 (6.3-15.5°C)	Zone 2 (15.5-16.9°C)	*Zone 3* *(16.9-18.2°C)*	Zone 4 (18.2-19.5°C)	Zone 5 (19.5-24.2°C)

4.1.1.11. Natural salinity levels

Based on the location of the proposed change in land use/activity, use the natural salinity levels spatial data (either shapefile or KML format) on the Buffer Zone website (https://sites.google.com/site/bufferzonehub/) (Figure 12) to estimate the likely salinity class out of the three broad categories (Table 16).

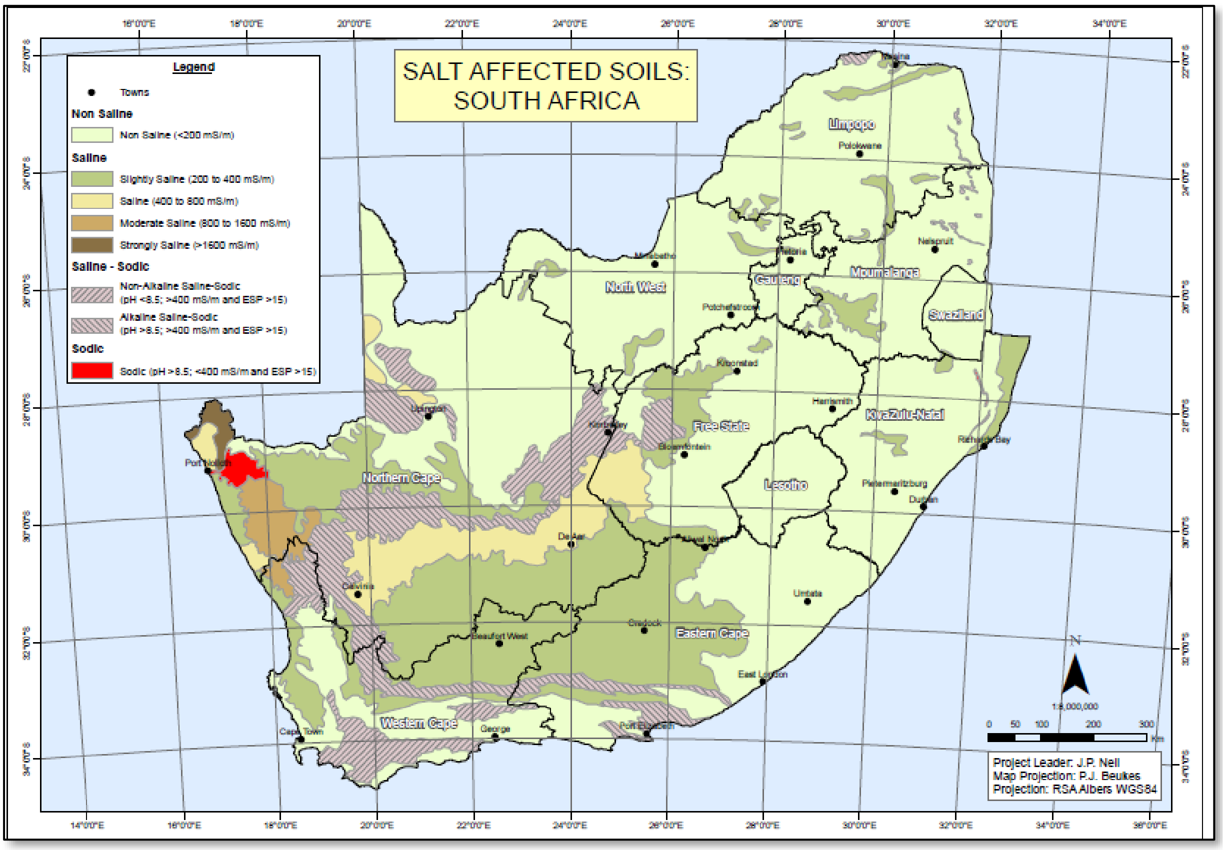


Figure 12 *– Salt-affected soils of South Africa (Nell, 2009)*

Table 16 *– Sensitivity classes based on natural salinity levels*

Criterion	**Sensitivity Classes**		
Natural salinity levels	*Non-saline (< 200 mS/m)*	Slightly saline (200-400 mS/m)	Saline and/or sodic (> 400 mS/m)

4.1.2. Field assessment

Although some sensitivity criteria can be assessed at desktop level, others must be assessed together with buffer zone attributes (Section 4) during a site visit. In the case of wetlands, eight individual criteria need to be assessed with reference to the methodologies outlined in this section of the report. It is important to point out that this assessment is undertaken based on an understanding of typical attributes of the HGM unit being assessed. However, in the case of very large wetlands that extend well beyond the development boundary, the assessment of vegetation and soil attributes should be based on observable wetland attributes adjacent to the planned development.

When undertaking field work, users are encouraged to print out the data capture sheet included in Annexure 1 and to populate this as they assess each criterion. Once captured, the information can be used to populate the Wetland Buffer Zone Tool.

4.1.2.1. Extent of open water in relation to the extent of the HGM unit

This assessment is informed by a rapid site assessment to estimate the average extent of open water (including any artificial impoundments) supporting submerged aquatic plants, fish and other aquatic life that may be sensitive to sediment and nutrient inputs. Where possible, this assessment should be supplemented with orthophoto maps or aerial photographs to understand the relative extent of the open water habitat in the HGM unit better. Once assessed, select the appropriate sensitivity class (Table 17).

Table 17 *– Sensitivity classes based on extent of open water in relation to the extent of HGM unit*

Criterion	**Sensitivity Classes**				
Extent of open water in relation to the extent of the HGM unit	High (> 9%)	Moderately high (7-9%)	*Moderate* *(4-6%)*	Low (0.5-3%)	Very low (< 0.5%)

4.1.2.2. Peat/high organic content versus mineral soils

Peat is defined as organic soil material with a particularly high organic matter content that, depending on the definition of peat, usually has more than 30% organic material (dry mass), is located in stable landscapes and requires permanently saturated conditions to form. Firstly, refer to the peatland database to check if peat has been recorded on-site. Secondly and more importantly, observe soil samples in the field. The presence of peat, Champagne soil form or high organic soil can generally be determined in the field based on observing the soil morphology and 'feeling' the soil sample in hand. Select the corresponding class (Table 18).

According to the initial findings of the WRC Peat Project (WRC Project K5/2346), a representative soil sample is:

- *"Peat where there is ≥ 30% organic material (dry mass) with depth at least 300 mm; 15-29% organic carbon with profile depth at least 300 mm.*
- *Champagne soil form where there is 9.1-14.49% organic carbon and an average of 10% organic carbon over a depth of 200 mm).*
- *High organic soils where there is 2-9.49% organic carbon over a profile depth of at least 100 mm."*

Table 18 *– Sensitivity classes for assessing the organic content of wetland soils*

Criterion	**Sensitivity Classes**		
Peat versus mineral soils	Peat/Champagne/high organic content	Mixed	Mineral

4.1.2.3. Sensitivity of the vegetation to burial under sediment

This assessment is based on observation during a rapid field visit of the growth form of the dominant plant species present in the HGM unit (Table 19). For the purposes of this assessment, the least sensitive vegetation includes robust, tall plants (such as trees, reeds and shrubs) that are unlikely to be affected negatively by high sediment inputs. Plant communities dominated by fast-colonising species (such as *Cynodon dactylon* and other creeping grasses) and plant communities characterised by low species diversity are generally regarded as being of low sensitivity. More sensitive communities are those characterised by short plants that can easily be smothered by sediment; plants that are slow growing (such as bulbous plants) and take time to colonise new areas; and plant communities with high natural diversity. The focus of this assessment is specifically on sensitive indigenous plant communities, so the occurrence of alien invasive species should not be considered. Should species of conservation concern be present that are likely to be highly sensitive to lateral impacts, these should be highlighted separately as part of the biodiversity assessment (Section 0).

Table 19 *– Sensitivity classes for vegetation to the burial under sediment*

Criterion	Sensitivity Classes				
Sensitivity of the vegetation to burial under sediment	High (short growing and slow colonising)	Moderately high	*Intermediate (moderate height and robustness OR plants typically fast colonising)*	Moderately low	Low (tall growing and fast colonising)

4.1.2.4. Sensitivity of the vegetation to increased availability of nutrients

This assessment is based on observation during a rapid field visit of the growth form of the dominant plant species present in the HGM unit (Table 19). Rating of this criterion is similar to Section 4.1.2.3. However, ratings should be more reliant on an understanding of the diversity of indigenous plants and their response to nutrient inputs[6] (Table 20). Particular note should be made of *Typha capensis*, which is known to proliferate under high nutrient levels and is therefore regarded as being of low sensitivity to nutrient inputs. Occurrence of alien invasive species should again not be considered.

Table 20 *– Sensitivity classes for vegetation to increased available nutrients*

Criterion	Sensitivity Classes				
Sensitivity of the vegetation to increased availability of nutrients	High (short and/or sparse vegetation cover with high natural diversity)	Moderately high	*Intermediate (short vegetation with moderate natural plant diversity)*	Moderately low	Low (tall and dense vegetation with low natural diversity)

[6] Note: Although little work has been done on the growth response of individual species to nutrients in South Africa, numerous studies have been undertaken in North America. Information on the response of many individual species to nutrients can be obtained from the National Database of Wetland Plant Tolerances at: http://www.epa.gov/owow/wetlands/bawwg/publicat.html#database1

4.1.2.5. *Sensitivity of the vegetation to toxic inputs, changes in acidity and salinity*

This assessment is based on observation during a rapid field visit of the growth form of the dominant plant species present in the HGM unit. In this instance, the assessment is based simply on an understanding of the diversity of indigenous wetland plants (Table 21). Occurrence of alien invasive species should again not be considered.

Table 21 *– Sensitivity classes for vegetation to toxic inputs, changes in acidity and salinity*

Criterion	Sensitivity Classes				
Sensitivity of the vegetation to toxic inputs, changes in acidity and salinity	High (high natural diversity)	Moderately high	*Intermediate (moderate natural plant diversity)*	Moderately low	Low (low natural diversity)

4.1.2.6. *Natural wetness regimes*

Natural levels of wetness are typically inferred from soil morphology (described from visual observations of soil samples extracted with a Dutch screw auger to a depth of 0.5 m) using the guidelines given in DWAF (2005). Knowledge of the hydric status of wetland plants can also provide a useful indication of wetness regimes in untransformed wetland areas (Table 22).

Table 22 *– Sensitivity classes based on natural wetness regimes*

Criterion	Sensitivity Classes				
Natural wetness regimes	Dominated by temporarily saturated soils	Mix of seasonal and temporarily saturated soils	*Dominated by seasonally saturated soils*	Mix of permanently and seasonally saturated soils	Dominated by permanently saturated soils

4.1.2.7. *Level of domestic, livestock and contact recreational use*

This assessment is based on an evaluation of land use around and directly downstream of water resources (within 5 km of the site). Where possible, this should be informed further by discussions with local stakeholders to establish the level of domestic, livestock and contact recreational water use (e.g. swimming and paddling) (Table 23).

Table 23 *– Sensitivity classes based on the level of domestic livestock and contact recreational use*

Criterion	Sensitivity Classes				
Level of domestic, livestock and contact recreational use	High	Moderately high	*Moderate*	Moderately low	Low

4.2. Determining the Sensitivity of Rivers and Streams

A range of indicators has been defined to assess the sensitivity of rivers to common threats posed by lateral land use impacts. This includes nine criteria that are assessed at desktop level and a further five criteria that are best assessed during a site visit. A summary of the criteria, indicating how they relate to different threat types is given in Table 24. Guidance on how to complete the desktop and field-based assessments is provided thereafter.

__Table 24__ – List of criteria and their relevance for determining the sensitivity of rivers to common threats posed by lateral land use impacts

	Criteria	Rivers Sensitivities from Lateral Inputs								
		Changes in water quantity	Changes in patterns of flow	Changes in sediment inputs and turbidity	Increased inputs of nutrients	Increases in toxic contaminants	Changes in acidity (pH)	Changes in concentration of salts	Changes in water temperature	Changes in pathogens
Desktop Assessment	Stream order	✓	✓		✓	✓	✓	✓	✓	
	Average catchment slope		✓	✓						
	The inherent runoff potential of catchment soils		✓	✓		✓				
	Longitudinal river zonation			✓					✓	
	Inherent erosion potential of catchment soils (K-factor)			✓	✓	✓				
	Inherent level of nutrients in the landscape				✓					
	Inherent buffering capacity						✓			
	Natural salinity levels							✓		
	Mean annual temperature	✓		✓	✓	✓	✓	✓		✓
In-field Assessment	Channel width	✓		✓	✓	✓	✓	✓		✓
	Perenniality	✓								
	Retention time				✓					
	River depth-to-width ratio								✓	✓
	Level of domestic, livestock and contact recreational use									✓

4.2.1. Desktop assessment

The desktop assessment should ideally be undertaken in the office and then be refined where necessary based on field investigations. This task involves mapping and interpreting a range of spatial datasets. It therefore requires the user to have experience in GIS or Google Maps™. A description of the method to be followed when assessing each criterion is provided here. Users are encouraged to print out the data capture sheet included in Annexure 2 and to populate this as they assess each criterion. Once captured, the information can be used to populate the Rivers Buffer Zone Tool.

4.2.1.1. Stream order

Using the Horton-Strahler stream ordering method for both perennial and non-perennial rivers, determine the stream order using 1:50 000 river coverage or 1:50 000 topographical maps to ascertain the stream order for the reach of river. Figure 13 illustrates how stream orders are incrementally determined relative to catchment position. This is a desktop procedure where stream order is manually determined using 1:50 000 topographical maps or river coverage in GIS. Alternatively, numbering may be derived using a GIS algorithm. Once stream order has been determined, assign the appropriate sensitivity class using Table 25[7].

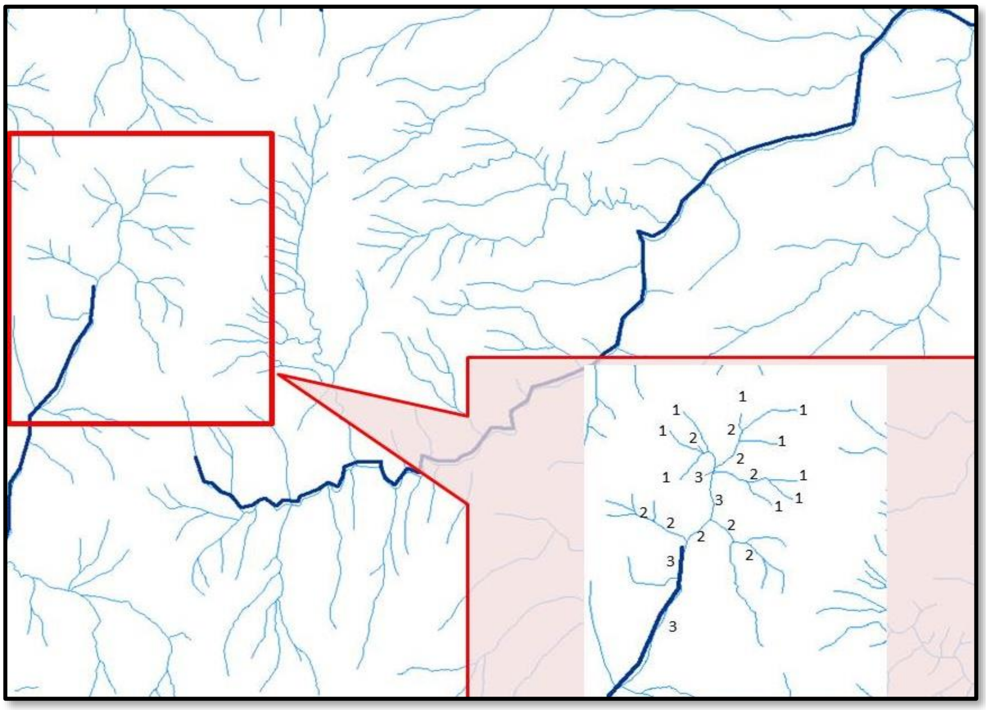


Figure 13 *– Illustration of how stream orders are determined incrementally*

Table 25 *– Sensitivity classes based on stream order*

Criterion	**Sensitivity Classes**				
Stream order	1st order	2nd order	*3rd order*	4th order	> 5th order

4.2.1.2. Average catchment slope

Refer to Section 4.1.1.3.

4.2.1.3. The inherent runoff potential of catchment soils

Refer to Section 4.1.1.4.

[7] Note that buffer zone guidelines are not prescriptively applied to “A” section channels. See the *Technical Guide* for further details on how such features should be handled.

4.2.1.4. *Longitudinal river zonation*

At desktop level, determine the suitable geomorphological classification of the river based on the classification system of Rowntree and Wadeson (2000) and establish which of the categories listed in Table 26 would best classify the river reach. In the case of large rivers, this information may be captured in existing datasets. Where information is not available, the slope of the river or stream can be estimated from topographical maps or using Google Earth Pro™. This classification should, however, be verified during the site visit where features such as channel substrate and depositional characteristics are considered in addition to longitudinal slope before allocating a final sensitivity class (

Table **27**).

