FRAMEWORK FOR THE MANAGEMENT OF WETLANDS WITHIN CATCHMENTS WHERE ESKOM OPERATES

Report to the

Water Research Commission

by

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EXECUTIVE SUMMARY

South Africa is a water stressed country. The definition of water stress is related to water scarcity as it includes the need to meet both human and ecological needs. The country also has huge economic development pressures and social upliftment challenges which increase the pressure on water availability (WWF, 2014). South Africa, with carbon emissions in 2012 at 330 000 kt (6.3 t per capita), ranks 19th in the world for total carbon emissions (Olivier et al., 2014). Eskom's coal-fired power stations are large contributors to South Africa's carbon emissions.

Since the revision of environmental policy and legislation that began after 1994 the legislative requirements for wetland management have become much more demanding – in particular the National Water Act (1998), the various parts of the National Environmental Management Act (1998), National Environmental Management Protected Areas Act (2003) and the National Environmental Management: Biodiversity Act (2004). There are also other acts that have effect on wetland management. These Acts require a high level of compliance from those working in and around wetlands. The legal requirements are evolving so it is necessary to keep abreast of the requirements and adapt to changes as they occur.

This can be challenging for the environmental managers at Eskom. The wetland management framework (WMF) has been developed to give guidance in the decision making and management of wetlands on Eskom property. The WMF, as developed, is suitable for broader application than just Eskom. The ecological and management principles are applicable anywhere in southern Africa and beyond. The legal aspects, however, are specifically South African. The framework may be applied to agricultural, urban, mining or other developments in South Africa with little modification. The intention of this document is that it should provide an industry standard that will get embedded in Eskom's *modus operandi* and be used by Eskom personnel. To this end the structure has followed that of the Eskom Project Life Cycle Model (PLCM). This project has added an extra dimension to the Eskom PLCM by creating a process for the management of wetlands within the current legal environment and the current understanding of the ecosystem services in a format that may be embedded within the existing PLCM.

Background

Eskom (originally ESCOM or EVKOM) was established in 1923 in terms of the Electricity Act of 1922. It follows that much of the infrastructure was built before the more recent understanding of the importance of the contributions of ecological infrastructure to the national economy or the spate of new legislation post 1994.

The realization amongst water managers that the country was going to be short of water came to the fore after the drought of the late 1960s. But it wasn't for another two decades or so that this knowledge became widely accepted. So water stress has been an issue since the late 20th century.

The earlier developments were put in place without the current understanding of the need to conserve water or the need to care for the environment by, for instance, protecting water quality or providing environmental flows.

Wetlands are now recognized as important providers of ecosystem services. A recent publication (De Groot et al., 2912) shows that inland wetlands are the most valuable

providers of ecosystem services of all the inland biomes. The greatest contribution to this value is the regulating services.

Eskom benefits from these services, but with the coal fired power stations of Mpumalanga and the Ingula PSS being in the upper catchments of major river systems, the activities of Eskom have the potential to influence the quality of the benefits provided by the ecological infrastructure to others downstream in the SES. It is, therefore, part of Eskom's corporate responsibility to the SES to conserve the wetlands that provide these benefits to the wider SES.

One of the requirements of the NWA is that a water use license (WUL) is required for any activity that will affect a water course or wetland. While not national policy, there is an emphasis on no net loss of wetlands in the issue of WULs and there is a corps of expertise that has developed around the management and rehabilitation of rivers and wetlands. The delineation of wetlands is a basic requirement for the issue of a WUL, as is the buffer zone around wetlands. The current regulatory zone around wetlands is 500 metres – as such any activity within the regulatory zone requires a Water Use Licence.

The demand for a high level of compliance creates the need for a defined and repeatable methodology for guiding environmental managers and others who plan developments that may impact on the environment to follow so that the impacts can be minimized and, where necessary, the required authorisations may be applied for in advance. The issue of authorisations is a fairly lengthy process and can delay projects if not taken into account early enough.

The wetland management framework (WMF) developed during this project incorporates the legal requirements in a way that integrates them into the overall process of managing wetlands on site during the various stages of the PLCM.

Eskom is one of seven South African companies (123 world-wide; 2014 figures) which have accepted the challenge of the UN CEO Water Mandate to embrace responsible water stewardship. This commits Eskom to a number of activities around caring for water and the institutional environment. In addition to the achievement of a high level of water management in-house, there is a commitment to influence the supply chain to do the same.

The ecological infrastructure that provides the benefits to the SES is not confined by the boundaries of individual properties but by catchments. The commitment through the CEO Water Mandate to manage the water resource should, therefore, be managed by consensus, catchment-wide within the complex SES. Eskom, being a major player within the catchments in which it operates, is in the position to begin to address this.

Objectives

The overall objective of this project was to develop and test an adaptable planning framework that streamlines the conservation of wetlands in areas where Eskom operates from coal to customer.

The following aims were addressed in order to achieve the overall objective:

- To conduct a situation analysis on the methods available to achieve ecologically sustainable energy generation.
- To develop an adaptable strategic framework that considers the sustainability of ecosystems at catchment scale and which can be implemented nationally.
- Collaboratively develop, streamline and test an Eskom environmental conservation management plan on selected sites.

- To understand the capacity needs necessary for the application of new monitoring tools, if any, and train the core group of implementing officers.
- To recommend further research on broader water and energy knowledge gaps.

Approach

The first step in the process of developing the required wetland management system was to conduct an extensive literature review.

Next, the wetland management framework (WMF) was incorporated into the Eskom Project Life Cycle Management (PLCM) process.

The incorporation of the WMF into the Eskom PLCM would embed it in the process. This would enable environmental managers, decision-makers and engineers to make valid decisions within the complexity of integrating issues from the ecological, legal, corporate responsibility and the broader environment of the social-ecological system (SES) in a manner congruent with the existing stages of project management.

An additional stage to the PLCM, 'Operation' between the steps of Commissioning and Handover and Close out was inserted.

In addition, the Eskom Water Strategy was examined and a generic structure of a large corporate organisation was drawn up to find the most appropriate section of the organisation to perform the various tasks.

The WMF has a total of 78 steps necessary to align with the PLCM. These are distributed as shown in Table 1. In each stage of the PLCM the aspects of wetland management that need to be addressed are listed consecutively so that the person using the framework can work through the stage and not omit anything.

Table ES1: Illustrating the number of action steps in the WMF addressing each category of the PLCM

Stage in the PLCM	Action steps
Pre-Feasibility	1-12
Feasibility	13-26
Business Plan	27-37
Planning and design	38-45
Contracting and procurement	46-48
Construction	49-53
Commissioning and hand-over	54-58
Operation	59-71
Close-out	72-74
Evaluate	75-78

Each action step has five components. The first is the stage of the PLCM that is being addressed. The second, the title of the action step, defines the scope of the step. The third gives the relevance to category of focus or impact. This is expressed by a symbol. The fourth component is a list of key questions which will guide the user in the actions to be taken to address the step. The final component lists the organisational elements which will need to be addressed.

Taking Action step 18 as an example: Perform Basic Design is illustrated in Table 2. In the WMF, the first three columns are colour coded differently for each step of the PLCM.

The WMF is designed in such a way that it can be accessed for the step relevant for the stage of the PLCM which is to be addressed. As a result there is some repetition in the overall framework to ensure that nothing important is omitted.

Table ES2: The application of the wetland management framework (WMF) in the context of the PLCM with action step 18 as the example

Stage	Action Steps	Focus or Impact	Core Questions	Organisational Elements
Feasibility	18 Perform basic design		I. Have wetlands and their buffer zones been indicated on the site lay-out plan? II. Are there any alternatives to the project design/lay-out to minimise impacts on wetlands, e.g.: a. Location (alternative properties) b. Site (alternative sites on the property) c. Activity alternatives d. Layout alternatives e. Design alternatives f. Technology alternatives, g. Operational alternatives? III. If rehabilitation will be undertaken, has a partnership with Working for Wetlands been established? IV. If artificial wetlands are considered, has a suitably qualified and experienced person been involved and has the time taken for the wetland to reach optimum efficiency been taken into account? Has maintenance infrastructure (such as cutting and removal of vegetation) been incorporated into the planning?	• Data and Information systems • Communication systems

1.1 SUB-FRAMEWORKS OF THE WMF

A number of sub-frameworks were considered while developing the WMF. This was considered necessary to capture the complexity of issues which needed to be addressed. These are listed below and described in greater detail after the WMF in the report:

- Hierarchy of conservation targets
- Wetland delineation
- Impact inventory
- Impact assessment
- Wetland health assessment
- Vegetation
- Prioritisation of wetlands for rehabilitation
- Rehabilitation of impacts

- Biodiversity corridors
- Buffer zones
- Indicators
- Vegetation management under transmission lines
- Ecosystem services
- Wetland offsetting
- Monitoring
- Ecosystem services for communities
- Pollution attenuation
- Constructed wetlands
- Natural wetlands
- Carbon storage in wetlands

Case studies

In order to test the WMF, four power stations were selected for the case studies as follows:

Decommissioned and return to service: Grootvlei

Operational: Matla and Kriel

Construction phase: Kusile.

A water management plan (WMP) was developed for Matla in three phases.

Phase 1: Preparation, Status Quo Analysis on site: The intended outcome of Phase 1 is to preserve the status quo on site.

Phase 2: Looking beyond the fence line: The intended outcome of Phase 2 is to develop an integrated wetland management plan.

Phase 3: Taking it a step further: The intended outcome of Phase 3 is engaging the supply chain and implement best practices and planning for closure.

The WMP also lists basic functions which need to be part of each of the phases.

Eskom's position in the social-ecological system was examined using the Framework developed by Anderies et al., 2004 (Figure 1). Eskom's relationship to the water resource was assessed in the following ways:-

- The relationship with users upstream in the catchment. This includes inter-basin transfers,
- The managing of aquatic ecological infrastructure on site,
- The relationship with users downstream of the Eskom activities,
- The management of aquatic ecological infrastructure over the transmission network and
- Eskom-owned mines and purchase agreements.

Eskom's role as a resource user was examined from the point of view of the commitment to the UN CEO Water Mandate.

The public infrastructure providers (Government Departments, the CMA, Olifants River Forum, etc.) set the rules for operating in the catchment. Eskom's role in this milieu was examined from the legal requirements point of view and their advocacy role.

Eskom's role with the public infrastructure has two branches. The first is their compliance with legislation and other rules and the second involves the use and maintenance of physical infrastructure such as water supply systems.

The arrows between the boxes indicate the interactions between the four boxes. The arrows at the top and bottom of the figure indicate socio-economic external influences over which Eskom has no control such as economic factors. The arrows coming into the sides indicate environmental influences over which Eskom has no control such as extreme weather events.

The framework was populated using the data from the case study on Matla power station.

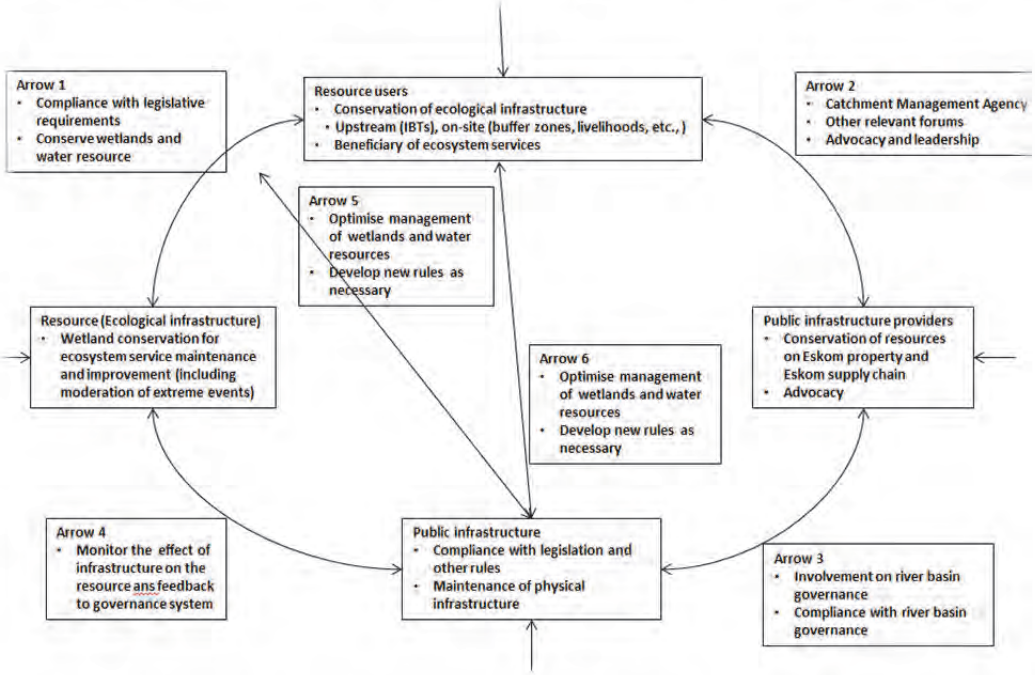

Figure ES1: Possible areas of involvement for Eskom in the Matla Wetlands case study, as defined by the Anderies Framework

A series of modules as power point presentations were developed on the following topics:

1. What is a wetland
2. National policy
3. Eskom Project Life Cycle Model
4. Adaptive management
5. Sub-frameworks for the wetland management framework
6. Using the wetland management framework.

There is a read-me file which explains how the hyperlinking system works. It is important to read this before starting.

Each of these modules has slides that are hyperlinked to relevant documents.

Managers and engineers need only do modules 1, 2 and 3. Personnel responsible for environmental management should do modules 2 through 6.

Results

The report consists of seven chapters that cover the following aspects of wetland management on Eskom properties.

There is also a series of 6 power point presentations covering relevant topics related to wetland management. Each of these has hyperlinks into relevant documents so that the reader may get more detail on each of the topics addressed. This is accompanied by an Instructors manual which gives the methodology. The modules are designed in such a way that managers and engineers need only do Modules 1, 2 and 3 while environmental managers need to do modules 2 to 6. The **README** file explains how the system should be used and it is important that the person reads this before starting.

The PowerPoint presentations cover the following topics:

1. Wetlands, ecosystems and biodiversity.
2. National policy and legislation, application for water use license and Eskom-specific policies.
3. The Eskom Project Life Cycle Model.
4. Adaptive management – the process of learning by doing.
5. Introducing the sub-frameworks on which the wetland management framework is based.
6. An exercise in using the wetland management framework.

Chapter 2: Literature Review

The literature review (Chapter 2) addresses a broad sweep of issues around wetland management. The focus of this chapter has been on South African literature, with the international literature included where relevant. The review covers the current policy and legislation as it applies to wetlands and includes such issues as wetland inventory, wetland delineation and buffer zones. The ecological aspects covered include aspects such as the sustainability of ecological infrastructure, ecosystem services provided by wetlands. Carbon sequestration and pollution attenuation by wetlands have been covered in some detail. Indicators of wetland health and impacts on wetlands have been reviewed. Rehabilitation and offsetting are topical discussion points and these have been covered. The place of constructed wetlands in the overall management milieu has been addressed. Eskom has internal policies on aspects such as vegetation and water management on Eskom property and servitudes. Where these have been made available, they have also been covered.

Chapter 3: The Wetland Management Framework

The steps of the wetland management framework (WMF) have been developed to match the Eskom Project Life Cycle Model (PLCM). The PLCM is the standard approach used by Eskom in managing its projects. The WMF adds a further dimension to the PLCM in that it provides the means whereby protection of the surface water environment, in particular wetlands, may be integrated into the standard PLCM in a logical manner. This was done so that the WMF may be used at any stage of an Eskom project to identify and address the relevant wetland issues while a project is progressing. The WMF is based on a number of sub-frameworks covering the range of topics needed to address the diverse aspects of wetland management. The following aspects are addressed for each of the 78 steps of the WMF:

- The relevance of the step to the category of focus or impact of the step (legal, environmental, social responsibility and the role of Eskom in the wider catchment management).
- One or more core questions to guide the process to address each step.

- The various corporate organizational elements which would be involved, for instance skills development systems, HR systems or data and information systems.

Chapter 4: Selected Case Studies to Test the Robustness of the wetland management Framework

Case study sites for testing of the WMF were selected on the criteria of the constructional (Kusile), operational (Matla and Kriel) and return-to-service (Grootvlei) phases of the PLCM. For each of these the level at which the steps of the WMF had been addressed was assessed. In each case, it was found that the legal issues were prioritised, but Kusile was the only Power Station (PS) that had addressed wetland management on the property. Following this, the steps of a wetland management plan for Matla PS were drawn up to guide the PS through the steps necessary to conform to the legal, environmental and corporate responsibility of Eskom on the site.

Chapter 5: The catchment perspective

Recognising that Eskom has a national footprint geographically and is a major user of water, the chapter addresses the responsibilities of Eskom (both Head Office and on site) concerning the management of environmental, social and institutional issues. The chapter is structured around two frameworks, that of Anderies et al. (2004) which assesses the robustness of a social ecological system (SES) and that of the Millennium Ecosystem assessment (2005) which defines the ecosystem services. Key references are provided for each category of responsibility to guide the activities identified. Finally, using the data and information from the Matla case study (Chapter 4), the Anderies framework has been populated at the desktop level using the quaternary catchments B11E and B11D as the wider SES. This illustrates the role of Eskom in the SES of the catchments in which Eskom is active.

Chapter 6: Future Research Needs

A number of sources were consulted during the identification of the future research needs. Some of the needs identified are Eskom-specific while others apply to other entities as well. Within the SES some are technical, some ecological, some economic, some related to policy and legislation and some related to community upliftment. The investigation of alternate technologies is also addressed.

Future research needs for the water / energy nexus

A total of 40 potential research areas have been identified for the WRC to consider. Some of these are directly relevant to Eskom. The following topics have been assessed as priority areas in a preliminary assessment. The full suite of research areas should, however, be considered before the final decisions are made.

- Technical Research
    - Soil carbon sequestration by wetlands and release of carbon when wetlands are disturbed (paragraph: Soil carbon).
    - Water conservation and demand management (water use efficiency) (paragraph: Water conservation and demand management). Various parts of the process use water at different rates, the selective catalytic reducing process and flue gas desulphurization may be identified as priority areas.

    - Integrated natural resource management. The possibility of the existing strategy being rolled out into the catchments where Eskom operates should be investigated (paragraph: Integrated natural resource management for the benefit of ecosystem services).
- Social/economic research
    - The benefits and costs of alternate technologies available to power generation, water use and impact on quality, impact on the environment and impact on food production. The contribution of each to the carbon footprint should be considered (Benefits and costs to power generation, water use and food production).
    - Ecosystem-based adaptation to climate change for Eskom-specific activities (The energy, agriculture and water nexus).
- Legal/policy research
    - Possible future changes in wetland or water policy and legislation (Consideration of possible future changes in wetland or water policy and legislation).

Conclusions

As South Africa is a water-stressed country, it is necessary that every water user play their part in conserving the resource. As a major industrial water user, Eskom has an important role to play both in water conservation and in a leadership capacity.

The wetland management framework (WMF) has been structured to mesh with Eskom's Project Life Cycle Model. In this way environmental managers are guided through the necessary activities for each phase of the PLCM. The WMF has been developed as a practical 'how to' guide for managing wetlands on Eskom's property to ensure a consistent level of performance across the organisation.

Industry perspective

From the industry perspective the wetland management framework represents best practice. It is recommended that a phased approach be taken when implementing the WMF on properties that were developed before the current legislation was promulgated, beginning with issues of legal compliance. Legal compliance is an aspect that is becoming increasingly important.

Keywords

Wetland management, ecosystem services, compliance, catchment management, corporate environmental responsibility.

Future review

The wetland management framework should be regarded as a living document. As such, once it is in use it should be reviewed to assess how it may be refined to fulfil Eskom's needs in a more focused way.

The legal landscape is still evolving. Changes in the policies, legislation and regulations affecting wetlands and water management should be anticipated and incorporated into the WMF as appropriate.

Return on investment

The return on investment may be considered in three ways. Firstly, the investment has resulted in the delivery of a wetland management framework which will empower

environmental managers to engage meaningfully in the planning and execution of activities within the PLCM. Secondly, if implemented as recommended, it has the potential to save Eskom from having to pay penalties for non-compliance to environmental and other requirements. Thirdly, the potential to harness ecological services to the benefit of Eskom through comprehensive wetland management, will contribute to the preservation of water quality and water availability.

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LIST OF ABBREVIATIONS

Abbreviation	Definition
AMD	Acid water from mine workings
ARC-ISCW	Agricultural Research Council – Institute for Soil, Climate and Water
ARD	Acid water from waste rock
BGIS	Biodiversity GIS
CDM	Clean development mechanism
CMA	Catchment management area
CSI	Corporate Social Investment
DEAT	Department of Environmental Affairs and Tourism
DPSIR	Driving forces, Pressures, States, Impacts, Responses Framework
DWA(F)	Department of Water Affairs (and Forestry) (up to 2014)
DWS	Department of Water and Sanitation (from 2014)
EIA	Environmental Impact Assessment
EIS	Ecological importance and sensitivity
EMP	Environmental management plan
EMS	Environmental management system
FGD	Flue Gas Desulfurization
GHG	Green House Gas
HR	Human Resources
IBT	Inter basin transfer
IWRM	Integrated water resource management
KAP	Knowledge, Attitude, Practice
MA (MEA)	Millennium ecosystem assessment
NFEPA	National Freshwater Ecosystem Priority Area
NWA	National Water Act (Act 36 of 1998)
PAH	Polycyclic aromatic hydrocarbon
PCBs	Poly Chlorinated Biphenyls
PCLM	Eskom Project Life-Cycle Model
PE	Primary Energy
PES	Present ecological state
PLCM	Project life cycle model
POP	Persistent organic pollutant
PS	Power station
RoD	Record of decision

Abbreviation	Definition
RQOs	Resource Quality Objectives
RWQO	Resource Water Quality Objectives
SACNASP	The South African Council for Natural Scientific Professions
SAM	Strategic Adaptive Management
SANBI	South African National Biodiversity Institute
SES	Socio-ecological system
TEEB	The Economics of Ecosystems and Biodiversity
UNFCCC	United Nations Framework Convention on Climate Change
URS	User Requirement Specification
WfWet	Working for Wetlands
WMA	Water management area
WMF	Wetland management framework
WMP	Water management plan
WRC	Water Research Commission
WRCS	Water resource classification system
WRM	Water resource management
WSLG	Water Sector Leadership Group
WUA	Water User Association
WUL	Water use licence

GLOSSARY OF TERMS

Term	Definition with a brief description
Ecological infrastructure	Ecological infrastructure refers to **naturally functioning ecosystems that deliver valuable services to people**, such as fresh water, climate regulation, soil formation and disaster risk reduction. It is the nature-based equivalent of built or hard infrastructure, and is just as important for providing services and underpinning socio-economic development.
Ecosystem services	The aspects of ecosystems (including ecosystem organisation or structure as well as process and/or functions) that are utilized by people to produce human well-being (Millennium Ecosystem Assessment, 2005). Ecosystem services are the benefits provided to the social-ecological system.
Integrity	Integrity is defined as the ability of a system to support "a balanced integrated, adaptive community of organisms having a species composition, diversity, and functional organization comparable to the natural habitat of the region" (Karr and Dudley, 1981; U.S. EPA, 2002a; Fennessy et al., 11 – 2007)
Resilience	The concept of resilience measures the amount of change or disruption that is required to transform the maintenance of a system from one set of mutually reinforcing processes and structures to a different set of processes and structures (Anderies et al., 2004).
Resource	The Resource is defined in terms of the ecosystem services it delivers. This definition integrates the ecosystem services from which the Social-Ecological System derives benefits with the health of the ecological infrastructure which provides these benefits.
Robustness	The concept of robustness is well developed in engineering, where it refers to the maintenance of system performance either when subjected to external, unpredictable perturbations, or when there is uncertainty about the values of internal design parameters (Anderies et al., 2004).
Social-ecological system (taken as equivalent to socio-ecological system)	A social-ecological system is a linked system of people and nature. (Roux et al., 2009); or, a socio-ecological system can be defined as people, their natural and human-made resources and the relationships among them (Anderies et al. 2004).

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1 INTRODUCTION

1.1 BACKGROUND

Internationally, the water supply crisis is ranked amongst the top five global risks both in terms of its likelihood to happen as well as its impact by the World Economic Forum 2013 report. Global freshwater demand is projected to exceed current supply by 40% by 2030. This will increase the risks on food, energy and industrial and human security globally. The projected shortage of water has a number of contributing factors which are listed below:

- Increasing water demand. Population growth and economic development contribute to a substantial increase in water demand.
- Water scarcity and unsustainable supply. Water is already over-allocated in many regions of the world and approximately 2.4 billion people (circa 1/3 of the world population) live in water stressed countries.
- Declining water quality. Poor water quality is an acute problem around the world with the main contributors globally being agricultural runoff, industrial wastewater and poorly treated human waste. The two major causes in South Africa are poorly treated municipal (human and industrial waste) and acid mine drainage.
- Unmet environmental, social and economic needs. While the water may be available to meet these needs, this may in some cases be a water resource management issue.
- Changing expectations. During the 20th century, the global population increased 4-fold while the water demand increased 9-fold.
- Climate change. Projections of climate change indicate that, firstly, in certain areas of the world precipitation will decrease while in others it will increase. Secondly, the nature of precipitation events will change, becoming less frequent and more violent. In addition, the projected increase in heat wave events will increase evaporation from rivers and storage reservoirs (UN CEO Water Mandate; World Economic Forum).

Where does South Africa fit into this picture? To quote the WWF (2014):

> South Africa is a chronically water stressed country with huge economic development pressures and social upliftment challenges.
>
> Water availability is one of the most decisive factors that will affect the economic, social and environmental well-being of South Africa over the next decade, and its supply is already precariously limited.
>
> In the past, South Africa has invested heavily in water infrastructure and this is, in part, why the country has enjoyed a false sense of water security. However, the country is fast approaching full utilisation of available surface water yields, and running out of suitable sites for new dams.
>
> Water supply issues cannot be solved by simply building more dams or creating more infrastructure, but rely heavily on rehabilitating, maintaining and conserving the natural areas which form the critical catchments and "water factories" for the country. Furthermore, climate change models also predict significant changes to both rainfall and temperature in southern Africa, which will affect water storage negatively.

Figure 1 provides an overview of the water stress experienced globally. South Africa is currently in the region of High Stress.

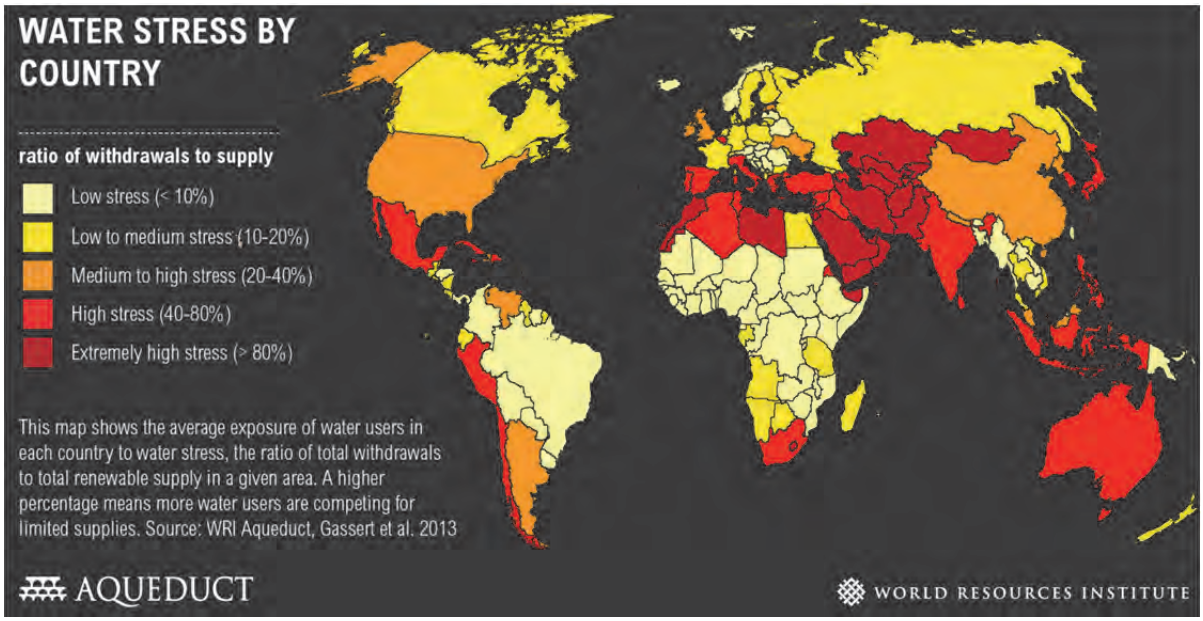


Figure 1: Illustrating the water stress experienced by countries globally (http://www.wri.org/sites/default/files/uploads/water_stress_by_country.png)

Water stress is a more inclusive term than water scarcity, and is defined by the Pacific Institute as follows:

> "Water stress" refers to the ability, or lack thereof, to meet human and ecological demand for water. Compared to scarcity, "water stress" is a more inclusive and broader concept. It considers several physical aspects related to water resources, including water scarcity, but also water quality, environmental flows, and the accessibility of water (http://pacinst.org/water-definitions/).

Eskom is one of the biggest industrial water users in the South Africa accounting for about 2% of the national water requirement in the year 2000 (NWRS, 2004). Eskom supplies over 95% of South Africa's electricity and generates 45% of the electricity used on the African continent (Eskom 2009a). In addition to this, the electricity distribution grid covers the entire country. Eskom also owns and manages several coalmines. Eskom generates the bulk of electricity used in South Africa and electricity is fundamental to the functioning of modern society. Much of the country's economic activity, as well as its social stability, depend on there being an efficient and reliable supply of electrical power. Thus, Eskom's water use is considered to be of strategic importance by the Department of Water and Sanitation. Water use designated as being of strategic importance will, however, be subject to the same efficiency criteria and water demand management requirements as is applied to other uses (NWRS, 2004).

United Nations CEO Water Mandate

Water poses one of the greatest sustainability challenges of the 21st Century. Water scarcity and pollution, among many other issues, threaten our ability to grow strong and stable economies, meet basic human needs, and protect healthy ecosystems (and the services they provide), while also posing severe human health problems. Business organizations are greatly affected by – and also often contribute to – these important issues.

Because of this, they are increasingly seeking more information and trying to understand how to address these challenges.

The UN CEO Water Mandate is a part of the UN Global Compact. The UN Global Compact 'asks companies to embrace universal principles and to partner with the United Nations. It has grown to become a critical platform for the UN to engage effectively with enlightened global business.' Launched in July 2007 by the UN Secretary-General, the UN CEO Water Mandate is a unique public-private initiative designed to assist companies in the development, implementation, and disclosure of water sustainability policies and practices (UN CEO Water Mandate).

The UN CEO Water Mandate is, thus, aimed at mobilising a critical mass of business leaders to embrace responsible water stewardship. Worldwide there are currently 123 companies that have signed up to embrace the principles of the mandate, with seven of these being South African companies (UN CEO Water Mandate, 2014). As a signatory to the UN CEO Water Mandate, Eskom actively encourages its suppliers and other role players to improve their water conservation, quality monitoring, wastewater treatment and recycling practices. Whilst some of their activities generate pollution, Eskom requires clean water for its own processes and also recognizes the value of the ecosystem goods and services generated by healthy ecosystems and the benefits that society derives from these. To this end, Eskom has developed its water management policy which addresses Eskom's contribution to the national long-term sustainability of the water resource and outlines how this is to be achieved. Eskom is committed to the maintenance of water resources within the catchments within which it operates, as it requires good quality water for its boiler and other operations. The national economy relies on the power generated by Eskom, but equally it is essential to maintain the natural water infrastructure in good condition so that it will continue to deliver the benefits on which the socio-economy depends. The utility is thus committed to ensuring that the ecosystems and wetlands in particular, under their jurisdiction are maintained in a healthy ecological state.

South Africa's water scarcity creates the imperative for increasing the efficiency of water use. Eskom is proactive in this and, in addition to being signatory to the UN CEO Water Mandate, has formed water management task teams to improve the efficiency of water usage. The current target for water use, utility-wide, is 1.32 ℓ kWh^{-1}. The target set for 2017 is 1.20 ℓ kWh^{-1} (Divisional Report Key indicators, 2012). This target puts pressure on Eskom Holdings to implement effective water conservation and water demand management across all their activities. However, dry cooling power stations use considerably less water, with Matimba Power Station, the largest dry-cooled power station in the world, using 0.1 ℓ kWh^{-1}. Medupi PS and Kusile PS will both use dry-cooling technology.

Eskom therefore saw the need to develop a generic framework for a conservation plan that may be implemented, with appropriate customization, on all its properties and contractually-bound coal suppliers (Please refer to the Terms of Reference in the block below). The Framework needs to be integrated into measures aimed at the management of Eskom's strategic and operational activities. The overall framework developed consists of several sub-frameworks, each designed to address specific aspects of Eskom's activities. For instance, the Conservation Plan Framework promotes the conservation of the environment together with the ecosystem services that the environment provides and the sustainable environmental planning framework within a catchment perspective has been developed with this in mind.

Eskom's Footprint

Geographically, Eskom has a national footprint although the coal-fired power stations are largely concentrated in the upper Olifants and upper Vaal basins in Mpumalanga (Figure 2). The water footprint, however, extends beyond the upper Olifants and Vaal basins as both

basins support economic activities which require more water than is available in the basins. The extra water is supplied by inter-basin transfers (IBT) from surrounding basins (

Figure 3) which effectively extends the geographical footprint to include the donor river basins. This has been taken into account in assessing the sustainable environmental planning as Eskom requires the assurance of supply of water (both quality and quantity) that is provided by these IBTs.

It was noted that, at the start of this project, Eskom had two other initiatives on wetlands. These were the booklet entitled 'Wetland classification and Risk Assessment Index' (Oberholster et al., 2014) and the development of a GIS supported wetland inventory of Eskom properties.

Figure 2: Map of Eskom's power generation and main distribution infrastructure. Kusile is not on this map (http://www.eskom.co.za/c/article/730/map-of-eskom-power-stations/

Figure 3: The inter-water management area transfers in the north eastern part of South Africa (NWRS 1, 2004: p 17)

In addition to the power generation infrastructure itself, Eskom has approximately 30 000 km of power line servitudes together with a number of substations associated with the distribution network.

Eskom's Water Strategy

As may be seen, Eskom's footprint is nation-wide. Taking cognisance of the fact that Eskom is a strategic user of water and that the utility accounts for circa 2-3% of South Africa's water use (Eskom Water Policy) with a footprint extending across the country, Eskom has engaged with the Department of Water and Sanitation National Water Resource Planning Directorate to develop a long-term water strategy. This strategy is based on the following principles:

- Social progress which recognizes the needs of everyone;
- Effective protection of the environment;
- Prudent use of natural resources
- Supporting an environment of high, stable economic growth and employment.

The strategy includes water demand management and reuse of effluents, and the key elements are as follows:

- Meet the water requirements for new power stations
- Meet the water requirements for existing power stations
- Develop long-term water plans to ensure security of water supply
- Develop and implement a water conservation and water demand management strategy
- Meet the water quality objectives of the various catchments
- Efficiently manage water cost increases into the future
- Actively influence policy, strategy, planning, legislative and regulatory issues related to water
- Engage stakeholders on water challenges and solutions.

(http://financialresults.co.za/2011/eskom_ar2011/cd_grp_commercial04.php).

The objectives identified in this strategy are to:

1. Ensure long term water scenario planning
2. Meet the water requirements for new and existing power stations
3. Meet the water quality objectives of the various catchments
4. Manage water cost increases into the future
5. Influence policy, strategy, legislation and regulatory environment
6. Regular communication and intervention with respective government departments and
7. other stakeholders by means of a dedicated advocacy and stakeholder engagement plan
8. Implementing a water conservation water demand management strategy
9. Water management assurance, advisory and supporting role to projects, power stations and coalmines.

In order to achieve the key elements and objectives of the water strategy, Eskom has developed the Vision 2030 which outlines the pathway and milestones to be followed between 2009 and 2030 which was presented to the Water Sector Leadership Group during 2009. The pathway and milestones are illustrated in Appendix 1 (Figures 4 and 5).

The milestones and targets relate mostly to compliance, partnerships, technology and management interventions which are all mostly focused on water use efficiencies. The improvement of water use efficiency will have an overall positive effect on the national water budget, including the environment.

ISO 14000

The ISO 14000 family of standards provide guidance towards sustainable environmental management and the standards together with the monitoring programmes, etc. developed under this framework should be applied to Eskom's activities. International standards are becoming increasingly important for organisations working together to achieve proactive environmental management, risk management, sound corporate governance and sound operational and financial practices. ISO 14000 also provides a yardstick which may be used by governments and regulatory bodies to assess and ensure alignment nationally and internationally. ISO 14000, widely used in Europe for management of the environment including wetlands, is gaining acceptance in the USA because of the standards that it offers in fields such as environmental auditing and environmental performance evaluation. In addition, it offers guidelines for sustainable development, pollution prevention and assurance of compliance. While ISO 14000 certification is not compulsory, it does offer a measure of competence in the sustainable management of the environment (The Wendel Insider, Fall 2003). South Africa ranks 72 out of 178 Countries in the Environmental Performance Index (http://epi.yale.edu/epi/country-rankings) and the focused implementation of ISO 14000 will help to improve this ranking.

Legislation

Eskom strives to comply with the legislative landscape within which it operates. The framework for wetland management needed to address this as a matter of priority. To this end the policies on water management and the management of alien and invasive vegetation on Eskom holdings complies with the requirements of national legislation. The framework underpins this by providing methods which will enable the improved management of wetlands and associated ecosystems on their property.

Water-Food-Energy Nexus

In 1911, John Muir observed, 'When we try to pick out anything by itself in nature, we find it hitched to everything else in the Universe.'

A century later, a gathering of the World Economic Forum discovered the same phenomenon. Four hundred top decision-makers listed the myriad looming threats to global stability, including famine, terrorism, inequality, disease, poverty, and climate change. Yet when we tried to address each diverse force, we found them all attached to one universal security risk: fresh water. (Margaret Catley-Carlson, Patron, Global Water Partnership, 2008-2010, Chair of World Economic Forum Global Agenda Council on Water Security) (quoted from Williams and Pittock, undated).

Eskom has taken cognisance of this interconnectedness through the integration of water and environmental management into the core business of electricity generation. The need for an adequate supply of good quality water is important for Eskom's on-going electricity generation capacity. The supply of sufficient water of good quality is the role of regulating and provisioning ecosystem services and these services depend on.

Kusile PS is the new build power station on the Highveld in western Mpumalanga, an area rich in wetlands. Concern for the impact of construction activities on, and the delivery of ecosystem services in, the wider catchment as led to the development of a wetland management strategy for Eskom's Kusile property (Harris et al., 2013). The wetland management strategy covers such aspects as the impact of turbidity on the functioning of wetland systems downstream of the development and also takes cognisance of Eskom's land and biodiversity policy which requires that measures are in place to limit impacts of infrastructure and other land uses and also comply with all legislation at all stages of the project life cycle.

1.2 LAYOUT OF THE REPORT

The report consists of seven chapters that cover the following aspects of wetland management on Eskom properties.

There is also a series of 6 power point presentations covering relevant topics related to wetland management. Each of these has hyperlinks into relevant documents so that the reader may get more detail on each of the topics addressed. This is accompanied by an Instructors manual which gives the methodology. The modules are designed in such a way that managers and engineers need only do Modules 1, 2 and 3 while environmental managers need to do modules 2 to 6. The **README** file explains how the system should be used and it is important that the person reads this before starting.

The PowerPoint presentations cover the following topics:

1. Wetlands, ecosystems and biodiversity
2. National policy and legislation, application for water use license and Eskom-specific policies.
3. The Eskom Project Life Cycle Model.
4. Adaptive management – the process of learning by doing.
5. Introducing the sub-frameworks on which the wetland management framework is based.
6. An exercise in using the wetland management framework.

Chapter 2: Literature Review

The literature review (Chapter 2) addresses a broad sweep of issues around wetland management. The focus of this chapter has been on South African literature, with the international literature included where relevant. The review covers the current policy and legislation as it applies to wetlands and includes such issues as wetland inventory, wetland

delineation and buffer zones. The ecological aspects covered include aspects such as the sustainability of ecological infrastructure, ecosystem services provided by wetlands. Carbon sequestration and pollution attenuation by wetlands have been covered in some detail. Indicators of wetland health and impacts on wetlands have been reviewed. Rehabilitation and offsetting are topical discussion points and these have been covered. The place of constructed wetlands in the overall management milieu has been addressed. Eskom has internal policies on aspects such as vegetation and water management on Eskom property and servitudes. Where these have been made available, they have also been covered.

Chapter 3: The Wetland Management Framework

The steps of the wetland management framework (WMF) have been developed to match the Eskom Project Life Cycle Model (PLCM). The PLCM is the standard approach used by Eskom in managing its projects. The WMF adds a further dimension to the PLCM in that it provides the means whereby protection of the surface water environment, in particular wetlands, may be integrated into the standard PLCM in a logical manner. This was done so that the WMF may be used at any stage of an Eskom project to identify and address the relevant wetland issues while a project is progressing. The WMF is based on a number of sub-frameworks covering the range of topics needed to address the diverse aspects of wetland management. The following aspects are addressed for each of the 78 steps of the WMF:

- The relevance of the step to the category of focus or impact of the step (legal, environmental, social responsibility and the role of Eskom in the wider catchment management).
- One or more core questions to guide the process to address each step.
- The various corporate organizational elements which would be involved, for instance skills development systems, HR systems or data and information systems.

Chapter 4: Selected Case Studies to Test the Robustness of the Environmental Conservation Framework

Case study sites the testing of the WMF were selected on the criteria of the constructional (Kusile), operational (Matla and Kriel) and return-to-service (Grootvlei) phases of the PLCM. For each of these the level at which the steps of the WMF had been addressed was assessed. In each case, it was found that the legal issues were prioritised, but Kusile was the only PS that had addressed wetland management on the property. Following this, the steps of a wetland management plan for Matla PS were drawn up to guide the PS through the steps necessary to conform to the legal, environmental and corporate responsibility of Eskom on the site.

Chapter 5: The Catchment Perspective

Recognising the Eskom has a national footprint geographically and is a major user of water, the chapter addresses the responsibilities of Eskom (both Head Office and on site) concerning the management of environmental, social and institutional issues. The chapter is structured around two frameworks, that of Anderies et al. (2004) which assesses the robustness of a social ecological system (SES) and that of the Millennium Ecosystem assessment (2005) which defines the ecosystem services. Key references are provided for each category of responsibility to guide the activities identified. Finally, using the data and information from the Matla case study (Chapter 4), the Anderies framework has been populated at the desktop level using the quaternary catchments B11E and B11D as the wider SES. This illustrates the role of Eskom in the SES of the catchments in which Eskom is active.

Chapter 6: Future Research Needs

A number of sources were consulted during the identification of the future research needs. Some of the needs identified are Eskom-specific while others apply to other entities as well. Within the SES some are technical, some ecological, some economic, some related to policy and legislation and some related to community upliftment. The investigation of alternate technologies is also addressed.

2 LITERATURE REVIEW

2.1 LITERATURE REVIEW

Water management

Professor Schulze of the University of KwaZulu-Natal (pers. comm.) observes that variability and uncertainty are two factors that Australia and South Africa have in common. The co-efficient of variability of the climate, rainfall in particular, of these countries is amongst the world's highest, and the variability of runoff varies by two to five times that of the rainfall. He notes that it is the temperature or precipitation events, not the averages, which have the impact.

This variability makes it imperative that South Africa manages its water resource carefully. The focus has been largely on managing the surface water to provide the assurance of supply necessary to support growth in a diverse economy and this has been an effective strategy. Surface water has been impounded where it occurs and, where necessary, infrastructure has been developed to move water to where it is required by means of inter-basin transfers (NWRS 1, 2004).

The present situation is that most of the potential dam sites have been used so few opportunities remain for obtaining more water from the surface environment. But the need for water to support growth and development remains, and as noted by the World Economic Forum (2014) the increase in the demand for water is strongly influenced by the changing expectations of people, with the 4-fold increase in population over the 20th century leading to a 9-fold increase in water consumption. While the NWRS 1 (2004) provides the foundation of water management, the second National Water Resource Strategy (NWRS 2, 2012) has adopted a different approach to management of the water resource, focusing on water security while taking cognisance of the high coefficient of variability of rainfall. It also takes note of the fact that the deterioration of water quality from eutrophication, acid mine drainage, salinization and microbial contamination need to be addressed. The vision guiding the NWRS 2 is aimed at serving the social-ecological system in all its complexity. To this end a number of core strategies will be followed in the management of the water resource to support the social-ecological system.

