The Design of a National Wetland Monitoring Programme

Implementation Manual

Volume 2

Report to the
WATER RESEARCH COMMISSION

by

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PREFACE

This document is the Implementation Manual (IM) for the South African National Wetland Monitoring Programme. It details the structures, processes and methods to be followed when instituting the programme and thus provides an outline of what is currently envisaged with regard to systematic monitoring of wetlands in the country. The procedures, indicators and indices described here need to be widely tested and refined during the early stages of implementation of the monitoring programme.

The Manual is Volume 2 of the monitoring programme (WRC Report 2269/2/16. Volume 1 is a consolidated technical report detailing the procedure and decisions made in developing IM (WRC Report 2296/1/16).

EXECUTIVE SUMMARY

Wetlands are complex and dynamic ecosystems that provide indispensable services to the people and the environment of South Africa. In order to protect and manage the remaining wetlands of the country, assessment, monitoring and reporting on the state of wetlands is crucial.

The South African Department of Water and Sanitation conceptualized a National Aquatic Ecosystem Health Monitoring Programme (NAEHMP) in the early 1990s. Although a number of monitoring programmes have been implemented under the NAEMP, a wetlands monitoring programme has yet to be established.

With this need in mind the WRC issued a directed call for a project entitled *the design of a National Wetland Monitoring Programme (NWMP) following a phased approach*. The phases were:

- Phase 1 – conducting a situation analysis regarding the complexities of monitoring wetland health or integrity and developing a framework that can serve as the basis for phases 2 and 3;
- Phase 2 – designing a monitoring programme and developing an implementation plan;
- Phase 3 Pilot testing.

The Objectives:

The monitoring programme design had the following objectives, to:

1. conduct an extensive literature review on wetland monitoring and assessment;
2. determine and illustrate fully the links with the National Aquatic Ecosystem Health Monitoring Programme, Working for Wetlands and other related programmes operated by national departments and provincial conservation authorities, ESKOM, etc.;
3. suggest scientifically accepted objectives that will lead to the design of NWMP;
4. develop or refine a core suit of practical and user-friendly indicators;
5. develop a sustainable governance structure and implementation plan;
6. describe the human capacity and budget required for a successful pilot and full scale implementation of the programme;
7. **produce, test and refine, where necessary, the scientific viability of the Implementation Manual(s) based on selected sites**;
8. recommend further research on wetland health assessment methods.

All the objectives were attempted and achieved. This Implementation Manual for the NWMP relates directly to objective 7 above.

Methodology

The framework, approach and decisions made in the designing of the NWMP are included in this document. Design was based on an approach of (1) minimising duplication, particularly with regard to wetland IAM methods and indicators currently being used; (2) minimising resource use, while maximising the value of outputs of wetland assessment and monitoring; (3) finding suitable methods for prioritising wetlands to be assessed and monitored; (4) adaptive management; and (5) maximum engagement and participation by stakeholder.

Indeed, the project team engaged stakeholders at all stages of the NWMP design process. Emanating from this stakeholder engagement process was an agreed purpose for the programme, namely *to* ***assess and monitor the extent of wetlands, threats to, and the change in the present ecological state and ecosystem services provided by wetlands in the country.*** A core suite of practical and user-friendly indicators were also selected for the NWMP by the stakeholders involved in the design process. The programme design was tested on the selected sites, which further strengthened the final reports

Results and Discussions

Two reports have emanated from this assignment, the Consolidated Technical Report (Volume 1, this report) and this Implementation Manual (Volume 2, both available from WRC). This Consolidated Technical Report is a consolidation of all deliverables of the assignment, providing the starting framework, indicators, methods, tools and procedures for implementing the NWMP in South Africa. It is based on the principle of adaptive management, which requires that the programme continues to evolve, adapting the framework, indicators, methods, tools and procedures, as appropriate, as experience is gained through implementation.

This Implementation Manual on the other hand, provides the processes, procedures and methods required to report Tier 1 indicators, to prioritize wetlands for Tier 2 and 3 assessments, and to carry out assessment and monitoring at each level.

The intention of the NWMP is to assess and monitor wetlands at three different spatial scales.

- Tier 1: National Scale Assessment of Wetlands, largely using existing datasets and desktop assessment methods. Results from Tier 1 of the NWMP will allow the NAEHMP to report on the extent of wetlands in the country, land-cover and land ownership and their surroundings and the extent to which wetlands in the country are protected.
- Tier 2: Rapid Assessment of Prioritised Wetlands involves the prioritisation of certain wetlands for further investigation, followed by field assessors spending approximately 4-8 hours at each wetland. Results from Tier 2 will allow reporting of eight indicators, namely the extent of the wetland; the present state of hydrology, geomorphology, vegetation and water quality; present ecological state based on land use; scores for ecosystem services provided by the wetland; and a measure of the threats posed by listed invasive plants to the wetland.
- Tier 3: Detailed Monitoring of Selected Wetlands, most of which will have been selected from Tier 2. The purpose of Tier 3 is to build a body of knowledge of wetland ecosystems and to monitor wetlands assessed as being of concern for one reason or another. A suite of indicators and protocols are provided for monitoring wetlands at this level of detail. Not all indicators will necessarily be monitored at Tier 3 wetlands. A monitoring plan will need to be developed for each of these wetlands, the details of such a plan, including the indicators, will depend on the reasons for investigating the wetland.

Conclusion and Recommendations

This Implementation Manual provides the processes, procedures and methods required to report Tier 1 indicators, 9-prioritize wetlands for Tier 2 and 3 assessments and to carry out assessment and monitoring at each level. This manual provides the information necessary for DWS to implement the NWMP.

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PURPOSE OF THE DOCUMENT

1 PURPOSE OF THE MANUAL

South Africa is required to monitor and report on the health of its water resources and aquatic ecosystems. The National Water Act (1998) mandates the country to develop national systems for monitoring the use of water resources and the health of aquatic ecosystems, including wetlands. In order to understand the extent and state of wetlands, and changes in these over time, it is necessary to collect biological, physical and chemical data about them.

The "state of wetlands" in the NWMP is used as an all-encompassing term for the extent of, the threats to, and present state of, wetlands.

Wetlands are complex systems and assessment and monitoring them can be difficult and intricate. The developers of the programme have therefore focussed on providing a user-friend and scientifically acceptable approach to monitoring and reporting on the state of South Africa's wetlands. It is important that both this manual and the whole programme continue to evolve and adapt as we improve our understanding of wetlands and how to monitor them.

The purpose of this manual is to describe the proposed processes, indicators, methods and protocols for the assessment and monitoring of wetlands. The intention is that authorities and members of the wetland community will be equipped with a set of protocols that allow them to ascertain the success or otherwise of wetland conservation and management actions, and hence of their investments.

Users of the manual are expected to include a broad range of users, with varying degrees of expertise in wetland science. For this reason, the manual provides both basic wetland and monitoring concepts as well as the relatively technical aspects of wetland monitoring. People using the manual are likely to include

- Departmental officials who have the responsibility for managing the implementation and maintenance of the programme at national level. The Department of Water and Sanitation (DWS) is mandated to fulfil this role but should collaborate and cooperate with the Department of Environmental Affairs (DEA) and the South African Biodiversity Institute (SANBI);
- personnel from provincial water, environment, agriculture and mining departments, provincial conservation agencies, Catchment Management Agencies (CMAs) and local government; and
- wetland practitioners and personnel from private organisations involved in managing, conserving or "developing" wetlands.

2 STRUCTURE OF THE MANUAL

The Implementation Manual is laid out in the following manner:

Introduction	Section 3 provides an overview of the NWMP
Framework	Section 4 provides an overview of the framework which guides the NWMP
Tier 1	Section 5 outlines the process for the National-level Desktop Assessment of Wetlands
Tier 2	Section 6 outlines the process for the Rapid Field Assessment of a Sub-set of Prioritized Wetlands
Tier 3	Section 7 outlines the process for the Monitoring Processes and Protocols for a Sub-Set of Tier 2 Wetlands
Data considerations	Section 8 deals with Data Quality Considerations when Reporting Wetland Indicators at a National Level
Field Guide	Section 9 provides a Field Guide to collecting data for Tier 2 and Tier 3 indicators in the NWMP

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ACRONYMS

CBD	Convention on Biological diversity
DEA	Department of Environmental Affairs
DEAT	Department of Environment Affairs and Tourism
DSF	Decision-support Framework
DSP	Decision-support Protocol
DSS	Decision-support System
DWA	Department of Water Affairs
DWAF	Department of Water Affairs and Forestry
DWS	Department of Water and Sanitation
EC	Ecological Category
EIS	Ecological Importance and Sensitivity
EPA	Environmental Protection Agency
ER	Ecological Reserve
EWR	Ecological Water Requirements
FAII	Fish Assemblage Integrity Index
FRAI	Fish Response Assessment Index
GIS	Geographic Information System
GPS	Global Positioning System
IHI	Index of Habitat Integrity
NAEHMP	National Aquatic Ecosystem Health Monitoring Programme
NEM: BA	National Environmental Management: Biodiversity Act
NWI	National Wetland Inventory
NWMP	National Wetlands Monitoring Programme
PES	Present Ecological State
RDM	Resource Directed Measures
RHP	River Health Programme
SAEON	South African Environmental Observation Network
SANBI	South Africa National Biodiversity Institute
US EPA	United States Environmental Protection Agency

INTRODUCTION

3 INTRODUCTION

This NWMP Implementation Manual is supported by a NWMP Consolidation Technical Report (WRC NWMP Vol 1 Report), which provides an overview of wetland assessment and monitoring both internationally and nationally, and provides supporting literature used when developing the programme.

This NWMP Implementation Manual provides the 'how to' collect data to report on the state of wetlands in the country. It is therefore, one component of the NWMP, as outlined in the NWMP Consolidation Technical Report.

3.1 WHY DO WE NEED TO MONITOR WETLANDS IN THE COUNTRY?

The National Water Act 38 of 1998 (the NWA) provides a mandate to the Department of Water and Sanitation (DWS) to monitor the use of water resources and the health of aquatic ecosystems, including wetlands. To address this mandate, DWS has established the National Aquatic Ecosystem Health Monitoring Programme (NAEHMP), which currently focusses on reporting the State of South African Rivers, through the River Health Programme (RHP), and estuaries, through the Estuaries Monitoring Programme. For the NAEHMP to be able to report on the health of wetlands, a separate programme is required. The National Wetland Monitoring Programme (NWMP), the subject of this document, focusses specifically on this need.

Although the NWA is the main driver of the wetland programme, South Africa also has commitments to other initiatives, such as State of the Environment reporting, the Convention of Biodiversity (CBD) and the Ramsar Convention, which also require wetland assessment and monitoring data. Many Water Use License (WUL) applications and Environmental Impact Assessment (EIAs) also use or generate monitoring data on specific, often small, wetlands. All these assessment, monitoring and reporting requirements were considered in the design of the NWMP.

3.2 WHAT IS THE NATIONAL WETLAND MONITORING PROGRAMME?

South Africa's National Wetland Monitoring Programme is a structured, systematic assessment, monitoring and reporting programme. The chief purpose of the NWMP is *to* ***assess and monitor the extent of wetlands, the threats to and the change in the present ecological state and ecosystem services provided by, wetlands in the country***. It is a *"state-of-wetlands*" reporting programme, designed to demonstrate trends in the state of wetlands over time.

What is wetland condition?

In the NWMP the term" condition" refers to the state or integrity of the biological, physical, and chemical components of a wetland ecosystem, and their interactions.

The NWMP enables South African decision-makers, stakeholders and academics to:

- meet international wetland reporting and monitoring obligations (i.e. Ramsar requirements);
- meet national wetland legislative monitoring and reporting obligations, as mandated;
- assess, monitor and report on the general condition and functioning of wetlands (i.e. "state of the wetlands");
- monitor the provision of ecosystem services by wetlands;
- support the estimation of changes in the socio-economic value of wetlands;
- provide data to support timeous intervention or corrective action with regard to threatened wetlands; and to
- guide and inform future wetland conservation and rehabilitation initiatives.

The developers of the NWMP took the following criteria into account. The programme should:

1) be cost effective;
2) consider resource constraints, both human and financial;
3) address national water and environmental imperatives;
4) assist in deciding which wetlands should be assessed and monitored;
5) be compatible with existing assessment, monitoring and reporting methods and data for wetlands in the country;
6) apply an adaptive management approach: the lessons learnt during implementation of the programme should feed back into continuous improvement and adaptation of the NWMP, which should not be viewed as static.

3.3 WHAT IS A WETLAND?

A wetland is defined in the National Water Act as land *which is transitional between terrestrial and aquatic systems where the water table is usually at or near the surface, or the land is periodically covered with shallow water, and which land in normal circumstances supports or would support vegetation typically adapted to life in saturated soil* (South Africa, 1998). This definition is used in this manual.

Wetlands included in the NWMP are all inland wetlands, both natural and artificial, with no existing connection to the ocean and characterised by the complete absence of marine exchange and/or tidal influence (adapted from Ollis *et al.,* 2013).

3.4 WHY ARE WETLANDS IMPORTANT?

Wetlands in South Africa are valuable from a biodiversity and ecosystem service perspective. They are important for the maintenance of biodiversity, providing a habitat for wetland dependent species such as giant bullfrogs and Wattled Cranes (Kotze et al., 2008). Wetlands also contribute to the livelihoods of many rural communities, providing:

- areas for cultivation of crops;

- grazing for animals;
- harvestable products such as reeds for building materials and weaving;
- recreation and tourism;
- socio-cultural significance, and
- plants and animals for medicinal uses, food production and for households to generate an income.

In addition to these benefits, wetlands provide a host of other services, often indirectly used by society. These services include purification of water, flood attenuation, trapping of sediments, nutrients and toxicants and hydrological buffering (Kotze, 2004). Understanding the state of our wetlands in South Africa is therefore of prime importance for their long-term conservation, management and usefulness.

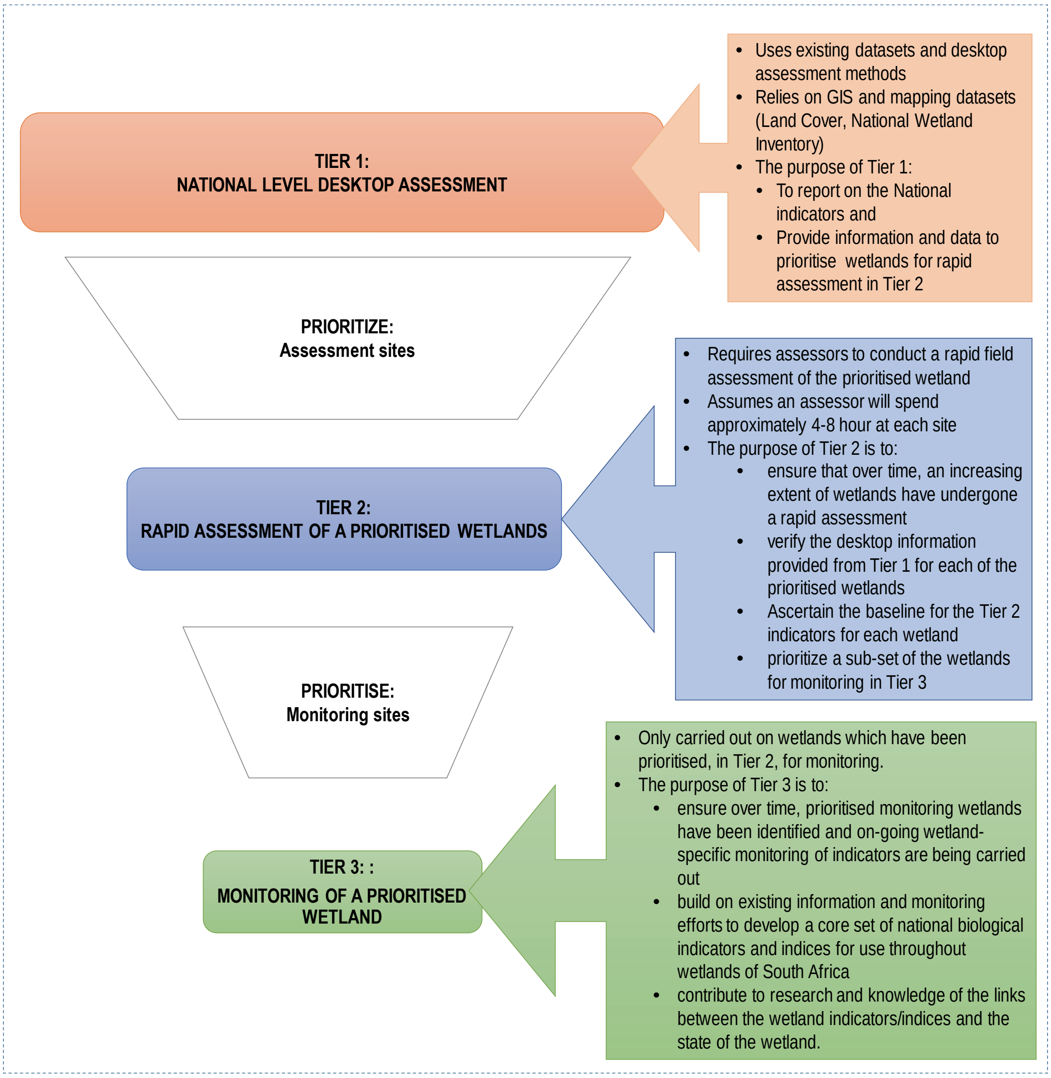
4 THE FRAMEWORK FOR THE NATIONAL WETLAND MONITORING PROGRAMME

The NWMP is based on a three-tiered hierarchical framework that allows assessment and monitoring of wetlands at different spatial scales. The three Tiers of the framework are (Figures 1 and 2):

Tier 1: National level desktop assessment

Tier 2: Rapid assessment of prioritised wetlands

Tier 3: Detailed monitoring of a proportion of Tier 2 wetlands.



- Uses existing datasets and desktop assessment methods
- Relies on GIS and mapping datasets (Land Cover, National Wetland Inventory)
- The purpose of Tier 1:
  - To report on the National indicators and
  - Provide information and data to prioritise wetlands for rapid assessment in Tier 2

- Requires assessors to conduct a rapid field assessment of the prioritised wetland
- Assumes an assessor will spend approximately 4-8 hour at each site
- The purpose of Tier 2 is to:
  - ensure that over time, an increasing extent of wetlands have undergone a rapid assessment
  - verify the desktop information provided from Tier 1 for each of the prioritised wetlands
  - Ascertain the baseline for the Tier 2 indicators for each wetland
  - prioritize a sub-set of the wetlands for monitoring in Tier 3

- Only carried out on wetlands which have been prioritised, in Tier 2, for monitoring.
- The purpose of Tier 3 is to:
  - ensure over time, prioritised monitoring wetlands have been identified and on-going wetland-specific monitoring of indicators are being carried out
  - build on existing information and monitoring efforts to develop a core set of national biological indicators and indices for use throughout wetlands of South Africa
  - contribute to research and knowledge of the links between the wetland indicators/indices and the state of the wetland.

Figure 1: NWMP Framework showing the assessment and monitoring hierarchy.

4.1 WHAT HAPPENS IN TIER 1: NATIONAL-LEVEL DESKTOP ASSESSMENT?

Tier 1 of the NWMP reports on four national indicators, using existing datasets and desktop assessment methods (Figure 2). The indicators rely predominately on GIS and mapping datasets (Land Cover, National Wetland Inventory), as opposed to direct measurement at a wetland scale.

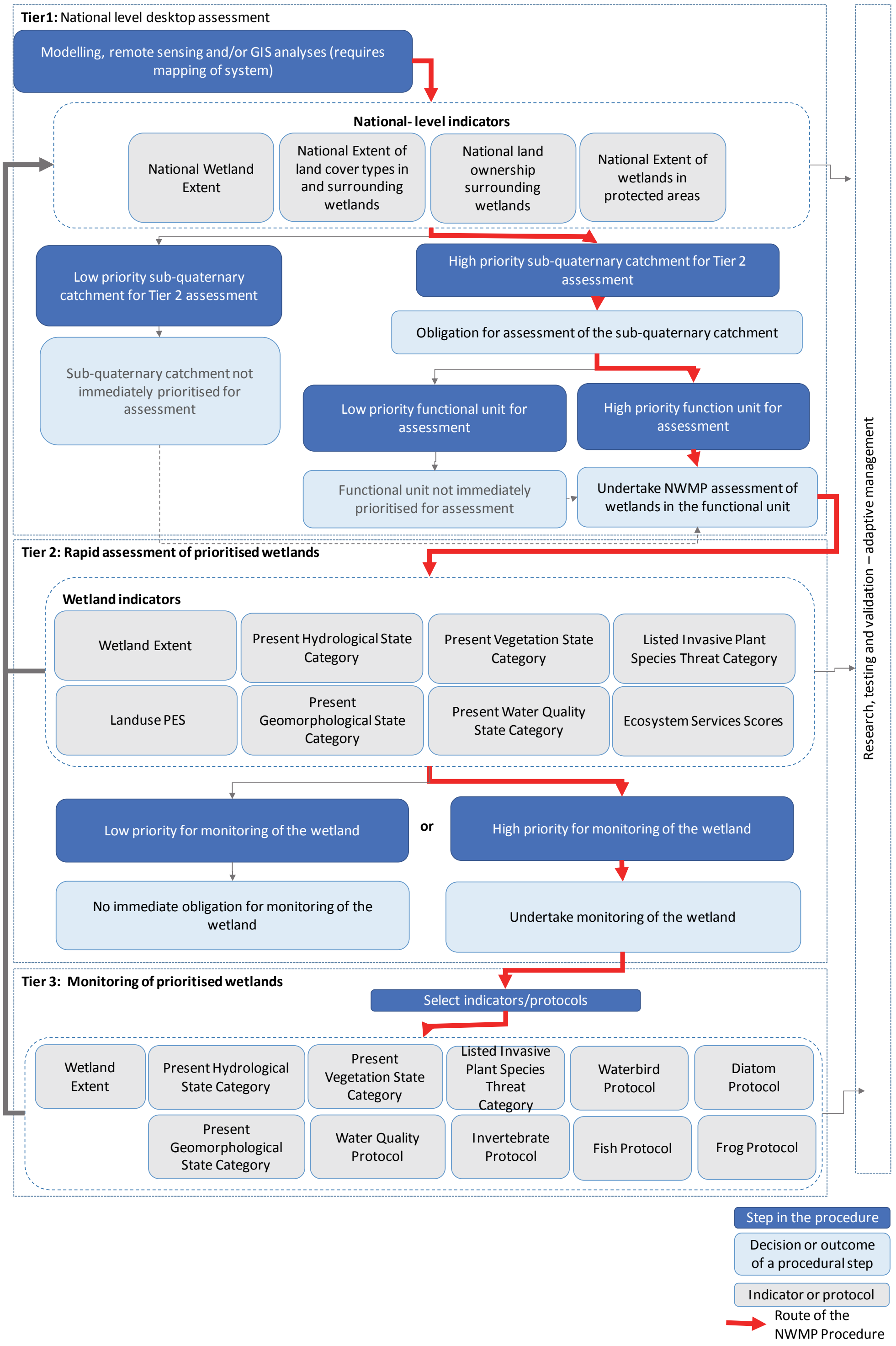


Figure 2: The NWMP Framework, showing activities and indicators of each three tiers in the programme. The solid red arrow denotes the NWMP processes to follow)

The data underlying this and the other tiers of the NWMP is the National Wetland Inventory (NWI). The starting point of assessing, monitoring and reporting the state of wetlands in the country is for the DWS: NAEHMP to obtain the latest NWI dataset from SANBI. The NWI is used to update the NWMP database and vice versa.

Since DWS is the organisation mandated to sustainably operate and manage the NWMP, the NAEHMP in DWS is primarily responsible for implementing and managing Tier 1 of the NWMP.

4.2 WHAT HAPPENS IN TIER 2: RAPID ASSESSMENT OF PRIORITISED WETLANDS

Tier 2 of the NWMP framework involves the rapid assessment of prioritised wetlands. South Africa has a significant number of wetlands, making it unrealistic and impractical to conduct field-based assessments of all wetlands in the country. Certain wetlands therefore need to be identified for more detailed field assessment. Annually, in conjunction with experts and partners, the NAEHMP will need to identify wetlands to undergo Tier-2 assessment. (See Section 5.6 for guidance on prioritising wetlands for assessment at Tier 2.)

What is a wetland assessment?

In the context of the NWMP, a wetland assessment is a rapid field assessment of eight indicators of the extent, present ecological state (PES) of, threats to, and ecosystem services provided by a wetland.

Eight indicators are examined in assessing Tier 2 wetlands (Figure 2). Tier 2 also requires the collection of a suite of basic attribute data for each of the wetlands (see Section 9.1.1 for details of these attributes). Attributes include background data for the wetland and those aspects of a wetland which are likely to pose a threat to the state of the wetland in future.

Tier 2 assessments are the responsibility of personnel of the NAEHMP and of the provincial authorities – effectively these are the people who would go into the field to conduct assessments of individual wetlands and capture the data in the NWMP database. NAEHMP partners and wetland stakeholders may also contribute to this tier of the NWMP. For example, the DEA assessments of Ramsar sites, assessments by organisations such as Eskom and Mondi, and assessments for Water Use Licenses and Environmental Impact Assessments, may all contribute data to Tier 2.

4.3 WHAT HAPPENS IN TIER 3: MONITORING OF A SUB-SET OF TIER 2 WETLANDS?

Tier 3 in the NWMP Framework involves monitoring wetlands visited in Tier 2 assessments and prioritised for further assessment. Two tools are used to prioritise wetlands for monitoring. Firstly, results of the Tier 2 assessment may indicate that ongoing monitoring of the wetland is necessary (e.g. a particular indicator or combination of indicators from Tier 2 may show there to be an issue of concern). Secondly, a criteria-based guideline for prioritising wetlands (see Section 6.5) can be used.

A primary objective of monitoring Tier 3 wetlands is to build a data set of physical, chemical and biological features of for the country as a whole. We know very little about the natural ranges of biophysical features of wetlands, let alone about the links between a change in a particular wetland attribute (such as the assemblage of frogs, fish or birds) and the change in the state of the wetland. It is necessary to build a knowledge base which will allow the wetland sector, in future, to use a change in a wetland attribute to indicate a change in the state of the wetland. A number of the Tier 3 wetlands can be considered to be Reference Wetlands, chosen specifically to record a wide variety of physical, chemical and biological attributes over time.

What is wetland monitoring?

Monitoring is defined as the ongoing measurement of wetland indicator(s) and protocols for a particular purpose

A suite of monitoring indicators and protocols are provided in this manual. It is not anticipated that all of these will be used to monitor every wetland in Tier 3. The selection of appropriate indicators and protocols for each wetland should be done while developing a monitoring plan for the wetland (see Section 5.6.1 of WRC NWMP Consolidation Technical Report and Section 4.4 of this implementation manual for more details on wetland monitoring plans). In short, only those indicators and protocols relevant to each prioritised wetland will be monitored. However, all of the indicators/protocols should be monitored in the Reference Wetlands.

4.4 ADAPTIVE MANAGEMENT IN THE NWMP

Although they may recognise the importance of the NWMP, personnel in agencies that are already overburdened with responsibilities and stretched thin by funding limitations, might find the task of implementing this new programme to be daunting. The programme should thus be implemented following an adaptive management approach, explicitly learning from the outcomes of the programme, accommodating change and thereby improving management decisions. In this way, both the NWMP and the wetlands being monitored, can be incrementally adapted and improved as the sector becomes familiar with the programme and more resources become available.

The application of adaptive management to the NWMP includes five main steps, as outlined in Figure 3. These five steps are intended to encourage a more thoughtful, disciplined approach to wetland management, assessment and monitoring. The NWMP implementation should be evaluated on an ongoing basis, adapting with the outcomes of these evaluations.

details on the process of design of the NWMP), namely:

- **Step 1:** setting a desired future for assessment and monitoring in the country. The purpose of the NWMP was selected by stakeholders as *to* ***assess and monitor the extent of and the threats to wetlands and the change in the present ecological state and ecosystem services provided by wetlands in the country***.
- **Step 2:** setting objectives: the objectives of the NWMP are:
  - to conduct national level assessments of potential threats to wetlands across the country
  - to conduct rapid assessments of the state of a subset of wetlands
  - to conduct monitoring of specific components of further subset of prioritised wetlands
- **Step 3:** Options to achieve the NWMP objectives. This Implementation Manual provides the ‘options’ for achieving the NWMP objectives in the form of the NWMP Framework, procedure, methods, tools, indicators and indicators.
- **Step 4:** Operationalising the NWMP. It is the responsibility of the DWS NAEHMP (working with key stakeholders such as SANBI, SAEON and DEA) to operationalise the NWMP by implementing this Implementation Manual.
- **Step 5:** Evaluate and Learn. The NWMP should be evaluated at various intervals, at least every second year, to adapt and modify the programme with lessons learnt from implementation.

The development of a wetland management and monitoring plan, as required in Tier 3 of the NWMP, should follow the five steps shown in Figure 3. These plans should be evaluated, adapted and modified annually. Similarly, the outcomes of monitoring of prioritised wetlands in the NWMP should inform the management/monitoring plan.

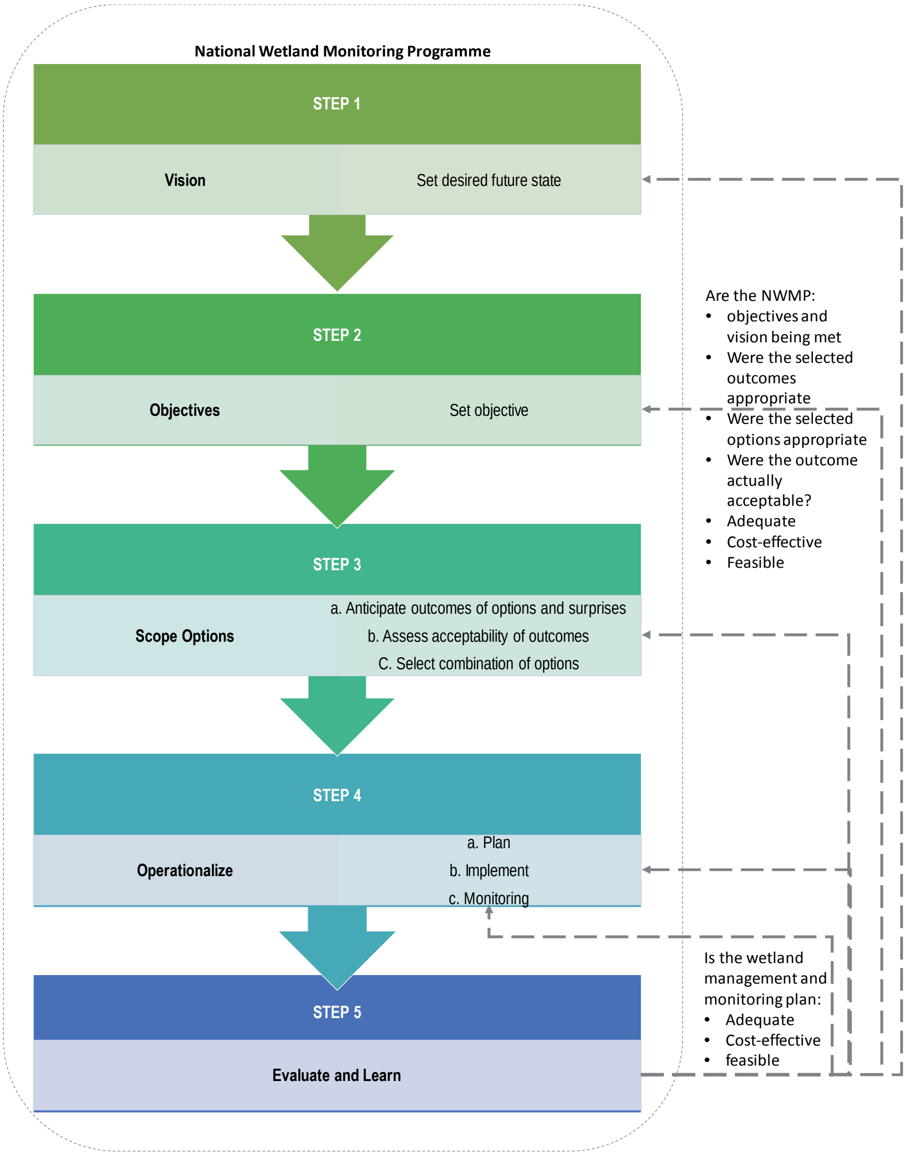


Figure 3: Adaptive management approach to the implementation of the NWMP and wetland management/ monitoring plans linked to the NWMP (adapted from Venter and Mitchell, 2015)

The design of the NWMP followed a process similar to that outlined in Figure 3 (see WRC NWMP Consolidation Technical Report for more details on the NWMP design process).

Section 5-9 below discusses the process to be followed for the implementation of the three Tiers of the NWMP Framework, outlines the detail of each indicator in the tier by providing a rationale for the indicator, the methods to be used to capture the data for the indicator and, where possible, provides case studies to demonstrate the results of the indicators.

In addition, Section 5-9 describes activities, such as prioritisation and other wetland assessment activities, which need to occur to ensure the implementation of the NWMP.

Since the NWMP also has the purpose of building scientific knowledge on wetlands in the country, all information and data collected in the three tiers of the programme will be housed within the NWMP database (see Section 5.8 and Appendix D of WRC NWMP Consolidated Technical Report for details on the NWMP database) and used to improve management and inform future research needs. The NWMP should focus on building this body of knowledge and support these research efforts in future.

TIER 1: NATIONAL-LEVEL DESKTOP ASSESSMENT OF WETLANDS

5 TIER 1: NATIONAL LEVEL ASSESSMENT OF WETLANDS

This Tier of the NWMP relies almost entirely on Geographic Information Systems (GIS) and remotely- sensed data to gather information about wetlands at a national level. Tier 1 will be implemented by DWS, at the intervals required for reporting of indicators in this tier of the NWMP.

The purpose of Tier 1: National level desktop assessment of Wetlands is twofold, namely to:

1. report on the national indicators using GIS and desktop assessment methods; and
2. provide information and data for identifying wetlands to undergo site-specific rapid assessment in Tier 2.

Figure 4 shows the four Tier 1 indicators in the NWMP, namely:

- total extent of wetlands in the country;
- total extent of each land-cover type in and around wetlands;
- land ownership of wetlands and their surroundings;
- total extent of wetlands in each protected area category.

The outcome of Tier 1 will be that the NAEHMP can report, at a national scale, the extent of wetlands in the country, what land-cover types can be found in and surrounding wetlands, the categories of land ownership of the land surrounding our wetlands, and the extent of protected wetlands in the country. This tier thus places wetlands into context at a national scale, in terms of size, potential threats, accessibility and protection. These indicators largely relate to 'threats' to wetlands in the country, in that a change in the indicator demonstrates that there may be an increased or decreased 'threat' to wetlands.

To report on the indicators in Tier 1 requires a range of datasets (Table 1). It is key that the latest version of each dataset be obtained to produce the most accurate and relevant base data. The accuracy of the indicators in the Tier of the NWMP is linked largely to the accuracy of the available GIS/mapping data. Hence, the confidence with which the results can be reported will vary for each indicator.

Table 1: Data required for Tier 1 of the National Wetland Monitoring Programme

Data	Source	Web Address/ Location
Latest National Wetland Inventory shapefile	SANBI	bgis.sanbi.org
Latest South African National Land-Cover Thematic Dataset	SANBI	bgis.sanbi.org
72X Class legend for land-cover datasets	SANBI	bgis.sanbi.org
Latest national protected areas shapefile	DEA	egis.environment.gov.za
Latest Cadastral shapefiles including erf and parent farms	Chief Surveyor General	csg.dla.gov.za
Latest national land user database, indicating land use entities for land portions	Chief Surveyor General	csg.dla.gov.za
Latest Cadastral shapefile indicating land portions/parcels	DEA	egis.environment.gov.za
Latest National Wetland Monitoring Programme dataset	Not available yet	Not available yet

The NWMP will report on each of these indicators at specific intervals, to demonstrate trends over time (five or ten years: see Section 5.6 of WRC Consolidated Technical Report for the reporting intervals recommended for each indicator).

Figure 4 shows the activities that are required to implement Tier 1 of the NWMP. Each of the national indicators is described in more detail in the section below.

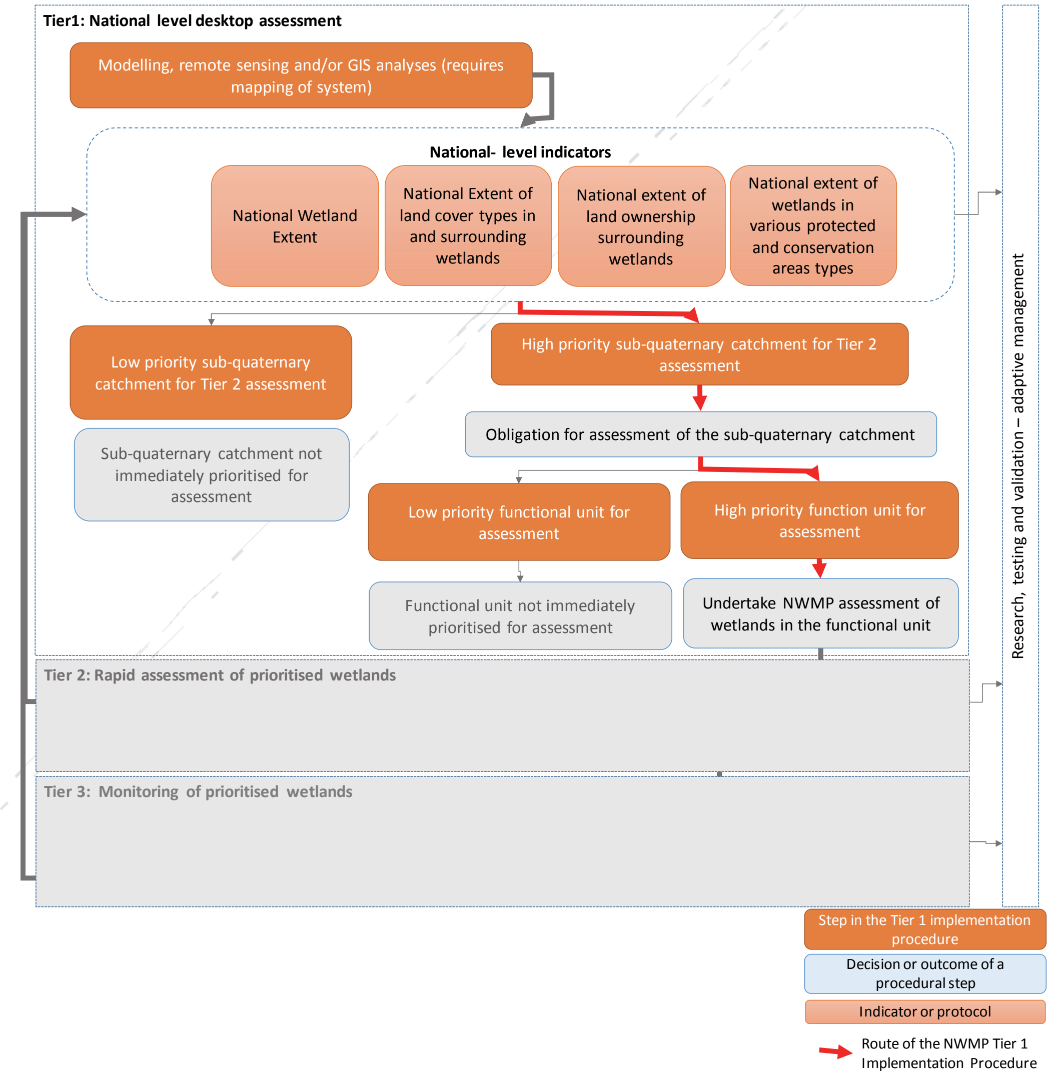


Figure 4: Process required for the implementation of Tier 1 of the NWMP. Red arrows in the figure indicate the sequence of steps to follow.

5.1 NATIONAL EXTENT OF WETLANDS

This indicator assesses the extent, in hectares, of wetlands in the country.

The mapping and estimation of trends in the extent of wetlands is essential to inform wetland management, assessments, monitoring and use in the country. Knowledge of the size and locality of wetlands will also inform the process of wetland prioritisation in Tier 2.

The following section describes the steps required to measure wetland extent at national level, the Cape Metro being used as a case study to demonstrate the method.

Step 1: Download the latest National Wetland Inventory shapefile. This will be typically found on the BGIS website (http://bgis.sanbi.org) (Table 2, and see Section 1.2.3 of the WRC NWMP Consolidated Technical Report for more details on the NWI). This layer forms the initial basedata for the NWMP and is a crucial component for the programme as a whole.

Table 2: Metadata for the wetland layer used in the case example

Data	***File Name***	***Date captured***	***Reference***	***Resolution***	***Location***
NFEPA wetland layer shapefile	*NFEPA_Wetlands.shp*	*July 2011*	*SANBI (Principle researcher: Jeanne Nel)*	*Digitised from 30 m resolution Landsat imagery, modified at 1:50 000*	(http://bgis.sanbi.org/nfepa/NFEPAmap.asp).

Step 2: Determine the extent (area) of all wetlands in the dataset. This is easiest if you merge all wetlands into one polygon and then calculate the area for the entire polygon.

Case example

The method to determine the extent of wetlands in the country was applied to a sample area of the country during testing of Tier 1 of the NWMP, namely the Cape Town Metro Municipality (Figure 5).

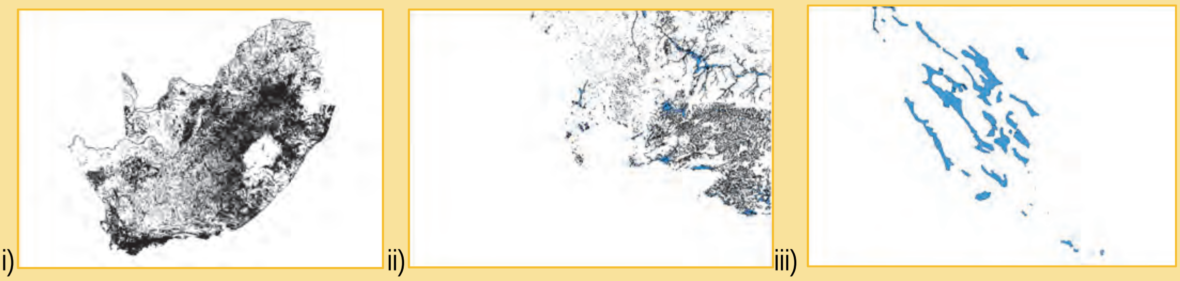


Figure 5: NFEPA wetland dataset (SANBI) for i) South Africa, ii) Cape Town Metropolitan Municipality and iii) the Cape Point region.

Using NWI data, the area of wetlands in the Cape Town Metropolitan Municipality was estimated at 8699 hectares or 3,5% of the Metro land area.

5.2 NATIONAL EXTENT OF LAND COVER TYPES IN AND SURROUNDING WETLANDS

This indicator reports the extent, in hectares, of various land-cover types within and surrounding the wetlands of the country.

Wetlands can be negatively affected by human activities. Change of land-cover within and surrounding a wetland, due to removal of natural vegetation during excavating drains, for cultivation, or for road construction, can lead to widespread wetland degradation, resulting in the reduction and loss of wetland functional effectiveness and ability to deliver ecosystem services or benefits to humans and the environment (Kotze *et al.*, 2008).

Land-cover changes can also affect the timing and amount of runoff entering a wetland, as well as residence time and the pattern of water-flow through the wetland. These factors in turn can affect the hydrological condition of wetlands (Macfarlane et al*.,* 2009).

What is land-cover?

Land-cover refers to the forests, wetlands, impervious surfaces, agricultural lands, and other physical and biological material covering the surface of the Earth. Land cover can be identified by analyzing satellite and aerial imagery.

This indicator makes use of the South African National Land-Cover (NLC) thematic dataset from the BGIS website (http://bgis.sanbi.org). The NLC is the most up-to-date (2014/15) land-cover for South Africa and is based on a combination of Landsat imagery and modelling applications.

The 72 land-cover classes in the NLC are used to identify land cover in and within a 100 m[1] area around wetlands by merging the 72 into the following 6 classes:

a) natural untransformed
b) waterbodies
c) degraded natural land
d) cultivated / plantations
e) mines / quarries
f) urban / built-up.

The steps required to generate the data for land-cover within and 100 meters around wetlands are illustrated below, using the Cape Metro as a case study (see Appendix E of the WRC NWMP Consolidated Technical Report for discussion of the buffer area around wetlands).

Step 1: Download the latest South African National Land-Cover (NLC) thematic dataset from the BGIS website (http://bgis.sanbi.org). Obtain the vector shapefile if possible (Figure 6 and Table 3). This dataset did not have a vector shapefile version at the time of download, but if possible the vector dataset should be obtained.

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[1] The NWMP currently recommends a 100 m buffer area to determine land cover around wetlands (see Appendix E of the WRC NWMP Consolidated Technical Report for discussion of the buffer area around wetlands). This may change in future due to the current regulations for GENERAL AUTHORISATION IN TERMS OF SECTION 39 OF THE NATIONAL WATER ACT, 1998 (ACT NO. 36 OF 1998) which defines the “extent of a watercourse “as including (for wetlands and pans) the area “within a 500 m radius from the boundary (temporary zone) of any wetland or pan”. (When the temporary zone is not present then the seasonal zone is delineated as the wetland boundary.)

Table 3: Metadata for the 2013-2014 South African National Land-Cover Dataset used in the case example

Data	*File Name*	*Date captured*	*Reference*	*Resolution*	*Location*
2013-2014 South African National Land-Cover Dataset	SA_Lcov_2013-14_GTI_utm35n_vs22b.img	April 2013-March 2014	GeoTerraImage (Director Remote Sensing: Mark Thompson)	Digitised from 30 m resolution Landsat imagery, recommended 1:75 000-1:90 000	http://bgis.sanbi.org/DEA_Landcover/project.asp

Figure 6: 2014 National Land Cover Dataset (GeoTerraImage 2014) for i) South Africa, ii) the Cape Town Metropolitan Municipality and iii) Cape Point.

If the vector shapefile is available, then continue with Step 3. If not, then proceed with Step 2.

Step 2: Polygonise the NLC thematic dataset. This converts the raster layer (image) into a vector layer (polygons). The NLC 2014 was polygonised into a vector shapefile (Figure 7).

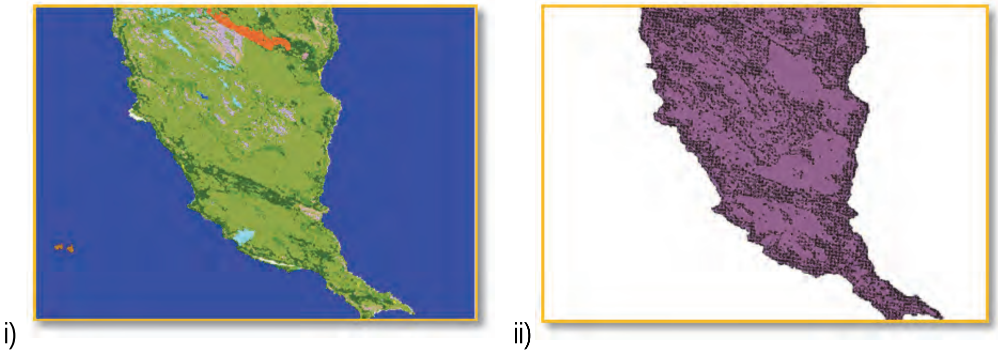


Figure 7: NLC 2014 (GeoTerraImage 2014) as a i) raster and as a ii) vector dataset.