Table 26 *– Broad geomorphological river classification (Rowntree and Wadeson, 2000)*

River Categories	Description
Mountain Stream	Steep to very steep gradients where gradients exceed 4% (includes mountain headwater streams). Substrates are generally dominated by bedrock and boulders, with cobbles or coarse gravels in pools.
Transitional River	Moderately steep stream dominated by bedrock and boulders; reach types include plain-bed, pool-riffle or pool-rapid; usually in confined or semi-confined valley. Characteristic gradient is 2-3.9%.
Upper Foothill River	Moderately steep, cobble bed or mixed bedrock-cobble bed channels, with plain-bed, pool-riffle or pool-rapid reach types; length of pools and riffles/rapids is similar. Characteristic gradient is 0.5-1.9%.
Lower Foothill River	Lower-gradient, mixed-bed alluvial channel with sand and gravel dominating the bed and may be locally bedrock controlled; reach types typically include pool-riffle or pool-rapid, with sand bars common in pools; pools are of significantly greater extent than rapids or riffles. Characteristic gradient is 0.1-0.5%.
Lowland River	Low-gradient, alluvial fine-bed channels, which may be confined, but fully developed meandering pattern within a distinct floodplain develops in unconfined reaches where there is increased silt content in bed or banks. Characteristic gradient is 0.01-0.1%.

Table 27 *– Sensitivity classes assigned for longitudinal river zonation*

Criterion	Sensitivity Classes				
Longitudinal river zonation	Upper foothill river	Transitional river	*Mountain stream*	Lower foothill river	Lowland river

4.2.1.5. *Inherent erosion potential of catchment soils (K-factor)*

Using the South African Atlas of Climatology and Agrohydrology (Schulze, 2007), determine the soil erodibility factor for the general catchment area within which the river reach occurs according to the corresponding soil erodibility classes and K-factors (Figure 14 and Table 28). For ease of use, soil erodibility K-factors are provided in both shapefile and KML format (https://sites.google.com/site/bufferzonehub/). For catchments characterised by more than one area of differing K-factors, an average area-weighted K-factor for the catchment will need to be determined.

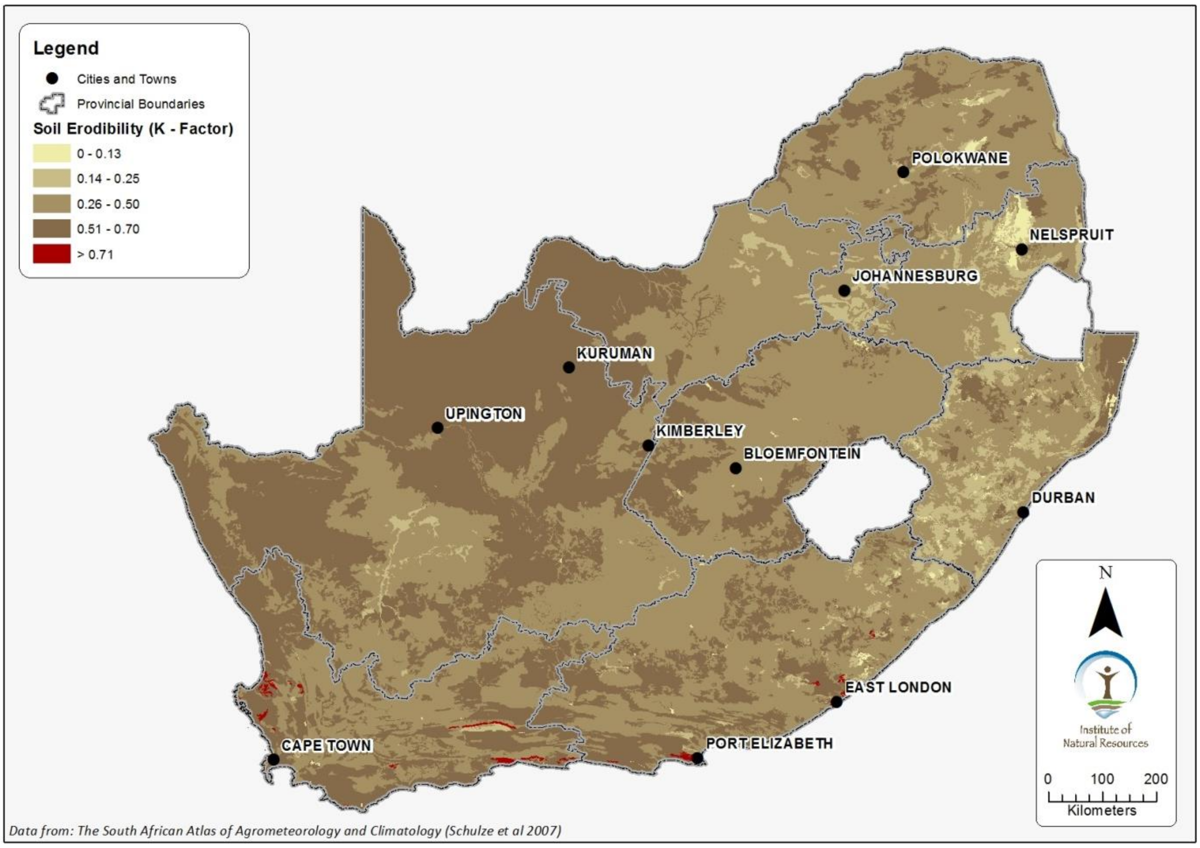


***Figure 14** – Soil erodibility (K-Factor) (Schulze, 2007)*

***Table 28** – Soil erodibility classes according to the prevailing soil K-factor*

Criterion	Sensitivity Classes				
Inherent erosion potential (K-factor) of catchment soils	< 0.13	0.13-0.25	*0.25-0.50*	0.50-0.70	> 0.70

4.2.1.6. Inherent level of nutrients in the landscape

Refer to Section 4.1.1.9.

4.2.1.7. Inherent buffering capacity

At desktop level, determine whether the river system has a low buffering capacity and is therefore sensitive to changes in pH (such as pure water) or has a high buffering capacity and is therefore less sensitive to changes in pH (such as 'hard' water rich in bicarbonate and carbonate ions) (Table 29). Refer to Day et al. (1998) (Figure 10, p. 195 and Table 2, p. 196) to broadly determine the relevant buffering capacity for the appropriate region (as groundwater is used as a surrogate for assessing buffering capacity at a regional level). For ease of use, the journal article is provided on the Buffer Zone website (https://sites.google.com/site/bufferzonehub/). Where additional information is available, *in situ* pH readings can be used as a reference to determine if the river's pH range is neutral or acidic (refer to Ollis et al., 2013).

Table 29 – *Sensitivity classes assigned for inherent buffering capacity*

Criterion	Sensitivity Classes		
Inherent buffering capacity	Pure waters with poor pH buffering	*Neutral pH*	'Hard' water rich in bicarbonate and carbonate ions or naturally acid waters high in organic acids

4.2.1.8. Natural salinity levels

Refer to Section 4.1.1.11.

4.2.1.9. Mean annual temperature

Refer to Section 4.1.1.10.

4.2.2. Field assessment

Although some sensitivity criteria can be assessed at desktop level, others must be assessed together with buffer zone attributes (Section 4) during a site visit. In the case of rivers, five individual criteria need to be assessed in accordance with the methodologies outlined in this section of the report. When undertaking field work, users are encouraged to print out the data capture sheet included in Annexure 2 and to populate this as they assess each criterion. Once captured, the information can be used to populate the Rivers Buffer Zone Tool.

4.2.2.1. Channel width

Widths of streams are grouped into five broad categories, obviating the need for detailed site-based measurements. Width is taken as the average distance between active channel banks along the river reach, which should be established during site visits or estimated based on measurements made from appropriate remote imagery such as that available on Google Earth™. The appropriate sensitivity score can then be assigned (Table 30).

Table 30 – *Sensitivity classes assigned based on channel width*

Criterion	Sensitivity Classes				
Channel width	< 1 m	1-5 m	*5-10 m*	10-20 m	> 20 m

4.2.2.2. Perenniality

At desktop level, perenniality may be interpreted from 1:50 000 topographical sheets, where rivers indicated with a solid line are considered to be perennial systems, and dotted lines represent non-perennial rivers (seasonal and intermittent) (Table 31). Distinction between seasonal and intermittent rivers is made where a seasonal river system consists of river systems that flow for extended periods during the wet season/s (generally between three and nine months), at intervals varying from less than a year to several years (Ollis et al., 2013). Intermittent rivers flow for a relatively short time of less than one season's duration (less than approximately three months) at intervals varying from less than a year to several years (Ollis et al., 2013). The perenniality of the watercourse can typically be identified by checking the stream bed for signs of wetness (linked to groundwater interaction) and the presence of hydric plant species in the active channel. In the case of intermittent streams, signs of wetness and hydric plant species may be absent.

Table 31 *– Sensitivity classes assigned based on perenniality*

Criterion	Sensitivity Classes		
Perenniality	Perennial systems (> 9 months)	*Seasonal systems (3-9 months)*	Intermittent systems (< 3 months)

4.2.2.3. Retention time

During the site visit, assess whether the section of river is generally free-flowing or slow moving during the rainy season (Table 32). In undertaking this assessment, note that the focus is essentially on differentiating between rivers dominated by pools and slow-flowing sections (which have a greater tendency for pollutants to accumulate) and more free-flowing rivers where pollutant inputs are likely to be washed through the system quickly.

Table 32 *– Sensitivity classes assigned for retention time*

Criterion	Sensitivity Classes	
Retention time	Generally free-flowing	Generally slow moving

4.2.2.4. River depth-to-width ratio

Conduct a rapid site assessment to determine the approximate depth and width of the river channel for the site, and then calculate the depth-to-width ratio (depth divided by width) (Table 33). The river depth should be assessed on typical (average) depths likely to be experienced in the active channel during the rainy season whereas the width is taken as that of the active channel.

Table 33 *– River depth-to-width sensitivity classes*

Criterion	Sensitivity Classes		
River depth-to-width ratio	Small < 0.25	Medium 0.25-0.75	Large > 0.75

4.2.2.5. Level of domestic, livestock and contact recreational use

Refer to Section 4.1.2.7.

4.3. Determining the Sensitivity of an Estuary

A range of indicators has been defined to assess the sensitivity of estuaries to common threats posed by lateral land use impacts. This includes six criteria that are assessed at desktop level, and a further three criteria that are best assessed during a site visit. A summary of the criteria indicating how they relate to different threat types is provided in Table 34. Guidance on how to complete the desktop and field-based assessments is provided thereafter.

Table 34 *– List of criteria and their relevance for determining the sensitivity of estuaries to common threats posed by lateral land use impacts*

Criteria		Sensitivities from Lateral Inputs								
		Changes in water quantity	**Changes in patterns of flow**	**Changes in sediment inputs and turbidity**	**Increased inputs of nutrients**	**Increases in toxic contaminants**	**Changes in acidity (pH)**	**Changes in concentration of salts**	**Changes in water temperature**	**Changes in pathogens**
Desktop Assessment	Estuary size	✓	✓	✓	✓	✓	✓	✓	✓	✓
	Estuary length	✓	✓	✓	✓	✓	✓	✓	✓	✓
	Inherent runoff potential of catchment soils		✓							
	Mouth closure as a measure of water exchange		✓	✓	✓	✓	✓	✓		
	Water clarity			✓	✓					
	Biogeographic zone								✓	
Some In-field Assessment Required	Perenniality of river inflows	✓								
	Presence of submerged macrophytes			✓	✓					
	Level of domestic, livestock and contact recreational use									✓

Note: *When delineating water resources in an estuarine environment, it is important to ensure that any freshwater wetland areas that extend beyond the supratidal zone are also mapped and included as part of the assessment. This is also relevant to estuaries dominated by freshwater inflows that therefore lack salt-tolerant plant species typical of most supratidal zones. In such instances, users may need to apply the Estuary Buffer Zone Tool to the main estuary body (and associated fringing wetland habitat) and apply the Wetland Buffer Zone Tool to fringing wetlands that are largely disconnected from tidal influence.*

4.3.1. Desktop assessment

The desktop assessment should ideally be undertaken in the office and then be refined where necessary based on field investigations. This task involves mapping and interpreting a range of spatial datasets and therefore requires the user to have experience in GIS or Google Maps™. A description of the method to be followed when assessing each criterion is provided here. Users are encouraged to print out the data capture sheet included in Annexure 3 and to populate this as they assess each criterion. Once captured, the information can be used to populate the Estuary Buffer Zone Tool.

4.3.1.1. Estuary size

A National Biodiversity Assessment (NBA) dataset is available for estuaries that includes an indication of the approximate size of each estuary based on the 5 m above mean sea level (AMSL) line (South African National Biodiversity Institute BiodiversityGIS (SANBI BGIS) or the tables provided on the Buffer Zone website https://sites.google.com/site/bufferzonehub/). Although this should provide a useful starting point, it may be necessary to check the approximate area of the estuary being assessed using more detailed contour data and available tools (such as GIS). Once the size of the estuary has been established, the corresponding sensitivity score is selected (Table 35).

Table 35 *– Sensitivity classes assigned for estuary size*

Criterion	**Sensitivity Classes**			
Estuary size	< 10 ha	*10-100 ha*	100-1000 ha	> 1000 ha

4.3.1.2. Estuary length

The length of all large estuaries is also available from the NBA dataset and can be used as a basis for scoring this criterion (refer to the tables provided on the Buffer Zone website https://sites.google.com/site/bufferzonehub/). If necessary, check the approximate length of the estuary being assessed using available tools (such as GIS) and determine the sensitivity score (Table 36).

Table 36 *– Sensitivity classes assigned for estuary length*

Criterion	**Sensitivity Classes**			
Estuary length	< 5 km	*5-10 km*	10-20 km	> 20 km

4.3.1.3. The inherent runoff potential of catchment soils

Refer to Section 4.1.1.4.

4.3.1.4. Mouth closure as a measure of water exchange

Use best available data to estimate the duration of mouth closure for a year (some guidance is provided in the tables on the Buffer Zone website https://sites.google.com/site/bufferzonehub/). This should ideally be informed by available studies and local knowledge. Where such information is lacking, Google Earth (2016) can be used to provide a coarse indication of the level of mouth closure (Figure 15 and Table 37).

Figure 15 *– Example of the use of Google Earth (2016) to estimate the approximate duration of mouth closure*

Table 37 *– Sensitivity classes assigned for mouth closure*

Criterion	Sensitivity Classes				
Mouth closure	> 81%	61-80%	*41-60%*	21-40%	< 20%

4.3.1.5. Water clarity

The NBA has classified all estuaries as 'clear', 'blackwater' or 'turbid' based on the quality of the freshwater inflow to the system. Users should therefore simply refer to the NBA dataset (refer to the tables provided on the Buffer Zone website https://sites.google.com/site/bufferzonehub/) and specifically to the classification of river water inflow types as an indication of estuary water clarity (Figure 16 and Table 38).

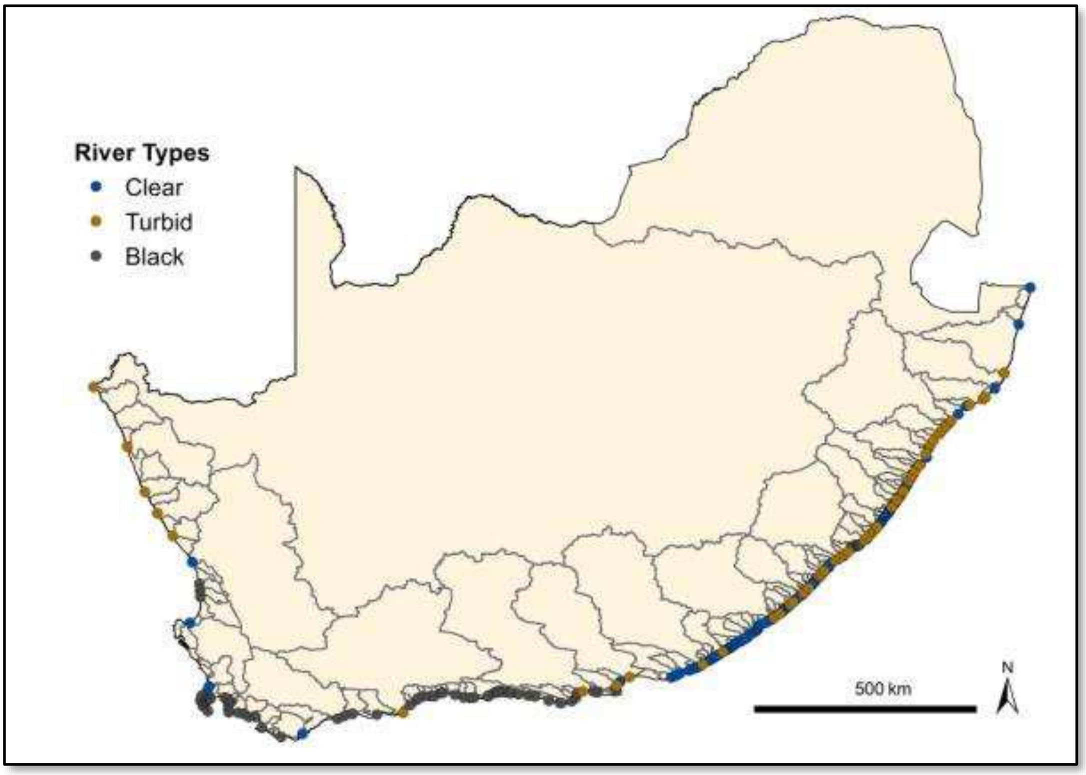


Figure 16 *– Dominant catchment type flowing into South Africa's estuaries (Van Niekerk & Turpie, 2012)*

Table 38 *– Sensitivity classes assigned for water clarity*

Criterion	Sensitivity Classes		
Water clarity	Clear	*Blackwater*	Turbid

4.3.1.6. Biogeographic zone

Determine the biogeographic zone in which the estuary is located using the map provided in Figure 17. This shows that all estuaries north of the Mbashe Estuary are subtropical, while those west of Heuningnes Estuary are cool temperate. Estuaries located in-between are classified as warm temperate estuaries (refer to the tables provided on the Buffer Zone website https://sites.google.com/site/bufferzonehub/; Table 39).