The core strategies (NWRS 2, 2013) are:

- Implementation of Equity Policy;
- Putting water at the centre of integrated development planning and decision-making;
- Ensuring water for equitable growth and development;
- Contributing to a just and equitable South Africa;
- Prioritising and ensuring the implementation of water conservation and demand management;
- Optimizing and stretching of our available water resources (groundwater, water re-use, desalination (including seawater), water systems optimization and rainwater harvesting);
- Committing to the protection of our water resources and ecosystems;
- Achieving effective and smarter water governance;
- Embedding sustainable business principles and practices in water resources and systems management;
- Implementing a water sector investment framework for infrastructure, human resource capacity and institutions;
- Engaging the private and water use sectors.

Eskom, as noted in Chapter 1, has engaged with the DWS in aligning its water strategy with the national interest. Flowing from this the Eskom Water Management Policy (2013) provides a framework through which Eskom's business should interact with the water resource throughout its value chain. As a strategic water user and signatory to the UN Global Compact – the CEO Water Mandate, Eskom commits to:

- Being proactive in addressing water sustainability issues within Eskom's activities
- Driving water sustainability within the wider social-ecological system
- Encourage companies throughout its value chain to subscribe to water sustainability practices
- Participate in multi-stakeholder forums on water sustainability issues
- Be transparent when dealing with water sustainability issues when dealing with DWS and other stakeholders
- Raise awareness of water sustainability issues across its area of operation
- Ensure that water forms part of sustainability indicators in business decision making
- Participate in national and international accreditations aimed at improving issues around water sustainability
- Invest in research and implementation of new technologies aimed at improving water efficiency and minimising impacts on water resources.

The importance of wetlands

Internationally, the importance assigned to wetlands is reflected by the number of organisations which focus on these ecosystems. The Ramsar Convention (Ramsar, 2014) was initially concerned with conserving habitat for migratory waterfowl but since its inception in 1971 it has broadened its scope in recognition of the important role wetlands play in the provision of livelihoods for people who depend on the stream of benefits that wetlands provide, and now the focus is on wise or sustainable use of wetlands. There are currently 168 contracting parties to the Ramsar Convention, with 2 168 wetlands designated as wetlands of international importance which have a combined area of 208 674 342 ha. Wetlands International is a global NGO with the mission of sustain and restore wetlands, their resources & biodiversity and works towards wetlands being treasured and nurtured for their beauty, the life they support and the resources they provide.

Wetlands are important providers of Ecosystem Services which the Millennium Ecosystem Assessment categorises as supporting, provisioning, regulating and cultural (MA, 2005). This categorisation has been used as a framework to focus the 21 handbooks which make up the toolkit on Wise Use of Wetlands developed by the Ramsar Convention on Wetlands, as shown in Figure 4 below.

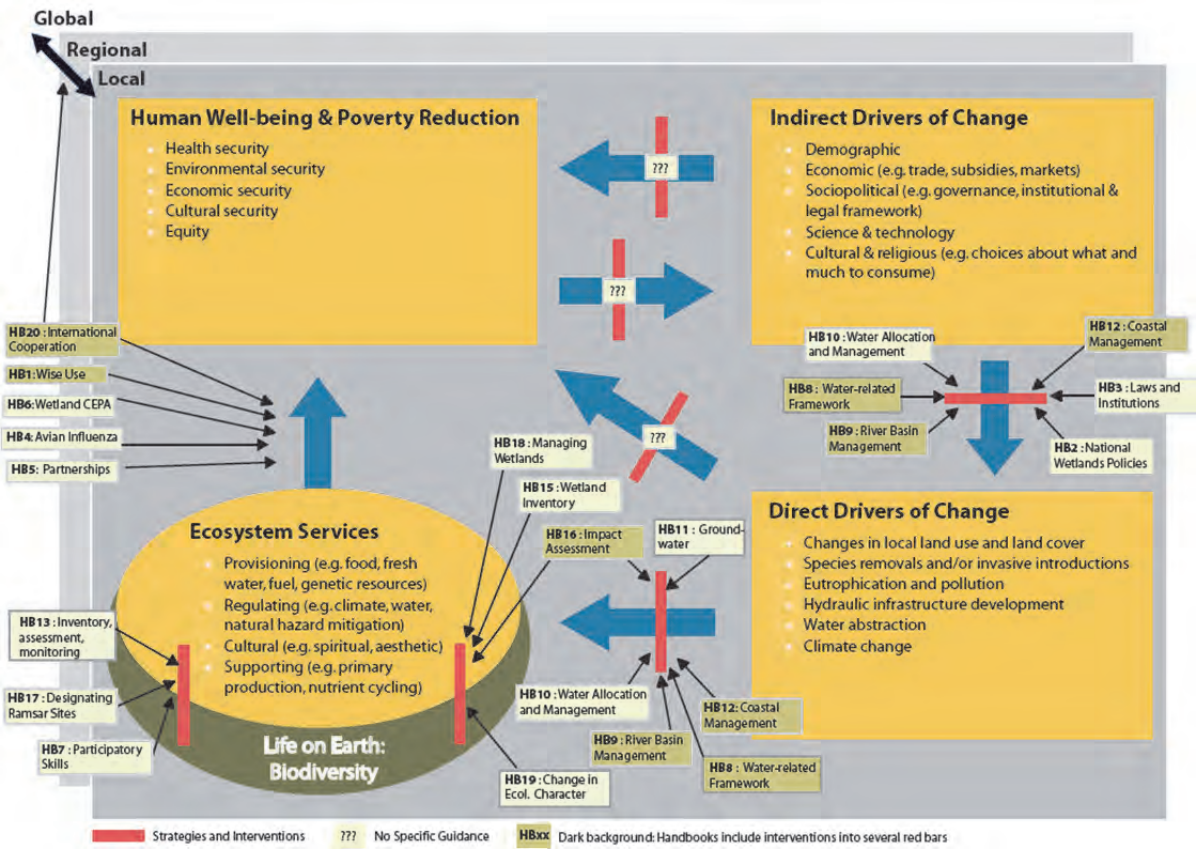


Figure 4: A Conceptual Framework for the Wise Use of Wetlands and the maintenance of their ecological character, and the application of the guidelines in the Ramsar 'toolkit' of Wise Use Handbooks 4th edition (vol. 1; 2010)

The contribution of wetlands to the hydrological cycle plays an important role maintaining the health of the water resource in addition to providing other services. Emerton and Bos (2004) give a number of key messages, three of which are quoted here:

- Ecosystems matter for people and water services
- Under-investment in ecosystems results in reduced water services
- Including ecosystem values in economic analysis improves decision-making

The South African Constitution (Act 108 of 1996) states that everyone has the right to an environment that is not harmful to their health or well-being and is protected for the benefit of present and future generations (Ch 2, para. 24). In addition, the vision for the NEPAD programme on conserving Africa's wetlands is:

> African countries and their people have healthy and productive wetlands and watersheds that can support fundamental human needs (clean water, appropriate sanitation, food security and economic development) (NEPAD, 2003).

Thus, the conservation of wetlands is institutionally enshrined.

The National Wetland Inventory, housed within SANBI (SANBI, undated) has to date mapped 2,9 million hectares of wetlands, amounting to 2,4% of South Africa's land surface).

There are a number of definitions of wetlands, and that of the National Water Act (DWAF, 1998) reads as follows:

> "wetland" means 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." (National Water Act, Act 36 of 1998; Chapter 1; Clause xxix).

In practice, this definition refers to palustrine wetlands, the type of wetland addressed by Oberholster et al. (2014), and for this document will be the definitive definition.

There are other definitions, however. The definition used by the Ramsar Convention is much broader and reads as follows:

> For the purpose of this convention wetlands are areas of marsh, fen, peatland or water, whether natural or artificial, permanent or temporary, with water that is static or flowing, fresh or salt, including areas of marine water the depth of which at low tide does not exceed six metres (Ramsar Convention, Article 1.1, 2009).

It should be noted that, in the Ramsar Convention documents quoted below, this is the definition that has been followed.

That accepted by SANBI for the South African National Wetland Classification System follows the Ramsar definition with minor changes, and is as follows:

> WETLAND: an area of marsh, peatland or water, whether natural or artificial, permanent or temporary, with water that is static or flowing, fresh, brackish or salt, including areas of marine water the depth of which at low tide does not exceed ten metres (SANBI, 2012).

While the definition of wetlands from the National Water Act (1998) has been followed in this document, the classification system followed is that of SANBI (2012). The functional units of this classification are:

- Channelled valley-bottom wetland
- Unchannelled valley-bottom wetland
- Floodplain wetland
- Depression
- Flat
- Hillslope seep
- Valleyhead seep

There are several Natural Resource Management Programmes in South Africa that work with wetlands, but their impact on wetland management or rehabilitation has not been evaluated. Nor have the management of individual wetlands and the cooperation of organisations managing these been evaluated. Kotze et al. (2009) in their review of the impact of the Natural Resource Management Programmes examine these issues under the following divisions:

- Part 1 broadly examines the impact of the Natural Resource Management Programmes which promote the conservation and rehabilitation of wetlands.
- Part 2 presents the framework that was used for assessing management effectiveness and applies this framework to 21 individual wetlands.

- Part 3 examines in further detail six of the 21 wetlands, and focuses on the relationship between participation in rehabilitation and the long-term sustainability of natural resource management.
- Part 4 presents a framework for assessing how effectively various organizations and programmes collaborate, and applies this framework to one of the 21 sites.

Specific ecosystem service functions of wetlands contributing to their importance in the social-ecological landscape are examined below.

In spite of this interest in wetlands, Mucina & Rutherford (2006) indicate that wetland vegetation types are not well known and that more attention should be given to the vegetation in these types of wetlands in the future. Against this backdrop, and using the same database system as used by SANBI (TURBOVEG) Sieben (2011) compiled vegetation data in wetlands in Kwazulu-Natal, the Free State and Mpumalanga and provided guidelines on the minimum data requirements and a sampling protocol. Van Ginkel et al. (2011) and Wentzel and Van Ginkel (2012) have provided in-depth information on certain wetland plants, but more is required to address the concern articulated by Mucina and Rutherford (2006).

Eskom recognises the importance of wetlands and that within the area of its jurisdiction across the country there are a number of wetlands. In terms of the legal requirements, Eskom is obliged to conserve these and to this end has developed the Eskom Wetland Classification and Risk Assessment Index Field Guide (Oberholster et al., 2014).

Wetlands and South African Legislation

There is no single piece of South African legislation dedicated to the protection of wetlands. However, the protection of wetlands has been directly or indirectly included in the following pieces of legislation. Armstrong (2009) provides a thorough coverage of the legislation valid at the time and the reader is referred to this document for detailed discussion of each piece of legislation. Certain regulations have been promulgated since Armstrong's 2009 synthesis and important ones are mentioned below.

National Environmental Management Act, 1998 (Act No. 107 of 1998): is the framework environmental legislation in South Africa and provides indirect protection for wetlands as an environmental resource.

National Environmental Management: Biodiversity Act, 2004 (Act 10 of 2004): This Act gives effect to ratified international agreements affecting biodiversity to which South Africa is a party, and which bind the Republic. Furthermore, the Minister may list ecosystems and species that are threatened or in need of protection, and these might include wetland ecosystems and species closely associated with wetlands. The Minister may also list threatening processes and activities in listed ecosystems and related to protected species. The Act also makes provision for the rehabilitation of ecosystems, which include wetlands. The Minister may also promulgate a list of invasive species and the required measures associated with these.

Regulation GN R543, 18 June 2010: Environmental Impact Assessment Regulations: provides for activities that may impact detrimentally on the environment to require prior environmental authorisation.

Regulation GN R544 (Listing Notice 1): sets out a list of identified activities which may not commence without environmental authorisation from the competent authority and which must follow the basic assessment procedure as provided for in regulations 21 to 25 of the NEMA EIA Regulations. These include activities in wetlands and estuaries.

National Environmental Management: Protected Areas Act (57 of 2003): The intention of the Act is to protect and conserve ecologically viable areas as well as their natural landscapes. These would include wetlands designated as or within protected areas.

National Environmental Management: Waste Act 2008 (Act 59 of 2008): In recognition of the adverse impact that poor waste management practices have locally and globally, the intention of this Act is to minimise pollution and so promote sustainable development.

National Water Act, 1998 (Act 36 of 1998): activities in and within 500 m of wetlands or the saltwater mixing zone of estuaries will require a water use licence. The Act also makes provision for the protection of water resources, which include all wetlands as well as the prevention of pollution and degradation of these resources.

Any activity which will impact a wetland requires that the wetland be delineated. The requirements for wetland delineation are reviewed below.

Regulation GNR 1352 (in terms of the NWA) of 12 November 1999, Regulations on Use of Water for Mining and Related Activities Aimed at the Protection of Water Resources: the regulation is specifically aimed at mining activities and prohibits water pollution and activities that may impact on the integrity of a water resource, such as the location of residue deposits and open cast or underground mining activities within 100 m or within the 1:100 year flood line of any water resource. The Regulations also makes provision for the protection of water resources during the mining of sand and alluvial minerals from watercourses and estuaries.

Conservation of Agriculture Resources Act, 1983 (Act 43 of 1983): sets out measures to prevent the spread of alien vegetation. Given the ideal growth opportunities afforded by wetlands for alien species, the protections of wetlands from invasive species are implied in this legislation. The legislation includes a list of alien and invasive species and the required measures to be taken in relation to these. The Act also provides for the regulation of control over the utilisation of agricultural resources in SA in order to promote the conservation of soil, water and vegetation (including wetlands). In accordance with the Act, Authorisation is required to:

1. Drain or cultivate any vlei, marsh or water sponge.
2. Cultivate any land within the flood area of a watercourse or within 10 m outside the flood-area of a watercourse.
3. Divert run-off from a water course, or
4. Burn veld, including wetland vegetation.

CARA: Regulation GNR 1048 of 24 May 1984 (as amended): makes provision for the protection of land and promotes the conservation of soil and water resources and natural vegetation through various measures, such as the prevention of soil erosion, the prevention of the disturbance of natural flow patterns and run-off, prevention of bush encroachment and makes provision for the restoration of land resources. Wetlands and their supporting hydrology are by definition included under the term “natural resources”.

National Forests Act, 1998 (Act 84 of 1998)**:** forestry activities that may impact on wetlands are regulated.

Mountain Catchments Act (Act 62 of 1970): this Act provides for the conservation, use, management and control of land situated in mountain catchment areas.

Wetland delineation

The definitive guideline for the delineation of wetlands in the environmental cluster of South African government departments is the Practical Field Procedure for The Identification and Delineation of Wetlands and Riparian Areas (Rountree et al., 2008). This document is the one referred to in licenses/permits issued by the DWS and so is the one which should guide Eskom’s activities relating to wetlands. Wetland is a term applied to a variety of ecosystems,

depending on the definition used and these have been briefly covered above (Paragraph 2.XX – Why are wetlands important?). The DWAF field procedure uses the definition from the NWA*:*

> "wetland" means 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 (paragraph xxix, Ch. 1; NWA, 1998).

Three broad zones are identified in the DWAF field procedure for the delineation of wetlands, and these are: the Permanent zone, the Seasonal zone (wet for much of the year) and the temporary zone (wet occasionally). The object of delineation is to identify the outer edge of the temporary zone. Wetlands are not always wet, particularly at the edge of the temporary zone, so four indicators have been provided for identifying the areas considered as wetlands. These four indicators are:

- **The Terrain Unit Indicator**: this indicator helps to identify those parts of the landscape where wetlands are more likely to occur.
- **The Soil Form Indicator**: this indicator identifies the soil forms, as defined by the Soil Classification Working Group (1991), which are associated with prolonged and frequent saturation.
- **The Soil Wetness Indicator**: this indicator identifies the morphological "signatures" developed in the soil profile as a result of prolonged and frequent saturation.
- **The Vegetation Indicator**: this indicator identifies hydrophilic vegetation associated with frequently saturated soils.

According to the wetland definition used in the National Water Act, vegetation is the primary indicator, which must be present under normal circumstances. However, in practise, the soil wetness and form indicators tend to be the most important, and the other indicators are used in a confirmatory role. The reason is that vegetation responds relatively quickly to changes in soil moisture regime or management and may be transformed; whereas the morphological indicators in the soil are far more permanent and will hold the signs of frequent saturation long after a wetland has been drained (perhaps for several centuries). Despite hydrology not being one of the four indicators listed above, the delineation procedure is substantially facilitated by an understanding of the broad hydrological processes that drive the frequency of saturation, particularly in the case of river channels.

Determining the boundaries of wetlands in the field

The field procedure provides detailed guidance for each of the steps below.

1. Get all the information that you can from maps, air photos, reports, other documents before going into the field. In practise, Google Earth is an accurate and readily accessible source of recent information. This desktop delineation will save a lot of time in the field.
2. Once in the field:

- Find a vantage point from which the wetland can be viewed. This will permit you to match the desktop delineation to the terrain.
- Starting at the bottom of the wetland, look for wetness or hydrophilic plants to identify the wettest part of the wetland.

- Move up the wetland to the point where the boundary of the temporary wetland/terrestrial zone is determined and put in a flag.
- Do enough transects across the wetland (temporary wetland/terrestrial zone boundary to temporary wetland/terrestrial zone boundary), flagging each until the wetland is delineated.
- Note the necessary and appropriate buffer zones.
- A point to watch for – if a wetland has been drained, the soil wetness indicators may still be present, but terrestrial plants will replace the hydrophilic plants.

3. Where the iron content of the soil is low, mottles may be scarce throughout the three wetness zones. Nevertheless, the general trend of an increase and then a decrease in mottle abundance, as one move from the temporary zone through the seasonal and then the permanent zone remains true.
4. In wetlands that are in very sandy soil or coarse sediment, organic material and iron oxides are often leached out, giving the soil a white, bleached look. In cases such as this, it is not possible to use normal soil wetness indicators for delineation. Reliance should instead be placed on other indicators.
5. Take special note of the 'specific cases' category in Appendix A of the document. These 'specific cases' do not conform to the general characteristics described above. The specific cases are:

- Hydrophilic vegetation growing on alluvial deposits that are too young to show the morphological indicators of wetness.
- Sandy soils such as occur along the coast. Note that sandy soils occurring inland, such as granitic soils, may also not show the typical indicators.
- Soils derived from quartzites and dolomites.

The DWS field procedure (DWAF, 2008) does not put much emphasis on ecoregions, only mentioning that each ecoregion may contain distinctive vegetation communities. The wetland classification system developed for the National Wetland Inventory of SANBI (Ewart-Smith et al., 2006) emphasises the influence of ecoregions on wetlands. The ecoregions will to some extent dictate the nature of wetlands occurring within the particular ecoregion. There are 31 Level 1 ecoregions in South Africa (including Lesotho and Swaziland) and each delineation needs to locate the wetland within the appropriate ecoregion, especially for the development of EIAs, EMPs, etc. Level 2 and Level 3 ecoregions provide greater detail and insight into the expected nature of the areas (Kleynhans et al., 2005).

The following hierarchical classification system is proposed for wetlands (SANBI, 2012):

Level 1	Connectivity to open ocean
Level 2	Level 1 Ecoregion (from Kleynhans et al., 2005)
Level 3	Landscape unit
Level 4	Hydrogeomorphic (HGM) unit (Level 4 is divided into a number of categories which vary depending on the landscape unit and the HGM unit.

In South Africa, methodologies for the formal identification and delineation of wetlands revolve primarily around the use of soil morphological indicators, with the soils of permanently saturated wetlands in particular being easily recognizable by their grey colour and mottled appearance. A number of wetland types and conditions have however been identified for which soil morphological indicators do not readily apply. These include

seasonally saturated to inundated wetlands in sandy coastal aquifers dominated by aeolian (windblown) sands. In many of these systems, both anoxic conditions and the mineral stripping via podsolization that leads to mottling do not occur. The soils of temporary wetlands in very arid areas are also often too shallow, too saline or too temporarily inundated to exhibit typical wetland features in their soils. Such wetlands are called “cryptic”, and cannot reliably be identified as wetlands during the dry season on the basis of standard wetland identification and delineation tools (Day et al., 2010). Day et al. (2010) and Bird (2010) propose indicators for the identification of temporary wetlands using invertebrates and plants as indicators and provide methods for using these indicators. These indicators should be used when the assessor is faced with the wetlands in sandy soils as covered in Annexure A of the DWAF (2008) field procedure.

Job (2008) also tested the DWAF (2008) field procedure widely in the Western Cape where wetlands may be difficult to identify. She found that 65% of wetlands could be identified using the indicators described in the DWAF (2008) field procedure, and the remaining 35% fell into the ‘special cases’ category. These were mostly sandy and low chroma soils. For these, the recommendation that she made are:

- Record the presence of a dark, high carbon content layer on the soil surface, and/or
- Thoroughly document landscape conditions and any remnant vegetation, soil, hydrology indicators, and then develop the rationale for considering the area to be wetland.

Buffer strips or zones

Buffer zones perform the following functions (from Table 1 in MacFarlane et al., in press):

- Maintaining basic aquatic processes
  - Maintaining channel stability
  - Groundwater recharge
  - Control of microclimate and water temperature
  - Flood attenuation
  - Maintenance of general wildlife habitat
- Reducing impacts on water resources from upstream activities and adjoining land uses
  - Storm water attenuation
  - Sediment trapping
  - Removal of toxics
  - Nutrient removal
  - Removal of pathogens
- Providing habitat for aquatic and semi-aquatic species
  - Provision of habitat for aquatic species
  - Screening of adjacent disturbances
  - Habitat connectivity
- Providing habitat for terrestrial species
  - Provision of habitat for terrestrial species
  - Habitat connectivity
- Ancillary societal benefits
  - Reduces flood risk

- Enhances visual quality
- Improve air quality
- Provides recreational opportunities
- Economic benefits

The role that buffers are able to play needs to be understood. For instance, they cannot mitigate point source impacts such as sewage outflows or storm water drains. These require other approaches.

The DWAF General Authorisation (2009) for any development occurring within 500 m of a wetland requires a risk-based evaluation of the potential impact of the project to be carried out on the development and the potential risks that the development may involve (N Fourie, pers comm.). There is a completed but not yet published Water Research Commission report (MacFarlane et al., in press. WRC Project number K5/2200) detailing research on the development of a process to assess the risk to a water body from the surrounding land use. This presents a repeatable method for assessing risk and will be tested by the DWS with a view to accepting it as the guideline for assessing the necessary buffer zone width to protect a body of water.

Wetland inventory

Volume 13 of the Ramsar Handbooks on Wise Use (2010) note that wetland inventory has multiple purposes which include:

- Listing particular types, or even all, wetlands in an area
- Listing wetlands of local, national and/or international importance
- Describing the occurrence and distribution of wetland taxa
- Describing the occurrence of natural resources such as peat, fish or water
- Establishing a baseline for measuring change in the ecological character of wetlands
- Assessing the extent and rate of wetland loss or degradation
- Promoting awareness of the value of wetlands
- Providing a tool for conservation planning and management
- Developing networks of experts and cooperation for wetland conservation and management.

The Ramsar Convention designated wetlands of international importance originally for their importance for water birds, especially migratory birds, but this scope has now been broadened. Most of the wetlands designated, however, are clearly defined and usually large. Volume 13 of the Ramsar handbooks for wise use (2010) presents a hierarchical approach for the delineation of wetlands for the sake of designating wetlands of international importance. The first steps are taken at desktop before moving into the field, as follows:

- Level 1: Desktop – the first assessment is at a broad level, considering the geology. Climate and ecoregion of the wetland. This is based on existing datasets.
- Level 2: Desktop – the second level of assessment is based on Level 1, but with the hydrology and vegetation of the wetland included.
- Level 3: Fieldwork is undertaken at this level to identify physical, physico-chemical and biological features of wetland complexes within each wetland region. This is done at a broad scale.
- Level 4: Level 4 assessment involves fieldwork to identify and analyse the physical, physico-chemical and biological features of wetland habitat within each complex. – plant

and animal assemblages and species – land and water use – wetland management at a greater level of detail than undertaken at Level 3.

Volume 13 of the Ramsar Handbooks (2010) gives detail on the monitoring requirements for designated wetlands. Recognising that monitoring can be expensive, programmes should be cost-effective and adequate for management purposes (see Section XX – Adaptive Management). Rapid assessment techniques are suitable for broad-scale implementation and may provide adequate data for broad-scale management. However, detailed quantitative monitoring is often required for specific sites. The Ramsar framework for the design of a monitoring framework is discussed under the section titled 'The identification, and development where necessary, of a suite of indicators for monitoring the health of the ecosystem services identified as important in the area to be conserved'.

Volume 15 of the Ramsar Handbooks on Wise Use (2010) provides a framework for planning a wetland inventory (Table 1). In order to complete the task to the standard required by the Ramsar Convention, the requirement is that all steps to be followed. They do, however, suggest that the emphasis may be placed on ecosystem services if this is desirable.

Table 1: A structured framework for planning a wetland inventory

Step	Guidance
1. State the purpose and objective	State the reason(s) for undertaking the inventory and why the information is required, as the basis for choosing a spatial scale and minimum data set.
2. Review existing knowledge and information	Review the published and unpublished literature and determine the extent of knowledge and information available for wetlands in the region being considered.
3. Review existing inventory methods	Review available methods and seek expert technical advice to: a) choose the methods that can supply the required information; and b) ensure that suitable data management processes are established.
4. Determine the scale and resolution	Determine the scale and resolution required to achieve the purpose and objective defined in Step 1.
5. Establish a core or minimum data set	Identify the core, or minimum, data set sufficient to describe the location and size of the wetland(s) and any special features. This can be complemented by additional information on factors affecting the ecological character of the wetland(s) and other management issues, if required.
6. Establish a habitat classification	Choose a habitat classification that suits the purpose of the inventory, since there is no single classification that has been globally accepted

Step	Guidance
7. Choose an appropriate method	Choose a method that is appropriate for a specific inventory based on an assessment of the advantages and disadvantages, and costs and benefits, of the alternatives.
8. Establish a data management system	Establish clear protocols for collecting, recording and storing data, including archiving in electronic or hardcopy formats. This should enable future users to determine the source of the data, and its accuracy and reliability. At this stage it is also necessary to identify suitable data analysis methods. All data analysis should be done by rigorous and tested methods and all information documented. The data management system should support, rather than constrain, the data analysis. A meta-database should be used to: a) record information about the inventory datasets; and b) outline details of data custodianship and access by other users.
9. Establish a time schedule and the level of resources that are required	Establish a time schedule for: a) planning the inventory; b) collecting, processing and interpreting the data collected; c) reporting the results; and d) regular review of the program. Establish the extent and reliability of the resources available for the inventory. If necessary make contingency plans to ensure that data is not lost due to insufficiency of resources.
10. Assess the feasibility & cost effectiveness	Assess whether or not the program, including reporting of the results, can be undertaken within under the current institutional, financial and staff situation. Determine whether the costs of data acquisition and analysis are within budget and that a budget is available for the program to be completed.
11. Establish a reporting procedure	Establish a procedure for interpreting and reporting all results in a timely and cost effective manner. The report should be succinct and concise, indicate whether or not the objective has been achieved, and contain recommendations for management action, including whether further data or information

Step	Guidance
	is required.
12. Establish a review and evaluation process	Establish a formal and open review process to ensure the effectiveness of all procedures, including reporting and, when required, supply information to adjust or even terminate the program.
13. Plan a pilot study	Test and adjust the method and specialist equipment being used, assess the training needs for staff involved, and confirm the means of collating, collecting, entering, analysing and interpreting the data. In particular, ensure that any remote sensing can be supported by appropriate "ground-truth" survey.

Inventory of SA Wetlands – NFEPA Project

SANBI has coordinated the South African wetland inventory since 2004 and has to date produced four versions of the National Wetland Map. Version 4 of the National Wetland Map formed the foundational data layer for the National Freshwater Ecosystems Priority Areas (NFEPA) project (Driver et al., 2011; Nel et al., 2011a, 2011b).

The NFEPAs are a set of strategic spatial priorities for conserving water ecosystems and supporting the sustainable use of water resources. Development pressures result in it not always being possible to maintain all water ecosystems in good ecological condition. However, in order to support the health and sustainability of water ecosystems and thus the provision of water-related ecosystem services, a certain proportion of water ecosystems need to be maintained in good ecological condition. The NFEPAs represent such a set of ecosystems, derived systematically and proactively, in the most efficient configuration, based on the best available science.

NFEPA maps are available on the SANBI BGIS website (http://bgis.sanbi.org) both as image files and as shape files that can be manipulated in GIS. In addition to the maps, two supplementary reports have been published:

- A technical report, which explains the scientific methods and stakeholder engagement process used to create the map products and the analysis of legal and institutional mechanisms available for implementing NFEPA products
- An implementation manual that provides guidance on how to use the FEPA maps in the water sector, the biodiversity sector and other key sectors whose planning and decision making impacts on freshwater ecosystems

The NFEPA maps provide a single, nationally consistent information source for incorporating water ecosystem goals into planning and decision-making processes. Not every FEPA can automatically be considered key ecological infrastructure, but when combined with other information sources, the NFEPA maps remain a primary input in the identification of ecological infrastructure of significance for water security.

The maps support integrated water resource management by providing guidance on how many rivers, wetlands and estuaries, and which ones, should remain in a natural or near-natural condition to support the water resource protection goals of the National Water Act. This does not mean FEPAs should be restricted from human use, but rather that they should be supported by good planning, decision-making and management to ensure that human use does not impact unduly on the condition of the resource.

The NFEPA project responds to the high levels of threat prevalent in river, wetland and estuary ecosystems of South Africa and provides strategic spatial priorities for conserving the country's freshwater ecosystems and supporting sustainable water resources.

The history of the NFEPA initiative, provided by SANBI on the following website (http://bgis.sanbi.org/nfepa/project.asp?) provides the following background history to the project.

Freshwater ecosystems provide a valuable natural resource, with economic, aesthetic, spiritual, cultural and recreational value. Yet the integrity of freshwater ecosystems in South Africa is declining at an alarming rate largely as a consequence of a variety of challenges that are practical (managing vast areas of land to maintain connectivity between freshwater ecosystems), socio-economic (competition between stakeholders for utilisation) and institutional (building appropriate governance and co-management mechanisms).

The first National Spatial Biodiversity Assessment (NSBA) in 2004 provided a national assessment of the status of terrestrial, river, marine and estuarine ecosystems and identified broad priority areas for biodiversity conservation for terrestrial ecosystems. Freshwater ecosystems were lacking as some critical datasets was unavailable. However, the NSBA highlighted the dire state of river ecosystems in South Africa, which were far worse than the state of terrestrial ecosystems.

In 2006, (Roux et al., 2006) a process was initiated to develop cross-sector policy objectives for conserving South Africa's inland water biodiversity, which led to the definition of a national goal for freshwater conservation policy in South Africa: "to conserve a sample of the full diversity of species and the inland water ecosystems in which they occur, as well as the processes which generate and maintain diversity". Five policy objectives, each with a set of recommendations, were identified in order to achieve this goal:

- Set and entrench quantitative targets
- Plan for the representation of inland water biodiversity
- Maintain the processes which encourage the evolution and persistence of ecosystems
- Establish a network of inland water conservation areas and
- Enable effective implementation

NFEPA takes forward the implementation of the Cross-Sector Policy Objectives for Inland Water Conservation. It also builds on the river component of the National Spatial Biodiversity Assessment (NSBA) 2004.

Roux et al. (2006) note that a loss of biodiversity inevitably leads to ecosystem degradation and the subsequent loss of important ecosystem services. This loss is most detrimental to the rural poor who rely directly on the ecosystem services, particularly the provisioning services, most heavily. Taking cognisance of the above, the quantitative target for inland water biodiversity conservation in South Africa has been set at 'at least 20% of each inland water ecosystem type (determined at an appropriate scale) should be in the Natural Class in the DWAF (now DWS) water resource classification system'. Rivers-Moore (2011), however, found that the Beta-diversity turned over in less than 20% of the river length in the upper reaches, requiring a higher percentage of the river than the blanket 20% to be conserved.

The national goal of the NFEPA initiative is

> To conserve a sample of the full variety or diversity of inland water ecosystems that occur in South Africa, including all species as well as the habitats, landscapes, rivers and other water bodies in which they occur, together with the ecosystem processes responsible for generating and maintaining this diversity, for both present and future generations.

The wetland inventory undertaken by SANBI is broader than a straightforward inventory, as it addresses the sustainability of wetlands and rivers and their contribution to the conservation of aquatic biodiversity. The NFEPA project was conceptualised with these objectives in mind.

Over 100 000 South African wetlands have been delineated during the NFEPA project using a combination of remote sensed data and existing mapped localities. The project team recognise that not all wetlands have been mapped and that there are some substantial gaps that still need to be filled. The NFEPA initiative, however, identifies priority wetlands and rivers for protection in South Africa and provides an important tool for planning and prioritising interventions.

The NFEPA project does not differentiate between the various types of wetland as defined by SANBI (2012). The different types of wetlands occur in different parts of the landscape and do not all provide the same basket of ecosystem services. For instance, un-channelled valley bottom wetlands, a critically endangered wetland type (Van Vuuren, 2014), are more effective at upgrading water quality than are channelled valley bottom wetlands, but impacts on unchannelled valley bottom wetlands tend to erode channels, reducing their effectiveness in the delivering this ecosystem service.

Ecological Infrastructure

Ecological infrastructure refers to naturally functioning ecosystems that deliver valuable services to people, such as water and climate regulation, soil formation and disaster risk reduction (Ecological infrastructure fact sheet, 2014). It is the nature-based equivalent of built or hard infrastructure, and is just as important for providing services and underpinning socio-economic development. Ecological infrastructure includes, for instance, healthy mountain catchments, rivers, wetlands, coastal dunes, and nodes and corridors of natural habitat, which together form a network of interconnected structural elements in the landscape. Manuel (2012) notes that in spite of integrated planning networks and the existence of good ecological information, the environment is often seen as an obstacle to development, and if the high growth rate envisaged by the national Development Plan (NPC, 2011) is to be achieved through construction and extraction-based development, then the environment will certainly be an obstacle. Planning and managing the ecological infrastructure will provide for ecologically sustainable development while promoting economic and social development. Investing in ecological infrastructure is a low-cost high-return development strategy with multiple social, economic and environmental gains.

Ecosystem Services Provided by Wetlands

Wetlands provide a variety of ecosystem services such as ground water recharge, flood attenuation, pollution abatement, habitat for biodiversity, recreation opportunities, and provide for the livelihood of some communities through the harvesting of resources. Barbier et al. (1997) provides the following examples: Wetland systems directly support millions of people and provide goods and services to the communities outside the wetland. For example, wetland soils are used for agriculture, fish are caught to eat, trees are cut for

timber and fuel wood and wetland reeds are harvested to make mats and to thatch roofs. Direct use takes the form of recreation, such as bird watching or hiking. Communities benefit indirectly from wetland functions or services. As flood water flows out over a floodplain wetland, the water is temporarily stored which reduces the peak river level to prevent flooding of riparian dwellers downstream. The value of wetland ecosystem services has also been emphasised by Becker (1998), who states that wetlands are considered to be a good last line of defence for water quality problems. Wetlands can retain up to 96% of nitrogen and 97% of phosphorus and thus have the potential to significantly lower the cost of sewage treatment (Bolund and Hunhammar, 1999). Table 2 summarises some of the ecosystem services offered by wetlands.

Table 2: Wetlands functions, related effects of functions, and corresponding societal values (Lechine et al., 1997 as adapted from NRC 1995)

Functions	Effects	Societal Value
Hydrologic • Short-term surface water storage • Long-term surface water storage • Maintenance of high water table **Biogeochemical** • Transformation, cycling of elements • Retention, removal of dissolved substances • Accumulation of inorganic sediments **Habitat and Food Web Support** • Maintenance of characteristics plant communities • Maintenance of characteristic energy flow	• Reduced downstream flood peaks • Maintenance of base flows, seasonal flow distribution • Maintenance of hydrophytic community • Maintenance of nutrient stocks within wetlands • Reduced transport of nutrients downstream • Retention of nutrients, metals, other substances • Food, nesting, cover for animals • Support for populations of vertebrates	• Reduced damage from floodwaters • Maintenance of fish habitat during dry periods • Maintenance of biodiversity • Wood production • Maintenance of water quality • Maintenance of water quality • Support for furbearers, waterfowl • Maintenance of biodiversity

The framework developed through the Millennium Ecosystem Assessment (2005) provides a way of understanding ecosystem services which has been widely adopted and is currently the standard. This has been taken further through the Economics of Ecosystems and Biodiversity (TEEB). The following brief descriptions of 17 ecosystem services are taken from the TEEB (The Economics of Ecosystems and Biodiversity) web site http://www.teebweb.org/resources/ecosystem-services/ .

Provisioning services

Provisioning Services are ecosystem services that describe the material or energy outputs from ecosystems. They include food, water and other resources.

Food: Ecosystems provide the conditions for growing food. Food comes principally from managed agro-ecosystems but marine and freshwater systems or forests also provide food for human consumption. Wild foods from forests are often underestimated.

Raw materials: Ecosystems provide a great diversity of materials for construction and fuel including wood, biofuels and plant oils that are directly derived from wild and cultivated plant species.

Fresh water: Ecosystems play a vital role in the global hydrological cycle, as they regulate the flow and purification of water. Vegetation and forests influence the quantity of water available locally.

Medicinal resources: Ecosystems and biodiversity provide many plants used as traditional medicines as well as providing the raw materials for the pharmaceutical industry. All ecosystems are a potential source of medicinal resources.

Regulating services

Regulating Services are the services that ecosystems provide by acting as regulators, e.g. regulating the quality of air and soil or by providing flood and disease control.

Local climate and air quality: Trees provide shade whilst forests influence rainfall and water availability both locally and regionally. Trees or other plants also play an important role in regulating air quality by removing pollutants from the atmosphere.

Carbon sequestration and storage: Ecosystems regulate the global climate by storing and sequestering greenhouse gases. As trees and plants grow, they remove carbon dioxide from the atmosphere and effectively lock it away in their tissues. In this way, forest ecosystems are carbon stores. Biodiversity also plays an important role by improving the capacity of ecosystems to adapt to the effects of climate change. (See also the section on carbon sequestration by wetlands below.)

Moderation of extreme events: Extreme weather events or natural hazards include floods, storms, tsunamis, avalanches and landslides. Ecosystems and living organisms create buffers against natural disasters, thereby preventing possible damage. For example, wetlands can soak up floodwater whilst trees can stabilize slopes. Coral reefs and mangroves help protect coastlines from storm damage.

Wastewater treatment: Ecosystems such as wetlands filter both human and animal waste and act as a natural buffer to the surrounding environment. Through the biological activity of microorganisms in the soil, most waste is broken down. Thereby pathogens (disease causing microbes) are eliminated, and the level of nutrients and pollution is reduced.

Erosion prevention and maintenance of soil fertility: Soil erosion is a key factor in the process of land degradation and desertification. Vegetation cover provides a vital regulating service by preventing soil erosion. Soil fertility is essential for plant growth and agriculture and well-functioning ecosystems supply the soil with nutrients required to support plant growth.

Pollination: Insects and wind pollinate plants and trees which is essential for the development of fruits, vegetables and seeds. Animal pollination is an ecosystem service mainly provided by insects but also by some birds and bats. Some 87 out of the 115 leading global food crops depend upon animal pollination including important cash crops such as cocoa and coffee (Klein et al., 2007).

Biological control: Ecosystems are important for regulating pests and vector borne diseases that attack plants, animals and people. Ecosystems regulate pests and diseases through the activities of predators and parasites. Birds, bats, flies, wasps, frogs and fungi all act as natural controls.

Habitat or supporting services

Habitats for species: Habitats provide everything that an individual plant or animal needs to survive: food; water; and shelter. Each ecosystem provides different habitats that can be essential for a species' lifecycle. Migratory species including birds, fish, mammals and insects all depend upon different ecosystems during their movements.

Maintenance of genetic diversity: Genetic diversity is the variety of genes between and within species populations. Genetic diversity distinguishes different breeds or races from each other thus providing the basis for locally well-adapted cultivars and a gene pool for further developing commercial crops and livestock. Some habitats have an exceptionally high number of species which makes them more genetically diverse than others and are known as 'biodiversity hotspots'

Cultural services

Recreation and mental and physical health: Walking and playing sports in green space is not only a good form of physical exercise but also lets people relax. The role that green space plays in maintaining mental and physical health is increasingly being recognized, despite difficulties of measurement.

Tourism: Ecosystems and biodiversity play an important role for many kinds of tourism which in turn provides considerable economic benefits and is a vital source of income for many countries. In 2008 global earnings from tourism summed up to US$ 944 billion. Cultural and eco-tourism can also educate people about the importance of biological diversity.

Aesthetic appreciation and inspiration for culture, art and design: Language, knowledge and the natural environment have been intimately related throughout human history. Biodiversity, ecosystems and natural landscapes have been the source of inspiration for much of our art, culture and increasingly for science.

Spiritual experience and sense of place: In many parts of the world natural features such as specific forests, caves or mountains are considered sacred or have a religious meaning. Nature is a common element of all major religions and traditional knowledge, and associated customs are important for creating a sense of belonging.

Implications for the study

Eskom is also a user of wetland ecosystem services, as are users downstream. One of the risks identified by Eskom relates to deteriorating water quality in the catchments where their power stations are situated. The optimisation of the ecosystem services associated with wetlands for the benefit of Eskom should be investigated and potentially harnessed.

In a series of publications (Wetland Management Series) (Dada et al., 2007 and others in the WET series, 2009) on wetland rehabilitation several tools were developed for use by South African role-players. These tools were developed as part of a comprehensive nine-year research programme on wetland management which was initiated in 2003 by the Water Research Commission (WRC) and a range of partners. The research examined wetland

rehabilitation, wetland health and integrity and the sustainable use of wetlands. The WET-EcoServices publication contains the tool used to assess the services that individual wetlands provide. The tool provides guidelines for scoring the importance of a wetland in delivering each of 15 different ecosystem services (including flood attenuation, sediment trapping and provision of livestock grazing).

Implications for the study

Well-researched tools have been developed specifically for the South African landscape to identify and evaluate ecosystem services associated with wetlands. New developments for which environmental authorisation is required, have to assess the potential impact on wetlands and the functions which they perform. Whilst the ecosystem services have been identified, this is not always pulled through to continuous monitoring and evaluation.

The Value of Ecosystem Services from Wetlands

The ecosystem services from wetlands have a higher value than other inland ecosystems. Table 3 (extracted from de Groot et al., 2012) gives the average values of the ecosystem services from a number of studies reported in the literature.

Table 3: The average values (in Int. $/ha y) of ecosystem services per biome (extracted from de Groot et al., 2012).

Biome ---------- Ecosystem services	Marine	Coral reefs	Coastal systems	Coastal wetlands	Inland wetlands	Rivers and lakes	Tropical forest	Temperate forest	Woodlands	Grasslands
No. of estimates	14	94	28	139	168	15	96	58	21	32
Provisioning	102	55 724	2 396	2 998	1 659	1 914	1 828	671	253	1 305
Regulating	65	171 478	25 847	171 515	17 364	187	2 529	491	51	159
Habitat	5	16 210	375	17 138	2 455	0	39	862	1 277	1 214
Cultural	319	108 837	300	2 193	4 203	2 166	867	990	7	193
Total economic value	491	352 249	28 917	193 845	25 682	4 267	5 264	3 013	1 588	2 871

Table **4** gives the breakdown of the contributions of the value of the benefits derived from ecosystem services for each of the main categories given in Table 3 for inland wetlands. The regulating services are the most valuable, making up 2/3 of the total value of the benefits.

Table 4: The average values (in Int.$/ha/yr) of ecosystem services for inland wetlands, showing the contributions of individual services to the total value (extracted from de Groot et al., 2012).