Step 3: create a 100 m area surrounding the wetlands. This will produce a layer which includes the wetland area as well as a 100 m area surrounding the wetland. Ensure that adjacent buffer polygons (for individual wetlands) are dissolved. This ensures that there is no double accounting of data found within the buffer.

Case example: A 100 m area was created around wetlands found in the Cape Town Metropolitan Municipality (Figure 8). It must be noted that the buffer extent includes the 100 m surrounding the wetland as well as the wetland area. Be cautious when utilising this tool.

Figure 8: NFEPA Wetlands with 100 m dissolved buffer at Cape Point.

Step 4: Clip the NLC vector layer using the 100 m buffer. This creates a layer containing a number of polygons consisting of land cover types within the buffer layer extent.

Case example: The NLC 2014 was clipped using the 100 m area around for all wetlands in the Cape Town Metropolitan Municipality (Figure 9).

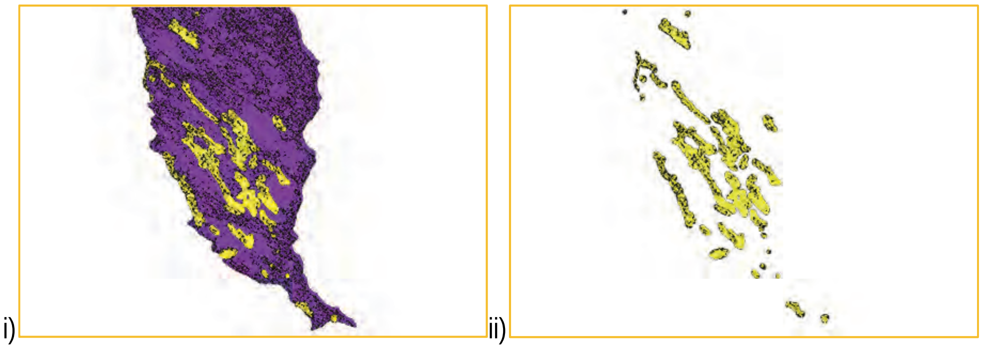


Figure 9: The 100 m buffer a) overlain on NLC 2014 vector dataset and b) clipped land cover

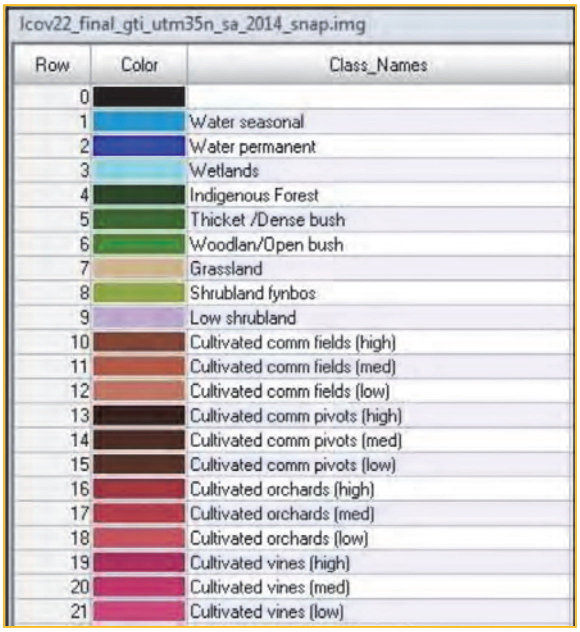
Step 5: Retrieve the appropriate Class Legend for Land-Cover Datasets from the BGIS website (bgis.sanbi.org) to identify the land cover classes for corresponding values.

Case example: The 72x class legend for land cover-datasets was obtained as it corresponds to the NLC 2014 (Table 4; Table 5). As the raster NLC dataset was polygonised into a vector dataset there was a need to incorporate additional fields with descriptions of land use types. This was done using the 72x class legend for land cover-datasets.

Table 4: Metadata for the 72x class legend for land-cover datasets used in the case example.

Data	*File Name*	*Reference*	*Location*
72x Class Legend for Land-Cover Datasets	72 x class land-cover legend.pdf		http://bgis.sanbi.org/DEA_Landcover/project.asp

Table 5: Example of the 72X Class Legend for Land-Cover Datasets used in the the NLC dataset.

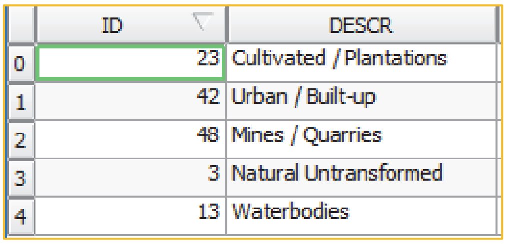


lcov22_final_gti_utm35n_sa_2014_snap.img

Row	Color	Class_Names
0	⬛	
1	🟦	Water seasonal
2	🟦	Water permanent
3	🟦	Wetlands
4	🟩	Indigenous Forest
5	🟩	Thicket /Dense bush
6	🟩	Woodlan/Open bush
7	🟫	Grassland
8	🟩	Shrubland fynbos
9	🟪	Low shrubland
10	🟫	Cultivated comm fields (high)
11	🟥	Cultivated comm fields (med)
12	🟥	Cultivated comm fields (low)
13	🟫	Cultivated comm pivots (high)
14	🟫	Cultivated comm pivots (med)
15	🟫	Cultivated comm pivots (low)
16	🟥	Cultivated orchards (high)
17	🟥	Cultivated orchards (med)
18	🟥	Cultivated orchards (low)
19	🟥	Cultivated vines (high)
20	🟥	Cultivated vines (med)
21	🟥	Cultivated vines (low)

Step 6: Merge polygons with general land cover types into one polygon. This simplifies the layer and allows for a general understanding of land cover types. This simplifies the legend from 72 classes to 6 classes and makes the data more manageable.

Case example: Polygons were merged into general land cover types for the Cape Town Metropolitan Municipality (Figure 10).



	ID	DESCR
0	23	Cultivated / Plantations
1	42	Urban / Built-up
2	48	Mines / Quarries
3	3	Natural Untransformed
4	13	Waterbodies

Figure 10: Land cover categories found within 100 m of wetlands in the Cape Town Metropolitan Municipality.

Step 7: Determine the area of each land-use class within the 100 m area around the wetland by using the field calculator. The field calculator is a tool in QGIS for calculating and editing new and existing data fields.

Step 8: Determine the percentage of each land-cover type within the 100 m area around the wetlands. This is done by dividing the area of each land cover class estimated in the previous step by the total wetland area (with the 100 m area) and multiplying by 100 in the field calculator[2].

Case example

The method for determining the extent of landcover types within and 100 metres around wetlands in the country was applied to a sample area of the country during testing of Tier 1 of the NWMP, namely the Cape Town Metro Municipality. Applying the methods resulted in the extent of landcover types in and100 m around wetlands in the Cape Town Metropolitan Municipality as shown in Table 6.

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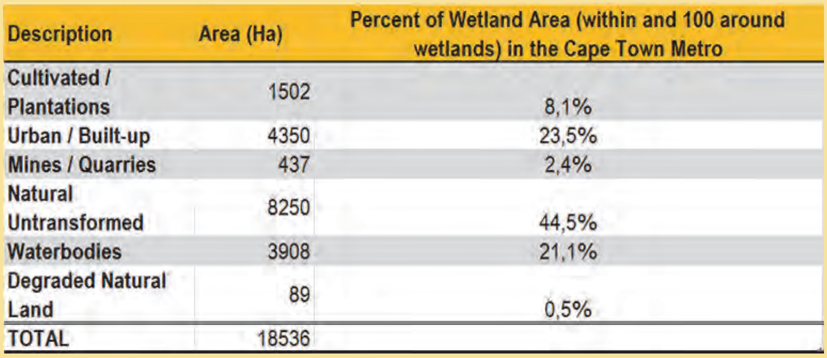
[2] The field calculator is a tool in QGIS for calculating and editing new and existing data fields.

Table 6: Area and percent of land-cover types within and 100 m area around wetlands in the Cape Town Metropolitan Municipality



Description	Area (Ha)	Percent of Wetland Area (within and 100 around wetlands) in the Cape Town Metro
Cultivated / Plantations	1502	8,1%
Urban / Built-up	4350	23,5%
Mines / Quarries	437	2,4%
Natural Untransformed	8250	44,5%
Waterbodies	3908	21,1%
Degraded Natural Land	89	0,5%
TOTAL	18536	

The example in Table 6 shows that the major landcover in and within a 100 metre area around the wetlands in the Cape Town Metro is natural untransformed land.

To see change over time, land-cover maps for several different years are needed. With this information, managers will be able to evaluate past management decisions, thereby gaining insight into the possible effects of their current decisions, before they are implemented.

5.3 NATIONAL EXTENT OF LAND OWNERSHIP SURROUNDING WETLANDS

This indicator reports the extent, in hectares, of wetlands in the country which are under various land ownership. Although not reflecting the 'state' of wetlands in the country, the indicator does reflect the state of tenure of the land on which these wetlands are located and to some extent would influence considerations in determining intervention and management of the wetlands.

This indicator is calculated using the national land spatial data, which can be obtained from the Surveyor-General. The database contains the following land-user entities:

a) government department
b) municipality
c) organisation
d) private person
e) private entity
f) traditional authority
g) unknown.

The steps required to generate the indicator, using the Cape Peninsula as a case study, are as follows.

Step 1: Request the latest cadastral dataset from the Chief Surveyor General's office. Make sure it includes the erf and parent farm shapefiles The erf layer includes portions within towns and the parent farms layer includes parent farm portions in the area. These layers, when overlain on one another, fit together to form a complete account of land portions across the chosen space See Table 7 for details.

Table 7: Metadata for the national land use database

Data	File Name	Reference	Location
National land user database	National WRC Database	Chief Surveyor General (The Chief Surveyor General: Mmuso Riba)	http://csg.dla.gov.za/contact.htm

<u>*Case example:*</u> Cadastral data were obtained from the Chief Surveyor-General (Table 8). These data have to be bought but government departments may request them at no cost pending a review of the work that needs to be done. The database contains multiple vector datasets but for the current purposes, only the erf and parent farm layers were needed (Figure 11).

Table 8: Metadata for the erf and parent farm dataset.

Data	File Name	Date captured	Reference	Location
Erf Dataset	Erf.shp	September 2011	Chief Surveyor General (Office of the Chief Surveyor General: Adjei Danso)	http://csg.dla.gov.za/contact.htm

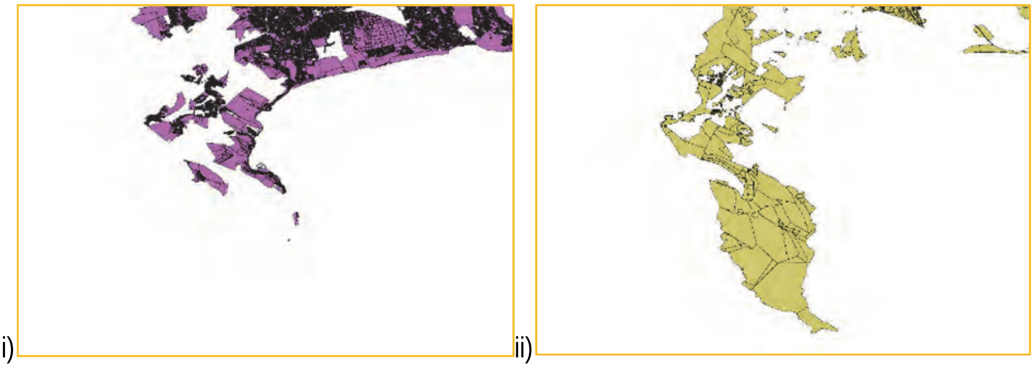

i) ii)

Figure 11: Cadastral data including i) Erf portions ii) Parent Farm portions for the Cape Peninsula

Step 2: Merge the erf and the parent farm layers into one layer. This will merge the attribute tables based on their fields, making a combined layer and attribute table.

Case example: The erf and parent farm layers were merged into a single layer for the Cape Point (Figure 12). Double check that the attributes have been combined correctly.

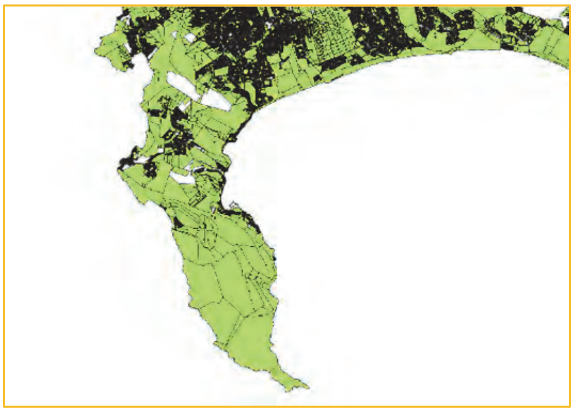


Figure 12: Combined erf and parent farm land portion dataset

Step 3: Clip the difference between the wetland inventory layer and the layer 100 m around the wetlands (created in section 5.3) to modify it into a doughnut. This will create a layer which includes the 100 m area around the wetlands but not the area of the actual wetlands.

Case Example: The difference between the wetlands layer and the 100 m area around the wetlands was clipped to create a 100 m doughnut around the wetlands found in Cape Point (Figure 13).

Figure 13: Wetland doughnuts derived from 100 m area around wetlands at Cape Point.

Step 4: Clip the combined erf-parent farm layer using the 100 m doughnut derived from the latest national wetland inventory layer. This creates a layer containing a number of polygons consisting of the various land portions within the 100 m doughnut.

Case example: The combined erf-parent farm layer was clipped using the 100 m doughnut derived from the NWI layer for Cape Point in the Cape Town Metropolitan Municipality (Figure 14).

Figure 14: The 100 m doughnut overlain on the combined erf-parent farm layer for a) Cape Town Metropolitan Municipality and b) the Cape Peninsula and the c) the clipped erf-parent farm layer.

Step 5: A table join must be used to link the land user data with the spatial land parcel data in the clipped 100 m doughnut. The alphanumeric data (21 digits) should be used to do this (ID or LPI). The attribute tables of the erf and parent farm layers include an “ID” field. This will correspond to the LPI codes in the land user database allowing for the identification of land users within the various land portions.

Case example: A table join was performed with the combined erf-parent farm layer for the Cape Peninsula and the national land-use database. This was done by joining the data based on LPI codes in the land use database and corresponding ID field in the erf-parent farm layer. Land use entities were merged into one single polygon so that the total area could easily be calculated using the field calculator[2].

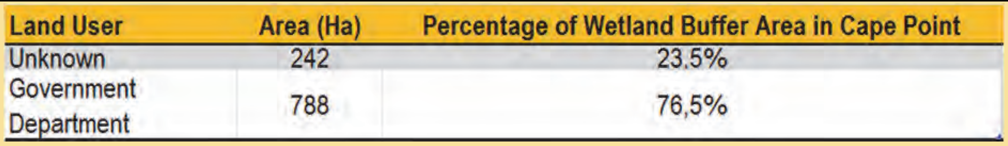
Step 6: Determine the total area of 100 m doughnut used by various land ownership type.

Note: The process of calculating total area occupied by land users may be easier if you merge all polygons with matching land users together.

Step 7: Determine the percentage of 100 m doughnut under various landownership types. Divide the area of the 100 m doughnut under each landownership type by the total area of the 100 m doughnuts and then multiply it by 100.

Case example: The percentage of 100 m wetland doughnut under each land ownerships types was calculated for the Cape Peninsula using the field calculator[2].

Table 9: Percentage of the 100 m wetland doughnut under each land ownerships type



Land User	Area (Ha)	Percentage of Wetland Buffer Area in Cape Point
Unknown	242	23,5%
Government Department	788	76,5%

The indicator shows that the majority (67%) of the wetlands and their surrounding 100 m on the Cape Peninsula are owned by government departments, with the remainder having unknown ownership.

5.4 NATIONAL EXTENT OF WETLANDS IN VARIOUS CATEGORIES OF PROTECTION

This indicator reports the extent, in hectares, of wetlands falling into the various categories of protection or conservation in the country.

The indicator provides evidence of the level of protection of wetlands in the country. The assumption can be made that if a wetland is in a protected area it is managed for conservation purposes and would be at low risk from changes in land ownership, land-cover and/or land use.

The indicator utilises the latest South African protected area dataset from the Department of Environmental Affairs and the SANBI protected area dataset (which includes a broader set of data) and using GIS determines the extent of wetlands within these protected areas. The DEA and SANBI protected areas categories of protected are shown in Table 10.

Table 10: Protected areas categories in the DEA and SANBI database

DEA Protected Areas Categories	SANBI Protected Areas Categories
Biosphere Reserve	Not included
Botanical Garden	Botanical Garden
Forest Nature Reserve	Specially protected forest areas
Marine Protected Area	Marine Protected Areas
Mountain Catchment Area	Mountain catchment areas
National Park	National Parks
Nature Reserve	Nature Reserves (including provincial nature reserves)
Protected Environment	Protected Environments
Ramsar Site	Not included
Special Nature Reserve	Special Nature Reserves
World Heritage Site	World Heritage Sites (the protected area layer includes only natural and not cultural World Heritage Sites)
	Unproclaimed Private Nature Reserves

The steps required to generate the indicator, using the Cape Metro as a case study, are as follows.

Step 1: Download the latest protected areas layer from the DEA (egis.environment.gov.za) and the protected areas layer from BGIS-SANBI (http://bgis.sanbi.org/index.asp?screenwidth=1366)

Case example: The South African protected area dataset 2015 was obtained (Table 11 and Figure 15).

Table 11: Metadata for the South African protected area dataset 2015 used in the case example

Data	*File Name*	*Date Captured*	*Reference*	*Resolution*	*Location*
South African protected area dataset 2015	SAPAD_OR_2015_Q2.shp	June 2015	DEA	*1:5 000*	*http://egis.environment.gov.za/Download.aspx?m=25*

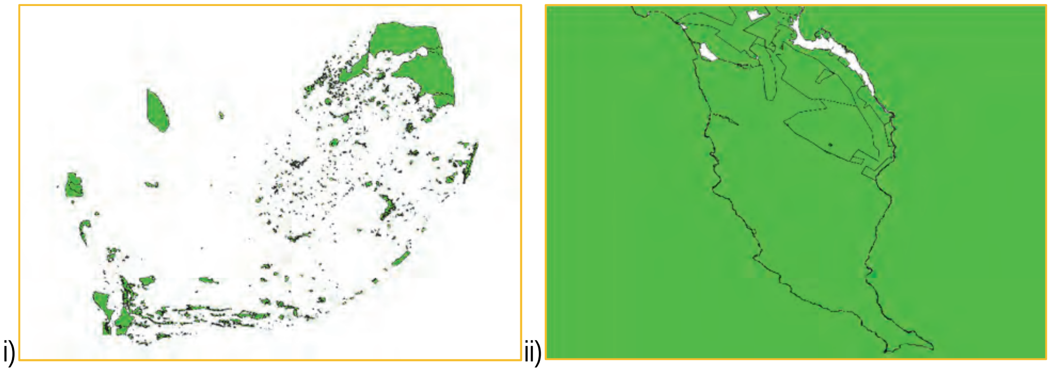


Figure 15: South African protected areas dataset (DEA) for i) South Africa, ii) the Cape Peninsula

Step 2: Overlay the latest national protected areas dataset with the latest national wetland inventory layer and join the attributes by location (this will join the attribute tables based on where features in the wetland layer are situated with relation to features in the protected area layer, allowing us to see the type of protection for each wetland feature).

Case example: The NWI dataset was overlaid with the national protected areas 2015 dataset and attributes were joined by their location (Figure 16).

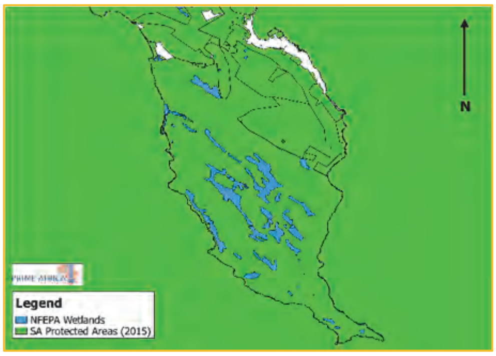


Figure 16: South African protected areas with wetlands at Cape Point.

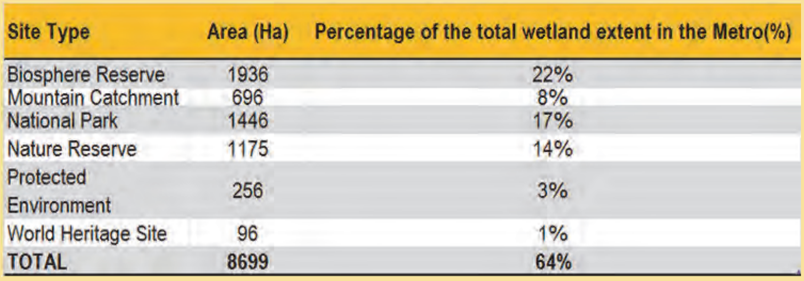
Step 3: Determine the total area of wetlands within the 11 protected areas categories. For the purposes of the categorisation of wetlands, if any part of a wetland falls within a protected area that entire wetland was included in the protected area total.

Note: The process may be easier if you merge all wetlands with matching protected areas together.

Step 4: Determine the percentage of the national wetland inventory layer within the various protected areas categories. This can be done by dividing the area of wetlands found within each protected area category by the total area of wetlands and then multiplying by 100.

Case example: The percentage of wetlands in each corresponding protected area category for the Cape Town Metropolitan Municipality was calculated (Table 12) using the field calculator[2].

Table 12: Percentage of the Cape Town Metropolitan Municipality wetland within each DEA protected area category



Site Type	Area (Ha)	Percentage of the total wetland extent in the Metro(%)
Biosphere Reserve	1936	22%
Mountain Catchment	696	8%
National Park	1446	17%
Nature Reserve	1175	14%
Protected Environment	256	3%
World Heritage Site	96	1%
TOTAL	**8699**	**64%**

Table 12 shows that the total extent of wetlands with some level of protection in the Cape Town Metro is 8699 hectares, amounting to 64% to the total area of wetlands in the Metro.

Figure 17 shows that the majority of wetland in protected areas of the Cape Town Metro fall within biosphere reserves, national parks and nature reserves. However, only 42% of the wetlands in the metro are found in areas formally declared as protected under legislation, i.e. National Parks, nature reserves, protected environments and World Heritage Sites.

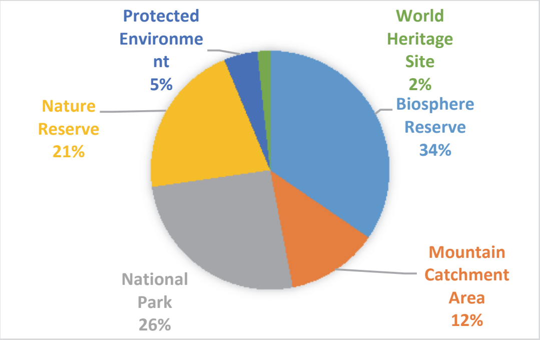


Figure 17: Percentage of wetlands in each protected areas category in the Cape Town Metropolitan Municipality

5.5 WHAT DO THE TIER 1 INDICATORS TELL US?

Case study

The indicators in Tier 1 provide a broad overview of wetlands in the country. For example, using the case study of the Cape Town Metro, one would conclude that the wetlands in the metro, although covering only a small proportion (3,5%) of the total area. have a moderate to high level of legislative protection, with at least 42% being found in areas formally declared as protected under the National Environmental Management: Protected Areas Act; the World Heritage Convention Act (Act 49 of 1999), Marine Living Resources Act (Act 18 of 1998), National Forests Act (Act 84 of 1998) and Mountain Catchment Areas Act (Act 63 of 1970).

At the same time, the case study showed that at least 67% of wetlands on the Cape Peninsula are found on government land. This could facilitate the inclusion of more of this wetland area into protected areas as the land is already under government management. Provincial environmental authorities may also have an influence on how these wetlands are managed.

5.6 PRIORITISATION OF WETLANDS FOR THE TIER 2 RAPID FIELD ASSESSMENT

The report provides a guide for identifying wetlands suitable for Tier 2 rapid assessment, using a rule-based model and expert opinion. Mackenzie et al. (1999) indicate that rule-based models *force scientists and managers to think about the problem to be solved, the decisions to be made, the components of the system, how they relate to each other and interact with one another*. The criteria chosen for the prioritisation exercise are adapted from those recommended by stakeholders at an NWMP design workshop held in Gauteng in May 2015. Each criterion was reviewed during the testing of the NWMP Implementation Manual to ensure that appropriate data and information would be available for the prioritisation process.

The prioritisation process in the NWMP is based on the following assumption:

a) the decision-makers (i.e. personnel from provincial and national departments, CMAs and municipalities) carrying out the prioritisation process in future will have a thorough knowledge of the wetlands in their jurisdiction that will undergo assessment and monitoring;
b) an adaptive management approach is useful – the prioritisation process will be reviewed annually;
c) the prioritisation process will include a representative sample of wetlands across ecoregions, and local decisions-makers will decide which wetlands to choose.

The philosophy behind Tier 2 of the NWMP is to facilitate, over the years of the programme, a rapid field assessment of as many of South Africa's wetlands as possible within the human, financial and resource constraints that affect aquatic health assessment and reporting in the country. Maximising returns and outputs from NWMP wetland assessments is crucial, allowing limited resources to be strategically directed at the prioritised wetlands in order to maximise the desired outcomes.

The reasons for needing to sample only a subset of the country's wetlands are threefold:

d) there are too many wetlands in the country for all of them to be assessed in the field;
e) there is a need to decide on the sequence of systems to be assessed;
f) there is a range of wetland types and ecoregions throughout the country.

The NWMP stakeholder recommended a suite of criteria be utilised to prioritise wetlands in Tier 2. These criteria should be utilised, in conjunction with expert opinion, to prioritised wetland to undergo Tier 2 wetlands. Criteria include:

g) categories of wetland types (HGMs)d
h) ecoregions which should be prioritised for wetland assessment.
i) management units within ecoregions which should be prioritised for Tier 2 wetland assessments.
j) important attributes of wetlands that should be considered in Tier 2 prioritisation of wetlands for assessment, including:
    a) conservation status including threatened ecosystem, i.e. vulnerable; critically endanger; centre of endemism; biological threats, i.e. red data species; Ramsar site and critical biodiversity areas
    b) ecosystem service provided by the wetland which can be inferred from the HGM types of the wetland (Table 13).

Table 13: Preliminary rating[3] of the ecosystem services[4] potentially supplied by a wetland based upon HGM type (taken from Kotze, 2014)

Regulatory services:	**Flood attenuation**	**Erosion control**	**Sediment trapping**	**Phosphate assimilation**	**Nitrate assimilation**	**Toxicant assimilation**
Floodplain[5] wetland	4	3	3.5	4	2	2
Valley-bottom wetland, channelled	2	3	3	3	2	2
Valley-bottom wetland, unchannelled	2.5	4	4	3	3	4
Seep with channelled outflow	1.5	4	1	1	4	4

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[3] The same range is scores from 0 to 4 is used as is applied by WET-EcoServices level 1 assessment.

[4] Although streamflow regulation has been omitted from Kotze (2014), the report indicates that scores for water supply is likely to provide some indication of this service.

[5] Kotze (2014) indicates that a floodplain wetland is taken as typically comprising predominantly floodplain flat with floodplain depressions contained within the flat. If a particular floodplain unit is characterized by the very limited extent of depressions, then this unit is probably best treated as a channelled valley bottom unless it is particularly wide (i.e. >500 m)

Seep without channelled outflow	1.5	4	1	1	4	3
Depression, exorheic	1.5	1	1	1	2	2
Depression, endorheic	1.5	1	1	1	2	2

Provisioning services:	**Water supply**	**Grazing**	**Plants for crafts**	**Medicinal plants**	**Indigenous/ wild foods**	**Cultivated foods**	**Tourism & recreation**
Floodplain wetland	3	4	3	2	3	4	4
Valley-bottom wetland, channelled	3	3	3	4	2	3	3
Valley-bottom wetland, unchannelled	3	3	4	3	2	3	3
Seep with channelled outflow	4	3	3	4	2	3	2
Seep without channelled outflow	2	3	2	3	1	3	2
Depression, exorheic[6]	3	3	2	1	4	2	3
Depression, endorheic	1	2	1	1	4	1	3

c) threat to the wetland from land use activities based on data collected in Section 5.3 of the Implementation Manual

d) importance of the wetland as a reference wetland based on expert opinion

Once wetland have been preliminary prioritised based on the above criteria, the NWMP management needs to determine what the reasonable number of wetlands are that can be dealt with by the programme and provincial environmental agencies.

Taking the pragmatic view of the number of Tier 2 wetlands to undergo assessment on an annual basis, and the minimum number of representative wetlands within each criteria category can be determined. For example, the NWMP and experts may decide to target 5 or 6 wetlands in each combination of HGM type, ecoregion, conservation status, ecosystem services provided and reference condition, perhaps in each CMA or each of the main drainage regions in the country. Selection of the individual wetlands to undergo the Tier 2 assessment from each of these categories can be determined by the NWMP and provincial agencies. Appendix F of the WRC NWMP Consolidated Technical Report however, does provide a guide for the NWMP or provincial agencies to prioritisation these Tier 2 wetlands at a sub-quaternary catchment (referred to as broad-scale management units) and fine-scale prioritisation of individual wetlands within the sub-quaternary catchment. Note: this guide of broad-scale and fine scale prioritisation of Tier 2 wetlands requires further testing at a national scale, once the NWMP database has been developed.

Expert inputs should be sought in the prioritisation process, especially in the provinces (i.e. Agencies; CMAs, etc.).

5.7 DESKTOP ASSESSMENT OF EXTENT AND PRELIMINARY TYPING OF THE PRIORITISED WETLAND

At this point in the NWMP process, a suite of wetlands will have been identified for rapid field assessment in a given year.

The NWMP dataset generated in Tier 1 should provide preliminary information such as land-use in and around the prioritised wetland, the landownership of the wetland and surroundings, the extent and level of protection of the wetland.

Desk-top mapping of the wetland is the next step in the process, estimating the wetland boundary from aerial photographs (available from http://www.ngi.gov.za/index.php/what-we-do/aerial-photography-and-imagery) and

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[6] Kotze (2014) indicates that exorheic depressions generally experience flushing, which prevents the accumulation of solutes. However, under arid conditions this flushing will often be inadequate to prevent such accumulations, and therefore under arid conditions these depressions may need to be treated as endorheic in terms of water supply.

drawing it onto the image, using clues such as topography, presence of water, and differences in vegetation. Wetland vegetation can be distinguished from adjacent terrestrial vegetation in aerial photos and using Google Earth by differences in colour, shading, texture and elevation (DWAF, 2005). It is possible to conduct a preliminary desktop boundary delineation of the wetland using the method outlined in Mbona et al. (2015).

Use pp. 15-18 in Mbona et al. (2015) to ascertain the boundaries of the prioritised wetland at a desktop level.

The document can be found on the NWMP CD in the folder *Supporting Tools.* The report is listed as: *2015, Mbona et al. Supporting better decision-making around coal mining*.

To map the wetland, find the prioritised wetland on Google Earth. The desktop identification of wetland extent can then be determined by looking for (Mbona et al., 2014):

k) visible patches of open water;
l) visible signs of the presence of vegetation clumps or patterns indicative of periodic soil saturation and indicator communities/species (i.e. vegetation colour, pattern and texture);
m) location within the landscape;
n) contour lines that indicate watersheds;
o) river lines that indicate the direction of water flow.

According to Mbona et al. (2015), on satellite imagery*:*

p) “wetlands often appear different in colour and texture from the surrounding dryland areas.
q) wetlands are most often found in low-lying regions in the landscape as channelled or unchannelled valley bottoms or in seepage areas at higher elevations as hillslope seeps. There is often connectivity between hillslope seeps and valley bottom wetland areas.
r) wetlands are sometimes found at the tops of mountains, generally on plateaus, however this is less common.
s) wetlands appear slightly differently depending on the soil and vegetation. However, wetlands can often appear darker than the surrounding dryland and have a more mottled texture. This is very common in the summer rainfall regions of South Africa where soils tend to be darker in water-logged areas.
t) wetlands are often difficult to farm and will often appear as unfarmed areas in a highly transformed agricultural landscape. The presence of dams on a farm is also a good indicator of where wetlands may be or where they may have once been.”

A preliminary indication of the hydrogeomorphic (HGM) type(s) in the wetland can also be made using the above mentioned preliminary desktop wetland map (See Section 9.2.3 for a more detailed description of wetland typing).

Use *WET-Health* Section 1.3.3, p. 32, for preliminary identification and mapping of HGM units.

The Wet-Health report can be found on the NWMP CD in the folder call *Supporting Tools/Wet-Health.* The report is listed as: *2009, Macfarlane et al. Wet-health.pdf*

PHASE 2: RAPID FIELD ASSESSMENT OF A PRIORITISED WETLAND

6 TIER 2: RAPID FIELD ASSESSMENT OF A TIER-2 WETLAND

Tier 2 of the NWMP is implemented at local scale, namely field assessment at the level of individual wetlands.

This Tier assumes that the field personnel conducting the rapid assessment of a prioritised wetland will spend approximately 4-8 hour at each assessment site. Field personnel will also need to spend some time prior to the field visit to collect preliminary data on the wetland and after the field visit to capture, analyse and report on the field results to the NWMP management unit.

The purpose of this Tier of the NWMP is to:

1. ensure that over time, more and more wetlands in the country have undergone a rapid assessment of their condition and of threats to their ecological state and the ecosystem services they provide;
2. verify the desktop information provided from Tier 1 for each of the wetlands
3. ascertain the baselines for the Tier 2 indicators for each wetland; specific issues of concern can also be identified at this stage;
4. prioritize a sub-set of the Tier 2 wetlands for long-term monitoring in Tier 3 (see Section 6.5 for guidelines on prioritizing wetlands for monitoring).

The outcome of Tier 2 is the collecting, capturing, analysis and reporting on eight indicators of present ecological state, threats to and ecosystem services provided by the Tier 2 wetlands (Figure 18).

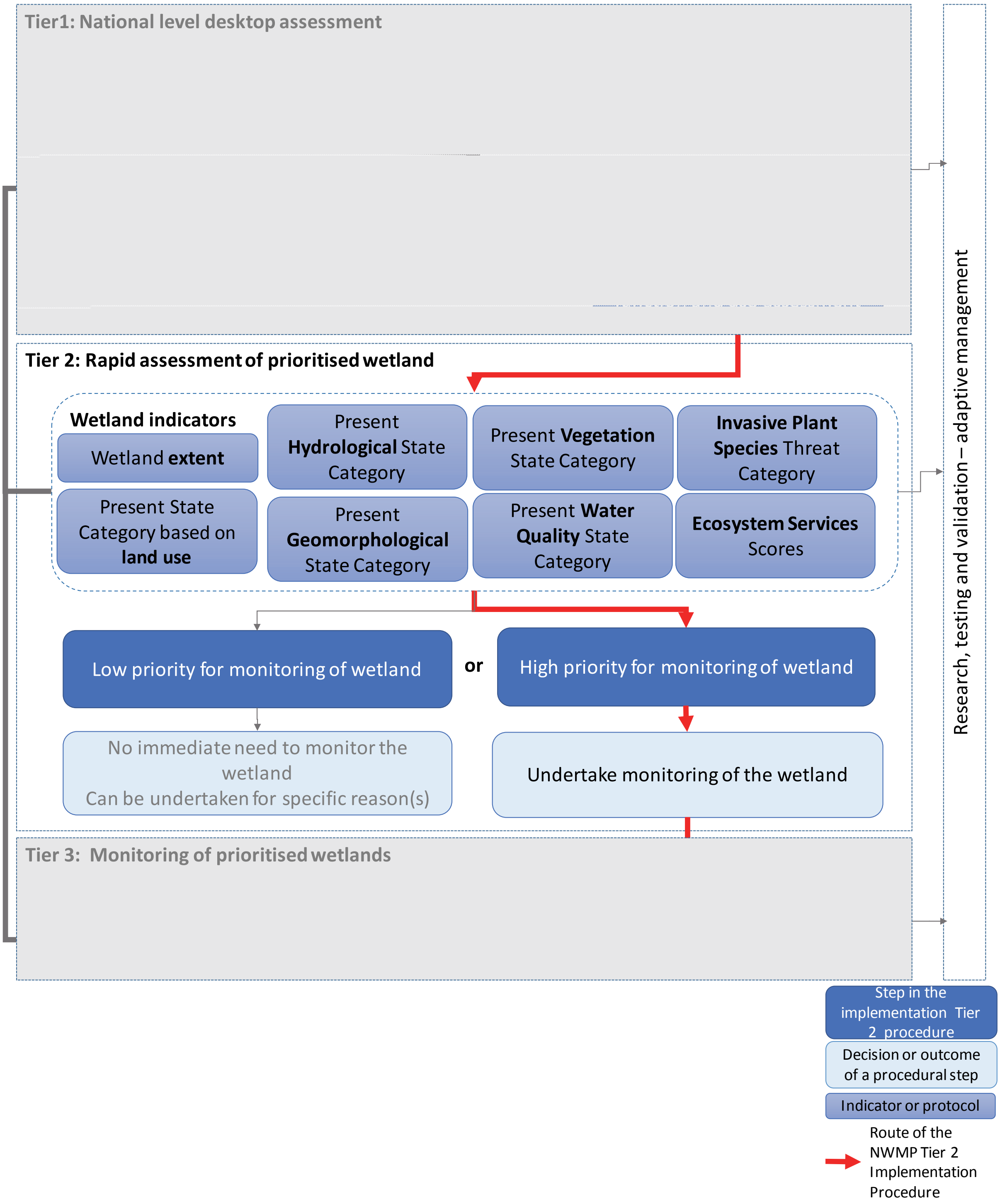

Figure 18: Process to follow to implement Tier 2 of the NWMP

A number of assessment methods have been developed in South Africa to report the Tier 2 indicators in the NWMP (see the NWMP CD for copies of each of the methods). Of note are:

1. the **Wetland Index of Health (IHI)** which (DWAF, 2007): provides a method to determine the Present Ecological State (hydrology; geomorphology; vegetation and water quality) for floodplain and channelled valley bottom wetlands.
2. **Level 1 WET-Health** (Macfarlane et al., 2009): also provides a method to determine the present hydrology; geomorphology and vegetation state for most wetlands.
3. **Rapid Ecological Reserve Determination (RERD) Method** (Rountree et al*.,* 2013) which provides a method for determining present water quality state for wetlands.
4. **Wet-EcoServices** (Kotze et al., 2009) which provides a method to determine the value of the ecosystems provided by the wetland.
5. **Wetlands and Wellbeing: A Decision Support System** (Kotze, 2014) which provides a decision support system for rapidly assessing, in the context of resilient social-ecological systems, the ecosystem services provided to the users of inland wetlands in South Africa.
6. Kotze (2015) Method for assessing wetland ecological condition based on land-cover type.

Noting that more than one method is available to determine the present hydrology; geomorphology; vegetation and water quality condition of a wetland, the WRC has developed a Decision-Support Framework (DSF) for Wetland Assessments in South Africa which consolidates all the geomorphological, hydrological, vegetation and water quality PES methods into a single tool for guiding the user through the assessment of a wetland using one of the (IHI; Wet-Health Level 1 and/or Rapid Ecological Reserve Determination**)** methods (Ollis et al., 2014). Note: the DSF does not combine methods – rather it guides the assessor through the various methods. T

Linked to this Decision-Support Framework is a 'decision-support-protocol tool' (DSP tool), which includes the excel spreadsheet that needs to be completed to conduct the rapid assessments of prioritised wetlands. The Present Ecological State indicators (i.e. hydrology; geomorphology, water quality and vegetation) in Tier 2 of the NWMP utilised the DSF to collect, capture and analyse the data for these indicators. The DSF and DSP Excel tool can be found on the NWMP CD in the file *NWMP Implementation Manual/Supporting Tools,* listed as *Decision-Support Protocol.*

Before a NWMP assessor enters the field to collect the data for these Tier 2 indicator, they should familiarise themselves with the methods applicable to each indicator (i.e. IHI; Wet-Health Level 1; Wet-EcoServices and the DSF and DSP tool). The assessor should also have attended one of the wetland assessment and monitoring training courses which are offered by various institutions in the country, as the methods utilised in the NWMP require a relatively high level of expertise in wetland assessment.

Implementation of Tier 2 of the NWMP is discussed in two sections of this document. Firstly, in this section of the Implementation Manual a basic outline is provided of the procedure to follow to implement Tier 2 and a simple outline of the indicators, methods and tools which can be utilised in this Tier.

Secondly, Section 9 of the Implementation Manual includes a Field Guide for implementing Tier 2. The Field Guide is a stand-alone document which the field assessor can print and carry into the field, for use when conducting the assessment of the wetland. The Field Guide contains guidance on how to verify the map and typing of the wetland and the data collection tools (spreadsheets) which should be completed to capture the data for each of the indicators in Tier 2.

6.1 PROCESSES INVOLVED IN TIER 2 OF THE NWMP

Tier 2 provides a systematic, structured way of collecting data on a wetland, as outlined in Figure 19 as:

a) **in the office prior to the field assessment** – collect preliminary data for the wetland based on maps, reports and databases

b) **in the field** – indicator and wetland data are collected and captured while visiting the prioritised wetland.
c) **in the office on returning from the field** – capturing data and reporting on results to the NWMP office at DWS.

The process outlined in Figure 19 has incorporated the steps required in the WRCs Decision-support Framework (which can be found on the NWMP CD in the file *NWMP Implementation Manual/Supporting Tools,* listed as *Decision-Support Protocol*). Although the steps in Tier 2 of the NWMP are shown as sequential, some of the steps may be iterative and may require 're-visiting' after completing a later step in the process. Each stage of Tier 2, with the related steps, is discussed in the following sections.

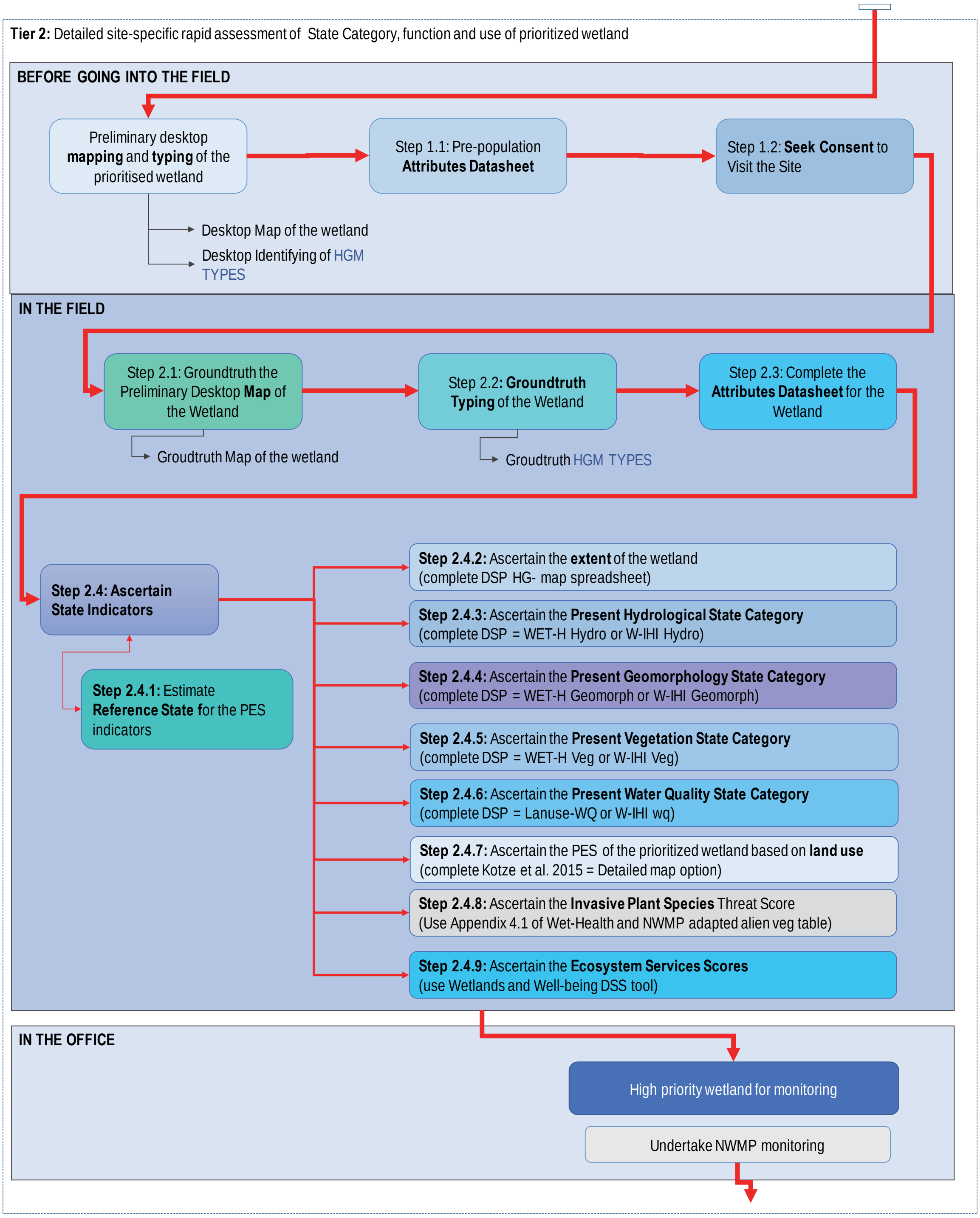

Figure 19: Stages and steps required to complete a rapid, field assessment of a prioritised wetland in Tier 2 of the NWMP.

6.2 IN THE OFFICE – BEFORE GOING INTO THE FIELD

6.2.1 Step 1.1: Pre-population of attributes datasheet

If you are systematically following the steps in this NWMP Implementation Manual, you will at the point have the following information for the prioritised wetland:

a) A desktop map of the extent of the wetland
b) A desktop assessment of the HGM type(s) of the wetland

The purpose of this step in the NWMP is to captures data on various attributes of the Tier 2 wetland, using a wetland attributes datasheet. The attributes datasheet needs to be populated in this step of the NWMP (the attributes datasheet can be found on the NWMP CD in the folder *NWMP Implementation Manual Supporting Tools/Attributes Datasheet*, as the file *Attributes Table*) The datasheet includes all attributes of the wetlands that can provide valuable background information about the wetland or wetland data which cannot be currently reported as indicators but may over time, as more data and information is collected for prioritised wetlands, provide valuable indications of wetland condition.

Complete NWMP attributes datasheet, found in Section 9.1.1 of this document, with desktop data on the prioritised wetland.

The attributes datasheet can also be found on the NWMP CD in the folder *NWMP Implementation Manual Supporting Tools/Attributes Datasheet*, as the file *Attributes Table*

6.2.2 Step 1.2: Seek Permission to Visit the Site

If you are systematically following the steps in this NWMP Implementation Manual, you will at this point in the process, have the following information for the Tier 2 wetland:

a) A desktop map of the extent of the wetland (produced in Section 5.7 above)
b) A desktop assessment of the HGM type(s) of the wetland (produced in Section 5.7 above)
c) A pre-populated Attributes Table for the wetland (produced in Section 6.2.1 above)

The purpose of this step, Step 2.1, of the NWMP process is to prepare for the field visit to the Tier 2 wetland by ensuring you have permission of the landowner to visit the site.

From indicator 5.3 provided from Tier 1 of the NWMP, determine the land ownership of the land surrounding the prioritised wetland. This will give an indication of whether the land surrounding the wetland is private, state or traditional land, providing guidance on how permission should be sought to access the prioritised wetland. A guide for seeking consent follows.