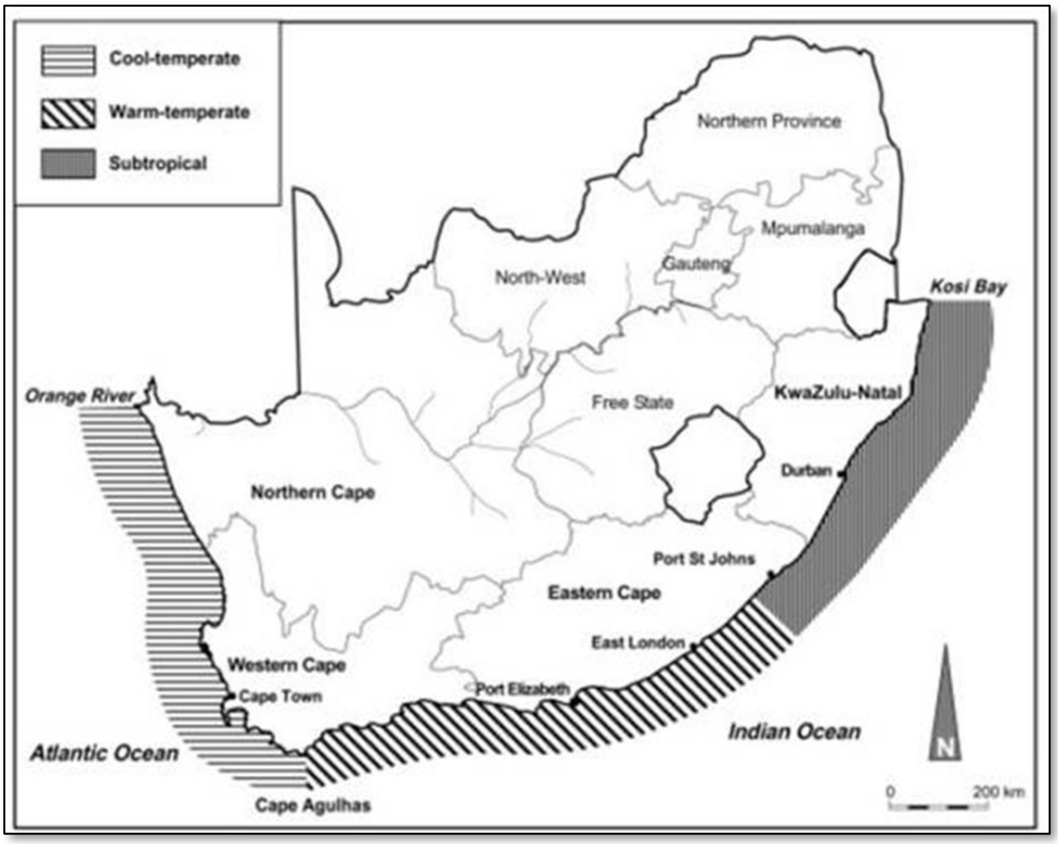


Figure 17 *– Map of biogeographic zones as used in the National Spatial Biodiversity Assessment (NSBA) for Estuarine Ecosystems (from Harrison, 2003)*

Table 39 *– Sensitivity classes assigned for biogeographic zones*

Criterion	Sensitivity Classes		
Biogeographic zone	Low latitude subtropical	*Moderate latitude warm temperate*	High latitude cool temperate

4.3.2. Field assessment

Although some sensitivity criteria can be assessed at desktop level, others must be assessed together with buffer zone attributes (Section 5) during a site visit. In the case of estuaries, three individual criteria need to be assessed in terms of the methodologies outlined in this section of the report. When undertaking field work, users are encouraged to print out the data capture sheet included in Annexure 3 and to populate this as they assess each criterion. Once captured, the information can be used to populate the Estuary Buffer Zone Tool.

4.3.2.1. Perenniality of river inflows

At desktop level, perenniality may be interpreted from 1:50 000 topographical sheets where rivers indicated with a solid line are considered to be perennial systems, and dotted lines represent non-perennial rivers (seasonal and intermittent) (Table 40). In the case on non-perennial systems, classification should be informed by local knowledge and guided by the definitions for 'intermittent' and 'seasonal' rivers provided.

Seasonal: *River systems that flow for extended periods during the wet season/s (generally between three and nine months), at intervals varying from less than a year to several years (Ollis et al., 2013).*

Intermittent: *Systems that flow for a relatively short time of less than one season's duration (less than approximately three months) at intervals varying from less than a year to several years (Ollis et al., 2013).*

Table 40 *– Sensitivity scores assigned for perenniality of river inflows*

Criterion	Sensitivity Classes		
Perenniality of river inflows	Intermittent	*Seasonal*	Perennial

4.3.2.2. Presence of submerged macrophytes

The NBA database is again used as a starting point for this assessment (refer to the relevant section of the estuarine technical report for the NBA (Van Niekerk & Turpie, 2012) provided on the Buffer Zone website https://sites.google.com/site/bufferzonehub/). This indicates those estuaries where submerged macrophytes are typically present. However, as estuaries are dynamic habitats that change in response to droughts and floods, this indicator should ideally be informed by site-based information. A conservative approach should be taken when scoring this criterion (Table 41).

Table 41 *– Sensitivity classes assigned for submerged macrophytes present*

Criterion	Sensitivity Classes	
Presence of submerged macrophytes	Yes	No

4.3.2.3. Level of domestic, livestock and contact recreational use

Refer to Section 4.1.2.7.

5. ASSESSING BUFFER ZONE CHARACTERISTICS

Prior to initiating this component of the assessment, it is critical that the starting line for aquatic impact buffer zones is first delineated in the field. In the case of rivers, this is the edge of the active channel or macro-channel floor, while in the case of wetlands and estuaries, it is the edge of the temporary zone and supratidal zone respectively. A systematic assessment of buffer zone attributes must then be undertaken to break the buffer zone into reasonably homogenous segments based on the four buffer zone attributes that need to be considered (Figure 18).

To undertake this assessment, variability in buffer zone attributes must be assessed during a site visit. In the case of small sites, it should be feasible to describe buffer attributes that reflect typical buffer characteristics for the site as a whole. In many instances, however, there may be significant variability in buffer zone characteristics that need to be accounted for. In this instance, existing buffer zones should be subdivided into discrete buffer segments with comparable buffer zone attributes. For practical purposes, these segments are typically > 100 m long but may need to be smaller in situations where buffer attributes vary significantly at a finer scale. The following approach to field work is advocated during site investigations:

- **Step 1:** Ensure that the water resource boundary has been delineated and is clearly understood (Refer to Technical Manual).
- **Step 2:** Ensure that the line from which the aquatic impact buffer zone is to be determined has been clearly delineated and can be identified in the field.
- **Step 3:** Consider the variability of the buffer slope around the delineated area and, if necessary, define separate buffer segments to cater for the different slope classes. (Note: this should be done initially at desktop level where contour information is available.)
- **Step 4:** Assess soil properties of buffer segments by taking soil samples along the potential buffer zone. When sampling the soil, focus on the top 20 cm that can be sampled using a soil auger. 'Average' soil permeability needs to be determined based on the soil textural class present. Take soil samples at approximately 5 m, 15 m and 30 m away from the delineated edge from where the aquatic impact buffer will be determined. These samples can either be mixed and assessed together, or assessed as three separate samples and then be used to define an 'average' textural class. This assessment should be repeated at regular intervals (for example 100 m) to identify any changes in textural attributes.
- **Step 5:** Identify any major changes in vegetation attributes along each buffer segment that will affect buffer zone effectiveness. Refine buffer segments accordingly (for example, differentiate between areas affected by cultivation versus intact grassland versus bare soil). When undertaking this assessment, consider options for rehabilitation and management prior to construction/operation and refine assessment units accordingly. When assessing vegetation attributes, preference should be given to the first 15 m of the buffer. If there is significant variation beyond this point, this may be used to refine your assessment.
- **Step 6:** Assess the microtopography of the buffer with a particular focus on identifying drains, gully erosion or the likes that may compromise buffer zone effectiveness. If necessary, refine buffer segments to cater for variations across the study area.
- **Step 7:** Ensure that buffer segments are clearly demarcated on your field map or by using a GPS. Document buffer zone attributes clearly for each segment.

Further guidance on assessing each of the buffer zone attributes is provided in this section of the report.

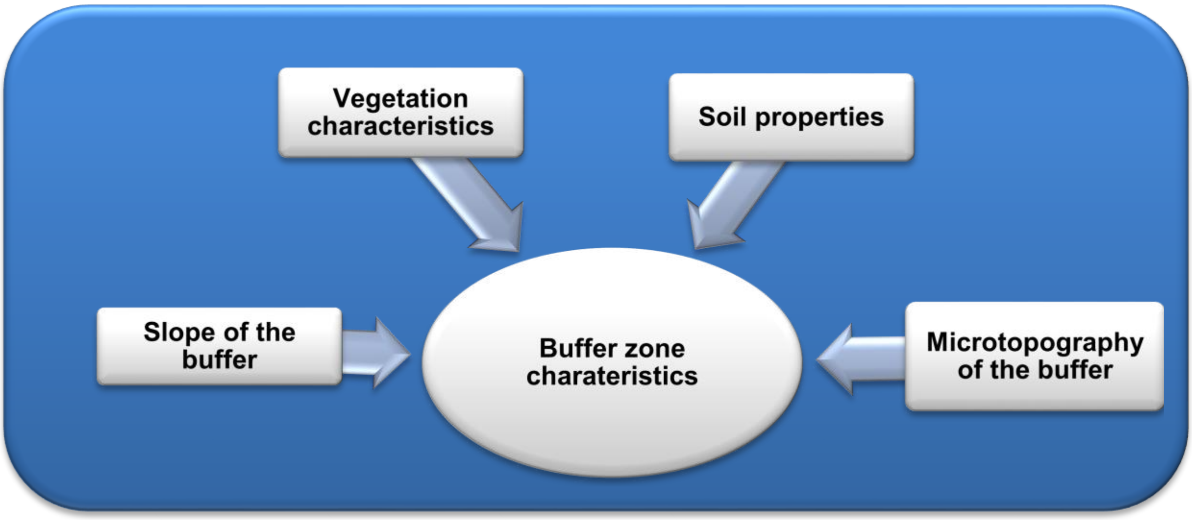


Figure 18 *– Key buffer zone characteristics important for determining an appropriate buffer zone*

5.1. Slope of the Buffer

Use a 1:10 000 topographic map or GIS with contour data of the study area to estimate the slope of the potential buffer associated with the proposed development (apply to area within *c.* 50 m of the edge of the water resource). If the steepest slope is less than 2%, all other slopes will be less than this, so no further calculations are required. If the slope is more than 2%, break the boundary of the water resource into units of variable slope classes as per the slope classes in Table 42.

Table 42 *– Slope classes used to assess buffer zone effectiveness*

Buffer Characteristic	Slope Class	Description
Slope of the buffer zone	Very gentle	0-2%
	Gentle	2.1-10%
	Moderate	*10.1-20%*
	Moderately steep	20.1-40%
	Steep	40.1-75%
	Very steep	> 75%

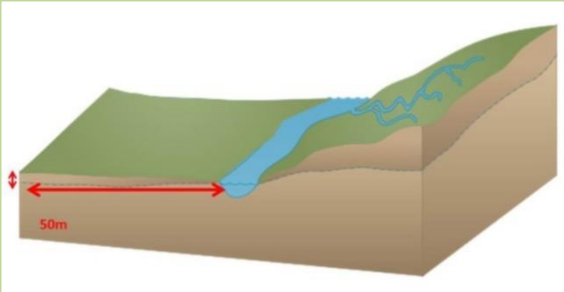
Slope is calculated by measuring the ratio of the horizontal distance between the lowest and highest contour on each slope and the vertical distance (difference between contour elevations). Slope is then expressed as a percentage as indicated in the text box and associated illustrations (Table 43).

If the horizontal distance is 50 m and the vertical distance is 0.5 m then:

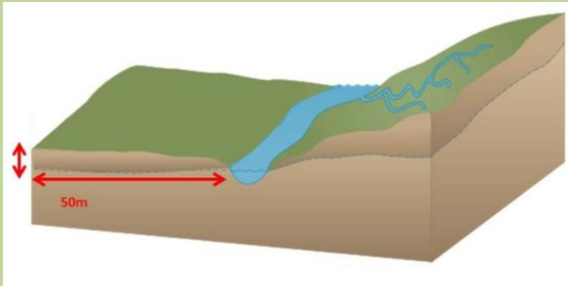
$$\text{Slope} = \frac{0.5}{50} \times 100$$

= 1%

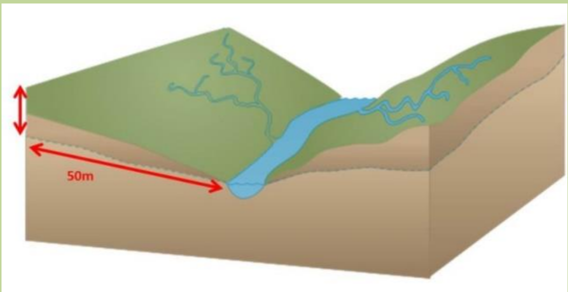
Table 43 *– Illustrations of slope classes*



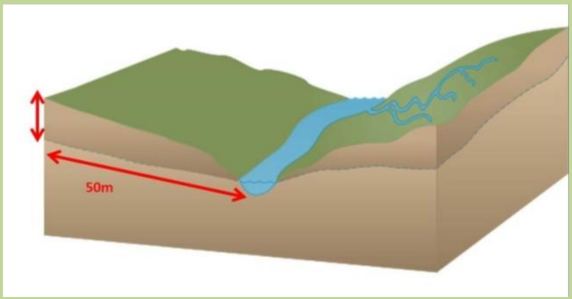
Very gentle slope with a vertical distance of between 0-1 m over *c.* 50 m of the edge of the delineated water course. Slope of 0-2%.



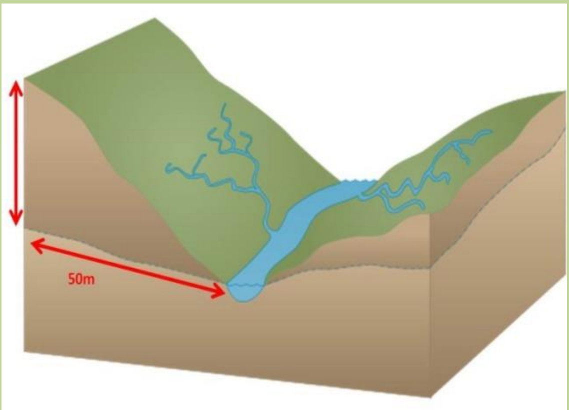
Gentle slope with a vertical distance of between 1.05-5 m over *c.* 50 m of the edge of the delineated water course. Slope of 2.1-10%.



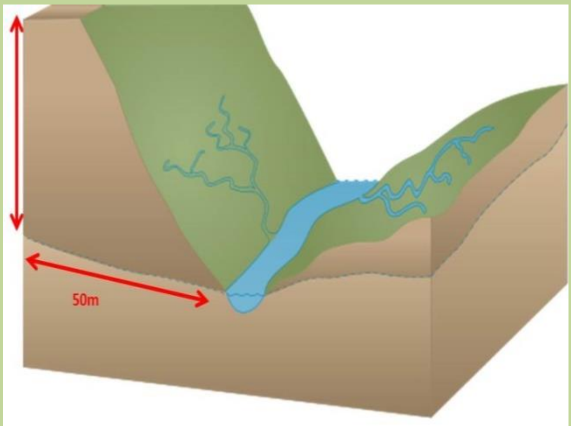
Moderate slope with a vertical distance of between 5.05-10 m over *c.* 50 m of the edge of the delineated water course. 10. Slope of 1-20%.



Moderately steep slope with a vertical distance of between 10.05-20 m over *c.* 50 m of the edge of the delineated water course. Slope of 20.1-40%.



Steep slope with a vertical distance of between 20.05-37 m over *c.* 50 m of the edge of the delineated water course. Slope of 40.1-75%.



Very steep slope with a vertical distance of greater than 37.5 m over *c.* 50 m of the edge of the delineated water course. Slope > 75%.

Note: *Where steps have been artificially created down a slope (such as those created through contour ploughing), the slope class can be adjusted downwards by one class.*

5.2. Vegetation Characteristics

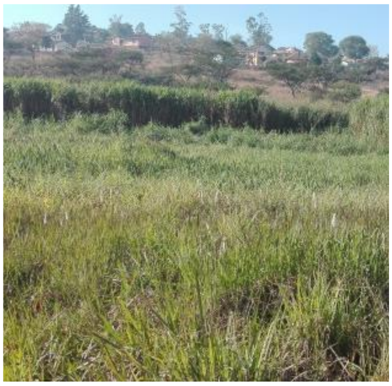
Assess current vegetation characteristics by specifically considering how well the vegetation is likely to slow down flows from shallow runoff during storm events. Key attributes to consider include the robustness of the vegetation (Will it provide a barrier to flow? Will it bend over and provide little resistance?) and interception potential, which is linked primarily to ground cover. The presence of plant litter at the soil surface should also be considered as this may also help to slow flows (Table 44 and Table 45).