ECOSYSTEM SERVICE	Int.$/ha/yr
PROVISIONING SERVICES	**1 659**
1 Food	614
2 Water	408
3 Raw materials	425
4 Genetic resources	
5 Medicinal resources	99
6 Ornamental resources	114
REGULATING SERVICES	**17,364**
7 Air quality regulation	
8 Climate regulation	488
9 Disturbance moderation	2986
10 Regulation of water flows	5606
11 Waste treatment	3015
12 Erosion prevention	2607
13 Nutrient cycling	1713
14 Pollination	
15 Biological control	948
HABITAT SERVICES	**2455**
16 Nursery service	1287
17 Genetic diversity	1168
CULTURAL SERVICES	**4203**
18 Esthetic information	1292
19 Recreation	2211
20 Inspiration	700
21 Spiritual experience	
22 Cognitive development	
TOTAL ECONOMIC VALUE	**25,682**

Kotze et al. (2009) developed a method for evaluating 15 ecosystem services delivered by wetlands. The authors recognise that different HGM types of wetlands offer different ecosystem services, for instance, floodplains characteristically contribute to the attenuation of floods and Unchannelled valley bottom wetlands are more effective at trapping sediments. They recognise, nevertheless, that the scores obtained from different wetland types may still be compared and will give a measure of the basket of benefits provided by the wetlands under consideration. This procedure provides the basis for estimating the ecosystem services available from a wetland. It also provides an effective method for determining the ecological importance and sensitivity of a wetland

Carbon Sequestration by Wetlands

Carbon sequestration is not given explicitly by de Groot et al. (Table 4), but Euliss et al. (2006) working on the prairies of North America, found that wetlands sequestered twice the organic carbon as no-till cropland on about 17% of the area, making wetlands important non-forest carbon sinks.

Carbon can occur in the soil either as inorganic or organic form. Inorganic carbon originates mainly from the parent material (Nelson & Sommers, 1996). Soil organic carbon (SOC) originates from living material. SOC is a dynamic component of an ecosystem, and its accumulation is based on a balance between input (organic matter production) and output (decomposition, methanogenesis, and erosion). Typical wetland characteristics contribute to the fact that wetlands are one of the most effective ecosystems for storing soil carbon (Adhikari et al., 2009); although it is important to note that not all wetlands, even if constantly waterlogged, accumulate carbon equally effectively. South African soils have low organic matter levels; according to Du Preez et al. (2011), about 58% of soils contain less than 0.5% organic carbon and only 4% contain more than 2% organic carbon. Although any ecosystem might have a high organic matter input, SOC is usually quickly lost to the atmosphere due to aerobic microbial decomposition of the organic matter. As wetlands are hostile environments for most microbes, these ecosystems have the ability to accumulate SOC very effectively (Fey, 2010):

- Wetlands are characterized by waterlogged soil. This inhibits the action of the dominant aerobic microbes and facilitates the activity of anaerobic microbes, slowing the decomposition of organic material and leading to the accumulation of SOC.
- Wetlands are usually acidic due to waterlogging. This limits the range of microbial types that can survive in this environment, contributing to reduced decomposition rates.
- Wetland soils are leached, providing little nutrition in the soil for microbes to survive.
- In cold environments SOC usually accumulates even more effectively as low temperatures also inhibit microbial activity. This is the reason why most peatlands of the world are found in the northern hemisphere (Hinsby, 2011).

Decomposition in wetlands is, however, a complex matter based on numerous secondary, inter-related factors such as climate, wetland type and hydrogeomorphic setting, hydroperiod, quality and quantity of the organic matter, microbial communities, electron acceptor supply, low redox potentials and pH (Reddy & DeLaune, 2008; Bernal & Mitch, 2006; Neue et al., 1997).

While wet, anaerobic soils in permanently wet wetlands tend to accumulate large amounts of organic matter in a partially decomposed condition (Adhikari et al., 2009), SOC in seasonal or temporary wetlands oxidizes during the dry periods. Both Bernal & Mitsch (2008) and Cresser et al. (2007) found that 40-60% of the carbon pool in soil occurs in the top 25 cm of the soil. SOC content and decomposition rates also decrease with the depth of a soil profile,

as most organic matter input takes place at the soil surface, (Reddy & DeLaune, 2008; Reddy et al., 2000).

Peatlands are wetlands characterized by the accumulation of a layer of decomposed organic material. The International Mire Conservation Group (IMCG) defines peatlands as wetlands with more than 30% organic matter (roughly equal to 20% organic carbon or more), in a layer of more than 30 cm thick. In South Africa, a wetland is regarded as a peatland when it contains 20% or more SOC of a thickness of 20 cm or more. Although peatlands cover only 3% of land area worldwide, they contain 30% of the global SOC, making them an invaluable carbon sink. Equally, destroyed or degraded peatlands can significantly contribute to greenhouse gas emissions. According to estimation by Maltby et al. (1993) the mineralization process in a drained peatlands starts immediately, and results in emission of carbon dioxide ranging between 2.5 and 10t C/ha/yr.

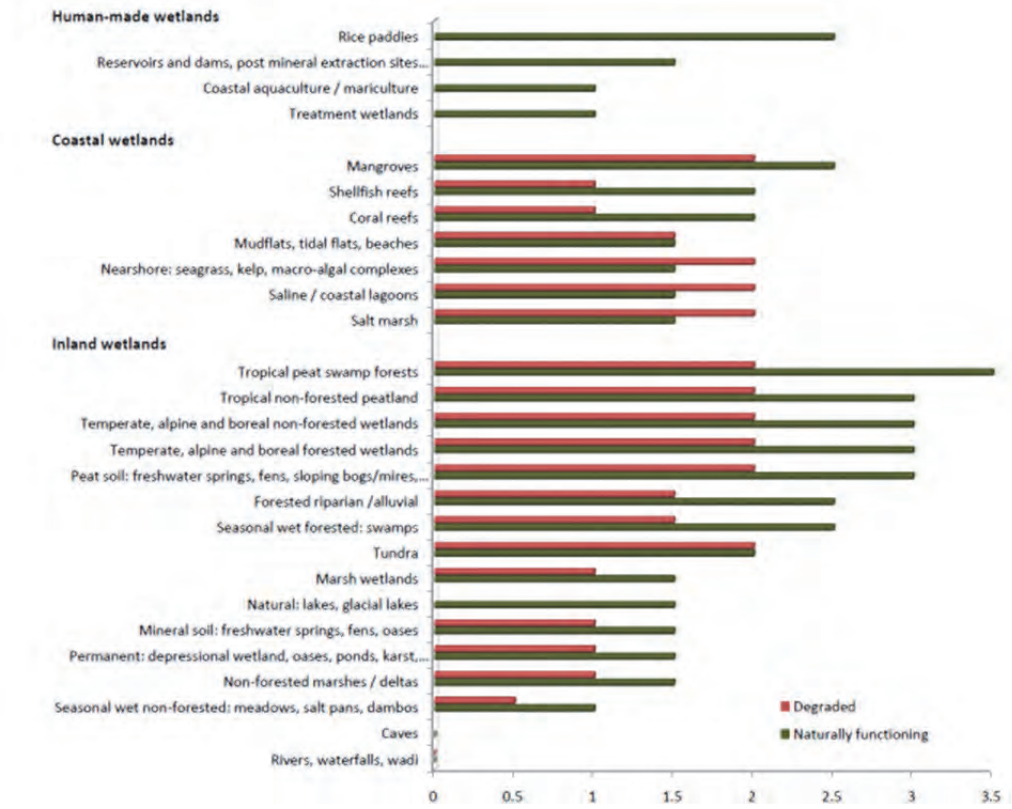


Figure 5: An example of the comparative qualitative assessment of the carbon storage capacity across wetland types derived from the DFN decision support matrix, comparing the relative carbon store size per unit area across wetland types

Implications for the study

Carbon plays an integral part in the chemical and physical functioning of wetlands. However, carbon is easily lost when a wetland is degraded or impacted on. In order for Eskom to realize the true value of the wetland systems found on their property, it is important that they understand the processes and dynamics of carbon in wetlands.

Wetlands play an important role in carbon sequestration and present opportunities for Eskom in this regard.

Ecosystem services derived from carbon in wetlands

According to Doran and Parkin (1994) soil quality is 'the capacity of soil to function within ecosystem and land use boundaries to sustain biological productivity, maintain environmental quality, and promote plant, animal and human health'. Soil health is 'the continued capacity of soil to function as a vital living system, within ecosystem and land use boundaries, to sustain biological productivity, promote the quality of air and water environments, and maintain plant, animal and human health'. The organic matter content of soils is a key attribute to both soil health and soil quality (Du Preez et al., 2010).

SOC is a major driver of biogeochemical processes in wetlands (Bernal & Mitch, 2008). It maintains the most important soil functions by improving cation exchange capacity, buffer pH, supplying nutrients such as nitrogen and phosphorous, providing long-term storage for nutrients in the soil, lowering bulk density, and increasing hydraulic conductivity, soil stability, infiltration capacity, and water holding capacity (Passoni et al., 2009; Reddy & DeLaune, 2008), all of which form an integral part of a very productive ecosystem. It also increases soil fertility (Jankauskas et al., 2006) and strongly influences the binding and buffering capacity of soil, thus diminishing the diffusion of pollution from soil to water (CEC, 2002).

Carbon credits and offsetting

Various definitions exist for the term 'carbon credit', but the message is the same. A carbon credit can be a certificate or permit showing that the holder has paid to have a certain amount of carbon dioxide removed from the environment (Collins English Dictionary, 2013). It can also be used as a generic term to assign a value to a reduction or offset of GHG emissions. A carbon credit is usually equivalent to one ton of carbon dioxide equivalent (The Carbon Credit Network, 2012) and can be traded in the international market at their current market price (Investopedia Inc., 2013).

The aim of carbon markets is to attempt to mitigate the increase in concentrations of GHGs. The Kyoto Protocol formed the basis for the current carbon economy. It was adopted in December 1997 in Kyoto, Japan, and came into force in February 2005 when the mandatory number of countries acceded to it. The Kyoto Protocol is only binding on countries regarded to be the main contributors of GHG emissions, and sets limits on the emissions of six GHGs by industrialised countries, who, in turn, set quotas on the emissions of local business and organizations. The targets vary between countries, but the aim is to have reduced the combined emissions by 5% of the 1990 levels by 2012 (Scholtz & De Villiers, undated).

The Carbon market concept originates from the Clean Development Mechanism (CDM), one of the Kyoto Protocol's three market-based mechanisms. It was envisaged as: "a way to allow industrial countries greater flexibility in meeting their emissions targets, while at the same time transferring cleaner technologies to developing countries so they can build cleaner technologies into their own economic development programs" (Scholtz & De Villiers, undated). There are two carbon markets:

- Verified Carbon Market – Verified Emission Reduction credits are bought by companies who wish to offset their carbon footprint.
- Compliance Carbon Market – The compliance market is reserved for institutional trade, where large companies are necessitated to offset their carbon footprint every year to reach the Kyoto Protocol targets enforced by their respective governments.

The trading of carbon on the carbon market follows an emissions-trading approach. GHG emissions are capped, where after markets are used to allocate the emissions among the group of regulated sources. This allows market mechanisms to drive industrial and

commercial processes to lower emissions or reduce carbon intensive approaches. There are two types of carbon transactions (Scholtz & De Villiers, undated):

- Allowance-based transactions – credits created and allocated to a party by regulators under a cap-and-trade regime such as the Assigned Amount Units under the Kyoto Protocol are purchased.
- Project-based transactions – credits are purchased from a project that already reduces GHG emissions. These projects are usually under the CDM or Joint Implementation mechanisms.

CDM projects result in three types of Kyoto units (UNFCC, 2008):

- Certified emission reductions (CERs) (issued for projects that reduce emissions);
- Temporary CERs and
- Long-term CERs (both temporary and long-term CERs are issued for projects that enhance removals through afforestation and reforestation projects).

The CDM Executive Board supervises the CDM, and is responsible for registering projects, approving methodologies for determining project baselines, monitoring emission reductions, and for issuing CERs (UNFCC, 2008).

Each user of carbon credits has a certain allowance of credits. Unused credits can be sold to users who are about to exceed their quotas, privately or on the open market (which functions almost like the stock exchange – the Chicago Climate Exchange and the European Union's Emissions Trading Scheme are examples hereof (Hansen, 2009)). Any GHG mitigation projects which generate carbon credits can use these to finance carbon reduction schemes between partners around the world. There are also many companies that sell carbon credits to commercial and individual customers who wish to lower their carbon footprint (UNFCC, 2007). As demand for energy grows, the total emissions must still stay within the cap, but it allows industry some flexibility and predictability in its planning to accommodate this.

A report by Hallowes (2009), however, deems carbon trading as a failure, stating that ‘there is no link between the price of carbon and the costs of climate change, or the costs of emissions reduction required to seriously mitigate climate change; and no necessary link between the number of credits in circulation and an overall reduction in greenhouse gas emissions.’

Carbon credits and offsetting in the European Union

EU initiatives to reduce greenhouse gas emissions include (EC, 2013):

- The European Climate Change Programme (ECCP), which has led to the implementation of new policies and measures;
- The EU Emissions Trading System, which has become the EU's key tool for reducing greenhouse gas emissions from industry most cost-effectively;
- Adopting legislation to raise the share of energy consumption produced by renewable energy sources, such as wind, solar and biomass, to 20% by 2020;
- Setting a target to increase Europe's energy efficiency by 20% by 2020 by improving the energy efficiency of buildings and of a wide array of equipment and household appliances;
- Binding targets to reduce CO_2 emissions from new cars and vans;
- Supporting the development of carbon capture and storage (CCS) technologies to trap and store CO_2 emitted by power stations and other major industrial installations.

Most of the EU initiatives revolve around cutting greenhouse gases through using less, or increasing efficiency. The EU mandate that by 2020, all member states would have cut their emissions up to 20% below the 1990 levels and up to 80-95% of the 1990 levels by 2050.

The EU states that “In the EU, the forest and agriculture sectors counter some of these emissions by removing an amount of carbon from the atmosphere equal to about 9% of the EU's total greenhouse gas emissions in other sectors. A variety of different land uses and management practices can limit emissions of carbon and enhance removals from the atmosphere within forestry and agriculture.” (EC, 2012). In addition to actual emission changes, they can trade according to the credits gained by participating in LULUCF (Land Use, Land Use Change and Forestry). These activities are contained to forestland management, cropland management, grazing land management and/or revegetation. Added later to LULUCF is wetland drainage and rewetting (EUROPA, 2012).

Carbon credits and offsetting in RSA

South Africa is one of the most carbon intensive economies in the world. CO_2 emissions for 2004 were estimated at 440-million tons (Hallowes, 2009). The designated national authority in South Africa is the Department of Energy. In practice, however, the Department of Environmental Affairs is the lead department for implementing UNFCCC and dealing with climate change.

According to Scholtz & De Villiers (undated) the first carbon credits were issued in June 2008 in South Africa. Since then 228 CDM projects have been submitted to the Department of Energy of which 189 were Project Idea Notes and 39 Project Design Documents (PDDs). Twenty of the 39 PDDs have been registered as CDM projects (7 was issued with carbon credits), and 19 are at different stages of the project cycle. These projects concerns bio-fuels, energy efficiency, waste management, fuel switching and hydro-power, and include sectors such as manufacturing, mining, agriculture, energy, waste management, housing, transport and residential. Very few South African companies have been awarded carbon credits, and the public remain hesitant to take advantage of CDMs. Examples of CDM projects in South Africa are:

- The Kuyasa project based in the Khayelitsha settlement in Cape Town. The project involved retrofitting eight low-cost houses and two crèches with energy-saving devices such as insulated ceilings, low-watt bulbs and solar water heaters, saving almost 2.85 tons of CO_2 each year. These buildings are 5% warmer in winter and 5% cooler in summer allowing a saving of up to 40% on electricity bills. In August 2004 the project was allowed to earn carbon credits. The project was also awarded joint third place at the global Point Carbon’s Best CDM Project 2004 Competition in Amsterdam.
- The eThekwini Municipality Landfill project aims to generate electricity through the fermentation of household waste. The methane released by the waste is then converted into electric power by generators. The project is expected to generate up to 10 Megawatts of electricity (enough to supply light to approximately 9000 homes). This will reduce the volume of coal burnt at city power stations, thereby reducing GHG emissions.
- More recently, Gold Fields’ Beatrix Mine in Welkom has been accorded CDM status. The project captures methane gas at source in the mine. The gas is then conveyed to the surface and then flared or used to generate electricity. It is expected that this activity will reduce the mine’s carbon emissions by 1.7 million tons of CO2 equivalent between 2011 and 2018. Gold Fields could earn up to R200 million from the sale of carbon credits that will be yielded from the Beatrix Mine project.

In 2004 Eskom accounted for more than 40% of South Africa's carbon emissions (Hallowes, 2009). However, according to Eskom's annual results presentation (Eskom, 2009; Eskom, 2011) the company has medium to long-term plans aligned to Government plans to mitigate and reduce relative emissions by 2025 by changing their CO2 footprint and diversifying their plant mix to reflect their climate change mitigation.

Implications for the study

South Africa is a signatory to the United Nations Framework Convention on Climate Change (UNFCCC) and the Kyoto Protocol, and is committed to sustainable development in such a way as to benefit to the economy, society and the environment. Eskom delivers an essential service to the country, but, being responsible for almost half of South Africa's carbon emissions, has a responsibility to investigate manners in which to alleviate the negative effects that their practices are having on a global scale.

Wetlands as a carbon sink

Available literature is contradictory concerning the global amount of wetland area. Kayranli et al. (2010) suggests that wetlands only cover approximately 2-6% of global surface area (depending on the definition of wetland), but contain a large proportion of the world's carbon (approximately 15×10^{14} kg). Mitsch and Gosselink (2007) suggest that wetlands cover 6-8% of the global surface area and are responsible for approximately one-third (approximately 450 petagrams) of the total SOC pool (estimated to be 1550 Pg).

According to Lal (2003) soil provides an estimated 2300 Pg (2.3×1018 g) of the total C pool. A 1982 study by Post et al. (1982) reported that wetlands cover 280 million ha globally, and the average carbon density in wetland is 723 t/ha. This amounts to a total of 202.44 billion tons of carbon in wetlands. According to Bernal & Mitch (2008), more research is needed to quantify more accurately the extent of wetlands' soil carbon pool worldwide and the importance of wetland type, hydrological fluctuations, and climate. Nevertheless, there is no doubt that by unit surface areas wetland ecosystems store more carbon than any other ecosystem in the world (RAMSAR Secretariat, 2010) (Figure 5).

Wetlands are generally regarded as a sink for atmospheric carbon, a definitive element to consider when accounting for the earth's carbon pool. If not managed properly however, they become a source of greenhouse gases (GHGs) (such as CO_2 and methane) (Adhikari et al., 2009; Bernal & Mitch, 2008). Conserving wetlands is therefore a practical way of maintaining existing carbon reserves and avoiding GHG emissions. However, recent literature reviews on the topic suggest that there is no commonly accepted agreement as to whether wetlands are actually carbon sources or sinks, and there exists disagreement in the interpretation of variables, reactions, and the impact of environmental conditions on carbon storage and release. Therefore, recommendations on how to adapt policies and planning processes to enhance carbon storage vary considerably (Kayranli et al., 2010).

Despite the recent disagreements on whether wetlands are a carbon source or sink, all types of wetland systems – including natural-, constructed-, and treatment wetlands – have at least the potential to sequester carbon (Kayranli et al., 2010)). Estimates of greenhouse gas fluxes from constructed and natural wetlands indicate that fluxes from constructed wetlands are higher than those from natural wetlands. Natural wetlands also have more carbon sequestration capacity than the constructed wetlands. Wetland protection and restoration measures can improve the carbon sequestration potential of wetlands. However, it takes several decades for the carbon sequestration ability of restored wetlands to reach levels comparable to those of natural wetlands.

Davidson (2010) notes that when carbon storage capacity is related to surface area, wetlands store more carbon than other ecosystems, as illustrated in Figure 6.

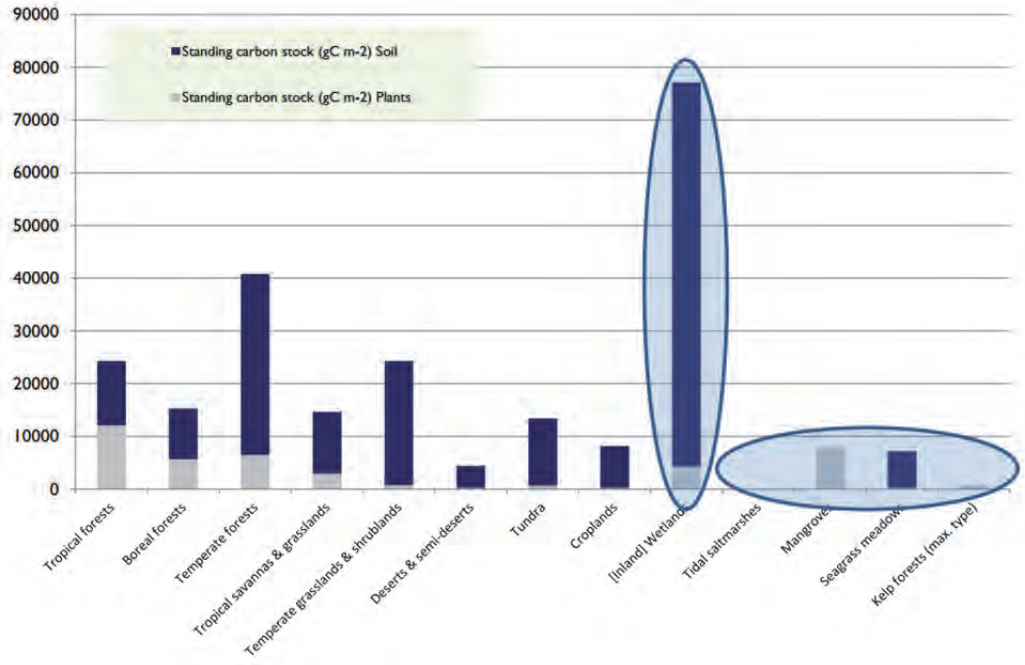


Figure 6: The carbon stock in both plants and soils for different biomes (Davidson, 2010)

The role of wetlands in Carbon offsetting

Up until recently, interest in restoring ecosystems to reduce or offset greenhouse gas emissions focused mostly on forestry. It is only in recent years that this focus has shifted towards wetland ecosystems, particularly peatlands (DFN, 2010). As mentioned before, it is important to note that different types of wetland ecosystems sequester carbon more or less efficiently (DFN, 2010; Hansen, 2009; Bridgham, 2006). The Danone Group, in collaboration with the IUCN and the Ramsar Convention Secretariat, compiled an extensive report to document the potential offset of mangrove and other wetland systems. Their findings are in Table 5 as follows:

Table 5: Results of the comparative qualitative assessment for all types of wetlands (adapted from DFN (2010))

	Mangroves	**Tidal saltmarshes**	**Tropical peat swamp forests**	**Temperate alpine and boreal forested wetlands**
Carbon storage	Medium-High C storage per unit area, but low total globally	Medium-High storage per unit area, but low total globally	High C storage per unit area, but Medium globally by total area	Low-High C storage per unit area, and High globally by total area
Carbon sequestration rates	High C sequestration rates	High sequestration rates	Medium sequestration rates (but highly variable)	Low-Medium sequestration rates
Emissions	Low trace gas emissions	Low trace gas emissions	Low trace gas emissions	Medium-High trace gas emissions
Restoration potential	High restoration potential (if hydrology functional), but Low emissions reduction globally from avoided degradation	Medium-High restoration potential, but Low for avoided degradation	Medium-High restoration potential; High potential for avoided degradation	Medium restoration potential; High avoided degradation potential
Ecosystem Services	High ecosystem services at community Level	Very High ecosystem service provision	Medium-High ecosystem service provision	Medium ecosystem services provision
Market development	Well positioned for market development	Positioning for market development is weak	Well positioned for market development	Good market positioning for some types
Potential for offset	Very High potential offset potential through restoration	High potential for offsets through restoration, but faces a current market gap	High offset potential, especially through avoided degradation	High offset potential, especially through avoided degradation, if there is effective management of trace gas emissions

As mentioned in the previous section, all analyses conclude that wetlands (even rehabilitated wetlands) have the potential to sequester atmospheric carbon in soils and plants. However, the wetlands' net effect on global warming potential is still uncertain (Hansen, 2009). While wetlands act as a carbon sink-reducing CO_2 levels, other GHGs may be released (primarily methane (CH_4) and nitrous oxide (N_20)). A wetland's release of CH_4 and N_20 can more than offset the global warming potential of the CO_2 it removes from the atmosphere. Bridgham et al. (2006) found no conclusive evidence that wetlands significantly alter the GHG stock of carbon. However, it is admitted that a lot of uncertainty surrounds the detail on releases of CH_4 and N_20 by wetlands.

Hansen (2009) developed a model with which to determine the viability of creating wetlands for carbon credits. He found that the economic potential of restoring wetlands for the sale of carbon offsets is limited, as the costs to rehabilitate the wetlands in his study exceeded per acre carbon sequestration values. Together, these results suggest that in most areas, creating wetlands for carbon offset production and sales is not likely to be economically viable for most landowners, especially for non-forested wetlands. However, if landowners were in the position to sell other wetland services such as water quality benefits, mitigation banking credits, or hunting rights in combination with carbon offsets, then creating wetlands might be profitable.

Implications for the study

The use of wetlands to sequester carbon for the purpose of carbon offsetting or trading is an attractive option. However, wetlands are unique, dynamic systems. Although a lot of research has been done on the sequestering potential of wetlands there are still uncertainties about whether we fully grasp the functioning completely.

Site Assessment vs. a Landscape Approach

The ability of a wetland to provide an ecosystem service such as water quality improvement, is reflected by landscape variables related to upstream and downstream land uses and land configurations (King et al., 2003), and therefore wetlands should not be viewed as isolated systems in the landscape, but rather as a response to broader environmental patterns. Wetlands are too often perceived as isolated from the larger ecosystems from which they form a part, whether it is aquatic or terrestrial. Riverine wetlands for example, are both sources (if degraded) and sinks of pollution, and should therefore be considered as a network of wetlands, rather than isolated patches in the landscape. Zedler and Kercher (2005) therefore propose that preserving and restoring wetlands to improve water quality requires a landscape approach, in order to find sites that can intercept a significant fraction of the water shed run-off. Riverine wetlands, for example, due to their extensive interface with uplands, have the capacity and opportunity for improving water quality (Brinson, 1988). On average at least 5% of temperate-zone watersheds should consist of wetlands in order to optimise ecosystem services derived from wetlands (Mitch and Gosselink, 2000). This figure will vary, however, depending on wetland type, catchment characteristics and water resource objectives. The authors therefore proposed that total wetland surface area required for optimising wetland functionalities, should be determined.

Turpie et al. (2010a) undertook a study to estimate the water treatment capacity of wetlands on a landscape scale in the South Western Cape. Samples were collected at over 100 points and analysed for a variety of water quality constituents. The authors obtained data from 19 water treatment works, which indicated that the average cost of removal of

ammonium nitrogen is in the order of R26 per kilogram. Based on this, the results from their study indicated that the average potential value of the wetlands in the study area is averaged R14 350 ha^{-1} yr^{-1} or a total of R328 million for the wetlands in the study area. The authors concluded that these values are high enough to compete with the alternative land uses that threaten the existence of wetlands. As such, wetlands should be given considerably more attention in land-use planning and regulation. The protection of wetlands in this context, especially in stressed catchments should be incentivised.

The reader is furthermore referred to the section in this document on the prioritisation of wetlands for rehabilitation, where wetlands and their ecosystem services reviewed are represented at several spatial scales, including on a catchment scale.

Implications for the study

The concept and methodology underlying the economic valuation of wetlands can be valuable tools for Eskom. Potential areas of application include: to quantify impacts on wetlands, wetland offsetting and banking as well as to analyse and quantify alternative options when proposed developments potentially impact on wetlands.

Such an assessment and valuation should however take place with due regard to the broader catchment characteristics and drivers of environmental change.

Wetlands on Eskom properties

Eskom has a national footprint (see Figure 2). Although the coal-fired power stations are concentrated in the eastern Highveld area, the power line and supporting infrastructure servitudes cover the country. The Eastern Highveld area is particularly rich in wetlands with wetlands covering an estimated 9.9% of the Upper Olifants River Catchment (Palmer et al., 2002). The power stations sited in this area are closely associated with wetlands. Two examples are shown in Figure 7a and b (Grootvlei PS and Matla PS).

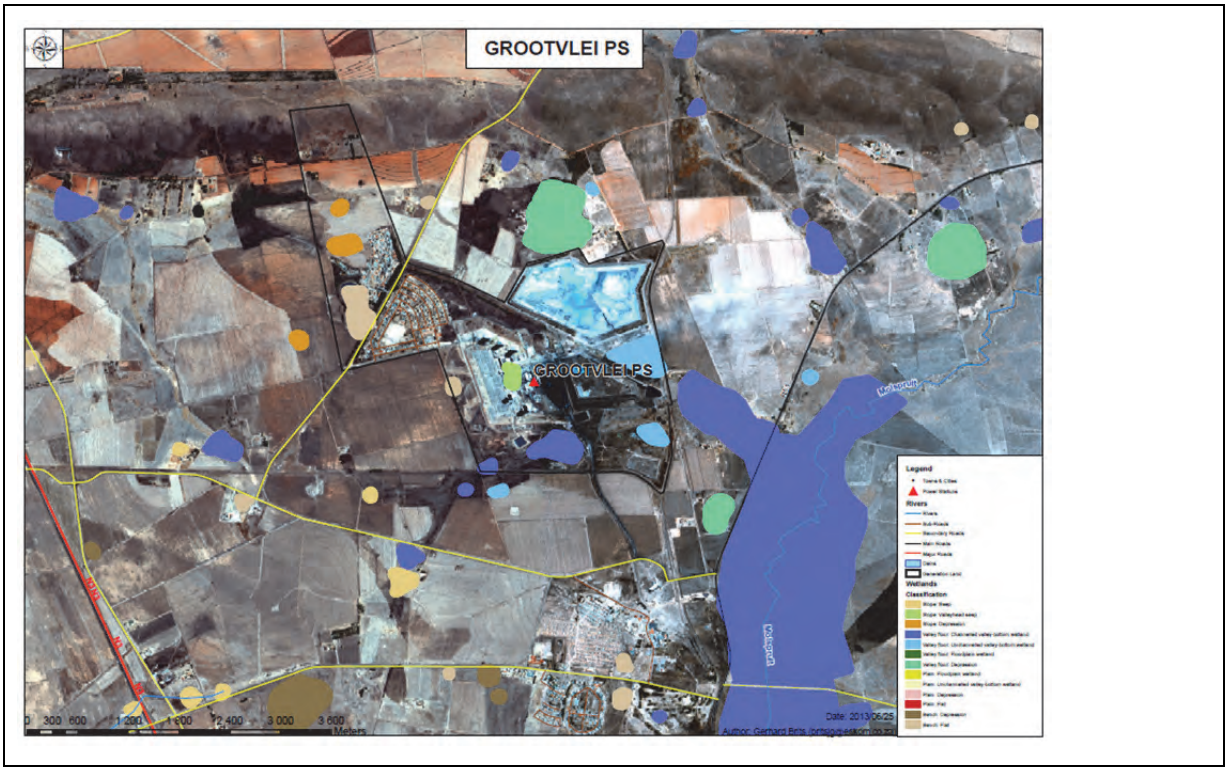


Figure 7: Wetlands on and adjacent to (A) the Grootvlei PS property

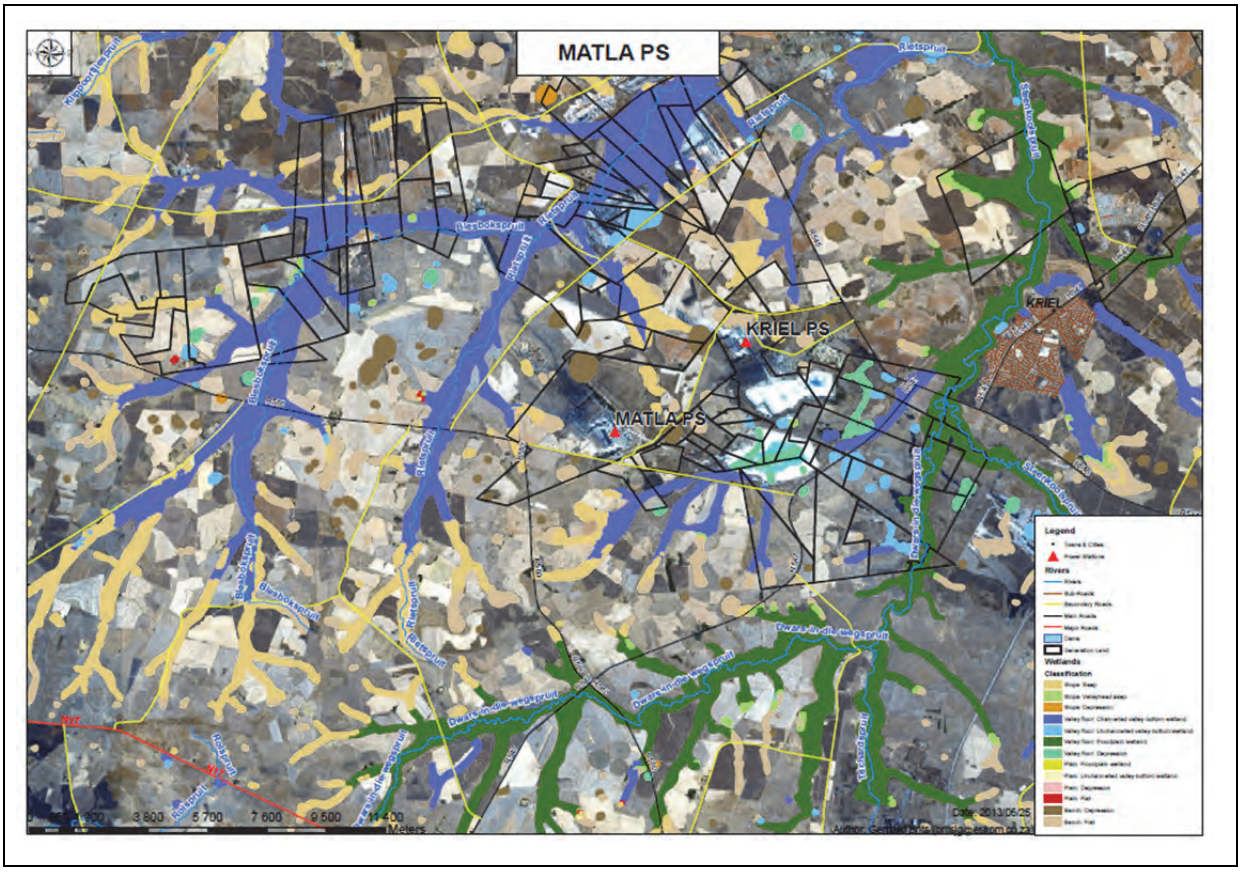


Figure 8: Wetlands on and adjacent to the Matla and Kriel PS property

An in-depth analysis of the wetlands on the Matla property is provided in Chapter 4.

The older power stations were established before the current legislation was promulgated. An exception to this is Kusile PS. A detailed wetland management strategy has been developed for the Kusile site which comprises 4 major sections – determination of the wetland baseline, avoidance of wetland impacts, mitigation of impacts and compensation. A key success factor of this strategy is the relationship between Eskom and Working for Wetlands, with an MOU having been signed between the two organisations. This document also takes cognisance of Eskom's Land and Biodiversity Policy which states that

> Eskom will ensure in the planning, construction, operation and decommissioning of their activities, that measures are in place to limit the impact of its infrastructure, land use and use of other resources on biodiversity and shall comply with all applicable legislation (Harris et al., 2013).

Water Quality and Pollution Attenuation

The DWAF (1996: Vol 1) describes water quality to be the "physical, chemical, biological and aesthetic properties of water which determine its fitness for a variety of uses and for protecting the health and integrity of aquatic ecosystems. Many of these properties are controlled or influenced by constituents that are either dissolved or suspended in water".

Water having the unique chemical property of polarity and hydrogen bonds, can dissolve; absorb; adsorb or suspend numerous compounds (including toxic compounds), thus losing its purity (Momodu and Anyakora, 2010). These compounds can be acquired from sources such as the surrounding environment; anthropogenic activities; animals and other biological activities (Momodu and Anyakora, 2010). The materials that are dissolved or suspended in the water may originate from point and non-point sources.

Point and non-point sources

Point sources are those sources which discharge a stream through a defined discharge point and these discharges tend to be continuous with little variability in the environment (Carpenter et al., 1998). Contaminants from point source discharges and their chemical concentrations can be measured and monitored at a specific point of release, and these can then be regulated and treated at the source (Carpenter et al., 1998). Examples of point sources are industrial and municipal wastewater effluent, runoff and leachate from waste disposal sites, runoff and groundwater infiltration from animal feedlots, runoff from mines, construction sites and oil fields, and sewers (Carpenter et al., 1998).

Non-point sources (which originate from a number of activities that stretch across the landscape) are those sources of contaminants that have been diluted by rainfall (which is already considered as impure) and thereafter drain into water bodies as overland flow, groundwater seepage or through precipitation from the atmosphere (Wanielista et al., 1977; Carpenter et al., 1998). Non-point sources are more difficult to control as they, by definition, they cannot be treated at source unless they can be collected. The sources of these contaminants, which can be from the natural environment (generally inorganic compounds) or from man-made pollutants which are from industries (inorganic or organic compounds), are difficult to trace and may have a greater detrimental effect on the quality of water (Wanielista et al., 1977). Non-point sources can be from either rural or urban regions where, for instance, agricultural pollutants (pesticides, fertilizers and other chemicals) are used in both subsistence and commercial farming (Wanielista et al., 1977). Pollutants from urban areas include solid wastes, organic chemicals, street surface contaminants (heavy metals, nutrients, pesticides, bacteria dirt and dust), and air and vehicle pollutants; where these may vary in quantity and their distribution (Wanielista et al., 1977). According to Williamson and

Morrisey (2000), the cumulative effects of non-point source pollution in these aquatic ecosystems are of great concern. The use of indicators is a method of measuring amounts of pollutants, including long term anthropogenic activities such as mining activities (Jumbe and Nandini, 2009); and measures the health and integrity of water by measuring the 'fitness for use' (DWAF, 1996).

Implications for the study

Eskom point and non-point sources include amongst others:

- Seepage from ash dams and coal storage areas directly into the groundwater and surface water systems
- Surface runoff from mines and power stations
- Acid Mine Drainage from coal mining operations

Seepage and overflows from unlined pollution containment dams and maturation ponds

Water quality indicators

Biological, chemical, and environmental indicators have been developed by researchers for sustainable natural resource management and these are used as "early warning" signals (Reed and Dougill, 2002). These "early warning" signals are shown by changes in the natural environment (Reed and Dougill, 2002) and these indicators that are measured tend to be more for harmful changes or degradation to the natural environment. According to Noble et al. (2003), "different indicators and different indicator levels identified as standards are used by water quality programs in different states, countries, and regions". These are also a quantitative measure of the pressures on the state of the environment and its changes, which use spatial and temporal evaluation criteria (da Silva and Rodrigues, 2004). In South Africa, The Department of Water Affairs and Forestry have developed criteria that list the critical levels of water quality indicators. These are used to measure the 'fitness for use' of the water for different categories of users. These levels vary slightly depending on the water body being tested, such as estuaries, freshwater environments, water at industrial sites, water for recreational use, for irrigation, and most importantly the critical limits for domestic use and drinking purposes. Some examples of indicators are levels of pH, Temperature, Dissolved Oxygen (DO), Turbidity, Specific conductivity or Total Dissolved Solids (TDS), Nitrates, and Chloride and Ammonium concentrations, and heavy metals. These guidelines are available in the DWAF South African Water Quality Guidelines of 1996.

Nutrients and heavy metals

Human impacts have also altered cycles such as the biogeochemical cycles, where anthropogenic influences have effected changes in Nitrogen (N), Phosphorous (P), and Carbon (C) cycles (Smith et al., 1999). Due to an increase in the use of agricultural fertilizers, N and P compounds have increased in ecosystems, and the total amount of N and P exported from the surface in runoff increases linearly with the N and P soil content (Smith et al., 1999). Humans use flowing waters as convenient wastewater disposal systems therefore *the loading of N and P to the world's rivers, lakes, and oceans is thus very strongly influenced by human population densities, the population densities of livestock, and land use* (Smith et al., 1999).

Nutrients, total dissolved or suspended solids, sulphates and heavy metals are present in aquatic ecosystems at varying concentrations (DWA, 2000; Coleman et al., 2011), where increases in nutrient concentrations affect the natural balance of aquatic ecosystems and

often result in eutrophication and degradation (DWA, 2000). Nutrients are transported from terrestrial to aquatic systems as dissolved pollutants in runoff (from agriculture, industry, urban runoff, domestic wastewater, and landfill leachate) or as particles in runoff as particulate pollutants (pollutants mobilised with soil particles through adsorption) (DWA, 2000). Heavy metals are widespread, non-degradable pollutants that are toxic and persistent in the environment (Jumbe and Nandini, 2009). Heavy metals have detrimental consequences on aquatic life and humans that utilize polluted water sources. Heavy metals enter water bodies and contaminate sediments via natural sources such as eroded minerals within sediments; leaching of ore deposits; volcanism extruded products, and terrestrial runoff; or via anthropogenic activities such as, solid waste disposal; leachate from landfills; industrial or domestic effluents; and harbour channel dredging (Zheng et al., 2008; Momodu and Anyakora, 2010). Simple engineering options that may improve the effects of pollution arising from these sources include (DWA, 2000):

- Riparian buffer zones
- Constructed wetlands
- Existing wetlands
- Drainage ditch management
- Vegetated filter strips
- Hedges

These basic ecological engineering options alter hydrological pathways so that water is directed through existing wetlands. Features such as oxbow lakes and other former channels on floodplains may greatly increase their nutrient and pollutant removal functions (DWA, 2000).

Implications for the study

An increase in pollutants can lead to the degradation of wetlands by accelerating the degradation of wetland health. Wetlands will be able to sustain themselves by attenuation for a period of time until critical limits and levels of pollutants have been reached. Wetland water quality should be monitored continuously (using South African DWS water quality guidelines) to minimise degradation so that they can continue to supply humans with the services from which we benefit.

Acid mine drainage (AMD)

Acid mine drainage (AMD) is the generation of acid caused by the exposure of rock containing certain sulphide minerals (most commonly Iron pyrite (FeS_2)) with air and water, resulting in the production of highly acidified water containing elevated concentrations of sulphate and metals (Keet, 2010). This can be recognised by a yellow/orange/brown tint to waters. In South Africa AMD is largely associated with gold and coal mining (Keet, 2010).

Risks associated with AMD (Keet, 2010):

- Harmful to ecosystems, presenting a massive environmental challenge
- Negatively impacts on quality of water resources
- Flooding and Decanting from disused mines
- Discharge does not meet water quality standards, but this shows no immediate threat (lag in environmental effects)
- Flooding of the Basin or catchment

- Effects to human and animal life
- Sinkholes in dolomitic areas
- Destruction of heritage value
- Difficulty for mines to achieve compliance with water quality standards within short time periods.

Short-term solutions are those that will prevent the rise of water levels in mine voids from exceeding the Environmental Critical Level (ECL is the highest water level in the mine void which can be allowed without the mine water negatively impacting on the shallow ground water aquifers and the surface water resources) (DWA, 2012). These short-term solutions to AMD as suggested by The Department of Water Affairs (DWA, 2012) include:

- The installation of pumps to extract AMD from mines to on-site treatment plants
- The construction of on-site water treatment plants in each basin, with the option of refurbishing and upgrading existing treatment facilities owned by the mines
- The installation of infrastructure to convey treated water to discharge into nearby watercourses.

The DWA has recently engaged in a key stakeholder and communication session and together they have developed a feasible long-term solution to AMD problems. This feasible solution will be *one that is technically sound, environmentally sustainable, economically viable, institutionally feasible & legally acceptable* (DWA, 2013). Figure 9 below explains the planning required for long-term solutions and will, to a large extent, be informed by existing information, monitoring initiatives, technical input and expert advice.