1) If the land is owned by the state, permission should be sought from the relevant government authority which would, in most cases, be a provincial or local government authority. These organisation are also useful sources of information on private land ownership. For instance, the local municipality can provide information (including contact persons) on traditional authorities and private land owners in their jurisdiction.
2) If the land is communal land, permission should be sought from the traditional authority (usually the chief). Ask the local municipality who to contract in these areas.
3) If the land is privately owned, contact the landowner for permission. This may require a visit to the site to seek permission, if the contact details of the owner are not available. However, the local municipality should be able to provide some details of individuals who own private land. Provincial authorities may also be able to assist with this issue.

6.3 IN THE FIELD – PROCESS FOR CARRYING OUT THE RAPID FIELD ASSESSMENT OF THE PRIORITISED WETLAND

6.3.1 When to conduct the fieldwork

Ideally, assessment of the prioritised wetland should be conducted during the wet season.

6.3.2 Step 2.1: Ground-truthing the Preliminary Desktop Map of the Prioritised Wetland

At this point in the process you will need to visit the Tier 2 wetland to carry out the field assessment of the wetland. You will need to collect the data to complete all the sections of the Field Guide in Section 9 of this Implementation Manual.

If you are systematically following the steps in this NWMP Implementation Manual and you have visited the Tier 2 wetland, you will at this point in the process, have the following information for the Tier 2 wetland:

a) A desktop map of the extent of the wetland (produced in Section 5.7 above)
b) A desktop assessment of the HGM type(s) of the wetland (produced in Section 5.7 above)
c) A pre-populated Attributes Table for the wetland (produced in Section 6.2.1 above)
d) A completed Field Guide for the wetland (produced by completing Section 9: Field Guide of this manual while you are at the wetland site)

The purpose of this step in the NWMP process is to ensure that the Tier 2 wetland meets the requirements of the national definition of a wetland (see glossary for definition) and to verify the preliminary desktop map boundaries of the wetland. The Preliminary Desktop Map is the map which was generated in Tier 1 above (See Section 5.7).

The most reliable indicators of wetlands are the redoxymorphic soil features[7], which develop due to prolonged saturation of the area (DWAF, 2008). These features can be used to indicate permanently, seasonally or temporarily inundated or saturated zones in the wetland (DWAF, 2008). A preliminary map, (from Tier 1 – see Section 5.7) will be provided to the field assessor, who should use the Rapid Assessment Datasheet (Table 29 of Section 9.2.2), developed by Mbona et al. (2015), to rapidly ground-truth the boundaries of a wetlands. The mapped extent can be confirmed in the field by taking GPS positions points using vegetation as a guide, and taking soils samples if time allows.

In the field, you will have completed Table 29 of Section 9.2.2 to confirm the boundary of the wetland and adjust (if necessary) the boundary on a hard copy of the map from Tier 1

On returning from the field, the field assessor should adjust the wetland boundary of the electronic map of the wetland. This can be done by editing the existing polygon using the appropriate software.

Insert the ground-truthed electronic map into the DSP tool worksheet name HGM_Map (see example in Table 14).

The DSP tool worksheet can be found on the NWMP CD in the folder *NWMP Implementation Manual Supporting Tools/Decision Support Framework and Tools,* lists at the Excel file *Decision Support Protocol.*

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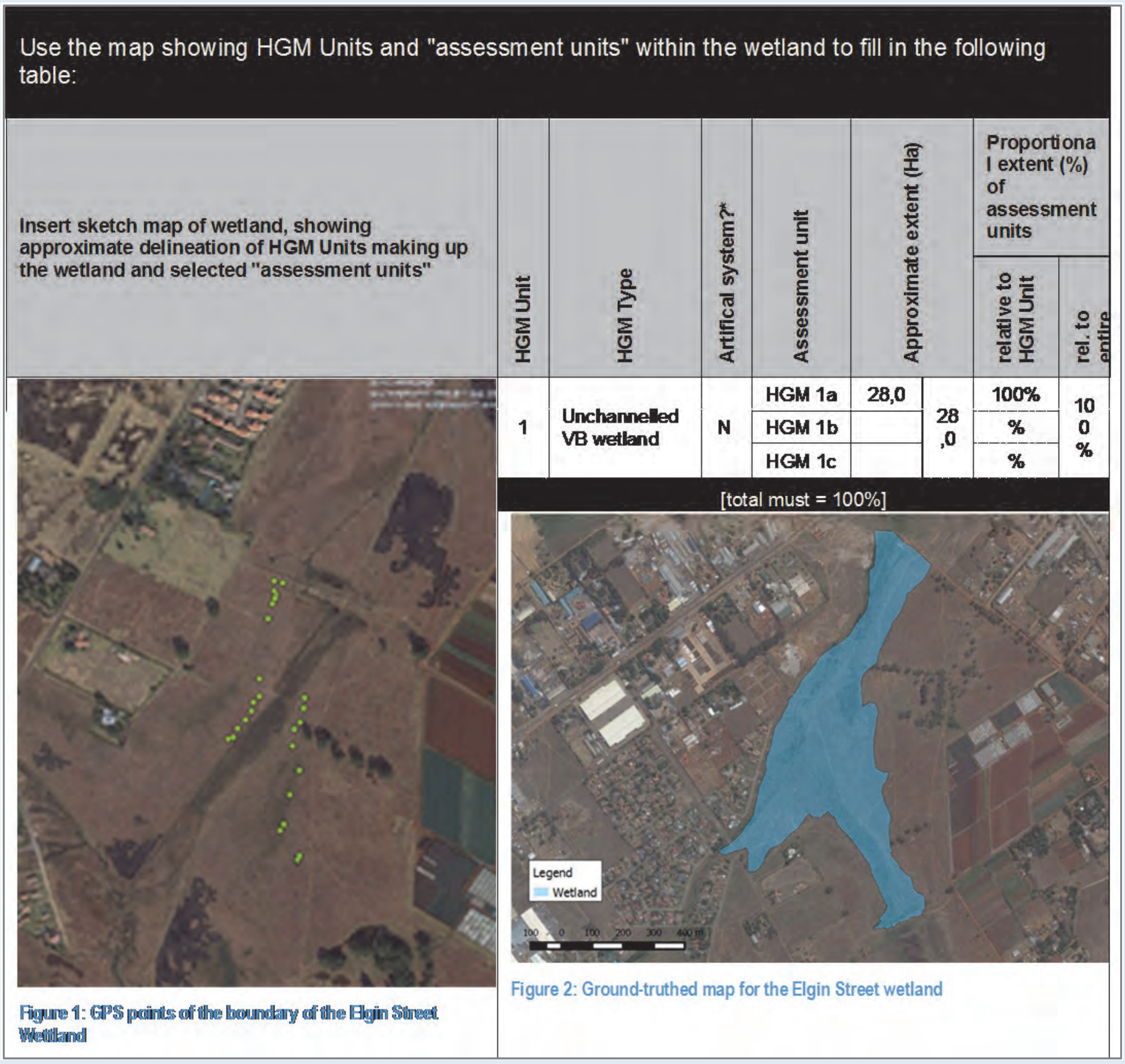
[7] physical and chemical changes in the soil due to (1) in the case of gleying, a change from an oxidizing (aerated) to reducing (saturated, anaerobic) environment; or (2) in the case of mottling, due to switching between reducing and oxidizing conditions (especially in seasonally waterlogged wetland soils) (DWAF, 2008).

Table 14: Example of the mapping and data which should be inserted into the electronic DSP tool spreadsheet called HGM type



Use the map showing HGM Units and "assessment units" within the wetland to fill in the following table:

Insert sketch map of wetland, showing approximate delineation of HGM Units making up the wetland and selected "assessment units"	HGM Unit	HGM Type	Artifical system?*	Assessment unit	Approximate extent (Ha)		Proportional extent (%) of assessment units	
							relative to HGM Unit	rel. to entire
	1	Unchannelled VB wetland	N	HGM 1a	28,0	28,0	100%	100%
				HGM 1b			%	
				HGM 1c			%	

[total must = 100%]

Figure 1: GPS points of the boundary of the Elgin Street Wetland

Figure 2: Ground-truthed map for the Elgin Street wetland

6.3.3 Step 2.2: Ground-truth the Type of the Prioritised Wetland

If you are systematically following the steps in this NWMP Implementation Manual and you have visited the Tier 2 wetland, you will at this point in the process have the following information for the Tier 2 wetland:

a) A ground-truthed map of the extent of the wetland (produced in Section 6.3.2: Step 2.1 above)
b) A desktop assessment of the HGM type(s) of the wetland (produced in Section 5.7 above)
c) A pre-populated Attributes Table for the wetland (produced in Section 6.2.1 above)
d) A completed Field Guide for the wetland (produced by completing Section 9: Field Guide of this manual while you are at the wetland site)

The purpose of this step is to ground-truth the desktop assessment of HGM type of wetland which was produced in Section 5.7 above. It is important to always remember that a single wetland could be made up of several HGM Units.

What is a HGM Unit?

Wetland HGM Units are distinguished primarily on the basis of:

- landform, which defines the shape and localised setting of the wetland;
- hydrological characteristics, which describe the nature of water movement into, through and out of the wetland; and
- hydrodynamics, which describe the direction and strength of flow through the wetland.

There are six wetland HGM Types in the South African typing of wetlands, namely channelled valley-bottom; unchannelled valley-bottom; floodplain; depression; seep and wetland flat (Ollis et al., 2013)

Ground-truthing the HGM types of the prioritised wetland should be based on Ollis et al. (2013) *Classification System for Wetlands and other Aquatic Ecosystems in South Africa*. At a minimum:

- the HGM types which make up a wetland should be identified (Level 4A of the *Classification System for Wetlands and other Aquatic Ecosystems in South Africa)*; and
- the wetland should be classed as natural or artificial (Level 6 *Classification System for Wetlands and other Aquatic Ecosystems in South Africa)*.

The *Classification System for Wetlands and other Aquatic Ecosystems in South Africa* document can be found on the NWMP CD in the folder *NWMP Implementation Manual Supporting Tools*, as the file called *2013, Ollis et al. Classification system for wetlands and other aquatic ecosystems in South Africa.*

A summary of wetland types and their features is provided in Section 9.2.3 of the Field Guide. Use this summary to identify the HGM units in the wetland. An example of mapping HGM types in a wetland is provided in Figure 20.

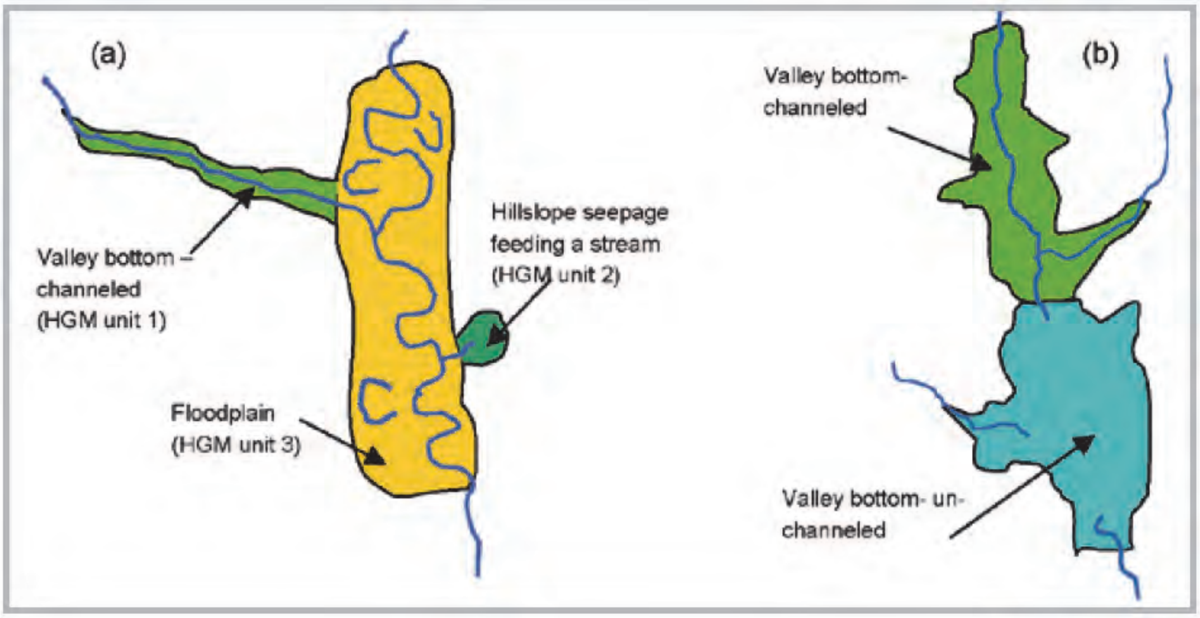


Figure 20: Two wetlands, the first comprising three different hydro-geomorphic units and the second comprising two units (taken from Kotze et al., 2008)

In the field, you will have used Section 9.2.3 Step 2.2 of the Field Guide to verify the HGM type (s) of the wetland and will have completed Figure 30 of the Field Guide to confirm the HGM units of the wetland

Once the identification, mapping and typing of the wetland has been completed in the field and you have returned to the office, ensure that Excel worksheet labelled HGM-map has been completed in the DSP (see example in Table 14 above).

Complete the worksheet name HGM_Map of the DSP Tool (see example in Table 14).

The DSP tool worksheet can be found on the NWMP CD in the folder *NWMP Implementation Manual Supporting Tools/Decision Support Framework and Tools,* lists at the Excel file *Decision Support Protocol.*

NOTE: if the HGM unit is artificial then the assessment cannot be carried out because there is no reference condition as a benchmark. It is important, however, to make notes on the physical, chemical and biological properties of the wetland, which may provide very important ecosystem services, even if its origin is not natural.

6.3.4 Step 2.3: Complete the Attributes Datasheet for the Wetland

If you are systematically following the steps in this NWMP Implementation Manual and you have visited the Tier 2 wetland, you will at this point in the process, have the following information for the Tier 2 wetland:

u) A ground-truthed map of the extent of the wetland (produced in Section 6.3.2: Step 2.1 above)
v) A ground-truthed HGM type(s) for the wetland (produced in Section 6.3.3: Step 2.2 above)
w) A pre-populated Attributes Table for the wetland (produced in Section 6.2.1 above)
x) A completed Field Guide for the wetland (produced by completing Section 9: Field Guide of this manual while you are at the wetland site)

The purpose of this step of the NWMP process is to verify and complete the pre-populated Attributes Table for the wetland. This will be done by filling in the missing data on the pre-population attributes datasheets (from Step 1.1) and verify the data in the field. The Attributes Datasheet can be found in Section 9.2.4 of the Field Guide.

In the field, you will have used Section 9.1.1. to complete *Table 29 NWMP Attributes Table* for the wetland

Once back in the office, load the data from the hard copy Attributes Datasheet into the NWMP database.

Complete the electronic Excel worksheet *Attributes Datasheet* using the data from Table 29 of the Field Guide (see Section 9.1.1. of this manual)

The electronic attributes datasheet can be found on the NWMP CD in the folder *NWMP Implementation Manual Supporting Tools/Attributes Datasheet*, as the file *Attributes Table*

6.3.5 Step 2.4: Assessment of the Condition Indicators

The purpose of this step is to collect the data to report the eight indicators of the wetlands condition.

Step 2.4.1: Determine Reference condition

If you are systematically following the steps in this NWMP Implementation Manual and you have visited the Tier 2 wetland, you will at this point in the process have the following information for the Tier 2 wetland:

y) A ground-truthed map of the extent of the wetland (produced in Section 6.3.2: Step 2.1 above)
z) A ground-truthed HGM type(s) for the wetland (produced in Section 6.3.3: Step 2.2 above)
aa) A completed Attributes Table for the wetland (produced in Section 6.3.4: Step 2.3 above)
bb) A completed Field Guide for the wetland (produced by completing Section 9: Field Guide of this manual while you are at the wetland site)

The purpose of this step is to determine the reference condition for the wetland.

What is the reference condition?

The reference condition is the assumed natural or pre-impacted condition of a wetland. Reference conditions are not static, but vary naturally over time. For this reason, "reference wetlands" are sometimes selected for long-term monitoring so that the natural variation in biophysical factors can be tracked over time. Some Tier 3 wetlands will be selected to act as reference wetlands.

A number of the indicators are Present Ecological State indicators, used for rapid assessment of the condition of some aspect such as hydrology, geomorphology, vegetation or water quality relative to the perceived natural reference condition. The natural reference condition is thus the benchmark against which change is assessed (Ollis et al., 2014a).

There are currently no comprehensive guidelines for ascertaining the natural reference states for South African wetlands, particularly since these may differ for each ecoregion and wetland type. The DSP tool does, however, provide a list of criteria that should be considered in ascertaining the natural reference condition of a wetland. The list is found in Table 33, Section 2.4 of the Field Guide.

In the field, you will have used Section 9.2.5 – Step 2.4.1. to complete *Table 33: Description of Perceived Natural Reference State* for the wetland

For assistance on completing Table 33: Description of perceived natural reference state, see p. 14 of Vol. 2 of Ollis et al. (2014). This report can be found on the NWMP CD in the folder *NWMP Supporting Tools and Methods/Decision Support Framework and Protocol,* as the file: 2014, Ollis et al. Vol 2. Development of a DS Framework for Wetland Assessment in SA;

The narrative criteria for reference wetlands provided by Ganet et al. (2004) may assist in identifying wetlands that are in reference condition. Some of the criteria are that the wetland in question would:

cc) have no history of drainage, filling, or excavation activities within the natural extent of the wetland;
dd) be well buffered by natural vegetation around the perimeter;
ee) have no direct discharges from municipalities or industries;
ff) have no indication of recent forestry activities within the drainage area;
gg) have no agricultural runoff, and no direct runoff from streets or highways;
hh) have no history of aquaculture, including fish rearing or stocking; and
ii) have no known history of or ongoing active pesticide (e.g. mosquitoes), herbicide, or algicide treatments within the wetland or drainage area.

Once back in the office, capture the data from *Table 33: Description of Perceived Natural Reference State* of the Field Guide into the Decision-Support Protocol Excel worksheet called Ref-state.

Complete the electronic Decision-Support Protocol Excel worksheet called *Ref-state*

The DSP tool worksheet can be found on the NWMP CD in the folder *NWMP Implementation Manual Supporting Tools/Decision Support Framework and Tools,* lists at the Excel file *Decision Support Protocol.*

Step 2.4.2: Ascertain the Present Hydrological State of the Prioritised Wetland

If you are systematically following the steps in this NWMP Implementation Manual and you have visited the Tier 2 wetland, you will at this point in the process have the following information for the Tier 2 wetland:

a) A ground-truthed map of the extent of the wetland (produced in Section 6.3.2: Step 2.1 above)
b) A ground-truthed HGM type(s) for the wetland (produced in Section 6.3.3: Step 2.2 above)
c) A completed Attributes Table for the wetland (produced in Section 6.3.4: Step 2.3 above)
d) A completed Field Guide for the wetland (produced by completing Section 9: Field Guide of this manual while you are at the wetland site)

e) The Reference Condition of the wetland (ascertained by completing Section 6.3.5 – Step 2.4.1 above).

The purpose of this step in the NWMP is to ascertain the Present Hydrological State of the wetland.

What is hydrology?

Wetland hydrology can be defined as the movement of both surface and sub-surface water into, through and out of a wetland (Macfarlane *et al.,* 2009). Hydrology is the driving force behind wetlands and their important processes, including waterlogging of soils, the availability of nutrients and solutes, and sediment fluxes, which in turn influence the wetland fauna and flora (Macfarlane *et al.,* 2009).

Hydrological condition or integrity is inferred from an analysis of catchment and/or on-site activities that have an impact on wetland hydrology (Macfarlane et al., 2009). Changes in hydrology can affect the overall structure of, and the biophysical processes taking place in, a wetland (Macfarlane et al., 2009).

The hydrology of a wetland can be altered by human or natural modifications, which in turn alter the distribution and retention patterns of water within the wetland (Venter and Mitchell, 2015). Hydrological patterns can also be affected by local climate characteristics and water inflow into the wetland (Macfarlane et al., 2009). Similarly, the hydrological conditions in a wetland can affect important processes, such as the development of anaerobic conditions in the soil (waterlogging), availability of nutrients and other solutes, and sediment fluxes, all of which can influence the fauna and flora of the wetland.

Reporting on this indicator is important not only for assessing the health of the wetland, but also for biodiversity conservation and for identifying wetlands that can be used as reference sites for hydrological condition. It is important to estimate the proportion of wetlands that approach a reference hydrological condition, as this would allow conservation authorities to consider conserving a representative sample of wetlands in relatively good hydrological condition (Dr D. Kotze, University of KwaZulu-Natal, *pers. comm.,* 2014).

The overall approach to rapidly estimating the present hydrological state of a wetland is to use either the IHI or WET-Health Level 1 assessment method, which quantify the impacts of human activity or clearly visible impacts on wetland hydrology, and then convert the impact scores to a Present Hydrological State score. This takes the form of assessing the spatial extent of impact of individual activities and then separately assessing the intensity of the impacts on the hydrology of the wetland. The extent and intensity are then combined to determine an overall magnitude of impact on hydrology. The combined score of the individual HGM unit scores provide the overall present hydrological score for the wetland.

Both the WET-IHI and WET-Health use a suite of criteria to ascertain the extent and intensity of impacts on the hydrology of a wetland (Figure 21). The assessment focusses largely on those activities that affect the timing and intensity of water coming from the upstream catchment, and distribution and retention of water within the wetland.

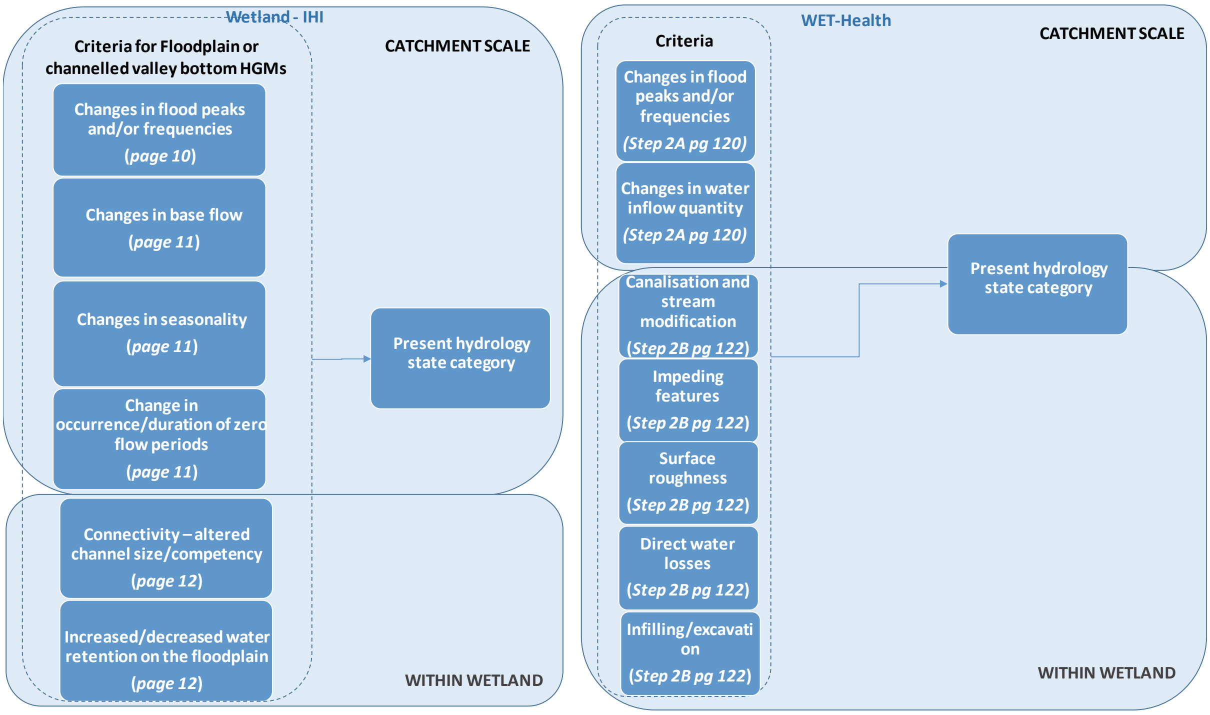


Figure 21: Catchment and wetland criteria use in the assessment of Present Hydrological State in the Wetland-IHI method (left) and Wet-Health Level 1 (right) methods (adapted from DAWF, 2007 and Macfarlane et al. 2009). Bracketed page numbers demonstrate the relevant page in IHI or Wet-Health document.

The present hydrological state assessment tools of Wet-IHI and Wet-Health have been incorporated into the DSP tool (Ollis et al., 2014a)

In the field, the DSP tool should be used to decide whether to use the W-IHI or Wet-Health Level 1 to estimate the present hydrological state of the wetland. Section 9.2.5 (Step 2.4.2) (Wet-Health) or Section 9.2.6 (W-IHI) of the Field Guide describes how to collect field data for this indicator. The data sheets that need to be completed during the assessment are also provided in these sections of the Field Guide of the manual.

In the field, you will have used *Table 34 and Table 35 of Section 9.2.5* (Wet-Health) or *Table 52 of Section 9.2.6* (IHI) of the Field Guide to capture the data for the present hydrological score for the wetland.

For assistance on completing Table 34 and 35, see p. 41 of Vol. 2 of Ollis et al. (2014a) and assistance with Table 52, see page 10 of the Wetland-IHI Manual (DWAF, 2007). These reports can be found on the NWMP CD in the folder *NWMP Supporting Tools and Methods,* listed:

a) in the *Decision Support Framework and Protocol* folder as the file called: 2014, Ollis et al. Vol 2. Development of a DS Framework for Wetland Assessment in SA;
b) as: 2007, DWAF. Manual for the assessment of a Wetland Index for South African Floodplains and Channelled Valley Bottom Wetland Types

Once back in the office, the relevant electronic worksheets of the DSP tool should be utilised to ascertain a present hydrological state score for the wetland. The combined hydrological score of the individual HGM unit will give the overall present hydrological state score for the wetland.

Once back from the field, capture the data collected in Table 34 and Table 35 of Section 9.2.5 or Table 52 of Section 9.2.6 (IHI) of the Field Guide to complete the electronic Decision-support Protocol worksheet *WET-H Hydro* or *W-IHI Hydro* and ascertain the present hydrological score category for the wetland

The DSP tool can be found on the NWMP CD in the folder *NWMP Implementation Manual Supporting Tools/Decision Support Framework and Tools,* lists at the Excel file *Decision Support Protocol.*

The “present hydrological state” score will assign the wetland to one of the PES categories shown in Table 15, which also provides a description of the inferred “state of hydrology”. If the score for the wetland is calculated as 2.5, for instance, the PES category will be a C, from which we can infer that the hydrology has been moderately modified from reference condition.

Table 15: Present hydrology scores, categories and descriptions (taken from Macfarlane et al., 2009 and DWAF, 2007)

Impact score range	**Description**	**Present Hydrology State Category**
0 - 0.9	Unmodified, natural	A
1 - 1.19	Largely natural. A slight change in hydrology processes is discernable but the system remains largely intact	B
2 - 3.9	Moderately modified. A moderate change in hydrology processes has taken place but the system remains predominantly intact	C
4 - 5.9	Largely modified. A large change in hydrology processes has occurred and the system is appreciably altered	D
6 - 7.9	Greatly modified. The change in hydrology processes is great but some features are still recognizable	E
8 - 10	Modificiations have reached a critical level as hydrology processes have been modified completely	F

Step 2.4.3: Ascertain the Present Geomorphological State of a Wetland

If you are systematically following the steps in this NWMP Implementation Manual and you have visited the Tier 2 wetland, you will at this point in the process have the following information for the Tier 2 wetland:

a) A ground-truthed map of the extent of the wetland (produced in Section 6.3.2: Step 2.1 above)
b) A ground-truthed HGM type(s) for the wetland (produced in Section 6.3.3: Step 2.2 above)
c) A completed Attributes Table for the wetland (produced in Section 6.3.4: Step 2.3 above)
d) A completed Field Guide for the wetland (produced by completing Section 9: Field Guide of this manual while you are at the wetland site)
e) The Reference Condition of the wetland (ascertained by completing Section 6.3.5 – Step 2.4.1 above).
f) The Present Hydrological State category for the wetland (ascertained by completing Section 6.3.5 – Step 2.4.2 above).

The purpose of this step in the NWMP is to ascertain the present geomorphologic state of the prioritised wetland. Geomorphic processes shape and control wetland structure. Wetlands are characterised by the temporary storage or net accumulation of sediment (Macfarlane *et al.,* 2008). Gullying and erosion in a wetland can lead to increases in the outputs of sediments from the wetland, which can threaten the natural structure and functioning of the wetland (Macfarlane et al., 2009).

Like the indicator of present hydrological state, the indicator of present geomorphological state can be estimated using either the Wetland-IHI or the Wet-Health Level 1 method. The overall present geomorphic state can be calculated using the intensity and magnitude of erosional, depositional and organic material (Venter and Mitchell, 2015). The criteria used by the two methods to calculate the Present Geomorphologic State are shown in Figure 22.

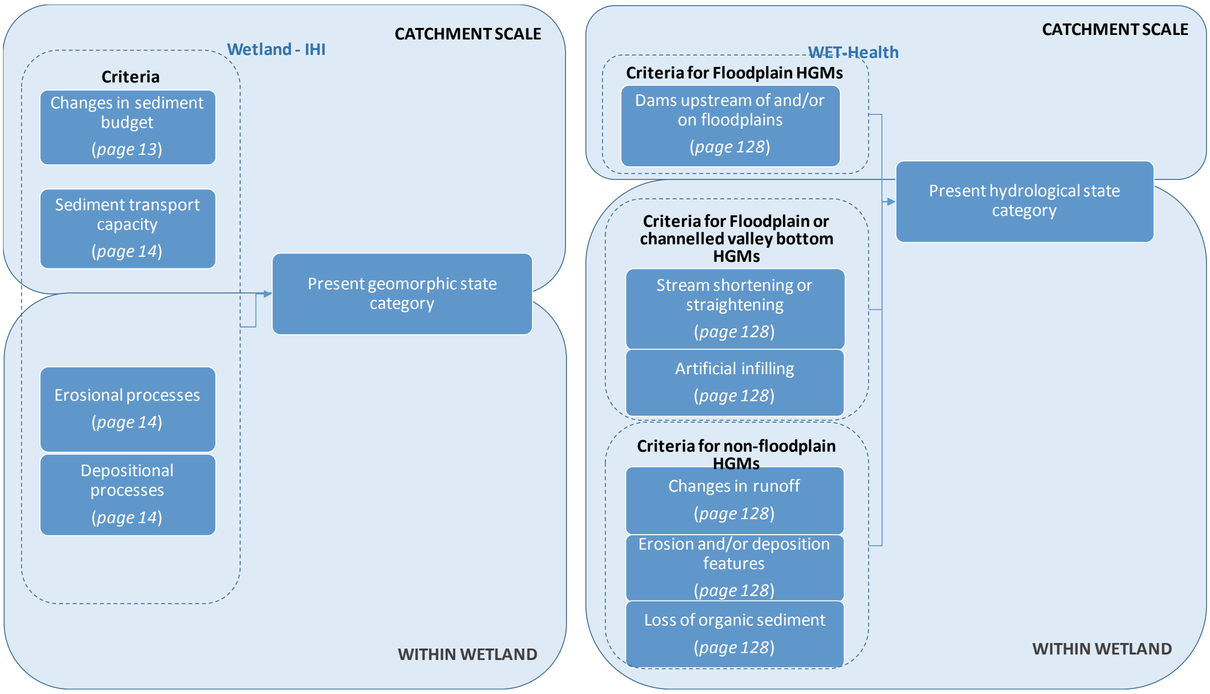


Figure 22: Catchment and wetland criteria use in the assessment of Present Geomorphological State in the Wetland-IHI method (left) and Wet-Health Level 1 (right) methods ((Adapted from Macfarlane et al., 2009 and DWAF, 2007). Bracketed page numbers demonstrate the relevant page in IHI or Wet-Health document.

The present geomorphological state assessment tools of Wet-IHI and Wet-Health have been incorporated into the DSP tool (Ollis et al., 2014a)

In the field, the DSP tool should be used to decide whether to use the WET-IHI or Wet-Health Level 1 to estimate the present geomorphological state of the wetland. Section 9.2.5 (Step 2.4.3) (Wet-Health) or Section 9.2.6 (WET-IHI) of the Field Guide describes how to collect field data for this indicator. The data sheets that need to be completed during the assessment are also provided in these sections of the Field Guide of the manual.

In the field, you will have used *Table 36 and Table 37 of Section 9.2.5* (Wet-Health) or *Table 53 of Section 9.2.6* (IHI) of the Field Guide to capture the data for the present geomorphological state category for the wetland.

For assistance on completing Table 36 and 37, see p. 41 of Vol. 2 of Ollis et al. (2014) and assistance with Table 53, see page 13 of the Wetland-IHI Manual (DWAF, 2007). These reports can be found on the NWMP CD in the folder *NWMP Supporting Tools and Methods,* listed:

c) in the *Decision Support Framework and Protocol* folder as the file called: 2014, Ollis et al. Vol 2. Development of a DS Framework for Wetland Assessment in SA;

d) as: 2007, DWAF. Manual for the assessment of a Wetland Index for South African Floodplains and Channelled Valley Bottom Wetland Types

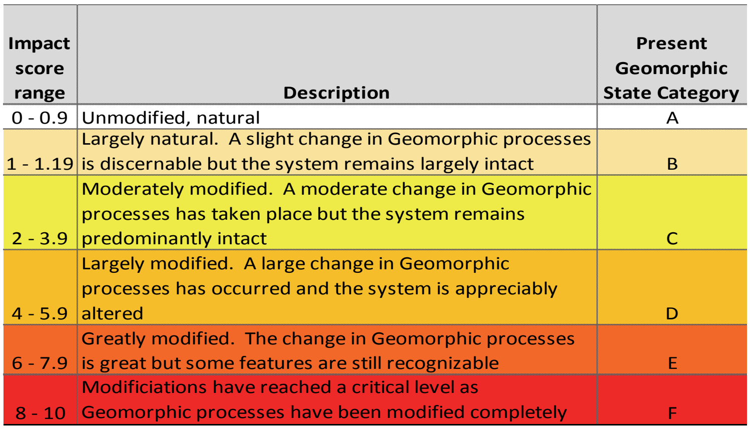
Once back in the office, the relevant electronic worksheets of the DSP tool should be utilised to ascertain a present geomorphological state score for the wetland. The combined geomorphological score of the individual HGM unit will give the overall present hydrological state score for the wetland.

Once back from the field, capture the data collected in Table 36 and Table 37 of Section 9.2.5 or Table 53 of Section 9.2.6 (IHI) of the Field Guide to complete the electronic Decision-support Protocol worksheet *WET-H Geomorph* or *W-IHI Geomorph* and ascertain the present geomorphological state category for the wetland

The DSP tool can be found on the NWMP CD in the folder *NWMP Implementation Manual Supporting Tools/Decision Support Framework and Tools,* lists at the Excel file *Decision Support Protocol.*

The score for present geomorphological state will assign the wetland to one of the PES categories shown in Table 16. A description of the inferred "state of geomorphology" in the wetland is also provided. If, for instance, the score for present geomorphological state is calculated in the DSP tool to be 2.5, the PES category for the wetland will be C, from which we can infer that the geomorphology of the wetland is moderately modified from reference condition.

Table 16: Present geomorphic scores, categories and descriptions (taken from Macfarlane et al., 2009 and DWAF, 2007)



Impact score range	Description	Present Geomorphic State Category
0 - 0.9	Unmodified, natural	A
1 - 1.19	Largely natural. A slight change in Geomorphic processes is discernable but the system remains largely intact	B
2 - 3.9	Moderately modified. A moderate change in Geomorphic processes has taken place but the system remains predominantly intact	C
4 - 5.9	Largely modified. A large change in Geomorphic processes has occurred and the system is appreciably altered	D
6 - 7.9	Greatly modified. The change in Geomorphic processes is great but some features are still recognizable	E
8 - 10	Modificiations have reached a critical level as Geomorphic processes have been modified completely	F

Step 2.4.4: Ascertain the Present State of the Vegetation of the Wetland

If you are systematically following the steps in this NWMP Implementation Manual and you have visited the Tier 2 wetland, you will at this point in the process have the following information for the Tier 2 wetland:

a) A ground-truthed map of the extent of the wetland (produced in Section 6.3.2: Step 2.1 above)
b) A ground-truthed HGM type(s) for the wetland (produced in Section 6.3.3: Step 2.2 above)
c) A completed Attributes Table for the wetland (produced in Section 6.3.4: Step 2.3 above)
d) A completed Field Guide for the wetland (produced by completing Section 9: Field Guide of this manual while you are at the wetland site)
e) The Reference Condition of the wetland (ascertained by completing Section 6.3.5 – Step 2.4.1 above).
f) The Present Hydrological State category for the wetland (ascertained by completing Section 6.3.5 – Step 2.4.2 above).
g) The Present Geomorphological State category for the wetland (ascertained by completing Section 6.3.5 – Step 2.4.3 above).

The purpose of this step of the NWMP is to ascertain the present vegetation state category for the wetland.

The condition and characteristics of the vegetation are sensitive measures of the effects of human activities on wetland ecosystems. Furthermore, the vegetation has an important influence on wetland functioning, for instance by affecting the pattern and rate of water-flow through the wetland. In addition, the vegetation provides habitat for other taxa, including vertebrates, invertebrates and microbes. A decline in the extent of natural vegetation can potentially affect both the condition of the wetland and the ecosystem services it provides.

Like the hydrological and geomorphological indicators, the state of the vegetation can be estimated using either the Wetland-IHI or Wet-Health Level 1 method. Some of the criteria used by the two methods are different, the focus of the Wetland-IHI being on land-use activities in and around the wetland, while the Wet-Health Level 1 method focusses on land-use categories (not activities). Figure 23 indicates those vegetation aspects to be investigated when conducting a field assessment of a wetland.

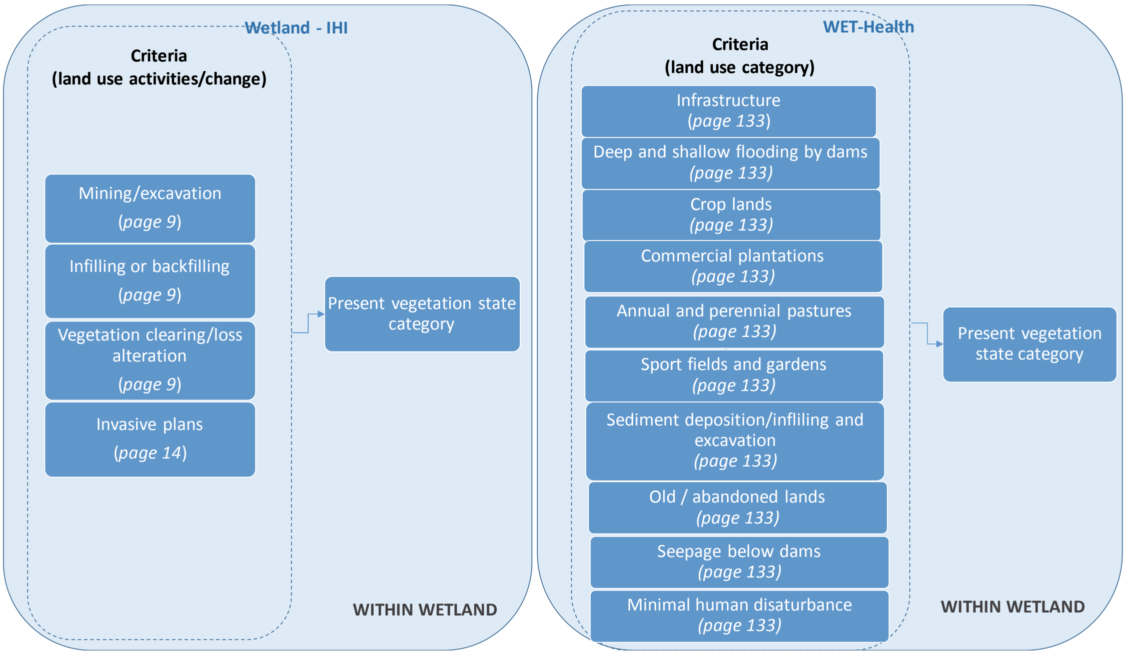


Figure 23: Catchment and wetland criteria use in the assessment of Present Vegetation State in the Wetland-IHI method (left) and Wet-Health Level 1 (right) methods. (Adapted from Macfarlane et al., 2009 and DWAF, 2007). Bracketed page numbers demonstrate the relevant page in IHI or Wet-Health document.

The vegetation assessment tools of Wet-IHI and Wet-Health have been incorporated into the DSP tool (Ollis et al., 2014a)

In the field, the DSP tool should be used to decide whether to use the WET-IHI or Wet-Health Level 1 to estimate the present vegetation state of the wetland. Section 9.2.5 (Step 2.4.4) (Wet-Health) or Section 9.2.6 (WET-IHI) of the Field Guide describes how to collect field data for this indicator. The data sheets that need to be completed during the assessment are also provided in these sections of the Field Guide of the manual.

In the field, you will have used *Table 38* (Wet-Health) or *Table 54 of Section 9.2.6* (IHI) of the Field Guide to capture the data for the present vegetation score for the wetland.

For assistance on completing Table 38, see p. 41 of Vol. 2 of Ollis et al. (2014a) and assistance with Table 54, see page 9 of the Wetland-IHI Manual (DWAF, 2007). These reports can be found on the NWMP CD in the folder *NWMP Implementation Manual Supporting Tools and Methods,* listed:

a) in the *Decision Support Framework and Protocol* folder as the file called: 2014, Ollis et al. Vol 2. Development of a DS Framework for Wetland Assessment in SA;
b) as: 2007, DWAF. Manual for the assessment of a Wetland Index for South African Floodplains and Channelled Valley Bottom Wetland Types

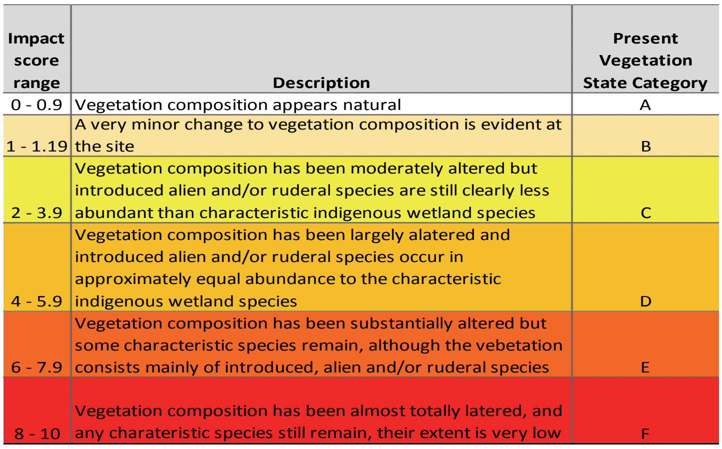
Once back in the office, the relevant electronic worksheets of the DSP tool should be utilised to ascertain a present vegetation state score for the wetland. The combined vegetation score of the individual HGM unit will give the overall present hydrological state score for the wetland.

Once back from the field, capture the data collected in Table 38 of Section 9.2.5 or Table 54 of Section 9.2.6 (IHI) of the Field Guide to complete the electronic Decision-support Protocol worksheet *WET-H WET-H Veg* or *W-IHI Veg* and ascertain the present vegetation state category for the wetland

The DSP tool can be found on the NWMP CD in the folder *NWMP Implementation Manual Supporting Tools/Decision Support Framework and Tools,* lists at the Excel file *Decision Support Protocol.*

The present vegetation state score will assign the wetland to one of the PES categories shown in Table 17. A description of the 'inferred state' of vegetation in the wetland is also provided. For instance, if the score is 0.8, the PES category will be A, from which we can infer that the vegetation is natural or nearly so.

Table 17: Present vegetation state scores, categories and descriptions (taken from Macfarlane et al., 2009 and DWAF, 2007)



Impact score range	Description	Present Vegetation State Category
0 - 0.9	Vegetation composition appears natural	A
1 - 1.19	A very minor change to vegetation composition is evident at the site	B
2 - 3.9	Vegetation composition has been moderately altered but introduced alien and/or ruderal species are still clearly less abundant than characteristic indigenous wetland species	C
4 - 5.9	Vegetation composition has been largely alatered and introduced alien and/or ruderal species occur in approximately equal abundance to the characteristic indigenous wetland species	D
6 - 7.9	Vegetation composition has been substantially altered but some characteristic species remain, although the vebetation consists mainly of introduced, alien and/or ruderal species	E
8 - 10	Vegetation composition has been almost totally latered, and any charateristic species still remain, their extent is very low	F

Step 2.4.5: Ascertain the Water Quality of the Wetland

If you are systematically following the steps in this NWMP Implementation Manual and you have visited the Tier 2 wetland, you will at this point in the process have the following information for the Tier 2 wetland:

a) A ground-truthed map of the extent of the wetland (produced in Section 6.3.2: Step 2.1 above)
b) A ground-truthed HGM type(s) for the wetland (produced in Section 6.3.3: Step 2.2 above)
c) A completed Attributes Table for the wetland (produced in Section 6.3.4: Step 2.3 above)
d) A completed Field Guide for the wetland (produced by completing Section 9: Field Guide of this manual while you are at the wetland site)
e) The Reference Condition of the wetland (ascertained by completing Section 6.3.5 – Step 2.4.1 above).
f) The Present Hydrological State category for the wetland (ascertained by completing Section 6.3.5 – Step 2.4.2 above).
g) The Present Geomorphological State category for the wetland (ascertained by completing Section 6.3.5 – Step 2.4.3 above).
h) The Present Vegetation State category for the wetland (ascertained by completing Section 6.3.5 – Step 2.4.4 above)

The purpose of this step of the NWMP is to ascertain the present water quality state for the wetland.

The National Water Act of South Africa (South Africa, 1998) recognizes that the water quality of wetlands needs to be assessed and, if necessary, managed. This indicator estimates the Present Ecological State with regards to the water quality of a wetland.

Water quality refers to the suitability of the chemical and physical conditions in water relative to the requirements of users, who may be humans or other organisms. The idea of water quality takes into account a number of important physical properties (e.g. temperature, dissolved gases) and the concentrations of numerous substances (e.g. common salt, nutrients, toxins) dissolved in the water.

Water quality (WQ) is affected by numerous physical and chemical factors such as the nature of the soil and the vegetation, position in the landscape, topography, water quantity, climate, groundwater and surface water chemistry, and hydrology, as well as virtually all human activities that affect wetlands. The following natural features particularly influence water quality:

- geology and soils of the catchment
- HGM and substrate type
- tributaries and ground water entering the system
- type and density of vegetation cover in and around the wetland.

At the same time, water quality is affected by human activities that allow chemicals to enter a wetland in surface water, in incoming suspended sediments, and ground water.

How to estimate reference conditions for water quality

If no reference condition WQ data are available for the wetland under consideration, it may be possible to infer, qualitatively at least, the physical and chemical attributes of the water prior to human modifications of the catchment. If the wetland is fed by a river or ground water, it may be possible to source physico-chemical data from a suitable DWS monitoring station; it is likely that the wetland will reflect the water chemistry of the source water. Finally, consult Malan and Day (2005) (chapters 3 and 4), who provide a database containing all available WQ data at the time that the volume was written, and describe the method for estimating WQ from land-use data.