Table 44 *– Vegetation characteristics used to assess buffer zone effectiveness*

Buffer Characteristic	Class	Description
Vegetation Characteristics	Ideal	Robust vegetation with high interception potential (vetiver grass filter strips/dense tall grass stands)
	Good	*Moderately robust vegetation with good interception potential (good condition tufted grass stands)*
	Fair	Moderately robust vegetation with fair interception (tufted grass stands but with lowered basal cover) OR less robust vegetation with very good interception (kikuyu pasture)
	Poor	Vegetation either short (< 5 cm) (maintained lawns) or robust but widely spaced plants with poor interception (e.g. trees or shrubs with poorly vegetated understory)
	Very poor	Vegetation either very short (< 2 cm) offering little resistance to flow or sparse and providing poor interception (e.g. degraded grasslands with very poor basal cover)

Note: *For the* ***construction phase****, the assessment should be based on current vegetation attributes. In situations where the buffer is degraded, simply 'protecting' a buffer with a set width may fail to provide the necessary characteristics to protect adjacent water resources. As such, management should aim to restore the buffer to a more naturally vegetated condition through the operational phase. The applicant therefore has the option of improving the buffer's vegetation attributes to minimise buffer requirements or foregoing buffer restoration and providing a wider but poorly vegetated buffer. If buffer restoration is adopted, the buffer should ideally be vegetated with native plant communities appropriate for the ecoregion or with a plant community that provides similar functions. Depending on the agreed approach, the appropriate class should be selected to calculate* ***operational phase*** *buffer zone requirements.*

__Table 45__ – Photographs and descriptions to aid in assessing vegetation characteristics

Vegetation Characteristics		Description
Ideal	 	Robust vegetation with high interception potential (such as vetiver grass filter strips/dense tall grass stands).
Good	 	Moderately robust vegetation with good interception potential (such as good condition tufted grass stands).
Fair	 	Moderately robust vegetation with fair interception (such as tufted grass stands but with lowered basal cover) OR less robust vegetation with very good interception (such as kikuyu pasture).
Poor	 	Vegetation either short (< 5 cm) (such as maintained lawns) or robust but with widely spaced plants with poor interception (such as trees or shrubs with poorly vegetated understory).

Vegetation Characteristics		Description
Very poor	 	Vegetation either very short (< 2 cm) offering little resistance to flow or sparse and providing poor interception (such as degraded grasslands with very poor basal cover).

5.3. Soil Properties

When sampling soil, focus on the top 20-30 cm that can be sampled using a simple soil auger. 'Average' soil permeability needs to be determined based on the soil textural class present. This can be estimated by taking and assessing soil samples at approximately 5 m, 15 m and 30 m away from the delineated edge. To undertake this assessment, take a small handful of soil (it should fit in the palm of your hand) and add sufficient water to work it in your hand to a state of maximum stickiness, breaking up any lumps that may be present. Now try to form the soil into a coherent ball. If this is impossible or very difficult (the ball collapses easily), then the soil is sand or loamy sand. If the ball forms easily but collapses when pressed between the thumb and the forefinger, then the soil is sandy loam. If the soil can be rolled into a thread but cracks when bent, then the soil is loam. If the thread can be bent without cracking and it feels slightly gritty, then the soil is clay loam, but if it feels very smooth, then the soil is clay (Figure 19). Once the soil texture has been established, use this information together with observations of soil surface conditions (such as shrinking cracks, earthworm channels) to place the soils into one of four classes (Table 46). Soil depth is another important aspect affecting permeability and is therefore used to adjust the permeability class in instances where soil depth is shallower than 30 cm.

Table 46 *– Buffer zone classes used to assess soil properties/characteristics*

Buffer Characteristic	Class	Description
Soil permeability	Low	Deep fine textured soils with low permeability (such as clay, sandy clay and clay loam) OR shallow (< 30 cm) soils with low to moderately low permeability
	Moderately low	Deep moderately fine textured soils (such as loam and sandy clay loam) OR shallow (< 30 cm) moderately drained soils
	Moderate	*Deep moderately textured soils (such as sandy loam) OR shallow (< 30 cm) well-drained soils*
	High	Deep well-drained soils (such as sand and loamy sand)

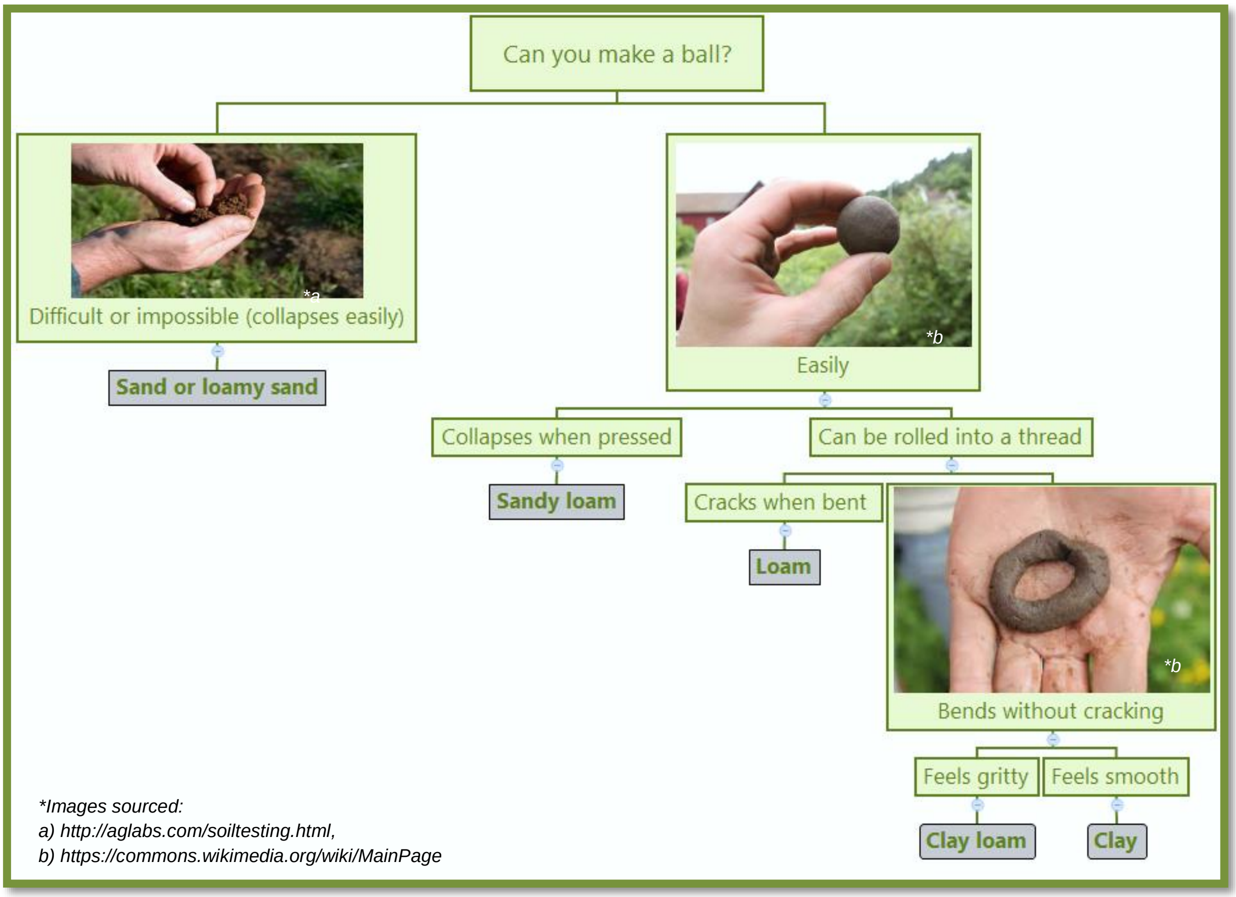


***Figure 19** – Flow chart to determine soil texture in the field (adapted from Ollis et al., 2013)*

***Note:** A more comprehensive guide for assessing soil texture can be found in Section 7.4.2 (particularly "Box 24: How to determine soil texture in the field") on p. 54 of Ollis, D.J., Snaddon, C.D., Job, N.M. and Mbona, N., 2012: Classification system for wetlands and other aquatic ecosystems in South Africa. User Manual: Inland Systems. SANBI Biodiversity Series 22. South African National Biodiversity Institute, Pretoria.*

5.4. Microtopography of the Buffer

Using Figure 20 and Table 47 as a guide, assess the uniformity of the microtopography within the buffer zone with a particular focus on identifying any areas characterised by concentrated flow paths, which can reduce buffer zone effectiveness. Note that unless topography in the buffer zone is steep and/or vegetation cover is poor, topography is typically classified as uniform to dominantly uniform. If significant variation exists, each area will need to be assessed as separate buffer segments.

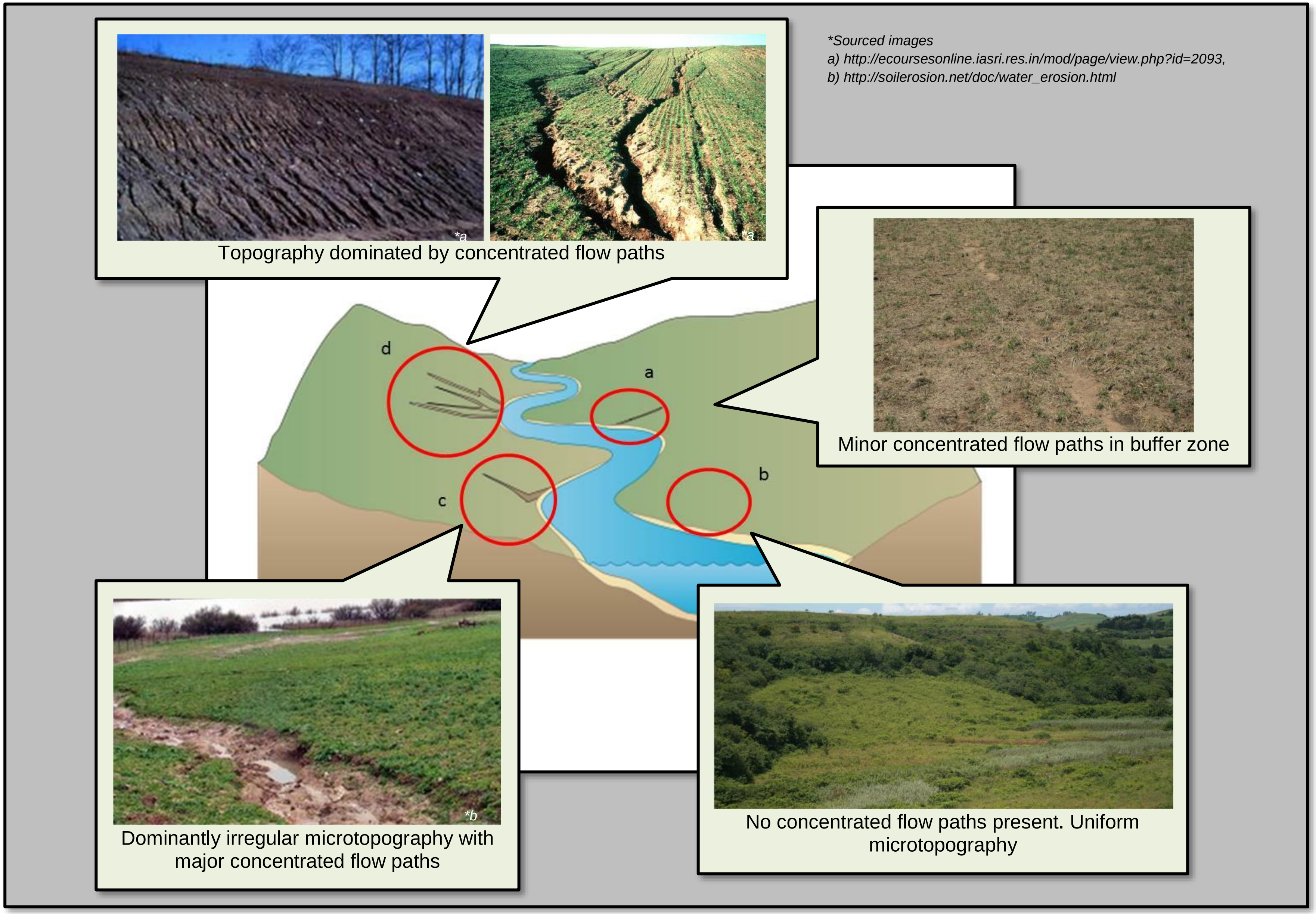


Figure 20 *– Photographs and descriptions to aid in assessing microtopography of the buffer zone*

Table 47 – *Classes used to assess the microtopography of the buffer zone*

Buffer Characteristic	Class	Description
Microtopography of the buffer zone	Uniform topography	Smooth topography with no concentrated flow paths anticipated
	Dominantly uniform topography	*Dominantly smooth topography with few/minor concentrated flow paths to reduce interception*
	Dominantly non-uniform topography	Dominantly irregular topography with some major concentrated flow paths (such as erosion gullies and drains) that will substantially reduce interception
	Concentrated flow paths dominate	Area of topography dominated by concentrated flow paths (i.e. depression, erosion gullies, drains)

6. CATERING FOR BIODIVERSITY PROTECTION (STEP 5)

Although the protection of riparian areas and aquatic impact buffer zones may be adequate to protect many aquatic species, such buffers may be insufficient to protect the range of aquatic and semi-aquatic species that rely on terrestrial habitat for their survival. It is therefore important that a range of additional aspects are considered to ensure that requirements for biodiversity protection are adequately catered for in development planning.

A critical aspect that needs to be considered specifically as part of the process to determine aquatic impact buffers is the sensitivity of important biodiversity elements to threats posed by lateral land use impacts. It is therefore important to reassess the sensitivity scores used to define aquatic impact buffer requirements and to adjust these if necessary to account for the susceptibility (sensitivity) of biodiversity elements to lateral impacts.

Practically, this requires the assessor to manually include a sensitivity rating for biodiversity in the accompanying Buffer Zone Tool in instances where the sensitivity of biota is likely to be higher than that of the water resource. A written justification for increasing the sensitivity to cater for any important biodiversity elements, including special habitats and species of conservation concern, should then be provided as indicated in the hypothetical example provided in Table 48.

Table 48 – *Hypothetical example of how to increase sensitivity ratings for biodiversity in the Buffer Zone Tools*

Threat posed by the proposed land use/activity		Sensitivity		Site-based risk class[8]	Justification for changes in threat ratings
		Water resource	Biodiversity		
Construction Phase	1. Alteration to flow volumes	VL		L	
	2. Alteration of patterns of flows (increased flood peaks)	L		VL	

[8] Note that the risk class is also informed by the threat rating for the proposed development, which is not indicated in this table.

Threat posed by the proposed land use/activity	Sensitivity		Site-based risk class[8]	Justification for changes in threat ratings
	Water resource	Biodiversity		
3. Increase in sediment inputs and turbidity	L	H	M	**Hypothetical example of justification**: Despite the low sensitivity of this floodplain system to sediment inputs, an important population of endangered plant species occurs directly down-slope of the proposed development. This could potentially be impacted significantly if stringent sediment control measures are not put in place. The biodiversity sensitivity rating has been increased accordingly.
4. Increased nutrient inputs	L	H	H	As above – plants are also likely to be sensitive to increases in nutrient inputs.
5. Inputs of toxic organic contaminants	L		M	
6. Inputs of toxic heavy metal contaminants	L		L	
7. Alteration of acidity (pH)	L		L	
8. Increased inputs of salts (salinization)	L		M	
9. Change (elevation) of water temperature	L		L	
10. Pathogen inputs (such as disease-causing organisms)	L		L	

Further guidance is provided in the Technical Manual, but it is important that responses to the following specific questions are also documented in the Buffer Zone Tools:

- Have important biodiversity elements been flagged for specific consideration?
- Has a survey been undertaken to verify occurrence and to establish the need to cater for these in development planning?
- Have core areas required to protect any species of conservation concern been identified and mapped?
- Have additional biodiversity buffers been defined to protect core areas and important habitat from outside disturbances?

- Could the planned development/activity affect an important local or regional ecological corridor?
- If connectivity is important, have corridor design guidelines been considered when defining corridor requirements?
- Have terrestrial habitat protection and management been considered?

When completing the *Buffer Zone Tools*, the assessor is simply required to answer 'Yes' or 'No' to each question and to include a brief comment to justify why any aspects were not considered. Note that further detail on any assessments undertaken, together with details of management zones recommended for biodiversity protection, need to be documented in the accompanying specialist report.

7. DELINEATING AND DEMARCATING BUFFER ZONE REQUIREMENTS (STEP 6)

The process of mapping buffers requires the use of GIS software, such as ArcGIS™ or QGIS™, which have tools to buffer mapped features. Although it is relatively simple to create a single buffer for the relevant feature (e.g. the boundary of a wetland, the active or macro-channel of a river, or the upper edge of the supratidal zone of an estuary), it becomes a little more challenging when there are multiple buffer distances that need to be mapped to determine the final buffer zone.

The division of the aquatic impact buffer zone into similar segments according to the varying buffer characteristics (slope, topography, vegetation and soil), the inclusion of buffer zone requirements from a biodiversity perspective (core habitats or corridors), or (in the case of some river systems) the inclusion of a riparian management zone, will all result in the user being required to map multiple buffer distances to determine the final buffer zone. Different approaches are recommended for the mapping of a simple buffer zone and a buffer zone that comprises multiple segments.

The different approaches recommended are:

- For a simple/single buffer distance – use GIS software tools that allow a user to select a **specific buffer width** (for example, a 30 m buffer for the resource being assessed).
- For multiple buffer segments/requirements – use GIS software tools that allow a user to buffer according to **attributes** for the feature that needs be buffered (for example, the edge of a large wetland needs to be buffered with five different buffer widths because of the buffer segments identified). It is recommended that buffering according to attributes should be the process followed when multiple buffers are required to establish an accurate final buffer zone.

Mapping Tip: Ensure that the 'End Type' in the GIS software used is set to rounded whilst running the buffer tool. This will avoid gaps occurring between the different buffer segments and ensure the boundary is continuous with a gradual change in buffer width between segments.

When mapping a buffer zone, it is important to remember that the buffer is only applicable to the land use/activity being assessed. Buffer zones should be clipped for the 'target area' only. Figure 21 shows a final buffer zone for an activity adjacent to a water resource that considers an aquatic impact buffer for the activity and biodiversity buffer requirements that may include aspects such as a core habitat area and an additional biodiversity buffer requirement for the core habitat.