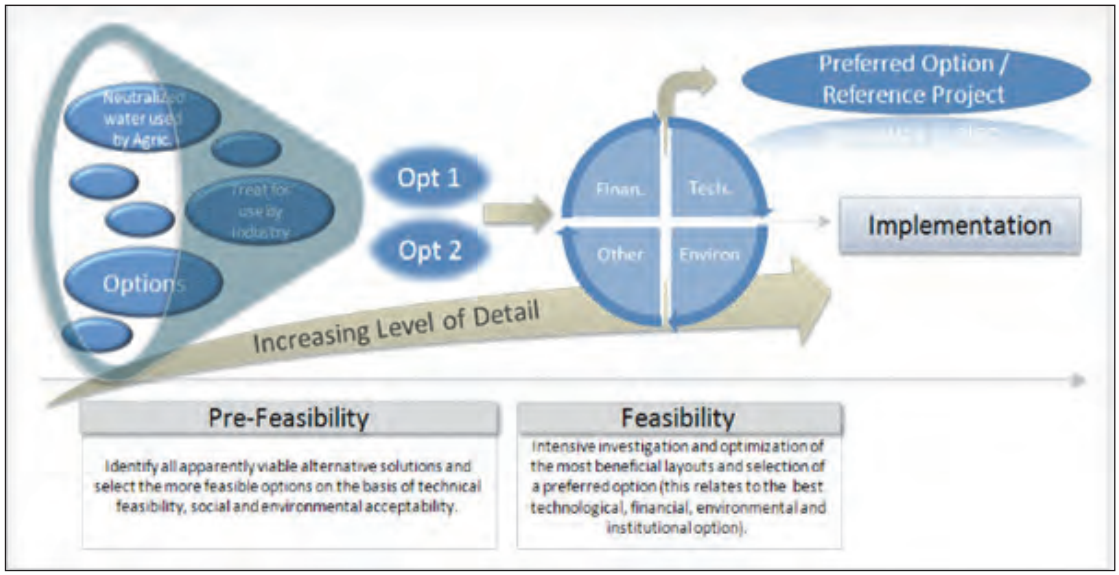


Figure 9: Planning and design for AMD long-term solutions (DWA, 2013)

This long-term solution has been designed to include all Interested and Affected Parties (I&APs) within an EIA process with the following objectives in mind:

- To undertake focused consultation with identified key stakeholders and stakeholder sectors/groups to assist in identifying sustainable solutions, technical options, management scenarios
- To engage identified key stakeholders in various relevant fields throughout the study, to obtain their input and comments on concepts, principles, and assessments of alternatives

- To assist the DWA to keep the wider stakeholder group informed of progress and key outcomes and to provide opportunities for constructive input to inform the feasibility study
- To communicate information to the wider stakeholder group in a manner that enhances their understanding of the AMD challenge and enables them to provide constructive inputs
- To record stakeholder input for consideration in informing the feasibility study.

Implications for the study

Eskom may need to use temporary short-term solutions as an intervention to possible AMD problems at their mines and/or power stations. Long-term solutions will need to be developed through feasibility studies and EIA processes and should include all the necessary stakeholders. This ensures for sufficient quality control processes to be put into place and thus reducing the volume of pollutants downstream.

Case study of the Vaal River

The Integrated Vaal River System is the largest in South Africa and 60% of the country's Gross Domestic Product is derived within this catchment. Therefore, subsistence and commercial users rely heavily on the ecosystem services provided by the catchment, one important service being the provision of water (Eon, 2012). This has been able to happen thus far as the water quality and its related pollution concentrations have not reached critical levels. A number of industries rely on this catchment for water and 90% of Eskom's base load generation comes from the Vaal (Eon, 2012). Currently the Vaal is experiencing water quality and seasonal flow problems. Water quality issues include eutrophication, microbial pollution, and increased salinity. This system requires intervention by at least 2014 to prevent water shortages (Eon, 2012).

Pollution attenuation

Wetlands are known to provide "sinks" for pollutants (including nutrients and metals). This is also known as pollution attenuation. The capacity for pollutant removal largely depends on the size of the wetland and the inputs received by the wetland which are related to their position along hydrological pathways (DWA, 2000). Wetlands can attenuate pollution when the input load of pollutants into a wetland is still below critical level. Wetland functioning can ensure the following (DWA, 2000):

- Acting as a sediment sink for deposited suspended solids and particulate-bound pollutants, including a proportion Chemical Oxygen Demand (COD)
- Denitrification processes that reduce NO_x to nitrogen
- Providing a medium for chemical ionic interchange at the surface and sub-surface layer (precipitation and adsorption)
- Provide the physical separation of particulates and particulate-bound pollutants from water at the sub-surface layer
- Reduce spray drift attenuation (attenuation of chemicals (such as those used in agriculture) that are transported by wind to wetlands)
- Assimilation of metals and nutrients by plants and other organisms (e.g. microbes).

Pollution attenuation can, therefore, improve the quality of water leaving the wetland. Some of the mentioned processes are seen in Table 6 below.

Table 6: Pollution attenuation processes to improve water quality (DWA, 2000)

Pollution type	Removal process
BOD/COD	Oxidation Absorption Filtration/sedimentation Microbial decomposition
Suspended solids/sediment	Filtration/sedimentation
Nitrogen/nitrogen compounds	Adsorption Assimilation/absorption Amonification-nitrification-denitrification
Phosphorus/Phosphorus compounds	Sorption/adsorption Bioaccumulation/absorption Ionic precipitation Particulate retention
Hydrocarbons and heavy metals	Absorption Caption exchange Bioaccumulation/absorption
Sulphur	Microbial oxidation or reduction
Bacteria	Adsorption Predation Sedimentation Sterilisation by UV light
Iron and manganese	Oxidation and precipitation

Implications for the study

Eskom should direct their efforts into protecting their wetlands as these can improve water quality and reduce environmental degradation through natural measures. Efforts should involve assessing the current wetland health (assessing hydrology, geomorphology, and vegetation) and then implementing rehabilitation or restoration method with continuous monitoring thereafter. Constructed wetlands and measuring offsets can be considered if existing wetlands are beyond rehabilitation interventions.

Sustainable Livelihoods and Economic Opportunities for Surrounding Communities

Approaches with reference to sustainable livelihoods have been developed by several global organisations (e.g. DFID) in a response to poverty alleviation policies in the late 1990's. These approaches encompass all aspects impacting on poverty levels in its broadest sense, and include education, health, financial services, security and natural resources. These aspects have been described as five types of capital, and include (Turpie, 2010b):

- Human Capital includes the levels of skills, knowledge, ability to work and level of health.
- Social Capital includes the strength of networks and connectedness, membership in groups and exchange relationships.
- Financial Capital includes the available stocks of, and regular inflows of, money.
- Physical Capital is the infrastructure, utilities, energy, technologies, access to information and tools and equipment.
- Natural Capital comprises the natural resource stocks, public goods such as biodiversity, air quality, and divisible goods such as land and trees.

Livelihoods are considered as sustainable when the above capital can cope with and recover from stress without undermining the natural resource base. Many communities in South Africa are directly dependent on natural systems to sustain their livelihoods. Wetlands in particular are valuable because of the services they provide for example providing grazing, fertile soil for the cultivation of crops, protein sources and material for thatching. It is therefore imperative to understand the degree of dependence of people's livelihoods before making decisions that may impact on the sustainability of their livelihoods (Turpie, 2010b).

Turpie (2010b) developed a simple index for the assessment of the importance of a wetland for the sustainable livelihood of communities surrounding a wetland. The assessment is based on the degree to which a wetland contributes to reducing the vulnerability of households to poverty. These more vulnerable households would be more dependent on the wetland in question. Figure 10 below provides an overview of the Wetland Livelihood Value Index.

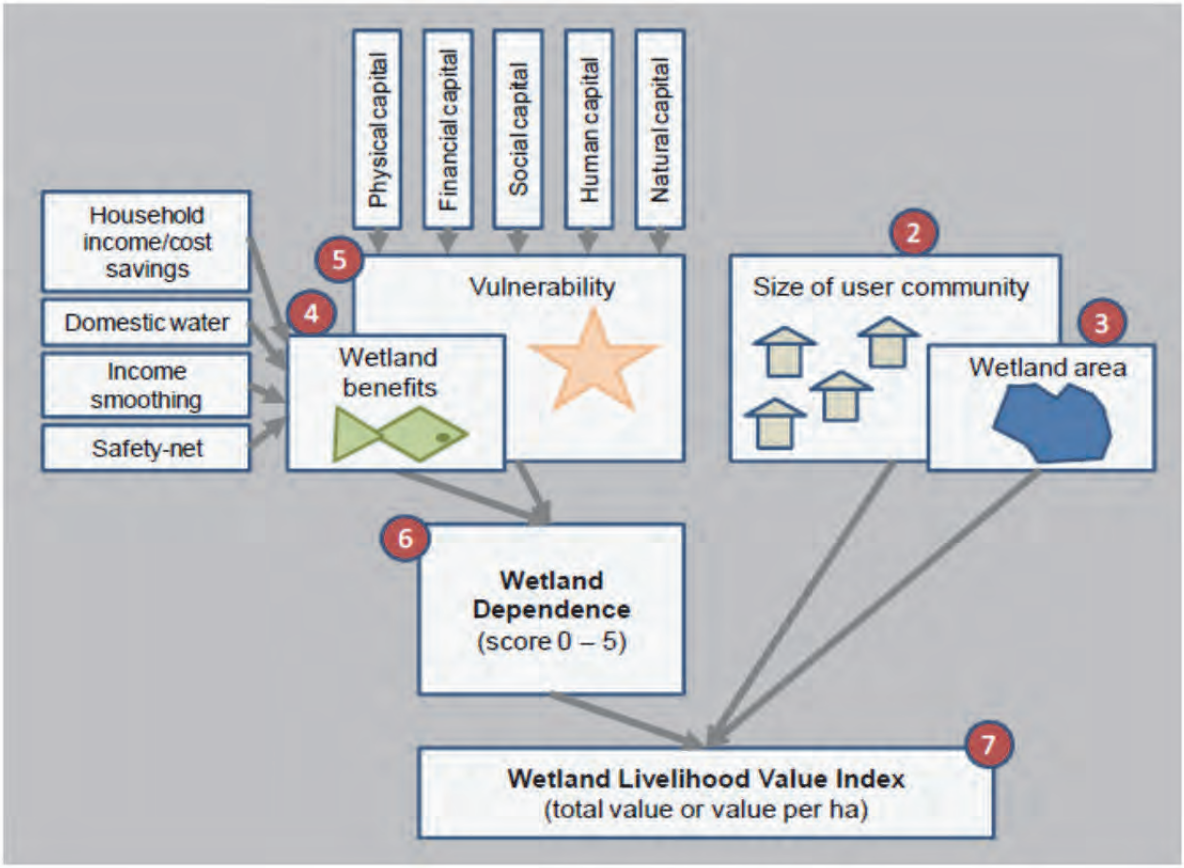


Figure 10: Overall structure of the Wetland Livelihood Value Index. Numbers in circles correspond to steps in the assessment process after step 1 (defining objectives and level of assessment (Turpie, 2010b))

Implications for the study

The relative importance of wetlands should include an investigation into the reliance of surrounding communities for their livelihood on wetlands that may be impacted by mines associated with Eskom's supply chain. In some instances, continued access to land to continue using the services that wetlands provide, will impact positively on sustainable livelihoods of communities reliant on wetland services. At the same time, the sustainable use of wetlands provides opportunities for wetland conservation whilst balancing corporate social responsibilities.

The compilation of a Management plan for wetlands associated with sustainable livelihoods will promote wise and sustainable use.

Indicators and early warning systems

According to the DPSIR framework (Drivers, Pressure, State Impact and Response Framework) there is a sequence of causal links between the stimulus causing a situation, the state of the system under consideration resulting from the pressures exerted by the stimulus, the impact on the system and the appropriate management response. This framework presents a structure within which all monitoring and indicators should be placed (see Figure 11, Kristensen, 2004). Placement within the framework indicates the relationship between the individual indicator and the change being monitored.

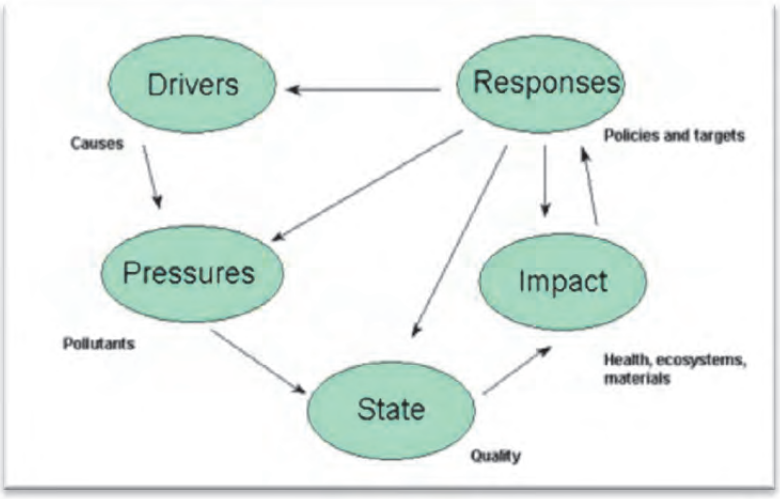


Figure 11: The DPSIR assessment framework (from Kristensen, 2004)

The understanding provided by the framework enables the link between the origin and consequence of a problem to be identified and so any planned interventions may effectively address the cause. In addition, it makes clear the relationship of how an indicator in one sector, say the state, addresses a driver or pressure.

The following examples from each of the categories of the DPSIR framework are taken from Kristensen (2004). A 'driving force' is a need, such as shelter, food, water and entertainment for an individual. In the industrial sector it may be the need to remain profitable, for instance. Driving forces lead to human activities such as food production, transport, the need for power, etc., which exert pressures on the environment. The state of the environment (e.g. the bio-physical and chemical components of the air, water, soil, etc.) is affected by these

pressures. These in turn impact on the health of humans and the environment. The response may address the causal chain at any point and interventions may be in the form of, for instance, policy or remedial action.

The DPSIR framework is used in the South African State of the Environment Reporting as it is viewed as providing a systems-analysis view of the relations between the environmental system and the human system (SOER, 2005).

Implications for the study

The DPSIR model is a useful tool to guide monitoring and record keeping requirements enabling an advance warning system.

The data sheets of the Eskom field guide (field sheet and score sheet) provide the basis for a monitoring programme but have not been arranged within the DPSIR framework.

Indicators are a reflection of a given situation or variables that help to measure change or progress in achieving objectives and reaching targets. If measured sequentially over time, indicators can indicate the direction and speed of change and can also be used to compare different areas or groups of people with respect to the existence of a given situation. The ideal indicator is:

- Valid (measures what it is supposed to measure)
- Objective (gives the same answer whenever it is applied)
- Sensitive (sensitive to changes in the situation)
- Specific (reflects only changes in the situation).

A hierarchy of indicators to establish the temporal and spatial trends in wetland ecosystems, the habitats provided and the species inhabiting the wetlands is presented in Volume 13 of the Ramsar Handbooks for Wise Use (2010). These indicators are designed to assess the pressures and threats to wetlands and to respond to or address these. The Ramsar convention has worked closely with the Convention for Biodiversity to develop indicators which track biodiversity changes, including the following:

- Trends in extent of selected biomes, ecosystems and habitats
- Trends in abundance and distribution of selected species
- Change in status of threatened species
- Trends in genetic diversity of domesticated animals, cultivated plants, and fish species of major socio-economic importance
- Coverage of protected areas
- Criteria and indicators for sustainable management of ecosystems
- Biodiversity used in food and medicine
- Water quality in aquatic ecosystems
- Trophic integrity of ecosystem
- Nitrogen deposition
- Numbers and cost of alien invasions.

Some of these indicators are relevant to the scale at which Eskom works and would need to be made specific to Eskom's needs. At a broad level, the initial tranche of effectiveness indicators, as determined by Ramsar, is given in Table 7.

Table 7: Effectiveness indicators for wetland health (Ramsar Vol. 9, 2010)

Indicator	Sub-indicator(s)
A. The overall conservation status of wetlands	i. Status and trends in wetland ecosystem extent ii. Trends in conservation status – qualitative assessment
B. The status of the ecological character of Ramsar Sites	i. Trends in the status of Ramsar Site ecological character – qualitative assessment
C. Trends in water quality	i. Trends in dissolved nitrate (or nitrogen) concentration ii. Trends in Biological Oxygen Demand (BOD)
D. The frequency of threats affecting Ramsar Sites	i. The frequency of threats affecting Ramsar Sites – qualitative assessment
E. Wetland sites with successfully implemented conservation or wise use management plans	i. Wetland sites with successfully implemented conservation or wise use management plans
F. Overall population trends of wetland taxa	i. Trends in the status of water bird biogeographic populations
G. Changes in threat status of wetland taxa	i. Trends in the status of globally-threatened wetland-dependent birds ii. Trends in the status of globally-threatened wetland-dependent amphibians
H. The proportion of candidate Ramsar Sites designated so far for wetland types/features	i. Coverage of the wetland resource by designated Ramsar Sites

Implications for the study

A number of indicators are to be found in the literature, each of which has been designed to monitor specific conditions. Certain indicators may be developed which will be generic to Eskom Holdings Ltd, for example the presence (with density) or absence of alien invasive biota. Other indicators will need to be developed to suit specific conditions which may be linked to ecoregions or other features specific to the area.

Once appropriate indicators have been selected these should be included in a monitoring programme. The Ramsar framework provides, in a series of logical steps, the design and planning of a monitoring programme (see Figure 12). This is not prescriptive and may be adapted as appropriate to the need (Ramsar Wise Use of Wetlands, Vol 18, 2010).

In order to ensure that a monitoring programme is effective it should be included within the framework of Strategic Adaptive Management (SAM) as described by Pollard and du Toit (2007) (see the following section titled 'Adaptive Management').

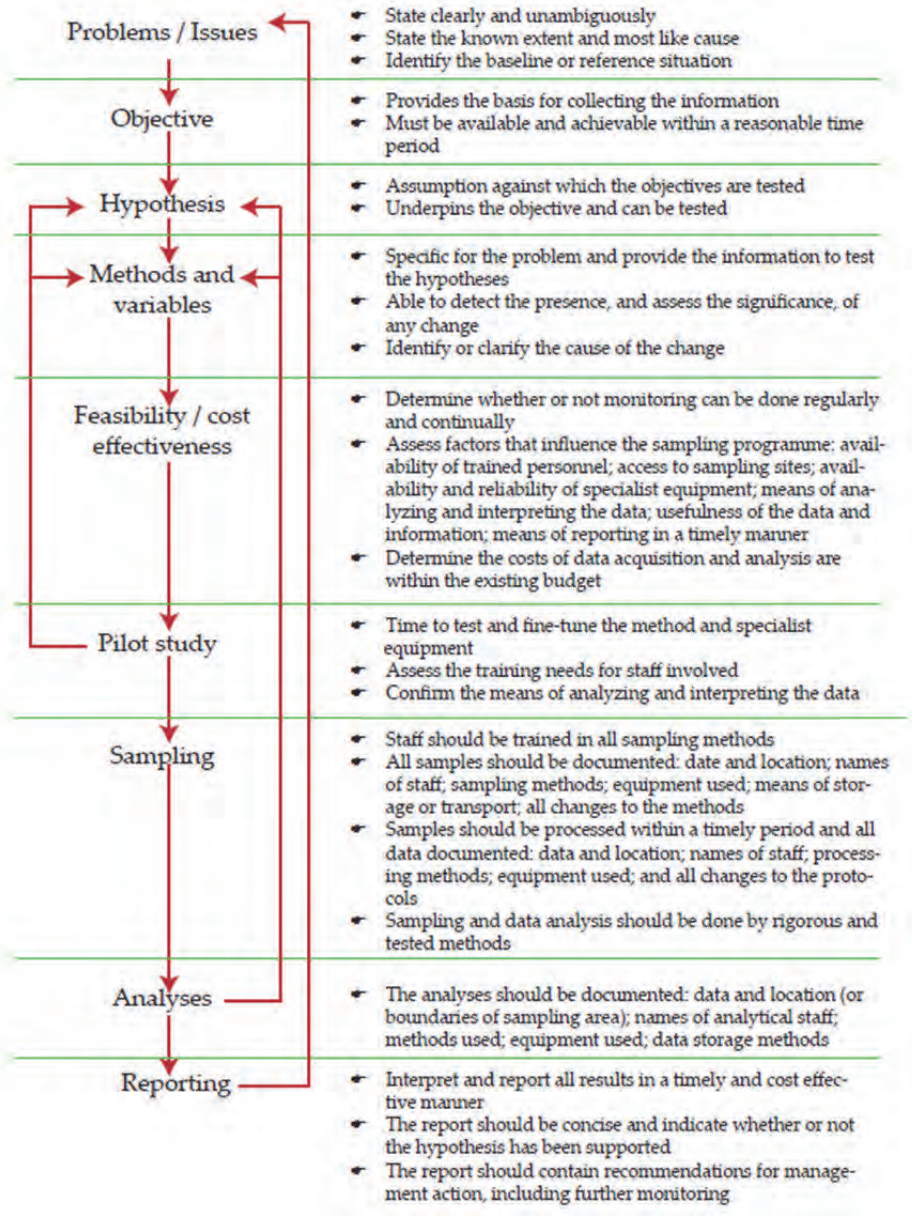


Figure 12: The generic design of a monitoring programme as given by Ramsar Convention (Wise Use Handbook 18, 2010). This is not prescriptive and should be adapted as required

The Eskom field guide provides Eskom's field workers with a standard procedure for assessing wetlands on their property. This procedure combines the wetland physiognomy (determined remotely) with field measurements such as vegetation and soil to complete a scorecard which will then provide a numerical score of the wetland condition. A monitoring and management programme could be based on the criteria measured in the Eskom Wetland Classification and Risk Assessment Field Guide (Oberholster et al., 2014).

Adaptive Management

"Adaptive management" was first introduced to the sphere of natural resource management by Holling (1978) with his concept of "Adaptive Resource Management". Adaptive management has been defined by Rogers and Lutton (2011) (quoting Meffe et al. (2002)) as: "The process of treating resource management as an experiment such that the practicality of trial and error is added to the rigour and explicitness of the scientific experiment, producing learning that is both relevant and valid".

Adaptive management may be practised with different levels of rigour which are broadly categorised as follows:

- Active (classic or true) adaptive management in which the emphasis is strongly on the scientific method, the process of "experiment" and on modelling
- Passive adaptive management in which there is much less emphasis on the scientific method/experiment and more on learning by a range of means/tools
- Documented trial and error in which there is no stipulated structure to the decision making process but what does happen and its consequences are nonetheless well documented.

Strategic Adaptive Management (SAM) as defined by from Biggs and Rogers (2003) and adapted by Pollard and du Toit (2007) falls under a) active adaptive management as described above, and one requirement is that each step is fully documented to allow for assessment of the achievement of the objectives during the review provided by the feedback loops. The SAM process is structured to guide a 'learning by doing' process through which there is an on-going assessment of effectiveness of the overall management programme, encouraging the refinement of the goals of management based on the results of management interventions as indicated by the monitoring programme. The basic steps in SAM are (from Pollard and du Toit 2007):

1. Visioning. Understand, with stakeholders, the social, economic and ecological context of the system to be managed, and the principles/values that guide management. Develop a broadly acceptable vision of the future.
2. Translate vision into ecosystem targets. Develop an objectives hierarchy that documents the sequential reasoning used in translating a broad societal values-based vision into science-based ecosystem outcomes.
3. Options analysis:

3.1. Scope the range of management options to achieve the desired future conditions and predict their likely outcomes under different scenarios. Expect the unexpected.
3.2. Assess the acceptability of outcomes from a range of perspectives
3.3. Select the best options in co-operation with stakeholders.

4. Operationalise (implement, monitor and audit achievements).
5. Reflect at each step. Is thinking and action congruent with principles/values? What does the knowledge gained tell us about (1) our understanding of the system, (2) its responses and, (3) how realistic are the desired outcomes and (4) how useful are the processes used to achieve them.

The process is outlined in Figure 13, which indicates the feedback loops which provide the review of the process. The same principle is recommended by Kotze (2004) for use by the Mondi Wetland Project, providing a structured review process for assessing the achievement of the stated objectives.

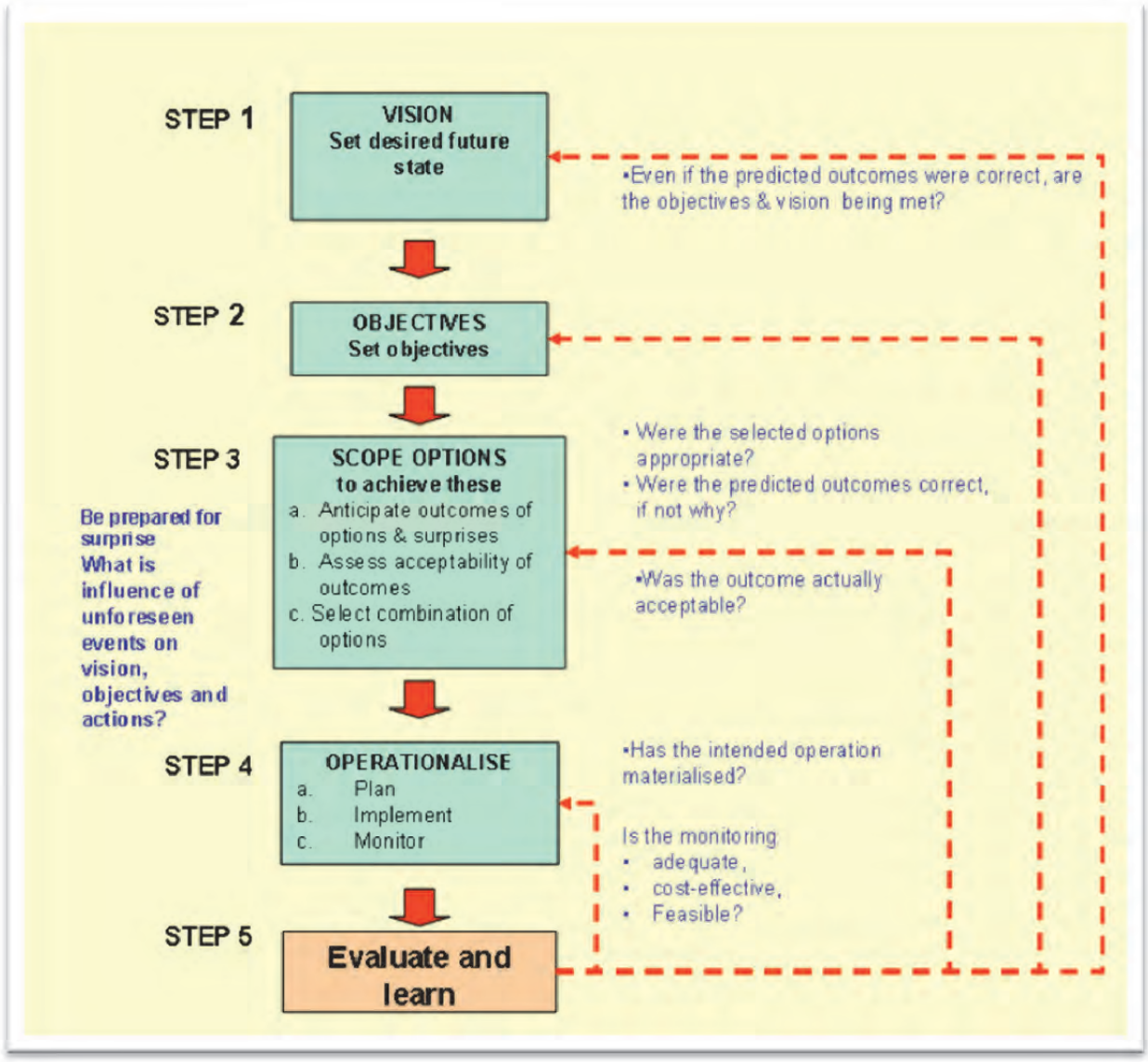


Figure 13: A framework for strategic adaptive management showing the 5 key steps (from Biggs and Rogers, 2003, adapted by Pollard and du Toit, 2007)

Implications for the study

Given that the overall aim of this project is to develop and test an adaptable planning framework that streamlines the conservation of wetlands in areas where Eskom operates from coal to customer, it is proposed that Eskom follows an active adaptive management process to ensure on-going improvement of and maintaining the relevance of this Wetland Management Framework (WMF).

The steps of the framework should be reviewed and refined as necessary as the framework is implemented.

Wetland Health Assessment

Wetland health is used to determine the ecophysical health or condition of the wetland; to understand if they are beyond repair, if they require rehabilitation and management interventions, or if they are healthy enough to be left alone due to little degradation (Macfarlane *et al*., 2009). Wetlands are measured by their similarity to or deviation from their natural characteristics, that is, the climate, geology, soil, water, nutrient supply, and radiant energy, together with its biotic community. If they have not been modified or experienced levels of disturbances from human impact, they are regarded as "natural" or "reference condition" (Macfarlane *et al*., 2009: 17). Wetland health is also assessed to determine the degradation factors so that appropriate intervention methods can be designed. Wetland health can be assessed at both the broad catchment level and the detailed individual wetland level based on field assessments and indicators.

When conducting health assessments, the objectives and the geographical boundaries need to be clearly defined (assisted by using GIS, orthophotos or topocadastral maps) and available resources such as:

- Possible land uses and their extent in the catchment area
- Presence of drains
- Dams or erosional features (including details such as depth, etc.)
- Loss of vegetation
- Types of indigenous or alien vegetation
- The mean annual precipitation and potential evapotranspiration (Macfarlane *et al*., 2009).

Wetland Health indicators:

The Water Research Commission is currently funding the design of a National Wetland Monitoring Programme for South Africa (WRC project number K5/2269). The following review of indicators covers the current South African situation, but the National Wetland Monitoring Programme, scheduled to be completed in early 2016, is likely to become the national benchmark for wetland monitoring.

Wetland health can be assessed by measuring indicators such as geomorphology, hydrology and vegetation. These assist for wetland rehabilitation and their planning and assessments (Macfarlane *et al*., 2009). Assessments of the geomorphology, hydrology and vegetation of wetlands may vary from the "present" ecological state (PES) to the "critically altered" state (categories A-F, with A being unmodified and F being at critical level) (see Table 8 below), as well as measuring them against the Trajectory of Change, that is, the threat or vulnerability to change (Macfarlane *et al*., 2009) (see descriptions below).

Table 8: Impact scores and Present State category describing the integrity of wetlands

Impact category	Description	Impact score range	Present State category
None	Unmodified, natural	0-0.9	A
Small	Largely natural with modifications. A slight change in ecosystem processes is discernible and a small loss of natural habitats and biota may have taken place.	1-1.9	B
Moderate	Moderately modified. A moderate change in ecosystem processes and loss of natural habitats has taken place but the natural habitat remains predominantly intact.	2-3.9	C
Large	Largely modified. A large change in ecosystem processes and a loss of natural habitat and biota and has occurred.	4-5.9	D
Serious	The change in ecosystem processes and loss of natural habitat and biota is great but some remaining natural habitat features are still recognizable.	6-7.9	E
Critical	Modifications have reached a critical level and the ecosystem processes have been modified completely with an almost complete loss of natural habitat and biota.	8-10	F

The Trajectory of change can also be scored in a “class range” to calculate the weighted score (see Macfarlane et al., 2009).

Measuring wetland health is symbolic as it is difficult to measure and compare similarities or differences to other wetlands as each wetland is a unique ecosystem. Wetlands are dynamic and respond to temporal changes – whether these are weekly, daily, seasonally, over longer periods due to climatic changes, or over geological and geomorphological evolutionary time scale. The range of these changes consequently makes functional, structural and compositional assessments difficult (Macfarlane *et al*., 2009). Therefore assessments can be done by measuring the hydrology component (which can measure for impacts due to the quantity and distribution in impacted or unimpacted states); as well as the geomorphology and vegetation components which can be used as indicators as they are visible and measurable. Geomorphology indicators can measure soil erosion and vegetation can measure alien invasive species or ruderal species (species adapted to rapidly colonize sites with disturbed soils). Measurable indicators need to take into account the differences between natural versus anthropogenic factors (Macfarlane *et al*., 2009). Ruderal species typically increase in abundance on disturbed sites but are gradually replaced by successional species as the site recovers.

The impact of hydrology, geomorphology and vegetation are scored quantitatively and measure the intensity and extent of impacts to result in the allocation of a score. The

magnitude of the score gives an overall indication of wetland health (see Table 9 and calculations below). Two levels can be used to assess wetland health:

- Level 1 assesses wetlands at a very low resolution to determine the overall wetland health in a catchment area
- Level 2 is an on-site, rapid but detailed assessment involving sampling and data collection thus making it more valuable information to use (Macfarlane et al., 2009).

Both require the identification of hydrogeomorphic units, that is, hydrology, and geomorphology and vegetation components.

Table 9: Guideline to assess the magnitude of impacts on wetland integrity

Impact category	Description	Impact score range
None	No discernible modification is such that it has no impact on wetland integrity.	0-0.9
Small	Although identifiable, the impact of this modification on wetland integrity is small.	1-1.9
Moderate	The impact of this modification on wetland integrity is clearly identified, but limited.	2-3.9
Large	The modification has a clearly detrimental impact on wetland integrity. Approximately 50% of wetland has been lost.	4-5.9
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.	6-7.9
Critical	The modification is present in such a way that the ecosystem processes of this component of wetland health are totally/almost totally destroyed.	8-10

Overall Health Rating =

*[(Hydrology score*3) + (Geomorphology score*2) + (Vegetation score*2)] / 7*

Magnitude = Extent / 100 x Intensity

Hydrology

Hydrology can be altered by human modifications or natural modifications within the wetland, which in turn alter the distribution and retention patterns of water within the wetland. Hydrological patterns can also be affected by the local climate – that is the mean annual precipitation and potential evapotranspiration, as well as the water inflows that are dependent on the geomorphology, vegetation types and land-uses within the catchment area (see Table 10 below) (Macfarlane et al., 2009).

Table 10: Different land use types and activities that may affect the inflow quantities to the HGM unit from the upstream catchment and the magnitude of their collective effects

	Land-use activity descriptors	Low High					Intensity of water loss[2]	Extent (%)	Magni-tude[3]
		0	-2	-5	-8	-10			
irrigation	(1) Duration of irrigation[R]			*Ad hoc*, supple-mentary	seasonal	Year-round			
	(2) Prevalence of water conserving practices[R]		High	Interme-diate	Low				
Other abstractions not used for irrigation in the catchment									
Alien plants	1 plant type[R]			Shrubs	Trees				
	2. distribution of alien woody plants in riparian areas[R]		Confi-ned to non-ripa-rian areas	Occur across riparian & non-riparian areas	Occur mainly in riparian areas				
Plantations	1 Tree type[R]				Wattle & pine	Eucalyp-tus			
	2 distribution of tree plantations in riparian areas[R]		Confi-ned to non-ripa-rian areas	Occur across riparian & non riparian areas	Occur mainly in riparian areas				
Sugar	1 crop type[R]		Sugar						
	2 distribution in riparian areas[R]		Confi-ned to non-ripa-rian areas	Occur across riparian & non riparian areas	Occur mainly in riparian areas				

	Land-use activity descriptors	Low High					Intensity of water loss[2]	Extent (%)	Magni-tude[3]
		0	-2	-5	-8	-10			
	Dams: specific allowance for releasing low flows within the operating rules of the dam[R]		Allow-ance made	No allowance made					

a. **Wetland Draining**

Several factors affect **wetland draining**. These include:

i. Wetland slopes – The steeper the slope of the wetland, the more efficiently the water drains from the wetland through the drains; and

ii. Hydraulic conductivity – A greater hydraulic conductivity of wetland soils can lead to a more effective drainage of removing sub-surface water from the wetland. If the wetland has mineral soil then the hydraulic conductivity is approximately measured on soil texture. If the HGM unit has peat (organic) soil, then the hydraulic conductivity is based on the degree of humification of the soil. Finer soil texture has smaller pore spaces between the particles, therefore water moves through the soil at a slower rate. Similarly, the more humified the peat, the finer the particles of organic matter, and the slower the water moves through the soil (Macfarlane et al., 2009).

b. **Level of Wetness**

Wetlands can also be affected by the level of wetness:

i. The greater the natural level of wetness of the wetland prior to any artificial drainage or gully erosion, the greater the potential for the area to be much drier due to artificial drains or erosion gullies. The natural level of wetness can generally be estimated by referring to a comparable unaltered wetland, but this may sometimes be impossible;

ii. Drains and gullies affect sub-surface flow – the deeper the drains and gullies in the affected area, the greater the potential of the drain and gully network to intercept sub-surface flow and to lead intercepted flow (sub-surface and surface) out of the wetland. The greater the density of drains, the more likely they are to effectively desiccate the section of wetland in which they occur; and

iii. Dams, weirs and poorly constructed road crossings can cause unnatural retention of water and reduce flow into a wetland. These affect the hydrological integrity of the wetland (see Table 11 and Table 12 below) (Macfarlane et al., 2009).

Table 11: Factors potentially contributing to an increase or decrease in the flood peak magnitude and/or frequency received by the HGM unit

Level of reduction	**Low High**					Score
	0	-2	-5	-8	-10	
1. Collective volume of dams in the wetland's catchment in relation to mean annual runoff (MAR)[R]*	<20%	20-35%	36-60%	60-120%	>120%	
2. Level of abstraction from the dams[R]	Low	Moderately low	Intermediate	Moderately high	high	
3. Specific allowance for natural floods within the operating rules of the dam[R]**	Good allowance made	Moderate allowance	Limited allowance	Poor allowance	No allowance	
Level of increase* **	**Low High**					**Score**
	0	+2	+5	+8	+10	
4. Extent of hardened surfaces in the catchment[R]	<5%	5-20%	21-50%	50-70%	>70%	

5. Extent of areas of bare soil in the wetland's catchment including that associated with poor veld condition[R]***	<10%	11-40%	41-80%	>80%		
Combined sore: [Average of (1), (2) and (3)] + [(4) + (5)]**** The combined score will be the range from -10 to +10 depending on whether the increases in peak flow are greater or smaller than the decreases.						

*MAR – mean annual rainfall (m^3) = [runoff (mm) / 1000 (m)] x [catchment area (ha) x 10 000 (m^2)]

Table 12: Typical changes in water distribution and retention patterns within an HGM unit as a result of obstructions

1.**Upstream impact of flooding**						
Extent of HGM unit affected by flooding upstream of the impeding structure[R]					ha	%
Descriptor	Low High					Score
	0	2	5	8	10	
1.Representation of different hydrological zones prior to flooding by the dam[R]	-	Seasonal and perma-nent zone both present and collective-ly >30%	Permanent and seasonal zones both present but collectively <30%	Seasonal zone present but permanent zone absent	Permanent and seasonal zones lacking (i.e. only the temporary zone present)	
Intensity of impact: score of (1) X 0.8*						
Magnitude of impact score: extent of impact/100 x intensity of impact						

2.Downstream impact on quantity and timing of flows to downstream portion of the HGM unit						
Extent of HGM unit affected downstream of the impeding structure[R]					ha %	
Descriptor	Low High					Score
	0	2	5	8	10	
Extent to which dams or roads interrupt low flows to down-stream areas[R]	No interrup-tion (e.g. many culverts through a road embank-ment)	Slight interruption (e.g. a moderate number of culverts through a road embankment)	Intermediate interruption (e.g. earth dam with very high seepage or road embankment with no/very limited culverts)	Moderately high interruption (e.g. earth dam with some seepage/flow releases)	High interruption (e.g. a concrete dam with no seepage and no low flow releases)	
Level of abstraction from the dam/s[R]	Low	Moderately low	intermediate	Moderately high	High	
Proportion of catchment flows intercep-ted[D]	Dam intercepts <20% of the affected area's catch-ment	Dam intercepts 21-40% of the affected area's catchment	Dam intercepts 41-60% of the affected area's catchment	Dam intercepts >80% of the affected area's catchment		
Collective volume of dam/s in relation to MAR of the affected area[D]	<20%	20-35%	36-60%	60-120%	>120%	

Intensity of impact: mean score of the THREE highest scoring factors x 0.8	
Magnitude-of-impact score: extent of impact/100 x intensity of impact	
*0.8 is the weighting factor. This is given relative to the impact of drainage channels, which are considered to have the greatest potential impact on hydrological integrity out of all the on-site factors considered, and is therefore assigned a weighting factor of 1.	
3. Combined impact	
Combined impact: Magnitude of impact for upstream + Magnitude of impact for downstream	

c. **Surface Roughness**

Surface roughness is primarily determined by vegetation (hummocks covered in vegetation). It can also affect water distribution and retention within a wetland, that is, the greater the surface roughness, the greater the frictional resistance to the flow of water, thus reducing the flow velocity through the wetland. Reduced flow velocity reduces the rate of erosion but is variable due to season variations in vegetation and the occurrence of fires (Macfarlane *et al*., 2009). Altered surface roughness can be assessed by assessing the HGM unit by:

i. Assessing current surface roughness;

ii. Estimating historical surface roughness under natural conditions; and

iii. Comparing current roughness with historical and natural conditions.

The hydrology can also be affected by land use activities such as dams, alien plants, commercial afforestation, and sugarcane within the wetland boundary, and depositional and erosional features from construction and excavation processes such as mining and sand winning.

Implications for the study

Expected impacts on wetland hydrology from activities by Eskom include:

- The establishment and extension of ash dams
- Cutting of vegetation in wetlands under power lines
- Holding dams
- Water abstraction
- Building of roads and other infrastructure such as transmission lines
- Cut-off drains
- Excavation from mining activities
- Dumping of waste rock, overburden and tailings
- Runoff from paved areas
- Engineering structures that cause channelling of flow thereby disrupting diffuse flow.

Geomorphology

Wetlands are affected by both inputs (which are generally equal to or greater) and outputs of sediments, where the inputs of sediments tend to be captured by wetlands. Geomorphic processes shape and control wetland structures, and gullying and erosion can lead to increases in the outputs of sediments which can threaten the natural structure and functioning of the wetland (Macfarlane et al., 2009).

Overall geomorphic impact

The overall impact of the geomorphic state can be calculated using the intensity and magnitude of erosional, depositional and organic material. More detail can be seen in Macfarlane et al. (2009: pages 87-89). The vulnerability of a wetland to erosion can also be measured as well as the predictions of the condition or geomorphological state over the next five years.

Table 13: Trajectory class, change score and the symbol used to evaluate the Trajectory of Change to the geomorphology of each HGM unit

Trajectory class	description	HGM unit change score	Class Range	Symbol
Improve slightly	Geomorphological condition is likely to improve slightly over the next 5 years	1	0.3 to 1.0	↑
Remain stable	Geomorphological condition is likely to remain stable over the next 5 years	0	-0.2 to +0.2	→
Deteriorate slightly	Geomorphological condition is likely to deteriorate slightly over the next 5 years	-1	-0.3 to -1.0	↓
Deteriorate greatly	Geomorphological condition is likely to deteriorate greatly over the next 5 years	-2	-1.1 to -2.0	↓↓

Implications for the study

Assessment of wetland health provides the basis from which both rehabilitation interventions may be planned and the impact on ecosystem services may be assessed.

Vegetation

Wetland vegetation has specific compositional and structural characteristics that provide specialised habitats for wetland dependent species and provide important services for local communities. It also provides an important service towards flood attenuation and nutrient retention. The “Present Vegetation State” is assessed against the deviation from the natural

conditions. Factors such as cultivation, grazing, changes in the hydrology (drying out of the catchment or wetland), water quality (e.g. high nutrient inputs), and geomorphology (e.g. alluvial depositions) can also cause changes in the vegetation characteristics within wetlands. Some indigenous species increase in abundance when a site is disturbed due to their ability to adapt to changing environments and waterlogging. See Table 14 below for the common disturbances in South Africa.

Table 14: Description of common disturbance classes in South African wetlands

Disturbance class	Description
Land uses commonly associated with complete with transformation of wetland habitat	
Infrastructure	Includes houses, roads and other permanent structures that totally replace wetland vegetation.
Deep flooding by dams	This includes situations where flooding is too deep for emergent vegetation to grow.
Land uses commonly associated with substantial-to-complete transformation of vegetation characteristics	
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 lands, tree plantations, sugarcane lands & madumbe fields, etc.
Commercial plantations	Common plantations include pine, wattle, gun, poplar. Other land uses such as vineyards and orchards may have a similar impact on wetland vegetation.
Annual pastures	These areas are characterized by frequent soil disturbance with a general removal of wetland vegetation. Some ruderal wetland species may become established but are frequently removed.
Perennial pastures	Although such areas generally include a high abundance of alien terrestrial grasses or legumes, the reduced disturbance frequently may permit the establishment of some wetland species.
Dense alien vegetation	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.
Shallow flooding by dams	Such areas can often be identified at the head or tail end or edges of dams.

Sports fields	These include cricket pitches, golf 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.
Gardens	Gardens are generally associated with urban environment.
Sediment deposition/infilling and 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 field). Excavation is the direct human removal (usually with heavy machinery) of sediment from the wetland, which is commonly associated with mining and sand winning.
Eroded areas	In wetlands this typically occurs as gully erosion.
Land uses commonly associated with moderate transformation of vegetation characteristics	
Old/abandoned lands	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 an HGM unit, it may be best to distinguish between vegetation classes comprising recently abandoned lands and areas comprising older lands that are at a more advanced successional stage of recovery.
Land uses generally associated with low or no transformation of wetland vegetation	
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.
Minimal human disturbance	These primary vegetation areas have not been significantly impacted by human activities, but may have been impacted upon by factors such as scattered alien plants. It may include wetland areas within game reserves or extensive grazing management systems. Small pockets of untransformed vegetation may also be set aside as streamside buffers on commercial landholdings.
Note: Scattered alien plants may occur in most of the above disturbance classes. Where this occurs, alien plants are considered as part of the larger disturbance class of which they are part (e.g. scattered bramble occurring within an old land), and the intensity of disturbance score is modified to account for the fine grain disturbances within them.	