Two methods are available for estimating the present water quality of wetlands, namely the Wetland Index of Habitat and Integrity (WET-IHI) for floodplains and channelled valley-bottom wetlands (DWAF, 2007), and the Rapid Ecological Reserve Determination (RERD) method of Rountree *et al. (*2013). The overall approach of the RERD method is to use land-use in the catchment surrounding the wetland to infer effects on WQ, and then to convert the impact scores to a Present Water Quality Condition. This takes the form of assessing the spatial extent (% of total catchment area) of various land-use activities in the catchment and combining this with the impact score for the relevant water quality constituents associated with the particular land-use.

The water quality assessment tools of WET-IHI and RERD have been incorporated into the DSP tool (Ollis et al., 2014a)

In most cases the standard water quality assessment methods (IHI and RERD) should be used for assessing wetlands but in certain situations the method for rivers should be utilised. These cases are highlighted in Table 18 below.

Table 18: Recommendations for sampling locality for water quality analyses in wetlands (from Rountree *et al.,* 2013)

Wetland type	Method to apply (river or wetland method)	Where to sample
Floodplain	If over-bank flooding occurs less than once per year, use the rivers method. If more frequent, use the wetland methods	Sample about 200 mm below the water surface, if possible, at inflow, outflow and middle of wetland
Valley bottom (with channel)	If the average width of the fringing wetland is **less than twice** the channel width, use the rivers method for the channelized section of the wetland. If more than this, use the wetland methods.	Sample about 200 mm below the water surface, if possible, at both inflow and outflow of wetland.
Valley bottom (without channel)	Use wetland methods	Sample about 200 mm below the water surface, if possible, at both inflow and outflow of wetland.
Seep	Current no WQ component. Use vegetation to assess and monitoring ecological condition	Take water samples from any free-standing water
Depressions	Use wetland methods	Sample free-standing exposed water, at a depth of 200 mm if possible, at edge of pan.

Use Table 18 to decide whether to use the River or Wetland water quality. If the river method, follow River Health Water Quality Assessment Method.

If the wetland methods are utilized (based on Table 18) then in the field, the DSP tool should be used to decide whether to use the WET-IHI or RERD to estimate the present vegetation state of the wetland. Section 9.2.5 (Step 2.4.5) (Wet-RERD) or Section 9.2.6 (WET-IHI) of the Field Guide describes how to collect field data for this indicator. The data sheets that need to be completed during the assessment are also provided in these sections of the Field Guide of the manual.

For assistance on completing the RERD method, see p. 44 of Vol. 2 of Ollis et al. (2014a) or pages 82-85 of Rountree *et al.* (2013). The IHI water quality method can be found on page 15 of the Wetland-IHI Manual (DWAF, 2007). All three of these reports can be found on the NWMP CD in the folder *NWMP Supporting Tools and Methods,* listed:

i) in the *Decision Support Framework and Protocol* folder as the file called: 2014, Ollis et al. Vol 2. Development of a DS Framework for Wetland Assessment in SA;
j) as: 2013, Rountree et al. Manual for the Rapid Ecological Reserve Determination of Inland Wetlands;
k) as: 2007, DWAF. Manual for the assessment of a Wetland Index for South African Floodplains and Channelled Valley Bottom Wetland Types

In the field, you will have used *Table 39* (RERD) or *Table 55 of Section 9.2.6* (IHI) of the Field Guide to capture the data for the present vegetation score for the wetland.

Once back in the office, the relevant electronic worksheets of the DSP tool should be utilised to ascertain a present water quality state score for the wetland.

Once back from the field, capture the data collected in Table 39 of Section 9.2.5 or Table 55 of Section 9.2.6 (IHI) of the Field Guide to complete the electronic Decision-support Protocol worksheet *Landuse-WQ* or *W-IHI wq* and ascertain the present water quality state category for the wetland

The DSP tool can be found on the NWMP CD in the folder *NWMP Implementation Manual Supporting Tools/Decision Support Framework and Tools,* lists at the Excel file *Decision Support Protocol.*

We have a very poor understanding of the direct links between each water quality constituent and the condition of a wetland, so it is necessary to start building a body of data from which the links can be identified. Rapid field assessments (i.e. Tier 2) should include the collection of water quality data. Collection in the field of pH, electrical conductivity, dissolved oxygen and temperature data is required for all Tier 2 wetlands. In addition, it is strongly recommended that water samples be collected for analysis of nutrients (and perhaps other variables) by the RQS laboratory of DWS. (Note that arrangements will need to be made with the RQS laboratory before samples are collected.) The land-uses identified during the assessment of the water quality of the wetland should be used as a guide when deciding which other water quality constituents should be analysed for each wetland (see Table 19). Protocols for water sampling can be found at https://www.dwa.gov.za/iwqs/reports/general/WRQM_Vol01_Sampling_protocol_Inorganic_chemical_analysis_s.pdf

Table 19: Water quality indicators for various land-uses. TSS = total suspended solids; EC = electrical conductivity

Land Use	**. Water Quality Determinand**						
	Nitrogen	**Phosphorus**	**TSS**	**Pathogens**	**EC**	**Metals**	**Turbidity**
Livestock	√	√	√	√			
Crop cultivation	√	√	√		√		
Wash off from urban areas and Informal settlement (Hard surfaces)	√	√	√	√		√	
Waste-water treatment works	√	√		√			
Mining (acid mine drainage) and power generation					√	√	
Commercial forestry	√	√					√

Case study

In testing the Implementation Manual, water quality data were collected from a wetland in the Gauteng region. The wetland was an unchannelled valley-bottom that appeared visually to be largely untransformed. On visiting the wetland, however, it was observed that a sewer line was discharging into the wetland just below Sample Point 1 in Figure 24. Sewage was channelled down an artificial drainage line and entered the wetland just above the Sample Point 2 on the map. The *E.coli* counts are thus higher at sampling point 2 than at either of the other points. The magnitudes of the other water quality determinands in the wetland are more difficult to relate to the condition of the wetland.

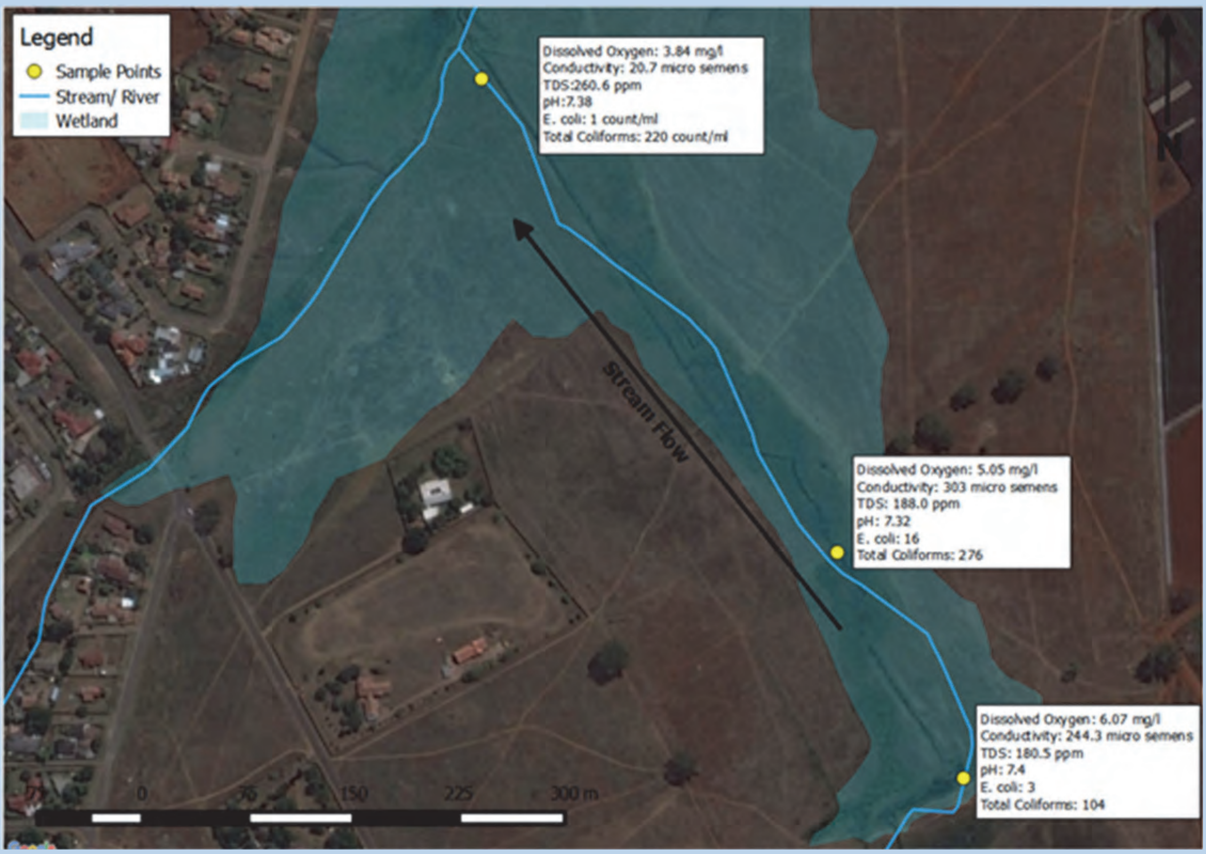


Figure 24: Water quality results for Sample Point 1 (bottom right point); Sample Point 2 (point in middle of image) and Sample Point 3 (top left point)

"Water quality" traditionally includes an estimate of human pathogens as measured by incubating samples of water under controlled conditions in the laboratory. If the intention of the NWMP is to include estimates of wetland quality from a human-health point of view, then such procedures will be necessary. DWS currently runs a National Microbial Monitoring Programme for Surface Waters (DWAF, 2002) and personnel from this programme should be approached for advice and collaboration. Furthermore, consideration should be given in future iterations of the NWMP to monitoring aquatic vectors of human diseases" mosquitoes and the snail vectors of bilharzia.

Step 2.4.6: Ascertain the Present Ecological State of a Wetland Based on Land-use

If you are systematically following the steps in this NWMP Implementation Manual and you have visited the Tier 2 wetland, you will at this point in the process have the following information for the Tier 2 wetland:

a) A ground-truthed map of the extent of the wetland (produced in Section 6.3.2: Step 2.1 above)
b) A ground-truthed HGM type(s) for the wetland (produced in Section 6.3.3: Step 2.2 above)
c) A completed Attributes Table for the wetland (produced in Section 6.3.4: Step 2.3 above)
d) A completed Field Guide for the wetland (produced by completing Section 9: Field Guide of this manual while you are at the wetland site)
e) The Reference Condition of the wetland (ascertained by completing Section 6.3.5 – Step 2.4.1 above).

f) The Present Hydrological State category for the wetland (ascertained by completing Section 6.3.5 – Step 2.4.2 above).
g) The Present Geomorphological State category for the wetland (ascertained by completing Section 6.3.5 – Step 2.4.3 above).
h) The Present Vegetation State category for the wetland (ascertained by completing Section 6.3.5 – Step 2.4.4 above)
i) The Present Water Quality State category for the wetland (ascertained by completing Section 6.3.5 – Step 2.4.5 above)

The purpose of this step of the NWMP is to ascertain the present ecological state of the wetland based on land-use within the wetland and its upstream catchment (Kotze et al., 2015).

What is landuse?

Land-use means what it says: how people use the landscape – whether for development, conservation, or mixed uses.

Land-use within a wetland and in the upstream catchment can directly and indirectly affect the hydrology, geomorphology, vegetation and water quality of a wetland, resulting in changes in the PES indicators of the prioritised wetland.

The method for determining PES based on land-use can be found in Kotze et al. (2015) *Part 2: The user manual.* The detailed-map option should be applied (Part 2, pp 35-42). A Field Guide with the field tools and the method of data collection are provided in Section 9.2.5 under Step 2.4.6. The method presents the user with a list of land-cover/disturbance types to which impact scores have been assigned, based on expert judgement.

In the field, you will have used *Table 41-43* of the Field Guide to capture the data for the present ecological state score for the wetland based on landuse

For assistance on completing Table 41-43, see p. 35 of Kotze et al. (2015). This document can be found on the NWMP CD in the folder *NWMP Implementation Manual Supporting Tools and Methods,* listed in the *PES based on landuse* folder, listed as the file called *2015, Kotze. A method for assessing wetland ecological condition based on land-cover type.*

Once back in the office, the Excel spreadsheet (Land Cover based method overall impact scores) should be completed to generate the present ecological state category based on landuse for the wetland under investigation.

Once back from the field, capture the data collected in Table 41-43 of the Field Guide into the electronic Excel worksheet *Land Cover based method overall impact scores* and ascertain the present ecological state category for the wetland

The excel worksheet can be found on the NWMP CD in the folder *NWMP Implementation Manual Supporting Tools/ PES based on landuse,* listed as the file *Land Cover based method overall impact scores.*

The landcover based method categories the wetland PES categories as:

Overall impact score range	Impact category	Description	PES category
0-0.9	None	No discernible modification or the modification is such that it has no impact on wetland integrity.	A
1-1.9	Small	Although identifiable, the impact of this modification on wetland integrity is small.	B
2-3.9	Moderate	The impact of this modification on wetland integrity is clearly identifiable, but limited.	C
4-5.9	Large	The modification has a clearly detrimental impact on wetland integrity. Approximately 50% of wetland integrity has been lost.	D
6-7.9	Serious	The modification has a clearly adverse effect on this component of habitat integrity. Well in excess of 50% of the wetland integrity has been lost.	E
10-Aug	Critical	The modification is present in such a way that the ecosystem processes of this component of wetland health are totally / almost totally destroyed.	F

Step 2.4.7: Ascertain the Threats Posed by Listed Invasive Plant Species

If you are systematically following the steps in this NWMP Implementation Manual and you have visited the Tier 2 wetland, you will at this point in the process have the following information for the Tier 2 wetland:

a) A ground-truthed map of the extent of the wetland (produced in Section 6.3.2: Step 2.1 above)
b) A ground-truthed HGM type(s) for the wetland (produced in Section 6.3.3: Step 2.2 above)
c) A completed Attributes Table for the wetland (produced in Section 6.3.4: Step 2.3 above)
d) A completed Field Guide for the wetland (produced by completing Section 9: Field Guide of this manual while you are at the wetland site)
e) The Reference Condition of the wetland (ascertained by completing Section 6.3.5 – Step 2.4.1 above).
f) The Present Hydrological State category for the wetland (ascertained by completing Section 6.3.5 – Step 2.4.2 above).
g) The Present Geomorphological State category for the wetland (ascertained by completing Section 6.3.5 – Step 2.4.3 above).
h) The Present Vegetation State category for the wetland (ascertained by completing Section 6.3.5 – Step 2.4.4 above)
i) The Present Water Quality State category for the wetland (ascertained by completing Section 6.3.5 – Step 2.4.5 above)
j) The Present Ecological State category of the wetland based on landuse (ascertained by completing Section 6.3.5 – Step 2.4.6 above)

The purpose of this step of the NWMP is to ascertain the level of threat posed to the wetland from listed invasive plant species.

This indicator thus reports on the cover by and recruitment of listed invasive plant species, as per NEM: BA (DEA, 2014), as a threat level. The NEM:BA list of invasive plant species can be found on the NWMP CD in the folder *NWMP Implementation Manual Supporting Tools/Threat of Listed Invasive Species,* listed as the file *National Environmental Management Biodiversity Act (102004) Alien and Invasive Species List, 2.*

The occurrence of listed invasive alien plants in wetlands is of great relevance to the condition of a wetland in that invasive plants may out-compete the indigenous plants and in severe cases of invasion, the indigenous vegetation may be almost entirely lost. Where transpiration rates of invasive plant species are higher than those of the native vegetation, the hydrology of the wetland may be affected. And where the invasive species are less effective in binding soil than the native vegetation is (e.g. Back Wattle, *Acacia mearnsii*, compared with palmiet, *Prionum serratum*) then erosion may increase. A loss of biodiversity may also occur.

The method for ascertaining the level of threat from listed invasive plant species is provided in Section 9.2.5 – Step 2.4.7 on page 126. The method was developed specifically for the NWMP. Before completing the table of Listed Invasive Plant Species (Table 44 in Section 9.2.5), ensure that the province, the size of the assessment unit, and the ecoregion have been captured in the Attributes Table, that the wetland has been mapped (see Step 2.1 above) and that the outer edge of the wetland is known.

In the field, you will have used *Table 44* of the Field Guide to capture the data to ascertain the level of threat to the wetland from listed invasive plant species

Once back in the office, the Excel spreadsheet (*Listed Invasive Plant Species Template*) should be completed to generate the threat level from listed invasive plant species for the wetland under investigation.

Once back from the field, capture the data collected in Table 44 of the Field Guide into the electronic Excel worksheet *Listed Invasive Plant Species Template* and ascertain the threat level to the wetland from listed invasive plant species

The excel worksheet can be found on the NWMP CD in the folder *NWMP Implementation Manual Supporting Tools/ Threat of Listed Invasive Species,* listed as the file *Listed Invasive Plant Species Template.*

The levels of threat posed to the wetland from listed invasive plant species are:

- Low risk if the final score of Table 44 is ≤10
- Medium risk if the final score of Table 44 is 11-80
- High Risk if the final score of Table 44 is >80

Case Study

In the field testing of the manual, three wetlands were assessed in Gauteng. The first – image (a) below – appeared visually to be relatively natural; the second – image (b) – appeared highly disturbed and the third – image (c) – was a pan. All three were in a highly urbanised environment. The listed invasive plants category for each of the wetlands is shown in Table 20.

Table 20: Case study: categorisation of risk from Listed Invasive Plants

Wetland Id	Size	Type	Listed Invasive Plant Category
Wetland 1	28 ha	Unchannelled valley bottom	Low
Wetland 2	5,3 ha	Unchannelled valley bottom	**High**
Wetland 3	24 ha	Pan	No Listed Invasive Plants

The results of the assessment were a confirmation of the visual assessment of the wetlands level of Listed Invasive Plants.

Figure 25 a) A wetland at low risk from Listed invasive plants; b) a wetland at high risk from Listed invasive plants; c) a pan with no listed invasive plant species within a perimeter of 50 meters of the wetland

Step 2.4.8: Ascertain ecosystem services of a wetland

If you are systematically following the steps in this NWMP Implementation Manual and you have visited the Tier 2 wetland, you will at this point in the process have the following information for the Tier 2 wetland:

k) A ground-truthed map of the extent of the wetland (produced in Section 6.3.2: Step 2.1 above)
l) A ground-truthed HGM type(s) for the wetland (produced in Section 6.3.3: Step 2.2 above)
m) A completed Attributes Table for the wetland (produced in Section 6.3.4: Step 2.3 above)
n) A completed Field Guide for the wetland (produced by completing Section 9: Field Guide of this manual while you are at the wetland site)
o) The Reference Condition of the wetland (ascertained by completing Section 6.3.5 – Step 2.4.1 above).
p) The Present Hydrological State category for the wetland (ascertained by completing Section 6.3.5 – Step 2.4.2 above).
q) The Present Geomorphological State category for the wetland (ascertained by completing Section 6.3.5 – Step 2.4.3 above).
r) The Present Vegetation State category for the wetland (ascertained by completing Section 6.3.5 – Step 2.4.4 above)

s) The Present Water Quality State category for the wetland (ascertained by completing Section 6.3.5 – Step 2.4.5 above)
t) The Present Ecological State category of the wetland based on landuse (ascertained by completing Section 6.3.5 – Step 2.4.6 above)
u) The Level of Threat from Listed Invasive Plant Species for the wetland (ascertained by completing Section 6.3.5 – Step 2.4.7 above)

The purpose of this step of the NWMP is to ascertain the ecosystem service score(s) for the wetland.

The capacity of an ecosystem to deliver different services is related to its condition. A "healthy" ecosystem may provide more, and a more sustained flow of, a variety of services compared to an ecosystem that is managed to provide a maximum amount of only one specific service, such as fish, crops or timber.

What are ecosystem services?

"Ecosystem services are the benefits people obtain from ecosystems. These include provisioning services ("goods") such as food and water; regulating services such as flood and disease control; cultural services such as spiritual, recreational, and cultural benefits; and supporting services, such as nutrient cycling, that maintain the conditions for life on Earth" (Millennium Ecosystem Assessment, 2005)

Good wetland management benefits both ecosystem and human health, affecting people in all social, economic and geographic categories. As well as increasing pressures on wetlands in South Africa, there is an increasing demand for ecosystem services particularly ensuring water quality in a transformed and transforming landscape (Hay et al., 2014). Healthy wetlands provide an array of services that are used in everyday life and that reduce vulnerability, particularly of the poor, to floods, drought, crop failure and disease.

This indicator provides information to decision-makers about those wetlands and ecoregions where ecosystem services are especially important, particularly to poor and indigent households. The indicator can identify areas where decision-makers need to consider the value of these services when considering applications to use or modify a wetland.

The Wetland and Well-being Decision Support System (DSS) of Kotze (2014b) should be used to estimate the ecosystem services provided by a wetland (available on the NWMP CD in the folder NWMP Implementation Manual Supporting Tools). The DSS allows for a preliminary assessment of ecosystem services, inferred from the HGM type and the structural types of vegetation in the wetland (Kotze, 2014b). Four simple steps are required of the operator of the DSS, namely:

1. Identify the HGM types. Proportional area of these types needs to be estimated to derive scores for the supply of ecosystem services based on an area- weighted average of the scores for the HGM types present in the unit.
2. Determine types of vegetation structure. Most wetlands comprise more than one vegetation structural type, requiring that in most cases a weighted average score be determined.
3. Preliminary ecosystem system score. Preliminary scores are calculated for all ecosystem services based on HGM and vegetation structural type/s. The HGM score and the Vegetation score are multiplied as follows to derive an overall score: Overall score = HGM score x (Vegetation score/4).
4. Determine the ecosystem services demanded from the wetland. Capture and score the various ecosystem services currently demanded from the wetland (this component does not currently affect the ecosystem services score but could in future be an NWMP indicator).

See Section 9.2.5, Step 2.4.8 for details on how to apply the method in the field. Users should familiarize themselves with the Field Guide in 9.2.5 before carrying out the assessment. The data sheets that need to be completed during the assessment are also provided in these sections of the Field Guide of the manual.

In the field, you will have used *Table 46-47* of the Field Guide to capture the data for the ecosystem score(s) for the wetland.

For assistance on completing Table 46-47, see Kotze (2014b). This document can be found on the NWMP CD in the folder *NWMP Implementation Manual Supporting Tools and Methods/ Wetland and Well-being Decision Support System,* listed as *2014, Kotze. Wetlands Wellbeing DSS.*

Once back in the office, the relevant electronic worksheets of the DSS tool should be utilised to ascertain the ecosystem services score(s) for the wetland.

Once back from the field, capture the data collected in Table 46-47 of Section 9.2.5 into the electronic Decision Support Supports worksheet *Supply – steps & data entry* and ascertain the ecosystem services scores for the wetland

The DSS tool can be found on the NWMP CD in the folder *NWMP Implementation Manual Supporting Tools and Methods/ Wetland and Well-being Decision Support System,* lists at the Excel file *Wetlands livelihoods DSS.*

Each ecosystem service provided by the wetland will score between 0-4, with 4 being very high potential provision of a particular ecosystem service by a wetland.

6.4 IN THE OFFICE

Once the assessor returns to the office, all relevant templates and worksheets should be completed as outlined above and the relevant data submitted to the DWS Directorate responsible for the NWMP. Data to be submitted include:

1. Extent of the wetland
2. HGM type(s) for the wetland
3. Reference condition utilised in the assessment
4. Present Hydrological State category (A-F) for the wetland
5. Present Geomorphological State category (A-F) for the wetland
6. Present Vegetation State category (A-F) for the wetland
7. Present Water Quality State category (A-F) for the wetland and results for pH, temp, EC and DO
8. Present Ecological State category (A-F) of the wetland based on landuse
9. Invasive Plant Species Threat Level (low-high) for the wetland
10. Ecosystem Service Scores (0-4) for the wetland

6.5 PRIORITISING WETLANDS FOR TIER 3 MONITORING

The philosophy of Tier 3 of the NWMP is that some of the wetlands assessed in Tier 2 will be selected for monitoring, based on a number of key criteria related to the wetland. They are: (1) the ecological importance and sensitivity of the catchment in which the wetland occurs and the conservation importance of the area, based on provincial/local conservation plans; (2) the important ecosystem services provided by the wetland as determined by the indicator of ecosystem service provided by the assessed wetland in Tier 2; and (3) the value of wetlands in reference condition, to allow the accumulation of hard data on the structure and functioning of the different types of wetland in the country.

At this point, indicator and spatial data generated from Tiers 1 and 2 should be available in the database and, together with the information in Table 21, will provide the basic information needed for selecting wetlands for Tier 3 monitoring.

Table 21: Criteria utilised for selection of wetlands for monitoring

Criterion	Why the criterion is important	Categories	Data source
Present Ecological State (PES) and Ecological Importance and Sensitivity (EIS)	**E**cological *importance* of a wetland is an expression of its importance in maintaining biological diversity and functioning at local and wider scales. Ecological *sensitivity* (or fragility) refers to the system's ability (or rather, lack of ability) to resist disturbance. *Resilience* refers to the system's ability to recover from disturbance once it has occurred. Both abiotic and biotic components of the system are taken into consideration in the assessment of ecological importance and sensitivity of aquatic ecosystems. The modus operandi followed by DWS's Directorate: Resource Directed Measures (RDM) for rivers is that, if the EIS is high the aim should be to improve its condition, although improvement may not always be realistic. The assumption made in this document is that if the EIS of the sub-quaternary catchment is high, then wetlands in this Sub-Quaternary Reach should be considered for monitoring.	Low=1; Medium=2; High = 3	https://www.dwa.gov.za/iwqs/rhp/eco/peseismodel.aspx
Provincial spatial biodiversity plans	A provincial spatial biodiversity plan has two main goals (SANBI website): - to guide conservation agencies by identifying priority areas for expansion and consolidation of protected areas - to guide land-use planners and decision-makers in other sectors by identifying critical biodiversity areas (CBAs) critical for conserving representative samples of biodiversity and maintaining ecosystem functioning. To identify CBAs, provincial spatial biodiversity plans use a range of data which may include: • land-cover map • availability of land-cover classes • vegetation map • threatened species • plants • birds • invertebrates • mammals • reptiles / amphibians • important aquatic features • unique features and pans • near-pristine conditions • features related to climate change.	• CBA (Irreplaceable) = 3; • CBA (Important) =2 • Ecological support area = 1	The following five provinces have completed provincial biodiversity plans: • Gauteng (C-Plan version 3.3) • Mpumalanga (Mpumalanga Biodiversity Conservation Plan) • Eastern Cape (Eastern Cape Biodiversity Conservation Plan) • KwaZulu-Natal (KwaZulu-Natal Biodiversity Conservation Plan) • North West (North West Biodiversity Conservation Assessment)
FEPAs, FEPA clusters and Ramsar sites	FEPAs are South African rivers and wetlands that have been identified as being of particular conservation importance. FEPA *clusters* of wetlands are found in relatively natural landscape matrices that allow for important ecological processes such as migration of frogs and insects between wetlands. SANBI's goal is that at least 20% of the wetland cluster areas identified for each wetland vegetation group (Nel, 2011). "Ramsar wetlands" have been identified	• Cluster=2; • Individual wetland = 1; • Ramsar = 3	http://bgis.sanbi.org/nfepa/project.asp

Criterion	Why the criterion is important	Categories	Data source
	internationally as being important for biodiversity conservation.		
Ecosystem Services	In all Millennium Assessment scenarios, actions taken to increase the supply of provisioning ecosystem services such as food and water result in reductions in the supply of supporting, regulating, and cultural services (MEA, 2005). Hence, prioritization of wetlands for monitoring based on biodiversity and regulating services score is crucial.	• Biodiversity Regulation = 3 • Regulating Services = 3; Provisioning Services =2; • Cultural Services =1	Data will emanate from the Tier 2 assessment of prioritised wetlands
	Change in landcover	In certain areas of the country, wetlands may be prioritised for monitoring based on the land-cover and land-use within and around the wetlands (for instance, major changes in either are expected, the wetland may be prioritised for monitoring).	
	Biome	In certain areas of the country, wetlands may be prioritised for monitoring based the biome in which they are found, i.e. fynbos biome wetlands	
	EcoRegion	In certain areas of the country, wetlands may be prioritised for monitoring based the EcoRegion in which they are found	

Wetlands with all condition indicators categorised as A (or sometimes B) may be potential Reference Condition sites and so should therefore be considered, in consultation with wetland experts, for Tier 3 monitoring.

Certain wetlands may be prioritised for monitoring irrespective of the above prioritisation. Some examples are

1. wetlands to be monitored to address current gaps in wetland knowledge;
2. provincially prioritised wetlands;
3. wetlands that already have good baseline data; and
4. wetlands that are deemed by experts as a ‘must’ for monitoring for various reasons.

In summary, wetlands will be selected for Tier 3 monitoring for a variety of reasons and by a variety of management authorities and wetlands scientists. In the long run, the number of sites chosen will depend on logistic and financial constraints as well as conservation or socioeconomic value.

PHASE 3: MONITORING OF SUB-SET OF TIER 2 WETLANDS

7 TIER 3: MONITORING PROCESS AND PROTOCOLS

This tier of the NWMP is carried out only on wetlands that have been identified, in Tier 2, for monitoring.

The purpose of this tier of the Framework is to:

(1) ensure that, over time, prioritised monitoring wetlands have been identified and on-going wetland-specific monitoring of indicators of condition, and/or protocols are being carried out for issue of concern;
(2) build on existing information and monitoring efforts to develop a core set of national biophysical indicators and indices for use in wetlands throughout South Africa and
(3) contribute to research and knowledge of wetland structure and functioning, and of the links between the wetland indicators/indices and wetland condition.

7.1 DECIDING WHAT TO MONITOR

Tier 3 wetlands will be monitored repeatedly, probably every three to five years, depending on financial resources and the degree of variability in the data from each field visit. The eight Tier 2 indicators will be re-evaluated on each occasion, together with additional indicators and protocols that will be decided specifically for each wetland and included in the Management Plan for the wetland. For instance, the Ecosystem Services score could be used if that score at Tier 2 level ‘triggers’ monitoring requirements for the wetland (see Table 22). If the wetland has a high score for biodiversity maintenance, though, then indicators/protocols related to biodiversity should be included in the monitoring plan.

Table 22: Recommended indicators and protocols to monitor in Tier 3 wetlands based on ecosystem services scores.

Ecosystem services supplied by wetlands				Tier 3 Wetland Monitoring Indicators/Protocols												
				Present Geomorphological State	Present Hydrological State	Vegetation State	Water Quality State	PES based on Land-use	Listed Invasive Plant Risk Score	Ecosystem Services Scores	Water Quality Protocols	Diatom Monitoring Protocol	Waterbird Monitoring Protocol	Invertebrate Monitoring Protocol	Fish Monitoring Protocol	Amphibian Monitoring Protocol
Ecosystem services supplied by wetlands	**Indirect benefits**	**Regulating and supporting benefits**	Flood attenuation		√		√	√								
			Streamflow		√		√	√								
		Water quality enhancement	Sediment Trapping	√		√		√			√					
			Phosphate assimilation	√	√	√	√	√			√	√				
			Nitrate assimilation		√	√	√	√			√	√				
			Toxicant assimilation		√		√	√			√	√				
			Erosion control	√		√	√	√			√					
			Carbon storage		√			√								
Direct benefits	Biodiversity Maintenance[8]			√	√	√	√	√	√	√	√		√	√	√	√
Provisioning benefits			**Provision of water for human use**		√		√	√		√	√	√				
			Provision of harvestable resources			√	√	√	√	√						
			Provision of cultivated foods			√	√	√	√	√						
Cultural benefits			Cultural heritage				√	√		√						
			Tourism and recreation				√	√		√						
			Education and research				√	√		√						

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[8] The specific biodiversity indicators will be chosen according to the particular issues of biodiversity concern in the wetland in question.

7.2 Monitoring at All Prioritised Wetlands

On visiting a wetland to carry out monitoring, the mapping of the extent of the wetland should be initiated or repeated to ascertain if there has been change over time.

A Level 2 Wet-Health Assessment should be conducted, providing Present Hydrological, Geomorphological and Vegetation State categories with greater confidence than the Level 1 assessments performed on Tier 2 wetlands. The method for conducting a Level 2 Wet-Health Assessment can be found on the NWMP CD in the folder call *Supporting Tools/Wet-Health.* The report is listed as: *2009, Macfarlane et al. Wet-health.* The worksheets for ascertaining the present ecological state scores for hydrology, geomorphology and vegetation using Wet-Health Level 2 can be found on the same CD in *Supporting Tools/Wet-Health/Datasheets.*

7.3 Monitoring Ecosystem Services

Monitoring of ecosystem services should use the protocols provided in Section 6.3.5 Step 2.4.8 of this report. Particular attention should be paid to those ESs currently providing benefits.

7.4 Monitoring Wetlands Water Quality and Based on Land Use

This Tier 2 indicator should be applied on each occasion that the wetland is revisited to provide a comparison between this estimation of WQ and actual physico-chemical data obtained during the monitoring process. See also the Tier 3 WQ monitoring protocol (Section 7.8), which should be followed for all wetlands, at least initially.

7.5 Monitoring Listed Alien Invasive Plant Species

The process used in the Tier 2 assessment of Listed Invasive Plant species should be used.

7.6 MONITORING PROTOCOLS

The following sections of the Implementation Manual provide a suite of monitoring protocols for the Tier 3 wetland. Monitoring protocols are included in the NWMP as future or 'potential' indicators. Stakeholders have indicated that it is important to monitor certain wetland characteristics for which indicators do not currently exist, or are untested. Monitoring protocols are thus provided in the NWMP as standardised approaches for collecting and analysing data for six wetland characteristics: water quality, fish, diatoms, invertebrates, waterbirds and frogs. Ideally, over time, experts can use these data to develop biotic indices for wetland types, to demonstrate relationships between each of the biotic characteristics and Tier 2 wetland indicators, and to demonstrate relationships between these wetland characteristics and a changes in wetland state, function or usefulness.

7.6.1 Monitoring Protocol for Aquatic Invertebrates

Developed by Prof Jenny Day, Freshwater Research Centre, Cape Town

Why is it important to measure and track aquatic invertebrates in wetlands?

Invertebrates have relatively short lifespans and many are confined to a fairly narrow range of environmental conditions. They are thus useful bio-indicators, particularly of aspects of water chemistry.

Invertebrates have been successfully used as indicators of ecosystem condition of rivers, particularly as indicators of water quality. For various reasons that are not entirely clear, invertebrates are poor indicators of wetland condition but they do provide a broad-brush indication of conditions such as permanence of water, and the degree of salinity, acidity and turbidity of the water. They are therefore of particular importance when attempting to estimate aspects of environmental condition where no water chemistry data are available, either because the data are historical or because the wetland has no standing water at the time of sampling. It is important to realise that, with our present state of knowledge, we are NOT able to estimate the *degree of impairment* of a wetland by examining the invertebrates and that *bio-assessment tools such as **SASS must not** be used for this purpose.*

What does the indicator tell us about the wetland?

The presence of certain taxa will indicate whether

- the water is perennial or not

- the water is saline or not

- the water is acidic or not

- in some cases, whether or not the wetland is in good condition.

In other words, invertebrates provide a first approximation of hydro-period and water chemistry and, if reference conditions are known, whether the water in the wetland has deviated from expected conditions.

Sampling Procedure:

What data need to be collected to report the indicator?

The presence or absence of certain invertebrate taxa needs to be ascertained. Quantitative data are not required.

Where can ancillary data be found?

Samples are collected in the field. For most effective use of invertebrates, it will be necessary to ascertain which taxa might be expected in an unimpaired wetland.

For this reason, a reference collection needs to be made each time the site is visited so that comparisons can be made. If a checklist of taxa found in the wetland (or in closely associated wetlands of the same type), is already available this should be consulted.

Collecting equipment

A **plankton net**. The following dimensions are useful but the exact size is not important. It is important, however, that the mouth of the net is rectangular or square so that even very shallow wetlands can be sampled, and that the mesh be ≤0.5 mm so that even larval forms can be collected. A useful net has a rectangular opening about 200 x 400 mm with a handle about a metre long. The pouch of the net itself is about 800 mm long. A useful additional feature is a small screw-off bottle at the narrow end to assist in removing specimens from the net.

Plastic **collecting jars or vials** if specimens are to be identified in the Lab., together with **90 or 96% ethanol** for preserving the material and **paper labels** that will fit inside the jar or vial. A **pencil** (*not ink)* for writing the label. 25-50cc plastic vials with well-fitting screw tops are recommended.

Timing of sample collection

In perennial wetlands the season of sampling is not crucial although more taxa are likely to be available in spring and summer than in autumn and winter. In wetlands *known* to be seasonal or ephemeral, sampling should ideally be carried out a week or two after inundation. The number of taxa changes with time after inundation so some taxa will be missed if sampling takes place very early or very late in the season.

Where to collect samples in the field

Most invertebrates are likely to be found in shallow, near-shore waters, usually in or close to plant cover. Few taxa occur in open water. If there is no choice about depth of water, it is worthwhile trying to sample close to the bottom. In lakes deeper than about 2 m, the number of taxa is reduced and sampling for invertebrates is probably not worthwhile unless estimating the diversity of the fauna is important. *Thoroughly clean the net before leaving a site to prevent inadvertent transport of eggs or resistant stages from one wetland to another*.

Sampling process

If standing water is present, collect invertebrates by sweeping the net several times though the water. Cover all available habitats (e.g. different species of plants). Be sure to sweep close to the bottom in order to include creeping as well as swimming forms. Turn the sample into a shallow white tray and, as far as possible, identify the living invertebrates in the field. If the sample is to be used for assessing biodiversity of the site, preserve a representative sample of invertebrates in ethanol in a labelled vial for detailed examination under a microscope at a later stage. The final concentration of ethanol should be about 70%, so dilute 90 or 96% ethanol as necessary. (NOTE: do not purchase absolute (100%) alcohol, which is vastly more expensive that 96%.)

If standing water is not present, dried mud can be collected and inundated in the laboratory. Details can be found in Day et al. (2010) or briefly in the section below.

How much time is needed in the field?

If the net is clean and ready to be used, sampling should take no more than five minutes. The sample should be studied for a further five minutes in order to identify the taxa present. If specimens are to be retained for laboratory examination, it will take another five minutes or so to preserve and label them.

How often should the data be collected in order to see changes in the wetland?

Frequency depends on the questions being asked. Once every two or three years is adequate for “condition of the wetland” reporting, when samples should be taken at the same time of year. Reduction in water quality will probably be reflected in the invertebrate assemblage within a couple of weeks. Tracking the effects of activities likely to result in reduced water quality probably needs samples to be taken every couple of weeks for the duration of a potentially detrimental activity.

Sample Handling and Analysis

At sample site and off site

It is assumed that field data will include simple physical and chemical measurements of conductivity, pH, etc. In the field, on the field sheet (Table 56), tick the relevant boxes to record the taxa visible on inspection of the sample in the white tray. Return the living specimens to the water when identifications have been completed. If identifications need to be confirmed, or if species identification is needed for a biodiversity assessment, preserve the specimens in 70% ethanol. Place a pencilled label *inside the vial* and close the lid tightly.

In the laboratory

Dry mud: divide the sample into two or three parts and place each in a plastic lunchbox about 100 x 150 mm in size. Tap or distilled water is added to a depth of about 30 mm. Allow tap water to stand for 24 hours to void any chlorine that maybe present. The containers are kept in an airy place in daylight and examined daily for several days to see if any invertebrate larvae hatch. If it is possible to control the temperature, keep the containers at a temperature similar to that which commonly occurs at the beginning of the rainy season (around 10^{o}C in winter-rainfall areas but closer to 20^{o}C in summer-rainfall areas). Keep the water topped up to prevent desiccation. Identify specimens as soon as they are mature enough to distinguish one taxon from another It is worthwhile preserving some specimens in 70% ethanol for later identification by experts, and as reference specimens.

Preserved specimens: identify to order or family using the photographs provided. If species identifications are required, consult the references given below.

How to analyse and interpret the data

Using the completed field sheet (Table 56) and the notes in Table 23, assess the condition of the wetland. Several examples follow.

A: Invertebrates collected from a wetland consist only of the brine shrimp *Artemia*. Interpretation: this is a very saline wetland, which may or may not dry up on occasion. The fact that any invertebrates (including *Artemia)* occur in the wetland indicates that pollutants are not present in any significant quantity.

B: Invertebrates collected from a wetland consist of red chironomid larvae, tubificid oligochaetes and syrphid fly larvae. Interpretation: very limited oxygen concentrations in the water, indicating organic pollution.

C: Invertebrates collected from a wetland consist of mayfly and damselfly nymphs, beetle larvae, copepods, ostracods and cladocerans. Interpretation: a diverse invertebrate fauna, indicating good physical habitat and no significant pollution.

D: Invertebrates collected from a wetland consist of fairy shrimps, flatworms, copepods and pleid bugs. Interpretation: this wetland must dry up on occasion because fairy shrimps are found only in temporary waters. The diversity of taxa suggests good physical habitat and no significant pollution.

E: Invertebrates hatching from a sample of dried mud consist of ostracods only. Interpretation: the sample does come from a wetland (ostracods being aquatic organisms). Water quality must be suitable for living organisms. It is not possible to say *why* other taxa are not present.

Table 23: Notes on environmental tolerances of important wetland invertebrates

Taxon	
Cnidaria: jellyfish	Usually in freshwater impoundments and other large water-bodies; not in temporary waters. Indicator value unknown.
Turbellaria: flatworms	Planarians (elongate, brown to black) usually in permanent fresh waters. Paler mesostome flatworms often in temporary waters.
Nematoda: roundworms	Ubiquitous. Very difficult to identify to species. Permanent or temporary, clean or polluted, fresh or saline, waters (i.e. of little indicator value).
Oligochaeta: earthworms	Common on the bottoms of wetlands. Bright red *Tubifex* contain haemoglobin (Hb), so can live in very organically polluted waters, where they may carpet the bottom. Others without Hb normally require fairly clean fresh water. Not known from temporary waters.
Hirudinea: leeches	Large blood-sucking leeches indicate presence of their hosts, usually fishes and/or frogs. Require fresh, relatively clean, water. Not known from temporary waters.
Gastropoda: snails & limpets	Many freshwater snails are able to breathe air so are not confined to oxygen-rich water (but can be found in relatively organically polluted waters). Limpets prefer clean waters. Some species of snail can survive desiccation by aestivating in the sediment. NB: several species of snail are invasive aliens and some are hosts of parasitic flukes: *Biomphalaria pfeifferi*, *Bulinus africanus* and *B. globosus* are hosts of human and bovine bilharzia. If sampling where these species occur, take care not to be infected with bilharzia by avoiding all contact with the water.
Bivalvia: mussels & clams	Not common but may occur in large numbers in fresh waters where conditions are suitable. The larvae of most large mussels are parasitic on the gills of fishes so their ranges are restricted where native fishes have disappeared. Not known from temporary waters.
Ostracoda: seed shrimps	Most species occur on or near the bottom but some swim. Some species are able to survive desiccation, so may be found in temporary waters. They usually emerge late in the inundation cycle. Water quality requirements not known but ostracods seldom occur in polluted or brackish waters.
Copepoda: copepods	Very common, especially in clean, open, fresh waters. Some species are able to survive desiccation, emerging after the large branchiopods.
Anostraca: fairy shrimps	Typical of temporary ponds, being found only in clean (and sometimes in turbid) temporary waters. They can be very transparent and are easily overlooked. Only larvae found in newly-inundated ponds but they grow to adulthood very rapidly (<10 days in many cases). *Artemia*, the brine shrimp, characterizes saline pans and salt works. Other species require fresh water.
Notostraca: shield shrimps	Typical of temporary ponds, including rice paddies. Voracious predators. Only larvae are found in newly-inundated ponds. May occur in relatively polluted and/or very turbid but fresh waters.
Conchostraca: clam shrimps	Typical of temporary ponds. Only larvae found in newly-inundated ponds but they grow to adulthood very rapidly (<10 days in many cases). May occur in very turbid but otherwise unpolluted fresh waters.
Cladocera: water fleas	Very common, especially in clean, open, fresh waters. Some species are able to survive desiccation, emerging quite late in the inundation cycle.

Reporting the indicator

Provide a list of the taxa found in the wetland and a short narrative of the kind indicated above. Until the invertebrates of a particular wetland (or group of similar wetlands in a single ecoregion) are well known, it will not be possible to report on invertebrates in the form of an index. It is important that the presence of Red Data and/or alien species is reported, where these can be identified.

What to do with the captured data

Specimens should be properly curated (see, for instance, Griffiths et al. 2015, pp. 336-340). Arrangements should be made with the Albany Museum, Grahamstown, for curation of suitable material. Invertebrate data should be entered into the NWMP database.

7.6.2 Monitoring Protocol for Diatoms

(taken from Matlala et al., 2011 and Rountree et al., 2013)

Why is it important to measure and track diatoms in wetlands?

Algae play important roles in wetland function and can be valuable indicators of the biological integrity and ecological conditions of wetlands (US EPA, 2002).

What do diatoms tell us about the wetlands?

Diatoms (a group of algae) are ever-present in aquatic ecosystems and can be indicators of wetland water quality. Studies of diatoms in wetlands have shown strong correlations between the magnitudes of physical and chemical attributes of water (e.g. salinity), and the diatom species present in a wetland. In addition, diatom species can provide insights into past hydrology such as recent flooding, standing water, or droughts (McCormick and Cairns Jr. 1994; US EPA, 2002; Lane and Brown, 2007).

Sampling Procedure

Substratum selection

Substratum selection will depend on the type of wetland and the vegetation found there. Substrata from which diatom samples can be obtained are, in order of preference:

- emergent macrophyte vegetation
- submerged macrophyte vegetation
- sediments.

Sampling

Submerged aquatic plants provide an excellent substratum for diatom attachment and may be sampled as follows. Select 5-10 stem in a radius of about 10 m. Place the selected stems in a clear plastic bag. Add little water in the bag and shake vigorously. Pour the suspended material in a plastic sampling bottle without including any large plant material.

Select 5-10 stems of **emergent macrophytes** in a radius of about 10 m. Cut each stem off about the water-line with a sharp knife. Lower a wide-mouthed bottle over the remaining section of the stem and cut it off where the stem emerges from the sediment. Invert the bottle and remove the stem. The stem should be placed in a clean tray with a little water. Remove the biofilm (which contains the diatoms) from the stem with a small brush or a hard object such as a spoon or blunt knife. Mix the diatom suspension well and place into plastic sampling bottle.

Sediments:

Select 1-2 m^2 of submerged sediments where diatom biofilms are visible. Gently remove the very top layer of the sediment using a spoon or a suction device such as pipette or large syringe. Sample 5-10 areas of sediment and transfer each sub-sample to the same sampling bottle.