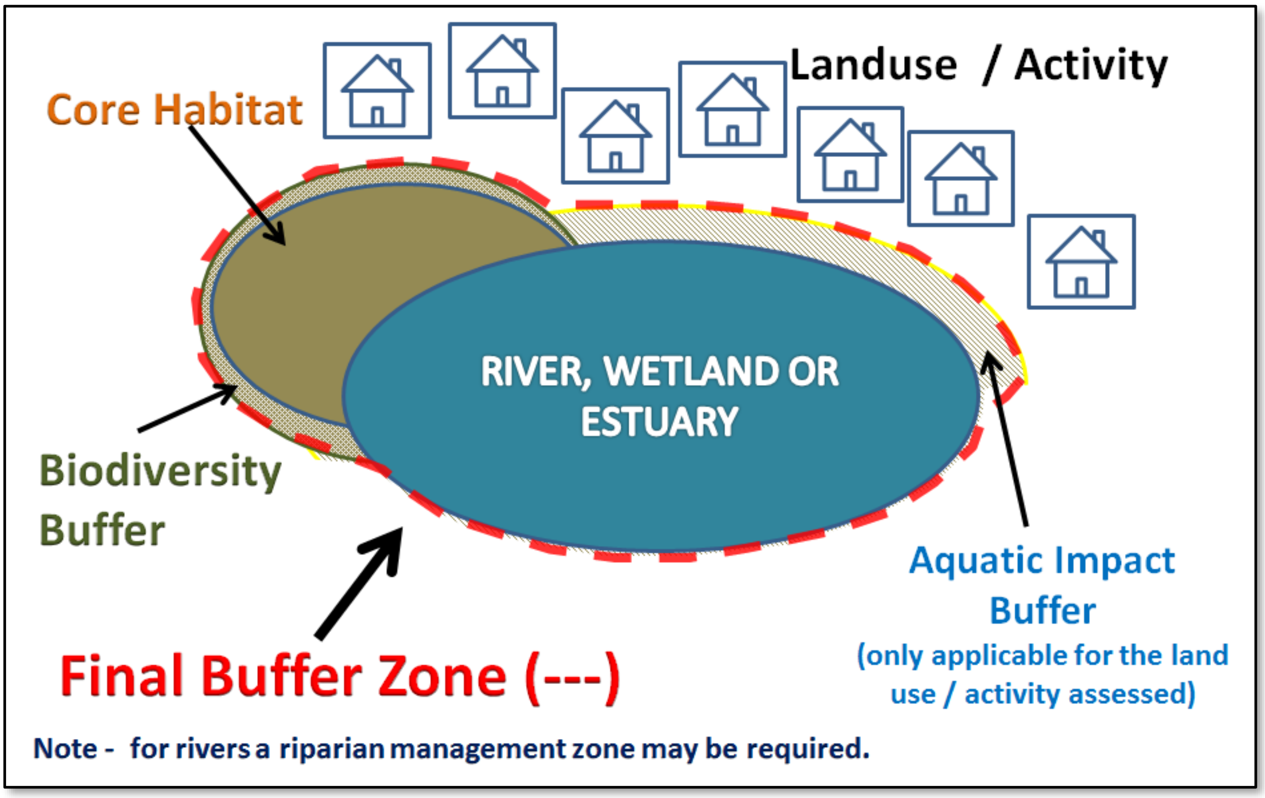


***Figure 21** – Final buffer zone for an activity adjacent to a water resource*

There is also a requirement to run through a basic checklist in the Buffer Zone Tools to confirm that the range of important aspects relating to buffer zone delineation and demarcation discussed in the Technical Manual have been adequately addressed. Key questions include:

- Has the water resource boundary been delineated?
- Has the delineation line for aquatic impact buffers been delineated?
- Have final aquatic impact buffer zones been mapped?
- Have setback requirements for water resource protection been delineated based on the maximum of the above?
- Have core areas, biodiversity buffers and biodiversity corridors been mapped?
- Is there a need for hydrological buffers to cater for potential groundwater impacts?
- Have additional restrictions relating to flood risk, erosion and climate change been accounted for?
- Have additional practical management considerations been considered?
- Have additional guidelines for special habitats such as forest habitats been considered?
- Have aesthetic considerations been considered and accounted for?
- Have recreational use values been considered and accounted for?

When completing the Buffer Zone Tools, the assessor is simply required to answer 'Yes' or 'No' to each question and to include a brief comment to support or justify the response as necessary.

8. DEFINING MANAGEMENT REQUIREMENTS (STEP 7)

Once a final buffer zone area has been determined, appropriate management measures need to be documented to ensure that the water quality enhancement and other buffer zone functions (including biodiversity protection) are maintained or enhanced. Key questions that need to be answered as part of the Buffer Zone Tools include:

- Has demarcation of setback areas been considered?
- Have management measures, necessary to maintain the functioning of setback areas, been defined?
- Have buffer management requirements been tailored to account for biodiversity protection?
- Has specific consideration has been given to integration of social imperatives, including access and use of buffer zones and how such use will be managed?
- Have management measures to ensure the continued functioning of additional mitigation measures been defined?

When completing the Buffer Zone Tools, the assessor is simply required to answer 'Yes' or 'No' to each question and to include a brief comment to indicate relevant information as necessary. These measures should ideally be integrated into the Environmental Management Plan (EMP) for the proposed development, as this includes a requirement to assign clear responsibilities for buffer zone management during both the construction and operation phases. The user is also encouraged to refer to the Technical Manual to obtain further background and guidance on how to ensure that management requirements are adequately defined.

9. DOCUMENTING MONITORING REQUIREMENTS (STEP 8)

Successful implementation will require regular monitoring of implementation to ensure that mitigation measures are effective. Although this aspect of the assessment has to be considered carefully, the assessor is simply required to indicate whether or not the following two aspects have been addressed in the relevant Buffer Zone Tool:

- Have construction phase monitoring requirements been defined?
- Have operational phase monitoring requirements been defined?

Specific monitoring requirements must be defined in the accompanying specialist report and integrated into the EMP for the proposed development.

10. CONCLUSION

The Practical Guide has been developed to provide users of the Buffer Zone Tools with the key information required to make informed and consistent decisions when determining appropriate buffer zones. A key focus of this document has been to provide clear supplementary guidance to allow users to consistently collect the information necessary to determine buffer zone requirements. It is important to note that this guide must be used together with the accompanying Technical Manual, which provides a range of additional supplementary information, particularly in relation to biodiversity protection and buffer zone management.

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Van Niekerk, L. and Turpie, J.K. (eds). (2012). South African National Biodiversity Assessment 2011: Technical Report. Volume 3: Estuary Component. CSIR Report No. CSIR/NRE/ECOS/ER/2011/ 0045/B. Council for Scientific and Industrial Research, Stellenbosch.

GLOSSARY[9]

Acidic:	Where the pH of water is less than 6.
Active channel:	The portion of river that conveys flowing water at sufficiently regular intervals to maintain channel form (the presence of distinct bed and banks) and keep the channel free of established terrestrial vegetation.
Alkaline:	Where the pH of water is greater than 8.
Anthropogenic:	Of, relating to, or resulting from, the influence of human beings on nature.
Aquatic impact buffer zone:	A buffer zone which acts as a barrier between human activities and sensitive water resources thereby protecting resource from adverse negative impacts.
Bedrock:	The solid rock that underlies unconsolidated material such as soil, sand, clay or gravel.
Biodiversity buffer zone:	A buffer zone designed to adequately mitigate adverse effects of adjacent land use activities on important biodiversity features.
Biodiversity corridor:	Typically, linear habitats that differ from a more extensive surrounding matrix, designed to link one or more patches of habitat to improve species movement and dispersal.
Braided river:	A stream with multiple channels that interweave as a result of division and rejoining of flow around interchannel bars, resembling (in plain view) the strands of a complex braid.
Buffer zone:	A strip of land with a use, function or zoning specifically designed to protect one area of land against impacts from another.
Catchment:	The land area from which water runs off into a specific wetland or aquatic ecosystem; a drainage basin.
Channel:	The part of a river bed containing its main current, naturally shaped by the force of water flowing within it.
Channelled valley bottom wetland:	A valley bottom wetland with a river channel running through it. Channelled valley bottom wetlands are characterised by their position on valley floors and the absence of characteristic floodplain features. Dominant water inputs to these wetlands are from the river channel flowing through the wetland, either as surface flow resulting from flooding or as subsurface flow, and/or from adjacent valley-side slopes (as overland flow or interflow).

[9] Terms defined in the glossary were sourced from the following documents:

Department of Water Affairs and Forestry. (2005). A practical field procedure for identification and delineation of wetlands and riparian areas. Department of Water Affairs and Forestry, Pretoria.

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Concentrated flow:	A flow of water contained within a distinct channel. Rivers are characterised by concentrated flow, either permanently or periodically.
Core habitat:	The area of natural habitat essential for long-term persistence of a species in its current distribution range.
Deposition:	The laying down of material that has been transported by running water (or wind).
Depression:	An inland aquatic ecosystem with closed (or near closed) elevation contours, which increases in depth from the perimeter to a central area of greatest depth, and within which water usually accumulates. Dominant water sources are groundwater, precipitation, interflow and diffuse or concentrated overland flow.
Diffuse (surface or subsurface) flow:	When water flow is not concentrated.
Ecosystem:	An ecological system in which there is constant interaction between biotic and abiotic components and in which nutrients are cycled.
Endorheic:	Basin or region from which there is little or no outflow of water (either on the surface as rivers, or underground by flow or diffusion through rock or permeable material).
Ephemeral (wetland or river):	Wetland or river or portion thereof with markedly short-lived inundation. Rivers that flow or flood for short periods of most years in a five-year period in response to unpredictable high rainfall events.
Episodic:	Highly flashy systems that flow or flood only in response to extreme rainfall events, usually high in their catchments. May not flow in a five-year period, or may flow only once in several years.
Erosion:	Physical and chemical processes that remove and transport soil and weathered rock.
Estuarine system:	A body of surface water (a) that is part of a watercourse that is permanently or periodically open to the sea (b) in which a rise and fall of the water level as a result of the tides is measurable at spring tides when the watercourse is open to the sea, or (c) in respect of which the salinity is measurably higher as a result of the influence of the sea. The upstream boundary of an estuary is taken to be the extent of tidal influence (the point up to where tidal variation in water levels can still be detected), or the extent of saline intrusion, or the extent of back-flooding during the closed mouth state, whichever is furthest upstream.
Event mean concentration:	Pollutant concentrations in runoff water reported as a mass of pollutant per unit volume of water (usually mg/ℓ), which allowed these values to be compared against wastewater limit values.
Exorheic:	A basin region characterised by outflow of water, usually involving drainage to the ocean.
Floodplain:	Valley bottom areas with a well-defined stream channel, gently sloped and characterised by floodplain features such as oxbow depressions and natural levees and the alluvial transport and deposition of sediment, usually leading to a net accumulation of sediment. Water inputs from main channel (when channel banks overspill) and from adjacent slopes.

Groundwater:	Subsurface water in the zone of saturation above an impermeable layer.
Hydrogeomorphic (HGM) type:	One of the seven primary HGM units of the classification system, as categorised at level 4A (namely, river or the following wetlands: floodplain, channelled valley bottom, unchanneled valley bottom, depression, seep or flat).
Hydrology:	The study of the properties, distribution and circulation of water on the earth.
Infiltration:	Downward permeation of water below the ground surface, either into the soil or into the groundwater.
Macro-channel:	With respect to river or stream channels, a 'macro-channel' refers to a compound channel form that typically develops as the result of incision by the active channel into former alluvial terraces, resulting in the active channel being generally confined within macro-channel banks, which may or may not be vegetated (Dallas, 2000).
Mineral soil:	Non-organic soil (with an average organic carbon content of less than 10% throughout a vertical distance of 200 mm) consisting primarily of rock and/ or mineral particles smaller than 2 mm in diameter. Mineral soils include sandy soil, silt (mud), clayey soil and loamy soil.
Organic soil:	Topsoil with an average organic carbon content of at least 10% throughout a vertical distance of 200 mm (after Soil Classification Working Group, 1991).
Peat:	A sedentarily accumulated material comprising of 30% (dry mass) of dead organic matter (after Joosten & Clark, 2002) generally formed under permanently saturated conditions.
Perennial:	Flows continuously throughout the year, in most years.
Precipitation:	The deposition of moisture on the earth's surface from the atmosphere, including dew, hail, rain, sleet and snow.
Rehabilitation:	Restoring processes and characteristics that are sympathetic to, and not conflicting with, the natural dynamic of an ecological or physical system.
Riparian zone/ habitat:	Area of land directly adjacent to the active channel of a river, which is influenced by the river-induced or river-related processes. The South African National Water Act (Act No. 36 of 1998) defines 'riparian habitat' to include "… the physical structure and associated vegetation of areas associated with a water course which are commonly characterised by alluvial soils, and which are inundated or flooded to an extent and frequency sufficient to support vegetation of species with a composition and physical structure distinct from those of adjacent land areas".
Salinity:	Saltiness; the concentration of dissolved inorganic solids in water. Salinity and total dissolved solids concentration are virtually identical in waters with small quantities of dissolved organic matter relative to the amount of inorganic matter (as is the case for waters with a high salinity, close to that of seawater at 35 g/ℓ). Conductivity can be used as a surrogate measure of salinity.
Saturated:	A condition in which the spaces between the soil particles are filled with water but surface water is not necessarily present.

Seasonal (as relates to non-perennial flow regime):	With water flowing for extended periods during the wet season/s (generally between a duration of three and nine months) but not during the rest of the year.
Seep:	A wetland area located on gently to steeply sloping land and dominated by the colluvial (gravity-driven) unidirectional movement of water and material down-slope. Seeps are often located on the side slopes of a valley but they do not, typically, extend onto a valley floor. Water inputs are primarily via subsurface flows from an up-slope direction. Note 1: Seeps are often associated with diffuse overland flow ('sheetwash') during and after rainfall events. Note 2: For purposes of the classification system, the drainage of a seep is classified (at Level 4C) according to whether water from the seepage area concentrates towards a point where it exits via channelized surface flow ('with channelled outflow') or whether water from the seepage area exits via diffuse surface or subsurface flow ('without channelled outflow'). It is important to note that a seep abutting a distinct river channel and feeding into the channel via diffuse surface flow or subsurface flow, but not having a channelized outlet from the seepage area to the adjacent channel, would be classified as a 'seep without channelled outflow' even though it feeds into a channel. Note 3: Seeps can occur in relatively flat or very gently-sloping landscapes where there is a unidirectional subsurface flow of water.
Submerged macrophytes:	Non-microscopic aquatic plants that are rooted in the underlying substratum of a wetland or aquatic ecosystem, with their foliage below the water surface. Submerged aquatic plants only produce reproductive organs (such as flowers) above the water surface. The rest of the plant generally remains under water.
Supratidal zone:	The area that is periodically inundated by tidal or flood waters and within which the subsurface-surface water is saline and is generally between 2.0 m and 3.5 m AMSL (SANBI, 2009).
Unchanneled valley bottom:	A valley bottom wetland without a river channel running through it. These wetlands are characterised by their location on valley floors, an absence of distinct channel banks, and the prevalence of diffuse flows. Water inputs are typically from an upstream channel and seepage from adjacent valley-side slopes, if present. Note 1: These areas are usually characterised by alluvial sediment deposition, generally leading to a nett accumulation of sediment and the presence of vegetation. Note 2: Preferential flow paths (minor channels) are often present, particularly towards the lower end of the wetland where flow often begins to concentrate.
Wetland:	"Land which is transitional between a terrestrial and aquatic system 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 supports or would support vegetation typically adapted to life in saturated soil." (National Water Act (Act No. 36 of 1998)).

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ANNEXURES

Annexure 1 – Desktop and Field Sheets for Wetland Buffer Zones

DESKTOP ASSESSMENT: ESTABLISHING BUFFER ZONES FOR WETLAND ECOSYSTEMS			
Assessor		**Date of assessment**	
Wetland		**HGM Unit**	

DESKTOP ASSESSMENT						
Climatic Factors						
MAP Class	0-400 mm	401-600 mm	601-800 mm	801-1000 mm	1001-1200 mm	> 1201 mm
Rainfall Intensity	Zone 1: Low	Zone 2: Moderate	Zone 3: High	Zone 4: Very High		
Mean Annual Temperature	Zone 1 (6.3-15.5 deg. C)	Zone 2 (15.5-16.9 deg. C)	Zone 3 (16.9-18.2 deg. C)	Zone 4 (18.2-19.5 deg. C)	Zone 5 (19.5-24.2 deg. C)	

Sensitivity criteria (section and page reference)	Circle or tick appropriate category				
Overall size Section: 4.1.1.1 Page: 8	Small (< 0.5 ha)	0.5-5 ha	Intermediate (6-50)	(51-300 ha)	Large (> 300 ha)
Method: Determine the approximate area of the wetland (HGM unit) being assessed using available tools (such as GIS, Google Earth Pro™) (Figure 4). Select the corresponding class from the dropdown menu provided in the Wetland Buffer Tool. The corresponding sensitivity modifier score is automatically entered into the calculation for determining an appropriate aquatic impact buffer zone.					
Size of the wetland relative to its catchment Section: 4.1.1.2 Page: 8	Large (> 20%)	10-20%	Intermediate (6-10%)	2-5%	Small (< 2%)
Method: This assessment requires the catchment of the HGM unit to be roughly estimated. Once estimated, the relative extent of the wetland is compared with that of catchment. Here, it is important to note that although the wetland itself may be large, the HGM unit potentially impacted may be small, and largely reliant on lateral inputs. A sensitivity score is then assigned with reference to Figure 5 in Section 4.1.1.2 and the above sensitivity scores. Note: In the case of groundwater-fed systems, sensitivity should be based on the anticipated importance of lateral flows to the groundwater system relative to the broader recharge area.					