Issues of importance

Vegetation is a key component of wetland definition in the NWA, but it may only be used as the primary indicator in undisturbed conditions. It provides a helpful field guide in locating the wetland boundary when the wetland has not been transformed.

Disturbances within the wetland can be referred to as “grain size” at a spatial scale. A coarse grain size (generally the case in a large-scale agricultural context) can be easily identified and mapped as large individual disturbance units using GIS. The aerial extent of each class is then estimated by summing the areas of mapped disturbance units. This extent is estimated as a proportion (%) of the HGM unit and recorded. Patches of fine-scale disturbance units are grouped and mapped as part of a coarse-scale disturbance unit (or units) and intensity and magnitude are calculated accordingly (Refer to Macfarlane et al., 2009). In either case, the aerial extent of each disturbance class is estimated as a proportion of the HGM unit and recorded. The cumulative cover (%) of individual patches (at a finer grain size) that form part of the disturbance class can be represented in the form of spatial mapping.

Alien vegetation poses one of the most significant threats to wetland vegetation and is a major focus of rehabilitation programs. Where further management intervention is needed, it is useful to identify the problem species and to obtain further insight into their occurrence and tabulate the data. It is important to stress that alien vegetation, especially *Typha capensis* and *Phragmites australis* occur naturally across many wetlands in South Africa. Many wetland areas are naturally dominated by a single species, especially in the permanently wet portions of a wetland, where only species tolerant of intense waterlogging are able to grow. It is important to note the classification of plants when identifying species in a wetland, that is, obligate wetland species, facultative wetland species, facultative species, facultative dryland species and dryland species. Similarly to the hydrology and geomorphology components, the Present Vegetation State can be assessed and scored using categories, Trajectory classes, change scores and symbols.

The three components, hydrology, geomorphology and vegetation are directly or indirectly interlinked. Thus measuring wetland health and ecosystem services determines their Present Ecological State (PES) and Ecological Importance and Sensitivity (EIS) respectively. These can be used to measure the current state of wetlands, the future impacts and changes to wetland health, to ensure that the appropriate management interventions can be planned and the success of these interventions can be monitored.

Impact inventory

(Pollution, altering of hydrological regimes, disturbances, invasive species, erosion and siltation)

Measuring impacts

MacFarlane and Kotze (2009) provide a series of indicators for assessing the health of wetlands. Broadly, these may be divided into hydrological indicators, geomorphological indicators and vegetation indicators. These assess both catchment-wide and on-site activities such as dam construction and irrigation in the catchment or the presence of drains, gullies, sediment plugs, loss of organic sediment or alien plants in the wetland. The WET-Health tool provides a way to score the intensity of the impact numerically. The magnitudes of the impact scores are then combined in a structured way to produce an overall wetland health score. The WET-Health assessment scorecard provides a status-quo against which future changes may be measured.

A definitive document for the determination of physical impacts on wetlands is Wet-Sustainable Use: *a system for assessing the sustainability of wetland use* (Kotze, 2010). This builds onto the WET-Health of MacFarlane and Kotze (2009), recognising that without a sustainable management system in place, a wetland is vulnerable to degradation and it follows that a degradation in the condition of a wetland will erode the flow of ecosystem services emanating from the wetland. While this document focuses on ecological sustainability, it considers the place of the wetland within the broader social ecological system (from household to international level) and involves consultation with users to garner their perspectives on the sustainability of land-use activities.

The assessment of impacts begins by asking to what extent the use of the wetland has altered the following components of the wetland's environmental condition:

- The distribution and retention of water,
- The erosion of sediment,
- The accumulation of soil organic matter (SOM),
- The retention of nutrients, and
- The natural species composition of the vegetation in the wetland.

The document provides two levels of assessment. Level 1 depends on several generalisations regarding the land that is being considered. Level 2 is structured around WET-Health (MacFarlane et al., 2009).

Following the assessment of the above 5 aspects, each is interpreted in terms of the consequences to the livelihoods of the ecosystem users. For instance, draining or erosion may provide opportunities for cultivation, but will impact on most of the provisioning services that would be provided by a healthy wetland downstream. Similarly, while invasion of wetlands by alien vegetation may provide some resource value, such as the provision of fuel, the resource base for medicine, crafts, thatching and livestock grazing is generally reduced.

In recognition of the importance of wetlands in the livelihoods of people and noting that many of these wetlands were degraded, Pollard et al. (2009) asked the questions '*what indicators can be used to assess the situation, to track change and to evaluate impacts?*'; and '*how can these be developed in a way that is meaningful both for managers but also for the users themselves?*' Fundamental to answering these questions is the concept that integrated management typically deals with interlinked, dynamic and hence complex systems. Complexity and systems thinking critiques conventional management approaches for their failure to recognise variability and linkages as essential properties of many complex systems. Indicators are thus needed that describe the performance of the individual systems and their contribution to the performance of wider systems. Since outcomes are not entirely predictable they have to be managed through a process of strategic adaptive management that embraces learning-by-doing. Indicators need to support this premise. Based on these concepts the authors developed a suite of indicators, some of which are specific to the cultivation methods used in the Craigieburn wetlands and others more widely applicable to wetlands in general. Examples of the latter are given in Table 15.

Table 15: A preliminary framework, based on core principles, for assessing the integrity of the wetland as a whole. Some potential indicators are listed. These principles are considered sufficiently robust for use at the micro-catchment scale (from Pollard et al., 2009)

	Area	Principles/ consideration	Potential indicators
1	**Water management**	Soil moisture maintenance and stability is critical, therefore: • Vegetation should act to slow water velocity. Assess the extent and cover of vegetation (Note the location (wetland, hillslope), dimension, status (active) and source) • Plot location, position and bed orientation both in the wetland and on the hillslopes must act to slow water and increase infiltration	Extent of cleared areas Footpaths and roads act to channel water and increase velocity
2	**Soil movement and erosion**	Control of soil movement and mitigation of erosion is essential, therefore: • Assess headcuts location and status (active) – is this an advancing headcut? • Assess gulley location, dimension and status: Is this a dynamic gulley (is it active/ incising or filling)? • Assess sediment deposition, sheet erosion, rills; (Note the location (wetland, hillslope), dimension, status (active) and source) • Assess field and plot location	Movement of headcut upward or laterally in stream channel Dimensions- gulley is widening or lengthening over time Sediment deposition within gulley (filling) Undercut banks to gulley (incising) Presence/ absence of sediment, sheet erosion, rills; Extent of the above Are fields located upstream and/or close to headcuts?
3	**Soil health**	Management of soil health is key for sustaining plant growth and biological activity. Soil health is a function of physical and chemical properties – many of which are a function of SOM • Soil fertility	See Table 5.2
3	**Extent and diversity of indigenous plants**	Maintaining vegetational cover in the micro-catchment and wetland plants is essential to soil moisture, fertility and sediment control, therefore; • Assess extent of indigenous vegetation and trend if change is evident. Of the total wetland area, the proportion that has been converted to another landuse should be determined • Assess diversity of indigenous vegetation • Evidence of practices regarding burning of residues. Burning of crop residues likely to have much more severe consequences than burning of standing litter in natural vegetation, with the latter possibly having very little effect on SOM levels. • Assess noteworthy species (e.g. protected or sensitive species if applicable).	Extent of indigenous vegetation (% of total) per sub-system (e.g. wetland zones, hillslope rangeland) Changes in extent (e.g. from aerials) Diversity of indigenous vegetation (if needed) Changes in extent (may not be possible)
4	**Sensitive areas: "no-go" zones**	Identify sensitive areas, e.g.: • Acid and P limited • Headcuts	See above

Volume 13 of the Ramsar Handbooks for Wise Use (para 52-55; 2010) provides a rapid assessment method which may be used for the assessment of both natural and anthropogenic disasters. The guidance recognizes that the purposes for rapid assessment of wetlands include:

- a) Collecting general biodiversity data in order to inventory and prioritize wetland species, communities and ecosystems; obtaining baseline biodiversity information for a given area;
- b) Gathering information on the status of a focus or target species (such as threatened species); collecting data pertaining to the conservation of a specific species;
- c) Gaining information on the effects of human or natural disturbance (changes) on a given area or species;
- d) Gathering information that is indicative of the general ecosystem health or condition of a specific wetland ecosystem;

- e) Determining the potential for sustainable use of biological resources in a particular wetland ecosystem; and
- f) Has been designed from the suite of methods available which can be tailored to the particular needs of the situation.

Implications for the study

Wet-Health provides indicators that have been developed specifically for SA conditions. These can be used for monitoring programs.

Impact assessment

Volume 16 of the Ramsar Handbooks for Wise Use (2010) provides a flow chart of the key steps in the impact assessment procedure which are given below (Figure 14). This procedure provides structure to the planning and implementation of an impact assessment which will ensure that nothing is left out. This will be of assistance to both specialists doing the impact assessment as well as managers who are overseeing the process.

In Volume 19 of the Ramsar handbooks on Wise Use of Wetlands, Ramsar provides a method for assessing the ecological character of a wetland. The ecological character is defined as the combination of the ecosystem components, processes and services that characterise the wetland at a given point in time. Determination of the ecological character will do two things, firstly it will provide the link between wetland health and the stream of ecosystem services that are used by people and secondly, it will provide a benchmark against which future assessments may be compared. This will provide a measure of the change in the services resulting from defined impacts on that wetland and will, through a process of adaptive management, enable the improvement of the stream of services to meet the requirements of the social-ecological system.

The Ramsar process described above is similar to the South African process of defining the desired state of an ecosystem and then putting interventions in place to manage towards the defined desired state.

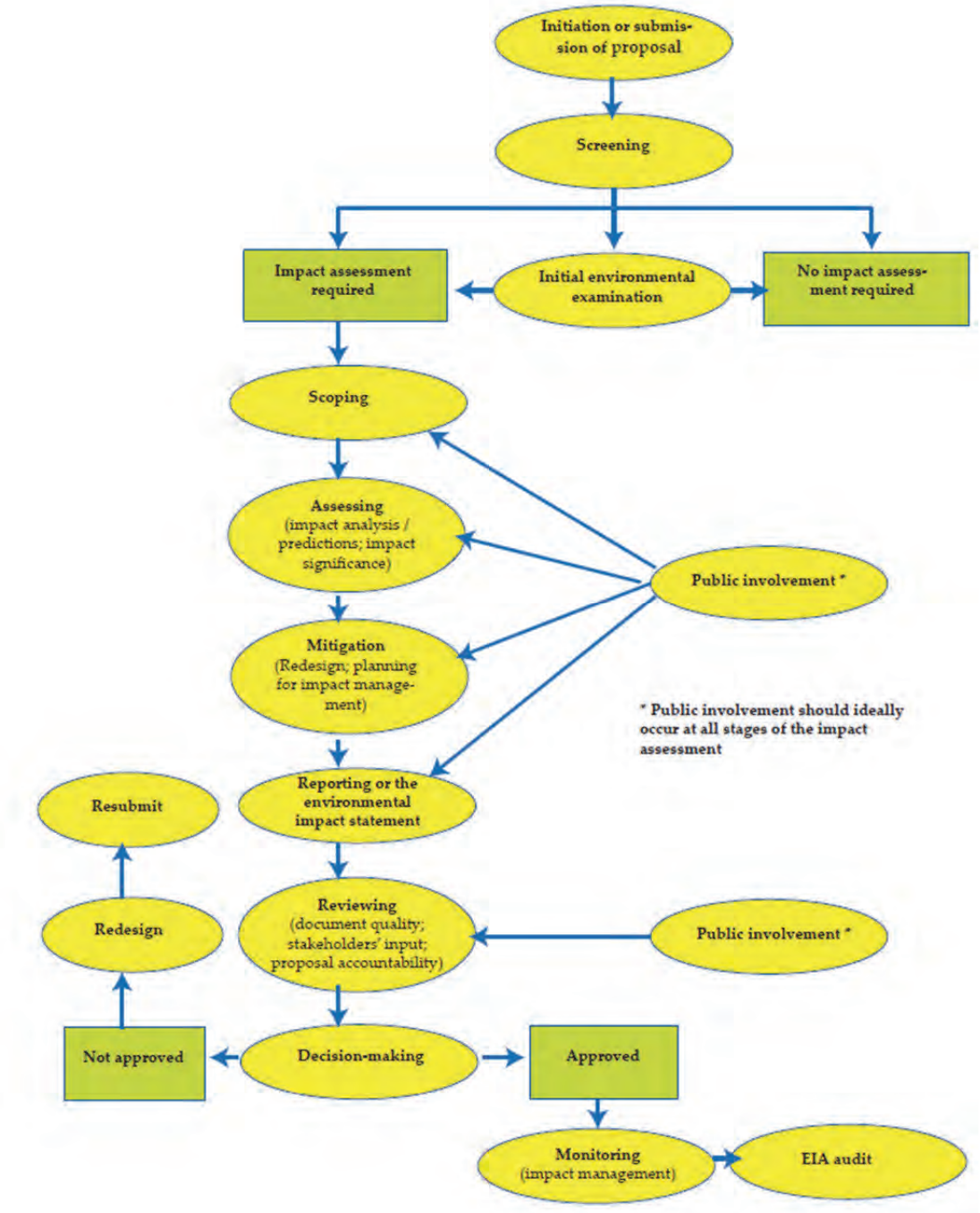


Figure 14: Flowchart of key steps in the environmental impact assessment procedure (from Ramsar Wise Use of Wetlands Vol. 16)

Implications for the study

The ideal of 'no net loss' of ecosystem services is applied to both wetland surface area and wetland functionality. It is necessary to know both the extent of surface area and the state of the wetland to be managed before any rehabilitation can be planned. The environmental impact assessment procedure requires managers to both assess the current state of wetlands under their jurisdiction as well as to predict the impact of land use, construction and other changes on wetlands.

Prioritisation of wetlands for rehabilitation and intervention

Wetlands for rehabilitation in South Africa need to be ranked in order of importance in order to direct limited resources appropriately (Rountree *et al*., 2009). Ranking or prioritisation values would be based on the objectives of the prioritisation process and this includes identifying and prioritising catchments and wetlands which match particular objectives, either for rehabilitation, conservation or monitoring activities (Rountree *et al*., 2009). Subsequent to this, the National Freshwater Ecosystem Priority Areas (NFEPA) has been published by the WRC. This identifies priority wetlands and rivers for protection in South Africa. This should be consulted in prioritisation and planning of interventions. The ranking can refer to criteria or objectives such as the hydrological functions, socio-economic values and biodiversity support aspects. Prioritising the same set of wetlands on different objectives will yield different outcomes depending on the criteria used for assessment.

The seven-step prioritisation process proposed by Rountree et al. (2009) is a spatial approach that looks at:

- Step 1: Define the aims and objectives of the prioritisation project
- Step 2: Identify the spatial extent of the study area (the spatial scale of the assessment determines which specific information and protocols can be used)
- Step 3: Collate available information
- Step 4: Develop prioritisation criteria
- Step 5: Screen for candidate catchments
- Step 6: Prioritise catchments
- Step 7: Assess the potential of prioritised catchments to meet the objectives

This process can be used at a national or provincial scale where they can be used to prioritise tertiary level catchments, at a regional scale they can be used to prioritise quaternary catchments and at a local spatial scale they can be used to prioritise individual wetlands, or clusters of wetlands (see Figure 15 below). Wetlands can be prioritised at the different scales based on who chooses to prioritise them (see Figure 16 below for prioritisation steps) (Rountree et al., 2009).

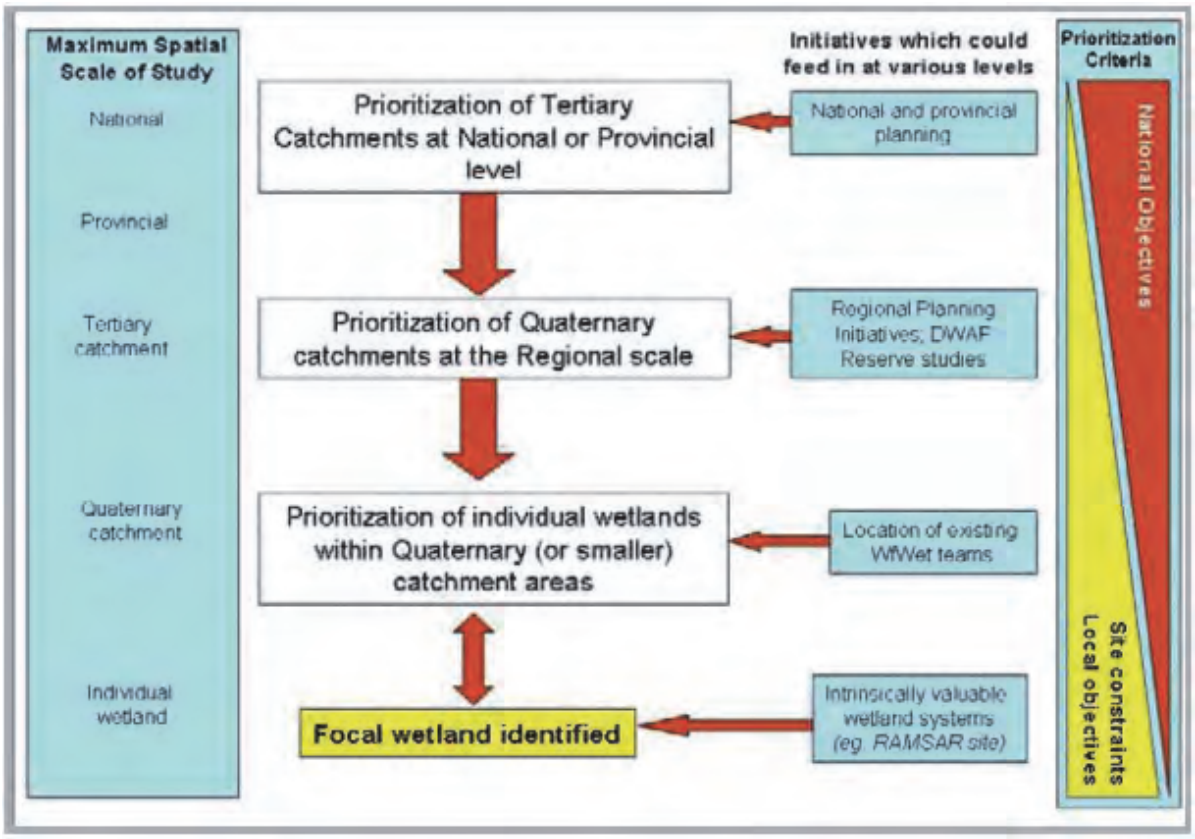


Figure 15: Spatial scales of prioritisation down to the catchment and sub-catchment level

Principles to guide and the requirements for the process of prioritisation:

Prioritisation and rehabilitation planning should incorporate the following:

- The contribution of landholders or users and other key stakeholders if practical and cost-effective.
- Protecting wetlands that are still intact or stable and that would be easier to improve.
- Those that are of high priority due to their provision of goods and services.
- Assess the current state of the wetland as it is due to the cumulative impacts of activities in the broader scale of the catchment, thus including the broader catchment and landscape.
- Ensure they are aligned with the catchment and biodiversity conservation plans.
- Consider the willingness and capacity for local people and local structures to become involved.
- Address the causes of degradation and prioritisation and rehabilitation plans that should be developed by a team of experts in design and planning and the ecological functioning of the wetland (Rountree et al., 2009).

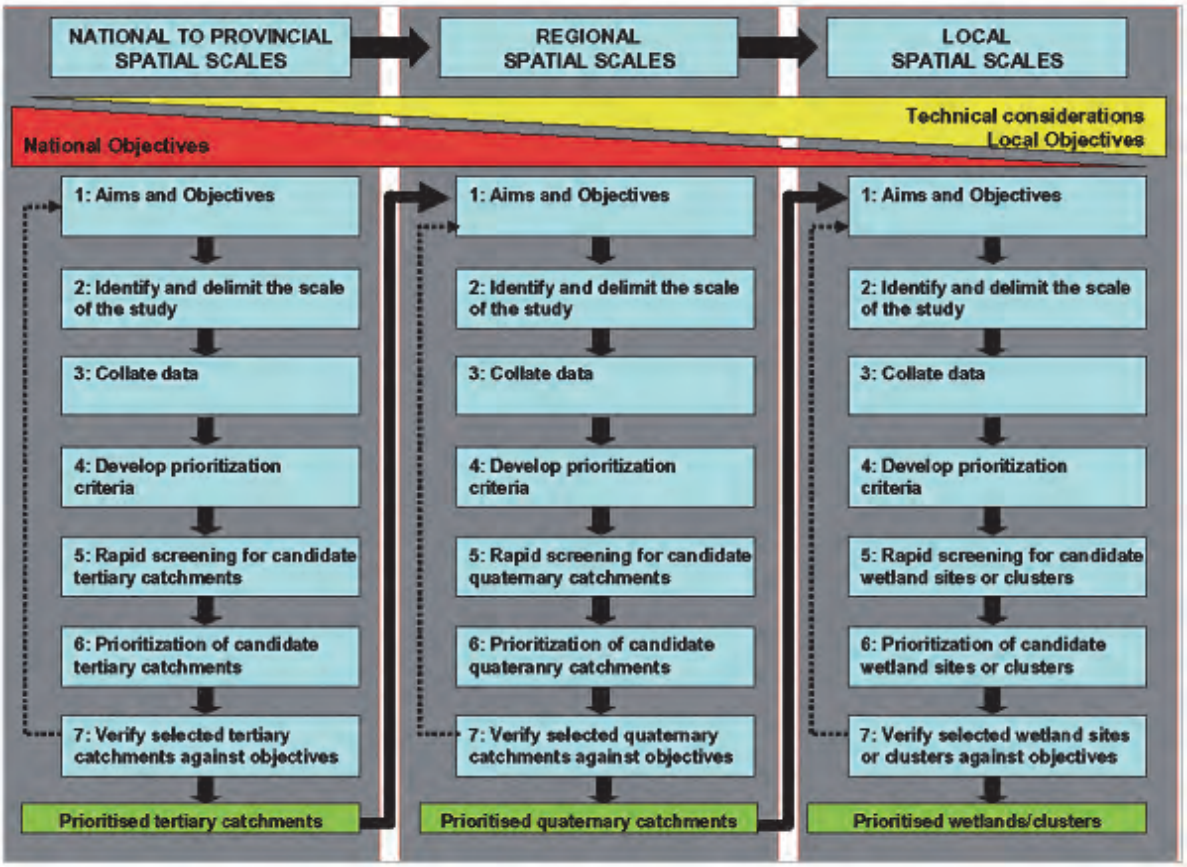


Figure 16: Wetland prioritisation steps that are required at different spatial scales

The seven-step prioritisation process is provided in more detail below (Rountree et al., 2009):

- **Step 1: Define the aims and objectives of the prioritisation project**

An aim and objective can be applied to rehabilitation projects that aims to improve the current condition of wetlands; conservation planning that aims to preserve biodiversity; and wetland reserve studies (environmental flow determination) that aim to improve understanding and management of wetlands.

a. Rehabilitation projects:

Rehabilitation projects focus on achieving biodiversity support, water quality improvement, sediment stabilisation or reinstated flooding regimes, as well as job creation and poverty relief as part of the Working for Wetlands (WfWetlands) Programme and their role in the government's expanded public works programmes.

b. Conservation Planning:

Wetlands at a national scale have been identified in South Africa by SANBI and in addition are in the process of being classified at a provincial and municipal level at a higher resolution. In South Africa the national conservation efforts have been to maintain RAMSAR sites, but in conservation planning we need to focus our rehabilitation efforts on those wetland types which are rare and unique, are at risk or are increasingly under threat, and those that provide habitats to endangered species.

c. Wetland Reserve Studies:

Wetland reserves (environmental flow determination) and water resources are managed by The Department of Water and Sanitation in South Africa. There is an urgent need to look at the resource quality objectives and ecological specifications to ensure that the current standard of wetlands is maintained. South Africa needs to be practical and focus on stratified sampling to study representative systems and also focus on priority wetland systems in given water management areas. This can assist to identify priority wetland systems in catchment area. One needs to identify high-risk wetland systems, systems with a high ecological integrity, provision of high-level goods and services, wetlands impacted on by water allocation, and those in an important water management area.

- **Step 2: Identify the spatial extent of the study area (the spatial scale of the assessment determines which specific information and protocols can be used)**

The spatial scale is defined in order to focus the study and guide the assimilation of relevant knowledge, information and data and the development of prioritisation criteria for selecting or scoring between various wetland areas or individual systems. Identifying the spatial scale is necessary as it is vital to recognise that the current and future condition of a particular wetland system is a product of the condition of the catchment and the activities within the catchment. Understanding specific wetland systems is necessary as generally the problems experienced are due to factors higher up in the catchment.

- **Step 3: Collate available information**

All available information about the wetlands, including data and local knowledge sources, possible indicators of wetland extent, type, characteristics and condition, location and surrounding land use activities needs to be collated for the study area.

- **Step 4: Develop prioritisation criteria**

Prioritisation criteria can be qualitative or quantitative (depending on the resolution of data and specialist knowledge) and need to address the objectives. Scoring corresponds to the objectives used, the scale of analysis, and the data and information that are available at that specific scale to address those criteria. Prioritisation criteria can include: wetland size, wetland condition, connectivity between the site and other wetlands or downstream rivers, rare plant/animal populations (biodiversity support), wetland type (rarity), diversity of vegetation types, level of ecosystem goods and services, proximity of the site to suitable, nodes of employment (in the case of rehabilitation programmes like WfWetlands which are linked to poverty alleviation), level of threats or likely future impacts, and specific ecosystem services of the wetland (e.g. prioritising the types of wetlands which improve water quality in a catchment with large water quality impacts over those that attenuate floods). See Table 16 below for prioritisation examples.

Table 16: Examples of wetland prioritisation

Available information	Use in screening or prioritisation
National, Provincial and Tertiary Catchment Scales	
National Wetlands Map	Course national-coverage showing the location and extent of larger wetlands across South Africa
Geology	Classification of wetland groupings
Biomes	Classification of broad-scale wetland groupings
EcoRegions	Classification of wetland groupings
Provincial Conservation Plans	Provides higher resolution information on wetland location, extent and possibly biological attributes. Not always available.
Land cover transformation	Gives an indication of the current bio-physical condition of wetlands
Regional and Quaternary Catchment Scales	
Vegetation Types	Classification of more-detailed wetland 'types'
Geology	Classification of wetland 'types'
EcoRegions	Classification of wetland 'types'
Provincial conservation plans	Provides higher resolution information on wetland location, extent and possibly biological attributes. Not always available.
Aerial photography or high-resolution satellite imagery	Gives an indication of the current bio-physical condition of wetlands

- **Step 5: Screen for candidate catchments**

Wetlands within catchments are shortlisted by scores for further data collection and detailed analysis as these may require more attention if not already within a protected area, as is the case with wetlands that are not assessed for conservation prioritisation. Sites which are heavily degraded, as well as sites that are near to pristine, could be excluded from the prioritisation assessment when looking at wetlands that require rehabilitation. If it is not possible to shortlist wetland sites, then all the sites can be potential priority sites. See Table 17 below for scoring the potential suitability of wetland sites for rehabilitation.

Table 17: Scores for the potential suitability of wetland sites for rehabilitation

Score	Description of the class
0	The returns are considered to be very low or the sites considered lost causes' that are extremely degraded (e.g. with a deeply incised gully throughout the length of the wetland) and which would be prohibitively expensive to rehabilitate
1	A site which has potential (e.g. reasonably intact areas threatened by headcut erosion) but where the returns are likely to be low (e.g. because the intact areas is relatively small, i.e.<3 ha and/or appears to have a low level of wetness) or uncertain
2	A site where the returns are potentially moderate (e.g. a moderately sized area with artificial drains that could be plugged or a moderately sized are threatened by gully erosion)
3	A site where returns are potentially high (e.g. a large area, i.e.>20 ha, with artificial drains that could be plugged or a large area threatened by gully erosion)

- **Step 6: Prioritise catchments**

Prioritisation criteria are developed to address the project objectives. If it is not possible to shortlist wetland sites, then all the sites can be potential priority sites. Tertiary catchments (national and provincial) can be prioritised using a GIS-based tool where it looks at land cover. At the quaternary scale, desktop analysis and field-based assessments need to be done with local and regional specialist knowledge at hand. One must always revisit the aims and objectives at the larger scale so as not to lose focus when constraints and opportunities are encountered at the smaller scale.

  - Tertiary catchment scale:

The GIS-based tool allows for resources to be more appropriately focussed at the national and provincial scales. Priority areas are chosen based on the key strategic national needs or services (such as biodiversity support to the supply of resources and erosion control) provided by the wetlands in the particular catchments. Six priority categories have been selected to focus on at a provincial level by members of national and provincial government, statutory bodies, civil society and the private sector; these are: hydrology, biodiversity, socio-economic, threats/impacts, physical, and strategic categories (see Table 18 below for detailed priority categories).

Table 18: Criteria used for Tertiary level catchment prioritisation (national and provincial scale)

National criteria	Examples of sub-criteria
Biodiversity	Biodiversity nodes/hotspots (biodiversity map)
	Protected areas
	Threatened or priority wetlands including the peat eco-regions
	Ramsar sites and their catchments
Hydrological	Water-stressed catchments
	Runoff per capita
	Water supply catchments
	Water quality at catchment scale
	International obligations with respect to water sharing
Socio-Economic	Nodes identified under the Integrated Sustainable Rural Development Strategy
	Urban renewal projects
	Livelihoods dependent on wetland goods and services?
	Poverty indicators
Threats/impacts	New land cover map
physical	Erodibility index
	Unique natural features, e.g. karst landscapes
	Density and distribution of wetlands (new land cover; wetland coverage; Cowan wetland regions)
Strategic	International rivers and boundaries
	Spatial development initiatives
	Existence of Catchment Management Agencies

From the above-mentioned six categories, 13 indicators were selected to address the prioritisation criteria, these are:

- National Biodiversity Priority Areas,

- Protected Areas,
- Peat Wetland Eco-regions,
- Ramsar Sites,
- Water-stressed Catchments,
- Water (Chemical) Quality,
- Spatial Development Initiatives (SDIs),
- Water Catchment Management Agencies (CMAs),
- Conservation Status Index,
- Erodibility (Soil) Index,
- Working For Water/Wetland Project,
- Locations,
- Poverty Gap Index, and
- Integrated Sustainable Rural Development and Urban Renewal Nodes.

These indicators can be selected and weighted to provide a single or integrated qualitative wetland-priority index value based on desired attributes for each tertiary catchment within South Africa and the output from the GIS model can be represented as maps (see a few of the selected criteria represented as GIS maps in Figure 17, Figure 18 and Figure 19 below).

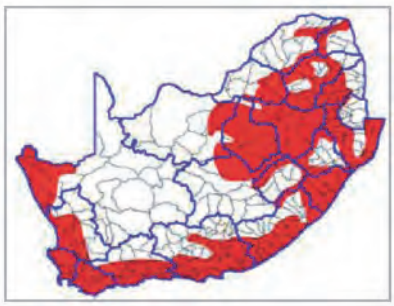


Figure 17: Biodiversity Priority Areas (i), Water Management Areas, and Tertiary catchments (GIS data available on NBI database)

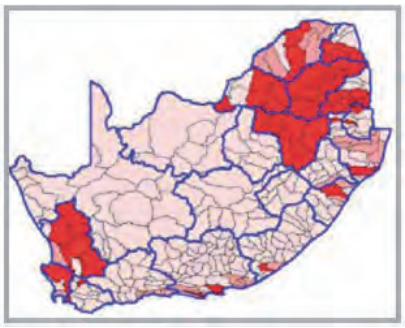


Figure 18: Water stressed catchments (v) Water Management Areas (WMAs) and Tertiary Catchments (Data available on DEA ENPAT (Environmental Potential Atlas) database and DWA Water Situation Assessment Model)

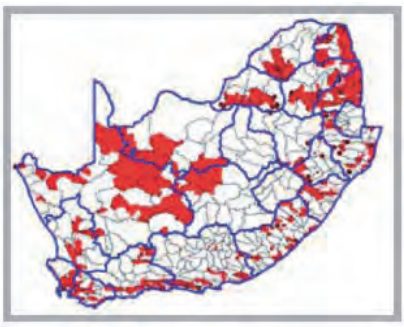


Figure 19: Working for Water and Working for Wetland Project locations (xi) Water Management Areas, and Tertiary catchments (Data available on the Working for Water (WfW) database)

Implications for the study

Eskom together with the DEA would need to assess the location of their wetlands in relation to the provincial and national priority catchment areas. Assessments will need to be based on the abovementioned 13 indicators. If they are within a priority catchment they will need to be protected with the correct rehabilitation, conservation or monitoring activities in place. If they are not within priority catchments, Eskom will need to rank and prioritise them on criteria or objectives such as the hydrological functions, socio-economic values and biodiversity support aspects and then implement rehabilitation, conservation or monitoring activities.

- Quaternary catchment scale:

Due to a lack of detailed level maps and tools for assessing quaternary catchments, prioritisation at the regional scale is done in the form of guidelines and on-site assessments for outlining the criteria and considerations for prioritisation of quaternary catchment areas, using expert knowledge, and/or regional databases as these become available. At a national level, one identifies a wetland on rarity from GIS tools, but at the local scale a wetland could or could not be prioritised due to the local landowner or land tenure arrangements which can only be found out from on-site assessments.

Sources of available data at the regional scale can include: regional experts/specialists, SANBI wetlands map to inform on the likely location and density of wetlands in a particular sub-catchment, high-resolution satellite data, aerial photography or other imagery such as Google Earth to conduct desktop surveys of wetland condition, and/or provincial C-plan wetlands information (not available for all provinces). A scoring system can also be developed to score each area (each quaternary catchment area within the priority tertiary catchment study area) to measure the catchment's suitability to meet the prioritisation criteria. This provides a prioritisation score for each candidate catchment being considered, thus allowing for the development of a list of prioritised catchments.

- Within the quaternary catchment scale:

This is a sub-catchment assessment that collates local scale information. A rapid assessment to shortlist candidate sites of priority wetlands can be done using the *WET-health* (to measure the present ecological state) (MacFarlane *et al*., 2009) or WET-*EcoServices* (Kotze et al., 2009b) guidelines to identify problems or priorities on-site so as to not make assumptions and mistakes of the effects from other catchments (see Table 19

below for WET-*EcoServices* ecological services and benefits). Individual wetlands need to be prioritised relative to other wetlands by using similar sources of available data as mentioned above for the regional scale. Similarly a scoring system can also be developed at the local scale. This method is done to assign indices of wetland services which can be used for comparative purposed between different wetlands. Different criteria are assessed and weights are assigned to the indices, depending on the objectives of the prioritisation project.

Table 19: WET-*EcoServices* ecological services and benefits

<table>
<tr><td rowspan="12">Wetlands benefits
(goods and services)</td><td rowspan="10">Indirect benefits</td><td rowspan="8">Hydrological benefits</td><td>Flood attenuation</td></tr>
<tr><td>Streamflow augmentation</td></tr>
<tr><td>Sediment trapping</td></tr>
<tr><td>Phosphate trapping</td></tr>
<tr><td>Phosphate assimilation</td></tr>
<tr><td>Nitrate assimilation</td></tr>
<tr><td>Toxicant assimilation</td></tr>
<tr><td>Erosion control</td></tr>
<tr><td colspan="2">Biodiversity conservation – integrity</td></tr>
<tr><td colspan="2">Biodiversity conservation – irreplaceably</td></tr>
<tr><td rowspan="5">Direct benefits</td><td colspan="2">Water supply</td></tr>
<tr><td colspan="2">Provision of harvestable resources</td></tr>
<tr><td colspan="2">Socio-cultural significance</td></tr>
<tr><td colspan="2">Tourism and recreation</td></tr>
<tr><td colspan="2">Education and research</td></tr>
</table>

A list of focal criteria used to identify local scale priority wetlands for rehabilitation is provided below:

- Focus on wetlands that are rare or represent rare types
- Focus on wetlands that are in good condition before those that are in poor condition
- Focus on deteriorating wetlands before stable or improving ones
- Focus on problems that are easiest to fix
- Focus on those sites that will generate a guaranteed immediate positive benefit before those that have potentially longer-term, but less certain, positive benefits

- Focus on those problems or sites perceived to be important by local communities or stakeholders before those not perceived to be important
- Recognise lost causes for what they are, and focus effort problems and sites where there is more chance of success
- Focus on those problems known to have tried and tested remedies
- Incorporate a broader (catchment or sub-catchment) level assessment to identify any causes that may be outside of the wetland itself
- Focus on wetlands with a good recovery potential
- Focus where the willingness and capacity for local people and local structures to become involved and address the causes of degradation are high.

Implications for the study

Wetland rehabilitation takes resources in the form of skilled planning, people to do the work, funds and time. Through the prioritisation of wetlands to be rehabilitated, Eskom could direct the available resources to the areas where they will have most impact. Publication of this prioritisation would be seen as a declaration of intention.

- **Step 7: Assess the potential of prioritised catchments to meet the objectives**

Once the prioritised sites have been identified, these are assessed against the original project objectives, criteria indicators, or the criteria scores, as sometimes they do not always adequately reflect the original intentions of the objectives (resolutions of data may be insufficient or correlations between parameters may be weak). Thus the last step is merely to do a "cross check" to ensure that the prioritisation criteria have been accurately assessed and scored, and that the selected priority sites are able to address the objectives of the study. If unsuitable then one needs to reassess the prioritisation scoring.

Rehabilitation of impacts

WET-Legal (Armstrong, 2009) guides the wetland manager through the plethora of South Africa's legislation dealing with wetlands. The guide covers legislation from the Departments of Water Affairs, Environmental Affairs and Agriculture as well as other pieces of relevant legislation. The requirements of the international agreements to which South Africa is signatory are explained. The guide also clarifies the activities which require authorisation and the laws that compel rehabilitation and/or action on the part of the user or landowner. Supporting this is an explanation of the responsibility of the person/organisation conducting the activity.

Gardner et al. (2012) and Dini (undated) outline the key message in dealing with wetlands during development, and that is as follows:

- **Avoidance**: Avoiding wetland impacts involves proactive measures to prevent adverse change in a wetland's ecological character through appropriate regulation, planning or activity design decisions.
- **Mitigation**: Mitigating wetland impacts refers to reactive practical actions that minimize or reduce *in situ* wetland impacts.

- **Compensation**: Compensating for wetland impacts refers to actions that are intended to offset the residual impacts on wetland ecological character that remain after any mitigation has been achieved. Dini (undated) makes the point that offsite mitigation is not a license to destroy wetlands or short circuit regulatory processes.

Alexander and McInnes (2012), in their Ramsar briefing note, describe the benefits of wetland restoration. The key messages that they convey are:

- Stop the global loss of wetlands to prevent further erosion of the stream of ecosystem services provided by wetlands on which the social ecological system relies.
- Prioritisation of the protection and restoration of wetlands applies to both the methods used and the wetlands themselves. The most effective way to protect wetlands is to remove the drivers/pressures that are causing the change in ecological character. Where this is not possible or where the damage has already been done, then appropriate rehabilitation interventions should be implemented. The wetlands to be protected or rehabilitated should also be prioritised.
- Restoration is not a substitute for protection. Protection is more cost effective than restoration and should be the intervention of choice.
- Holistic wetland restoration objectives should be formulated. Experience has shown that where this is not practiced the restoration interventions are prone to failure.
- Decision makers should recognise the full suite of restoration benefits to provide the ecosystem services as described in the Millennium Ecosystem Assessment (2005).

A number of the key messages given above are covered in detail in the reports emanating from the Wetlands Research Programme: Wetland Rehabilitation of the Water Research Commission and these are covered individually below. There are a large number of wetlands of a variety of types in a range of Ecozones and land uses and many of these are degraded and require rehabilitation.

A range of land cover classes identified based on the National Land cover database for SA have been identified with respect to their impacts on water inputs to, and retention of water within, wetlands. If present in the catchment, these land cover classes can either 1) increase or 2) decrease water inputs to a wetland, OR if present in a wetland itself, they can 3) increase direct water losses from the wetland, 4) reduce surface roughness, 5) impede the flow of water in a wetland or 6) enhance the flow of water in a wetland. Ellery et al. (2010) have examined the effect of each category of land cover change from the natural condition on each of these parameters and have assigned an intensity of impact score to each. For instance, the Land Cover Change Impact Metric is based on the recognition that wetland structure and function are fundamentally affected by the hydrological regime and this may take several forms (Figure 20).

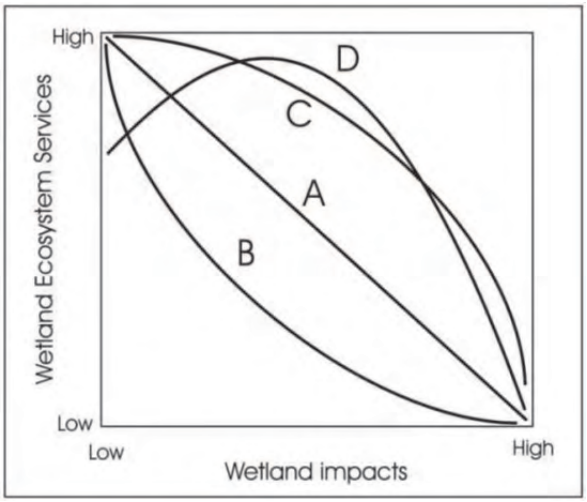


Figure 20: Possible relationships that might be expected between functional effectiveness scores (i.e. the provision of wetland ecosystem services, as assessed using WET-EcoServices) and wetland impact scores (as assessed using WET-Health) (From Ellery et al., 2010)

A. Linear – e.g. abstraction of water for irrigation in a catchment.

B. Drastic reduction with small impact – e.g. erosion

C. Small impacts have little effect on wetland functionality, but the negative impact on functionality increases exponentially to the impact – e.g. pollutants

D. Small impacts may increase the provision of ecosystem services, followed by a drastic decline in the provision of ecosystem services with increase in the impact – e.g. the effect of gullies on flood attenuation.

Macfarlane et al. (2009) provide a toolkit for assessing wetland health. The output of this impact and indicator-based toolkit provides an assessment of the intensity and magnitude of impact per HGM and guides follow up rehabilitation activities as necessary.

Kotze et al. (2009b) guides the process of assessing 15 benefits of the regulating and supporting services provided by inland, palustrine wetlands, noting a number of characteristics which may influence each of the services, and provides a score sheet for recording the data in a way that is transparent. It also prompts the user to identify threats to the wetland and possibilities for enhancing the benefits realised.

Kotze et al. (2009c) have developed a process to inform the planning of the wetland rehabilitation process that integrates into the broader management of the wetland and catchment, and which produces sustainable outcomes. This is achieved through the provision of three main elements:

- Background information on wetland rehabilitation,
- Guiding principles for rehabilitation, and
- A framework with step-by-step guidelines for undertaking the planning and implementation of wetland rehabilitation.

Russell (2009) follows the rehabilitation planning with a comprehensive manual on the selection and implementation of rehabilitation methods that are appropriate for the particular problem being addressed and for the wetland and its catchment context.

It gives the key concepts relating to wetland degradation, especially from erosion and gives detailed guidance for the design and implementation of interventions for the rehabilitation of inland palustrine wetlands and their catchments, focusing particularly on wetlands associated with natural drainage networks. Although some aspects of the tool require high levels of civil engineering expertise, it is designed primarily for rehabilitation workers who have completed training in soil conservation, life sciences or engineering at a diploma level and who have practical field experience.

Assessment of the effectiveness of implementation interventions is covered in the publication WET-RehabEvaluate (Cowden and Kotze, 2009). WET-RehabEvaluate recognises that monitoring and evaluation are closely linked to planning and provides the background to rehabilitation and step by step guidelines for monitoring and evaluation of rehabilitation projects. It gives guidance on how to review the achievement of the objectives of the rehabilitation, the identification of performance indicators, the development of a monitoring evaluation plan and how to report on performance. Outcomes of the monitoring and evaluation are based on system integrity and the delivery of ecosystem services by the rehabilitated wetland as measured by WET-Health (MacFarlane et al., 2009) and WET-Ecoservices (Kotze et al., 2009b).