Sample preparation

The sample should be prepared according to the Figure 26 below:

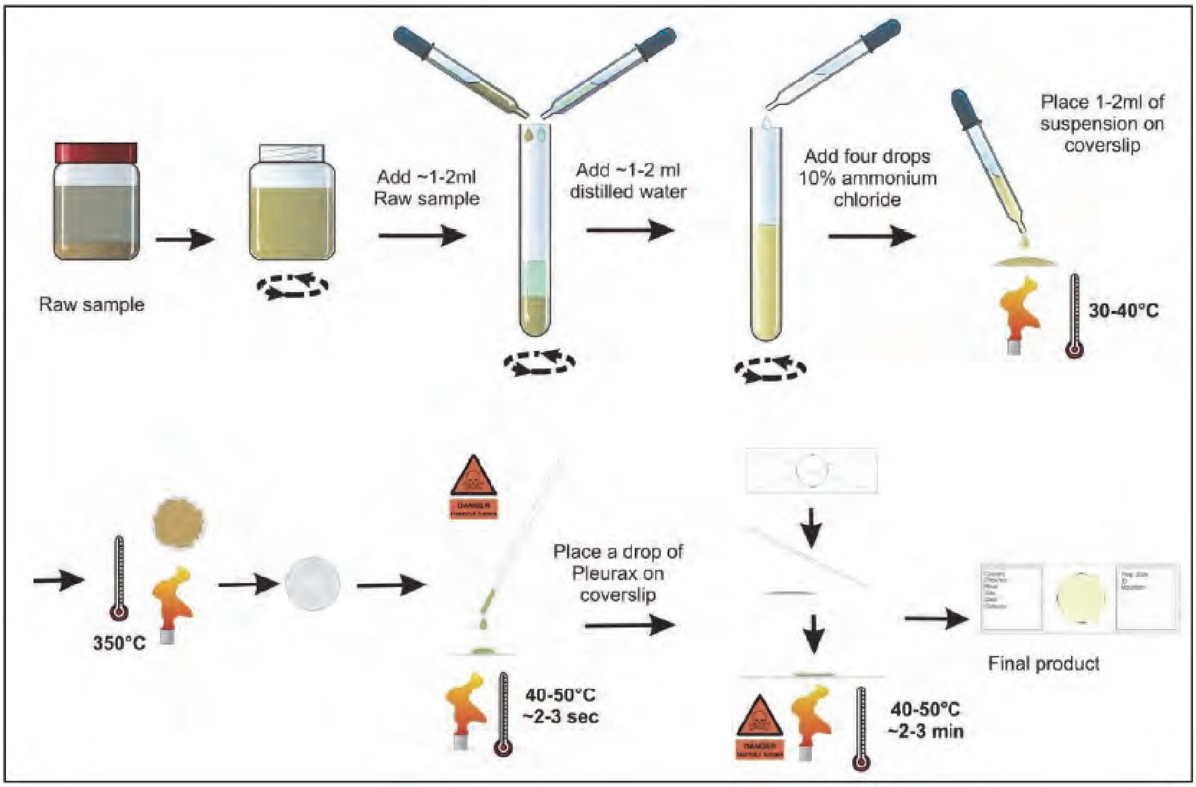

Figure 26: Schematic representative of diatom sample preparation (taken from Rountree et al., 2013)

Sample analysis and interpretation

- The total number of valves to be counted for each sample varies according to the purpose of the analysis and according to the need to produce statistically good results; a standard count of 400 diatom valves is recommended.
- A magnification of 1000x times should be used, preferably in conjunction with phase-contrast optics.
- 400 cells should be enumerated and recorded; detailed rules for enumeration (Taylor et al., 2007a) may be found below. Electronic counting programs such as Opticount are available to facilitate this procedure.
    - Identification should be to species level when possible and follow Taylor et al. (2007b), available from http://www.wrc.org.za/Knowledge%20Hub%20Documents/Research%20Reports/TT281-07.pdf and Krammer and Lange-Bertalot, 1986- 91 (available from www.koeltz.com).
- Enumeration of the sample is the most labour intensive step in the process of diatom analysis and may take up to four hours to complete.

Data analysis

One programme which was designed for the calculation of diatom indices is OMNIDIA (Lecointe et al., 1993).

Table 24: Linking the specific pollution index (SPI) score, general environmental water quality condition and WQ Ecological Category (adapted from De la Rey et.al., 2004)

Diatom Index score (SPI)	General WQ condition	WQ Ecological Category
>17	High quality	A
13-17	Good quality	B
9-13	Moderate quality	C
5-9	Poor quality	D
<5	Poor quality	E/F

7.6.3 Protocol for Monitoring Amphibians

Provided by Dr Jeanne Tarrant, Endangered Wildlife Trust, Threatened Amphibian Programme

Why is it important to measure and track amphibians?

Global declines in amphibian populations, some of which have occurred in protected areas, dictate that a vigilant approach is needed when implementing monitoring regimes in order to keep track of population numbers and to identify stressors if declines are noted (Dodd, 2003). Declines in amphibian populations suggests that these animals may be sensitive to environmental degradation, in particular water quality, which implies that they may be useful as indicator species of a decline in the condition of aquatic ecosystems (Blaustein and Wake, 1990; Phillips, 1990; Griffiths and Beebee, 1992; Halliday, 2000). Degradation of amphibian breeding waters as a result of human activities has been proposed as the second biggest contributor to the observed decline of this taxon (Bradford et al., 1992). Frogs and tadpoles are also relatively easy to catch and study (Beebee, 1996; Shrum, 2004). Relatively few species occur at each freshwater site, though, so statistical models have not been developed using frogs.

The value of amphibians as useful bio-indicators depends on their relative sensitivity to environmental factors. Adult frogs play an important, usually intermediate, role in food-webs because they are both prey and predator. This position in the food chain also changes with their development, in that tadpoles also feed on algae, making them even more sensitive to different stressors. Thus, frogs and toads may be used as biological indicators for assessing the effects of environmental factors that may cause the decline of amphibian populations (Simon et al., 2011). Owing to their low vagility (i.e. their limited ability to move long distances and at speed), they are particularly sensitive to habitat fragmentation and are vulnerable to the changes brought about through habitat transformation (Carr and Fahrig, 2001; Cushman, 2006).

Population monitoring is thus an important tool not only for improving the understanding of amphibian behaviour and ecology, but also for gauging population trends and detecting possible population declines (Dodd, 2003; Veith et al., 2004; Field et al., 2005). In South Africa, monitoring of amphibians is not well developed, with protocols being implemented so far only in the Drakensberg by North-West University (Weldon pers. comm.) and the Western Cape by CapeNature (A. Turner pers. comm.). Most recently, specific monitoring protocols have been developed for four of KwaZulu-Natal's threatened frog species, which inhabit an array of different habitats including scarp forest, grassland and coastal wetlands (Tarrant, 2015).

What do amphibians tell us about the wetland?

Wetlands provide very important habitat for amphibians, with approximately 20% of frog species making use of wetland systems including marshes and swamps globally. Frogs and toads may be used as biological indicators for assessing the effects of environmental factors that may cause the decline of amphibian populations.

Sampling Procedure

What data need to be collected to report the indicator?

Data collection will depend on the site and area as there are few amphibian species that occur throughout southern Africa. Monitoring can focus on single species, particularly if the focus is on threatened taxa. Monitoring protocols for several threatened species in South Africa have already been developed and implemented (see below). Sampling can also focus on community assemblages at particular sites and this can be a useful indicator for detecting changes in community structure. Site selection, and therefore species selection, should also be determined according to priority wetlands.

Where can data be found?

Fieldworkers should familiarise themselves with the various frog species in the areas that they will be monitoring, including the calls of these species. Good field guides include:

- Du Preez & Carruthers, 2009. *A complete guide to the frogs of southern Africa*. Struik Nature
- Du Preez & Carruthers, 2011. *Frogs & Frogging in South Africa*. Stuik Nature.

A smart-phone app based on the complete guide will also be available in 2015 and will provide a very useful tool in the field for identifying frogs and their calls.

The monitoring and surveillance protocol for threatened frogs in KwaZulu-Natal (Tarrant, unpublished) is also a useful document for monitoring of those specific species and can be made available as required.

Equipment needed in the field

- Protective wear (gumboots/waders)
- Headlamps/torches
- GPS
- Frog App or access to call recordings for reference
- Song Meters are useful (see below)

Also see the section below on very important hygiene protocols.

Data sheets

Data sheets can be tailored for specific needs/wetlands or species but should record at least the following information:

- date
- time
- location (including GPS points as relevant)
- weather conditions (including rainfall, humidity, temperature of water and air)
- water quality conditions as relevant
- habitat description and perceived threats
- general observations
- name of observer.

Frogs are often easiest "sampled" by identifying and counting the calls they make, often at night. For call surveys the calling density categories are:

#	Exact number calling
1	None calling
2	< 5 calling
3	5-10 calling
4	> 10 calling
5	> 20 calling

The use of Song Meters

Song Meters are digital recording devices (Wildlife Acoustics, Inc., Massachusetts) that allow for pre-set programming to record data for specified lengths of time. Frog calls can be recorded for up to 700 hours. Depending on the number of microphones used, several areas can be monitored by a single song meter. This is an effective tool for monitoring calls in the absence of humans and across the breeding season, reducing the need for site visits. The devices are able to record temperature and can also be modified to record humidity, rainfall and other environmental variables, essentially acting as an on-site weather station and thereby providing extremely important information on species ecology and behaviour.

When should the data be collected in the field?

Most frog species are active during the rainy season. For the eastern parts of the country this is usually over spring and summer (August to February), while in the western regions this is usually late winter and early spring. Timing can depend strongly on the species, however, as some are prolonged breeders and will be active throughout the season, whereas others such as Giant Bullfrogs, *Pyxicephalus adspersus*, and Western Leopard Toads, *Amietophrynus pantherinus*, are explosive breeders and are only active for very short periods in response to weather conditions.

Where should you collect the data in the field?

This would depend on the conditions and size of the site. For presence/absence sampling, a single or a few data-collection points around the edge of the wetland are sufficient, as long as the same points are used consistently. For call surveys, transects are used within or adjacent to the wetland area and should be standardised for each visit. Transect length will also depend on wetland size, but 50-150 m is recommended.

How should you collect the data in the field?

Amphibians have complex life cycles and as such may require several sampling techniques which include active sampling (e.g. visual encounter, call surveying, egg mass counts) and passive sampling (traps, covers and data loggers). It is unlikely that a single technique can be used for sampling an entire community, and techniques for single species should be applied according to the life history of the target species. For community assemblages it is usually best to employ more than one method (Dodd, 2003). Monitoring protocols should be standardised where possible and repeatable in the long-term (at least 10 years) in order to detect whether population changes are a result of human disturbance or to natural fluctuations (Dodd, 2003; Rödel & Ernst, 2004; Veith et al., 2004). Monitoring protocols must also always employ bio-security measures to prevent introduction and/or spread of disease, particularly the amphibian chytrid fungus *Batrachochytrium dendrobatidis (Bd)*, which has been detected in several species, including threatened species, in South Africa (Tarrant et al., 2013). See previous sections for hygiene protocols.

Method: Call Surveys

Most species of frog use calls to attract mates and establish breeding habitats. Frog calls are species-specific and observers can use calls to locate and identify different species of frogs easily and reliably within a study area (Passmore and Carruthers, 1995). It is considered that the use of male calls is “highly efficient and indispensable in sampling of species that are more readily detected by their calls than by sight” (Rödel and Ernst, 2002). Population sizes of rare frogs have been successfully estimated using calling males in Australia and Europe (Driscoll, 1998; Anderson et al*.,* 2004; Hollis, 2004). The number of calling males should be recorded at categories of: 1 = 0 frogs calling; 2 = 1-5 individuals calling; 3: 5-10 individuals calling; and 4 = >10 individuals calling at each point monitored. Population size can be estimated by dividing the total area of transects by the total area of the wetland times the number of frogs. Under the assumption that the male to female ratio is 1:1 the total adult population size can be calculated by doubling the number of adult males recorded.

How long does it take to collect the data in the field?

Length of time in the field depends on the methods used and the target species. For most species it is appropriate to use call surveys and, since most frogs are nocturnal, this usually must take place at night, usually between the hours of 19:00 and 00:00, over a period of 1-2 hours (or depending on the transect lengths). Automated recording equipment is becoming increasingly popular for amphibian monitoring as it can be programmed to record throughout the night, and can be set up to record for a certain length of time per hour, etc. This equipment is expensive, however, so it is most likely to be used in priority sites and will be dependent on available budget.

How often should the data be collected to be able to reflect change?

Ideally on a monthly basis during the course of the breeding season, or at least once annually during the peak activity period if known.

Training

Training of personnel selected for carrying out the monitoring protocols is crucial. Amphibians can be difficult to identify and for most monitoring procedures described above, knowledge of the target species call and behaviour is essential. Staff must be supplied with the necessary equipment for carrying out the actual monitoring as well as support for data analysis and interpretation. In terms of time, a minimum of 10 years of data collection is not unreasonable for understanding the population status of amphibians, and to measure the extent of variation associated with sampling data. The monitoring protocol described here is intended to set guidelines for fieldworkers and staff. Training sessions to identify frog species through calls and visuals are recommended.

Sample Handling and Analysis

At sample site and off site

For call surveys, minimal sampling of live frogs is required as it is sufficient to record aural (sound) information. Where direct handling and sampling may be required, the hygiene protocol below must be followed. Where several sites are surveyed in a single trip the procedures below must also be followed to prevent possible spread of disease.

Hygiene protocols

Amphibian declines have been directly linked to both toxic contamination (Boone & Bridges, 2003; Hayes et al., 2006; Relyea, 2005) and disease, in particular, amphibian chytridiomycosis, which has now been identified as a major cause of amphibian declines (Berger et al., 1998; Berger et al., 1999; Briggs et al., 2010; Skerratt et al., 2007). As a result, field workers need to avoid becoming vectors of disease organisms or toxic chemicals between study sites, so they must employ stringent bio-security protocols (Dodd, 2003). (For the hygiene protocol to prevent the spread of *Bd* between sites see St-Hilaire et al., 2007). Measures to reduce the risk of spreading infection between sites are particularly important in the case of threatened frog species, where protocols should be applied even over very short distances. Equipment and footwear should be cleaned and disinfected at the commencement of fieldwork and between sites (Table 25). This is done by removing excess mud and rinsing or spraying boots with disinfectant (5% bleach solution) or allowing them to air-dry before visiting the next site. If swabbing for *Bd* is required, a fresh pair of latex gloves is used for each animal and the caught frog is held in one hand and swabbed using the other. The cotton tip of the swab was gently stroked five times each over the ventral surfaces of the thighs, tibia, ventrum and webbing of the live frog (Figure 27), which is then released at the point of capture.

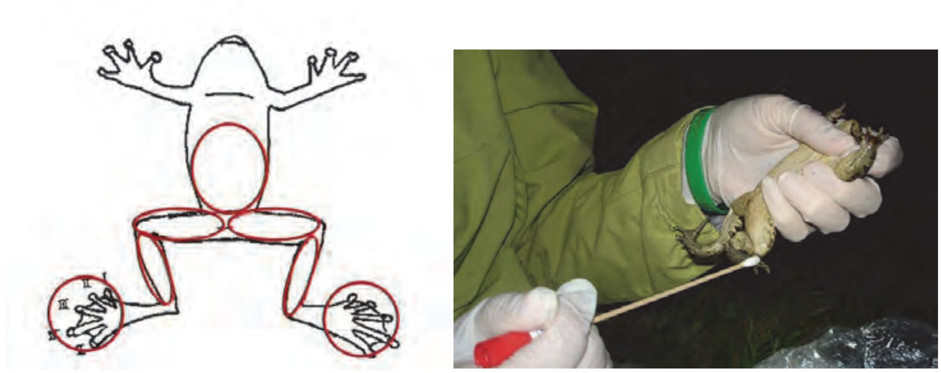

Figure 27: Correct swabbing procedure for chytrid fungus using one pair of gloves and one plastic bag per frog.

Table 25: Bio-security protocol for preventing cross-contamination of frog pathogens

Protective wear & equipment	Disinfection/sanitizing method
Non-permeable boots (gumboots) or waders	If only one site is visited, wash thoroughly in water and allow to dry fully in sun following surveying. If more than one site visited in single survey, rinse in bleach solution immediately after leaving each study site.
Nets (for tadpole sweeping)	If only one site is visited, wash thoroughly in water and allow to dry fully in sun following surveying. If more than one site visited in single survey, rinse in bleach solution immediately after leaving each study site.
Latex/vinyl gloves	Properly dispose of after each handling session (one pair per animal)
Plastic bags (for holding frogs/specimens)	Properly dispose of after each use.

Additional Precautions

- Avoid contact between used and unused protective wear and equipment.
- House specimens separately.
- Do not urinate in or near water-bodies.
- Clean hands thoroughly after handling specimens.
- Clean hands thoroughly after leaving each site.
- Do not use insect repellent on hands when handling amphibians.

A vigilant approach should also be employed to prevent the introduction of a novel strain of *Bd* that could be potentially lethal to certain South African species. Although *Bd* appears to now be endemic to many regions of the world, with populations able to persist with low levels of infection (Briggs et al., 2010; Tobler & Schmidt, 2010), experiments have shown that infection with novel strains of *Bd* can be fatal even when local strains are not (Gahl et al., 2011). Coupled with the potential unknown effect of additional stressors such as climate change and anthropomorphic habitat transformation, South Africa could still experience population declines as a result of chytridiomycosis. As such, identification of potentially susceptible species and likely areas of infection are essential first steps for any form of mitigation, from the development of a surveillance programme to *ex-situ* population management.

At the office/lab

Data recorded on site on data sheets should be transferred to an electronic version as soon as possible (no longer than a week after monitoring). This data should be sent to the relevant managers/regional ecologists, the NWMP office in DWS, and Jeanne Tarrant (Endangered Wildlife Trust) for consolidation and storage.

How to analyse the data

Data analysis will be conducted as relevant for the species/area to determine population trends. The data analysis must be conducted in conjunction with NWMP and EWT. The results of the data analysis will be stored in the NWMP database, as well as in the EWT Biodiversity Databank, if relevant.

How to interpret the data

The example provided is specific to the Critically Endangered Pickersgill's Reed Frog, *Hyperolius pickersgilli*, which is a coastal wetland specialist, so interpretation is likely to be suitable for abundance estimates of other wetland species. Call surveys were conducted over 12 weeks at one of the known sites in the 2013/2014 season to estimate abundance of the frogs.

Results

Many of the monitoring points showed some variation in call density over the course of the monitoring period, while no calls were detected for almost one third (32%) of the monitoring points. Spearman rank order tests showed that calling activity was positively correlated with water depth. The highest call densities were recorded in sections of the wetland where water depth fluctuated between 200 and 600 mm. No significant difference existed for call data among the two transects ($p = 0.0998$) when tested for compatibility and representation. Thus data were evenly distributed across compatible transects and deemed useful for calculating population estimates of the wetland. Call intensity fluctuated during the breeding season, reaching a peak in December and was strongly correlated with temperature as well as rainfall and humidity [making use of national weather data]. It appears the entire breeding season was included in the monitoring period, starting in October and continuing until the end of January. When compared over time there was no significant difference ($p > 0.05$) in overall call intensity over time, except for one survey, rendering the temporal data useful for interpreting population size estimate.

Using descriptive statistics, the mean score for the combined call data over time was calculated at 1.3 male per 100 m^2. Extrapolated to the full area of the study wetland of 31,557 m^2 this translates to 401 male frogs. Assuming a sex ratio of 1:1, the population estimate for the study site is 802adult Pickersgill's Reed frogs.

Reporting

What to do with the captured data

The captured data must be sent to the relevant NWMP Data Manager on a monthly or annual basis, as dictated by the sampling protocol. The records should be distributed to the relevant provincial authorities for inclusion in their records and/or to the ADU Virtual Museum FrogMAP Project: http://vmus.adu.org.za. The summary of call estimate data should feed into the National Wetland Monitoring Programme database and be entered into the population and trends section of provincial databases as relevant. These data can be used in the State of Biodiversity Report and in other province-wide reports and analyses. The data will also be stored in the Endangered Wildlife Trust's Biodiversity Databank (BDB).

Detection of trends in population size and/or community assemblages should be used to design management regimes as necessary. If declines are detected, the probable cause(s) must be determined. Where these causes are controllable and not related to long-term climatic conditions, recommendations will be made to mitigate, control or eliminate the cause of decline. This adaptive monitoring protocol shall be appropriately amended to include monitoring of controllable threats.

7.6.4 Protocol for Monitoring of Water birds

Provided by Jerome Ainsley of Co-ordinated Waterbird Counts (CWAC)

It is recommended that water bird monitoring is done using the same protocols developed for the CWAC project (available http://cwac.adu.org.za/forms.php). They are simple and time-proven and if followed, comparison can be made with the counts already in the database from years past. Waterbird data collected as part of the NWMP should be shared with the curators of the CWAC project as this data would become part of the CWAC reporting and data analysis process.

Why is it important to measure and track water birds?

The overall number of water bird species and the specific numbers of each species give strong indications as to the health of a wetland ecosystem.

What do water birds tell us about the wetland?

As a general rule, the richer the species array, and the higher the number of individuals, the healthier the wetland is. The presence and prevalence of some species over others can point to the water being fairly saline (this can be an entirely natural thing, such as when a pan is drying out), or can suggest the presence of raw sewage.

Sampling Procedure:

What data need to be collected?

The water bird species present, and the number of individuals of each species. A water bird species list can be found at http://cwac.adu.org.za/species.php

What tools/ do you need to collect the data in the field?

Pen, paper and clipboard. Binoculars. A birding telescope may be necessary at wetlands where the birds are at a distance. A comprehensive bird book will be sufficient to identify water bird species. Birding experience will help with separating the more difficult-to-identify migratory waders. The aspects of the method for counting, which should be standardized, are as follows:

a. Number of people counting – the number of counters should be fixed such that the job can be done in a reasonable amount of time but without excessively disturbing the birds.
b. Routes followed – the routes that the counters follow should be fixed and marked on the site map. The route should be laid out to afford the best possible coverage of the area without repetition. Routes should always be followed in the same direction.
c. Time of day – counts should always be conducted during the same hours of the day.
d. Viewing technique – an appropriate viewing technique should be chosen and used consistently (e.g. stationary from a hide, mobile on foot, mobile from a vehicle, mobile from a boat, aerial survey or some combination of these).
e. Viewing aids – appropriate aids (e.g. binoculars and telescopes of particular magnification, photography from particular vantage points, aerial photography) should be chosen and used consistently. It is important not to use inadequate equipment, such as binoculars across long stretches of open water where telescopes are essential for proper identification of species.
f. Personnel – if possible counters should be experienced in identifying water birds. If necessary, training should be provided, particularly in identifying waders. Counts will benefit from repeated use of the same counters who know the area, know the techniques and know the birds.
g. Counting techniques – the manner in which the actual counting is done and recorded should be standardised as far as possible. Again this may require some training and will benefit from personal experience. Factors which cannot be standardised such as weather conditions and water levels should be recorded and reported so that these effects can be taken into account.

When should the data be collected in the field?

Early morning is the best time to conduct a water bird count.

Where should you collect the data in the field?

Follow the same method each time. Count from the same points each time and follow the same routes. If a wetland has been monitored previously, ensure that the method used previously is followed (see each site description at http://cwac.adu.org.za/)

How should you collect the data in the field?

Record each species and the numbers of individuals of each species.

Approximately how long does it take to collect the data in the field?

At a small wetland the water bird count can be done in less than an hour. A large wetland can take a whole morning. Very large sites should be divided into sections, and each section counted simultaneously.

How often should the data be collected to be able to reflect change?

Twice a year is the minimum (between Jan 15th and Feb 15th in summer, and during July in winter). If possible more frequent counts should be done.

How to analyse the data

Comparison of counts can be made year on year and season on season. Refer to past counts for registered sites at http://cwac.adu.org.za/

How to interpret the data

If the number of species and/or the number of individuals shows a marked decline for no obvious reason, further investigation into the health of the wetland ecosystem is indicated.

What to do with the captured data

Submit the count results to the NWMP office at DWS and also online at http://cwac.adu.org.za/ Continuity of water bird counts is important as this allows short and long term changes to become apparent.

The following documents are available at the above web site:

1. What is a CWAC site? (125Kb)
2. Counters, Compilers & Coordinators (124Kb)
3. Basic aims and protocol (123Kb)
4. Basic counting techniques (161Kb)
5. Equipment (122Kb)
6. Specialised counting techniques (131Kb)
7. Species identification (126Kb)
8. Census Form Guidelines (143Kb)
9. Site Data Collection Form (127Kb)
10. Guidelines – Site Data Collection Form (61Kb)

Persons involved in water bird counts should familiarise themselves with the above documents.

7.6.5 Protocol for Monitoring Water Quality

Developed by Prof Jenny Day, Freshwater Research Centre, Cape Town

The commonly measured physical attributes that contribute to water quality include temperature, electrical conductivity, turbidity, and the concentrations of dissolved gases. Each of these can be measured relatively simply using field-based meters. In contrast, tens of thousands of chemical substances could potentially occur in a sample of water, although only relatively few are commonly found in measurable concentrations. These include the “major ions” (calcium, magnesium, potassium, sodium, sulphate, chloride, bicarbonate and carbonate), which are present in relatively high concentrations (a few milligrams per litre) even in natural fresh waters. Other naturally-occurring solutes, which include compounds of P, N and silica, fluoride, and a number of metals such as iron and manganese, and numerous organic compounds, are present at much lower concentrations (often only a few micrograms per litre). The actual concentrations of these natural constituents vary according to the geological and vegetation setting of a wetland.

Human activities contribute to a decrease in water quality (i.e. a decrease in “fitness for use” of the water) by increasing the concentrations of naturally occurring substances like nutrients and salts, or by adding substances like pesticides that are not part of the normal chemistry of water. All of these chemical constituents of water require relatively sophisticated analytical techniques and are measured in the laboratory. The lower the concentration of these substances, the more difficult it is to measure them accurately and yet accurate measures are crucially important for substances such as nutrients, and toxins such as pesticides and heavy metals. For this reason, it’s important to know which chemical substances are likely to be present in concentrations higher than they would occur naturally, and to be able to measure them accurately. NOTE that very few laboratories use techniques that can measure low but environmentally significant concentrations of nutrients. You need to enquire about the detection limits of nutrients of the laboratory (including those of DWS, SABS and the CSIR) that you are planning to use for analysing nutrients.

Sampling Procedure

What data need to be collected?

Electrical conductivity, dissolved oxygen, pH, temperature and turbidity, and chlorophyll if possible, must be measured in all wetlands because they serve as baseline water quality measures. The condition of the wetland and human activities in the quaternary catchment will indicate which additional constituents should be quantified. Table 26 indicates the constituents most likely to be elevated as a result of various land-use activities, and therefore most likely to repay measurement.

Table 26: constituents most likely to be elevated as a result of various land-use activities. Measurement of constituents in parentheses should be considered if significant pollution is indicated.

Sources	Constituents to be analysed
Livestock	nitrogen: nitrate, nitrite, ammonium (organic nitrogen, total nitrogen) phosphorus: soluble reactive phosphate or equivalent (total phosphorus) Total Suspended Solids as turbidity pesticides (specific pesticides chosen according to known applications in the catchment) (agrichemicals such as hormones, antibiotics and/or endocrine disrupting compounds if biological damage such as limb deformities are noticed)
Crop cultivation	nitrogen: nitrate, nitrite, ammonium (organic nitrogen, total nitrogen) phosphorus: soluble reactive phosphate or equivalent (total phosphorus) Total Suspended Solids as turbidity salinity as EC pesticides (specific pesticides chosen according to known applications in the catchment)
Wash off from urban areas and informal settlements	nitrogen: nitrate, nitrite, ammonium (organic nitrogen, total nitrogen) phosphorus: soluble reactive phosphate or equivalent (total phosphorus) Total Suspended Solids as turbidity human pathogens (heavy metals)
Waste-water treatment works	nitrogen: nitrate, nitrite, ammonium (organic nitrogen, total nitrogen) phosphorus: soluble reactive phosphate or equivalent (total phosphorus) Total Suspended Solids as turbidity human pathogens (heavy metals) (chemicals such as hormones, antibiotics and/or endocrine disrupting compounds if biological damage such as limb deformities are noticed)
Mining	sulphates (if acid mine drainage is suspected) pH (if acid mine drainage is suspected) toxic metals
Industrial effluents and power generation	This is very industry-specific, especially effluents from the chemical industry and will require investigation.
Commercial forestry	nitrogen: nitrate, nitrite, ammonium (organic nitrogen, total nitrogen) phosphorus: soluble reactive phosphate or equivalent (total phosphorus) Total Suspended Solids as turbidity

Guidance for Completing the WQ Field Attributes Form

It is important that the assessor walk the entire assessment area prior to completing the fieldwork. During this investigation, the assessor should make note of the presence of potential wetland stressors (such as roads, maintained vegetation, and stormwater runoff) and consider the effect of potential stressors on the subject wetland. The assessor should take notes liberally, documenting important site features and reasoning used in best professional judgment to fill in the water quality section of the Attributes Table (see Section 9.2.4).

The assessor needs to understand how each water quality constituent listed in Table 27 affects the wetland in question. Valuable information can be found at https://www.dwa.gov.za/iwqs/wq_guide/Pol_saWQguideFRESHAquaticecosystemsvol7.pdf for South African water quality guidelines for aquatic ecosystems. Note that guidelines have not been drawn up for all constituents so the assessor may have to go to the international literature (e.g. US EPA standards at https://www.epa.gov/wqc and Australian and New Zealand guidelines at http://www.environment.gov.au/system/files/resources/53cda9ea-7ec2-49d4-af29-d1dde09e96ef/files/nwqms-guidelines-4-vol1.pdf.

Table 27: Description of water quality indicators to be assessed, what they indicate, potential causes of change and what this means for a wetland (adapted from Davies and Day, 1998; D'Arcy et al., 2000a cited by Campbell et al., 2004; Pegram and Gorgens, 2001; DWAF, 1996) and recommended boundary values for PES (Malan and Day, 2012)

Water quality constituent and recommended units	What does this constituent indicate about water quality?	Impact of Change on the Aquatic Environment	Recommended Boundary Values for Wetland's Present Ecological State (Malan and Day, 2012)
Electrical conductivity (mS/m) and salinity (PSU)	EC is an indirect measure of total dissolved salts and salinity. High salinities may be natural or may have an anthropogenic cause	Change in the suite of organisms: most are able to survive only within a relatively narrow range of salinities.	**A:** within the 95%ile or <80% **B/C:** <200% **D/E:** >200% deviation from median for the Reference Condition
pH	pH is a measure of the acidity / alkalinity of the water.	Excessively low or high pH levels can be detrimental to aquatic organisms and can affect the taste of water. South-western Cape waters are naturally low in pH. Wetlands in mining areas may be affected by acid mine drainage, resulting in very low pH values (<2) and concomitant dissolution of toxic and radioactive metals.	**A:** within the 95%ile or <80% **B/C:** <200% **D/E:** >200% deviation from median for the Reference Condition
Dissolved oxygen (mg/l) or saturation (%)	Dissolved oxygen is important for most aquatic life forms. It is produced during photosynthesis of aquatic plants and algae and when water movement causes aeration.	Sustained low levels may lead to respiratory distress while excessively high levels (super saturation) can cause 'gas bubble' disease in fish. Anoxia (complete loss of oxygen) can result from decay of algal blooms.	
Pathogens: Faecal coliforms or *Escherichia coli* (cells/100 ml)	*Escherichia coli* is a particular species within the group of faecal coliform organisms. *E.coli* is specific to humans and warm-blooded animals and birds. It is not usually pathogenic itself but indicates the presence of faeces, and therefore of other potential pathogens such as cholera.	Health risks to humans and other mammals. For commentary on coliform counts, see http://oasisdesign.net/water/quality/coliform.htm	
Nitrogen: nitrite-N, nitrate-N, ammonium-N, total N (µg/l)	Nitrogen is an essential plant nutrient and plays an important role in determining the degree of eutrophication in a water body.	Eutrophication	**Ammonium (mg N/L)** **A:** ≤0.03 **B/C:** ≤0.05 **D/E:** >0.05 **Nitrate and nitrite (mg**

Water quality constituent and recommended units	What does this constituent indicate about water quality?	Impact of Change on the Aquatic Environment	Recommended Boundary Values for Wetland's Present Ecological State (Malan and Day, 2012)
			N/L) **A:** ≤0.015 **B/C:** ≤0.07 **D/E:** >0.07
Phosphorus: phosphate-P. total P (µg/l)	Phosphorus is an essential plant nutrient and plays an important role in determining the degree of eutrophication in a water body.	Eutrophication	**Total phosphorus (mg P/L)** **A:** ≤0.02 **B/C:** ≤0.06 **D/E:** >0.06 **Phosphate (mg P/L)** **A:** ≤0.01 **B/C:** ≤0.04 **D/E:** >0.04
Suspended solids (mg/l) and turbidity (NTUs)	Suspended solids refer to particulate matter moved by water. When such solids come out of suspension they form part of the sediments on the bed.	Sedimentation of wetlands encourages encroachment of vegetation; some suspended particles adsorb or release nutrients and toxins. Turbidity affects photosynthesis, eyesight of visual predators	
Oil & grease and other hydrocarbons (mg/l)		Physical clogging, interference with dissolved gases crossing the water surface; toxicity.	
Biodegradable organic waste (mg/l)		Increased oxygen demand, nutrient enrichment, increased turbidity: eutrophication and interference with community structure	
Toxic metals (µg/l or ng/l)		Toxicity.	
Biocides (µg/l or ng/l)		Toxicity; some are suspected of disruption of endocrine systems in vertebrates. Can be estimated using vitellogenin assays.	

Where should you collect the data in the field?

The wetland type and availability of water will determine the sites for water sampling. See Table 28 for details. It is necessary to sample water for chemical analyses at only one site per HGM unit unless clear indications of disturbance indicate differences in WQ in different parts of the HGM unit. Where possible, take water samples at a depth of about 200 mm. Make a note if the water is very shallow and murky.

Table 28: Sampling sites according to wetland type

Wetland type	Sampling site(s)
Floodplain	Sample inflow, middle and outflow and middle of wetland
Valley bottom (with channel)	Sample both at inflow and outflow of wetland
Valley bottom (without channel)	Sample both at inflow and outflow of wetland
Seep	Sample from any point where surface water is visible.
Depression	Sample exposed water at the edge

What tools/instruments do you need to collect the data in the field?

You will need electronic meters to measure DO, pH, Ec, temperature, turbidity and chlorophyll. Ensure that you are thoroughly familiar with the operation of each probe and that each has been properly calibrated before use. *Read the instruction manual.* Be sure to take spare batteries, membranes, etc.

Be aware that some sampling sites may be contaminated with human faeces, toxic chemicals or the snail hosts of bilharzia. If this is likely to be the case, always use gloves and wash thoroughly with soap and water after visiting each sampling site.

Use the DWS water sampling protocols for collecting, preserving, storing and transporting water samples, in particular

- Sampling Protocol for Inorganic Chemical Analysis https://www.dwa.gov.za/iwqs/reports/general/WRQM_Vol01_Sampling_protocol_Inorganic_chemical_analysis_s.pdf
- Sampling Protocol for Eutrophication Monitoring https://www.dwa.gov.za/iwqs/reports/general/WRQM_Vol02_Sampling_protocol_eutrophication_monitoring.pdf

Collection of water for microbial analysis requires very specific sampling gear, including sterile bottles. Consult the following document: https://www.dwa.gov.za/iwqs/microbio/Document/NMMP_implementation_Surfaces.pdf

How to analyse the data

You may be able to submit the water samples to the Department's RQS laboratory for analysis. Be aware, though, that this laboratory is not always able to detect low concentrations, of nutrients in particular, and that it may be necessary to use a better equipped laboratory. *It is crucial that the detection limits of nutrient analyses are sufficiently low that nutrient levels can be quantified even at very low levels.*

How to interpret the data

Interpret results against boundary values in Table 28, where available. Alternatively, compare results with previous data. Once some data have been generated within the NWMP, it will be possible to provide more specific indicators of water quality.

What to do with the captured data

Submit data to the NWMP database.

7.6.6 Protocol for Monitoring Fish

The Fish Response Index Manual should be used to monitor fish in wetlands. The manual is available on the NWMP CD in the folder NWMP Implementation Manual Supporting Tool, listed as: *2007, Kleynhans. Module D – Fish Response Assessment Index.*

DATA QUALITY IN THE NWMP

8 DATA QUALITY CONSIDERATIONS

The NWMP is all about data, its collection and its reporting in a meaningful and accurate manner. These data tell the story of wetlands in the country and highlight the threats and pressures placed on our wetlands. The credibility of the NWMP rests on the quality of the data that is produced. If NWMP data are not credible, we will be unable to manage and conserve wetlands in an effective and efficient manner, and the value of the NWMP will be lost.

There are a number of ways to ensure that the data produced by the NWMP meet the quality requirements to produce scientifically credible results.

1. Perhaps the most crucial of these is the expertise and skills of the people involved in the sustainable operation and maintenance of the NWMP, particularly the skill and expertise of the individuals who carry out field assessments and monitoring. Although, legislatively, the DWS is responsible for the NWMP, the programme is designed in a manner that private sector and other governmental institutions involved in wetland management, conservation and reporting can also contribute data to the NWMP. The skills and expertise of the wetland sector as a whole is thus crucial to the quality of data within the NWMP.

   Field assessors in the NWMP should have undergone training and should be accredited in the NWMP methods, which are not new but are currently being used in the wetland sector (see Section 6 for more detail). In addition, the NWMP recommends that teams of at least two assessors carry out the assessment and monitoring of wetlands. One manner of minimising bias in indicator results is for the specialist (led) assessor to compare the indicator results of the two assessments and use their best judgement to determine the final indicator results, i.e. although one may assume that the led assessor would have the most accurate indicator results. The comparing of results will assist the specialist assessor in determining gaps/omissions in their dataset and indicators results.

2. Another means of generating good-quality data is by ensuring scientifically credible design of the methods. Methods must also be repeatable (i.e. produce comparable results) when different people apply the same method to the same wetland; and when the same person repeats the same method at different wetlands.

3. Linked to repeatable methods is the need to ensure that the Reference Conditions defined for each wetland are clearly documented. This will ensure that future assessments and monitoring utilise the same reference against which to determine the indicators in the NWMP.
4. Data assurance can also be achieved by ensuring that specialist analysis of data is conducted by individuals and organisation who meet all proficiency requirements, e.g. laboratories that have SANAS accreditation for analytical methods.
5. Good record keeping is also an essential part of quality assurance. Original datasheets should be kept. Data must be collected and captured in a standardised manner using metadata fields outlined for each indicator in the NWMP.
6. It is also vital that transcription of data from data sheets to electronic format is accurate. Back-checking of a representative sample should be done at certain intervals. The manner in which data are managed and stored can also contribute to quality assurance. Efficient and effective management and storage of the NWMP data are an essential pre-requite for successful assessment and monitoring of wetlands in the country. Data management and storage must be standardised and follow a rigorous procedure to ensure high-quality reliable data.

With the NWMP being a public sector initiative, data quality in this programme needs to adhere to South Africa's *Data Quality Policy 001: Policy on Informing Users of Data Quality, Feb 2006.* This policy defines data quality in terms of "*fitness for use*". Whether data and statistical information are fit for use depends on the intended use and on the characteristics of the data or information.

The following criteria should apply to statistical data in the NWMP:

- The relevance of statistical information reflects the degree to which it meets the real needs of users.
- Accuracy: – the degree to which the information correctly describes the phenomena it was designed to measure.
- Timeliness: minimal delay between the reference point to which the information pertains, and the date on which the information becomes available.
- Accessibility: – the ease with which they can be obtained
- Interpretability: – the ease with which users can understand statistical information through interpreting the available metadata.
- Coherence: – the degree to which it can be successfully brought together with other statistical information within a broad analytic framework and over time.
- Methodological soundness: – the application of international standards, guidelines, and agreed practices to produce statistical outputs.
- Integrity: – maintain the confidence users have in the agency producing statistics and ultimately, in the statistical product.

To ensure the quality of mapping and a standardisation of process utilised in the mapping of wetland in South Africa, the SANBI mapping guideline is utilised in the NWMP.

GLOSSARY

The definitions of terms provided below are applicable to the NWMP and have been adapted for the programme.

Assessment	In the NWMP is the act of estimating the condition of wetland indicators at Tier 2 of the framework. This provides the first-level information from which a monitoring plan can be devised for wetlands considered in Tier 3 of the NWMP.
Afforestation/plantation	The establishment of forests by natural succession or by the planting of tress on land where they did not formerly grow, e.g. establishment of monoculture of pines, eucalypts or wattle (DEA SoE Glossary)
Attribute	A characteristic feature or component of a wetland
Buffer	A strip of land surrounding a wetland
Condition	Wetland condition refers to its current state, compared to reference or best state, for physical, chemical, and biological characteristics (EPA)
Biodiversity hotspot	An area that is identified as a conservation priority because it contains a large number of species, many endemic or otherwise of importance (DEA SoE Glossary)
Catchment	The area from which water flows towards a common point. The surface and subsurface catchment areas may not coincide. The extent of catchment areas is defined by hydrological divides.
Conservation	The maintenance of environmental quality and functioning (DEA State of the Environment Glossary of Terms)
Degradation	Deterioration of the ecological infrastructure or productivity of an area (DEA SoE Glossary)
Delineation (of a wetland)	Defining the boundary of a wetland based on soil, vegetation, and/or hydrological indicators (Duthie, 1999)
Communal land	Land that is owned and managed communally, generally by traditional authorities (DEA SoE Glossary)
Diatom	Microscopic alga with a silicon "shell" in two separate halves
Ecosystem	The dynamic complex of animals, plants and micro-organisms and their non-living environment (soil, water, climate and atmosphere) interacting as a functional unit (DEA SoE Glossary)
Ecosystem services	The beneficial functions such as water quality regulation, nutrient cycling, soil fertility maintenance, regulation of the concentration of atmospheric gases and cultural and recreational opportunities provided by ecosystems (DEA SoE Glossary)
EcoClassification:	This is a procedure to determine and categorise the ecological state of various biological and physical attributes compared to the reference state. The procedure of Eco Classification describes the health of a water resource and derives and formulates management targets / objectives / specifications for the resource. This provides the context for monitoring the water resource within an adaptive environmental management framework. The classification ranges from A (natural) to F (highly impacted).

GLOSSARY

	(DWAF, 2007)
EcoRegion	"*Ecoregions are areas of general similarity in ecosystems and in the type, quality, and quantity of environmental resources* (US EPA (DWAF, 2007)
EcoStatus	The overall Present Ecological State (PES) or current state of the resource. It represents the totality of the features and characteristics that bear upon its ability to support an appropriate natural flora and fauna and its capacity to provide a variety of goods and services. The EcoStatus value is an integrated ecological state made up of a combination of various PES findings from component Ecostatus assessments (such as for invertebrates, fish, riparian vegetation, geomorphology, hydrology and water quality)
Endorheic	of closed drainage (e.g. a pan) (Duthie, 1999)
Endemic	A plant or animal species that occurs naturally in and is restricted to a particular geographical region.
Eutrophication	A process of nutrient enrichment of aquatic ecosystems, mainly by nitrates and phosphates, which stimulates excessive algal growth. (DEA SoE Glossary)
Floodplain	A wetland inundated when a river overtops its banks during flood events, resulting in the soils being saturated for extended periods of time (Duthie, 1999)
Hydrogeomorphic (HGM) Classification	A wetland classification system based on the position of a wetland in the landscape (geomorphic setting), dominant sources of water, and the flow and fluctuation of water once in the wetland.
HGM unit	A type of aquatic ecosystem distinguished primarily on the basis of, (i) landform (which defines the shape and localised setting of the ecosystem); (ii) hydrological characteristics (which describe the nature of water movement into, through and out of the ecosystem); and (iii) hydrodynamics (which describe the direction and strength of flow through the ecosystem) (Ollis et al., 2013).
Hydrology	The science of dealing with the properties and circulation of water both on the surface and under the earth
Impacts	Positive and negative, primary and secondary, directly or indirectly, intended or unintended long-term effects on the extent, health and ecosystem services provided by a wetland (adapted from OCED, 2002).
Indicator	A quantitative or qualitative factor or variable that provides a simple and reliable means of reflecting the changes in extent, health and ecosystem services provided by a wetland (adapted from OCED, 2002). A measure that helps to assess the extent of the success with which goals are being achieved. Based on complex information or data, indicators are often used to measure how resources are being managed (DEA SoE Glossary)
Indigenous species	Species native to a particular area

GLOSSARY

Invasive alien plant	Alien plants are non-natives; invasive plants have a tendency to spread to a degree that is detrimental to the environment in which they occur.
Land cover	The physical land type such as forest or open water.
Monitoring	In the NWMP, defined as the ongoing measurement of wetland characteristics for a specific purpose
National park	State land set aside for the protection of plants, animal and scenery and for human enjoyment (DEA SoE Glossary)
Present Ecological State (PES)	The current ecological condition of natural ecosystem, assessed as the degree of deviation from the Reference State [insert reference].
Prioritised wetlands	In the NWMP are those wetlands which undergo Tier 2 Rapid Assessment and Tier 3 Monitoring.
Quaternary catchment	All the land area from mountaintop to seashore which is drained by a single river and its tributaries. Each catchment in South Africa has been subdivided into secondary catchments, which in turn have been divided into tertiary. Finally, all tertiary catchments have been divided into interconnected quaternary catchments. A total of 1946 quaternary catchments have been identified for South Africa. These subdivided catchments provide the main basis on which catchments are subdivided for integrated catchment planning and management [reference to be inserted].
Redoxymorphic	a property of wetland soils associated with wetness and resulting from reduction and oxidation
Rapid assessment	evaluation of the state of a wetland characteristic that takes only a few hours
Reference state/condition	The natural or pre-impacted condition of an ecosystem.
Reference Site	A minimally impaired site that is thought to be representative of the natural conditions of other sites of the same type and region
Red data species	Threatened or endangered species that appear on a Red Data list
Wetland	Defined in the National Water Act as the *land which is transitional between terrestrial and aquatic systems where the water table is usually at or near the surface, or the land is periodically covered with shallow water, and which land in normal circumstances supports or would support vegetation typically adapted to life in saturated soil* (South African; 1998)
Surface water	Water found on the surface of the land

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APPENDIX 3: NWMP FIELD GUIDE

9 NWMP FIELD GUIDE

This Field Guide provides the wetland assessor with the processes and tools to be completed in the field during the assessment of a wetland. Figure 28 provides the steps for completing the wetland assessment, with the following sections (9.1.1-9.2.6) providing the field tools to be completed for each of the steps. On returning to the office, the field assessor should follow the instructions in Section 6.2-6.4 to capture the field data and report on the individual indicators.

NOTE that in the following tables, the sections to be completed in the field are coloured purple.