Sensitivity criteria (section and page reference)	Circle or tick appropriate category				
Average slope of the wetland's catchment Section: 4.1.1.3 Page: 9	< 3%	3-5%	6-8%	9-11%	> 11%
Method: Average slope can be roughly calculated from available topographic maps or from GIS datasets or Google Earth™ information. This is done by taking elevation readings from (i) the upper-most point of the catchment and (ii) the site being assessed and then calculating the altitudinal change. Thereafter, the distance between these points is measured and average slope estimated by dividing the altitudinal change by the distance from the upper reaches of the catchment. This can also be calculated in Google Earth Pro™ by drawing a line feature from the top of the wetland to the top of the catchment (along the stream line) and viewing the elevation profile.					
The inherent runoff potential of catchment soil Section: 4.1.1.4 Page: 10	Low (A and A/B)	Mod. Low (B)	Moderate (B/C)	Mod. High (C)	High (C/D and D)
Method: The SCS-SA uses information on hydrologic soil properties to estimate surface runoff from a catchment (Schulze et al., 1992). Use the SCS-SA layer (Figure 7; https://sites.google.com/site/bufferzonehub/) to determine the appropriate hydrological soil group that best defines the catchment where the change in land use/activity will occur (Table 8). Select the corresponding class from the dropdown menu provided in the Wetland Buffer Tool (Table 9). The equivalent modifier score is automatically entered into the calculation for determining an appropriate aquatic impact buffer zone.					
The extent to which the wetland (HGM) setting is generally characterised by subsurface water input Section: 4.1.1.5 Page: 11	High (hillslope seepage)	Moderately high	Intermediate (remaining HGM types)	Moderately low	Low (floodplain)
Method: Assign a sensitivity score based on the above grouping of different HGM types. At a rapid level, it is assumed that hillslope seepages are characterised by high levels of lateral input and floodplains by low levels, and further that the other HGM types are characterised by intermediate levels. Where site assessments are undertaken, or further detailed information is available, this assumption should be verified and sensitivity scores adjusted where required based on field observations.					
Perimeter-to-area ratio Section: 4.1.1.6 Page: 12	High (> 1600 m/ha)	Moderately high (1600-1201 m/ha)	Intermediate (1200-801 m/ha)	Moderately low (800-401 m/ha)	Low (< 400 m/ha)
Method: Determine the approximate perimeter of the wetland being assessed and divide this by the area to obtain a perimeter-to-area ratio. Use this to place the wetland into one of the three classes indicated (Figure 8).					
Vulnerability of the HGM type to sediment accumulation Section: 4.1.1.7 Page: 13	Depression – endorheic, flat	Depression – exorheic	Hillslope seep, valley head seep, unchanneled valley bottom	Channelled valley bottom	Floodplain wetland
Method: Assign a sensitivity score based on the above grouping of different HGM types.					

<table>
<tr><th>Sensitivity criteria (section and page reference)</th><th colspan="5">Circle or tick appropriate category</th></tr>
<tr><td>Vulnerability of the wetland to erosion given the wetland's slope and size
Section: 4.1.1.8 Page: 13</td><td>High
(Vulnerability score: 10)</td><td>Moderately high
(Vulnerability score: 8)</td><td>Moderate
(Vulnerability score: 5)</td><td>Moderately low
(Vulnerability score: 2)</td><td>Low
(Vulnerability score: 0)</td></tr>
<tr><td colspan="6">Method: The approximate longitudinal slope of the wetland must be estimated based on available information. This may include using contour data available from a topographical map, more detailed contour data or by coarsely estimating slope in Google Earth Pro™. To calculate longitudinal slope, simply estimate the change in elevation from the top to the bottom of the wetland, divide this value by the length of the wetland and convert into a percentage. Measurement of the approximate area of the wetland is based upon the method outlined in 4.1.1.1. The vulnerability score is then derived with reference to Figure 9, which assumes that wetland area is a proxy for discharge. The vulnerability score so attained is used to place the wetland into one of the five classes indicated (Table 13).</td></tr>
<tr><td>Inherent level of nutrients in the landscape
Section: 4.1.1.9 Page: 14</td><td>Very low base status</td><td>Low base status</td><td>Low to moderate base status</td><td>Moderate base status</td><td>High base status</td></tr>
<tr><td colspan="6">Method: The base status of natural soil fertility is used to broadly determine the inherent level of nutrients in the landscape. The natural fertility map (Turner, 2016) was derived from the original ARC-ISCW Soil Leaching Status map with five classes (Schoeman & Van der Walt, 2004). Based on the location of the proposed change in land use/activity, refer to Figure 10 (https://sites.google.com/site/bufferzonehub/) to estimate the relevant likely natural fertility base status class (Table 14).</td></tr>
<tr><td>Natural salinity levels
Section: 4.1.1.11 Page: 16</td><td colspan="2">Naturally low saline levels</td><td colspan="2">Intermediate salinity levels</td><td>Naturally saline systems</td></tr>
<tr><td colspan="6">Method: Based on the location of the proposed change in land use/activity, use natural salinity levels spatial data for South Africa provided on the website (https://sites.google.com/site/bufferzonehub/) (Figure 12) to estimate the likely salinity class out of the three broad categories (Table 16).</td></tr>
</table>

FIELD SHEET: ESTABLISHING BUFFER ZONES FOR WETLAND ECOSYSTEMS				
Assessor			**Date of assessment**	
Wetland			**HGM Unit**	

FIELD ASSESSMENT
When undertaking the assessment of buffer zone requirements, it is important to follow a structured sampling protocol. This should start with a systematic assessment of buffer zone attributes to break the buffer zone into reasonably homogenous buffer segments (typically > 100 m). This should be followed by an assessment of sensitivity criteria which may also vary across the assessment site. The following approach to field work is advocated during site investigations: • **Step 1**: Ensure that the water resource boundary has been delineated and is clearly understood. • **Step 2**: Ensure that the line from which the aquatic impact buffer zone is to be determined has been clearly delineated and can be identified in the field. • **Step 3**: Consider the variability of the buffer slope around the delineated area and if necessary, define separate buffer segments to cater for the different slope classes (this should be done initially at desktop level where contour information is available). • **Step 4**: Assess soil properties of buffer segments by taking soil samples along the potential buffer zone. When sampling the soil, focus on the top 20 cm that can be sampled using a simple soil auger. An 'average' soil permeability needs to be determined based on the soil textural class present. Taking soil samples at approximately 5 m, 15 m and 30 m away from the delineated edge is recommended. These samples can either be mixed and assessed together or can be assessed as three separate samples and then be used to define an 'average' textural class. This assessment should be repeated at regular intervals (such as 100 m) to identify any changes in textural attributes. • **Step 5**: Identify any major changes in vegetation attributes along each buffer segment that will affect buffer zone effectiveness, and refine buffer segments accordingly (for example, differentiate between areas affected by cultivation versus intact grassland versus bare soil). When undertaking this assessment, consider options for rehabilitation and management prior to construction/operation and refine assessment units accordingly. When assessing vegetation attributes, preference should be given to the first 15 m of the buffer. If there is significant variation beyond this point, this may be used to refine your assessment. • **Step 6**: Assess the microtopography of the buffer with a particular focus on identifying drains, gully erosion or the likes that may compromise buffer zone effectiveness. If necessary, refine buffer segments accordingly to cater for variations across the study area. • **Step** 7: Ensure that buffer segments are clearly demarcated on your field map or by using a GPS and that buffer zone attributes are clearly documented for each segment. • **Step 8**: Assess sensitivity criteria with an initial focus of wetland attributes, but then noting any changes in sensitivity of vegetation and biota across different buffer segments.

<table>
<tr><th colspan="10">Buffer Zone Attributes</th></tr>
<tr><th rowspan="2">Buffer zone criteria</th><th colspan="5">Circle or tick appropriate category. Where more than one segment use corresponding scores</th><th colspan="4">Buffer Segment</th></tr>
<tr><th>1</th><th>2</th><th>3</th><th>4</th><th>5</th><th>A</th><th>B</th><th>C</th><th>D</th></tr>
<tr><td>Slope of the buffer
Section: 5.1
Page: 32</td><td>Very gentle
(0-2%)</td><td>Gentle
(2.1-10%)</td><td>Moderate
(10.1-20%)</td><td>Moderately steep
(20.1-40%)</td><td>Steep
(40.1-75%)</td><td></td><td></td><td></td><td></td></tr>
<tr><td colspan="10">Method: Use a 1:10 000 topographic map or GIS with contour data of the study area to measure the steepest slope of the potential buffer associated with the proposed development (apply to area within c. 50 m of the edge of the water resource). Slope is calculated by measuring the ratio of the horizontal distance between the lowest and highest contour on each slope and the vertical distance (difference between contour elevations). Slope is expressed as a percentage (for example, if the horizontal distance is 50 m and the vertical distance is 0.5 m, then the slope = 0.5 ÷ 50 × 100% = 1%). If the steepest slope is less than 2%, all other slopes will be less than this, so no further calculations are required. If the slope is more than 2%, break the boundary of the water resource into units of variable slope classes.</td></tr>
<tr><td>Vegetation characteristics (Construction phase)
Section: 5.2
Page: 34</td><td rowspan="2">Ideal
Robust vegetation with high interception potential (vetiver grass filter strips/dense tall grass stands)</td><td rowspan="2">Good
Moderately robust vegetation with good interception potential (good condition tufted grass stands)</td><td rowspan="2">Fair
Moderately robust vegetation with fair interception (tufted grass stands but with lowered basal cover) OR less robust vegetation with very good interception (kikuyu pasture)</td><td rowspan="2">Poor
Vegetation either short (< 5 cm) (maintained lawns) or robust but widely spaced plants with poor interception (trees or shrubs with poorly vegetated understory).</td><td rowspan="2">Very poor
Vegetation either very short (< 2 cm) offering little resistance to flow or sparse and providing poor interception (degraded grasslands with very poor basal cover)</td><td></td><td></td><td></td><td></td></tr>
<tr><td>Vegetation characteristics (Operational phase – realistic management state)
Section: 5.2
Page: 34</td><td></td><td></td><td></td><td></td></tr>
<tr><td colspan="10">Construction and operational methods: Assess current vegetation characteristics by specifically considering how well the vegetation is likely to slow down flows from shallow runoff during storm events. Key attributes to consider include the robustness of the vegetation (Will it provide a barrier to flow? Will it bend over and provide little resistance?) and interception potential which is linked primarily to ground cover. The presence of plant litter at the soil surface should also be considered as this may also help to slow flows. Note: For the construction phase, the assessment should be based on current vegetation attributes unless significant changes to buffer segment attributes are expected prior to construction (for example, through rehabilitation). In situations where the buffer is degraded, simply ‘protecting’ a buffer with a set width may fail to provide the necessary characteristics to protect adjacent water resources. As such, management should aim to restore the buffer to a more naturally vegetated condition through the operational phase. The applicant therefore has the option of improving the buffer’s vegetation attributes to minimise buffer requirements or foregoing buffer restoration and providing a wider but poorly vegetated buffer. If buffer restoration is adopted, the buffer should ideally be vegetated with native plant communities that are appropriate for the ecoregion or with a plant community that provides similar functions. Depending on the agreed approach, the appropriate class should be selected to calculate operational phase buffer zone requirements.</td></tr>
</table>

<table>
<tr><th colspan="10">Buffer Zone Attributes</th></tr>
<tr><th rowspan="2">Buffer zone criteria</th><th colspan="5">Circle or tick appropriate category. Where more than one segment use corresponding scores</th><th colspan="4">Buffer Segment</th></tr>
<tr><th>1</th><th>2</th><th>3</th><th>4</th><th>5</th><th>A</th><th>B</th><th>C</th><th>D</th></tr>
<tr><td>Soil properties
Section: 5.3
Page: 36</td><td>Low
Deep fine textured soils with low permeability (clay, sandy clay and clay loam) OR shallow (< 30 cm) soils with low to moderately low permeability</td><td>Moderately low
Deep moderately fine textured soils (loam and sandy clay loam) OR shallow (< 30 cm) moderately drained soils</td><td>Moderate
Deep moderately textured soils (sandy loam) OR shallow (< 30 cm) well-drained soils</td><td>High
(Deep (> 30 cm) well-drained soils (loamy sand and sand))</td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td colspan="10">Method: Take a sample of the soil in the buffer zone or up-slope area and use the following technique to assess soil texture: Take a small handful of soil (it should fit in the palm of your hand) and add sufficient water to work it in your hand to a state of maximum stickiness, breaking up any lumps that may be present. Now try to form the soil into a coherent ball. If this is impossible or very difficult (the ball collapses easily) then soil is sand or loamy sand. If the ball forms easily but collapses when pressed between the thumb and the forefinger, then soil is sandy loam. If the soil can be rolled into a thread but cracks when bent, then soil is loam. If the thread can be bent without cracking and it feels slightly gritty, then soil is clay loam, but if it feels very smooth, then soil is clay. Once soil texture has been established, use this information, together with observations of soil surface conditions (e.g. shrinking cracks, earthworm channels) to place the soils into one of four classes. Note that soil depth is another important aspect affecting permeability and is particularly relevant to soils with well-drained soils. In order to address this, coarse-textured soils (such as loamy sand and sand) that are shallow (< 30 cm in depth) should be rated as having ‘moderate’ soil permeability. (Note: A more comprehensive guide for assessing soil texture is included in Ollis et al., (2013): Refer to Section 7.4.2 and particularly “Box 24: How to determine soil texture in the field”).</td></tr>
<tr><td>Micro-topography of the buffer zone
Section: 5.4
Page: 37</td><td>Uniform topography (Smooth topography with no concentrated flow paths anticipated)</td><td>Dominantly uniform topography (Dominantly smooth topography with few/minor concentrated flow paths to reduce interception)</td><td>Dominantly non-uniform topography (Dominantly irregular topography with some major concentrated flow paths (such as erosion gullies and drains) that will substantially reduce interception)</td><td colspan="2">Concentrated flow paths dominate (Area of topography dominated by concentrated flow paths (such as depression, erosion gullies and drains))</td><td></td><td></td><td></td><td></td></tr>
<tr><td colspan="10">Method: Use a 1:10 000 topographic map or GIS with contour data of the study area to assess the general topography of landscape and identify potential concentrated flow paths. During field inspections, investigate buffer zone characteristics with a particular focus on identifying drains, gully erosion or the likes that may compromise buffer zone effectiveness. Note: ‘Steps’ down a slope may prove to be more effective than a flat slope.</td></tr>
</table>

<table>
<tr><th colspan="10">Buffer Zone Attributes</th></tr>
<tr><th rowspan="2">Buffer zone criteria</th><th colspan="5">Circle or tick appropriate category. Where more than one segment use corresponding scores</th><th colspan="4">Buffer Segment</th></tr>
<tr><th>1</th><th>2</th><th>3</th><th>4</th><th>5</th><th>A</th><th>B</th><th>C</th><th>D</th></tr>
<tr><th colspan="10">Wetland Attributes</th></tr>
<tr><th>Sensitivity criteria</th><th colspan="5">Circle or tick appropriate category</th><th colspan="4"></th></tr>
<tr><td>Extent of open water in relation to the extent of the HGM unit
Section: 4.1.2.1
Page: 17</td><td>High
(> 9% of the area)</td><td>Moderately high
(7-9%)</td><td>Moderate
(4-6%)</td><td>Low
(0.5-3%)</td><td>Very low
(< 0.5%)</td><td colspan="4"></td></tr>
<tr><td colspan="10">Method: This assessment uses a rapid site assessment to estimate the average extent of open water (including any artificial impoundments) supporting submerged aquatic plants, fish and other aquatic life that may be sensitive to sediment and nutrient inputs. Where possible, this assessment should be supplemented with orthophoto maps or aerial photographs that can be used to understand the relative extent of open water habitat in the HGM unit better. Once appropriately assessed, select the appropriate sensitivity class (Table 17).</td></tr>
<tr><td>Peat/high organic content versus mineral soils
Section: 4.1.2.2
Page: 17</td><td colspan="2">Peat/Champagne/high organic content</td><td>Mixed</td><td colspan="2">Mineral</td><td colspan="4"></td></tr>
<tr><td colspan="10">Method: Peat is defined as organic soil material with a particularly high organic matter content which, depending on the definition of peat, usually has > 30% organic material (dry mass), is located in stable landscapes and requires permanently saturated conditions to form. Firstly, refer to the peatland database to check if peat has been recorded on the site. Secondly and more importantly, observe soil samples in the field. The presence of peat, Champagne soil form, or high organic soil can generally be determined in the field based on observation of soil morphology and ‘feel’ of the soil sample in the hand. Select the corresponding class (Table 18).</td></tr>
<tr><td>Sensitivity of the vegetation to burial under sediment
Section: 4.1.2.3
Page: 18</td><td>High
(short growing and slow colonising)</td><td>Moderately high</td><td>Intermediate
(moderate height and robustness or plants typically fast colonising)</td><td>Moderately low</td><td>Low
(tall growing and fast colonising)</td><td colspan="4"></td></tr>
<tr><td colspan="10">Method: This assessment is based on observation during a rapid field visit of the growth form of the dominant plant species present in the HGM unit (Table 19). For the purposes of this assessment, the least sensitive vegetation includes robust, tall plants (such as trees, reeds and shrubs) that are unlikely to be negatively affected by high sediment inputs. Plant communities dominated by fast-colonising species (such as Cynodon dactylon and other creeping grasses) and plant communities characterised by low species diversity are generally regarded as being of low sensitivity. More sensitive communities are those characterised by short plants that can easily be smothered by sediment; plants that are slow growing (such as bulbous plants) and take time to colonise new areas; and plant communities with high natural diversity. The focus of this assessment is specifically on sensitive indigenous plant communities, so the occurrence of alien invasive species should not be considered. Should species of conservation concern be present that are likely to be highly sensitive to lateral impacts, these should be highlighted separately as part of the biodiversity assessment.</td></tr>
</table>

Buffer Zone Attributes									
Buffer zone criteria	Circle or tick appropriate category. Where more than one segment use corresponding scores					Buffer Segment			
	1	2	3	4	5	A	B	C	D
Sensitivity of the vegetation to increased availability of nutrients Section: 4.1.2.4 Page: 18	High (short and/or sparse vegetation cover with high natural diversity)	Moderately high	Intermediate (short vegetation with moderate natural plant diversity)	Moderately low	Low (tall and dense vegetation with low natural diversity)				
Method: This assessment is based on observation during a rapid field visit of the growth form of the dominant plant species present in the HGM unit adjacent to planned developments. Note must be made of the height of natural vegetation, diversity of indigenous vegetation, and occurrence of important plant species. Particular note should be made of *Typha capensis*, which is known to proliferate under high nutrient levels and is therefore regarded as being of low sensitivity to nutrient inputs. Occurrence of alien invasive species should not be considered (Table 20).									
Sensitivity criteria	Circle or tick appropriate category								
Sensitivity of the vegetation to toxic inputs, changes in acidity and salinity Section: 4.1.2.5 Page: 19	High (high natural diversity)	Moderately high	Intermediate (moderate natural plant diversity)	Moderately low	Low (low natural diversity)				
Method: This assessment is based on observation, during a rapid field visit, of the growth form of the dominant plant species present in the HGM unit adjacent to planned developments. Note must be made of the height of natural vegetation, diversity of indigenous vegetation, and occurrence of important plant species. Occurrence of alien invasive species should not be considered (Table 21).									
Natural wetness regimes Section: 4.1.2.6 Page: 19	Dominated by temporarily saturated soils	Mix of seasonal and temporarily saturated soils	Dominated by seasonally saturated soils	Mix of permanently and seasonally saturated soils	Dominated by permanently saturated soils				
Method: Natural levels of wetness is typically inferred from soil morphology (described from visual observations of soil samples extracted with a Dutch screw auger to a depth of 0.5 m) using the guidelines given in DWAF (2005). Knowledge of the hydric status of wetland plants can also provide a useful indication of wetness regimes in untransformed wetland areas (Table 22).									