When wetlands have been degraded it may not be possible to restore them to their original state, and in this case, as a final option and in order to achieve the ideal of no net loss (Dini, undated), a license for wetland mitigation banking may be sought. Cox and Kotze (2008) assessed the appropriateness of wetland mitigation banking as a mechanism for securing aquatic biodiversity in the grassland biome of South Africa. Mitigation banking was first developed in the USA to address their 'no net loss' policy. Canada has not accepted mitigation banking as they say it encourages a 'commodity' approach. In South Africa offsets have been applied with limited success and sustainability. South African legal instruments are considered adequate, but tools appropriate to South African conditions are not yet available. In the USA it was found that small, *ad hoc* wetland mitigation offsets had a high failure rate because they did not have the necessary resources to ensure their success and were difficult to control. As a result the USA model has gone the route of fewer, larger banks which have the resources to ensure sustainability. In basins such as the Colorado where water is scarce, the water to maintain the bank has to be purchased, making the running of a mitigation bank an expensive process. The South African model, as developed by Cox and Kotze (2008) puts the role of banker into the hands of Working for Wetlands, a state organisation. This gets around many of the problems experienced in the USA with its private banking system. This model still needs to be tested in practice, and the upper Olifants, Mpumalanga, has been selected as the case study area. A difference between the USA system and that proposed for South Africa is that South Africa requires the wetland offset to be in the same catchment as the wetland that it is to 'replace'. In the USA they have found that a single larger wetland has a generally greater benefit than many smaller ones for functions such as supporting water bird populations.

Wetland offsetting and no net-loss

Wetland offsetting

The focus up to this point in time has largely been on conserving representative sites from a biodiversity perspective. However, the South African wetland offset guidelines (SANBI and DWS, 2014) state that any offset should preferable be made in the same sub-catchment but at least in the same quaternary in order to maintain the flow of ecosystem services to the quaternary catchment.

Implications for the study

The consideration of wetlands within an ecosystem approach is vital to ensure their long-term survival. Wetlands as a percentage of surface area in a catchment have also not been mainstreamed in South Africa. As a leader in the landscape of corporate environmental responsibility, Eskom is in the ideal position to raise the debate on this issue, especially with reference to wetland offsetting initiatives. Given the ability of wetlands to attenuate especially non-point source pollution, these measures could improve water quality in the catchments that Eskom operates in.

> Biodiversity offsets are measurable conservation outcomes resulting from actions designed to compensate for significant residual adverse biodiversity impacts arising from project development after appropriate prevention and mitigation measures have been taken. The goal of biodiversity offsets is to achieve no net loss and preferably net gain of biodiversity on the ground with respect to species composition, habitat structure, ecosystem function and people's use and cultural values associated with biodiversity (SANBI and DWS, 2014).

The ideal of wetland offsets is to achieve a measurable "no net loss" or "net gain" conservation outcomes (SANBI and DWS, 2014). The goal of quantifying losses or gains distinguishes offsets from other compensatory conservation methods. In summary, offsets seek to mitigate or compensate for impacts on the environment from project development after the necessary measures have been taken to first minimize and avoid these impacts this can also be known as "compensatory mitigation" (SANBI and DWS, 2014). An example of compensation mitigation is of aquatic systems in the United States if America to restore and maintain the chemical, physical and biological integrity of the waters as developed in their Clean Water Act (SANBI and DWS, 2014). When planning offsets, a hierarchy needs to be considered, see Figure 21 below for steps.

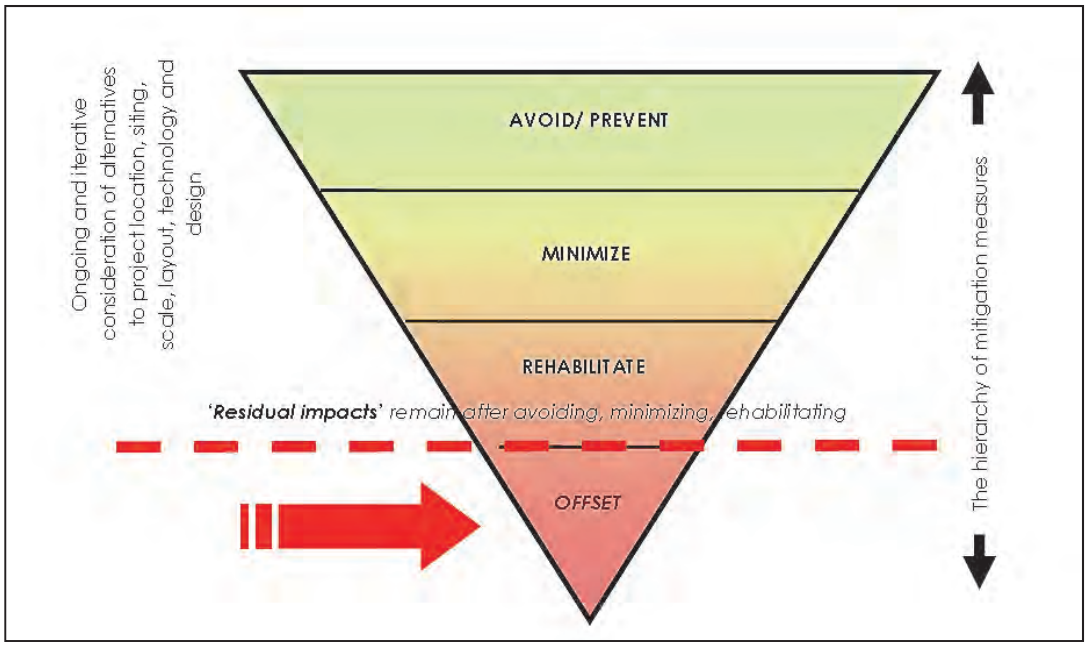


Figure 21: The mitigation hierarchy (SANBI and DWS, 2014)

A draft set of best practice guidelines for designing and implementing wetland offsets (SANBI and DWS, 2014) has been generated in response to the need to develop a comprehensive technical guideline for wetland offsets, with a particular emphasis on coal mining in the Mpumalanga Highveld. The report addresses the following aspects:

- **Offset site selection**: guidelines to inform the site selection process through a structured protocol and supporting guidance.
- Methodology for **calculating offset ratios**: appropriate compensation for residual impacts on wetlands is provided, in line with the principle of 'no-net-loss' or 'net gain'.
- **Technical protocols** to evaluate wetlands as part of the wetland offset methodology: **Monitoring** the rehabilitation process and project sign-off

This document provides valuable information and will be directing future wetland offsetting in SA.

Implications for the study

SANBI and DWS, 2014. *Wetland Offsets: A best practice guideline for South Africa* is the definitive resource for wetland offsetting in South Africa.

Wetland conservation in national and international legislation

At an international level, wetland protection is important across a range of conventions, such as the Ramsar Convention, Convention on Biological Diversity and the United Nations Convention to Combat Desertification (SANBI and DWS, 2014). International guidelines and standards on offsets are emerging and principles on biodiversity offsets were developed by members of the Business and Biodiversity Offset Programme (BBOP) Advisory Committee as the basis for the design and implementation of high quality biodiversity offsets (SANBI and DWS, 2014). This standard ensures for the best practice biodiversity offsets and thus verifying their success by complying with all relevant national and international laws. In South Africa, national laws directly or indirectly relate to wetland protection, conservation and management; but more specifically relating to general water, biodiversity and ecosystem conservation. Such laws include The South African Constitution 108 of 1996, The National Environmental Management Act 107 of 1998, The Environmental Impact Assessment (EIA) regulations, The National Water Act 36 of 1998, The General Authorisations (GAs), The National Environmental Management: Biodiversity Act No 10 of 2004, The Conservation of Agricultural Resources Act 43 of 1967, The National Forest Act 84 of 1998, The Natural Heritage Resources Act 25 of 1999, The National Environmental Management: Protected Areas Act 57 of 2003, and The Mountain Catchments Areas Act 62 of 1970 (SANBI and DWS, 2014). South Africa is currently developing biodiversity offset guidelines that will be used nationally. These incorporate widely accepted general principles of design and implementation which have been published in the Business and Biodiversity Offset Programme of 2009.

Overview of Wetland Offset Framework

A step-wise process is outlined below detailing the steps taken to assess possible lasting impacts of a proposed development. First the wetland must be delineated, and then divided into hydrogeomorphic units. Then an assessment of the following factors must be done:

- Importance of the wetland to biodiversity conservation;

- Its Present Ecological State reflecting its current health and integrity (see section 8 for detailed breakdown on wetland health); and
- Its key ecosystem services, thereby differentiating between the direct and indirect services;
- The species of conservation concern (wetland dependent species which will be impacted upon), should be assessed.

See a more detailed guideline to the steps of the Wetland Offset Framework by SANBI and DWS, (2014). Figure 22 presents an overview of Wetland Offset Framework.

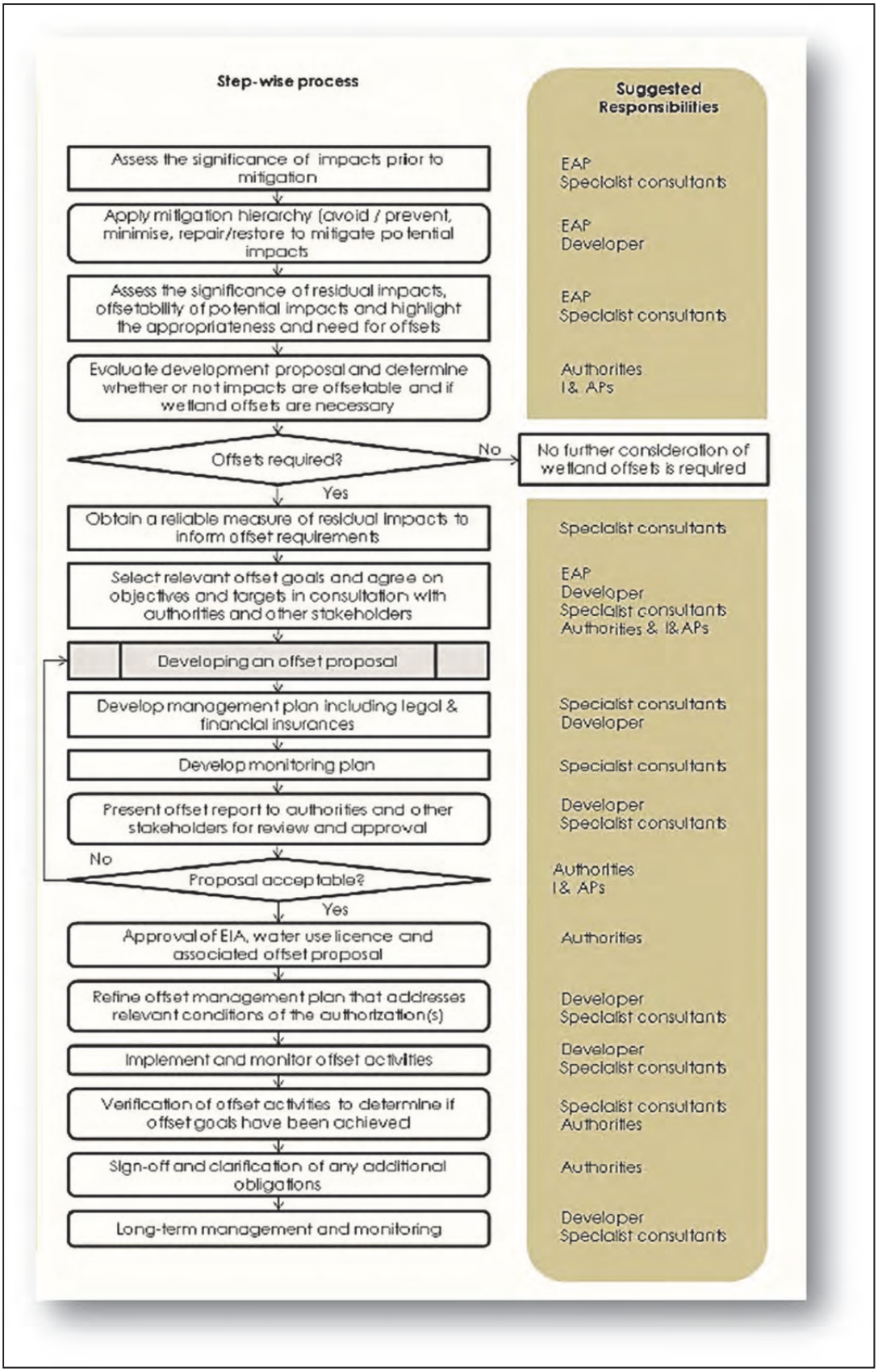


Figure 22: Overview of Wetland Offset Framework

Wetland mitigation banking

A wetland mitigation bank is a wetland area that has been restored, created, enhanced or preserved, which is then set aside to compensate for future conversions of wetlands for development activities. Credits may be purchased by developers whose activities may lead to wetland losses. The number of credits required are determined and authorised by the relevant authority (Cox and Kotze, 2008). According to Cox and Kotze (2008) “wetland mitigation banking (WMB) is the key mechanism applied in the United States to give effect to their policy of ‘no-net loss’ of wetlands, and has been implemented within a regulatory framework over the past two decades. The mechanism is designed to facilitate compliance with regulatory requirements by providing for the establishment of new wetland areas or "banks," in advance of anticipated losses. Where unavoidable impacts are authorised, developers are able to purchase the banked credits to offset the losses.

Case study in South Africa

Cox and Kotze (2008) mentioned that in South Africa various forms of compensation are being applied to offset wetland loss due to the impact of development activities. For example the Department of Water Affairs has been responsible for planning the rehabilitation of approximately 338 ha of wetland in the Upper Mooi River Catchment in KwaZulu-Natal to offset the loss of wetlands to be inundated by the proposed Spring Grove Dam. The AngloCoal Off-Site Wetland Mitigation Project is another example of an attempt to implement effective compensation for impacts to wetlands from surface mining in the Upper Olifants River Catchment.

Cox and Kotze (2008) analysed four of the examples included in their study and concluded that they show a lack of consistency in the compensatory measures applied and accepted by the regulatory authorities in authorising the projects considered. They consequently indicated the technical, institutional and legal requirements for the successful implementation of WMB in South Africa and proposed a framework for WMB in SA.

The report by Cox and Kotze (2008) lays the groundwork for an assessment of the appropriateness and feasibility of wetland mitigation banking to secure/sustain inland water biodiversity within the grasslands biome at a demonstration level. The National Grasslands Biodiversity Programme (NGBP) (established under the South African National Biodiversity Institute (SANBI)) identified 15 priority clusters for conservation and has been working with coal mines in the grass lands biome of South Africa to mainstream the protection of this biome. WMB has been identified by the NGBP as one of the mechanism to promote biodiversity conservation in the areas under threat for coal mining. A pilot project to test the framework developed by Cox and Kotze (2008) has been implemented over a 5-year period to test the feasibility of the framework.

How to achieve wetland offsets

In order to achieve wetland offsets (SANBI and DWS, 2014) stated that:

- They need to be protected in the form of legal implementation (such as in NEMA under the Protected Areas Act) in order to increase the current "value" of a wetland system and the long term persistence of wetland biodiversity
- There needs to be averted loss which refers to physical activities that prevent loss or degradation of existing wetland systems and its biodiversity (these can be counted as “gains” as they contribute to achieving the ideal of “no net loss”)

- Some may need to undergo rehabilitation/restoration in order to manipulate the physical, chemical, or biological characteristics of a degraded wetland system in order to repair or improve wetland integrity and associated ecosystem services
- There needs to be an establishment of new wetland systems in some catchment areas where they didn't exist before which leads to "gains" in wetland area, functions and biodiversity values
- There needs to be direct compensation to affected parties for loss of ecosystem services which can be done by monetary compensation or regulating the supporting services.

Implications for the study

We are aware of a study commissioned for the New Largo Colliery (dated 2012) for

Anglo American Thermal Coal for a wetland offset plan. The study is undertaken by Wetland Consulting Services. It would be imperative for the compilation of this study to pursue alignment with related initiatives in the catchments in which Eskom operates.

Vegetation management

Eskom has clearly defined environmental procedures for managing vegetation growing within the servitudes, recognising that vegetation management within power line and other servitudes has financial, social and environmental implications (Anon., 2010). The procedures state that clearing of vegetation needs to be done as economically as possible, without causing unnecessary environmental damage and without impacting on the rights and requirements of the landowner and other interested and affected parties. In terms of the Occupational Health and Safety Act, 1993 (Act 85 of 1993), "The supplier, or user of power lines shall control vegetation in order to prevent it from encroaching on the minimum safety clearances of the power lines and the owner of the vegetation shall permit such control". Trees that are growing close enough to power lines to threaten them should they fall will be removed, but indigenous vegetation that does not interfere with the safe operation of the power line should be left undisturbed. Species protected by law will not be cut without a permit from the relevant authority. Alien vegetation, specifically category 1, 2 and 3 plants, will be controlled and removed in such a way as not to spread propagules. The risk of fire below the power lines needs to be kept to a minimum, so vegetation needs to be kept under control. But apart from this, indigenous vegetation will not be disturbed. Some general restrictions are that deep valleys, environmentally sensitive areas and legally protected areas shall not be cleared provided that the vegetation poses no threat to the safe operation or reliability of the power line. Measures to prevent soil erosion shall, at all times, be implemented and rivers, watercourses and other water bodies shall at all times be kept clear of vegetation trimmings and debris. The integrity of riparian areas shall be maintained by only trimming the parts of trees directly affecting the safe operation of the power line.

Implications for the study

The Eskom vegetation guidelines are comprehensive, although the practical application in the field cannot be guaranteed, especially if untrained workers are utilised to control vegetation. A relevant on-the-job-training course should be investigated.

Artificial and Constructed Wetlands

Function of constructed wetlands

Wetlands are nature's biological filters and are crucial for the improvement of water quality and pollution reduction (Sheoran and Sheoran, 2006). Wetlands assist in the prevention of floods through water retention. As wetlands are water rich areas they also attract a wide variety of animals, therefore acting as an enhancer and protectors of biodiversity. Artificial wetlands are sometimes spontaneously created by a change in the landscape, for example next to roads due to increased run-off. Constructed wetlands on the other hand are designed with a specific purpose in mind. Constructed wetlands assists in pollution reduction through removal of nutrients and other harmful pollutants, including acid mine drainage (AMD) from surface or underground coal mines (Nicomrat et al., 2006). Established constructed wetlands have the capacity to fulfil the same functions as natural wetlands and have the potential to become somewhat self-sustaining in fulfilling these functions (Arroyo et al., 2010). This self-sustainability is often referred to as "passive" technology. Constructed wetlands can also increase biodiversity (Batty et al., 2005) by increasing wildlife habitats (Arroyo et al., 2010). They can also function as environmental recreational sites (HydrateLife, 2012), and can provide educational possibilities (Odinga et al., 2011).

Several mechanisms are involved in the removal of pollutants from water entering a natural or constructed wetland. Sedimentation, for example is *recognized as the principle process in the removal of heavy metals from waste water in natural and constructed wetlands* (Sheoran and Sheoran, 2006). Sedimentation occurs when metals or other suspended particulate are accumulated into large enough particles to sink, and the metals and other particulate matter are then trapped within the wetland sediments. Another mechanism for removing metals is through sulphate-reducing bacteria (SRB). Wetland plants also remove nutrients such as phosphate or nitrate by "uptake or precipitation near the roots". Plants need to be carefully chosen to fulfil the required functions, because different plant species respond differently to different forms of pollution (Russel, 2009). Consideration however, must be given to legislation governing alien species and declared weeds. In certain cases, for example the water hyacinth (*Eichhornia crassipes*), plants may have useful properties for the purposes of pollutant removal, but are declared weeds and are not allowed to be deliberately planted in a wetland or in a specific region (Russel, 2009). It is important to consider the complete "life-cycle" of constructed wetlands. Plants absorb pollutants, but upon saturation it is required to dispose of them in an environmentally friendly manner. Composting or burning the plants will release the contaminants back into the environment, making the use of the constructed wetlands redundant (Russel, 2009). Bacteria are removed through a combination of sedimentation (due to their adherence to sediments), increased opportunities for predation and exposure to UV (Cohen, 2006).

Construction

Constructing wetlands can entail either making use of only a "pure" wetland or to use it in conjunction with other pollution reducing methods. The use of "pure" wetlands depends on the required designed function, the amount of land area available, the pH, and other environmental factors such as which plants will grow where. This type of "pure" wetlands is also referred to as passive treatment. The inclusion of other methods in conjunction with wetlands includes the use of additional limestone or other chemical techniques as pre-treatment before the water enters the wetland (Greger and Nyquist, 2009). Using "pure" wetlands reduces the need to chemically treat water, but pre-treating water has the potential to extend a constructed wetland's life.

Cost, maintenance and lifetime

Various and conflicting opinions are evident in the literature (Sheoran and Sheoran, 2006), (Cohen, 2006), (Gitari et al., 2011), (HydrateLife, 2012), however, it appears that a good approach to decide whether a constructed wetland is cost-effective or not is to compare it to other alternatives that could potentially treat the same or similar problems.

There are several opinions regarding the lifetime period of constructed wetlands, these opinions range from a life of approximately 5 years (Russel, 2009) and can be as long as 20 to 30 years (Coleman et al., 2011). Ideally, the constructed wetland should be self-sustaining, however maintenance might be required when it becomes evident that plants have reached their saturation point and need to be replaced (Coleman et al., 2011). Concerns have been raised by experts about the saturation-point of the plants used in the constructed wetlands, especially when the constructed wetland is used to treat non-biodegradable pollutants such as metals (Arroyo et al., 2010).

An increase in the amount of mosquitos (Malan et al., 2009) could be a consequence of a constructed wetland, especially if the conditions are in line with their breeding habits. Methods, such as draining and in-filling, can be employed to regulate the mosquito population (Malan et al., 2009).

Feasibility

A report by Grobelaar et al. (2004) stated that “the use of wetlands for the treatment of mine water has been a failure under South African conditions…after more than 25 years of research into the matter.” Further in the document the authors divide wetlands into two types: “Well-constructed structures kept under anaerobic conditions and harvested periodically to remove heavy metal build-up” and the second type, that is wetlands that are not well maintained and merely becoming toxic waste sites. The authors classify South African wetlands into this category.

Current research on the functioning of the rehabilitation on the 139 ha Zaalklapspruit wetland in the Mpumalanga Highveld coal mining area, a wetland receiving AMD, is showing promising results in the capacity of the wetland to improve water quality. The Zaalklapspruit was originally an unchannelled valley bottom wetland, but agricultural activities had caused a channel to be eroded through the wetland. The rehabilitation has re-established the typical unchannelled wetland pattern of water flow across the entire wetland, slowing the passage of water through the wetland. Initial monitoring results have shown an increase in pH and a reduction in the level of dissolved metals (Van Vuuren, 2014). Van Vuuren (2014) notes that, while wetlands do not have unlimited capacity to improve water quality, when employed as part of an integrated water quality improvement strategy together with such measures as reducing the pollution at source, they can fulfil a useful role.

The USA though, have had demonstrated success with constructed wetlands. As a result of research by the US Bureau of Mines, over 400 engineered wetlands were constructed on mined lands in the previous four years (Kleinmann, 2006). Mine operators indicated that the wetlands assisted in reducing the amount of chemical treatment required. The amount saved in the amount of chemicals used, repaid the cost of constructing the wetland in under a year.

A research and development project by the Environment Agency (Wiseman, 2002) “demonstrated that passive constructed wetland treatment systems can be an effective and low cost means of mine water treatment for both net alkaline and net acidic discharges.” Five wetlands in various phases where analysed. The wetlands were not problem-free, but the main recommendation from the research, was that a “routine inspection and maintenance programme” should be developed. It was also noted that a characteristic of constructed wetlands is that they are low maintenance, not maintenance free.

Implications for the study

Constructed wetlands are an environmental and an economically viable treatment method, however a plan needs to be in place to ensure that routine inspection is done and that there is a maintenance programme. A pilot project as a first step would assist with determination of the feasibility of constructed wetlands within the Eskom context.

3 THE WETLAND MANAGEMENT FRAMEWORK

3.1 THE WETLAND MANGEMENT FRAMEWORK: INTRODUCTION

An Overview of the Term "Adaptive Management"

Given that the overall aim of this project is to develop and test an *adaptable planning framework* that streamlines the conservation of wetlands in areas where Eskom operates from coal to customer, it is necessary to unpack what the term means in this context.

"Adaptive management" was first introduced to the sphere of natural resource management by Holling (1978) with his concept of "Adaptive Resource Management". Adaptive management has been defined by Rogers and Lutton (2011) (quoting Meffe et al. (2002)) as:

> The process of treating resource management as an experiment such that the practicality of trial and error is added to the rigour and explicitness of the scientific experiment, producing learning that is both relevant and valid.

Adaptive management can be summarised under three headings:

- **Active** (classic or true) adaptive management in which the emphasis is strongly on the scientific method, the process of "experiment" and on modelling
- **Passive** adaptive management in which there is much less emphasis on the scientific method/experiment and more on learning by a range of means/tools
- **Documented trial and error** in which there is no stipulated structure to the decision making process but what does happen and its consequences are nonetheless well documented.

Active adaptive management has the following basic steps:

1. List imaginative policy options
2. Model system function and likely response to the new policy
3. Identify gaps in knowledge during the modelling process
4. Management actions designed and implemented as large scale experiment to fill information gaps
5. Monitor system performance/response to management manipulation
6. Modify model on basis of experiment outcomes to decide on best policy.

It is proposed that Eskom follows an active adaptive management process to ensure on-going improvement of and maintaining the relevance of this Wetland Management Framework (WMF). Figure 23 below provides an overview of an adaptive management framework compiled by Kotze (2004) for the Mondi Wetlands Project.

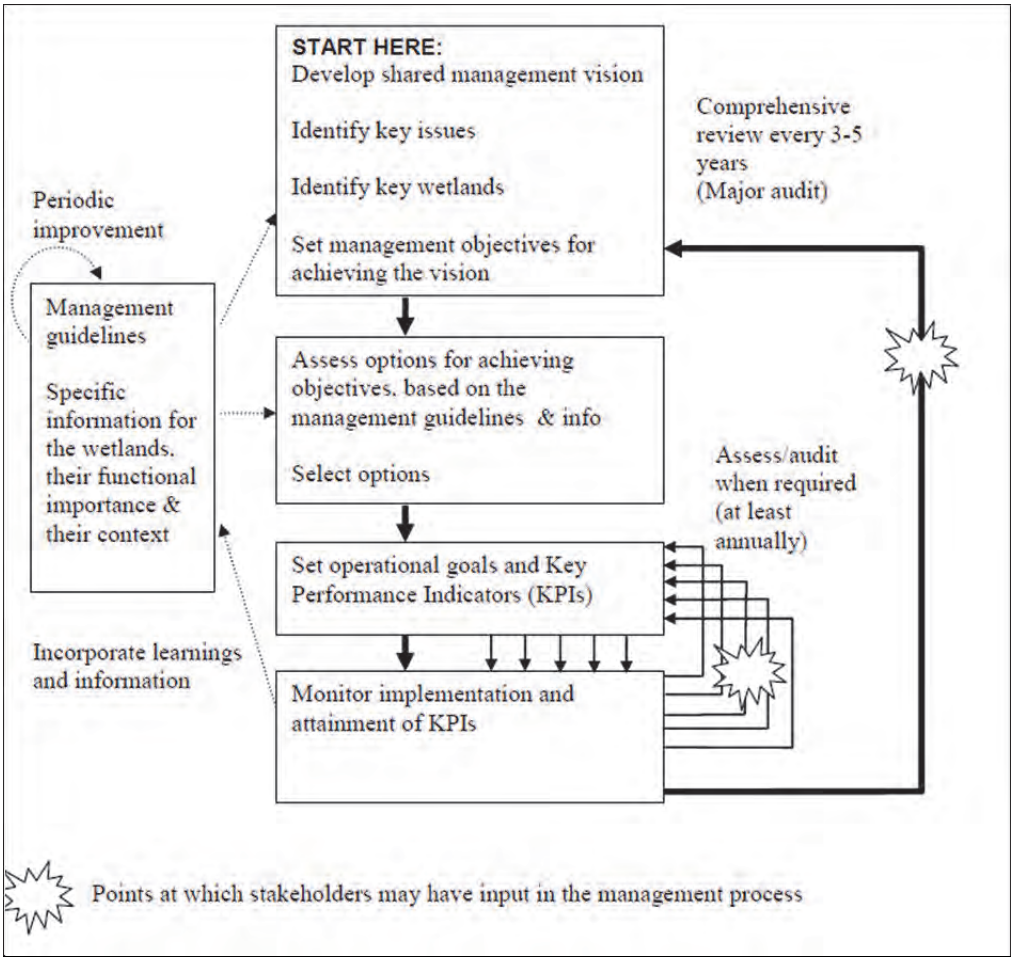


Figure 23: An overall adaptive management framework for the management of open areas by Mondi (Kotze, 2004)

PURPOSE OF THIS WMF

Defining the Term "Framework"

A framework has been aptly defined by the Business Directory as: "A broad overview, outline, or skeleton of interlinked items which supports a particular approach to a specific objective, and serves as a guide that can be modified as required by adding or deleting items. (http://www.businessdictionary.com/definition/framework.html#ixzz2WfiFH7fk, 2013).

Within the context of the WMF, it is important to acknowledge that this represents a broad overview, outline or skeleton of interlinked items to support Eskom's commitment to ensuring that the ecosystems (and wetlands in particular), under their jurisdiction are maintained in a healthy ecological state. The WMF should therefore be seen as a generic framework for a conservation plan that must be implemented, with appropriate customisation.

This WMF will therefore promote the conservation of the environment, with due cognisance of the ecosystem services that it provides. The Framework will adopt the principle of adaptive management with the feedback loops designed to ensure that the principle of 'learning by doing' is effectively implemented. The overall framework will consist of several sub-frameworks, each designed to address specific aspects of Eskom's activities. These sub-frameworks will be integrated into the overarching WMF in such a way that the

Framework will provide Eskom with a cohesive plan which addresses their need to sustainably manage the wetlands under their jurisdiction.

Vision, Values and Objectives of the WMF

The following vision, values and objectives underlie the WMF:

VISION

Eskom strives for no overall net loss of wetland ecosystem services in the catchments in which Eskom operates.

VALUES

a) Eskom ascribes a high value to wetlands, both for their intrinsic value as well as for the ecosystem services they provide.
b) Eskom aims to fully understand and minimise the direct and indirect impact of all its externalities on wetlands and the catchments (including its human settlements) to which wetlands provide ecosystem services.
c) Eskom aims to support stakeholders in their efforts to promote water resource management in the catchments in which Eskom operates.

OBJECTIVES

a) Support management, planning, mitigation and restoration efforts through consistent and accurate digital maps of all wetlands and riparian areas that will allow the promotion and monitoring of its ecological integrity.
b) Recognising the benefits derived from ecosystem services, Eskom understands wetland ecology and functioning by identifying and describing the range of natural variability in wetland ecological infrastructure in the areas where Eskom and its suppliers operates.
c) Evaluate and describe the impacts of Eskom's activities on wetlands and riparian areas.
d) Eskom's dependence on ecosystem services. Identify important ecological infrastructure that contributes to Eskom activities / sustainable energy.
e) Apply effective performance standards, monitoring tools, and management practices to enhance the effectiveness of compulsory and voluntary mitigation, restoration planning and resource management.
f) Promote collaboration with stakeholders as well as information and data sharing amongst relevant stakeholders.
g) Facilitate identification and protection of high-quality sites, sites of ecological importance and particularly vulnerable wetlands. This includes identifying and protecting sites important for Eskom activities / sustainable energy
h) Encourage multi-stakeholder efforts to address threats to wetlands and riparian areas.
i) Integrate wetland protection into all aspects of the life cycle of its projects and those of its suppliers.
j) Develop renewable energy options.

Sub-frameworks of the WMF

An overview of the sub-frameworks contained in this WMF is provided below:

a) Hierarchy of conservation targets

Given the varied nature and role of wetlands in the landscape, it will be required to take cognisance of and set conservation targets for each type of wetland affected by Eskom's operations.

b) Monitoring and evaluation

Indicators will be developed to monitor each of the sub-frameworks described below. These will be based on the findings of the research and the targets set. This section will be completed after the pilot study.

c) Carbon and wetlands

Wetlands are considered important sinks for greenhouse gasses. Wetlands under Eskom's jurisdiction will be ranked in terms of their Green House Gas (GHG) attenuation potential. This will ensure that the criteria and targets related to wetland conservation take cognisance of this important wetland function.

d) Wetland off-setting

There are times when Eskom is unable to avoid impacting on, or destroying wetlands. This sub-framework will outline the decision-making process on how this destruction may be offset to ensure no-net loss in the particular catchment.

e) Biodiversity conservation

This sub-framework will give methods for assessing the conservation status of the areas under consideration and outline the necessary interventions and monitoring process to ensure that targets are met.

f) Ecosystem services for communities

This sub-framework will set out the process for identifying and evaluating the value of the ecosystem services used by communities and how these will be affected by Eskom activities. Where the impact may be negative, the framework will include feedback loops to assess mitigation measures where these are appropriate. At the same time, opportunities will be identified to promote access to wetland goods and services by surrounding communities, in support of Eskom's social responsibility initiatives.

g) Pollution attenuation for Eskom and their mines

The potential of wetlands (both natural and artificial) to attenuate pollution levels in surface water could be harnessed by Eskom to promote water quality in the catchments within which it operates. Understanding and incorporating this within the initial wetland inventory, will ensure that the criteria and targets related to wetland conservation take cognisance of this important wetland function.

h) RQOs of feeder catchments

Based on the pollution attenuation potential of wetlands, Eskom can set strategic conservation and rehabilitation targets to improve catchment water quality.

i) Waste treatment

Eskom generates a variety of wastes, some of which are air-borne, some water-borne and some solid. Each of these categories of waste will stress the environment and negatively impact on the biodiversity. This sub-framework will guide the effective management of the various treatment methods (e.g. high rate, artificial wetland, etc.) that may be selected. The Eskom policy of zero liquid effluent discharge will be progressively implemented, but this sub-framework will guide waste management under the current waste management regime.

APPROACH TO THE WMF

Action Categories

The elements of the Framework have been divided into four broad approaches to guide and focus the user with respect to the purpose of the elements contained in the framework. Table 20 below provides an explanation of the categories and their focus and impact areas, as well as the symbols that will be used in the WMF. The categories are:

- Catchment perspectives
- Corporate social responsibility
- Harnessing ecosystem services for the benefit of Eskom (including carbon and climate change issues)
- Legal compliance.

These categories were devised based on current Eskom initiatives, policies, strategies and value systems. Examples of prominent Eskom initiatives are provided in the two text boxes below:

Eskom presented its **Vision 2030 with respect to water pathways** to the Water Sector Leadership Group (WSLG) during 2009. This included milestones for the period 2009 to 2015 and 2016 to 2030 and includes targets related to compliance, partnerships, technology and management interventions which are all mostly focused on water use efficiencies.

These are given in the Annexure.

Eskom Water Strategy

Principles:

a) Social progress which recognizes the needs of everyone
b) Effective protection of the environment
c) Prudent use of natural resources
d) Supporting an environment of high, stable economic growth and employment

The major **water strategic objectives** identified in Eskom's Water Strategy are:

a) Ensure long term water scenario planning
b) Meet the water requirements for new and existing power stations
c) Meet the water quality objectives of the various catchments
d) Manage water cost increases into the future
e) Influence policy, strategy, legislation and regulatory environment
f) Regular communication and intervention with respective government departments and other stakeholders by means of a dedicated advocacy and stakeholder engagement plan
g) Implementing a water conservation water demand management strategy
h) Water management assurance, advisory and supporting role to projects, power stations and coal mines.

Specific actions undertaken**/subtasks** of relevance for this study include:

a) Endorsement of the UN CEO Water mandate
b) Ensuring zero liquid effluent discharge
c) The compilation of a procedure for coal supply contracting, in order to ensure suppliers are legally compliant
d) Closure plans for defunct and cost-plus mines

Table 20: Wetland management framework approach and symbols used to indicate the category of focus or impact

Symbol	Category of Focus or Impact
	**Legal compliance** This category refers to measures that Eskom has to take to ensure that it is in compliance with relevant South African legislation.
	**Harnessing ecosystem services for the benefit of Eskom (including carbon and climate change issues)** This category refers to ways in which Eskom can promote and sustainably use ecosystem good and services, on which the organisation as well as human health and wellbeing depends.
	**Corporate social responsibility** This category refers to matters “beyond the Eskom fence line” and is mainly strategic in nature with reference to maintaining good relationships with surrounding communities as well as support the need for social development, upliftment and poverty reduction in South Africa.
	**Catchment perspectives** This category refers to matters “beyond the Eskom fence line” and is mainly strategic in nature with reference to the current and future state of water resource in the relevant catchment.

Organisational Alignment

In order to ensure that the WMF is entrenched within Eskom, it is necessary to promote alignment with its organisational systems. Figure 24 below summarises the main systems that are typical of large organisations such as Eskom. It also indicates external linkages and that scientific principles should underlie the WMF.

As such, throughout the WMF, linkages with these systems will be indicated. For example, to ensure optimum access to data and information with respect to wetlands, it would be ideal to centralise such information or ensure its uptake in a catalogue of metadata.The WMF will, in cases such as these, remind the user to manage data by referring to “Data and Information Systems”. In the same manner, should the need for education and awareness become evident, the WMF will refer the user to Skills Development Systems.

To ensure that the WMF is properly entrenched within the organisation, corporate communication about its existence is advised.

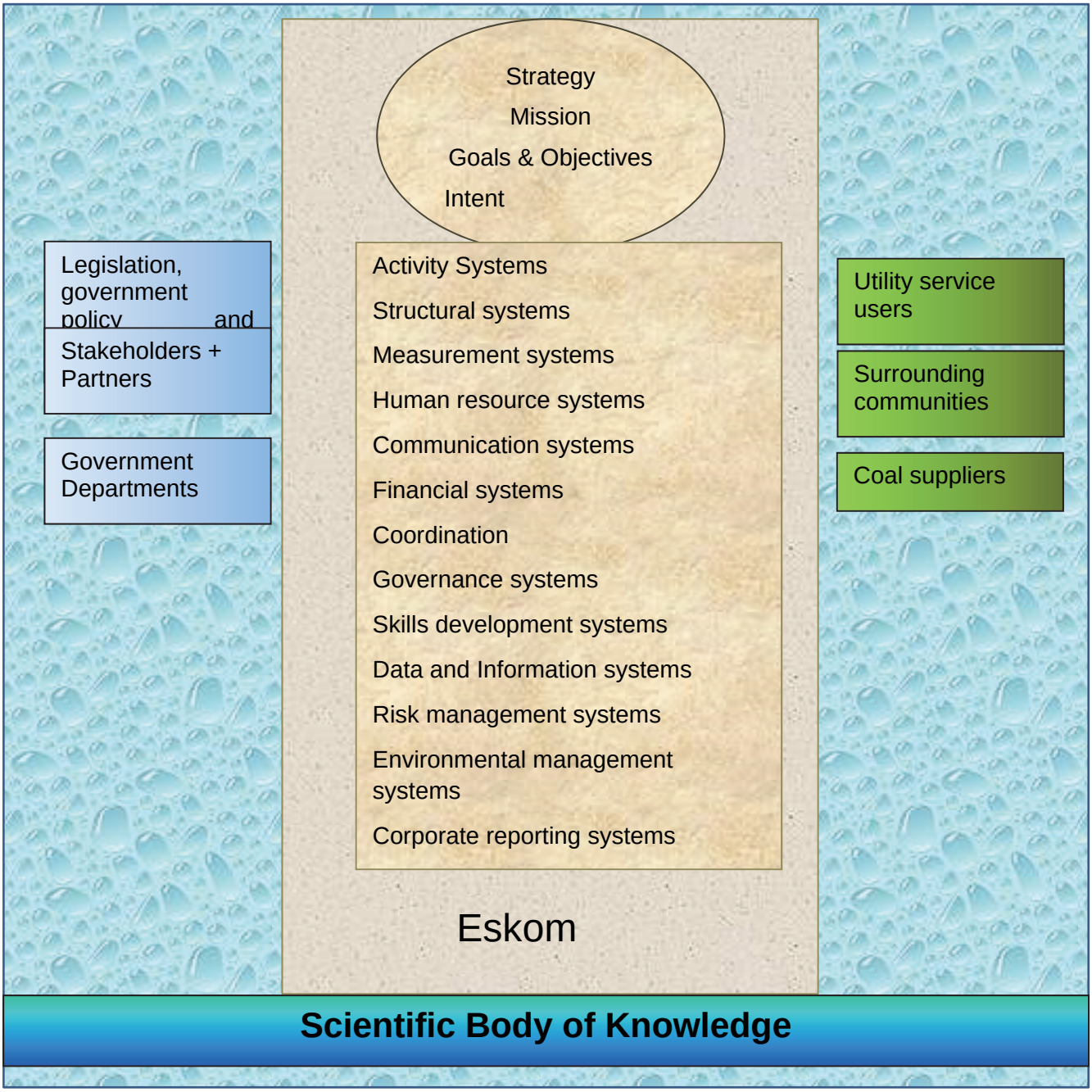


Figure 24: The different organisational systems that characterise an organisation

The Eskom Project Life-Cycle Model (PLCM)

The WMF is ultimately aligned with the Eskom PLCM. The PLCM prescribes different project phases and the step required for each. The PLCM, as the accepted practice and management model of the life cycle of projects, is therefore ideal to form the foundation of the WMF.

The PLCM is represented below, and the appropriate category () or focus area (as explained in Table 20), has been indicated next to each of the steps. The PLCM table also made provision for a column indicating the desired alignment with organisational systems as shown in Figure 24. The PLCM table also refers the user to the appropriate sub-framework to consult for more detail. It also guides the user by asking essential or core questions which the user should aim to answer.

Table 21 below is thus the starting point for the WMF. Users engaged in the different project life phases (whether for example construction or operation), should refer to the relevant sections of the WMF as indicated for scientific and best practice guidelines.

Note that for the purpose of the WMF, the authors added “Operations” as a category to the PLCM.