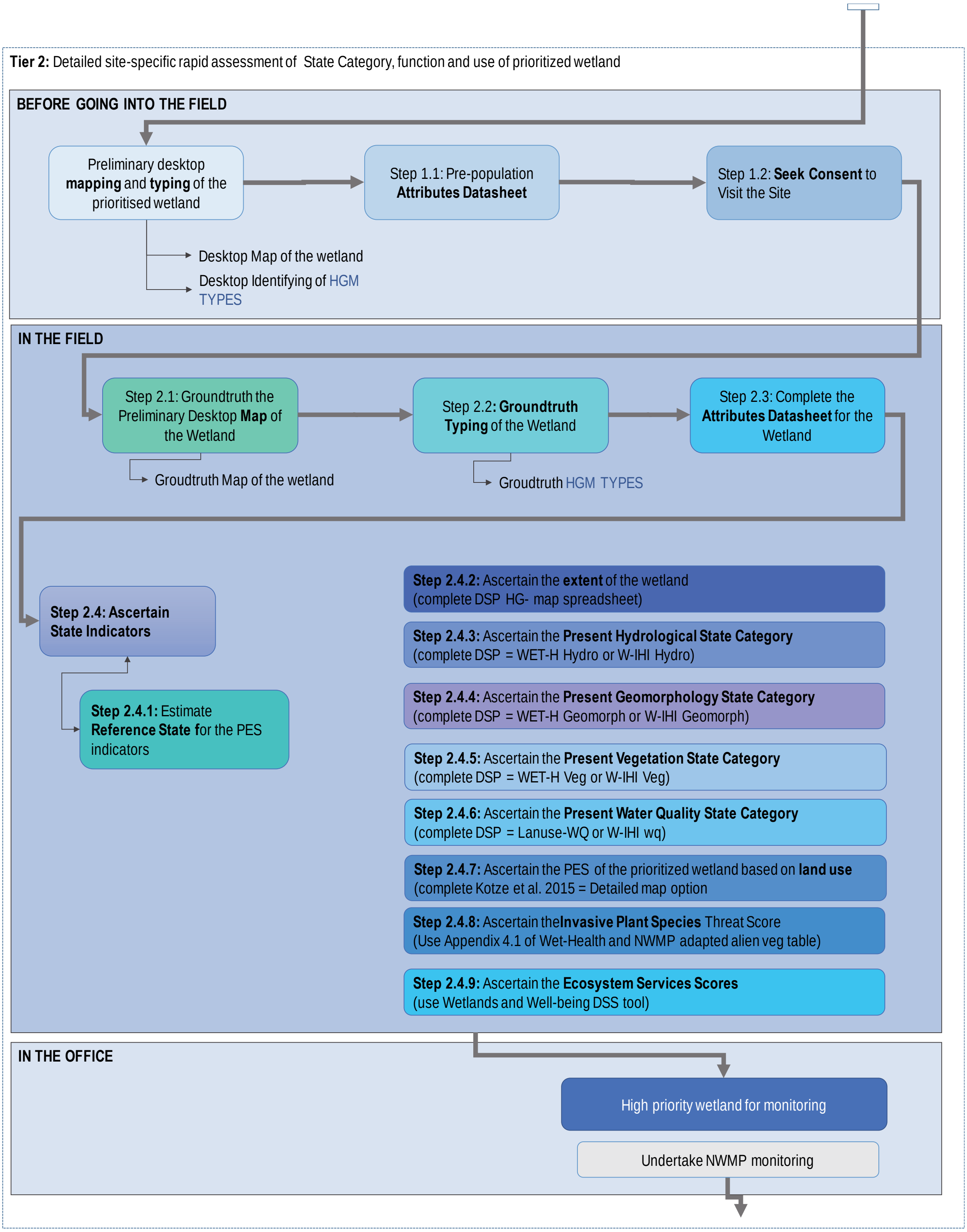


Figure 28: Stages and steps required to complete a rapid, field assessment of a wetland in Tier 2 of the NWMP.

FIELD GUIDE: IN THE OFFICE

9.1 IN THE OFFICE – BEFORE GOING INTO THE FIELD

9.1.1 Step 1.1: Pre-population Attributes Datasheet

A wetland attributes datasheet needs to be populated for the prioritised wetland (Table 29). The datasheet includes all attributes of the wetlands that can provide valuable background information about the wetland or wetland data that cannot currently be reported as indicators but may over time, as more data and information is collected for prioritised wetlands, provide valuable indications of wetland condition.

Table 29: NWMP Attributes Table

SECTION A: ASSESSOR INFORMATION (TO BE FILLED IN BEFORE OR DURING SITE VISIT)

BACKGROUND		
Name of Assessor		
Organisation		
Photographs taken		List from # to # as captured in the flashcard
Longitude and latitude	S	
	E	

SECTION B: SITE INFORMATION (TO BE FILLED IN BEFORE OR DURING SITE VISIT)

SITE ATTRIBUTES								
Site ID (NWMP code)								
Wetland Name (e.g. if none available farm or suburb or reserve name)								
Land ownership	Government		Private		Tribal Authority			Other
Contact Details of Landowner								
Permission Required	Yes		NO		Details			
Province		**Political Region (municipality)**						
Closest Town		**Water Management Area**						
Ecoregion		**Ecoregion 2**						
Secondary Catchment #		**Quaternary Catchment #**						
Veg type: Mucina and Rutherford								
Rainfall Region	Summer		Winter		AseasonaL			
Landuse in catchment	Natural un-transform		Waterbodies		Cultivated		Invasive Plants	
	Grazing		Brick making		Old land		Roads	
	Abstraction		Bridge		Dumping/infilling		Mines/quarries	
	Degraded Natural land		Urban / Built-up		Plantation		Other	

A: WETLAND ATTRIBUTES								
Wetland type	Dam		Seep		Depression		Channelled Valley Bottom	
	Floodplain		Channelled Valley Bottom		Flat			
Altitude								
Position in landscape	Slope		Bench		Plain		Valley-bottom	
Mean Annual Precipitation (MAP)								
Potential Evapotranspiration (PET)								
Visual Description of the Wetland								
Estimated Length								
Estimated Breadth								
Approximate area of whole wetland [1]	<0.5 ha	0,5-<1 ha	1-<5 ha	5-<10 ha	10-<20 ha	20<50 ha	>50 ha	
Approximate size of area assessed	<0.5 ha	0,5-<1 ha	1-<5 ha	5-<10 ha	10-<20 ha	20-<50 ha	>50 ha	
Setting	Urban		Rural					
Presence/evidence of:	Drains (ha)		Dams (ha)		Erosion (ha)		Urban / Built-up	
	Burning from fire (ha)		Groundfire (yes/no)		Pollution-sewage		Vegetation clearing	
B. LANDSCAPE ATTRIBUTES								
Protection status of the wetland (NWMP Tier 1)			National (4), provincial (3), municipal (1 or 2) or public area (0-1)					
Protection status of the vegetation type			SANBI guidance on the protection status of surrounding vegetation					
C: WATER ATTRIBUTES							**Guide**	
Presence of surface water	Yes		No					
Areal extent of open water								
Depth (mean and max.)							If available	
Inundation	Intermittent		Seasonal		Permanent			
NWCS (national wetland classification system)							Information relating to the typing of the wetland based on the National Wetland Classification System of SANBI (2009) can be entered here.	
Water source	River		Overland flow		Hillslope inflow/shallow groundwater		Goundwater	
	Rain		Unsure					
Sites							Sampling sites at the wetland from which water quality have been collected.	
Water quality type							Broad statement of water quality type, e.g. brackish, polluted, brown-coloured.	
Habitat description							Habitat at which the sample was taken (e.g. open water, emergent macrophytes) can be recorded here.	
Water quality results	GPS point (sample point 1)						Turbidity	
							pH	
							EC	
							DO	

			Temp	
Water quality results	GPS point (sample point 2)		Turbidity	
			pH	
			EC	
			Temp	
			DO	
Water quality results	GPS point (sample point 3)		Turbidity	
			pH	
			EC	
			DO	
			Temp	

9.1.2 Step 1.2: Seek Permission to Visit the Site

From indicator 5.3 provided from Tier 1 of the NWMP, determine the land ownership of the land surrounding the wetland. This will give an indication of whether the land surrounding the wetland is private, state-owned or traditional land, providing guidance on how permission should be sought to access the prioritised wetland (see Section 5.6 for guidelines on how to seek access prioritised wetlands).

Permission should be sought from the owner of the land surrounding the wetland to carry out the rapid assessment of all wetlands to be visited (see Section 6.2.2 for a guide on seeking permission to sites).

9.1.3 Checklist of Field Tools Required

Before going into the field, ensure that the following tools are available to the assessor and ensure that the assessor takes these tools with him or her into the field.

- Pen/pencil and notebook
- GPS
- Camera
- DPS Datasheets (see Section 9.2) – either the Wet-Health or IHI datasheets for hydrology, geomorphology and veg and the IHI or Land-use datasheets for water quality
- Attributes datasheet
- Listed Invasive Plant Species Table
- Soil auger – for mapping extent
- Hard copy of the best available map of the extent of the wetland

FIELD GUIDE: IN THE FIELD

9.2 IN THE FIELD – PROCESS FOR CARRYING OUT THE RAPID FIELD ASSESSMENT OF THE PRIORITISED WETLAND

9.2.1 When to conduct the fieldwork

Ideally, assessment of the prioritised wetland should be conducted during the wet season. In the winter rainfall region, the best time for identifying plants is late spring, when they are likely to be flowering.

9.2.2 Step 2.1: Ground-truth Mapping and Typing of the Prioritised Wetland

The purpose of this step is to confirm that the wetland meets the definition of a wetland (see Glossary) and to verify its extent. In the step the field assessor should use the Rapid Assessment Datasheet (Table 30). The mapped extent can be confirmed in the field by taking GPS points, using vegetation as a guide, and taking soil samples if time allows. GPS co-ordinates are recorded on Table 30. It must be noted whether the wetland boundary was adjusted as a result of the field visit.

Table 30: Wetland mapping Rapid Assessment Datasheet which was developed in Mbona et al. (2015)

Sub-WMA		**QUINARY No.**		**DATE**
WET_ID/gps point	**Boundary Adjusted?**	**HGM Type**	**Dominant Plants (use plant codes shown in Table 31)**	**NOTES**

Table 31: Example of a list of dominant wetland plants (taken from Mbona et al., 2015)

Code	Scientific Name	Code	Scientific Name
ARNE	*Arundinella nepalensis*	**LIMO**	*Limosella* sp.
APJU	*Aponogeton junceus*	**MEAQ**	*Mentha aquatica*
CAAU	*Carex austro-africana*	**MIJU**	*Miscanthus junceus*
CEAS	*Centella asiatica*	**NYTH**	*Nymphoides thunbergiana*
CYMA	*Cyperus marginatus*	**PERS**	*Persicaria* sp.
IMCY	*Imperata cylindrica*	**PHAU**	*Phragmites australis*
FUPU	*Fuirena pubescens*	**PYNI**	*Pycreus nitidus*
JUEF	*Juncus effusus*	**RANU**	*Ranunculus* sp.
JUEX	*Juncus exsertus*	**SCBR**	*Schoenoplectus brachyceras*
JULO	*Juncus lomatophyllus*	**SCBR**	*Schoenoplectus corymbosus*
JUOX	*Juncus oxycarpus*	**SCMU**	*Schoenoplectus muriculatus*
LEHE	*Leersia hexandra*	**TYCA**	*Typha capensis*
		XYRI	*Xyris* sp.

The adjustments to the boundary must also be noted on a hard copy of the.

On return to the office, complete Section 6.3.2-Step 2.1 of this document to capture the relevant data.

9.2.3 Step 2.2: Typing the Wetland

The purpose of this step is to ground-truth the classification of HGM units in the wetland. It is important to remember that a single wetland may be made up of several HGM Units.

Hydrogeomorphic types refer to the shape of the landform and how the water flows through this landform. Based on Ollis et al., 2015, the HGM Units in the prioritised wetlands can be distinguished primarily on the basis of:

(i) Landform, which defines the shape and localised setting of the wetland.
(ii) Hydrological characteristics, which describe the nature of water movement into, through and out of the wetland.
(iii) Hydrodynamics, which describe the direction and strength of flow through the wetland

Certain HGM Units are typically associated with particular landscape settings (Figure 29). For example, seeps typically occur on slopes, valley-bottom wetlands typically occur along valley floors, and floodplain wetlands typically occur on plains (Ollis et al., 2014)

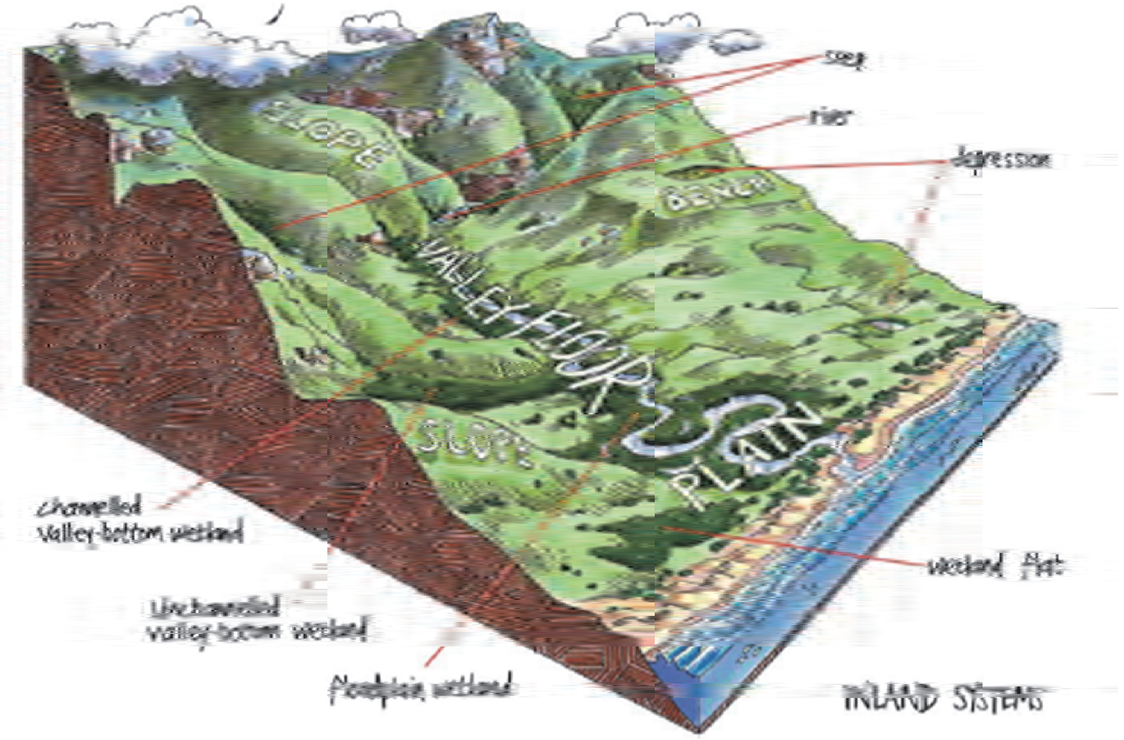


Figure 29: Landscape setting of wetland HGM types (taken from Ollis et al., 2014a)

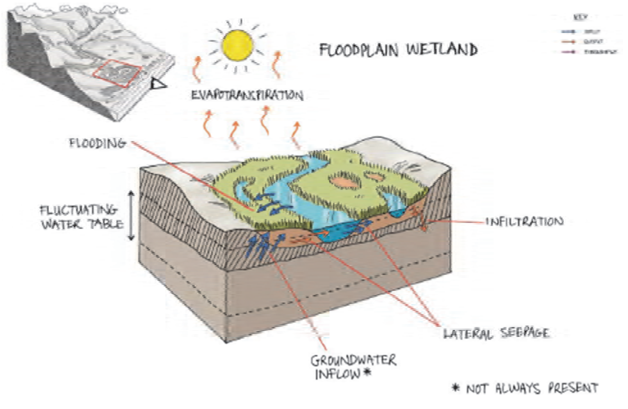
Six primary HGM types are recognised for wetlands (Table 32), based on the predominant movement of water into, through and out of the various HGM Types. A brief description of each HGM type is provided in Table 32.

Ollis et al. (2014) provides the following additional tips on deciding which HGM Units are relevant:

- **No clear HGM type:** if you encounter a situation where a wetland does not fit into one of the above categories, you should select the HGM Unit that has hydrological and geomorphological characteristics that most closely resemble those of your system. Looking at the landscape setting can help in identifying the most appropriate HGM Unit because certain HGM Units are more likely to occur in particular landscape settings than they are in others (see Table 32).
- **More than one HGM Unit in a wetland:** It may also be that you need to split your wetland into more than one HGM Unit.
- **Too many HGM Units in a wetland:** On the other hand, you will also run into problems if you try to split an aquatic ecosystem into too many HGM Units. It is very important that the entire HGM Unit is classified and considered as a single entity. For example, if an endorheic depression consists of an unvegetated central portion that is permanently inundated with open water and a seasonally saturated outer margin that is vegetated, the entire wetland (i.e. the open-water central portion and the vegetated outer margin, together) is classified as a single HGM Unit, namely a ‘depression (endorheic)’.
- **Alluvial fans:** alluvial fans do not clearly fall into any of the HGM Types. In order to classify a particular alluvial fan correctly, you would need to know the landscape settings of the different portions of the fan and you would need to gain an understanding of how water and sediment is likely to be moving into, through and out of the system.
- **Wetland on the gentle toe-slope that feed a river on the valley floor:** is difficult to classify are wetlands on the gentle toe-slope that feed into a river running along a valley floor. If

- there is a distinct slope along which there is likely to be a unidirectional (diffuse) flow of water and the valley floor along which the adjacent river is flowing is very narrow – then it would probably be most appropriate to classify the wetland as a ‘seep’;
- the valley floor had been wider and/or the slope of the wetland was gentler, in which case the wetland would more than likely be fed by the river during high flows – then it would then have been more appropriate to classify the wetland as a ‘channelled valley-bottom wetland’.

Table 32: Summary description of the six HGM types described by Ollis et al. (2014), including the features and diagram of the components of the HGM type

Wetland HGM Type	Components of the HGM Type
Floodplain wetland—a wetland area which can be found mostly on a flat or gently-sloping piece of land adjacent to and formed by an alluvial river channel under its present climate and sediment load. Floodplain wetlands contain several key features: (i) a depositional surface formed by an alluvial river[9], (ii) formed under the current climate and sediment load. (iii) flat surfaces may be present along the margins of a river from previous eras of differing climate and/or sediment load, and these surfaces are called terraces. Terraces are generally not currently being generated by river depositional processes. (iv) flooded (or inundated), during moderate peak flow events (such as a 1.5-year or 2-year flood).	

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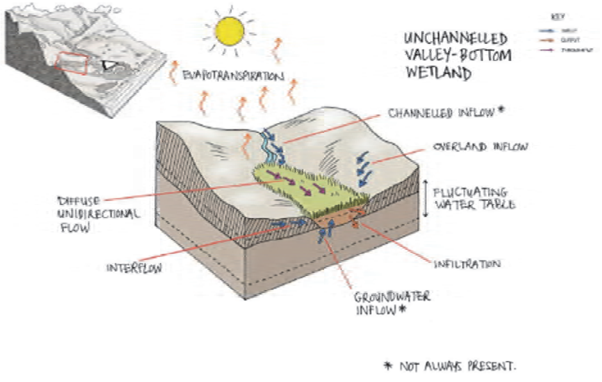
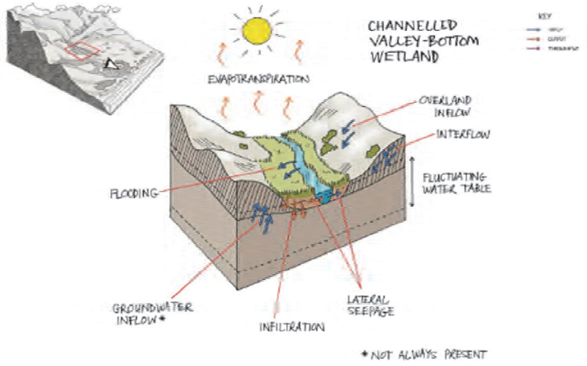
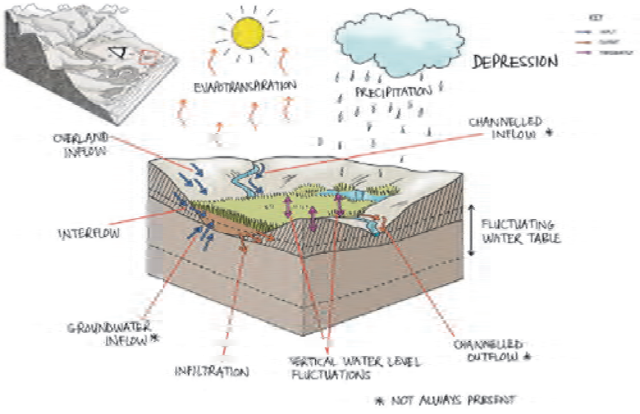
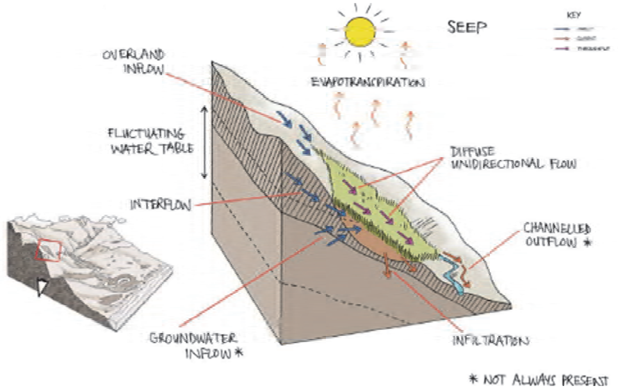
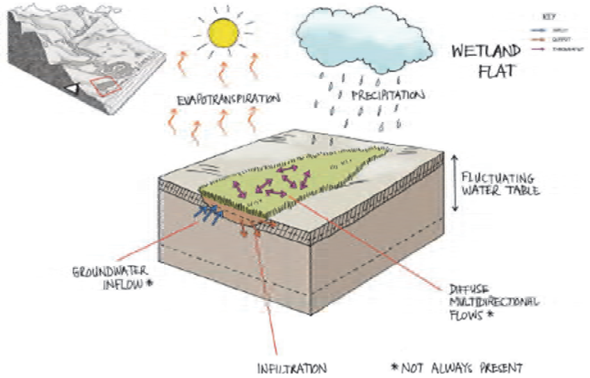
[9] Alluvial river channels are self-formed features, meaning that they are shaped by the magnitude and frequency of the floods that they experience, and the ability of these floods to erode, deposit, and transport sediment. Alluvial channels are, therefore, formed in material that is able to move during moderate floods. This means that the bed and banks of an alluvial river channel are characteristically made up of unconsolidated mobile sediments such as silt, sand or gravel, or (in some cases) cobbles and small boulders. Alluvial river channels tend to erode their banks and deposit the eroded material on bars and on their floodplains.

Wetland HGM Type	Components of the HGM Type
Unchannelled valley-bottom wetland—a valley-bottom wetland without a river channel running through it. Unchannelled valley-bottom wetlands are characterised by (i) their location on valley floors, (ii) an absence of distinct channel banks, and the prevalence of diffuse flows. (iii) Water typically comes from an upstream channel that becomes dominated by diffuse (surface and subsurface) flow as it enters the wetland, with seepage from adjacent slopes. There may also be groundwater input into the wetland. (iv) Water characteristically moves through the wetland in the form of diffuse surface or subsurface flow, but the outflow may be in the form of either diffuse or concentrated surface flow. (v) Infiltration and evapotranspiration from unchannelled valley-bottom wetlands can be significant, but horizontal, unidirectional, diffuse surface flow tends to dominate these wetland systems.	
Channelled valley-bottom wetland—a valley-bottom wetland with a river channel running through it. Channelled valley-bottom wetlands must be considered as wetland ecosystems that are distinct from, but sometimes associated with, the adjacent river channel itself, which must be classified as a 'river' Channelled valley-bottom wetlands are characterised by: (i) their location on valley floors, (ii) the absence of characteristic floodplain features and (iii) the presence of a river channel flowing through the wetland.	

Wetland HGM Type	Components of the HGM Type
Depression—a wetland with closed (or near-closed) elevation contours, which increases in depth from the perimeter to a central area of greatest depth and within which water typically accumulates. Although they may at times have a river flowing into or out of them, depressions are especially characterised by their closed (or at least near-closed) contour shape, which makes them relatively easy to identify on topographic maps. Depressions can be classified as: (i) 'exorheic' (i.e. outward-draining) (ii) 'endorheic' (i.e. inward-draining) (iii) artificially regulated outflow drainage = 'dammed'. In addition, the outflow drainage can be categorised as 'unknown'. The characterisation of the inflow characteristics of a depression is important in understanding the functioning of this type of aquatic ecosystem, and in their management. Depressions can be further subdivided on the basis of their inflows drainage characteristics, into: (i) 'with channelled inflow' (ii) 'without channelled inflow'. Concentrated overland flow is typically a major source of water for depressions with channelled inflow, whereas this is not the case for depressions without channelled inflow, which tend to be fed primarily by interflow and/or groundwater. Depressions may be flat-bottomed (in which case they are often referred to as pans) or round-bottomed and may have any combination of inlets and outlets or lack them completely.	
Seep—a wetland area located on gently to steeply sloping land and dominated by colluvial (i.e. gravity-driven), unidirectional movement of water and material down-slope. Seeps have the following characteristics: (i) often located on the side-slopes of a valley but they do not, typically, extend onto a valley floor; (ii) water enters primarily via subsurface flows from an up-slope direction; (iii) water movement through the seep is mainly in the form of interflow, with diffuse overland flow (known as sheetwash) often being significant during and after rainfall events; (iv) associated with geological formations (lithologies) and topographic positions that cause either groundwater to discharge to the land surface or rain-derived water to 'seep' down-slope as subsurface interflow; (v) can also be categorised into those 'with channelled outflow' and those 'without channelled outflow' It is important to bear in mind that seeps can occur in relatively flat or very gently-sloping landscapes, as long as there is sufficient slope for there to be a unidirectional subsurface flow of water.	
Wetland flat—a level or near-level wetland area that is not fed by water from a river channel, and which is typically situated on a plain or a bench. Closed elevation contours are not evident around the edge of a wetland flat. The primary source of water for a wetland flat is precipitation, with the exception of wetland flats situated on a coastal plain where groundwater may rise to or near the ground surface. Dominant hydrodynamics in wetland	

Wetland HGM Type	Components of the HGM Type
flats are bidirectional vertical fluctuations, with weakly developed multidirectional horizontal water flows present in some cases, Water typically leaves a wetland flat through evapotranspiration and infiltration. Wetland flats are characterised by vertical water movements associated with precipitation, groundwater inflow, infiltration and evapotranspiration. Horizontal water movements within these wetlands, if present, are multi-directional, due to the lack of any significant change in gradient within the wetland.	

If you are struggling to identify the most appropriate HGM Unit, you may need to obtain more information about the system before being able to proceed with the wetland typing.

Wetland type at a desktop level can only be done with relatively low confidence (Ollis et al., 2014). This step in the NWMP has the purpose of ground-truthing the HGM typing of the prioritised wetland.

Using Figure 30, confirm the HGM units which can be found in the prioritised wetlands (For more details of each HGM type refer to Ollis et al., 2014). Verify the results of your confirmation using Table 32 and on the provided map.

Being a rapid assessment, there will not be time to examine the entire HGM unit thoroughly in the field. Instead, specific parts of the HGM unit need to be identified for particular attention. The map of the wetland extent and the stratification of the wetland into individual HGM units serve as useful guides in directing the focus of the field examination (Macfarlane, 2009).

Key 2: HGM Unit (Level 4)

LEVEL 4A (HGM type)

1. Is the Inland System of a linear landform with clearly discernable bed and banks, which permanently or periodically carries a **concentrated** flow of water?

a) YES .... **River** [see Section 5.1] (go to **Level 4B*** or to **Key 3a**: River Flow Type)

b) NO .... (go to **2**)

2. Is the Inland System a **wetland** (or, in some cases, an **open waterbody**), which is situated adjacent or close to a distinct **active channel** of a **river** <u>and</u> likely to be subject to water input from periodic (intermittent to seasonal) overtopping of the **channel** banks?

a) YES .... (go to **3**)

b) NO .... (go to **4**)

3. Is the **wetland** (or **open waterbody**) located on a **valley floor** <u>and</u> likely to receive water via (surface and subsurface) runoff from one or both of the adjacent valley side-slopes, with an <u>absence</u> of river-derived depositional features that are characteristic of a **floodplain** (such as levees)?

a) YES .... **Channelled valley-bottom wetland** [see Section 5.3.1] (go to **Key 3b**: Hydroperiod Category)

b) NO .... **Floodplain wetland** [see Section 5.2] (go to **8** or to **Key 3b**: Hydroperiod Category)

4. Is the Inland System a **wetland** (typically **vegetated**) <u>without</u> clearly discernable **channel** banks, which is characterised by a permanent <u>or</u> periodic, **diffuse**, unidirectional through-flow of water (often dominated by subsurface flow)?

a) YES .... (go to **5**)

b) NO .... (go to **6**)

5. Is the **wetland** located on a **valley floor**?

a) YES .... **Unchannelled valley-bottom wetland** [see Section 5.3.2] (go to **Key 3b**: Hydroperiod Category)

b) NO .... **Seep** [see Section 5.5] (go to **9** or to **Key 3b**: Hydroperiod Category)

6. Is the Inland System a **wetland** <u>or</u> **open waterbody** with closed (or near-closed) elevation contours that increases in depth from the perimeter to a central area of greatest depth, and within which water typically accumulates?

a) YES .... **Depression** [see Section 5.4] (go to **10** or to **Key 3b**: Hydroperiod Category)

b) NO .... (go to **7**)

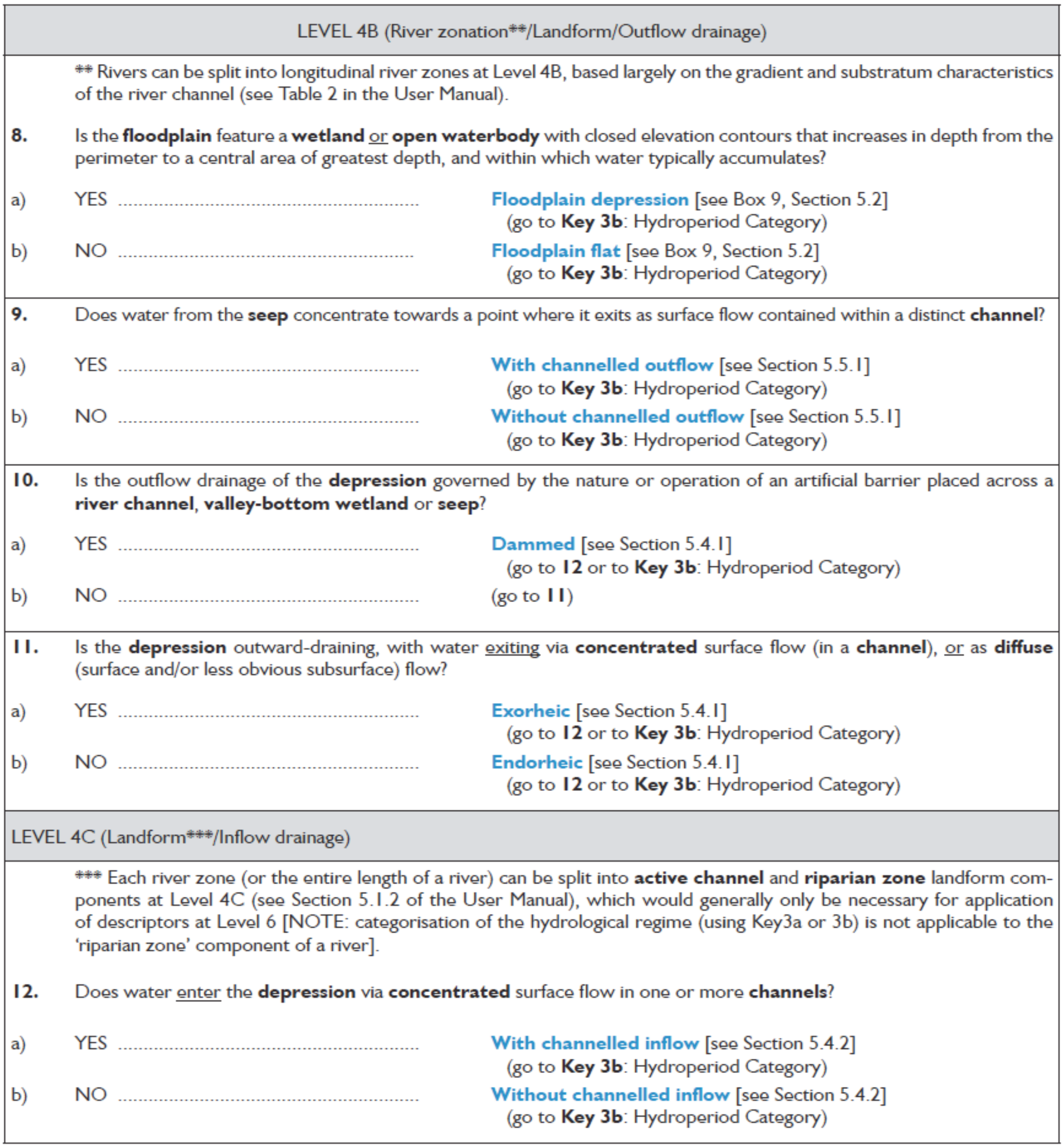
7. Is the Inland System a level or near-level **wetland** that is <u>not</u> fed by water from a **river channel**, typically located on a **plain** or a **bench**, and which is dominated by vertical water movements (horizontal water movements are very weak and multi-directional, if present at all)?

a) YES .... **Wetland flat** [see Section 5.6] (go to **Key 3b**: Hydroperiod Category)

b) NO .... (go back to **1**)

---

* A **river** can be split into longitudinal **river zones** at Level 4B (using Table 2 on p. 22 of the User Manual), each of which can be categorised separately in terms of river flow type (using Key 3a), if necessary. At Level 4C, each longitudinal zone can be split into the **active channel** and **riparian zone** components of the river, for the application of descriptors at Level 6.



LEVEL 4B (River zonation**/Landform/Outflow drainage)

** Rivers can be split into longitudinal river zones at Level 4B, based largely on the gradient and substratum characteristics of the river channel (see Table 2 in the User Manual).

8. Is the **floodplain** feature a **wetland** or **open waterbody** with closed elevation contours that increases in depth from the perimeter to a central area of greatest depth, and within which water typically accumulates?

a) YES .... **Floodplain depression** [see Box 9, Section 5.2] (go to **Key 3b**: Hydroperiod Category)

b) NO .... **Floodplain flat** [see Box 9, Section 5.2] (go to **Key 3b**: Hydroperiod Category)

9. Does water from the **seep** concentrate towards a point where it exits as surface flow contained within a distinct **channel**?

a) YES .... **With channelled outflow** [see Section 5.5.1] (go to **Key 3b**: Hydroperiod Category)

b) NO .... **Without channelled outflow** [see Section 5.5.1] (go to **Key 3b**: Hydroperiod Category)

10. Is the outflow drainage of the **depression** governed by the nature or operation of an artificial barrier placed across a **river channel**, **valley-bottom wetland** or **seep**?

a) YES .... **Dammed** [see Section 5.4.1] (go to **12** or to **Key 3b**: Hydroperiod Category)

b) NO .... (go to **11**)

11. Is the **depression** outward-draining, with water exiting via **concentrated** surface flow (in a **channel**), or as **diffuse** (surface and/or less obvious subsurface) flow?

a) YES .... **Exorheic** [see Section 5.4.1] (go to **12** or to **Key 3b**: Hydroperiod Category)

b) NO .... **Endorheic** [see Section 5.4.1] (go to **12** or to **Key 3b**: Hydroperiod Category)

LEVEL 4C (Landform***/Inflow drainage)

*** Each river zone (or the entire length of a river) can be split into **active channel** and **riparian zone** landform components at Level 4C (see Section 5.1.2 of the User Manual), which would generally only be necessary for application of descriptors at Level 6 [NOTE: categorisation of the hydrological regime (using Key3a or 3b) is not applicable to the 'riparian zone' component of a river].

12. Does water enter the **depression** via **concentrated** surface flow in one or more **channels**?

a) YES .... **With channelled inflow** [see Section 5.4.2] (go to **Key 3b**: Hydroperiod Category)

b) NO .... **Without channelled inflow** [see Section 5.4.2] (go to **Key 3b**: Hydroperiod Category)

Figure 30: Hydrogeomorphic Unit (Level 4) (taken from Ollis et al., 2014 page 115).

On return to the office, complete Section 6.3.3-Step 2.2 of this document to capture the relevant data.

9.2.4 Step 2.3: Complete the Attributes Datasheet for the Wetland

Using the pre-population attributes datasheets from Step 1.1, fill in the missing datasets and verify the data you inserted in the office.

On return to the office, complete Section 6.3.4-Step 2.3 of this document to capture the relevant data.

9.2.5 Step 2.4: Assessment Indicators

The purpose of this step is to collect the data to report the eight indicators of the wetlands condition.

Step 2.4.1: Ascertain the reference condition

The purpose of this step is to determine the reference condition for the wetland.

Table 33 provides a list of criteria that should be considered in ascertaining the natural reference condition of a wetland.

Table 33: Description of perceived natural reference state of the wetland assessment unit (taken from Ollis et al., 2014)

Aspect	**Perceived natural reference state***	**Confidence**	**OPTIONAL: Current state**	**Confidence**
WETLAND TYPE				
HGM type				
HYDROLOGY				
Inundation hydroperiod				
Permanently inundated				
Seasonally inundated				
Intermittently inundated				
Never/rarely inundated				
Maximum depth of inundation				
Saturation hydroperiod				
Permanently saturated				
Seasonally saturated				
Intermittently saturated				
Dominant water inputs (top 2 or 3)				
Dominant water outflows (top 2 or 3)				

Aspect	Perceived natural reference state*	Confidence	OPTIONAL: Current state	Confidence
GEOMORPHOLOGY				
Dominant substratum type (surface)				
Bedrock				
Boulders				
Cobbles				
Pebbles/gravel				
Sandy soil				
Silt (mud)				
Clayey soil				
Loamy soil				
Organic soil / peat				
Salt crust				
Other				
Dominant substratum type (subsoil)				
Bedrock				
Boulders				
Cobbles				
Pebbles/gravel				
Sandy soil				
Silt (mud)				
Clayey soil				
Loamy soil				
Organic soil / peat				
Other				
Erosional features (describe below)				
Depositional features (describe below)				
VEGETATION				
Approximate aerial cover (by vegetation)				
Dominant vegetation cover type				
Unvegetated (bare ground)				
Aquatic vegetation				
Shrubs/Thicket				
Forested wetland (swamp forest)				
Herbaceous: geophytes				
Herbaceous: grasses				
Herbaceous: herbs/forbs				
Herbaceous: sedges/rushes				
Herbaceous: reeds				
Herbaceous: restios				
Herbaceous: palmiet				
NFEPA WetVeg Group	<look up on relevant NFEPA map and	n/	<look up on relevant NFEPA map and	n/

Aspect	**Perceived natural reference state***	**Confidence**	**OPTIONAL: Current state**	**Confidence**
	enter info here>	a	enter info here>	a
Exposure to fires/burning				
Exposure to grazing/trampling by animals				
WATER QUALITY				
Salinity				
pH				
Turbidity/TSS				
Trophic status (nutrient levels)				
Algal growth				
Water colour				
GENERAL	<enter written description below>		<enter written description below>	
Short written description of characteristic features of the wetland assessment unit				

On return to the office, complete Section 6.3.5-Step 2.4,1 of this document to capture the relevant data.

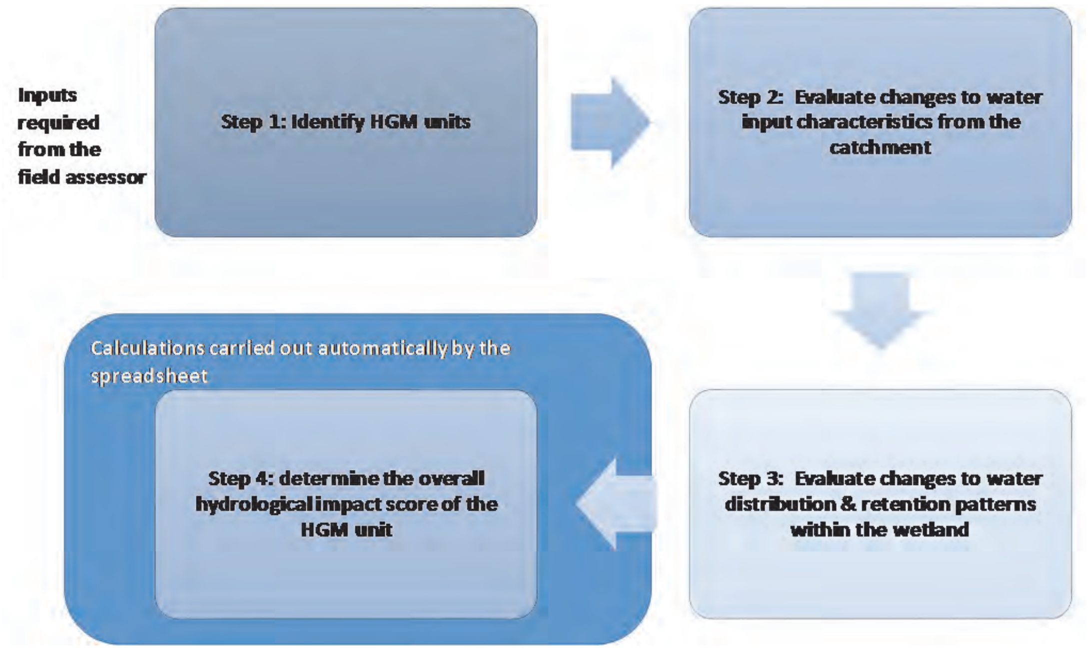
Step 2.4.3: Tools for Collecting Data for the Present Hydrological State of a Wetland

This indicator reports the present hydrological state of an assessed wetland. The hydrology of the wetland is the the distribution and movement of water through a wetland and its soils.

The overall approach to rapidly determining a present hydrological state category for the prioritised wetland is to use the IHI (see Section 9.2.6 for tools) or Wet-Health Level 1 assessment methods. The WET-Health (Level 1) **or** Wetland IHI score-sheets can be used for *floodplain and channelled valley-bottom wetlands*, whereas **only** the WET-Health (Level 1) score-sheet is applicable in determining the present hydrological state of *unchannelled valley bottom wetlands and seeps* (Ollis et al., 2014b). In the case of the *depressions and wetland flats*, **neither** WET-Health nor Wetland IHI is applicable for estimating the present hydrological state of the wetland. NOTE that, for the sake of consistency and repeatability, *the same* tool (WET-Health or the IHI) should be used in all the wetlands being assessed.

Table 34 is the field guide that can be taken into the field to capture the data required to report the Present Hydrological State of the prioritised wetland.

Steps to ensure all the relevant hydrological data are collected during the wetland assessment:



How to collect the data:

- **Step 1:** ensure the HGM type(s) has been ascertained
- **Step 2:** In this step, estimate the extent of the catchment of each of the HGM units and land-use activities **upstream or upslope** of the HGM unit being examined. The wetland catchment refers to the area up-slope of the wetland from which water flows into the wetland (Kotze et al., 2015). Using the descriptions in column 4 of Table 34, assign the alteration class score of the impacts. Enter the score into column 3 of Table 34.

Table 34: Wet-Health Level 1 Field Guide to capturing the data to report the present hydrological state of the prioritised wetland. The table provides a 'guideline' in column 4 (choose class score from this list) for selecting an Alteration Class Score for column 3 (taken from Ollis et al., 2014)

Nature of Alteration	Intensity rating guidelines	Alteration Class Score	Taken from Ollis et al. (2014)	Land-use factors contributing to impacts, and any additional notes	Confidence rating
Reduction in flows (water inputs)	Table 5.1				
Increase in flows (water inputs)	Table 5.1				
Combined impact Score		**0**			
Change in flood patterns (peaks)	Table 5.2				

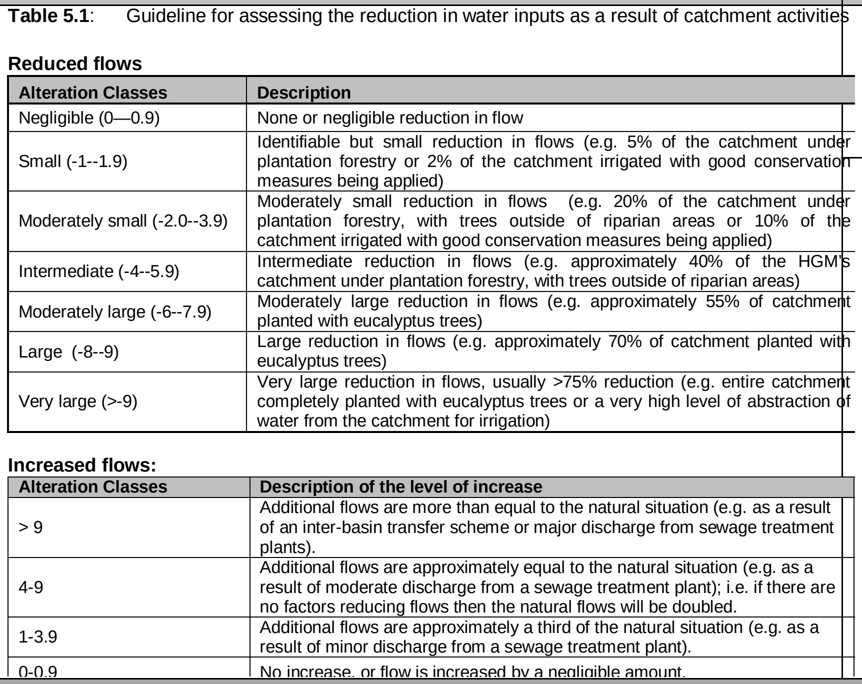


Table 5.1: Guideline for assessing the reduction in water inputs as a result of catchment activities

Reduced flows

Alteration Classes	Description
Negligible (0—0.9)	None or negligible reduction in flow
Small (-1--1.9)	Identifiable but small reduction in flows (e.g. 5% of the catchment under plantation forestry or 2% of the catchment irrigated with good conservation measures being applied)
Moderately small (-2.0--3.9)	Moderately small reduction in flows (e.g. 20% of the catchment under plantation forestry, with trees outside of riparian areas or 10% of the catchment irrigated with good conservation measures being applied)
Intermediate (-4--5.9)	Intermediate reduction in flows (e.g. approximately 40% of the HGM's catchment under plantation forestry, with trees outside of riparian areas)
Moderately large (-6--7.9)	Moderately large reduction in flows (e.g. approximately 55% of catchment planted with eucalyptus trees)
Large (-8--9)	Large reduction in flows (e.g. approximately 70% of catchment planted with eucalyptus trees)
Very large (>-9)	Very large reduction in flows, usually >75% reduction (e.g. entire catchment completely planted with eucalyptus trees or a very high level of abstraction of water from the catchment for irrigation)

Increased flows:

Alteration Classes	Description of the level of increase
> 9	Additional flows are more than equal to the natural situation (e.g. as a result of an inter-basin transfer scheme or major discharge from sewage treatment plants).
4-9	Additional flows are approximately equal to the natural situation (e.g. as a result of moderate discharge from a sewage treatment plant); i.e. if there are no factors reducing flows then the natural flows will be doubled.
1-3.9	Additional flows are approximately a third of the natural situation (e.g. as a result of minor discharge from a sewage treatment plant).
0-0.9	No increase, or flow is increased by a negligible amount.