Buffer Zone Attributes									
Buffer zone criteria	Circle or tick appropriate category. Where more than one segment use corresponding scores					Buffer Segment			
	1	2	3	4	5	A	B	C	D
Level of domestic, livestock and contact recreational use Section: 4.1.2.7 Page: 19	High	Moderately high	Moderate	Moderately low	Low				
Method: This assessment is based on an evaluation of land use around and directly downstream of water resources (within 5 km of the site). Where possible, this should be informed further by discussions with local stakeholders to establish the level of domestic, livestock and contact recreational water use (such as swimming and paddling) (Table 23).									

Annexure 2 – Desktop and Field Sheets for River Buffer Zones

DESKTOP ASSESSMENT: ESTABLISHING BUFFER ZONES FOR RIVER ECOSYSTEMS			
Assessor		**Date of assessment**	
River		**Assessment Unit**	

DESKTOP ASSESSMENT						
Climatic Factors						
MAP Class	0-400 mm	401-600 mm	601-800 mm	801-1000 mm	1001-1200 mm	> 1201 mm
Rainfall Intensity	Zone 1: Low	Zone 2: Moderate	Zone 3: High	Zone 4: Very High		
Mean Annual Temperature	Zone 1 (6.3-15.5 deg. C)	Zone 2 (15.5-16.9 deg. C)	Zone 3 (16.9-18.2 deg. C)	Zone 4 (18.2-19.5 deg. C)	Zone 5 (19.5-24.2 deg. C)	

Sensitivity criteria (section and page reference)	Circle or tick appropriate category				
Stream order Section: 4.2.1.1 Page 21	1st order	2nd order	3rd order	4th order	> 5th order
Method: Using the Horton-Strahler stream ordering method for both perennial and non-perennial rivers, determine the stream order using 1:50 000 rivers coverage or 1:50 000 topographical maps to ascertain the stream order for the reach of river. Figure 13 illustrates how stream orders are incrementally determined relative to catchment position. This is a desktop procedure where stream order is manually determined using 1:50 000 topographical maps or rivers coverage in GIS. Alternatively, numbering may be derived using a GIS algorithm.					
Average catchment slope Section: 4.2.1.2 Page: 21	< 3%	3-5%	6-8%	9-11%	> 11%
Method: Average slope can be calculated simply from available topographic maps, GIS datasets or Google Earth™ information. This is done by taking elevation readings from (i) the upper-most point of the catchment and (ii) the site being assessed and then calculating the altitudinal change. Thereafter the distance between these points is measured, and average slope estimated by dividing the altitudinal change by the distance from the upper reaches of the catchment. This can also be calculated in Google Earth Pro™ by drawing a line feature from the top of the wetland to the top of the catchment (along the stream line) and viewing the elevation profile.					
Inherent runoff potential of catchment soils Section: 4.2.1.3 Page: 21	Low (A and A/B)	Mod. Low (B)	Moderate (B/C)	Mod. High (C)	High (C/D and D)
Method: The SCS-SA uses information on hydrologic soil properties to estimate surface runoff from a catchment (Schulze et al., 1992). With reference to the SCS-SA KML layer coverage provided, determine the appropriate hydrological soil group that best defines the entire catchment, or where the catchment is characterised by more than one soil grouping, a weighted approach should be applied to determine the runoff potential of the entire catchment.					

<table>
<tr><th>Sensitivity criteria (section and page reference)</th><th colspan="6">Circle or tick appropriate category</th></tr>
<tr><td>Longitudinal river zonation
Section: 4.2.1.4 Page: 22</td><td>Upper foothill river</td><td colspan="2">Transitional river</td><td>Mountain stream</td><td>Lower foothill river</td><td>Lowland river</td></tr>
<tr><td colspan="7">Method: At desktop level, determine the suitable geomorphological classification of the river based on the classification system of Rowntree and Wadeson (2000) and establish which of the following categories the river would be classed as:
• Mountain stream – steep to very steep gradients where gradients exceed 0.04 (includes mountain headwater streams). Substrates are generally dominated by bedrock and boulders, with cobbles or coarse gravels in pools.
• Transitional river – moderately steep stream dominated by bedrock and boulders; reach types include plain-bed, pool-riffle or pool-rapid; usually in confined or semi-confined valley. Characteristic gradient is 0.02-0.039.
• Upper foothill river – moderately steep, cobble bed or mixed bedrock-cobble bed channels, with plain-bed, pool-riffle or pool-rapid reach types; length of pools and riffles/rapids is similar. Characteristic gradient is 0.005-0.019.
• Lower foothill river – lower-gradient, mixed-bed alluvial channel with sand and gravel dominating the bed and may be locally bedrock controlled; reach types typically include pool-riffle or pool-rapid, with sand bars common in pools; pools are of significantly greater extent than rapids or riffles. Characteristic gradient is 0.001-0.005.
• Lowland river – low-gradient, alluvial fine-bed channels, which may be confined, but fully developed meandering pattern within a distinct floodplain develops in unconfined reaches where there is increased silt content in bed or banks. Characteristic gradient is 0.0001-0.001.
• Rapid site assessments are recommended in addition to desktop determination procedures, to verify site specific river characteristics. The aforementioned features should be considered when conducting site assessments, for example, typically channel substrates and deposition features.</td></tr>
<tr><td>Inherent erosion potential (K-factor) of catchment soils
Section: 4.2.1.5 Page: 22</td><td>< 0.13</td><td colspan="2">0.13-0.25</td><td>0.25-0.50</td><td>0.50-0.70</td><td>> 0.70</td></tr>
<tr><td colspan="7">Method: Using the South African Atlas of Climatology and Agrohydrology (Schulze, 2007), determine the soil erodibility factor for the general catchment area within which the river reach occurs according to the corresponding soil erodibility classes and K-factors (https://sites.google.com/site/bufferzonehub/).</td></tr>
<tr><td>Inherent level of nutrients in the landscape
Section: 4.2.1.6 Page: 23</td><td>Very low base status</td><td colspan="2">Low base status</td><td>Low to moderate base status</td><td>Moderate base status</td><td>High base status</td></tr>
<tr><td colspan="7">Method: The base status of natural soil fertility is used to broadly determine the inherent level of nutrients in the landscape. The natural fertility map (Turner, 2016) was derived from the original ARC-ISCW Soil Leaching Status map with five classes (Schoeman and van der Walt, 2004). Based on the location of the proposed change in land use/activity, refer to Figure 10 (https://sites.google.com/site/bufferzonehub/) to estimate the relevant likely natural fertility base status class (Table 14).</td></tr>
<tr><td>Inherent buffering capacity
Section: 4.2.1.7 Page: 23</td><td colspan="2">Pure waters with poor pH buffering</td><td colspan="2">Neutral pH</td><td colspan="2">‘Hard’ water rich in bicarbonate and carbonate ions or naturally acid waters high in organic acids</td></tr>
<tr><td colspan="7">Method: At desktop level, determine whether the river system has a low buffering capacity and is therefore sensitive to changes in pH (pure water) or has a high buffering capacity and is therefore less sensitive to changes in pH (‘hard’ water rich in bicarbonate and carbonate ions) (Table 29). Refer to Day et al. (1998) to determine broadly the relevant buffering capacity of groundwater (as this is used as a surrogate for the regional assessment of buffer capacity) for the relevant catchment (Figure 10, p. 195 and Table 2, p. 196 of Day et al., 1998). In addition, in situ pH readings likely to be required for the assessment of the river, can be used as a reference to determine if the rivers pH range is neutral or acidic (see Ollis et al., 2013).</td></tr>
</table>

Sensitivity criteria (section and page reference)	Circle or tick appropriate category				
Natural salinity levels Section: 4.2.1.8 Page 24			Non-saline (< 200 mS/m)	Slightly saline (200-400 mS/m)	Saline and/or sodic (> 4 00 mS/m)
Method: Based on the location of the proposed change in land use/activity, refer to Figure 12 to estimate the likely salinity class out of the three categories (Table 16).					

FIELD SHEET: ESTABLISHING BUFFER ZONES FOR RIVER ECOSYSTEMS				
Assessor			**Date of assessment**	
River			**Assessment Unit**	

FIELD ASSESSMENT
When undertaking the assessment of buffer zone requirements, it is important to follow a structured sampling protocol. This should start with a systematic assessment of buffer zone attributes to break the buffer zone into reasonably homogenous buffer segments (typically > 100 m). This should be followed by an assessment of sensitivity criteria which may also vary across the assessment site. The following approach to field work is advocated during site investigations: • **Step 1**: Ensure that the water resource boundary has been delineated and is clearly understood. • **Step 2**: Ensure that the line from which the aquatic impact buffer zone is to be determined has been clearly delineated and can be identified in the field. • **Step 3**: Consider the variability of the buffer slope around the delineated area and if necessary, define separate buffer segments to cater for the different slope classes (this should be done initially at desktop level where contour information is available). • **Step 4**: Assess soil properties of buffer segments by taking soil samples along the potential buffer zone. When sampling the soil, focus on the top 20 cm which can be sampled using a simple soil auger. An 'average' soil permeability needs to be determined based on the soil textural class present. Taking soil samples at approximately 5 m, 15 m and 30 m away from the delineated edge is recommended. These samples can then either be mixed and assessed together or can be assessed as three separate samples and then be used to define an 'average' textural class. This assessment should be repeated at regular intervals (such as 100 m) to identify any changes in textural attributes. • **Step 5**: Identify any major changes in vegetation attributes along each buffer segment that will affect buffer zone effectiveness, and refine buffer segments accordingly (for example, differentiate between areas affected by cultivation versus intact grassland versus bare soil). When undertaking this assessment, consider options for rehabilitation and management prior to construction/operation and refine assessment units accordingly. When assessing vegetation attributes, preference should be given to the first 15 m of the buffer. If there is significant variation beyond this point, this may be used to refine your assessment. • **Step 6**: Assess the microtopography of the buffer with a particular focus on identifying drains, gully erosion or the likes that may compromise buffer zone effectiveness. If necessary, refine buffer segments accordingly to cater for variations across the study area. • **Step** 7: Ensure that buffer segments are clearly demarcated on your field map or by using a GPS and that buffer zone attributes are clearly documented for each segment. • **Step 8**: Assess sensitivity criteria with an initial focus of river attributes, but then noting any changes in sensitivity of vegetation and biota across different buffer segments.

Buffer Zone Attributes									
Buffer zone criteria	**Circle or tick appropriate category. Where more than one segment use corresponding scores**					**Buffer Segment**			
	1	**2**	**3**	**4**	**5**	**A**	**B**	**C**	**D**
Slope of the buffer Section: 5.1 Page: 32	Very gentle (0-2%)	Gentle (2.1-10%)	Moderate (10.1-20%)	Moderately steep (20.1-40%)	Steep (40.1-75%)				
Method: Use a 1:10 000 topographic map or GIS with contour data of the study area to measure the steepest slope of the potential buffer associated with the proposed development (apply to area within *c.* 50 m of the edge of the water resource). Slope is calculated by measuring the ratio of the horizontal distance between the lowest and highest contour on each slope and the vertical distance (difference between contour elevations). Slope is expressed as a percentage (for example: if the horizontal distance is 50 m and the vertical distance is 0.5 m then the slope = 0.5 ÷ 50 × 100% = 1%). If the steepest slope is less than 2%, all other slopes will be less than this, so no further calculations are required. If the slope is more than 2%, break the boundary of the water resource into units of variable slope classes.									

<table>
<tr><th colspan="25">Buffer Zone Attributes</th></tr>
<tr><th rowspan="2">Buffer zone criteria</th><th colspan="20">Circle or tick appropriate category. Where more than one segment use corresponding scores</th><th colspan="4">Buffer Segment</th></tr>
<tr><th colspan="4">1</th><th colspan="4">2</th><th colspan="4">3</th><th colspan="4">4</th><th colspan="4">5</th><th>A</th><th>B</th><th>C</th><th>D</th></tr>
<tr><td>Vegetation characteristics (Construction phase)
Section: 5.2 Page: 34</td><td colspan="4" rowspan="2">Ideal
Robust vegetation with high interception potential (vetiver grass filter strips/dense tall grass stands)</td><td colspan="4" rowspan="2">Good
Moderately robust vegetation with good interception potential (good condition tufted grass stands)</td><td colspan="4" rowspan="2">Fair
Moderately robust vegetation with fair interception (tufted grass stands but with lowered basal cover) OR less robust vegetation with very good interception (kikuyu pasture)</td><td colspan="4" rowspan="2">Poor
Vegetation either short (< 5 cm) (maintained lawns) or robust but widely spaced plants with poor interception (trees or shrubs with poorly vegetated understory)</td><td colspan="4" rowspan="2">Very poor
Vegetation either very short (< 2 cm) offering little resistance to flow or sparse and providing poor interception (degraded grasslands with very poor basal cover)</td><td></td><td></td><td></td><td></td></tr>
<tr><td>Vegetation characteristics (Operational phase – realistic management state)
Section: 5.2 Page: 34</td><td></td><td></td><td></td><td></td></tr>
<tr><td colspan="25">Construction and operational methods: Assess current vegetation characteristics by specifically considering how well the vegetation is likely to slow down flows from shallow runoff during storm events. Key attributes to consider include the robustness of the vegetation (Will it provide a barrier to flow? Will it bend over and provide little resistance?) and interception potential which is linked primarily to ground cover. The presence of plant litter at the soil surface should also be considered as this may also help to slow flows. Note: For the construction phase, the assessment should be based on current vegetation attributes unless significant changes to buffer segment attributes are expected prior to construction (for example, through rehabilitation). In situations where the buffer is degraded, simply ‘protecting’ a buffer with a set width may fail to provide the necessary characteristics to protect adjacent water resources. As such, management should aim to restore the buffer to a more naturally vegetated condition through the operational phase. The applicant therefore has the option of improving the buffer’s vegetation attributes to minimise buffer requirements or foregoing buffer restoration and providing a wider but poorly vegetated buffer. If buffer restoration is adopted, the buffer should ideally be vegetated with native plant communities that are appropriate for the ecoregion or with a plant community that provides similar functions. Depending on the agreed approach, the appropriate class should be selected to calculate operational phase buffer zone requirements.</td></tr>
<tr><td>Soil properties
Section: 5.3 Page: 36</td><td colspan="5">Low
Deep fine textured soils with low permeability (clay, sandy clay and clay loam) OR shallow (< 30 cm) soils with low to moderately low permeability</td><td colspan="5">Moderately low
Deep moderately fine textured soils (loam and sandy clay loam) OR shallow (< 30 cm) moderately drained soils</td><td colspan="5">Moderate
Deep moderately textured soils (sandy loam) OR shallow (< 30 cm) well-drained soils</td><td colspan="5">High
(Deep (> 30 cm) well-drained soils (loamy sand and sand))</td><td></td><td></td><td></td><td></td></tr>
<tr><td colspan="25">Method: Take a sample of the soil in the buffer zone or up-slope area and use the following technique to assess soil texture: Take a small handful of soil (it should fit in the palm of your hand) and add sufficient water to work it in your hand to a state of maximum stickiness, breaking up any lumps that may be present. Now try to form the soil into a coherent ball. If this is impossible or very difficult (the ball collapses easily) then soil is sand or loamy sand. If the ball forms easily but collapses when pressed between the thumb and the forefinger, then soil is sandy loam. If the soil can be rolled into a thread but cracks when bent, then soil is loam. If the thread can be bent without cracking and it feels slightly gritty, then soil is clay loam, but if it feels very smooth, then soil is clay. Once soil texture has been established, use this information, together with observations of soil surface conditions (e.g. shrinking cracks, earthworm channels) to place the soils into one of four classes. Note that soil depth is another important aspect affecting permeability and is particularly relevant to soils with well-drained soils. In order to address this, coarse-textured soils (such as loamy sand and sand) that are shallow (< 30 cm in depth) should be rated as having ‘moderate’ soil permeability. (Note: A more comprehensive guide for assessing soil texture is included in Ollis et al., (2013): Refer to Section 7.4.2 and particularly “Box 24: How to determine soil texture in the field”).</td></tr>
</table>

Buffer Zone Attributes								
Buffer zone criteria	**Circle or tick appropriate category. Where more than one segment use corresponding scores**				**Buffer Segment**			
	1 2 3 4 5				**A**	**B**	**C**	**D**
Microtopography of the buffer zone Section: 5.4 Page: 37	Uniform topography (Smooth topography with no concentrated flow paths anticipated)	Dominantly uniform topography (Dominantly smooth topography with few/minor concentrated flow paths to reduce interception)	Dominantly non-uniform topography (Dominantly irregular topography with some major concentrated flow paths (such as erosion gullies and drains) that will substantially reduce interception)	Concentrated flow paths dominate (Area of topography dominated by concentrated flow paths (such as depression, erosion gullies and drains))				
Method*:* Use a 1:10 000 topographic map or GIS with contour data of the study area to assess the general topography of landscape and identify potential concentrated flow paths. During field inspections, investigate buffer zone characteristics with a particular focus on identifying drains, gully erosion or the likes that may compromise buffer zone effectiveness. Note: ‘Steps’ down a slope may prove to be more effective than a flat slope.								