Table 21: The application of the wetland management framework (WMF) in the context of the PLCM

Stage	Action Steps	Relevance to Category of Focus or Impact *(with reference to* Table 20*)*	Core Questions	Organisational Elements *(with reference to* Figure 24*)*
Pre-Feasibility	1. Establish Core project team		i. Is the team aware of the wetland management framework?	Skills development systems
	2. Perform Concept design		i. Will any wetlands be affected? ii. Has a desktop-level assessment been done to determine the area of wetlands on site, its ecosystem services and the spatial relationship to other activities? iii. What is the overall environmental state of the catchment? iv. Are the RQOs being met currently? v. How would WMF influence the concept design? vi. What is the status of the wetland from a conservation perspective (e.g. has it been listed as conservation worthy?) vii. Is the establishment of artificial wetlands a feasible option to treat and prevent run-off or effluent that can cause environmental pollution? viii. Are there any opportunities for wetland related research, promoting CSI through sustainable livelihoods, carbon offsetting or wetland rehabilitation? ix. What kind of data sets is already available for the wetlands on site, and how can they be incorporated/utilized?	Data and Information systems

Stage	Action Steps	Relevance to Category of Focus or Impact *(with reference to* Table 20*)*	Core Questions	Organisational Elements *(with reference to* Figure 24*)*
	3. Perform stakeholder needs assessment		i. Are surrounding communities reliant for their livelihood on wetland services – e.g. grazing, harvesting of grass/reeds, etc.? ii. Will sustainable livelihoods be affected? iii. Will eco-tourism potential be affected?	Corporate Social Responsibility
	4. Perform base infrastructure assessment		i. Is any infrastructure located in, or close to, the wetlands on site?	Coordination Governance systems Data and Information systems Risk management systems Environmental management systems
	5. Legal and regulatory requirements		i. In what way will wetlands be affected? ii. What are the legal implications? iii. Are wetland offsets required?	Governance systems
	6. Partner selection		i. Are partnerships required? ii. Who needs to get involved from a wetland perspective? iii. Are potential partners aware of and sensitive to wetland impacts?	Data and Information systems

Stage	Action Steps	Relevance to Category of Focus or Impact *(with reference to* Table 20*)*	Core Questions	Organisational Elements *(with reference to* Figure 24*)*
	7. Commercial and financial structure		i. Are there funds available in case the wetland need restoration or special management?	Financial systems Supply chain systems
	8. Business case and risk assessment		ii. What ecosystem services can be harnessed? iii. What ecosystem services will be affected? iv. Is there an opportunity for poverty alleviation or sustainable livelihoods through wetland use? v. What will the implication be of wetland modification for the catchment? vi. Which neighbouring landowners need to contribute to the initiative?	Communication systems Data and Information systems
	9. Stakeholder management		i. Who uses the wetland at present? ii. What goods and services is the wetland being used for at present? iii. How will wetland modification affect neighbouring properties or neighbouring communities? iv. Is it necessary to engage with SANBI, DEA, the local wetland management forum, Working for Wetlands, local catchment management agency or DWA at this stage?	Communication systems Data and Information systems
	10. Project development planning		i. What will the impact be on wetlands? ii. What are the drivers of wetland change and the current responses? iii. Have wetlands and their buffer zones been indicated on the proposed site layout plan?	Communication systems Data and Information

Stage	Action Steps	Relevance to Category of Focus or Impact *(with reference to* Table 20*)*	Core Questions	Organisational Elements *(with reference to* Figure 24*)*
			iv. If wetlands will be destroyed or significantly modified, what will be the impact on the ability of the catchment to continue to provide ecosystem services at the same level than before? v. Will the RQOs be met? vi. Are wetland offsets required? vii. Are there any alternatives to minimise/avoid impacts: – Location (alternative properties) – Site (alternative sites on the property) – Activity alternatives – Layout alternatives – Design alternatives – Technology alternatives, – Operational alternatives viii. What are the opportunities for rehabilitation, conservation or wetland offsetting? ix. Has the required buffer zones been determined? (Regulatory line of 500 m from boundary of wetland) x. Have the required environmental authorisations/water use authorisations been identified as well as the impact it will have on the time line and project budget?	systems

Stage	Action Steps	Relevance to Category of Focus or Impact *(with reference to* Table 20*)*	Core Questions	Organisational Elements *(with reference to* Figure 24*)*
	11. Screen, prioritise and approval		i. Have wetland management issues been included in the screening criteria? ii. What are the implications of these action steps on previous findings with respect to wetland on site and in the catchment?	Communication systems Data and Information systems
	12. Assess stage and plan next stage		i. Have all wetland actions been concluded and carried over to the next phase?	Communication systems Data and Information systems
Feasibility	13. Structure and establish DCO and PMO Contract and 3rd party structures		i. Are there any wetland activities which will require the inclusion of a formal position/role in the PMO?	Financial systems Supply chain systems
	14. Deal structuring and bankable report		i. How would WMF influence the bankable report? ii. What are the financial implications of decisions taken regarding wetlands on site?	Financial systems Supply chain systems

Stage	Action Steps	Relevance to Category of Focus or Impact *(with reference to* Table 20*)*	Core Questions	Organisational Elements *(with reference to* Figure 24*)*
	15. Preliminary site selection		i. What is the status of the wetlands on site? ii. Have wetlands and their buffer zones been indicated on the site layout plan? (Regulatory zone 500 m) iii. What will the impact be on wetlands as well as on the drivers of wetland change? iv. What are the current responses to wetland impacts? v. What is the role of the wetland/s in the catchment and have any been earmarked for conservation? vi. What is the PES and EIS status? vii. If wetlands will be destroyed or significantly modified, what will be the impact on the ability of the catchment to continue to provide ecosystem services at the same level than before? viii. Are there any alternatives to minimise impacts: – Location (alternative properties) – Site (alternative sites on the property) – Activity alternatives – Layout alternatives – Design alternatives – Technology alternatives, – Operational alternatives ix. What are the opportunities for rehabilitation, conservation or wetland offsetting? x. Has the required buffer zones been determined? xi. Have the required environmental and water use	Communication systems Data and Information systems

Stage	Action Steps	Relevance to Category of Focus or Impact *(with reference to* Table 20*)*	Core Questions	Organisational Elements *(with reference to* Figure 24*)*
			authorisations been identified as well as the impact it will have on the time line and project budget? xii. Has the possible impact on the RQOs been identified? xiii. Is there a wetland rehabilitation plan?	
	16. Execute EIA, regulatory and legal		i. Has a wetland specialist been appointed to undertake wetland studies? i. Is the wetland specialist SACNASP registered in the appropriate professional category? ii. Does the scope of the wetland study adequately address the requirements of the project as well as the objectives of this Framework? iii. Have all wetlands and their buffer zones been delineated and identified? iv. Have the PES and EIS been determined as well as which specific ES are important. Have all wetland health impacts and threats been identified? v. Is there an appropriate environmental management plan to prevent/manage wetland impacts? vi. Has the delineation data (shape files) been obtained from the Consultant? vii. Has an application been submitted for all relevant environmental authorisations? viii. If a wetland offset is required, has the necessary information required to determine offsets been acquired? ix. Have all the impacts to the wetland been identified?	Data and Information systems Communication systems Financial systems Supply chain systems

Stage	Action Steps	Relevance to Category of Focus or Impact *(with reference to* Table 20*)*	Core Questions	Organisational Elements *(with reference to* Figure 24*)*
			x. Have the necessary samples been taken in order to determine the carbon stock of the wetland? xi. Has the potential effect on the RQOs been identified?	
	17. Produce user requirement spec (URS)		ii. Have relevant WMF requirements/guidelines been included in the URS?	Data and Information systems Communication systems
	18. Perform basic design		i. Have wetlands and their buffer zones been indicated on the site layout plan? ii. Are there any alternatives to the project design/lay-out to minimise impacts on wetlands, e.g.: – Location (alternative properties) – Site (alternative sites on the property) – Activity alternatives – Layout alternatives – Design alternatives – Technology alternatives, – Operational alternatives iii. If rehabilitation will be undertaken, have a	Data and Information systems Communication systems

Stage	Action Steps	Relevance to Category of Focus or Impact *(with reference to* Table 20*)*	Core Questions	Organisational Elements *(with reference to* Figure 24*)*
			partnership with Working for Wetlands been established? iv. If artificial wetlands are considered, have a suitably qualified and experienced person been involved, and has the time taken for the wetland to reach optimum efficiency been taken into account? Has maintenance infrastructure (such as cutting and removal of vegetation) been incorporated into the planning?	
	19. Develop contracting strategy			
	20. Finalise Primary Energy (PE)		i. What are the contractual obligations of suppliers with respect to wetland management and protection? ii. What best practices can be given through to suppliers? iii. Does the relevant department responsible for PE understand the wetland implication of the requirements for PE? (e.g. additional water abstraction/discharge and the impact that will have on the catchment?)	Data and Information systems Communication systems Financial systems Supply chain systems

Stage	Action Steps	Relevance to Category of Focus or Impact *(with reference to* Table 20*)*	Core Questions	Organisational Elements *(with reference to* Figure 24*)*
	21. Finalise site selection		i. Have wetlands been prioritised for interventions, such as rehabilitation or protection? ii. Have wetlands and their buffer zones been indicated on the site layout plan? iii. Have the correct ranking value been assigned to the wetlands in terms of their potential GHG sequestration?	Data and Information systems Communication systems
	22. Prepare and distribute RFIs		i. Have relevant wetland matters been included in the RFI?	
	23. Establish project management support		i. Does the project require any special wetland support?	Data and Information systems Communication systems Financial systems Supply chain systems
	24. Establish CO management support			

Stage	Action Steps	Relevance to Category of Focus or Impact *(with reference to* Table 20*)*	Core Questions	Organisational Elements *(with reference to* Figure 24*)*
	25. Compile business case		i. Is a business case required for any of the wetland actions?	Data and Information systems Communication systems Financial systems Supply chain systems
	26. Assess stage and plan next stage		i. Have all wetland actions been concluded and carried over to the next phase?	Data and Information systems Communication systems Financial systems Supply chain systems
Business Plan	27. Develop engineering specifications		ii. What are the implications of the engineering specifications on wetland management and conservation? i. Did the engineering specification take into account the status and dynamics of the wetlands on site?	Data and Information systems Communication systems Financial systems Supply chain systems

Stage	Action Steps	Relevance to Category of Focus or Impact *(with reference to* Table 20*)*	Core Questions	Organisational Elements *(with reference to* Figure 24*)*
	28. Finalise Regulatory and legal approvals		i. Have the required environmental and water related authorisations been received?	Data and Information systems Communication systems Environmental Management Systems Risk management systems
	29. Finalise feedstock supplies contracts		i. What are the contractual obligations of suppliers? ii. What best practices can be given through to suppliers?	Supply chain systems
	30. Resolve commercial and financial issues			

Stage	Action Steps	Relevance to Category of Focus or Impact *(with reference to* Table 20*)*	Core Questions	Organisational Elements *(with reference to* Figure 24*)*
	31. Project execution strategy		i. Have all wetland management actions been captured in the strategy? ii. If a wetland offset is required, has funds been set aside for this activity?	Data and Information systems Communication systems Financial systems Supply chain systems
	32. Life cycle operation plan		i. Have appropriate indicators been defined to monitor and measure wetland related actions? ii. Have the appropriate skills been assigned to the project? iii. Is oversight required to make sure that the operational team uses the best practices?	Data and Information systems Communication systems Financial systems Supply chain systems Skills development system HR systems
	33. Finalise power purchase agreement			

Stage	Action Steps	Relevance to Category of Focus or Impact *(with reference to* Table 20*)*	Core Questions	Organisational Elements *(with reference to* Figure 24*)*
	34. Detailed business plan developed		i. Have all wetland management actions been captured in the business plan?	Financial systems Supply chain systems
	35. Initiate and structure project set-up		i. Have the appropriate skills and responsibilities been assigned to the project? ii. Are environmental/wetland awareness programs required for contractors on site?	Skills development system HR systems
	36. Data hand over to execution		i. Have any delineation plans and management actions been handed over to the appropriate person on site? ii. Are the contractors properly trained regarding the wetland issues on site?	Skills development system HR systems Supply chain systems Data and Information systems Communication systems
	37. Assess stage and plan next stage		i. Have all wetland actions been concluded and carried over to the next phase?	Supply chain systems
Planning & Design	38. Project Start-up			

Stage	Action Steps	Relevance to Category of Focus or Impact *(with reference to* Table 20*)*	Core Questions	Organisational Elements *(with reference to* Figure 24*)*
	39. Establish project organisational structure		i. Have the appropriate skills and responsibilities for wetland management been assigned to the project?	Skills development system HR systems
	40. Pre-qualify suppliers		i. What are the contractual obligations of suppliers? ii. What best practices can be given through to suppliers?	Skills development system HR systems Supply chain systems Data and Information systems Communication systems

Stage	Action Steps	Relevance to Category of Focus or Impact *(with reference to* Table 20*)*	Core Questions	Organisational Elements *(with reference to* Figure 24*)*
	41. Long-lead-time items: issue enquiry		i. If any artificial wetlands are planned, has the time taken to reach optimum efficiency been communicated? ii. Are the relevant persons aware that water use licenses (in cases required where wetlands are to be affected) have a long lead-time and that this may impact on project execution schedules? iii. Have the implications of long-term monitoring of carbon stocks in the wetlands been communicated?	Skills development system HR systems Supply chain systems Data and Information systems Communication systems Financial systems
	42. Detailed procurement and contracting plan		i. What are the contractual obligations of suppliers? ii. What best practices can be given through to suppliers? iii. Do contractors have the relevant experience, and correct methodology, etc.?	Skills development system HR systems Supply chain systems Data and Information systems Communication systems
	43. Detailed funding and call-down plan		i. In the case of mining, what are the implications in the Quantum of Financial Provision for wetland rehabilitation and management as well as any remnant hydrological impacts?	Financial systems

Stage	Action Steps	Relevance to Category of Focus or Impact *(with reference to* Table 20*)*	Core Questions	Organisational Elements *(with reference to* Figure 24*)*
	44. Project implementation plan		i. Have all wetland actions been included? ii. Is a stakeholder management plan included? iii. Does the plan include appropriate monitoring, measurement and reporting tools? iv. Has the conditions of the licenses/EIAs granted by the environmental authorities been adhered to?	Supply chain systems Data and information Environmental management systems
	45. Assess stage and plan next stage		i. Have all wetland actions been concluded and carried over to the next phase?	Supply chain systems Data and information
Contracting & Procurement	46. Complete balance of enquiries		i. What are the contractual obligations of suppliers? ii. What best practices can be given through to suppliers?	Supply chain systems Data and information Communication systems
	47. Update project implementation plan		i. Have wetlands and their buffer zones been indicated on the site layout plan? ii. Have any new wetland actions emerged that have to be added? iii. Is the project still in line with the licenses/EMPs that were granted as well as the management objectives for the wetlands?	Data and information Environmental management

Stage	Action Steps	Relevance to Category of Focus or Impact *(with reference to* Table 20*)*	Core Questions	Organisational Elements *(with reference to* Figure 24*)*
	48. Assess stage and plan next stage		i. Have all wetland actions been concluded and carried over to the next phase?	Supply chain systems Data and information
Construction	49. Establish site support infrastructure		i. Have wetlands and their buffer zones been indicated on the site layout plan? ii. Have wetlands and their buffer zones been demarcated as no-go zones? iii. How will communities continue to gain access to the wetland that sustains their livelihoods? iv. Where necessary, have wetland crossings/culverts been properly installed? v. Have contractors been briefed about no-go wetland areas? vi. Have contractors been properly trained in the relevant wetland issues/Environmental Management Plan of the wetland on site?	Data and information Skills development systems Communication systems Procurement systems Risk management systems Environmental management systems
	50. Manage detail design		i. Have wetlands and their buffer zones been indicated on the site layout plan? ii. Have any new issues emerged which can potentially impact on wetlands? iii. If wetlands are to be rehabilitated, are the detailed designs done to the satisfaction of WfWet?	Risk management systems Environmental management systems

Stage	Action Steps	Relevance to Category of Focus or Impact *(with reference to* Table 20*)*	Core Questions	Organisational Elements *(with reference to* Figure 24*)*
	51. Build/Execute		i. Are wetland impacts being closely monitored? This includes not only unauthorised access and activities in wetlands, but also unintended run-off, emergency incidents, fires and contractors disturbing wetland fauna. ii. In the case of accidental damage to a wetland, have the matter been reported to the relevant authorities and an appropriate mitigation and rehabilitation plan compiled? iii. Is there a communication channel to ensure that any changes to site layout or construction methodologies will be communicated timeously to the responsible environmental officer on site?	Risk management systems Environmental management systems Communication systems Financial and procurement systems
	52. Operational readiness		i. Have a set of indicators been defined to determine operational readiness with respect to wetlands?	Environmental management systems
	53. Assess stage and plan next		i. Have all wetland actions been concluded and carried over to the next phase?	Supply chain systems Data and information
Commissioning & Hand-over	54. Start-up and commissioning		i. Are wetland impacts being closely monitored? This includes not only unauthorised access and activities in wetlands, but also unintended run-off, emergency incidents, fires and contractors disturbing wetland fauna.	Risk management systems Environmental management systems

Stage	Action Steps	Relevance to Category of Focus or Impact *(with reference to* Table 20*)*	Core Questions	Organisational Elements *(with reference to* Figure 24*)*
	55. Hand-over		i. Has a new baseline assessment on all wetlands been executed? ii. Has the responsibility of wetland monitoring been assigned to a party? iii. Have residual contactor responsibilities with respect to wetland rehabilitation and maintenance been defined? iv. Are communities adequately trained to effectively manage wetlands under their control? v. Have new staff been trained and supplied with all relevant information?	Supply chain systems Data and information Skills Development Systems HR systems
	56. Consolidate documentation		i. Have wetland management been incorporated into procedures and management plans of the ISO 14001 EMS for the site? ii. Have a copy of the final site plan with wetlands and their buffer zones been obtained? iii. Have all relevant information been stored for easy retrieval and for reference to lessons learnt?	Environmental Management Systems Data and information systems
	57. Demobilise site office and staff		i. Have wetland barriers been removed? ii. Have all areas that have been damaged been rehabilitated?	Environmental Management Systems
	58. Assess stage and plan next stage		i. Have all wetland actions been concluded and carried over to the next phase?	Supply chain systems Data and information

Stage	Action Steps	Relevance to Category of Focus or Impact *(with reference to* Table 20*)*	Core Questions	Organisational Elements *(with reference to* Figure 24*)*
Operation*	59. Understand the Status Quo of the site		i. Do the personnel on site understand where the wetlands are and what its significance are? ii. What are the operational requirements associated with wetlands and wetland structures on site (e.g. WULA and RoD conditions)? iii. Are the personnel on site trained to recognize negative impacts on the wetlands?	HR Systems Skills development system Communication system Environmental Management systems
	60. Wetland delineation, Buffer zones and ecological corridors		i. In what way will the physical presence of these be indicated and respected and maintained? ii. Are the RQOs being monitored? iii. Has the maintenance of wetland offsets been taken into account?	Environmental Management systems
	61. Understand aspects and impacts related to operations with reference to wetlands		i. How will changing operational requirements with a potential to impact on wetland be identified, prevented and mitigated? ii. In the case of emergency incidences, are there an appropriate emergency response plan and how will wetlands be rehabilitated? iii. Who will monitor wetland health and identify any pending problems – e.g. erosion, establishment of alien and declared weeds?	Environmental Management systems Communication systems Data and information systems

Stage	Action Steps	Relevance to Category of Focus or Impact *(with reference to* Table 20*)*	Core Questions	Organisational Elements *(with reference to* Figure 24*)*
	62. Understand permit and other legal requirements		i. Should any operational parameters change, or the mitigation and rehabilitation of wetland impacts, are the legal requirements understood?	Risk management systems Environmental management systems
	63. ISO 14001		i. Is wetland management (including wetland offsets) included in EMS documentation? ii. Is this updated, maintained and reviewed?	Environmental management systems
	64. Monitoring and Reporting		i. What are the reporting requirements associated with wetlands and wetland structures on site (e.g. WULA and RoD conditions)? ii. What are the reporting requirements associated with the ecological indicators of the wetlands on site?	Data and information systems Procurement management systems Financial management systems
	65. Training and awareness		i. Has wetland management been included in induction training, general awareness programs and job specific training of relevant individuals? ii. Are records kept of this?	Skills development
	66. Environmental Incidents		i. Is there an appropriate incident management protocol?	Environmental management systems

Stage	Action Steps	Relevance to Category of Focus or Impact *(with reference to* Table 20*)*	Core Questions	Organisational Elements *(with reference to* Figure 24*)*
	67. New work and expansions of site operations		i. Is there a communication channel to ensure that any changes to site operations will be communicated timeously to the responsible environmental officer on site?	Communication systems
	68. Stakeholder management		i. Has a stakeholder forum been created and is regular communication being undertaken?	Communication systems Stakeholder management
	69. Sustainable livelihoods		i. Has a stakeholder forum been created and is regular communication being undertaken?	Communication systems Stakeholder management
	70. Wetland rehabilitation		i. Should wetlands have to be rehabilitated, what are the legal implications? Have the appropriate stakeholders, such as WfWet been involved? ii. Have the RQOs of the catchment been taken into account when planning rehabilitation?	Environmental management systems Stakeholder management
	71. Fire		i. Is there an appropriate fire management plan and how is this controlled, implemented and maintained? ii. If the wetlands on site contain peat deposits, has it been specifically addressed the fire management plan?	Environmental management systems Risk management plan

Stage	Action Steps	Relevance to Category of Focus or Impact *(with reference to* Table 20*)*	Core Questions	Organisational Elements *(with reference to* Figure 24*)*
Close-out	72. Initiate Plant life cycle plan O&M		i. Has a monitoring, measuring and reporting schedule been included? ii. What are the implications for artificial wetlands, wetland maintenance and rehabilitation? iii. What are the offset requirements? iv. What are the budget requirements?	Environmental management systems Risk management plan Financial management systems Data and information management
	73. Close-out project		i. Have a wetland assessment been done to determine the status quo at this stage?	Environmental management systems Data and information management
	74. Assess stage and plan next stage		i. Have all wetland actions been concluded and carried over to the next phase?	Supply chain systems Data and information

Stage	Action Steps	Relevance to Category of Focus or Impact *(with reference to* Table 20*)*	Core Questions	Organisational Elements *(with reference to* Figure 24*)*
Evaluate	75. Conduct post project review		i. Have wetland management actions been reviewed and measured against pre-determined indicators?, e.g. compliance with RQOs, Wetland offsets being maintained in good condition. ii. Have the monitoring results of wetland health indicators been compiled and summarized to indicate shortcomings in the project?	Data and information systems Skills development systems
	76. Evaluate project governance and operational delivery		i. Did the Adaptive Management Framework fulfil its purpose?	
	77. Evaluate technical delivery		i. Was training and awareness adequate? ii. Were staff/contractors appropriately skilled to deal with wetland issues? iii. Did artificial wetlands, wetland rehabilitation methodologies render the required outcomes? iv. Have the monitoring of ecological indicators been evaluated for efficiency	Skills development systems HR systems Data and information systems
	78. Feedback and lessons learnt		i. What lessons can be incorporated into the Adaptive Management Framework? ii. What actions are required to ensure on-going management for the environmental team? iii. What best practices can be given through to stakeholders and the wetland community?	Skills development systems HR systems Data and information systems

Essential Background Information Related to Scientific and Best Practices

The WMF includes scientific and best practice guidelines. A list of these is indicated below in Table 22 and has been linked to one of the 4 categories of impact or focus. Recurring and/or cross cutting issues have been indicated below each of the listed aspects in italics and blue font.

Table 22: List of scientific and best practices included in the WMF with reference to the Category of Impact/Focus

	Aspect	Category of Impact/Focus
1	The water/energy nexus: Key water and environmental challenges facing Eskom and current measures to address these	
2	Wetlands and the South African legislation	
3	Wetland delineation and wetland inventory with respect to both Eskom premises and the catchments within which they operate ***Hierarchy of conservation targets*** *Given the varied nature and role of wetlands in the landscape, it will be required to take cognisance of and set conservation targets for each type of wetland affected by Eskom's operations.* ***RQOs of feeder catchments*** *Based on the pollution attenuation potential of wetlands, Eskom can set strategic conservation and rehabilitation targets to improve catchment water quality.* ***Hydrological integrity*** *It is vital to understand water use by different role players within a catchment to ensure that the hydrological integrity of wetlands is maintained. In order to set realistic conservation targets, an understanding of current and future water use in the catchment is required.* ***GHG sinks*** *Wetlands are considered to be important sinks for greenhouse gasses. Wetlands under Eskom's jurisdiction will be*	

	Aspect	Category of Impact/Focus
	ranked in terms of their GHG attenuation potential. This will ensure that the criteria and targets related to wetland conservation take cognisance of this important wetland function.	
4	Impact inventory (pollution, altering of hydrological regimes, disturbances, invasive species, erosion and siltation)	
5	Impact Assessment	
6	Wetland Health Assessment	
7	Vegetation	
8	Prioritisation of wetlands for rehabilitation and intervention ***Hierarchy of conservation targets*** *Given the varied nature and role of wetlands in the landscape, it will be required to take cognisance of and set conservation targets for each type of wetland affected by Eskom's operations.* ***RQOs of feeder catchments*** *Based on the pollution attenuation potential of wetlands, Eskom can set strategic conservation and rehabilitation targets to improve catchment water quality.* ***Hydrological integrity*** *It is vital to understand water use by different role players within a catchment to ensure that the hydrological integrity of wetlands is maintained. In order to set realistic conservation targets, an understanding of current and future water use in the catchment is required.* ***GHG sinks*** *Wetlands are considered to be important sinks for greenhouse gasses. Wetlands under Eskom's jurisdiction will be ranked in terms of their GHG attenuation potential. This will ensure that the criteria and targets related to wetland conservation take cognisance of this important wetland function.*	

	Aspect	Category of Impact/Focus
9	Rehabilitation of impacts ***RQOs of feeder catchments*** *Based on the pollution attenuation potential of wetlands, Eskom can set strategic conservation and rehabilitation targets to improve catchment water quality.*	
10	Biodiversity corridors ***Biodiversity conservation*** *This sub-framework will give methods for assessing the conservation status of the areas under consideration and outline the necessary interventions and monitoring process to ensure that targets are met.*	
11	Buffer Zones	
12	Indicators and early warning systems ***Monitoring and evaluation*** *Indicators will be developed to monitor each of the sub-frameworks described below. These will be based on the findings of the research and the targets set.*	
13	Vegetation management	

	Aspect	Category of Impact/Focus
14	Ecosystem services ***Hierarchy of conservation targets*** *Given the varied nature and role of wetlands in the landscape, it will be required to take cognisance of and set conservation targets for each type of wetland affected by Eskom's operations.* ***RQOs of feeder catchments*** *Based on the pollution attenuation potential of wetlands, Eskom can set strategic conservation and rehabilitation targets to improve catchment water quality.* ***Hydrological integrity*** *It is vital to understand water use by different role players within a catchment to ensure that the hydrological integrity of wetlands is maintained. In order to set realistic conservation targets, an understanding of current and future water use in the catchment is required.* ***GHG sinks*** *Wetlands are considered to be important sinks for greenhouse gasses. Wetlands under Eskom's jurisdiction will be ranked in terms of their GHG attenuation potential. This will ensure that the criteria and targets related to wetland conservation take cognisance of this important wetland function.*	
15	Sustainable livelihoods and economic opportunities for surrounding communities ***Ecosystem services for communities*** *This sub-framework will set out the process for identifying and evaluating the value of the ecosystem services used by communities and how these will be affected by Eskom activities. Where the impact may be negative, the framework will include feedback loops to assess mitigation measures where these are appropriate. At the same time, opportunities will be identified to promote access to wetland goods and services by surrounding communities, in support of Eskom's social responsibility initiatives.*	

	Aspect	Category of Impact/Focus
16	Wetland Offsetting ***Wetland off-setting*** *There are times when Eskom is unable to avoid impacting on, or destroying wetlands. This sub-framework will outline the decision-making process on how this destruction may be offset to ensure no-net loss in the particular catchment.* ***GHG sinks*** *Wetlands are considered to be important sinks for greenhouse gasses. Wetlands under Eskom's jurisdiction will be ranked in terms of their GHG attenuation potential. This will ensure that the criteria and targets related to wetland conservation take cognisance of this important wetland function.*	
17	Relative importance of wetlands with respect to percentage of the total catchment surface area, as well as wetland type ***Hierarchy of conservation targets*** *Given the varied nature and role of wetlands in the landscape, it will be required to take cognisance of and set conservation targets for each type of wetland affected by Eskom's operations.* ***RQOs of feeder catchments*** *Based on the pollution attenuation potential of wetlands, Eskom can set strategic conservation and rehabilitation targets to improve catchment water quality.* ***Hydrological integrity*** *It is vital to understand water use by different role players within a catchment to ensure that the hydrological integrity of wetlands is maintained. In order to set realistic conservation targets, an understanding of current and future water use in the catchment is required.* ***GHG sinks*** *Wetlands are considered to be important sinks for greenhouse gasses. Wetlands under Eskom's jurisdiction will be ranked in terms of their GHG attenuation potential. This will ensure that the criteria and targets related to wetland conservation take cognisance of this important wetland function.*	

	Aspect	Category of Impact/Focus
18	Carbon storage in wetlands ***GHG sinks*** *Wetlands are considered to be important sinks for greenhouse gasses. Wetlands under Eskom's jurisdiction will be ranked in terms of their GHG attenuation potential. This will ensure that the criteria and targets related to wetland conservation take cognisance of this important wetland function.*	
19	Water Quality and Pollution Attenuation ***Pollution attenuation for Eskom and their mines*** *The potential of wetlands (both natural and artificial) to attenuate pollution levels in surface water could be harnessed by Eskom to promote water quality in the catchments within which it operates. Understanding and incorporating this within the initial wetland inventory, will ensure that the criteria and targets related to wetland conservation take cognisance of this important wetland function.* ***Waste treatment*** *Eskom generates a variety of wastes, some of which are air-borne, some water-borne and some solid. Each of these categories of waste will stress the environment and negatively impact on the biodiversity. This sub-framework will guide the effective management of the various treatment methods (e.g. high rate, artificial wetland, etc.) that may be selected. The Eskom policy of zero liquid effluent discharge will be progressively implemented, but this sub-framework will guide waste management under the current waste management regime.* ***RQOs of feeder catchments*** *Based on the pollution attenuation potential of wetlands, Eskom can set strategic conservation and rehabilitation targets to improve catchment water quality.*	

	Aspect	Category of Impact/Focus
20	Artificial and Constructed Wetlands ***Waste treatment*** *Eskom generates a variety of wastes, some of which are air-borne, some water-borne and some solid. Each of these categories of waste will stress the environment and negatively impact on the biodiversity. This sub-framework will guide the effective management of the various treatment methods (e.g. high rate, artificial wetland, etc.) that may be selected. The Eskom policy of zero liquid effluent discharge will be progressively implemented, but this sub-framework will guide waste management under the current waste management regime.*	

3.2 USING THE WMF

This section of the document provides an overview of how to consult the WMF, the specific actions that that follow after consulting the WMF as well as indicate the required feedback loop to ensure that learning are incorporated into the WMF.

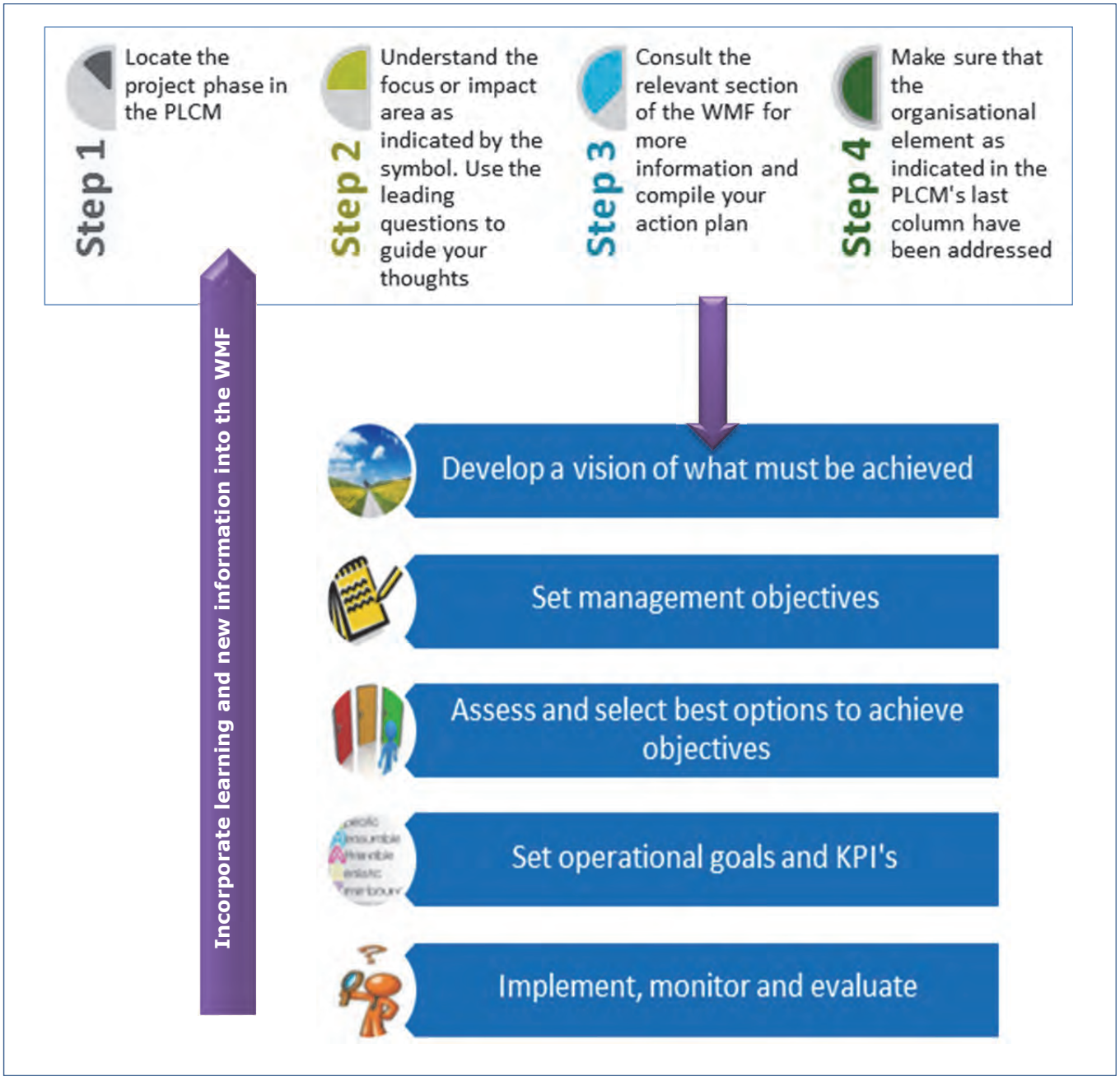


Figure 25: How to consult the WMF

WETLAND DELINEATION WITH RESPECT TO BOTH ESKOM PREMISES AND THE CATCHMENTS WITHIN WHICH THEY OPERATE

Pre-Feasibility

The need

The following pieces of legislation have bearing on all developments which may affect wetlands (Armstrong, 2009): There have been changes to the legislation since Armstrong (2009) that need to be taken into account.

i. The Constitution, 1996
ii. National Environmental Management Act, 1998 (NEMA)
iii. National Water Act 36 of 1998 (NWA)
iv. Conservation of Agricultural Resources Act 43 of 1983 (CARA)
v. National Forests Act 84 of 1998 (NFA)
vi. National Heritage Resources Act 25 of 1999 (NHRA)
vii. National Environmental Management: Biodiversity Act 10 of 2004 (Biodiversity Act)
viii. National Environmental Management: Protected Areas Act 57 of 2003 (Protected Areas Act)
ix. Mountain Catchments Areas Act 62 of 1970

In addition, there are other pieces of legislation which may apply under certain circumstances, such as the World Heritage Conventions Act 49 of 1999, the Seashore Act 21 of 1935 and the Marine Living Resources Act 18 of 1998. Provincial and local government legislation may also have specific relevance to specific instances.

Any developments which encroach on a wetland will need a Water Use License (WUL) from the DWA. It is, thus, important that the location and extent of wetlands on a site is taken into consideration early in the planning process.

Property boundaries are imposed on the natural ecosystem and so if the stream of ecosystem services is to be conserved, then it is necessary to consider the entire ecosystem, and not just the part under the jurisdiction of Eskom. The desktop assessment should, thus, take account of neighbouring systems as well, and as far as possible include them in the planning process.

The Process

Preliminary wetland assessment may be conducted using Eskom's wetland classification and risk assessment index field guide (Eskom, undated). Wetland delineation is, however, a specialised task demanding a high level of compliance. It should be done by practitioners who are properly qualified. It may be worth Eskom's while to train a member of staff to delineate wetlands. Otherwise, qualified practitioners may be contacted through the South African Wetland Society (http://society.wetlands.za.net/index.htm) if someone has not already been identified. At the Pre-feasibility step, locate and make contact with a suitable service provider.

Feasibility

The need

Accurate delineation of wetlands at the early stages of planning a development is necessary because this will form part of the application for the permits and licences required for the planned developments to proceed.

The process

a) With the wetland expert on site, confirm that all wetlands have been correctly identified.
b) Following the approved process (DWAF, 2008), ensure that all wetlands are delineated, marked on the ground and mapped. The process should include the identification of the type of wetland as well as any features which may need special attention. This information may also be needed when assessing the stream of ecosystem services form the wetland (Section 14 of the document).
c) While the wetland expert is on site it is necessary to have the present ecological state (PES), ecological importance and sensitivity (EIS) and threats to the wetland health determined (Anon, 1999; DWAF, 2004; DWAF, 2008; Kleynhans, 1999; MacFarlane et al., 2009). The reason for this is that if it becomes necessary to apply for a wetland offset permit, the authorities will assume that the wetland to be impacted is in 'A' class and determine the offset accordingly. Whereas if the wetland is in a 'B' or 'C' class the requirements for the offset will be adjusted accordingly. This will determine if there is an attribute that needs special conservation attention.
d) All the results of the delineation, PES and EIS determinations should be handed to the contract managers. This should include all maps, electronic and paper.
e) The delineation and the determination of the PES and EIS will enable the planning to take account of wetlands and assess the potential impacts of the development, including any mitigation measures which may be necessary.
f) These documents may then be submitted to the relevant authorities to get the required environmental authorisations.

Integral to the delineation of wetlands is the determination of the buffer zones around the wetlands. This is covered in Section 11 of this document.

Business Plan

Ensure that all documents related to the findings of the wetland delineation, PES and EIS determinations have been made available to the business planning process, and are accounted for in this process.

Construction

Ensure that the wetlands, as delineated and marked on the ground, as well as their buffer zones (Section 11) have been demarcated as no-go zones for all construction processes.

Commissioning and Hand-over

Conduct a new baseline assessment on all wetlands to monitor impacts of the construction process on wetlands, and remediate/rehabilitate impacts as necessary.

Operation

The environmental management system (EMS) provides a model based on ISO 14001 within which there is guidance for continual improvement in the management of the environmental responsibilities of an organisation (DEAT, 2004). This model should be adopted and kept

updated. Any change in operations should be communicated to the environmental office which should conduct routine monitoring. The environmental office should report on the state of wetland management in terms of the conditions set out in the Water Use License, the RoD and other permitting requirements that may exist. It may be expedient to develop a standard format for this report. This report will provide communication from the environmental office to the central management office. It is important that this communication is open and that operational decisions which will affect the environment are communicated timeously to the environmental office. Communication should also be maintained with the stakeholder forum, although this will not cover the same level of operational detail as the communication with the management office. All documents should be lodged in the central repository.

During the operational phase, the wetland demarcation should be maintained so that operations do not interfere with the wetlands. After any incident, such as fire or a spill, which may destroy the demarcation, the wetland and demarcations should be returned to the required state in terms of the environmental management plans (EMP).

Evaluate

The adaptive management cycle should address the integrity of the wetland as initially delineated – see Section 21 below.

3.3 IMPACT INVENTORY (POLLUTION, ALTERING OF HYDROLOGICAL REGIMES, DISTURBANCES, INVASIVE SPECIES, EROSION AND SILTATION)

Pre-feasibility

The need

It is necessary to know the health of the wetlands on the site before the start of any activities. The reasons for this are:

- Are there different sites on which to develop? If there are, then the following procedures should be undertaken on each site. This will contribute to the decision-making process.
- The condition (or health) of the wetlands on a greenfield site will form part of the application for a water use license (WUL). Where any mitigation, rehabilitation or offset activities are necessary the condition (or health) of the wetlands at the beginning of the project will form the basis for conditions imposed through the WUL or other permits. In addition, it will set the baseline for decisions on any mitigation, rehabilitation or offset activities to be carried out.
- The impacts on the wetland(s) should be considered when planning the developments that are to be undertaken. This will provide the basis for decisions on alternate layout, design, technology and operational aspects to minimise impacts which should be considered in the overall planning.

Working for Wetlands has been mandated by DEA to perform or oversee wetland activities which require permitting. So, Working for Wetlands should be engaged early on in the process and their guidance sought when assessing impacts on wetlands.

The process

Impacts before activities begin on the site

The existing impacts on the site should be inventoried using the method described in WET-Health (MacFarlane e al., 2009). There are two components to this method. The first is done at desktop using aerial photography, Google Earth or some similar resource. From this it is possible to gauge the likely threats or impacts on a site from the surrounding land use. The second component requires an experienced wetland scientist to examine the wetland site and identify and inventorise the impacts on the ground. This will set the baseline for further negotiation in permit applications and site planning.

Planning during the pre-feasibility phase

Once the wetlands have been mapped and existing impacts determined it is possible to consider the planned developments. Inventorying impacts from the development should consider the following points:

- The options of layout, design, technology and operations should form part of the inventory of the impacts on the site and their mitigation.
- Layout of infrastructure on the site – this should be planned and inventoried with the impacts that the infrastructure will have on wetlands during the construction and operation phases. For instance, hard surfaces (including roads) will alter the runoff pattern on the site; culverts will channel flow that previously may have been diffuse across the site, causing erosion; effluents streams from the planned activities need to be handled in a way that will minimise impacts on the wetlands and so the infrastructure to handle effluents should be sited with this in mind. Where there is more than one site being considered the available options should be assessed for all sites.

The impacts originating from neighbouring properties or originating on the Eskom site and impacting on neighbouring properties should be inventoried. Options for working together with neighbours, where advantageous, should be considered at this stage so that they may form part of the Public Participation Process of the project.

Feasibility

Decisions taken at the pre-feasibility stage should be passed to the Feasibility stage for incorporation into the final planning.

Business Plan

The impact inventory will complement the assessment of the impacts of the development and they will need to be incorporated into the process of obtaining the WUL and other permits necessary the project to proceed.

Planning and Design

The planning and design should take account of the impacts as inventoried and incorporate appropriate mitigation strategies where relevant.

Contracting and procurement

Where relevant, clauses on the prevention or minimisation of impacts as inventoried and assessed should be included in work package contracts.

Construction

Plan to ensure that foreseen impacts are minimised during the construction phase.

Be alert for impacts that were not foreseen, and mitigate these.

Operation

The initial impact inventory was completed at the pre-feasibility stage. This inventory should be monitored and updated at between one and five year intervals, depending on the indicators selected. Changes that have taken place both on the site and in the adjacent landscape which may change the situation should be recorded. This document should be lodged in the central repository.

Evaluate

Confirm that the impacts foreseen during the pre-feasibility phase were assessed correctly. Note any impacts that were not foreseen and how they have been mitigated.

Ensure that the adaptive management process includes indicators that will identify and assess the impacts of the development (see Section 21 below).

3.4 IMPACT ASSESSMENT

Pre-feasibility

The need

Having inventoried the impacts on the site before any development has taken place, it is necessary to assess the health of the wetlands. The reasons for this are:

- The state of the wetland's health will provide a baseline against which impacts during the construction and operation phases will be assessed. If this is not done it will be assumed that all wetlands were in 'A' class – see the following bullet point.
- The condition (or health) of the wetlands on a greenfield site will form part of the application for a water use license (WUL). Where any mitigation, rehabilitation or offset activities are necessary the condition (or health) of the wetlands at the beginning of the project will form the basis for conditions imposed through the WUL or other permits. In addition, it will set the baseline for decisions on any mitigation, rehabilitation or offset activities to be carried out.

Working for Wetlands has been mandated by DEA to perform or oversee wetland activities which require permitting. So, Working for Wetlands should be engaged early on in the process and their guidance sought when assessing impacts on wetlands.

The Process

Impacts before activities begin on the site

The existing impacts on the site should be assessed using the method described in WET-Health (MacFarlane e al., 2009). There are two components to this method. The first is done at desktop using aerial photography, Google Earth or some similar resource. From this it is possible to gauge the likely threats or impacts on a site from the infrastructure to be developed as well as the surrounding land use. The second component requires an experienced wetland specialist to examine the wetland site and identify and assess the impacts on the ground. This will serve to test projections of the impacts on the ground.

Planning during the pre-feasibility phase

Once the wetlands have been mapped and existing impacts assessed it is possible to consider the planned developments. The planning should consider the following points:

- The options of layout, design, technology and operations should form part of the assessment of the impacts on the site and their mitigation.
- Layout of infrastructure on the site – this should be planned in consideration with the impacts that it will have on wetlands during the construction and operation phases. For instance, hard surfaces (including roads) will alter the runoff pattern on the site; culverts will channel flow that previously may have been diffuse across the site, causing erosion; effluents streams from the planned activities need to be handled in a way that will minimise impacts on the wetlands and so the infrastructure to handle effluents should be sited with this in mind.

Impacts originating from neighbouring properties or originating on the Eskom site and impacting on neighbouring properties should be included in the assessment. Options for working together with neighbours should be planned.

Feasibility

Decisions taken at the pre-feasibility stage should be passed to the Feasibility stage for action.

The projections of impacts made at the pre-feasibility stage may be checked/ground-truthed by the wetland specialist.

Business Plan

Assessment of the impacts of the development need to be incorporated into the process of obtaining the WUL and other permits necessary for the project to proceed.

Planning and Design

The planning and design should take account of the impacts as assessed and incorporate appropriate mitigation strategies where relevant.

Contracting and Procurement

Ensure that contractors are aware of their potential impacts and abide by the plans to mitigate these. Where relevant, clauses on the prevention or minimisation of impacts as inventoried and assessed should be included in work package contracts.

Construction

Plan to ensure that foreseen impacts are minimised during the construction phase.

Be alert for impacts that were not foreseen, and mitigate these.

Operation

Impacts from the operations on site have been identified and plans have been put in place to mitigate these. The potential impact of any changes in the operations should be assessed both in terms of the legal requirements as well as changes in the ecosystem services and measures to mitigate these impacts should be put in place.

Incident management plans should be drawn up to address accidents that will potentially occur. Training on avoiding and managing incidents in and around wetlands should be included in the training programmes for staff as well as the induction course for contractors on site.

Incidents and any changes in incident management should be reported regularly and the reports should be lodged in the central repository.

Evaluate

Confirm that the impacts foreseen during the pre-feasibility phase were assessed correctly. Note any impacts that were not foreseen and how they have been mitigated.

Ensure that there the adaptive management process includes indicators that will assess the impacts of the development and operations.