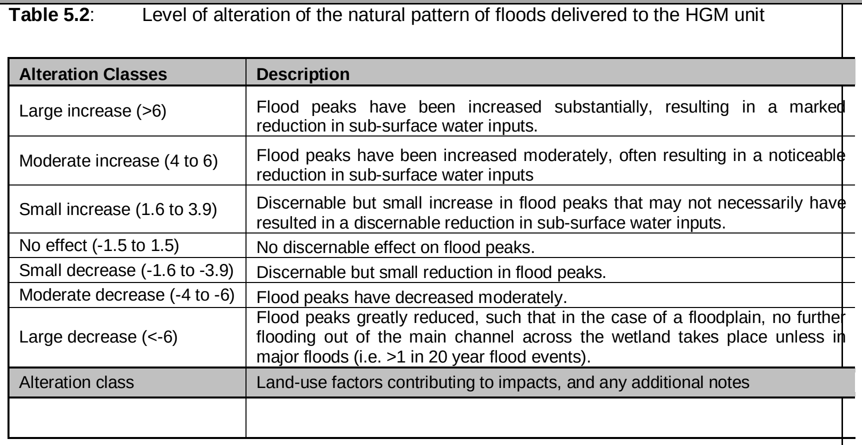


Table 5.2: Level of alteration of the natural pattern of floods delivered to the HGM unit

Alteration Classes	Description
Large increase (>6)	Flood peaks have been increased substantially, resulting in a marked reduction in sub-surface water inputs.
Moderate increase (4 to 6)	Flood peaks have been increased moderately, often resulting in a noticeable reduction in sub-surface water inputs
Small increase (1.6 to 3.9)	Discernable but small increase in flood peaks that may not necessarily have resulted in a discernable reduction in sub-surface water inputs.
No effect (-1.5 to 1.5)	No discernable effect on flood peaks.
Small decrease (-1.6 to -3.9)	Discernable but small reduction in flood peaks.
Moderate decrease (-4 to -6)	Flood peaks have decreased moderately.
Large decrease (<-6)	Flood peaks greatly reduced, such that in the case of a floodplain, no further flooding out of the main channel across the wetland takes place unless in major floods (i.e. >1 in 20 year flood events).
Alteration class	Land-use factors contributing to impacts, and any additional notes

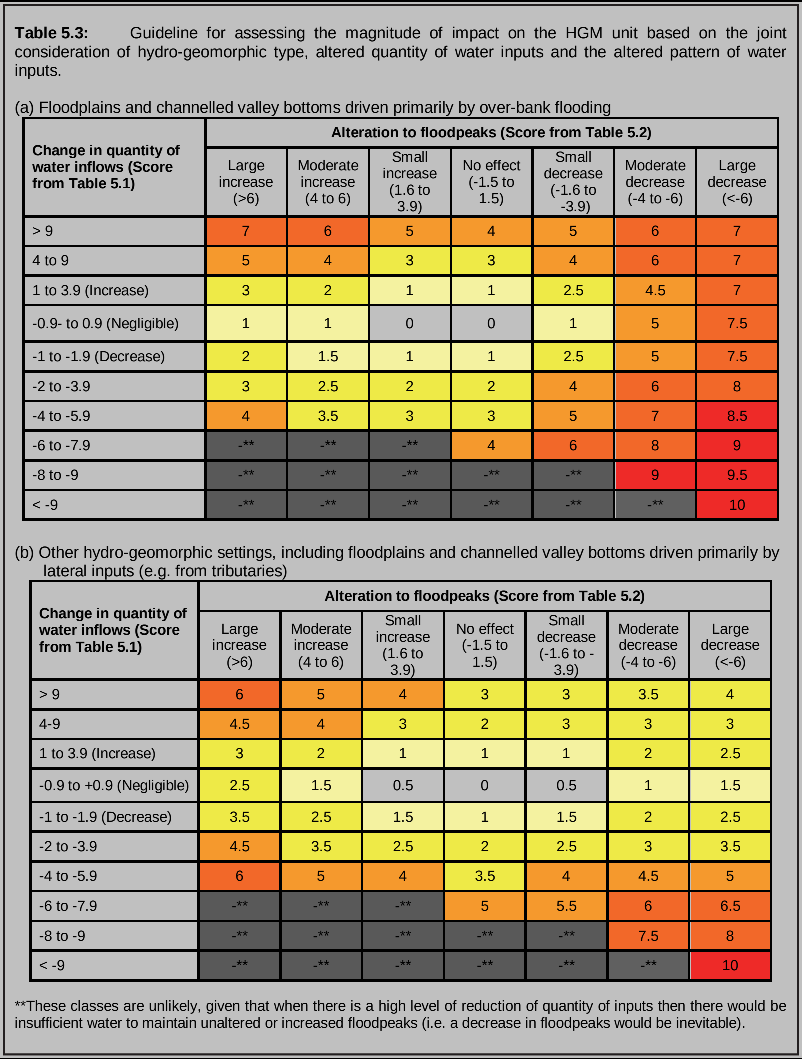
Nature of Alteration	Intensity rating guidelines	Alteration Class Score	Taken from Ollis et al. (2014)	Land-use factors contributing to impacts, and any additional notes	Confidence rating
Magnitude of impact Score	Table 5.3			Note: Separate tables are provided for combining the scores for (a) floodplain and channelled valley bottom wetlands and (b) other HGM settings.	

Table 5.3: Guideline for assessing the magnitude of impact on the HGM unit based on the joint consideration of hydro-geomorphic type, altered quantity of water inputs and the altered pattern of water inputs.

(a) Floodplains and channelled valley bottoms driven primarily by over-bank flooding

Change in quantity of water inflows (Score from Table 5.1)	**Alteration to floodpeaks (Score from Table 5.2)**						
	Large increase (>6)	Moderate increase (4 to 6)	Small increase (1.6 to 3.9)	No effect (-1.5 to 1.5)	Small decrease (-1.6 to -3.9)	Moderate decrease (-4 to -6)	Large decrease (<-6)
> 9	7	6	5	4	5	6	7
4 to 9	5	4	3	3	4	6	7
1 to 3.9 (Increase)	3	2	1	1	2.5	4.5	7
-0.9- to 0.9 (Negligible)	1	1	0	0	1	5	7.5
-1 to -1.9 (Decrease)	2	1.5	1	1	2.5	5	7.5
-2 to -3.9	3	2.5	2	2	4	6	8
-4 to -5.9	4	3.5	3	3	5	7	8.5
-6 to -7.9	-**	-**	-**	4	6	8	9
-8 to -9	-**	-**	-**	-**	-**	9	9.5
< -9	-**	-**	-**	-**	-**	-**	10

(b) Other hydro-geomorphic settings, including floodplains and channelled valley bottoms driven primarily by lateral inputs (e.g. from tributaries)

Change in quantity of water inflows (Score from Table 5.1)	**Alteration to floodpeaks (Score from Table 5.2)**						
	Large increase (>6)	Moderate increase (4 to 6)	Small increase (1.6 to 3.9)	No effect (-1.5 to 1.5)	Small decrease (-1.6 to -3.9)	Moderate decrease (-4 to -6)	Large decrease (<-6)
> 9	6	5	4	3	3	3.5	4
4-9	4.5	4	3	2	3	3	3
1 to 3.9 (Increase)	3	2	1	1	1	2	2.5
-0.9 to +0.9 (Negligible)	2.5	1.5	0.5	0	0.5	1	1.5
-1 to -1.9 (Decrease)	3.5	2.5	1.5	1	1.5	2	2.5
-2 to -3.9	4.5	3.5	2.5	2	2.5	3	3.5
-4 to -5.9	6	5	4	3.5	4	4.5	5
-6 to -7.9	-**	-**	-**	5	5.5	6	6.5
-8 to -9	-**	-**	-**	-**	-**	7.5	8
< -9	-**	-**	-**	-**	-**	-**	10

**These classes are unlikely, given that when there is a high level of reduction of quantity of inputs then there would be insufficient water to maintain unaltered or increased floodpeaks (i.e. a decrease in floodpeaks would be inevitable).

- **Step 3:** Evaluate changes to water distribution & retention patterns within the wetland. Within the wetland, estimate, using Table 35, the extent in hectares (column 3) affected by each activity, and assess the intensity of each activity in column 4.

Table 35: Within the wetland, estimate the extent in hectares (column 3) affected by each activity, and assess the intensity of each activity in column 4

<table>
<tr><th></th><th colspan="2">Intensity rating guidelines</th><th>Extent (%)[1]</th><th>Intensity (0-10)</th><th>Land-use factors contributing to impacts</th><th>Confidence rating</th></tr>
<tr><td>Gullies and artificial drainage channels</td><td>Table 5.5</td><td>

Table 5.5 Guideline for assessing the intensity of impact of erosion gullies and artificial drainage channels on the affected area of the HGM unit

<table>
<tr><th>Intensity of impact</th><th>Impact category description</th></tr>
<tr><td>None (0.5)</td><td>While drainage channels or gullies may be present, they are having no readily discernible impact on water distribution and retention (e.g. because they are completely blocked).</td></tr>
<tr><td>Small (1.5)</td><td>Although identifiable, the impact of drainage channels or gullies on water distribution and retention is small (e.g. because the drains are poorly intercepting flow and are very shallow)</td></tr>
<tr><td>Moderate (3)</td><td>The impact of drainage channels or gullies on water distribution and retention is moderate (e.g. owing to a moderate density and depth of drains and a gentle slope and fine texture of soil that limit the draining effect)</td></tr>
<tr><td>Large (5)</td><td>The impact of drainage channels or gullies on water distribution and retention is large (e.g. because the drain density is high but the moderate depth of the drains and/or the fine texture and gentle slope of the wetland prevent the impact from being serious or critical).</td></tr>
<tr><td>Serious (7)</td><td>The impact of drainage channels or gullies on water distribution and retention is serious (e.g. because the drains density is high, drains are deep and very effectively intercept flow through the wetland, but one or more features are present (e.g., fine texture of soil) that prevents the impact being critical).</td></tr>
<tr><td>Critical (9)</td><td>The impact of drainage channels or gullies on water distribution and retention is critical (e.g. because the drains density is high, drains are deep and very effectively intercepting flow through the wetland and no features are present which may be limiting the draining effect of the channels.</td></tr>
</table>

Factors affecting intensity of impact of artificial drainage channels include:

- Natural features of the site, including the lower the MAP: PET ratio, the steeper the wetland slope and the coarser the texture of the wetland soil, the greater the intensity of impact of any artificial drains present.
- Features of the drains, including: the deeper the drains, the denser the drains, the greater the flow interception by the drains, and the lower the obstructions in the drains, the greater the intensity of impact.
- See Section 2, Step 3A for further guidance if necessary.

</td><td></td><td></td><td></td><td></td></tr>
<tr><td>Modifications to existing channels</td><td>Table 5.6</td><td>

Table 5.6 Guideline for assessing the intensity of impact of modifications to an existing channel on the affected area of the HGM unit.

<table>
<tr><th>Intensity of impact</th><th>Impact category description</th></tr>
<tr><td>None (0.5)</td><td>No discernible modifications to the natural stream channel</td></tr>
<tr><td>Small (1.5)</td><td>Although identifiable, the impacts of any modifications to the natural stream channel are small (e.g. as a result of slight increase in cross sectional area, increase in length of stream or reduction in surface roughness of the channel)</td></tr>
<tr><td>Moderate (3)</td><td>Modifications to the natural stream channel have a moderate impact (e.g. as a result of an intermediate increase in cross sectional area or length of stream or an intermediate reduction in surface roughness of the channel; usually with a low to intermediate dependency of the HGM unit on bank overspill)</td></tr>
<tr><td>Large (5)</td><td>Modifications to the natural stream channel have a large impact (e.g. as a result of a moderately high increase in cross sectional area or length of stream or the largest possible reduction in surface roughness of the channel; usually with an intermediate to high dependency of the HGM unit on bank overspill)</td></tr>
<tr><td>Serious (7)</td><td>Modifications to the stream channel have a serious impact (usually a result of a combination of high modification to 2 or 3 of the factors or a considerable increase in cross sectional area) but some overtopping probably still occurs, although much less frequently than was the case naturally. There should be a high dependency of the HGM unit on bank overspill.</td></tr>
<tr><td>Critical (9)</td><td>Modifications to the natural stream channel have a critical impact (i.e., modifications are so great that no over-topping of the channel ever takes place; and with a high dependency of the HGM unit on bank overspill)</td></tr>
</table>

Factors affecting the intensity of impact of channel modifications include:

- Dependency of the HGM unit on bank overspill from the channel rather than from lateral inputs
- Extent to which bank overspill is reduced, which is determined by the following three factors given in order of importance: stream cross sectional area, stream length and surface roughness in the stream channel.
- See Section 2, Step 3A for further guidance if necessary.

</td><td></td><td></td><td></td><td></td></tr>
<tr><td>Reduced roughness</td><td>Table 5.7</td><td>

Table 5.7 Guideline for assessing the intensity of impact of altered surface roughness on the affected area of the HGM unit

<table>
<tr><th>Intensity of impact</th><th>Impact category description</th></tr>
<tr><td>None (0.5)</td><td>No readily discernible impact on surface roughness.</td></tr>
<tr><td>Small (1.5)</td><td>Although identifiable, the decrease in roughness is low (e.g. a change from robust sedges of intermediate height (0.5-1m) to short vegetation (e.g. rye grass) with only a minor impact on water retention.</td></tr>
<tr><td>Moderate (3)</td><td>The decrease in roughness is moderate (e.g. a change from tall, robust vegetation (e.g. phragmites reeds) to short vegetation resulting in a clear reduction in water retention.</td></tr>
<tr><td>Large (5)</td><td>The decrease in roughness is high (e.g. a change from tall very robust vegetation (e.g. dense swamp forest) to short vegetation resulting in a marked decrease in water retention.</td></tr>
</table>

- See Section 2, Step 3C for further guidance if necessary.

</td><td></td><td></td><td></td><td></td></tr>
</table>

<table>
<tr><th></th><th>Intensity rating guidelines</th><th>Extent (%)[1]</th><th>Intensity (0-10)</th><th>Land-use factors contributing to impacts</th><th>Confidence rating</th></tr>
<tr><td>Impeding features (e.g. dams) – upstream effects</td><td>Table 5.8</td><td>

Table 5.8 Guideline for assessing the intensity of impact of flow-impeding structures on the affected (flooded) area upstream of the impeding feature.

<table>
<tr><th>Intensity of impact</th><th>Impact category description</th></tr>
<tr><td>None
(0.5)</td><td>No readily discernible impact on water distribution and retention (e.g. because many culverts present to allow free flow of water)</td></tr>
<tr><td>Small
(1.5)</td><td>Discernable but small increase in saturation from flooding with seasonal and permanent zones both present and collectively >30% in the flooded area prior to modification.</td></tr>
<tr><td>Moderate
(3)</td><td>Moderate increase in saturation from flooding with permanent and seasonal zones both present but collectively <30% in the flooded area prior to modification.</td></tr>
<tr><td>Large
(5)</td><td>Large change in saturation associated with areas where seasonal zone is present but the permanent zone was absent prior to flooding.</td></tr>
<tr><td>Serious
(7)</td><td>Serious change in saturation associated with wetland areas of temporary wetness i.e. permanent and seasonal zones were lacking prior to flooding.</td></tr>
</table>
</td><td></td><td></td><td></td></tr>
<tr><td>Impeding features – downstream effects</td><td>Table 5.9</td><td>

Table 5.9 Guideline for assessing the intensity of impact of flow-impeding structures on the affected area downstream of the impeding feature.

<table>
<tr><th>Intensity of impact</th><th>Impact category description</th></tr>
<tr><td>None
(0.5)</td><td>No readily discernible impact on water distribution and retention (e.g. because many culverts present to allow free flow of water). Saturation levels remain largely unaltered.</td></tr>
<tr><td>Small
(1.5)</td><td>Discernable reduction in saturation, but impact is small (e.g. the volume of storage upstream of feature is small relative to MAR and no abstraction takes place from the stored water).</td></tr>
<tr><td>Moderate
(3)</td><td>Reduction in flow and saturation is moderate (e.g. the volume of storage upstream of the impeding feature is moderate relative to MAR and low abstraction takes place from the stored water).</td></tr>
<tr><td>Large
(5)</td><td>Reduction in flow and saturation is large (e.g. the volume of storage upstream of impeding feature is large relative to MAR and moderate abstraction takes place from the stored water)</td></tr>
<tr><td>Serious
(7)</td><td>Reduction in flow and saturation is serious (e.g. the volume of storage upstream of impeding feature is large relative to MAR and high abstraction takes place from the stored water). This results in considerable desiccation of the downstream wetland area.</td></tr>
</table>
</td><td></td><td></td><td></td></tr>
<tr><td>Increased on-site water use</td><td>Table 5.10</td><td>

Table 5.10 Guideline for assessing the intensity of impact of direct water losses[1] on the affected area of the HGM unit

<table>
<tr><th>Intensity of impact</th><th>Impact category description</th></tr>
<tr><td>None
(0.5)</td><td>Although there may be a change from the natural vegetation, there is no discernable impact.</td></tr>
<tr><td>Small
(1.5)</td><td>Although identifiable, only minor desiccation occurs (e.g. because plants with a moderately higher water use than the natural vegetation have been introduced into the affected area of the HGM).</td></tr>
<tr><td>Moderate
(3)</td><td>The impact causes moderate change in wetness regimes in the affected area (e.g. because plants with a moderately higher water use than the natural vegetation dominate the affected area of the HGM unit).</td></tr>
<tr><td>Large
(5)</td><td>The impact causes significant change in wetness regimes in the affected area (e.g. because plants with a much higher water use than the natural vegetation occur extensively in affected area of the HGM unit, but do not completely dominate the unit, or water abstraction from the unit is moderately high).</td></tr>
<tr><td>Serious
(7)</td><td>The impact causes a major change in wetness regimes in the affected area (e.g. because plants with a much higher water use than the natural vegetation dominate the affected area or water abstraction from the affected area of the unit is very high).</td></tr>
</table>

[1] This excludes direct losses from evaporation from a dam, which would be covered under the impacts from impeding features (Table 5.8)
</td><td></td><td></td><td></td></tr>
</table>

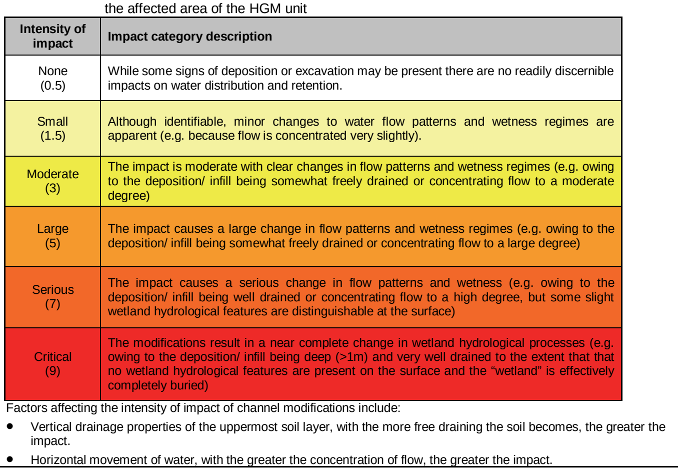
	Intensity rating guidelines	Extent (%)[1]	Intensity (0-10)	Land-use factors contributing to impacts	Confidence rating
Deposition/infilling or excavation	Table 5.11 				
	Combined impact Score [3]				

Table 5.11 Guideline for assessing the intensity of impact of recent deposition/infilling or excavation on the affected area of the HGM unit

Intensity of impact	Impact category description
None (0.5)	While some signs of deposition or excavation may be present there are no readily discernible impacts on water distribution and retention.
Small (1.5)	Although identifiable, minor changes to water flow patterns and wetness regimes are apparent (e.g. because flow is concentrated very slightly).
Moderate (3)	The impact is moderate with clear changes in flow patterns and wetness regimes (e.g. owing to the deposition/ infill being somewhat freely drained or concentrating flow to a moderate degree)
Large (5)	The impact causes a large change in flow patterns and wetness regimes (e.g. owing to the deposition/ infill being somewhat freely drained or concentrating flow to a large degree)
Serious (7)	The impact causes a serious change in flow patterns and wetness (e.g. owing to the deposition/ infill being well drained or concentrating flow to a high degree, but some slight wetland hydrological features are distinguishable at the surface)
Critical (9)	The modifications result in a near complete change in wetland hydrological processes (e.g. owing to the deposition/ infill being deep (>1m) and very well drained to the extent that that no wetland hydrological features are present on the surface and the "wetland" is effectively completely buried)

Factors affecting the intensity of impact of channel modifications include:

- Vertical drainage properties of the uppermost soil layer, with the more free draining the soil becomes, the greater the impact.
- Horizontal movement of water, with the greater the concentration of flow, the greater the impact.

v) **Step 4:** determine the overall hydrological impact score of the HGM unit. On returning to the office, the DSP tool should be used to capture the data collected in Tables 34 and 35 and the present hydrological state score will automatically be calculated for the wetland.

Follow the guide provided in Section 6.3.5, Step 2.4.2 to capture and report on this indicator.

Step 2.4.3: Tools for Collecting Data for the Present Geomorphology State of a Wetland

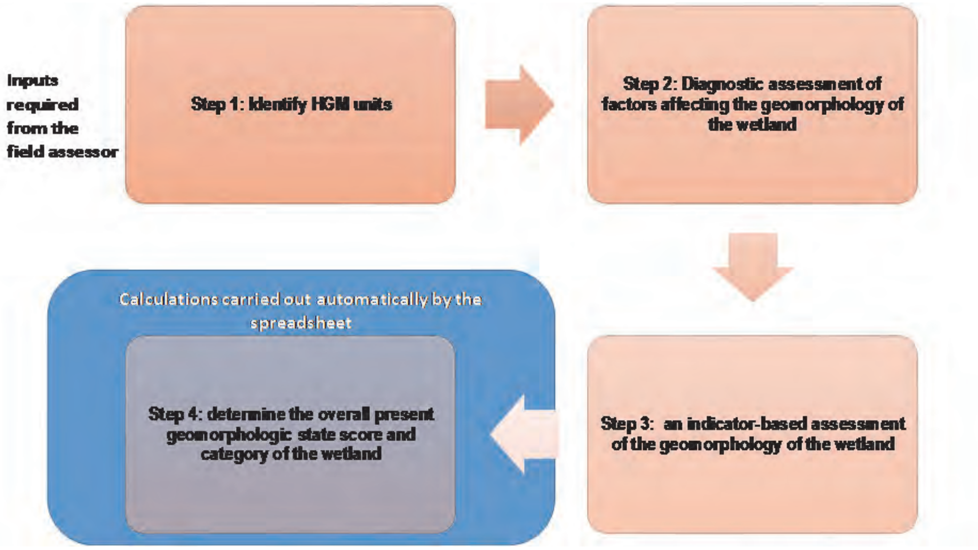
This indicator reports the present geomorphological state of the prioritised wetland.

The overall approach for rapid assessment of the present geomorphological state is to use the IHI (see Section 9.2.6 for tools) or Wet-Health Level 1 assessment methods. The WET-Health (Level 1) **or** Wetland IHI score-sheets can be used for *floodplain and channelled valley-bottom wetlands*, whereas **only** the WET-Health (Level 1) score-sheet is applicable in determining the present geomorphological state of *unchannelled valley bottom wetlands and seeps* (Ollis et al., 2014b). In the case of the *depressions and wetland flats*, **neither** WET-Health nor Wetland IHI is applicable to determine the present geomorphological state of the wetland (Ollis et al., 2014). NOTE that, for the sake of consistency and repeatability, *the same* tool (Wet-Health Level 1 or the IHI) should be used in all the wetlands being assessed.

Assessment of the geomorphological state of a wetland is conducted by carrying out a diagnostic assessment of factors affecting the geomorphology of the wetland (e.g. upstream dams, stream diversion/shortening, infilling and increased run-off) followed by an assessment of the state of geomorphology (e.g. erosional and depositional features and loss of organic matter).

Table 36 and 37 is the field guide that can be taken into the field to capture the data required to report the Present Geomorphological State of the prioritised wetland.

Steps to ensure all the relevant geomorphological data are collected during the wetland assessment:



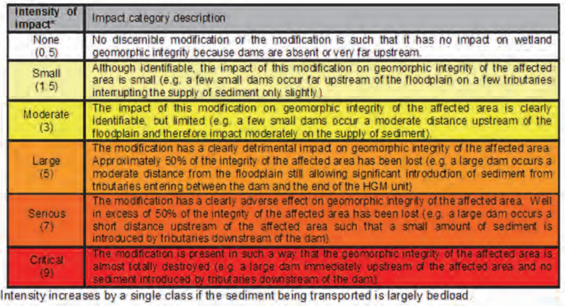
How to collect the data:

- **Step 1:** ensure the type and extent of HGM types have been identified for the wetland.
- **Step 2:** Diagnostic assessment of factors affecting the geomorphology of the wetland. Using the extent rating guideline shown in column 4 of Table 36, provide the extent (%) of each impact on the geomorphology of the wetland. Fill in this extent (%) in column 8. Using the intensity rating guidelines in column 5, score the intensity of each impact on the prioritised wetland and insert this score into column 4.
- **Step 3:** Indicator-based assessment of the geomorphology of the wetland. Using Table 37, provide the extent (%) of each impact on the geomorphology of the wetland. Fill in this extent (%)in column 5. Using the intensity rating guidelines in column 7, score the intensity of each impact on the prioritised wetland and insert this score into column 8.
- **Step 4:** estimate the overall present geomorphological state of the HGM unit. On returning to the office, use the DSP tool to capture the data collected in Table 36 and Table 37 to infer the score for present

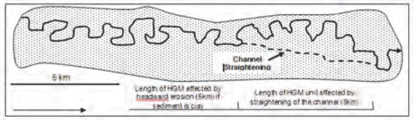
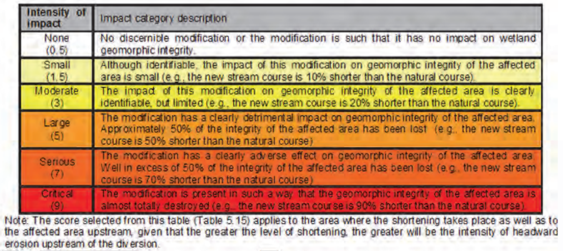
geomorphological state. This score and the category will automatically be calculated for the wetland, once the data are entered into the DSP tool.

Follow the guide provided in Section 6.3 Step 2.4.3 to capture and report on this indicator.

Table 36: Wet-Health Level 1 Field Guide to collect the data for the diagnostic assessment of the present geomorphic state of the prioritised wetland. (taken from Ollis et al., 2014)

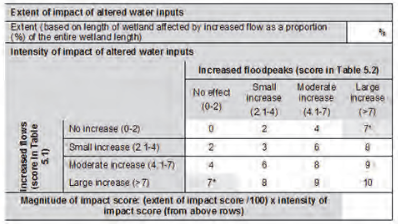
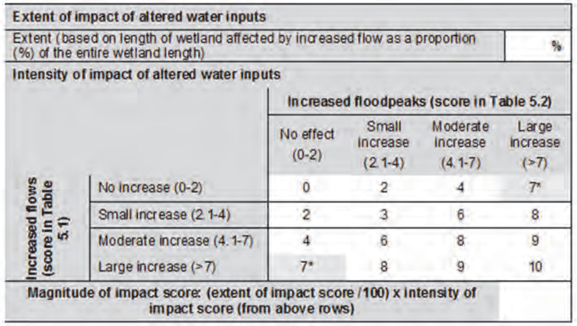
<table>
<tr><th>Impact type</th><th>Applicability to HGM type</th><th>Extent rating guidelines</th><th>Extent rating guidelines (Taken from Ollis et al., 2014b)</th><th>Extent (%)[1]</th><th>Intensity rating guidelines</th><th>Intensity rating guidelines</th><th>Intensity (0 - 10)</th><th>Land-use factors contributing to impacts, and any additional notes</th></tr>
<tr><td colspan="9">Diagnostic component</td></tr>
<tr><td>(1) Upstream dams</td><td>Floodplain</td><td>See next column</td><td>3 Extent is determined based upon the area of the HGM unit that is flooded (in the case of a dam in the HGM unit) and the area of the HGM unit area downstream of the dam (for a dam upstream of the HGM unit, this will be 100% of the HGM unit).</td><td></td><td>Table 5.14</td><td>

Intensity of impact*	Impact category description
None (0.5)	No discernible modification or the modification is such that it has no impact on wetland geomorphic integrity because dams are absent or very far upstream.
Small (1.5)	Although identifiable, the impact of this modification on geomorphic integrity of the affected area is small (e.g. a few small dams occur far upstream of the floodplain on a few tributaries interrupting the supply of sediment only slightly).
Moderate (3)	The impact of this modification on geomorphic integrity of the affected area is clearly identifiable, but limited (e.g. a few small dams occur a moderate distance upstream of the floodplain and therefore impact moderately on the supply of sediment).
Large (5)	The modification has a clearly detrimental impact on geomorphic integrity of the affected area. Approximately 50% of the integrity of the affected area has been lost (e.g. a large dam occurs a moderate distance from the floodplain still allowing significant introduction of sediment from tributaries entering between the dam and the end of the HGM unit)
Serious (7)	The modification has a clearly adverse effect on geomorphic integrity of the affected area. Well in excess of 50% of the integrity of the affected area has been lost (e.g. a large dam occurs a short distance upstream of the affected area such that a small amount of sediment is introduced by tributaries downstream of the dam).
Critical (9)	The modification is present in such a way that the geomorphic integrity of the affected area is almost totally destroyed (e.g. a large dam immediately upstream of the affected area and no sediment introduced by tributaries downstream of the dam).

* Intensity increases by a single class if the sediment being transported is largely bedload.
taken from Macfarlane et al. (2007)</td><td></td><td></td></tr>
<tr><td>(2) Stream diversion/ shortening</td><td>Floodplain, Channeled VB</td><td>See next column</td><td>4 Extent of area affected by stream straightening is expressed by measuring the length of the wetland affected by stream straightening and expressing this as a percentage of the overall length of the HGM unit. Extent of the wetland affected by stream diversions is determined based upon a distance upstream of the point of diversion along the channel of 20 km if the sediment is sandy and 5 km if it is clayey (or to the upstream end of the HGM unit if this is less than the specified distance). The specified distances are given based on the fact that headward erosion in the stream channel advances much more readily through sand than through clay. Assume that in the example given below the sediment was clayey, then the length of wetland affected by diversion and straightening would be 5 + 6 km, which, expressed as a proportion of the total length of the wetland, would be 11/17 km= 65%.

 </td><td></td><td>Table 5.15</td><td>

Intensity of impact	Impact category description
None (0.5)	No discernible modification or the modification is such that it has no impact on wetland geomorphic integrity.
Small (1.5)	Although identifiable, the impact of this modification on geomorphic integrity of the affected area is small (e.g., the new stream course is 10% shorter than the natural course).
Moderate (3)	The impact of this modification on geomorphic integrity of the affected area is clearly identifiable, but limited (e.g., the new stream course is 20% shorter than the natural course).
Large (5)	The modification has a clearly detrimental impact on geomorphic integrity of the affected area. Approximately 50% of the integrity of the affected area has been lost (e.g., the new stream course is 50% shorter than the natural course)
Serious (7)	The modification has a clearly adverse effect on geomorphic integrity of the affected area. Well in excess of 50% of the integrity of the affected area has been lost (e.g., the new stream course is 70% shorter than the natural course)
Critical (9)	The modification is present in such a way that the geomorphic integrity of the affected area is almost totally destroyed (e.g., the new stream course is 90% shorter than the natural course).

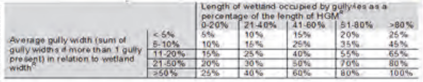
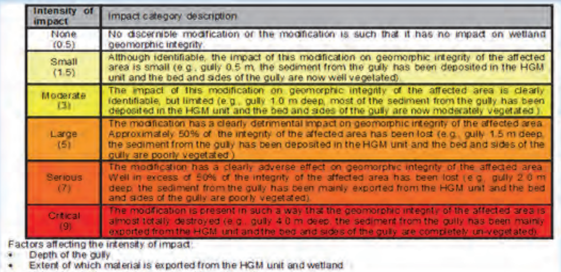
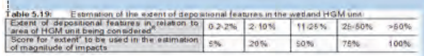
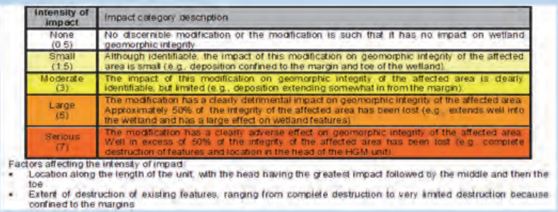
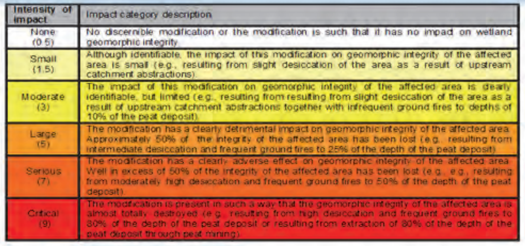
Note: The score selected from this table (Table 5.15) applies to the area where the shortening takes place as well as to the affected area upstream, given that the greater the level of shortening, the greater will be the intensity of headward erosion upstream of the diversion.
taken from Macfarlane et al. (2007)</td><td></td><td></td></tr>
</table>

Impact type	Applicability to HGM type	Extent rating guidelines	Extent rating guidelines (Taken from Ollis et al., 2014b)	Extent (%)[1]	Intensity rating guidelines	Intensity rating guidelines	Intensity (0 - 10)	Land-use factors contributing to impacts, and any additional notes
Diagnostic component								
(3) Infilling	Floodplain, Channeled VB	See next column	5 Extent of area affected by infilling is based on the following guideline: for a small stream (i.e., 1st to 2nd order stream), filled area + 1 km upstream and downstream, and for a large stream (i.e. > 3rd order) 2 km upstream and downstream. Intensity of impact is based on the extent to which flow is blocked by embankments given as a percentage of the HGM width, divided by 10 to give a score ranging from 0 to 10. For example, if embankments block flow across 1.4 km of an HGM unit that is 2 km wide (70% of width) then intensity of impact is 70÷10=7.		See below [5]	5 Extent of area affected by infilling is based on the following guideline: for a small stream (i.e., 1st to 2nd order stream), filled area + 1 km upstream and downstream, and for a large stream (i.e. > 3rd order) 2 km upstream and downstream. Intensity of impact is based on the extent to which flow is blocked by embankments given as a percentage of the HGM width, divided by 10 to give a score ranging from 0 to 10. For example, if embankments block flow across 1.4 km of an HGM unit that is 2 km wide (70% of width) then intensity of impact is 70÷10=7.		
(4) Increased runoff	Non-floodplain HGMs	Table 5.16			Table 5.16	 taken from Macfarlane et al. (2007)		

Extent of impact of altered water inputs

Extent (based on length of wetland affected by increased flow as a proportion (%) of the entire wetland length)					%
Intensity of impact of altered water inputs					
		Increased floodpeaks (score in Table 5.2)			
		No effect (0-2)	Small increase (2.1-4)	Moderate increase (4.1-7)	Large increase (>7)
Increased flows (score in Table 5.1)	No increase (0-2)	0	2	4	7*
	Small increase (2.1-4)	2	3	6	8
	Moderate increase (4.1-7)	4	6	8	9
	Large increase (>7)	7*	8	9	10
Magnitude of impact score: (extent of impact score /100) x intensity of impact score (from above rows)					

Table 37: Wet-Health Level 1 Field Guide to collect the data for the indicator-based assessment of the present geomorphic state of the prioritised wetland. (taken from Ollis et al., 2014)

Impact type	Applicability to HGM type	Extent rating guidelines	Extent rating guidelines (Taken from Ollis et al., 2014b)	Extent (%)[1]	Intensity rating guidelines	Intensity rating guidelines	Intensity (0 - 10)	Land-use factors contributing to impacts, and any additional notes
Indicator-based component								
(5) Erosional features	**All non-floodplain HGMs**	Table 5.17			**Table 5.18**	 **taken from Macfarlane et al. (2007)**		
(6) Depositional features	**All non-floodplain HGMs**	Table 5.19	**taken from Macfarlane et al. (2007)** 		**Table 5.20**	 **taken from Macfarlane et al. (2007)**		
(6) Loss of organic matter	**All non-floodplain HGMs with peat**	See next column	6 Extent of the area affected by organic matter reduction is based on the extent of peat subject to desiccation, ground fires or extraction, expressed as a percentage of the HGM unit.		**Table 5.21**	 **taken from Macfarlane et al. (2007)**		

		Length of wetland occupied by gully/ies as a percentage of the length of HGM[R]				
		0-20%	21-40%	41-60%	51-80%	>80%
Average gully width (sum of gully widths if more than 1 gully present) in relation to wetland width[R]	< 5%	5%	10%	15%	20%	25%
	5-10%	10%	15%	25%	35%	45%
	11-20%	15%	25%	40%	55%	65%
	21-50%	20%	30%	50%	70%	80%
	>50%	25%	40%	60%	80%	100%

Intensity of impact	Impact category description
None (0.5)	No discernible modification or the modification is such that it has no impact on wetland geomorphic integrity.
Small (1.5)	Although identifiable, the impact of this modification on geomorphic integrity of the affected area is small (e.g., gully 0.5 m, the sediment from the gully has been deposited in the HGM unit and the bed and sides of the gully are now well vegetated).
Moderate (3)	The impact of this modification on geomorphic integrity of the affected area is clearly identifiable, but limited (e.g., gully 1.0 m deep, most of the sediment from the gully has been deposited in the HGM unit and the bed and sides of the gully are now moderately vegetated).
Large (5)	The modification has a clearly detrimental impact on geomorphic integrity of the affected area. Approximately 50% of the integrity of the affected area has been lost (e.g., gully 1.5 m deep, the sediment from the gully has been deposited in the HGM unit and the bed and sides of the gully are poorly vegetated)
Serious (7)	The modification has a clearly adverse effect on geomorphic integrity of the affected area. Well in excess of 50% of the integrity of the affected area has been lost (e.g., gully 2.0 m deep; the sediment from the gully has been mainly exported from the HGM unit and the bed and sides of the gully are poorly vegetated).
Critical (9)	The modification is present in such a way that the geomorphic integrity of the affected area is almost totally destroyed (e.g., gully 4.0 m deep, the sediment from the gully has been mainly exported from the HGM unit and the bed and sides of the gully are completely un-vegetated).

Factors affecting the intensity of impact:
- Depth of the gully
- Extent of which material is exported from the HGM unit and wetland
- Extent to which vegetation is absent from the gully

Table 5.19: Estimation of the extent of depositional features in the wetland HGM unit

Extent of depositional features in relation to area of HGM unit being considered[R]	0.2-2%	2-10%	11-25%	25-50%	>50%
Score for "extent" to be used in the estimation of magnitude of impacts	5%	20%	50%	75%	100%

Intensity of impact	Impact category description
None (0.5)	No discernible modification or the modification is such that it has no impact on wetland geomorphic integrity.
Small (1.5)	Although identifiable, the impact of this modification on geomorphic integrity of the affected area is small (e.g., deposition confined to the margin and toe of the wetland).
Moderate (3)	The impact of this modification on geomorphic integrity of the affected area is clearly identifiable, but limited (e.g., deposition extending somewhat in from the margin).
Large (5)	The modification has a clearly detrimental impact on geomorphic integrity of the affected area. Approximately 50% of the integrity of the affected area has been lost (e.g., extends well into the wetland and has a large effect on wetland features).
Serious (7)	The modification has a clearly adverse effect on geomorphic integrity of the affected area. Well in excess of 50% of the integrity of the affected area has been lost (e.g., complete destruction of features and location in the head of the HGM unit).

Factors affecting the intensity of impact:
- Location along the length of the unit, with the head having the greatest impact followed by the middle and then the toe
- Extent of destruction of existing features, ranging from complete destruction to very limited destruction because confined to the margins

Intensity of impact	Impact category description
None (0.5)	No discernible modification or the modification is such that it has no impact on wetland geomorphic integrity.
Small (1.5)	Although identifiable, the impact of this modification on geomorphic integrity of the affected area is small (e.g., resulting from slight desiccation of the area as a result of upstream catchment abstractions).
Moderate (3)	The impact of this modification on geomorphic integrity of the affected area is clearly identifiable, but limited (e.g., resulting from resulting from slight desiccation of the area as a result of upstream catchment abstractions together with infrequent ground fires to depths of 10% of the peat deposit).
Large (5)	The modification has a clearly detrimental impact on geomorphic integrity of the affected area. Approximately 50% of the integrity of the affected area has been lost (e.g., resulting from intermediate desiccation and frequent ground fires to 25% of the depth of the peat deposit).
Serious (7)	The modification has a clearly adverse effect on geomorphic integrity of the affected area. Well in excess of 50% of the integrity of the affected area has been lost (e.g., e.g., resulting from moderately high desiccation and frequent ground fires to 50% of the depth of the peat deposit).
Critical (9)	The modification is present in such a way that the geomorphic integrity of the affected area is almost totally destroyed (e.g., resulting from high desiccation and frequent ground fires to 80% of the depth of the peat deposit or resulting from extraction of 80% of the depth of the peat deposit through peat mining).

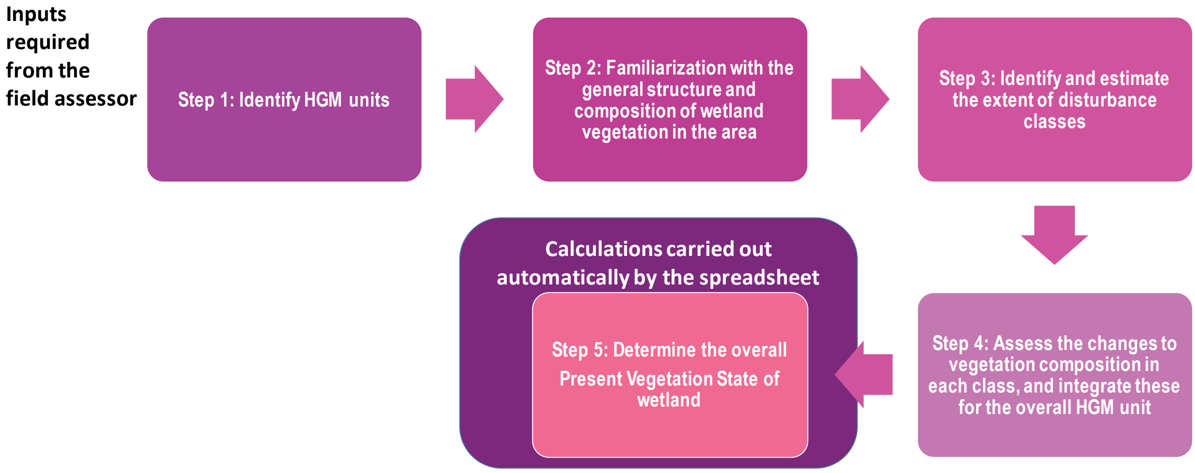
Step 2.4.4: Tools for Collecting Data for the Present Vegetation State of a Wetland

The condition and characteristics of the vegetation within and surrounding a wetland provide a sensitive measure of human impacts on wetland ecosystems.

The overall approach for rapidly estimating a present state of the vegetation is to use the IHI (see Section 9.2.6 for tools) or Wet-Health Level 1 assessment methods.

Table 38 provides the Wet-Health Level 1 Field Tool that can be used in the field to capture the data required for reporting on the present geomorphological state of the wetland.

Steps to ensure all the relevant vegetation data are collected during the wetland assessment



How to collect the data:

- **Step 1:** ensure the type and extent of HGM types have been identified for the wetland.
- **Step 2:** Familiarize yourself with the general structure and composition of wetland vegetation in the area. In order to evaluate changes in vegetation, it is important to have a reasonable regional appreciation of the appearance and composition of wetland vegetation under natural conditions (. Macfarlane et al. (2009) recommend that this be *done by undertaking brief field visits to a range of wetlands within the region or working together with a person with a good knowledge of the vegetation of the area*.
- **Step 3:** Identify and estimate the extent of disturbance classes. A list of common disturbance classes that may typically be found in wetlands is outlined in column 1 of Table 38. Using this table, fill in an estimate of the extent of each disturbance class as a proportion of the HGM unit in column 3. The extent is typically estimated by roughly mapping the extent of each disturbance class on a sketch map or by using GIS to obtain a more accurate estimate.
- **Step 4:** Assess the changes to vegetation composition in each class, and integrate these for the overall HGM unit. The degree of change within each disturbance class should be estimated and intensity scores filled in in column 5 of Table 38.
- **Step 5:** determine the overall present vegetation state for the wetland. On returning to the office, the DSP tool should be utilised to capture the data collected in Table 38 to infer the score for present state of the vegetation. This score and category will automatically be calculated for the wetland once the data is entered into the DSP tool. Follow the guide provided in Section 6.3 Step 2.4.4 to capture and report on this indicator.

Table 38: Wet-Health Level 1 Field Guide to capturing the data to report the present vegetation state of the prioritised wetland (taken from Ollis et al., 2014). Only fill in data in the purple columns.

Disturbance Class	Description	Extent (%)	ypical intensity	Intensity (0-10)[1]	Magnitude [2]	Additional Notes	Confidence rating
Infrastructure	This includes houses, roads and other permanent structures that have totally replace wetland vegetation		10		0,0		
Deep flooding by dams	This includes situations where flooding is too deep for emergent vegetation to grow		10		0,0		
Shallow flooding by dams	such shallows can often be identified at the head or tail end or edge of dams		4-8		0,0		
Crop lands	these lands are still in use and when active are generally characterized by almost total indigenous vegetation removal (predominance of introduced species) Examples include maize and sugarcane lands, madumbe fields, etc.		8-10		0,0		
Commercial plantations	Common plantations include pines, wattle, gum, poplar. Other land uses such as vineyards and orchards may have a similar impact on wetland vegetation		7-10		0,0		
Annual pastures	Areas characterised by frequent soil disturbance with a general removal of wetland vegetation. Some ruderal wetland species may become established but are removed on a frequent basis		9 - 10		0,0		
Perennial pastures	Although such areas generally include a high abundance of alien terrestrial grasses or legumes, the reduced disturbance frequency may permit the establishment of some wetland species		4 - 10		0,0		
Dense Alien vegetation patches.	where dense patches of alien plants can be identified within a wetland system, they should be identified as a separate disturbance class and evaluated as a unit		5-10		0,0		
Sports fields	these include cricket pitches, gold courses and the like, where a species such as Kikuyu have been introduced and are maintained through intensive management. These are often located within areas of temporary wetland where terrestrial species generally dominate		7-10		0,0		
Gardens	Gardens are generally associated with urban environments		6-10		0,0		
Areas of sediment deposition/ infilling & excavation	deposition includes sediment from excessive erosion or human disturbance (e.g. a construction site) upstream of the wetland, which is carried by water and deposited in the wetland. Infilling is the placement by humans of fill material in the wetland (e.g. for sports fields). Excavation is the direct human removal (usually with heavy machinery) of sediment from the wetland, which is commonly associated with mining and sand winning		4-10		0,0		

Disturbance Class	Description	Extent (%)	ypical intensity	Intensity (0-10)[1]	Magnitude [2]	Additional Notes	Confidence rating
Eroded areas	Typically occurs as gully erosion		3-9		0,0		
Old / abandoned lands (Recent)	These secondary vegetation areas have typically been altered through historic agricultural practices, but are in the process of recovering. They are generally characterized by a high relative abundance of ruderal species, but this abundance may vary greatly depending on time since cultivation ceased. In cases where this varies greatly within the HGM unit, it may be worthwhile to distinguish between vegetation classes comprising recently abandoned lands and vegetation classes comprising older lands that are at a more advanced successional stage of recovery		7-9		0,0		
Old / abandoned lands (Old)			3-8		0,0		
Seepage below dams	Earthen dams used for agricultural purposes often allow water to leak through the wall, creating artificial wetter areas below the dam wall. Such areas are typically characterized by an increase in hydric species.		1-5		0,0		
Untransformed areas	These primary vegetation areas have not been significantly impacted by human activities. This may include wetland areas within game or extensive grazing management systems. Small pockets of untransformed vegetation may also be set aside as streamside buffers on commercial landholdings		0-3		0,0		

[1] Default scores are provided which should be adjusted based on field investigations or local knowledge

[2] Magnitude of impact score is calculated as extent / 100 x intensity of impact. This score will automatically be calculated when the extent (%) of each disturbance class is captured in the DSP excel spreadsheet

[3] The overall magnitude of impact score for the HGM unit is the sum of magnitude cores for each disturbance class

Step 2.4.5: Tools for Collecting Data for the Water Quality of the Prioritised Wetland

The National Water Act of South Africa (South Africa, 1998) recognizes that the water quality of wetlands needs to be assessed and, if necessary, managed. Water quality refers to the suitability of the chemical and physical conditions in water relative to the requirements of users, who may be humans or other organisms. The idea of water quality takes into account a number of important physical properties (e.g. temperature, dissolved gases) and the concentrations of numerous substances (e.g. common salt, nutrients, toxins) dissolved in the water.