River Attributes						
Sensitivity criteria	**Circle or tick appropriate category**					
Channel width Section: 4.2.2.1 Page: 24	< 1 m	1-5 m	5-10 m	10-20 m	> 20 m	
Method: Widths of streams are grouped into five broad categories, obviating the need for detailed site-based measurements. Width is taken as the distance between active channel banks, which can be established during site visits or estimated based on measurements made from appropriate remote imagery such as that available on Google Earth.						
Perenniality Section: 4.2.2.2 Page: 24	Perennial systems (> 9 months)	Seasonal systems (3-9 months)	Intermittent systems (< 3 months)			
Method: At desktop level, perenniality may be interpreted from 1:50 000 topographical sheets, where rivers indicated with a solid line are considered to be perennial systems, and dotted lines represent non-perennial rivers (seasonal and intermittent). Distinction between seasonal and intermittent rivers is made where the former consists of river systems that flow for extended periods during the wet seasons/s (generally between three and nine months), at intervals varying from less than a year to several years (Ollis et al., 2013). Intermittent rivers flow for a relatively short time of less than one season’s duration (less than approximately three months) at intervals varying from less than a year to several years (Ollis et al., 2013). The perenniality of the watercourse can typically be identified by checking the stream bed for signs of wetness (linked to groundwater interaction) and the presence of hydric plant species in the active channel. In the case of intermittent streams, signs of wetness and hydric plant species may be absent.						

<table>
<tr><th colspan="7">River Attributes</th></tr>
<tr><th>Sensitivity criteria</th><th colspan="6">Circle or tick appropriate category</th></tr>
<tr><td>Retention time
Section: 4.2.2.3
Page: 25</td><td colspan="2">Generally free-flowing</td><td colspan="3">Generally slow moving</td><td></td></tr>
<tr><td colspan="7">Method: During the site visit, assess whether the section of river is generally free-flowing or slow moving during the rainy season (Table 32). In undertaking this assessment, note that the focus is essentially on differentiating between rivers dominated by pools and slow-flowing sections (which have a greater tendency for pollutants to accumulate) and more free-flowing rivers where pollutant inputs are likely to be washed through the system quickly.</td></tr>
<tr><td>River depth-to-width ratio
Section: 4.2.2.4
Page: 25</td><td colspan="2">Small
< 0.25</td><td colspan="2">Medium
0.25-0.75</td><td>Large
> 0.75</td><td></td></tr>
<tr><td colspan="7">Method: Conduct a rapid site assessment to determine the approximate depth and width of the river channel for the site and then calculate the depth-to-width ratio (depth divided by width). The river depth should be assessed in based on typical (average) depths likely to be experienced in the active channel during the rainy season whereas the width is taken as that of the active channel.</td></tr>
<tr><td>Level of domestic, livestock and contact recreational use
Section: 4.2.2.5
Page: 25</td><td>High</td><td>Moderately high</td><td>Moderate</td><td>Moderately low</td><td>Low</td><td></td></tr>
<tr><td colspan="7">Method: This assessment is based on an evaluation of land use around and directly downstream of water resources (within 5 km of the site). Where possible, this should be informed further by discussions with local stakeholders to establish the level of domestic, livestock and contact recreational water use (e.g. swimming and paddling etc.) (Table 23).</td></tr>
</table>

Annexure 3 – Desktop and Field Sheets for Estuarine Buffer Zones

DESKTOP ASSESSMENT: ESTABLISHING BUFFER ZONES FOR ESTUARIES			
Assessor		**Date of assessment**	
Estuary		**Estuary portion**	

DESKTOP ASSESSMENT						
Climatic Factors						
MAP Class	0-400 mm	401-600 mm	601-800 mm	801-1000 mm	1001-1200 mm	> 1201 mm
Rainfall Intensity	Zone 1: Low		Zone 2: Moderate	Zone 3: High		Zone 4: Very high

Sensitivity criteria (section and page reference)	Circle or tick appropriate category				
Estuary size Section: 4.3.1.1 Page: 27	< 10 ha	10-100 ha		100-1000 ha	> 1000 ha
Method: A national NBA dataset is available for estuaries and includes an indication of the approximate size of each estuary based on the 5 m AMSL line (SANBI BGIS or https://sites.google.com/site/bufferzonehub/). Although this should provide a useful starting point, it may be necessary to check the approximate area of the estuary being assessed using more detailed contour data and available tools (such as GIS). Once the size of the estuary has been established, the corresponding sensitivity score is selected (Table 35).					
Estuary length Section: 4.3.1.2 Page: 27	< 5 km	5-10 km		10-20 km	> 20 km
Method: The length of all large estuaries is also available from the NBA dataset and can be used as a basis for scoring this criterion (https://sites.google.com/site/bufferzonehub/). If necessary, check the approximate length of the estuary being assessed using available tools (such as GIS) and determine the sensitivity score (Table 36).					
The inherent runoff potential of catchment soils Section: 4.3.1.3 Page: 27	Low (A and A/B)	Moderately low (B)	Moderate (B/C)	Moderately high (C)	High (C/D and D)
Method: The SCS-SA uses information on hydrologic soil properties to estimate surface runoff from a catchment (Schulze et al., 1992). With reference to the SCS-SA KML layer coverage provided, determine the appropriate hydrological soil group that best defines the entire catchment, or where the catchment is characterised by more than one soil grouping, a weighted approach should be applied to determine the runoff potential of the entire catchment.					

Sensitivity criteria (section and page reference)	Circle or tick appropriate category				
Mouth closure Section: 4.3.1.4 Page: 27	> 80%	61-80%	41-60%	21-40%	< 20%
Method: With the use of available data estimate the duration of mouth closure for a year. Google Earth can be used to review mouth closure over an extended timeframe to estimate approximate mouth closure for a year (Figure 15).					
Water clarity Section: 4.3.1.5 Page: 28	Clear	Blackwater	Turbid		
Method: The NBA has classified all estuaries as ‘clear’, ‘blackwater’ or ‘turbid’ based on the quality of the freshwater inflow to the system. Users should therefore simply refer to the NBA dataset (https://sites.google.com/site/bufferzonehub/) and specifically to the classification of river water inflow types as an indication of estuary water clarity (Figure 16 and Table 38).					
Biogeographic zone Section: 4.3.1.6 Page: 29	Subtropical	Warm temperate	Cool temperate		
Method: Determine the biogeographic zone in which the estuary is located using the above categories and Figure 17 in Section 4.3.1.6 of the Practical Guide. This shows that all estuaries north of the Mbashe Estuary are subtropical, while those west of Heuningnes Estuary are cool temperate. Estuaries located in-between are classified as warm temperate estuaries.					

FIELD SHEET: ESTABLISHING BUFFER ZONES FOR ESTUARIES				
Assessor			**Date of assessment**	
Estuary			**HGM Unit**	

FIELD ASSESSMENT
When undertaking the assessment of buffer zone requirements, it is important to follow a structured sampling protocol. This should start with a systematic assessment of buffer zone attributes to break the buffer zone into reasonably homogenous buffer segments (typically > 100 m). This should be followed by an assessment of sensitivity criteria which may also vary across the assessment site. The following approach to field work is advocated during site investigations: • **Step 1**: Ensure that the water resource boundary has been delineated and is clearly understood. • **Step 2**: Ensure that the line from which the aquatic impact buffer zone is to be determined has been clearly delineated and can be identified in the field. • **Step 3**: Consider the variability of the buffer slope around the delineated area and if necessary, define separate buffer segments to cater for the different slope classes (this should be done initially at desktop level where contour information is available). • **Step 4**: Assess soil properties of buffer segments by taking soil samples along the potential buffer zone. When sampling the soil, focus on the top 20 cm which can be sampled using a simple soil auger. An ‘average’ soil permeability needs to be determined based on the soil textural class present. Taking soil samples at approximately 5 m, 15 m and 30 m away from the delineated edge is recommended. These samples can either be mixed and assessed together or can be assessed as three separate samples and then be used to define an ‘average’ textural class. This assessment should be repeated at regular intervals (such as 100 m) to identify any changes in textural attributes. • **Step 5**: Identify any major changes in vegetation attributes along each buffer segment that will affect buffer zone effectiveness and refine buffer segments accordingly (e.g. differentiate between areas affected by cultivation vs intact grassland vs bare soil). When undertaking this assessment, consider options for rehabilitation and management prior to construction/operation and refine assessment units accordingly. When assessing vegetation attributes, preference should be given to the first 15 m of the buffer. If there is significant variation beyond this point, this may be used to refine your assessment. • **Step 6**: Assess the microtopography of the buffer with a particular focus on identifying drains, gully erosion or the likes that may compromise buffer zone effectiveness. If necessary, refine buffer segments accordingly to cater for variations across the study area. • **Step** 7: Ensure that buffer segments are clearly demarcated on your field map or by using a GPS and that buffer zone attributes are clearly documented for each segment. • **Step 8**: Assess sensitivity criteria with an initial focus of estuary attributes, but then noting any changes in sensitivity of vegetation and biota across different buffer segments.

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<tr><th rowspan="2">Buffer zone criteria</th><th colspan="5">Circle or tick appropriate category. Where more than one segment use corresponding scores</th><th colspan="4">Buffer Segment</th></tr>
<tr><th>1</th><th>2</th><th>3</th><th>4</th><th>5</th><th>A</th><th>B</th><th>C</th><th>D</th></tr>
<tr><td>Slope of the buffer
Section: 5.1 Page: 32</td><td>Very gentle
(0-2%)</td><td>Gentle
(2.1-10%)</td><td>Moderate
(10.1-20%)</td><td>Moderately steep
(20.1-40%)</td><td>Steep
(40.1-75%)</td><td></td><td></td><td></td><td></td></tr>
<tr><td colspan="10">Method: Use a 1:10 000 topographic map or GIS with contour data of the study area to measure the steepest slope of the potential buffer associated with the proposed development (apply to area within c. 50 m of the edge of the water resource). Slope is calculated by measuring the ratio of the horizontal distance between the lowest and highest contour on each slope and the vertical distance (difference between contour elevations). Slope is expressed as a percentage (for example: if the horizontal distance is 50 m and the vertical distance is 0.5 m then the slope = 0.5 ÷ 50 × 100% = 1%). If the steepest slope is less than 2%, all other slopes will be less than this, so no further calculations are required. If the slope is more than 2%, break the boundary of the water resource into units of variable slope classes.</td></tr>
<tr><td>Vegetation characteristics (Construction phase)
Section: 5.2 Page: 34</td><td rowspan="2">Ideal
Robust vegetation with high interception potential (vetiver grass filter strips/dense tall grass stands</td><td rowspan="2">Good
Moderately robust vegetation with good interception potential (good condition tufted grass stands)</td><td rowspan="2">Fair
Moderately robust vegetation with fair interception (tufted grass stands but with lowered basal cover) OR less robust vegetation with very good interception (kikuyu pasture)</td><td rowspan="2">Poor
Vegetation either short (< 5 cm) (maintained lawns) or robust but widely spaced plants with poor interception (trees or shrubs with poorly vegetated understory)</td><td rowspan="2">Very poor
Vegetation either very short (< 2 cm) offering little resistance to flow or sparse and providing poor interception (degraded grasslands with very poor basal cover)</td><td></td><td></td><td></td><td></td></tr>
<tr><td>Vegetation characteristics (Operational phase – realistic management state)
Section: 5.2 Page: 34</td><td></td><td></td><td></td><td></td></tr>
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<tr><th colspan="10">Buffer Zone Attributes</th></tr>
<tr><th rowspan="2">Buffer zone criteria</th><th colspan="5">Circle or tick appropriate category. Where more than one segment use corresponding scores</th><th colspan="4">Buffer Segment</th></tr>
<tr><th>1</th><th>2</th><th>3</th><th>4</th><th>5</th><th>A</th><th>B</th><th>C</th><th>D</th></tr>
<tr><td>Soil properties
Section: 5.3 Page: 36</td><td>Low
Deep fine textured soils with low permeability (clay, sandy clay and clay loam) OR shallow (< 30 cm) soils with low to moderately low permeability</td><td>Moderately low
Deep moderately fine textured soils (loam and sandy clay loam) OR shallow (< 30 cm) moderately drained soils</td><td>Moderate
Deep moderately textured soils (sandy loam) OR shallow (< 30 cm) well-drained soils</td><td>High
(Deep (> 30 cm) well-drained soils (loamy sand & sand))</td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td colspan="10">Method: Take a sample of the soil in the buffer zone or up-slope area and use the following technique to assess soil texture: Take a small handful of soil (it should fit in the palm of your hand) and add sufficient water to work it in your hand to a state of maximum stickiness, breaking up any lumps that may be present. Now try to form the soil into a coherent ball. If this is impossible or very difficult (the ball collapses easily) then soil is sand or loamy sand. If the ball forms easily but collapses when pressed between the thumb and the forefinger, then soil is sandy loam. If the soil can be rolled into a thread but cracks when bent, then soil is loam. If the thread can be bent without cracking and it feels slightly gritty, then soil is clay loam, but if it feels very smooth, then soil is clay. Once soil texture has been established, use this information, together with observations of soil surface conditions (e.g. shrinking cracks, earthworm channels) to place the soils into one of four classes. Note that soil depth is another important aspect affecting permeability and is particularly relevant to soils with well-drained soils. In order to address this, coarse-textured soils (such as loamy sand and sand) that are shallow (< 30 cm in depth) should be rated as having ‘moderate’ soil permeability. (Note: A more comprehensive guide for assessing soil texture is included in Ollis et al., (2013): Refer to Section 7.4.2 and particularly “Box 24: How to determine soil texture in the field”).</td></tr>
<tr><td>Microtopography of the buffer zone
Section: 5.4 Page: 37</td><td>Uniform topography
(Smooth topography with no concentrated flow paths anticipated)</td><td>Dominantly uniform topography
(Dominantly smooth topography with few/minor concentrated flow paths to reduce interception)</td><td>Dominantly non-uniform topography
(Dominantly irregular topography with some major concentrated flow paths (such as erosion gullies and drains) that will substantially reduce interception)</td><td>Concentrated flow paths dominate
(Area of topography dominated by concentrated flow paths (such as depression, erosion gullies and drains))</td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td colspan="10">Method: Use a 1:10 000 topographic map or GIS with contour data of the study area to assess the general topography of landscape and identify potential concentrated flow paths. During field inspections, investigate buffer zone characteristics with a particular focus on identifying drains, gully erosion or the likes that may compromise buffer zone effectiveness. Note: ‘Steps’ down a slope may prove to be more effective than a flat slope.</td></tr>
</table>

Estuary Attributes

Sensitivity criteria	Circle or tick appropriate category					
Perenniality of river inflows Section: 4.3.2.1 Page: 30	Intermittent	Seasonal	Perennial			
Method: At desktop level, perenniality may be interpreted from 1:50 000 topographical sheets where rivers indicated with a solid line are considered to be perennial systems and dotted lines represent non-perennial rivers (seasonal and intermittent). Distinction between seasonal and intermittent rivers is made where the former consists of river systems that flow for extended periods during the wet seasons (generally between three and nine months), at intervals varying from less than a year to several years (Ollis et al., 2013). Intermittent rivers flow for a relatively short time of less than one season’s duration (less than approximately three months) at intervals varying from less than a year to several years (Ollis et al., 2013). In the case on non-perennial systems, classification should be informed by local knowledge and guided by the definitions for ‘Intermittent’ and ‘Seasonal’ rivers provided.						
Submerged macrophytes present Section: 4.3.2.2 Page: 30	Yes	No				
Method: The NBA database indicates those estuaries where submerged macrophytes are present. The estuary habitat adjacent to the planned development should be checked in the field for the presence of submerged macrophytes. Reports and aerial photographs should also be used to assess whether submerged macrophytes have occurred in the area. This is necessary as these plants are dynamic and rapidly change their habitat distribution in response to droughts and floods.						
Level of domestic, livestock and contact recreational use Section: 4.3.2.3 Page: 30	High	Moderately high	Moderate	Moderately low	Low	
Method: This assessment is based on an evaluation of land use around and directly downstream of water resources (within 5 km of the site). Where possible, this should be informed further by discussions with local stakeholders to establish the level of domestic, livestock and contact recreational water use (e.g. swimming and paddling etc.) (Table 23).						

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