Water quality (WQ) is affected by numerous physical and chemical factors such as the nature of the soil and the vegetation, position in the landscape, topography, water quantity, climate, groundwater and surface water chemistry, and hydrology, as well as virtually all human activities that affect wetlands.

To ascertain the present water quality state of the wetland, you will need to assign an impact rating (-5 to +5) in each of the purple boxes in Table 39, reflecting the change in the particular water quality component (pH, Salts, Nutrients, Water Temperature, Turbidity, Oxygen or Toxics) associated with each landuse activity. Some combinations are not required to be assessed as there are no likely perceived impacts relating to wetland systems. In these cases, the boxes are hatched and shaded out.

Table 39: RERD Field Guide to capturing the data to report the water quality state of the prioritised wetland (taken from Rountree et al., 2013). Only fill in data in the purple columns.

			SALTS			**Nutrients**		**Sediments**		**TOXICS**						
Landuse categories	**Landuse (in wetland and catchment)**	**pH**	**SO4**	**K**	**NaCl**	**P**	**N**	**Clastic**	**Organic**	(All toxins score equally. Max impact score = 5)	**SUM OF IMPACT RATING SCORES**	**Adjusted for weighting**	**Default ratings**	**% AREA (MAJOR LANDUSES ONLY)**	**AREA WEIGHTED SCORES**	**RATING**
Infrastructure	Housing (sewered)										8	14	**2**		0	0
	Housing (unsewered)										17	29	**3**		0	0
	Industrial (or mixed industrial/residential)										34	49	**5**		0	0
															0	0
Agriculture	Non-irrigated croplands										11	20	**2**		0	0
	Irrigated croplands										12	20	**2**		0	0
	Non-irrigated pasture										11	18	**2**		0	0
	Irrigated pasture										13	22	**3**		0	0
															0	0
Commercial plantations	Commercial plantations										7	13	**2**		0	0
	Dense alien trees/shrubs										5	11	**2**		0	0
Natural vegetation	Natural vegetation (and low-intensity grazing)										1	3	**0**		0	0

Landuse categories	**Landuse (in wetland and catchment)**	**pH**	**SALTS**			**Nutrients**		**Sediments**		**TOXICS**	**SUM OF IMPACT RATING SCORES**	**Adjusted for weighting**	**Default ratings**	**% AREA (MAJOR LANDUSES ONLY)**	**AREA WEIGHTED SCORES**	**RATING**
			SO4	**K**	**NaCl**	**P**	**N**	**Clastic**	**Organic**	(All toxins score equally. Max impact score = 5)						
															0	0
Other	Sports fields										5	9	**1**		0	0
	Gardens										5	9	**1**		0	0
																0

Follow the guide provided in Section 6.3 Step 2.4.5 to capture and report on this indicator.

Table 40: table to adjust PES category

ADJUSTMENT OF PES CATEGORY	**YES/NO?**	**ALTERED RATING SCORE**
1. Is the wetland well-buffered by natural vegetation? Then **improve** PES score by 1 category		
2. Are there point-sources of pollutants discharging directly into the wetland or immediately upstream? Then **lower** PES score by 1 category		
3. If there is mining or power generation activity in the catchment, **lower** PES score by half a category		
3. Is there intensive agriculture within the wetland itself? Then **lower** PES score by 1 category		
4. Has flow been significantly altered from natural? Then **lower** PES score by half a category		
5. Is the areal extent of urban landuse > 50% of catchment? Then **lower** PES score by 1 category		
	PES SCORE	
	PES% SCORE	100%

Step 2.4.6: Tools for Collecting Data for the Present Ecological State of a wetland based on land use

This indicator determines a Present Ecological State (A-F) of the wetland based on **land-use** within the wetland and its upstream catchment (Kotze *et al.,* 2015).

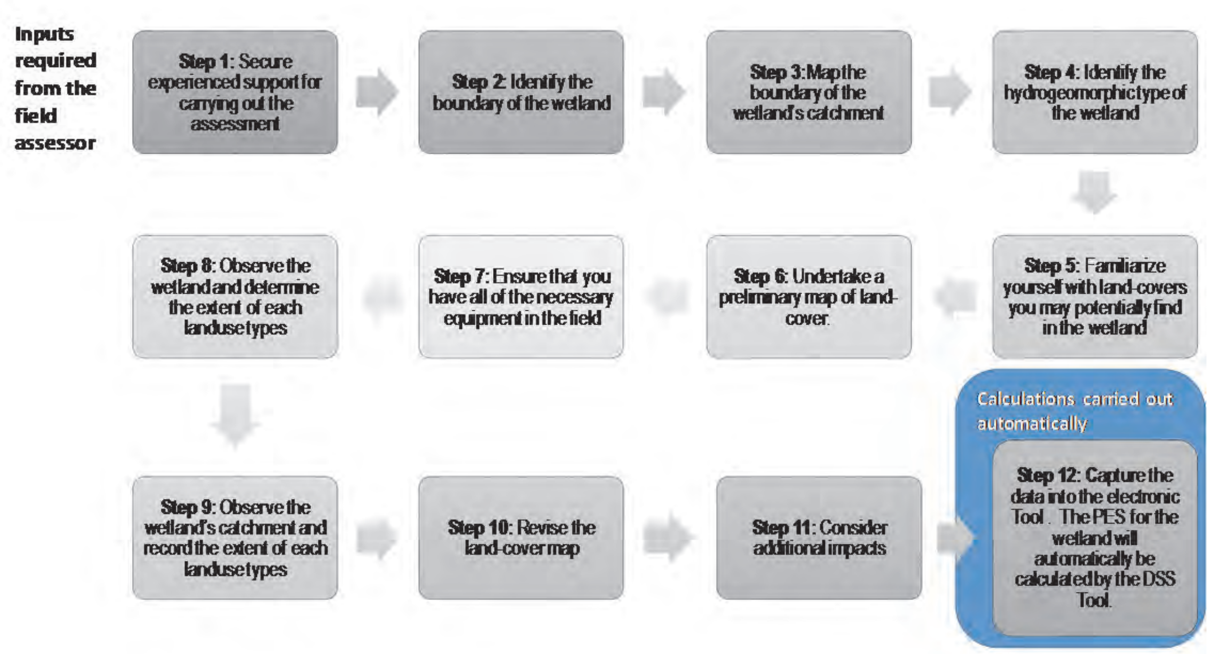
The method for assessing wetland ecological condition based on land-cover type is provided in Kotze et al. (2015). The method provides a list of land-cover/disturbance types commonly occurring in wetlands, linked to impact scores to each of these types (Kotze et al., 2015). The assessor needs to:

- identify the different disturbance types present in a wetland and
- then to identify the extent of each type of these land-cover.

For this indicator, the "semi-quantitative detailed-map" option outlined in Kotze et al. (2015) is used to estimate the PES for the wetland, based on land-cover.

Tables 41-43 provide the Field Tool which can be used to capture the data in the field.

Steps to ensure all the data is collected during the wetland assessment:



How to collect the data:

The following steps need to be completed before going into the field (taken from Kotze et al., 2015):

- **Step 1:** Secure experienced support for carrying out the assessment. If you are not familiar with the area in which the prioritised wetland is located, contact someone who does have this experience to guide you in the assessment, particularly with the assessment of vegetation.
- **Step 2:** Identify the boundary of the wetland (see section 9.2.2 for guidance on this step).
- **Step 3:** Map the boundary of the wetland's catchment. The wetland catchment refers to the area up-slope of the wetland from which water flows into the wetland (Kotze et al., 2015). A contour map of the area is useful to assist in mapping the catchment.
- **Step 4:** Identify the hydrogeomorphic type of the wetland – see Section 9.2.3
- **Step 5:** Familiarize yourself with land-covers you may potentially find in the wetland. Table 41, including footnotes, provides a list of land-cover types and the likely intensity of the impacts commonly associated with each land-cover type in the wetland. For impacts arising from within the wetland, first record in Table 42 the extent of the different land-covers in the wetland then record in Table 43 any additional impacts to the natural land-cover area if present.
- **Step 6:** Undertake a preliminary map of land-cover. Make a preliminary map of the land-cover types in the wetland and the associated wetland catchment. Use Table 41-43 as a guide. Create the map using either a GIS (Geographic Information System) or Google Earth Pro http://www.google.co.za/earth/download/gep/agree.html).

Steps to carry out in the field

- **Step 7:** Ensure that you have all of the necessary equipment in the field.
    - Table 41 to 43, and the photographs of the land-cover types
    - A pen/pencil and notepad, a GPS (Geographical Positioning System) and a camera
    - A field-guide for the identification of alien plants, e.g. Bromilow (2010)
- **Step 8:** Observe the wetland and determine the extent of each land-use type. Observe the wetland from a nearby vantage point and walk through the wetland to:
    - verify the land-covers mapped in the office (make sure you visit all of the different land-cover types mapped in the office);
    - record in column 10 of Table 41 the extent of the different land-covers in the wetland;
    - record in column 7 of Table 42 any additional impacts to the natural land-cover area if present.
- **Step 9:** Observe the wetland's catchment and record the extent of each land-use type. Briefly drive or walk through the wetland's upstream catchment to verify the land-covers mapped in the office. For impacts arising from within the wetland's upstream catchment, record in column 5 the extent of the different land-cover types in the wetland's upstream catchment of Table 43.
- **Step 10:** Revise the land-cover map. Revise the land-cover map for the wetland and its catchment based on field observations.
- **Step 11:** Consider additional impacts. Consider any additional impacts listed in Table 42, e.g. the release of point-source wastewater into the wetland or a greatly altered fire regime (may range from wetlands burnt too frequently to not at all).

Step 12: Once back in the office, capture the data from Table 41-43 into the electronic DSS Tool (see NWMP CD for copy of tool). The PES for the wetland will automatically be calculated by the DSS Tool. On returning to the office, follow the guide provided in Section 6.3 Step 2.4.6 to capture and report on this indicator.

Table 41: Impact intensity scores for the hydrology, geomorphology, water quality and vegetation components of ecological condition for a range of different land-cover types potentially occurring within a wetland (taken from Kotze, 2015)

Land-cover / disturbance types		Intensity of impact scores								
AREAS OF THE WETLAND IMPACTED BY HUMAN ACTIVITIES, WHERE THE RETENTION OF WATER IS REDUCED OR UNAFFECTED		Hydrology	Geomorphology			Water quality	Vegetation	**Overall Impact**	Extent (%)	Magnitude
			Mineral	Organic	Overall					
Annual crops, commercial, irrigated	Conventional tillage, with severe artificial drainage[3]	7,5	4,0	7,0	5,5	7,0	10,0	**7,5**		0,0
	Conventional tillage, with moderate artificial drainage	5,0	4,0	5,0	4,5	6,0	9,5	**6,1**		0,0
	Conventional tillage, with negligible artificial drainage	3,5	3,0	3,0	3,0	5,0	9,0	**4,9**		0,0
	Minimum tillage, with severe artificial drainage	7,0	2,5	5,0	3,8	5,0	10,0	**6,5**		0,0
	Minimum tillage, with moderate artificial drainage	4,0	2,5	3,0	2,8	4,0	9,5	**4,9**		0,0
	Minimum tillage, with negligible artificial drainage	2,5	2,0	2,0	2,0	3,0	9,0	**3,9**		0,0
Annual crops, commercial, not irrigate	Conventional tillage, with severe artificial drainage	7,0	4,0	7,0	5,5	6,0	10,0	**7,1**		0,0
	Conventional tillage, with moderate artificial drainage	4,0	4,0	5,0	4,5	5,0	9,5	**5,6**		0,0
	Conventional tillage, with negligible artificial drainage	2,5	3,0	3,0	3,0	4,5	9,0	**4,5**		0,0
	Minimum tillage, with severe artificial drainage	6,5	2,5	5,0	3,8	5,0	10,0	**6,3**		0,0
	Minimum tillage, with moderate artificial drainage	3,5	2,5	3,0	2,8	4,0	9,5	**4,8**		0,0
	Minimum tillage, with negligible artificial drainage	2,0	2,0	2,0	2,0	3,0	9,0	**3,8**		0,0
Annual crops, subsistence	With severe artificial drainage	7,0	2,5	5,0	3,8	4,5	10,0	**6,4**		0,0
	With moderate artificial drainage	3,5	2,5	3,0	2,8	3,5	9,5	**4,7**		0,0
	With negligible artificial drainage	2,5	2,0	2,0	2,0	2,5	9,0	**3,8**		0,0
Sugarcane	With severe artificial drainage	8,0	3,5	6,5	5,0	5,0	10,0	**7,1**		0,0
	With moderate artificial drainage	5,0	2,5	4,5	3,5	4,0	9,5	**5,4**		0,0
	With negligible artificial drainage	3,5	2,0	2,5	2,3	3,0	9,5	**4,4**		0,0
Vineyards	With severe artificial drainage	7,0	2,0	5,0	3,5	4,0	10,0	**6,2**		0,0
	With moderate artificial drainage	3,5	2,0	3,0	2,5	3,0	9,5	**4,5**		0,0
	With negligible artificial drainage	2,5	1,5	2,0	1,8	2,0	9,0	**3,7**		0,0
Orchards	With severe artificial drainage	7,0	2,0	5,0	3,5	5,5	10,0	**6,6**		0,0
	With moderate artificial drainage	4,0	2,0	3,0	2,5	4,5	9,5	**5,0**		0,0
	With negligible artificial drainage	3,0	1,5	2,0	1,8	3,5	9,0	**4,2**		0,0
Planted pastures, annual	With severe artificial drainage	7,0	3,0	6,0	4,5	4,5	10,0	**6,6**		0,0
	With moderate artificial drainage	3,5	2,5	4,0	3,3	3,5	9,5	**4,8**		0,0
	With negligible artificial drainage	2,5	2,0	2,0	2,0	3,0	9,5	**4,1**		0,0
Planted pastures, perennial	With severe artificial drainage	7,0	2,0	3,5	2,8	3,5	9,5	**5,8**		0,0
	With moderate artificial drainage	3,0	1,5	2,5	2,0	3,0	9,0	**4,1**		0,0
	With negligible artificial drainage	1,5	1,0	1,0	1,0	2,0	9,0	**3,2**		0,0
Unmaintain	With severe artificial drainage	7,0	2,5	3,5	3,0	2,0	9,0	**5,4**		0,0

Land-cover / disturbance types		Intensity of impact scores								
AREAS OF THE WETLAND IMPACTED BY HUMAN ACTIVITIES, WHERE THE RETENTION OF WATER IS REDUCED OR UNAFFECTED			Geomorphology							
		Hydrology	Mineral	Organic	Overall	Water quality	Vegetation	**Overall Impact**	Extent (%)	Magnitude
ed perennial pastures	With moderate artificial drainage	3,0	1,5	2,5	2,0	1,5	8,5	**3,7**		0,0
	With negligible artificial drainage	1,0	1,0	1,0	1,0	1,0	8,0	**2,6**		0,0
Recently abandoned lands	With severe artificial drainage	7,0	2,0	6,0	4,0	2,5	9,0	**5,8**		0,0
	With moderate artificial drainage	3,0	2,0	3,0	2,5	2,0	8,5	**3,9**		0,0
	With negligible artificial drainage	1,0	2,0	2,0	2,0	1,5	8,0	**2,9**		0,0
Old abandoned lands/ semi-natural areas	With severe artificial drainage	7,0	3,0	5,5	4,3	2,0	8,0	**5,5**		0,0
	With moderate artificial drainage	3,0	2,5	2,5	2,5	1,5	6,0	**3,2**		0,0
	With negligible artificial drainage	1,0	1,5	1,5	1,5	1,0	4,0	**1,8**		0,0
Tree plantations	Plantations of eucalypt trees	8,0	4,0	4,0	4,0	3,0	10,0	**6,4**		0,0
	Plantations of pine, wattle or poplar trees	6,0	4,0	3,0	3,5	3,0	10,0	**5,7**		0,0
Dense infestations of invasive alien plants	Infestation of eucalypt trees	8,0	4,0	4,0	4,0	3,0	9,0	**6,2**		0,0
	Infestation of pine, wattle or poplar trees	6,0	4,0	3,0	3,5	3,0	9,0	**5,4**		0,0
	Infestation of American brambles or other herbaceous invasive alien plants	2,0	4,0	3,0	3,5	3,0	8,5	**4,0**		0,0
Erosion gullies	Erosion gully with negligible vegetation colonization	7,0	10,0	10,0	10,0	5,0	9,0	**7,7**		0,0
	Erosion gully colonized with vegetation (mainly alien species)	6,0	7,0	7,0	7,0	3,0	9,0	**6,2**		0,0
	Erosion gully colonized with vegetation (mainly indigenous species)	6,0	7,0	7,0	7,0	2,0	7,0	**5,6**		0,0
Infrastructure (Urban and roads)	Formal residential	10,0	7,0	7,0	7,0	4,0	10,0	**8,0**		0,0
	Informal residential	8,0	6,0	6,0	6,0	7,0	10,0	**7,8**		0,0
	Commercial/industrial	10,0	7,0	8,0	7,5	7,0	10,0	**8,8**		0,0
	Roads10	10,0	7,0	7,0	7,0	5,0	10,0	**8,2**		0,0
Infilling without infrastructure	Natural sediment/soil used as infill	10,0	8,0	7,0	7,5	4,0	10,0	**8,1**		0,0
	Landfill material or solid waste (e.g. concrete rubble, plastic)	10,0	8,0	7,0	7,5	7,0	10,0	**8,8**		0,0
	Mine dumps (spoil from the mining of underlying rock)	10,0	9,0	8,0	8,5	10,0	10,0	**9,7**		0,0
Mines and quarries	Mining of clay or sand	9,0	10,0	10,0	10,0	7,0	9,0	**8,8**		0,0
	Mining of underlying rock	10,0	10,0	10,0	10,0	10,0	10,0	**10,0**		0,0
Sports fields or gardens	Sports fields or gardens on the original wetland ground surface	3,0	2,0	3,0	2,5	3,0	9,0	**4,2**		0,0
	Sports fields or gardens on wetland which has been infilled	10,0	6,0	5,0	5,5	3,0	10,0	**7,4**		0,0
Recent sediment	Recent sediment deposition (deep, resulting in loss of wetland conditions)	10,0	6,0	3,0	4,5	3,0	10,0	**7,2**		0,0

Land-cover / disturbance types		Intensity of impact scores								
AREAS OF THE WETLAND IMPACTED BY HUMAN ACTIVITIES, WHERE THE RETENTION OF WATER IS REDUCED OR UNAFFECTED		Hydrology	Geomorphology			Water quality	Vegetation	**Overall Impact**	Extent (%)	Magnitude
			Mineral	Organic	Overall					
deposits	Recent sediment deposition (shallow, with wetland conditions persisting, although diminished)	4,0	3,0	2,0	2,5	2,0	5,0	**3,4**		0,0
Dams, ponds and areas where were water supply has been artificially sustained	Deep flooding by dams/ artificial ponds or upstream of embankments, not used for aquaculture	7,0	6,0	3,0	4,5	2,0	10,0	**6,0**		0,0
	Deep flooding by dams/ artificial ponds or upstream of embankments, used for aquaculture	7,0	6,0	3,0	4,5	5,0	10,0	**6,7**		0,0
	Shallow flooding by dams/ artificial ponds or upstream of embankments in the unit8	3,0	3,0	2,0	2,5	2,0	5,0	**3,1**		0,0
	Paddy fields	5,0	2,0	5,0	3,5	5,0	7,0	**5,1**		0,0
	Seepage downslope of dams or embankments or areas where water supply has become more sustained (e.g. from irrigation return flows)	3,0	1,0	3,0	2,0	1,0	5,0	**2,8**		0,0
DRAINED NATURAL	With severe artificial drainage	6,0	1,5	4,0	2,8	0,5	6,0	**4,1**		0,0
	With moderate artificial drainage	3,0	1	1,5	1,3	0,5	3,0	**2,1**		0,0
NATURAL	With negligible/no artificial drainage	0,0	0	0	0,0	0,0	0,0	**0,0**		0,0

Table 42:Additional impacts to natural vegetation which have not been included in the land-cover assessment in Table 41 (taken from Kotze, 2015)

	Hydrology	Geomorphology	Water quality	Vegetation	**Overall intensity**	Extent	Magnitude
The point source release of wastewater into the wetland	4,0	3,0	8,0	6,0	**5,1**		0,0
Seepage from a dam located immediately upstream	3,0	1,0	1,0	3,0	**2,1**		0,0
Pumping of water out of the wetland or its catchment	6,0	2,0	1,0	5,0	**3,8**		0,0
Marked increase in the frequency of fire in the wetland	2,0	2,0	2,0	3,0	**2,2**		0,0
Suppression of fire	2,0	1,0	1,0	5,0	**2,2**		0,0
Marked increase to the natural grazing of the wetland	2,0	2,0	3,0	4,0	**2,7**		0,0
Suppression of grazing	1,0	1,0	0,0	3,0	**1,2**		0,0
Scattered invasive alien plants	1,0	1,0	1,0	2,0	**1,2**		0,0
No observable on-site impacts	0,0	0,0	0,0	0,0	**0,0**		0,0

Table 43: Impact intensity scores for a range of different land-cover types potentially occurring in a wetland's catchment (taken from Kotze, 2015).

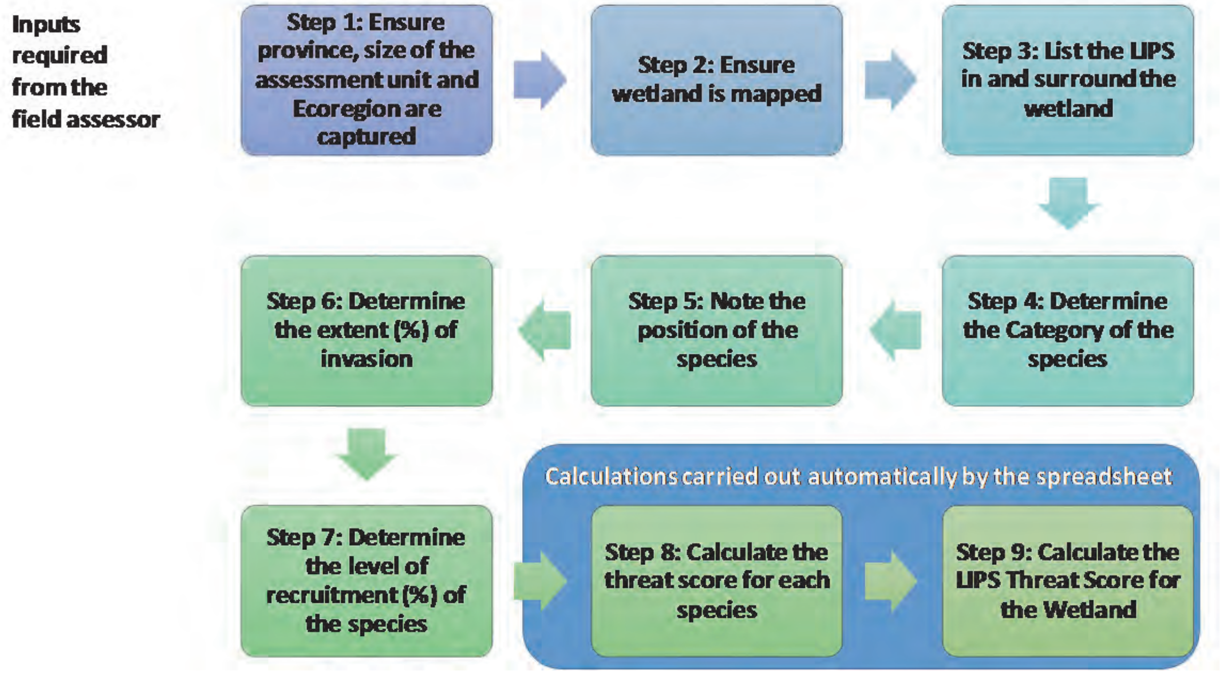
Land-cover / disturbance types	Impact intensity			Extent (%)	Magnitude
Land-covers in the wetland's catchment	**Water quantity & pattern**	**Water quality**	**Overall Impact**		
Tree plantations, eucalypt	8,0	3,0	**5,5**		0,0
Tree plantations, pine, wattle or poplar	6,0	3,0	**4,5**		0,0
Orchards	5,0	6,0	**5,5**		0,0
Vineyards	4,0	4,0	**4,0**		0,0
Annual commercial (row) crops, irrigated	5,0	6,0	**5,5**		0,0
Annual commercial (row) crops, not irrigated	4,0	5,0	**4,5**		0,0
Annual subsistence crops	4,0	4,0	**4,0**		0,0
Sugarcane	4,0	4,0	**4,0**		0,0
Mines and quarries	7,0	9,0	**8,0**		0,0
Built up dense settlements, roads railway lines and airfields	7,0	5,0	**6,0**		0,0
Golf courses, sports fields & low density settlements	2,0	4,0	**3,0**		0,0
Old lands/ semi-natural vegetation	0,0	1,0	**0,5**		0,0
Natural vegetation	0,0	0,0	**0,0**		0,0
Eroded areas	5,0	5,0	**5,0**		0,0
Dams	7,0	2,0	**4,5**		0,0

Step 2.4.7: Tools for Collecting Data for threats posed by Invasive Plant Species

This indicator reports on the extent and recruitment of listed invasive plant species as a threat score.

Data for this indicator are entered into Table 44 and captured into the Excel spreadsheet found in the file called "Listed_Invasive_Species_Score" on the NWMP CD.

Steps to ensure all the data on alien plants are collected during the assessment



How to capture the data:

1. Before completing the NWMP Listed Invasive Plant Species table (Table 44), ensure the province, size of the assessment unit and Ecoregion have been captured in the Attributes Table.
2. Ensure the wetland has been mapped (see Step 2.1 above).
3. Fill in the name of each Listed Invasive Plant Species (LIPS) into Table 44. Plants should be included if they are within the wetland or within 50 meters of the wetland edge. Listed Invasive Plant Species can be can be obtained from *National Environmental Management: Biodiversity Act 2004 (Act No, 10 Of 2004: Alien and Invasive Species Lists, 2014* (see the NWMP CD for a copy of the document).
4. Fill in the NEM:BA category (column 3) of the species on Table 44. The category of the species can be found in National *Environmental Management: Biodiversity Act 2004 (Act No, 10 of 2004: Alien and Invasive Species Lists, 2014* (see the NWMP CD for a copy of the document).
5. Note the position of the species in column 3 of Table 44.
6. Decide the extent (%) of invasion by the particular species. This is the extent, as a percent of the wetland extent, that has been invaded by the particular species. Three categories are used:
    - 1-25% = relatively low level of invasion: score = 1
    - 25-60% = moderate level of invasion: score = 2
    - >60% = high level of invasion: score = 3

Fill in the selected score in column 5: Extent

7. Determine the level of seedling recruitment[10] of each species. Three categories are used:
   - 1 = no or little visible seedling recruitment
   - 2 = moderate visible seedling recruitment
   - 3 = very successful visible seedling recruitment.

   Fill the selected score into column 6: Recruitment

8. The threat score for each species is automatically calculated when the data are entered in the Excel Spreadsheet back in the office. On returning to the office, follow the guide provided in Section 6.3 Step 2.4.7 to capture and report on this indicator.

Table 44: NWMP table to capture and calculate the Listed Invasive Plant Score for the assessment unit

#	Name of Invasive Plant Species (note: include both terrestrial and aquatic listed species)	NEM:BA Category	Buffer zone (50 meters surrounding wetland) or within wetland	Extent of Invasive Plant Species (% area invaded))	Recruitment seen	Species Threat Score (Extent score + recruitment Score)
				1-25% = 1 25-60% = 2 >60% =3	1=absent or low 2 = medium 3 = very successful	
1						0
2						0
3						0
4						0
5						0
6						0
7						0
8						0
9						0
10						0
11						0
12						0
13						0
14						0
15						0
16						0
17						0
18						0
19						0
20						0
21						0

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[10] *Recruitment refers to the process by which new individuals found a population or are added to an existing population. Although recruitment may refer to clonal offspring, by far the most common means of recruitment is by seedlings.*

Although not currently utilised to estimate the Listed Invasive Species threat score for the wetland, it is necessary to document any other alien species found in the wetland. Use Table 44 for the purpose, following the same process outlined above for the document of Listed Invasive Plant Species.

Table 45: Table to capture the alien species threats to the wetland

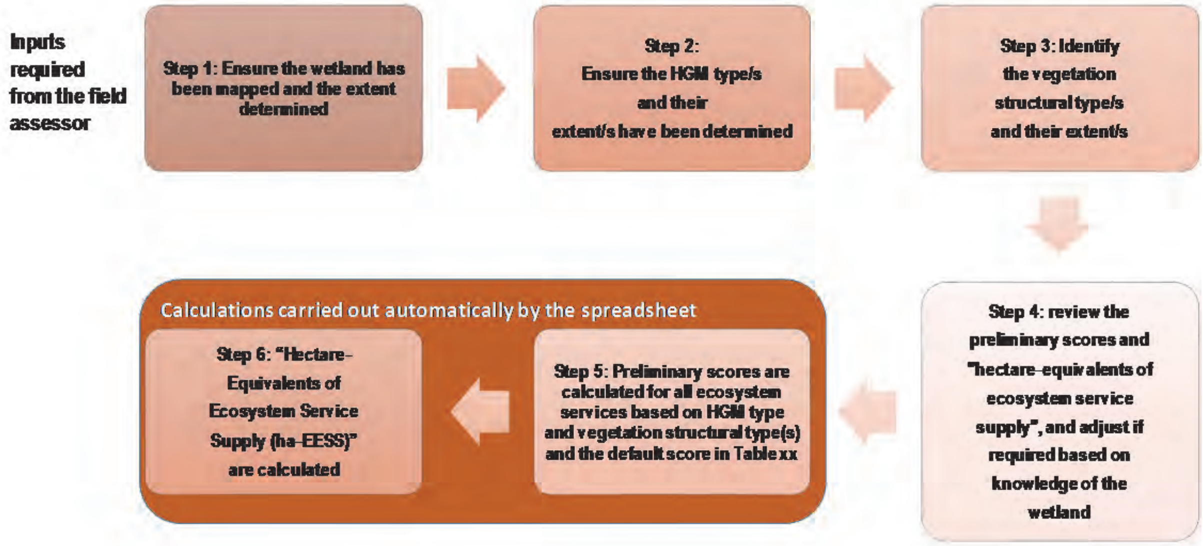
#	Name of Alien Plant Species (note: include both terrestrial and aquatic species)	Buffer zone (50 meters surrounding wetland) or within wetland	Extent of Alien Plant Species (% area invaded))	Recruitment seen
			1-25% = 1	1=absent or low
			25-60% = 2	2 = medium
			>60% =3	3 = very successful
1				
2				
3				
4				
5				
6				
7				
8				
9				
10				
11				
12				
13				
14				
15				
16				
17				
18				
19				
20				
21				

Step 2.4.8: Tools for Collecting Data for Ecosystem Services Scores for a Wetland

The tool used to collect and estimate the ecosystem services provided by a wetland is the Wetlands and Well-being DSS by Kotze (2014). The DSS is designed to generate a preliminary scoring of several ecosystem services by inference from the wetland's hydrogeomorphic (HGM) type and the structural vegetation types (including cultivated lands) present in the wetland.

S

teps to ensure that all the ES data are collected during the wetland assessment



How to capture the data:

1. Ensure the wetland has been mapped (see Section 9.2.2) and the extent of the wetland ascertained (see Section 9.2.3).
1. Ensure that the HGM types and the proportional area of each is assessed using Table 46.
2. Identify the vegetation types and estimate their extent. Fill in the extent (% cover) of each vegetation type into column 2 of Table 46.
3. Steps 4-6 are completed once the field data have been captured into the DSS Excel Spreadsheet (found in the folder *NWMP Implementation Manual Supporting Tools/ Decision Support Framework and Protocol* of the NWMP CD).

Table 46: Estimate the percent of each HGM type in the wetland (Kotze, 2014)

HGM Types	**Extent (%)**
Floodplain	
Valley bottom, channelled	
Valley bottom, unchannelled	
Seep with channelled outflow	
Seep without channelled outflow	
Depression, exhorheic	
Depression, endorheic	
TOTAL	

Must total 100

Table 47: Table to capture the extent (%) of vegetation types in the wetland (Kotze, 2014)

Vegetation Types	Extent (%)
Natural/semi-natural	
short/medium grass, primary	
Short/Medium grass, secondary	
Tall, robust grass	
Short/medium Sedges/rushes/restios	
Reeds, Phragmites	
Reeds, Typha	
Palmiet	
Herbs, annual	
Herbs, perennial	
Geophytes	
Forest	
Shrub/thicket	
Aquatic, floating	
Aquatic, submerged	
Transformed, not flood-protected	
Planted pastures	
Sugar cane	
Orchards	
Vineyards	
Annual crops	
Transformed, flood-protected	
Planted pastures	
Sugar cane	
Orchards	
Vineyards	
Annual crops	

Although the demand for ecosystem services are not currently used to estimate the Ecosystem Services Score indicator, it is important to capture this data in the field. This can be done using Table 48-51 which includes:

Table 48: Scoring the level of current use of the ecosystem services

Ecosystem services	Level of use*	Evidence of use/additional notes
Flood attenuation		
Erosion control		
Sediment trapping		
Phosphate assimilation		
Nitrate assimilation		
Toxicant assimilation		
Water supply		
Grazing		
Plants for crafts		
Medicinal plants		
Indigenous/ wild foods		
Cultivated foods		
Tourism & recreation		

*Level of use is scored as: Nil, Low, Moderate or High

Table 49: Scoring the beneficiaries and their dependency

	Local		Downstream		Provincial to national	
Ecosystem services	Beneficiaries*	Dependency **	Beneficiaries	Dependency	Beneficiaries	Dependency
Flood attenuation						
Erosion control						
Sediment trapping						
Phosphate assimilation						
Nitrate assimilation						
Toxicant assimilation						
Water supply						
Grazing						
Plants for crafts						
Medicinal plants						
Indigenous/ wild foods						
Cultivated foods						
Tourism & recreation						

*The number of beneficiaries is scored on a coarse scale of 0, 1, 10, 100, 1000, 10 000, >10 000

**Dependency is scored on a scale of: 1=Minimal importance to wellbeing; 2= Moderately important for wellbeing; 3= Critical for wellbeing

Table 50: Scoring opportunities to increase the benefits from ecosystem services

	Opportunity score*	Describe the opportunity/s
Flood attenuation		
Streamflow regulation		
Erosion control		
Sediment trapping		
Phosphate assimilation		
Nitrate assimilation		
Toxicant assimilation		
Water supply		
Grazing		
Plants for crafts		
Medicinal plants		
Indigenous/ wild foods		
Cultivated foods		
Tourism & recreation		

*Opportunity is scored as: Nil (0), Low (1), Moderate (2), High (3), Very high (4)

Table 51: Scoring costs of a wetland on local people (Kotze, 2014)

	Severity score*	Description of the negative effects and likely causes
Habitat for invertebrate disease hosts		
Habitat/ roosting sites for crop pests		
Cover for criminals		
Increased fire hazard		
Difficulty of crossing		
Flooding and dampness of property		
Pathogens in the wetland		
Solid waste in the wetland		
Other		

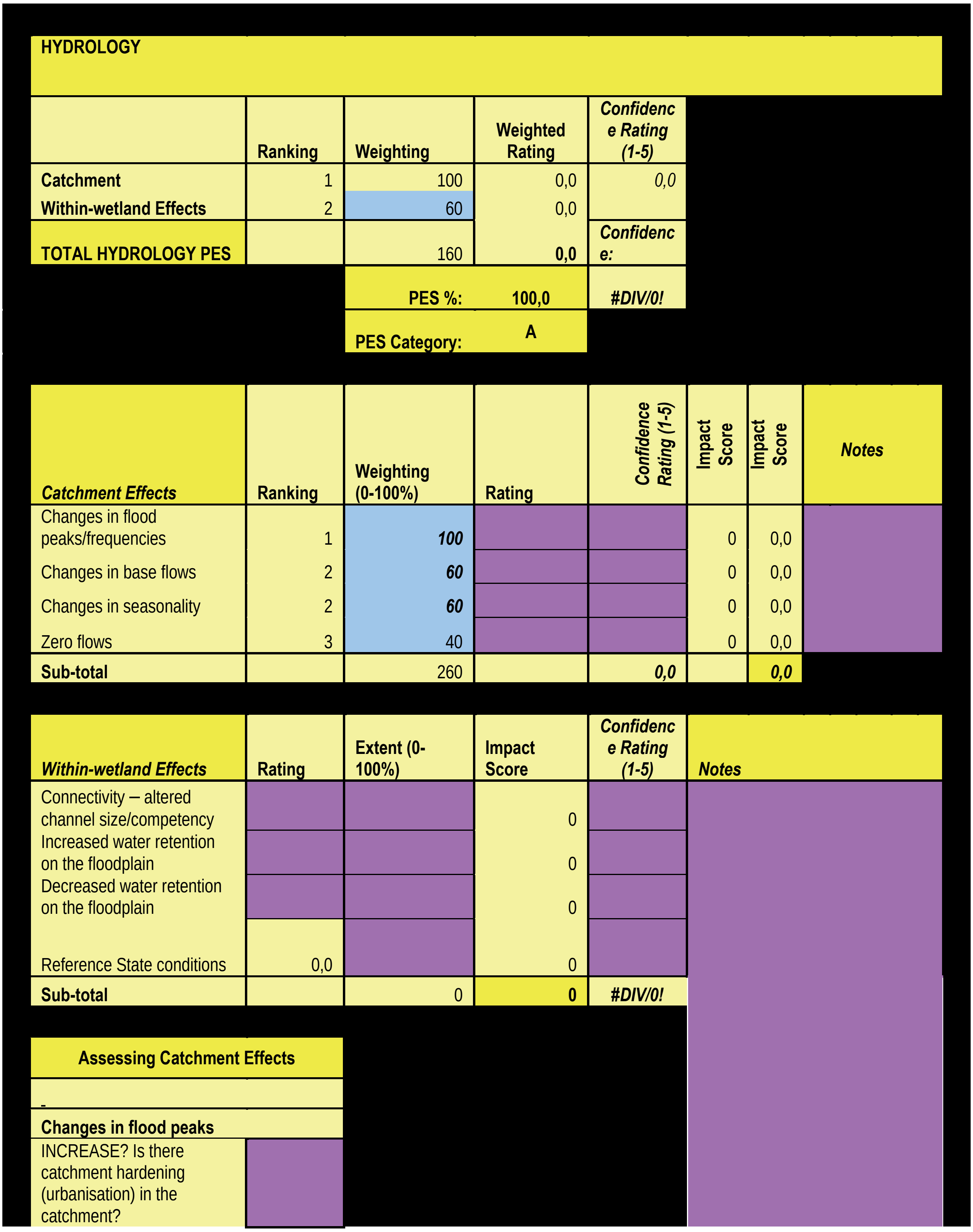
*Severity of the negative effects is scored as: Nil, Low, Moderate or High

On returning to the office, follow the guide provided in Section 6.3 Step 2.4.8 to capture and report on this indicator.

9.2.6 IHI Tools

Step 2.4.2: IHI tools for present hydrological state

Table 52: IHI tool to capture data to ascertain the present hydrological state category of the wetland (DWAF, 2007)



HYDROLOGY

	Ranking	Weighting	Weighted Rating	*Confidence Rating (1-5)*
Catchment	1	100	0,0	*0,0*
Within-wetland Effects	2	60	0,0	
TOTAL HYDROLOGY PES		160	**0,0**	***Confidence:***
		PES %:	**100,0**	***#DIV/0!***
		PES Category:	**A**	

Catchment Effects	Ranking	Weighting (0-100%)	Rating	*Confidence Rating (1-5)*	Impact Score	Impact Score	***Notes***
Changes in flood peaks/frequencies	1	***100***			0	0,0	
Changes in base flows	2	***60***			0	0,0	
Changes in seasonality	2	***60***			0	0,0	
Zero flows	3	40			0	0,0	
Sub-total		260		***0,0***		***0,0***	

Within-wetland Effects	Rating	Extent (0-100%)	Impact Score	*Confidence Rating (1-5)*	***Notes***
Connectivity – altered channel size/competency			0		
Increased water retention on the floodplain			0		
Decreased water retention on the floodplain			0		
Reference State conditions	0,0		0		
Sub-total		0	**0**	***#DIV/0!***	

Assessing Catchment Effects	
-	
Changes in flood peaks	
INCREASE? Is there catchment hardening (urbanisation) in the catchment?	

DECREASE? Are there many small dams, or a very large dam, upstream of the wetland?			
Changes in base flow			
INCREASE: are there any interbasin transfers, or releases of elevated flows to cater for irrigation?			
DECREASE: is there extensive abstraction for irrigation, or extensively afforested areas, upstream of the wetland?			

On returning to the office, follow the guide provided in Section 6.3 Step 2.4.2 to capture and report on this indicator.

Step 2.4.3: IHI tool to collect data for the present geomorphic state indicators

Table 53: IHI tool to capture data to ascertain the present geomorphological state category of the wetland (DWAF, 2007)

Catchment effects	**Ranking**	**Weighting (0-100%)**	**Rating**	***Confidence Rating (1-5)***	**Impact Score**	***Notes***
Change in **SEDIMENT BUDGET** (calculate below)	1	100	0,0		0,0	
					0,0	

Within-wetland Effects	**Ranking**	**Weighting (0-100%)**	**Rating (0-5)**	***Confidence Rating (1-5)***	**Impact Score**	**Weighted Impact Score**
Erosional features	1	***100***			0	0,0
Depositional features	2	***10***			0	0,0
Sub-total		110		0,0		***0,0***

SEDIMENT BUDGET					***Notes***
If you don't know the answer, leave the cell blank					
Increases in sediment supply	***Change?***	**Increase in sediment transport capacity**	***Change?***		
Can you see evidence of extensive active erosion in the catchment?		Have flood peaks increased due to catchment hardening?			
Is there active bank erosion of the channel in the wetland?		Has an interbrain transfer scheme increased the erosive capacity			

		of the flow?	
Are there many dirt roads in the catchment, and/or are the hillslopes under cultivation?		Have releases from upstream dams *increased* the erosive capacity of the flow? (e.g. sustained high flow releases below very large dams)	
Have any upstream dams or weirs been breached, causing an increase in sediment supply?		Has the capacity of the channel been increased by, for example, levee construction along the channel edges, or channel deepening/widening and/or straightening?	
Has the vegetation cover of the catchment decreased for any reason?			
Decreases in sediment supply		**Decrease in sediment transport capacity**	
Is sediment being trapped by dams or weirs upstream of the wetland?		Has the frequency and/or size of floods been reduced by an upstream dam?	
If there are upstream dams, are there any major tributary confluences between the dam and the wetland system that could introduce replace some sediment?		Has there been a decrease in flow due to diversions from the upstream channel?	
Are there weirs or causeways or other obstructions across the channel, upstream of the wetland, which would trap sediment?			
Has there been sediment mining in any areas?			
Has there been an increase in the catchment vegetation cover?			
Given the above, to what extent do you think the sediment supply to the wetland has changed? (-10 to +10)		**Given the above, to what extent do you think the transport capacity in the wetland has changed? (-10 to +10)**	

On returning to the office, follow the guide provided in Section 6.3 Step 2.4.3 to capture and report on this indicator.

Step 2.4.4: IHI tool for collecting data for the present vegetation state indicator

Table 54: IHI tool to capture data to ascertain the present vegetation state category of the wetland (DWAF, 2007)

VEGETATION ALTERATION – the impacts of landuse activities *within* the wetland on the vegetation of the wetland

Estimate the impact **RATING** (0-5) and aerial **EXTENT** (0-100 %) of the various landuse activities on the wetland system

Landuse Activities on the wetland	**Ranking**	**Weighting**	**Rating (0-5)**	**Extent (0-100%)**	**Impact Score**	**Impact Score**	***Confidence Rating (1-5)***	***Notes (describe the details of impacts***
Mining/Excavation	1	***100***			0	0		
Infilling/Backfilling	2	***70***			0	0		
Vegetation Clearing/Loss/Alteration	3	***60***			0	0		
Weeds or Invasive plants	4	***50***			0	0		
Percentage in Reference State	6	0	0		0	0		
VEGETATION ALTERATION SCORE				0		**0**	***Confidence:***	

On returning to the office, follow the guide provided in Section 6.3 Step 2.4.4 to capture and report on this indicator.

Step 2.4.5: IHI tools for collecting data for the present water quality sate indicator

Table 55: IHI tool to capture data to ascertain the present water quality state category of the wetland (DWAF, 2007)

		CONSIDER THE IMPACT OF THESE ACTIVITIES ON WATER QUALITY:																		
		Modified flow conditions	Inundation: Weirs	Inundation: Dams	Effluent: Urban areas	Effluent: Cultivation (agricultural activities; return flows)	Effluent: Industries	Effluent: Mining	Instream plants (macrophytes) & algae (incl. blue-green)	Forestry	Roads & crossings	Invasive riparian vegetation	Riparian vegetation removal	Bed disturbance: Bull dozing, sand mining, etc.	Bank disturbance: vegetation removal, artificial covering.	Solid waste disposal (rubbish disposal)	**AVERAGE**	**MEDIAN**	**MODE**	**RATING** (use avg, median or mode) **
Water Quality Components	**pH**															☒	**#DIV/0!**	**#NUM!**	**#N/A**	
	Salts															☒	**#DIV/0!**	**#NUM!**	**#N/A**	
	Nutrients															☒	**#DIV/0!**	**#NUM!**	**#N/A**	
	Water Temp.															☒	**#DIV/0!**	**#NUM!**	**#N/A**	
	Turbidity															☒	**#DIV/0!**	**#NUM!**	**#N/A**	
	Oxygen																**#DIV/0!**	**#NUM!**	**#N/A**	
	Toxics																**#DIV/0!**	**#NUM!**	**#N/A**	

		RATING			Weighting			Confidence (1-5)			*Notes*
Water Quality	**pH**		**0,0**		**1**					0	** It is actually recommended that the ABSOLUTE MAXIMUM impact score be used as the overall rating for each parameter (i.e. the highest absolute value in each row)
	Salts		**0,0**		**1**					0	
	Nutrients		**0,0**		**1**					0	
	Water Temp.		**0,0**		**1**					0	
	Turbidity		**0,0**		**1**					0	
	Oxygen		**0,0**		**1**					0	
	Toxics		**0,0**		**1**					0	

On returning to the office, follow the guide provided in Section 6.3 Step 2.4.5 to capture and report on this indicator.

10 APPENDIX 1: DATA COLLECITON SHEET FOR MONITORING INVERTEBRATES

Table 56: Field sheet for invertebrates

Depth of water at sampling site		Surface area sampled	
Taxon (tick box if present)			
Cnidaria jellyfish		Conchostraca clam shrimps	
Turbellaria flatworms		Cladocera water fleas	
Nematoda roundworms		Acarina water mites	
Oligochaeta earthworms		Ephemeroptera mayfly nymphs	
Hirudinea leeches		Odonata dragon-, damsel-fly nymphs	
Gastropoda snails & limpets		Trichoptera caddisfly larvae	
Bivalvia mussels & clams		Hemiptera true bugs	
Ostracoda seed shrimps		Coleoptera beetle larvae & adults	
Copepoda copepods		Culicidae mosquito larvae	
Anostraca fairy shrimps		Chironomidae midge larvae	
Notostraca shield shrimps		Ceratopogonidae biting midge larvae	
Other taxa			