3.5 WETLAND HEALTH ASSESSMENT

Pre-Feasibility

<u>Before any activities take place on the site</u>

The health of wetlands on the site should be assessed prior to any activities taking place on the site following the method described in MacFarlane et al. (2009). At the same time the threats to wetland health should be identified so that these may be taken into account, and mitigated where possible, in the planning and development of the site. The present ecological state (PES) of the wetland should be determined at this stage as this will set the baseline against which future health assessments will be made. At the same time the Ecological Importance and Sensitivity (EIS) should be determined (DWAF, 2004; 2007; 2008).

The assessment of Wetland Health together with the determination of the PES and EIS will give an indication of which of the ecosystem services are important in the system.

Feasibility

Ensure that the health of the wetland has been determined and that threats to the health have been defined.

Ensure that the PES and EIS have been determined.

Business Plan

The business plan should address the management of the threats to wetland health such as alien invasive plants, erosion, siltation, etc. It should also address the formation of strategic partnerships with other stakeholders and in particular with Working for Wetlands and Working for Water as appropriate.

Contracting and Procurement

Ensure that those contracted to work on site understand the importance of maintaining wetland health and abide by the requirements set for wetland protection on the site.

Operation

Maintaining wetland health is a requirement in terms of the WUL and the RoD. It is important that this is communicated through training and general awareness creation to all personnel employed on the site. As ecosystems are not confined within property boundaries, it is also necessary to communicate the activities in the wetlands with the stakeholder forum, specifically adjacent property holders, so that all understand what is to be achieved.

Evaluate

A suitable indicator of wetland health should be included in the adaptive management framework.

3.6 VEGETATION

Pre-Feasibility

The initial wetland impact inventory and assessment will have identified the presence of alien invasive vegetation where this is an issue, and its control will have been planned.

Regulations have been gazetted requiring control of invasive alien plants (SANBI, viewed June 2013). In summary, category 1a or 1b species must be removed and destroyed and species in category 2 and 3 may only be kept under certain conditions. The species of concern are listed on the SANBI web site. Personnel involved in the management of vegetation on Eskom property should be trained in the recognition and handling of these plants.

Feasibility

The ecoregion of the country into which the wetland falls (Kleynhans et al., 2008) will determine what indigenous vegetation may be expected to occur in a wetland. This will have been identified during the determination of the PES and EIS.

The threats and impacts to the wetland will have been determined through the impact inventory, the impact assessment and the wetland health assessment. One impact, or threatened impact, that should be closely managed is the presence of alien invasive vegetation. Alien invasive vegetation is detrimental to wetlands for a variety of reasons, all of which lead to a change (usually negative) in the stream of ecosystem services which the wetland delivers.

During the Feasibility phase plans should be made to promote the growth of indigenous vegetation cover and to control any alien invasive vegetation which may be present. Where possible, a strategic partnership should be formed with the Working for Wetlands and/or Working for Water programmes of DEA. Working for Wetlands have been mandated by DEA to conduct wetland rehabilitation, and so are able to advise and help in this regard where required.

Business Plan

The business plan should include measures to conserve wetland health, such as the on-going control of alien vegetation where it occurs and the promotion of indigenous vegetation.

Vegetation management is an on-going activity. While the initial clearance of alien invasive vegetation may be a once-off activity, the follow-up is likely to go on for a decade or longer and this should be noted in the plan.

Contracting and Procurement

Teams engaged to work on the vegetation in wetlands should be trained in the Recognition and handling of alien vegetation. The guidelines issued by Eskom (Eskom 2009; 2010) provide the basis from which to work. Detail on certain species of invasive plants is available from SANBI.

Operation

During the EMS process objectives and targets will have been set for the management of vegetation on Eskom property, and for the purpose of this framework specifically for vegetation management in wetlands. Progress towards these targets should be monitored and reported in the routine reports submitted to the central management office.

Where a dense infestation of alien vegetation has been cleared it is advisable to seed or plant the area with suitable indigenous vegetation to hasten recovery and so reduce erosion during the recovery period. Contact details of nurseries where seed or plant material may be sourced are available from Working for Wetlands personnel.

In the management of alien invasive vegetation regular communication with the stakeholder forum is important, as any area where the alien invasive vegetation is not controlled will serve as a source of reinvasion, so increasing the length of time needed to control the problem indefinitely.

Evaluate

Monitoring of the vegetation in and around wetlands should be on going.

3.7 PRIORITISATION OF WETLANDS FOR REHABILITATION AND INTERVENTION

Pre-Feasibility

In recognition that resources for the rehabilitation of wetlands are limited, it is necessary to prioritise interventions so that maximum impact may be achieved by the interventions initiated. The tool that is available for wetland prioritisation is WET-Prioritise (Rountree et al., 2009). WET-Prioritise may be used at national, regional or local scale. There may be times when resources need to be assigned at the national level, but there may, equally, be times when wetlands on a single site need to be prioritised. This tool can cope with this variation in scale.

The steps to be considered in the prioritisation of wetlands for rehabilitation are to identify the role of the wetland/s in the catchment and whether the catchment has it been earmarked for conservation (Driver et al., 2011). And, for instance, is the aim to address structural rehabilitation, water quality or some other wetland function? Or is there a need to consider applying for a wetland offset (or off-site mitigation – See relevant section below).

Feasibility

Decisions on which interventions are the most important may have to be made on a national, regional or local scale. This section focuses on the local scale.

In consideration of the health of the wetland, the nature of the impacts on the wetland and the stream of ecosystem services which the wetland should deliver together with the nature and extent of rehabilitation required, interventions on the wetlands on a site may be prioritised.

Business Plan

Wetlands prioritised for rehabilitation should be listed in the Business Plan for the appropriate action.

The strategic partnership with Working for Wetlands should cover this aspect as well.

Contracting and Procurement

Contracting and procurement should be done in conjunction with Working for Wetlands.

Operation

The aim(s) of the wetland management, as articulated in the prioritisation process, should be recorded in the EMS documentation which will be reviewed in the cycle of adaptive management.

Evaluate

A suitable indicator(s) should be identified for use in the adaptive management cycle to monitor the success of the prioritisation process in achieving the original aim(s) of the intervention.

3.8 REHABILITATION OF IMPACTS

Pre-Feasibility

During the pre-feasibility assessment, the wetlands on site should be examined to see whether they need to be rehabilitated and how they can be conserved. In a situation where impacting on a wetland is inevitable the options for wetland management as laid out by SANBI should be investigated. The ideal is “no net loss” of wetlands. Firstly, wetlands should be avoided as far as possible. If it is not possible to avoid the wetlands, then any impact should be minimised. Only as a last resort should residual impacts be compensated by wetland offsets (Dini, undated).

Working for Wetlands should be consulted for advice on addressing the rehabilitation of impacts on wetlands.

Feasibility

Planning of when and how to rehabilitate wetlands should be addressed. Those which may be

Construction

Wetland crossings and culverts should be designed in such a way as to cause minimal disturbance to the wetland. One thing to avoid as far as possible is the channelling of flow as this will disrupt the diffuse flow through the wetland and is likely to cause a channel to develop which will lead to erosion and the loss of wetland function.

Commissioning and Hand-over

Ensure that all construction material has been removed from wetlands and that any damage has been rehabilitated.

Operation

Ensure that, during the course of operation, the conditions of the WUL and RoD are followed. If changes in operation will influence the wetlands, then determine the effects and implement any necessary rehabilitation.

3.9 BIODIVERSITY CORRIDORS

Pre-Feasibility

Determine where biodiversity corridors are necessary and plan for these. Biodiversity corridors should be planned together with buffer zones.

Planning and Design

Mark out the biodiversity corridors as required.

Construction

Ensure that the biodiversity corridors are laid out and respected.

Operation

Biodiversity corridors should be kept clear of disruption and disturbance as this will reduce their effectiveness.

Evaluate

The Adaptive management process should monitor two aspects: 1) the integrity/disturbance of the corridor, and 2) the usage, against the foreseen usage.

3.10 BUFFER ZONES

Pre-Feasibility

The width of a buffer zone around a wetland will vary depending on the land use and the level of protection required. General agricultural activities may require a buffer zone of 30 meters. Forestry activities will require a buffer zone of a minimum of 20 m. The ROD or the WUL may give guidance on the actual width required. There is currently a WRC-funded project on buffer zones and this will give further guidance on this topic.

Feasibility

Ensure that the required buffer zone is included in the planning of developments.

Construction

Ensure that the buffer zones around wetlands are protected in the same way that wetlands are protected.

3.11 INDICATORS AND EARLY WARNING SYSTEMS

Pre-Feasibility

Monitoring can become expensive and so indicators need to be selected to accurately give the required information as inexpensively as possible. For instance, the invasion of a wetland by terrestrial vegetation will indicate that the wetland is drying.

The location of the indicator in the DPSIR framework will then guide the management response to the change. In the above example, for instance, the indicator indicates a change in state with the reason for the change (or Driver) being a change in the hydrology of the wetland. Therefore the management intervention should be aimed at the hydrology.

Determine the aspects of wetland management which need to be monitored and design effective indicators to detect change. Some indicators, such as erosion or head cuts, may need to be monitored annually or more often during the wet season. Others, such as the invasion of terrestrial vegetation, may only need to be monitored every 3 to 5 years unless there has been a change in the catchment or operation of the site which poses a threat to, for instance, the wetland hydrology.

Indicators may be structural, for instance, the example of the indicator given above, or functional.

Feasibility

Design, with the help of experts where necessary, indicators appropriate to the wetland situation with which you are confronted. Some ideas for indicators are given in 'Eskom's wetland classification and risk assessment index field guide'.

Operation

Indicators should form part of an adaptive management programme which is designed to monitor progress towards achieving the vision or desired future state for the wetland (See relevant below).

3.12 VEGETATION MANAGEMENT

Pre-Feasibility

Eskom has well defined guidelines for the management of vegetation on its property and servitudes. These guidelines include managing vegetation in wetlands. These guidelines should guide activities in two ways:

i. All personnel responsible for vegetation management should be fully trained in the implementation of the guidelines, and

ii. The guidelines should be revised at appropriate intervals to ensure that they address all statutory requirements for management of vegetation.

Operation

Vegetation management on Eskom property should be supervised by a competent person.

3.13 ECOSYSTEM SERVICES

Pre-Feasibility

The ecosystem services delivered by the wetlands need to be assessed. It is recommended that assessment of ecosystem services be undertaken by an expert. While this can be done for the Eskom property alone, it will be of more use if the system is taken as a whole, i.e. assess the Eskom property in conjunction with the neighbouring properties that are part of the same system. In this way, the overall ecosystem will be considered, and the areas where the wetland condition is less than optimal will be identified for appropriate intervention. The key general reference to the identification of ecosystem services is the Millennium Assessment (MA, 2005) and references specific to the Olifants River Basin in the North-East of South Africa are the report on the nature, distribution and value of aquatic ecosystem services of the Olifants, Inkomati and Usutu to Mhlatuze Water Management Areas (DWA, 2010). This content of this report has been further developed by the reports from the Directorate Water Resource Classification (2011a; 2011b). Knowledge of the ecosystem services provided by the wetlands on the site and neighbouring properties will assist in prioritising the aspects of wetland management that have been identified as needing attention. Some other useful references in this respect are Ginsburg et al. (2010); Kotze et al. (2010); Turpie (2010a; 2010b); Turpie and Kleynhans (2010); Turpie et al. (2010).

Once the ecosystem services delivered by the wetlands have been assessed it will be possible to plan for any interventions necessary to restore or enhance these. In planning this, it is necessary to take the requirements of the WUL and ROD into account.

Useful Resources

Directorate Water Resource Classification, 2011a. Department of Water Affairs, South Africa, May 2011.

Classification Of Significant Water Resources In The Olifants Water Management Area (WMA 4): Report 3a: Report on IUAs and Report on Socio-economic evaluation framework and the decision-analysis framework. Report 3b: Analysis scoring system. RDM/WMA04/00/CON/CLA/0311 DWAF (2004).

Development of a framework for the assessment of wetland ecological integrity in South Africa. Phase 1: Situation Analysis. by MC Uys. Contributors G Marneweck and P Maseti. Report No. 0000/00/REQ/0904 ISBN No.: 0-621-35474-0. Resource Quality Services, Department of Water Affairs and Forestry, Pretoria, South Africa.

Directorate Water Resource Classification, 2011b. Department of Water Affairs, South Africa, July 2011. Classification Of Significant Water Resources In The Olifants Water Management Area (WMA 4): Report on Socio-economic evaluation and the decision-analysis framework. RDM/WMA04/00/CON/CLA/0411

Ginsburg, A.E., J.G. Crafford and K.R. Harris. 2010*. Framework and Manual for the evaluation of aquatic ecosystems services for the Resource Directed Measures*. WRC Report TT 462/10. Water Research Commission, Pretoria.

DWA, 2010. *The nature, distribution and value of aquatic ecosystem services of the Olifants, Inkomati and Usutu to Mhlatuze Water Management Areas*. Contract Report by Anchor Environmental Consultants for Department: Water Affairs, 362pp.

Kotze D, H Malan, W Ellery, I Samuels and L Saul: Series Editor: H Malan, 2009. *Wetland Health And Importance Research Programme 7: Assessment of the environmental condition, ecosystem service provision and sustainability of use of two wetlands in the Kamiesberg uplands*. Report to the Water Research Commission

MA, 2005. Millennium Ecosystem Assessment: *Ecosystems and human well-being*: synthesis. Island Press, Washington, DC

Turpie J, K. Lannas, N. Scovronick and A. Louw., 2010. Wetland valuation. Vol I: *Wetland ecosystem services and their valuation: a review of current understanding and practice*. Series editor H Malan: Wetland Health and importance Research Programme **8**. WRC Report No. TT 440/09.

Turpie J, 2010a. Wetland valuation. Vol II: *Wetland valuation case studies*. Series editor H Malan: Wetland Health and importance Research Programme **9**. WRC Report No. TT 441/09.

Turpie. J 2010b. Wetland valuation. Vol III: *A tool for the assessment of the livelihood value of wetlands* Series editor H Malan: Wetland Health and importance Research Programme **10**. WRC Report No. TT 442/09.

Turpie and M. Kleynhans. 2010. Wetland valuation. Vol IV: *A protocol for the quantification and valuation of wetland ecosystem services*. Series editor H Malan: Wetland Health and importance Research Programme **11**. WRC Report No. TT 443/09.

3.14 WETLAND OFFSETTING

Pre-Feasibility

Wetland offsetting should be considered only after measures have been taken to, firstly, avoid wetlands and, secondly, to minimise any impacts. Only then will permit applications for offsetting (onsite or offsite) be considered. SANBI has developed the document entitled ‘Towards a best practice guideline for wetland offsets in South Africa’ (SANBI and DWS, 2014) out for review. It is intended for DWA and DEA to endorse this document so that when the need for wetland offsetting is permitted, it will be done in terms of this guideline.

3.15 MONITORING

Pre-Feasibility

The monitoring programme should be designed following the framework of Strategic Adaptive Management (SAM) as illustrated in Figure 26 (Pollard and du Toit, 2007). This provides a rigorous structure within which the vision for the wetland (or other ecosystem) is set and the interventions to achieve this vision are monitored and recorded. In this way it is possible to follow and assess the development of interventions based on management decisions and to adjust these as necessary to meet the vision for the desired future state of the wetland.

While it is essential that Eskom personnel and other stakeholders who are concerned play an active role in the development of the SAM framework, it is recommended that the process is facilitated by someone experienced in the SAM process. This will ensure that Eskom will get the maximum benefit from the implementation of SAM.

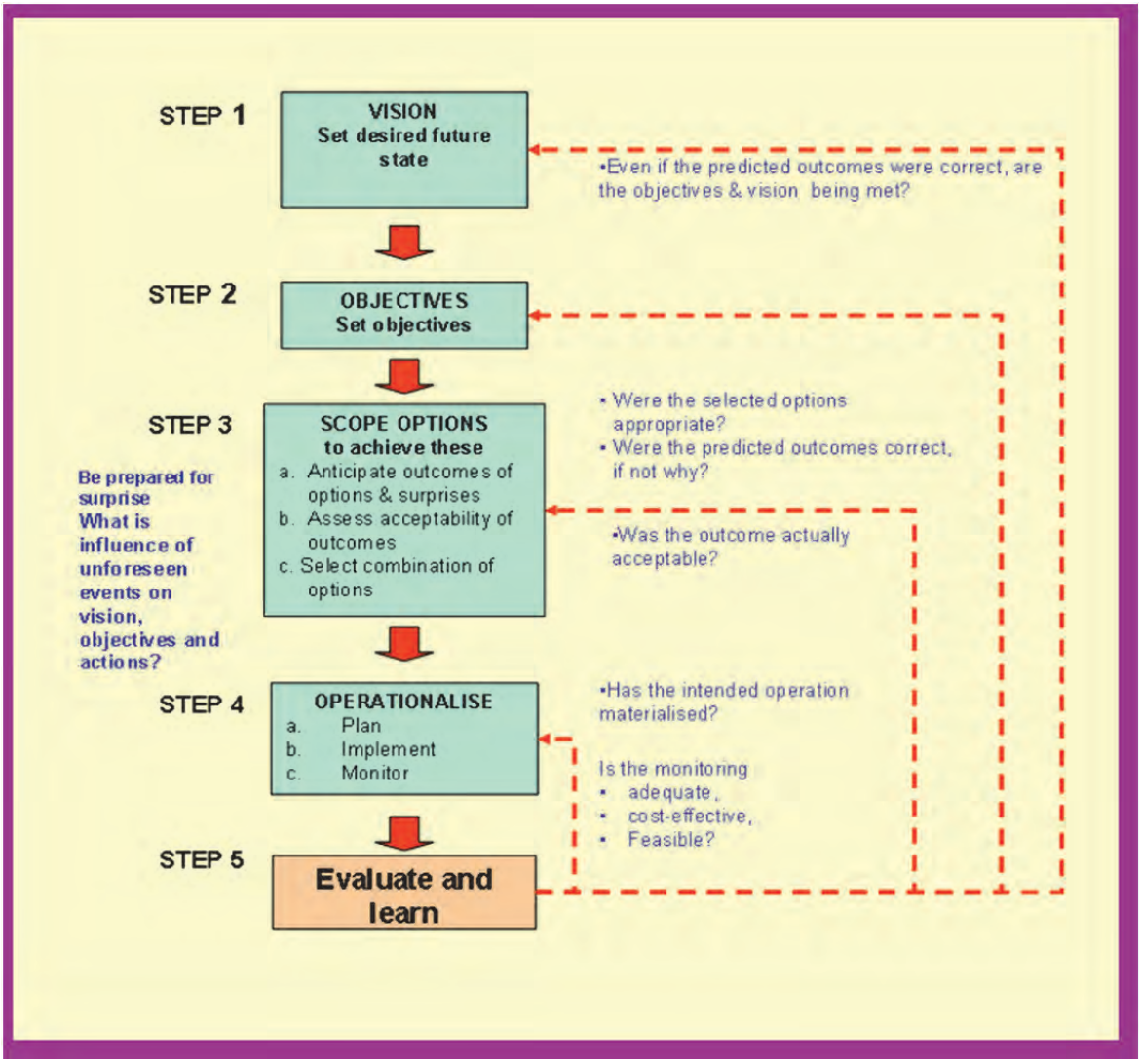


Figure 26: A Framework for SAM showing 5 key steps (from Biggs & Rogers 2003, adapted by Pollard & du Toit, 2007)

Operation

The rigour of the SAM process requires that records be kept of each step taken and that each decision and its outcome are followed over time to ensure that the interventions taken will achieve the desired state.

3.16 ECOSYSTEM SERVICES FOR COMMUNITIES

Purpose of this sub-framework:

This sub-framework will set out the process for identifying and evaluating the value of the ecosystem services used by communities and how these will be affected by Eskom activities. Where the impact may be negative, the framework will include feedback loops to assess mitigation measures where these are appropriate. At the same time, opportunities will be identified to promote access to wetland goods and services by surrounding communities, in support of Eskom's social responsibility initiatives.

High-level overview:

An investigation into the reliance of surrounding communities for their livelihood on wetlands is required. In some instances, continued access to land to continue using the services that wetlands provide, will impact positively on sustainable livelihoods of communities reliant on wetland services. At the same time, the sustainable use of wetlands provides opportunities for wetland conservation whilst balancing corporate social responsibilities. The compilation of a Management Plan for wetlands associated with sustainable livelihoods will promote wise and sustainable use.

Useful Resources

Abbot Grobicki (Pty) Ltd, 2002. *Cultivation of plants in restored urban wetlands for income generation in local communities*. WRC Report No 1054/1/02.

J Turpie Wetland Valuation. Vol iii: *A Tool for the Assessment of the Livelihood Value of Wetlands*, 2010. WRC Report No TT 442/09.

Sharon Pollard, Derick du Toit, Tessa Cousins, Donovan Kotze, Edward Riddell and Claire Davis, 2010. *Sustainability indicators in communal wetlands and their catchments: Lessons from Craigieburn wetland, Mpumalanga*. WRC Report No. 1709/1/10.

D Kotze, H Malan, W Ellery, I Samuels and L Saul, 2010, *Assessment of the environmental condition, ecosystem service provision and sustainability of use of two wetlands in the Kamiesberg Uplands*. WRC Report No. TT 439/09.

Biodiversity GIS (BGIS), http://bgis.sanbi.org/

W Ellery, S Grenfell, M Grenfell, C Jaganath, 2010. *A method for assessing cumulative impacts on wetland functions at the catchment or landscape scale*, WRC Report No. TT 437/09.

Prefeasibility

Perform Concept design

A. As a first step, it will be required to ascertain whether any wetland will be affected by the proposed project as well as its conservation and health status.
    a) Available data (such as those from BGIS) can be consulted to determine if wetlands occur on site
    b) A site visit may be required to identify any wetlands on site. Note that during dry seasons/periods it may be difficult to identify wetlands
    c) Reports from Consultants may contain the required information
    d) The environmental services associated with the wetland should be identified, using the appropriate tools (Refer to the section on wetland identification and assessment).
B. If wetlands are present on site, it will be required to determine in what way its presence will influence the concept design as well whether any social or economic dependencies exists. The methodology is discussed in the section below. (Any modifications of on-site hydrology, might affect wetlands on adjacent properties or downstream in the catchment. This must be taken into consideration.)

Perform Stakeholder Needs Assessment

The extent (spatial and ecosystem services as well as wetland hydrology) of wetland impacts/modification must be understood in order to identify and engage with stakeholders. Affected owners and/or users of land should be considered as potential stakeholders.

Ascertaining the level of direct reliance on wetland goods and services to sustain livelihoods will be an important step to understand the needs of communities in particular who use wetlands for a variety of social, cultural and economic benefits. The steps that need to be undertaken in the assessment process are as follows (based on J. Turpie, 2010):

a. Define the objectives and level of study
b. Define the study area boundaries and wetland dependent community;
c. Describe habitats and provision of services
d. Score benefits derived from wetland(s)
e. Assess vulnerability of local community
f. Assess current level of dependence on the wetland(s)
g. Calculate Wetland Livelihood Value Index
h. Assess sustainability of the community-wetland relationship.

Perform Base Infrastructure Assessment

New infrastructure related to supply of services or access to the site, should also be investigated in the same manner, in order to determine whether any wetlands and associated social and economic reliance on goods and services from them will be affected.

Legal and Regulatory Requirements

The legal implications of any impact on or proposed use of wetlands must be ascertained. Refer to the relevant section providing an overview of the legal matters pertaining to wetlands. Legal Counsel can be obtained, or the matter discussed with the relevant authorities.

Legal implications may impact on:

- Project time frames and project budget due to the need for environmental authorization
- Project feasibility in cases where wetlands have been classified as a high priority for conservation
- Project budget due to the need for rehabilitation of impacts associated with the proposed project
- Project time frames due to the need to execute specialist studies and consult with stakeholders

It must also be noted that South African legislation does not distinguish between natural and artificial wetlands. Wetlands that are or have been artificially created will after a certain number of years have the same legal status as naturally occurring wetlands.

Partner Selection

Depending on the nature of the proposed project, a wetland partner may be required. For example in the case of rehabilitation, Working for Wetlands is a suitable partner. The local Wetland Management Forum of the relevant catchment will be a good source of information on potential partners.

In instances of community livelihoods and wetlands, community representatives will have to be selected. Wetlands and their hydrological regime oven stretch over property boundaries and it is therefore important to ensure that landowners in such cases be involved in the initiative as partners.

Commercial and Financial Structure

The appropriate commercial and financial vehicle has to be identified with relevance the matter at hand. For example:

- Providing funding for rehabilitation
- Providing and managing of seed funding for community initiatives
- Managing contributions from landowners and grant funding
- Providing for and management of funding for the execution of studies and research
- Holding land in trust for communities
- Compensating communities for loss of livelihoods.

Business Case and Risk Assessment

Should it be found that livelihoods will be **negatively affected**, it should be understood in what way this will happen, in order to compensate communities for their loss. For example if access to a wetland is cut off and with it the opportunity to harvest materials for roofing or making baskets, in what way can communities still access the raw materials needed or can supplementary materials be supplied?

If **opportunities** have been identified to actively support wetland conservation through sustainable livelihoods, the nature of the particular wetland will dictate the services that it can provide in a sustainable manner. The report by Kotze et al. (see “Useful Resources” above) provides detail on how to execute studies of this nature. For example, it is possible to cultivate economically valuable plants at high density in wetlands, and if growing conditions are optimized then it should be possible for such a project to become a sustainable source of employment and wetland protection. Cultivation practices should be promoted which rehabilitate wetland function and be of a non-automated nature. The cultivation site must be actively monitored over the long-term, to detect and manage the environmental impacts of the project. It is recommended that pristine wetlands be promoted for the least invasive forms of livelihood support. Altered degraded wetlands can be considered for cultivation (where planting will enhance the ecological and hydrological functioning of the wetland) as well as harvesting of natural vegetation/resources. It will be vital to discuss any proposed cultivation and other uses with the relevant authorities.

Stakeholder Management

Given that issues of livelihoods are by nature emotive, it is advisable that a stakeholder management plan be compiled, setting out who must be consulted in what way, as well as the frequency there-off. Stakeholder management might involve aspects of education, training and awareness.

For the purposes of education, training and awareness, especially in circumstances requiring behaviour change, the required assessments have to be done in order to ensure that education and awareness interventions are effective. KAP studies (Knowledge, Attitude, Practice) provide a good indication of the manner in which

Project Development Planning

Given that this phase of the PCLM represent an investigation with a greater amount of detail, the same guidelines can be used as is explained above in this section.

Screen, Prioritise and Approval

During this phase, it will be determined to establish whether any new decisions have been taken that will necessitate a repeat of the processes described above. The final decisions and their related wetland implications must be talked forward into the next phase.

Assess Stage and Plan Next Stage

The final decisions and their related wetland implications must be talked forward into the next phase.

3.17 POLLUTION ATTENUATION FOR ESKOM AND THEIR MINES WITH RELEVANCE TO RQOS OF FEEDER CATCHMENTS

Eskom generates a variety of wastes, some of which are air-borne, some water-borne and some solid. Each of these categories of waste will stress the environment and negatively impact on the biodiversity. This sub-framework will guide the effective management of the various treatment methods that may be selected. The Eskom policy of zero liquid effluent discharge will be progressively implemented, but this sub-framework will guide waste management under the current waste management regime.

Wetlands have adapted to more acidic and higher salt loads due to their position in the landscape. Wetlands therefore are worthy of conservation given that they act as natural sinks for the products (within limits) of mine water effluents.

The potential of wetlands (both natural and artificial) to attenuate pollution levels in surface water could be harnessed by Eskom to promote water quality in the catchments within which it operates. Understanding and incorporating this within the initial wetland inventory, will ensure that the criteria and targets related to wetland conservation take cognisance of this important wetland function.

Based on the pollution attenuation potential of wetlands, Eskom can set strategic conservation and rehabilitation targets to improve catchment water quality.

Useful Resources

Environmental Protection Agency, U.S. Army Corps of Engineers: *Guiding Principles for Constructed Treatment Wetlands: Providing for Water Quality and Wildlife Habitat*.

Waste Treatment

Although wetlands have long been recognized for their flood control and water quality improvement functions, the unrestricted use of natural wetlands as receptacles for point and nonpoint sources of pollution may have adverse effects on wetlands and wetland biota. If natural wetlands are the ultimate receiver of polluted runoff, the potential impacts of such discharges must be investigated and appropriate management practices designed to minimize

any impacts. Pre-treated effluent however, may be used to restore degraded wetland systems, provided that the source water meets all applicable water quality standards and criteria and the practice would result in a net environmental benefit to the wetland being restored. The requirement for legal compliance and authorisations before commencing such a practice, must however be investigated.

Artificial Wetlands

Although it takes a certain length of time for an artificial wetland to function at an optimal level and that a certain level of routine maintenance is required to support continued optimum functioning. Artificial wetlands have been used successfully in a variety of situations. As with any system (natural or manmade) it must be acknowledged that due to its nature as an open system, it should not be viewed in isolation from surrounding landscapes and ecosystems, as well as social and economic needs. The ecosystem goods and services associated with artificial wetlands are not limited to pollution attenuation only, but can supply refuge for biodiversity and supply for example reeds and grasses for thatching and crafts. When developing a constructed treatment wetland, consideration should be given to its role within the relevant catchment, as well as within the broader ecosystem context of the region, such as location of the wetland in relation to wildlife corridors and potential threats from the introduction of alien invasive species. Constructed wetlands should also mimic natural features as far as possible.

The decision to proceed with the creation of artificial wetlands is dependent on a variety of factors. Artificial wetlands can be considered should it be found that:

a) A specific non-point or point source of pollution upstream impact negatively on water quality (for example an informal settlement inadequately serviced with sanitation) artificial wetlands can be created to attenuate pollution levels
b) Interventions of a low/passive technological nature are feasible, artificial wetlands can provide a “polishing” factor to effluents or run-off (from example coal storage areas where problems are experienced with sediment loads to catchment)
c) Habitat suitable for wetland associated species are diminishing in the catchment and artificial wetlands can supplement existing habitat
d) A constructed wetland is a cost-effective alternative when compared to other alternatives that could potentially treat the same or similar problems
e) Monitoring and maintenance requirements
f) Size of land required
g) Quality and quantity of effluent to be treated
h) Nature of waste to be treated, e.g. biodegradability
i) Nature of available land, e.g. undisturbed and of high conservation value
j) Unauthorised access and access by undesirable animals
k) Potential linkages with existing systems to supplement or to improve issues of connectivity
l) Socio-economic potential, e.g. harvesting of wetland products
m) Vector breeding, e.g. mosquitoes
n) Opportunities of the effluent to restore the hydrology of natural wetlands.

Given discouraging trends observed in the literature with respect to South African case studies (in strong contrast with findings elsewhere) it is advisable that a pilot project be undertaken before large-scale rollout of artificial wetlands.

The nature of the wastes generated by Eskom and their supply chain has to be classified and analysed in order to determine whether artificial/constructed wetlands are a feasible option with reference to pollution attenuation.

The wastes typically generated by Eskom and its suppliers are:

Type of waste	**Potential of constructed wetlands to attenuate pollution related to waste type**
Boiler ash slurry	Run-off and leaching from storage facilities: Yes
Brine	No
Hydro carbon contaminated soil and water	No
Coal fines slurry	Run-off and leaching from storage facilities: Yes
Overburden and waste rock from mining operations (Spoil)	Run-off and leaching from storage facilities: Yes
Mine pit dewatering effluent	Yes, depending on PH levels or after appropriate pre-treatment
Storm water contaminated by run-off from hard surfaces typically containing a variety of substances such as: – Hydro carbons – Coal dust – Coarse fly ash – Sewage sludge	Run-off and leaching from storage facilities: Yes
Nitrates leached into ground water from blasting operations	Yes
Laboratory waste	No
Solid waste from households and offices	Run-off and leaching from storage facilities: Yes
Sewage sludge	Run-off and leaching from storage facilities: Yes
Treated sewage effluent	Yes
Acid water from waste rock (ARD) and mine workings (AMD)	Run-off and leaching: Yes
A mixture of hazardous wastes such as batteries, paint, solvents and used oils, etc.	No
Asbestos	No
Flue Gas Desulfurization (FGD) Wastes: Wet FGD systems resulting in waste slurry of hydrated calcium sulphate and sulphite, and unreacted lime, stabilized with	Run-off and leaching from storage facilities: Yes

Type of waste	Potential of constructed wetlands to attenuate pollution related to waste type
fly ash and co-disposed with boiler ash slurry	
Blow-down from boilers and recirculating cooling water systems and cooling tower sludge	Run-off and leaching from storage facilities: Yes
Poly Chlorinated Biphenyls (PCBs) from transformer oil	No
Radio-active waste	No
Methane releases from collieries	No
Discarded coarse rock (high ash content)	Run-off and leaching from storage facilities: Yes
Coal Washery rejects and coal wash water	Depending on PH and level of pre-treatment: Run-off and leaching from storage facilities: Yes
Demineralization regenerant products, e.g. Polycarboxylic Acid.	No

Determination of the Risk Associated with Wastes

Determination of the risk associated with a particular waste, will aid in the determination of appropriate management actions. The section below provides an overview of the methodology to assess risk significance.

Significance is the product of probability and severity rating divided by the mitigation potential:

$$Significance = \frac{Probability \times Severity}{Mitigation}$$

Probability and Severity will be determined based on the following:

Determining the Severity of an Impact

Determination of the severity of an impact is a function of intensity, duration and extent, divided by the extent to which mitigation can successfully be applied:

$$Severity = intensity + duration + extent$$

Each of the 4 factors used to determine the severity of an impact, are described below:

- INTENSITY FACTOR

The level of intensity is the sum of volume, toxicity, social impact and ecological impacts.

Note that either Volume A or Volume B is used (refer to the description) but never both at the same time.

	Low (1)	Medium (3)	High (5)	Sub Total (Sum)
Volume (A) (refers to process input and output substances/material or products)	Less than 80 m^3 at any one time (or low volumes relative to industry/commercial standards)	Between 80 and 300 m^3 at any one time (or medium volumes relative to industry/commercial standards)	In excess of 300 m^3 at any one time (or high volumes relative to industry/ commercial standards)	
Volume (B) (refers to natural resources)	Relatively small	Medium	Large	
Toxicity	Toxicity is on par with everyday goods in wide-spread use and is biodegradable.	Toxicity can be compared to those that have to be handled with some caution and are non-biodegradable.	Toxicity is on par with toxic/dangerous/ flammable substances that are non-biodegradable.	
Social	No or very limited impact	Some impact on immediate communities, but cannot be considered as disruptive	Major disruptive impact on surrounding communities	
Ecological	Natural functions not affected or negligible.	Environment affected but natural functions and processes continue (Some damage or wildlife injury may occur). Impact is reversible or irreplaceable loss will not occur	Environment affected to the extent that natural functions are altered to the extent that it will permanently or over the long term cease (Major damage or wildlife injury could occur). Irreplaceable loss will occur.	
			Total	

- DURATION

Duration is assessed and a factor awarded in accordance with the following:

	Duration of Impact	**Duration factor**
Short term	The duration of the is impact is 1 Year or less	Factor 1
Medium term	The duration of the is impact is 1-5 Years	Factor 3
Long term	The duration of the is impact is 5 to 25 years	Factor 4
Permanent	The duration of the is impact is longer than 25 years and can be considered as permanent	Factor 5

- EXTENT

Describes the physical extent the impact and factors are awarded according to the following:

	Extent of the impact	**Extent factor**
Site	The impact only exists within the activity's footprint	Factor 1
Local	The impact could impact on the whole or a considerable portion of the properties on which the activity is undertaken as well as neighbouring properties	Factor 3
Regional	The impact could affect the area, neighbouring as well as other areas further away than the immediate neighbours	Factor 5

- PROBABILITY

Probability describes the likelihood of the impact actually occurring, and is rated as follows:

	Possibility that impact will occur	**Rating**
Improbable	Low possibility of impact occurring due to design or history	1
Probable	Distinct possibility that impact will occur	2
Highly probable	Most likely that impact will occur	3
Definite	Impact will definitely occur	5

- SIGNIFICANCE RATING

Following from the above, the Significance rating can now be determined as follows:

Significance = severity x probability

The significance rating thus determined should influence the proposed project as described below:

Negligible (calculated Significance Rating < 25)

– *Positive and negative impacts of negligible significance are unsubstantial and should have little or no influence on the proposed development project.*

Low (calculated Significance Rating 25 < 50)

– *The impact is limited and should not have a material effect on the decision to continue. Management intervention is required.*

Moderate (calculated Significance Rating 50 < 90)

– *Positive impact: Should weigh towards a decision to continue, should be enhanced in final design.*

– *Negative impact: Should weigh towards a decision to terminate proposal, or mitigation should be performed to reduce significance to a low significance rating.*

–

High (calculated Significance Rating > 90)

– *Positive impact: Continue*

– *Negative impact: If mitigation cannot be implemented effectively (into the moderate category), proposal should be terminated.*

Table 23 below provides an example of how the unmitigated significance ratings are calculated:

Table 23: Calculation of unmitigated ratings

Probability		***Severity***						**Severity Rating**	**Significance Rating** (Probability x Severity rating)	
		Intensity		*Duration*		*Extent*				
Probable	**2**	*Low*	*4*	*Short Term*	*1*	*Local*	*2*	**7**	**14**	**Negligible**
Probable	**2**	*Low*	*4*	*Medium Term*	*3*	*Regional*	*3*	**10**	**20**	**Low**
Definite	**5**	*Medium*	*12*	*Medium Term*	*3*	*Local*	*2*	**19**	**85**	**Moderate**
Definite	**5**	*High*	*20*	*Permanent*	*5*	*Site*	*1*	**26**	**180**	**High**

MITIGATION

Mitigation will be calculated as follows:

Description	Factor Allocated
Mitigation is not possible or positive impact of mitigation is negligible. Impact remains irreversible.	1
Mitigation is possible to some extent with moderate levels of positive impact. Impact is largely reversible with only a small portion that remains as irreversible.	2
Mitigation is possible with moderate to high levels of positive impact. Impact is reversible.	3
Mitigation is possible to such an extent that all negative impacts are reduced significantly or eliminated. Impact is completely reversible.	4

$$Significance = \frac{intensity + duration + extent}{Mitigation\ potential}$$

Natural Wetlands

Collectively, wetlands in a catchment can have a positive impact on water quality. The extent of wetland surface area required to maintain or improve water quality in a catchment is dependent on a large number of variables, such as:

a) The nature of the water quality problems experienced in the catchment
b) The hydro-geomorphic position of wetlands in the landscape
c) The relative position of wetlands with reference to any pollution sources in a catchment.

The RQOs set for a catchment can also provide further guidance as to the critical extent of wetland surface area that will be required in especially a developing catchment. It is acknowledged that at this stage, the matter of required wetland surface area vs. catchment surface area with respect to the delivery of ecosystem goods and services are “blue sky” and that each catchment being unique and dynamic, will require dedicated studies.

An observation of the levels of development in a catchment as well as the temporal and spatial nature of water quality constituents is an important starting point. Should any of the aforementioned criteria have a significant negative trend, a joint investigation with suitable stakeholders should be undertaken to determine the optimal wetland surface area, wetland types as well as levels of wetland health that will be required to sustain or improve water resource quality in a catchment.

A useful method in this regard is to link wetland health and the provision of ecosystem services to national land cover change data sets, which are readily available. Land cover is used as an indicator of impacts on hydrological functioning and through consulting numerical metrics predefined by Ellery et al; loss of wetland functionality can be deducted. Using coarse-resolution land cover categories as a basis to assess impacts to wetlands is a very basic tool,

however given the broad scale at which it will be applied, it will generally be sufficiently accurate for the purpose of strategic assessments (Ellery et al., 2010).

3.18 CARBON STORAGE IN WETLANDS

With a global and national focus on climate change, the role of wetlands in carbon storage and sequestration has received increasing attention. This sub-framework provides an overview of important steps to promote and to protect the carbon sequestration abilities of wetlands during the PLCM.

Wetlands in general, but particularly peat lands, store large quantities of carbon (see Figure 8, page 39). Wetlands may, thus, contribute to the adaptation and mitigation strategies that Eskom of South Africa may commit to in the future.

Useful Resources

Adhikari, S., Bajracharaya, R.M. & Sitaula, B.K. 2009. A Review of Carbon Dynamics and Sequestration in Wetlands. *Journal of Wetlands Ecology*. Vol. 2, pp. 42-46.

Donovan, P. 2012. Measuring soil carbon change: A flexible, practical, local method. The soil carbon coalition.

Environment and Natural Resources Committee. 2010. Inquiry into Soil Carbon Sequestration in Victoria. Parliament of Victoria. Parliamentary Paper. No. 362 Session 2006-10.

JuFeng, Z., Kun, C., GenXing, P., SMITH, P. LianQing, L., XuHui, Z., JinWei, Z., XiaoJun, H., YanLing, D. 2011. Perspectives on studies on soil carbon stocks and the carbon sequestration potential of China. *Chinese Science Bulletin*. Vol. 56, nr. 35: 3748-3758.

Kayranli, B., Scholz, M. Mustafa, A. & Hedmark, A. 2010. Carbon Storage and Fluxes within Freshwater Wetlands: a Critical Review.2010.Carbon Storage and Fluxes within Freshwater Wetlands: a Critical Review. Wetlands. Vol 30:111-124.

Mitra, S., Wassmann, R. & Vlek, P. 2005. An appraisal of global wetland area and its organic carbon stock. *Current Science*. Vol. 88, No. 1.

Potter, C., Klooster, S., Hiatt, S., Fladeland, M., Genovese, V., & Gross, P. 2006. Methane Emissions from Natural Wetlands in the United States: Satellite-Derived Estimation Based on Ecosystem Carbon Cycling. *Earth Interactions*. Volume 10, no. 22.

Powell, K., Wynn, J., Rains, M., Stewart, M. 2008. Towards a soil-property-based index of wetland “harm”. Unpublished presentation.

Sulaeman, Y., Budiman, M. & McBratney, A.B. 2010. Monitoring Spatio-Temporal Changes of Soil Carbon in Java Using Legacy Soil Data. Proceedings of Inernational Workshop on Evaluation and Sustainable Management of Soil Carbon Sequestration in Asian Countries. Bogor, Indonesia.

Victoria, R., Banwart, S., Black, H., Ingram, J., Joosten, H., Milne, E., & Noellemeyer, E. 2012. The benefits of Soil Carbon: Managing soils for multiple economic, societal and environmental benefits. UNEP yearbook.

Wylynko, D. 1999. Prairie wetlands and carbon sequestration Assessing sinks under the Kyoto Protocol. International Institute for Sustainable Development.

Pre-feasibility

Determine whether there are existing data sets that relates to the wetlands on site, and acquire those available. Relevant datasets include topographic data such as contours, water quality and -level monitoring data, soil data, land-use history, and climate and rainfall data.

The need

In order to understand the functioning and dynamics of the wetlands on site, a good understanding of baseline data is required. Wetlands are tremendously variable – in terms of carbon stock wetlands are sensitive to large-scale factors such as climate variation, as well as local scale factors such as water quality and hydro-period.

The process

The following sources can be consulted for information:

- The South African Weather Service or specific weather monitoring stations such as the ARC-ISCW, for climate and rainfall data
- The Geological Society, for baseline geological maps (if not already in Eskom's possession). Eskom will probably be in possession of more detailed geological information for the area.
- The Department of Water Affairs, for any data relating to water level monitoring such as borehole data or water quality data
- The ARC-ISCW for data relating to the soil in the area
- The South African National Biodiversity Institute, for information on the vegetation in the area
- The Surveyor General, for topographical data (if possible more detailed land surveyor data is preferable)
- The Surveyor General, for aerial imagery, current and historical
- Universities that might have done research in the area, for any information regarding the wetland on site
- Eskom, for any specialist reports that might already be available such as geohydrological reports

Feasibility

A soil scientist or wetland specialist (or preferably a wetland pedologist) should be appointed to determine the carbon stock of the wetland. The wetland delineation should be utilized to demarcate the area for which carbon stock will be calculated. The results of this analysis should be a separate report from the wetland delineation report as this data will be used in the future to compare against the monitoring data. In this report, any impacts to the wetlands on site that might affect carbon emissions must be clearly indicated and described.

The need

Carbon plays an integral part in the chemical and physical functioning of wetlands, which is an important ecosystem in terms of carbon sequestration. Carbon is easily lost when a wetland is degraded or impacted on. Very little information is available in South Africa regarding the carbon stock in different types of wetlands under different land-uses. There is therefore a large opportunity for Eskom to be on the forefront of research of carbon pools in wetlands in South Africa.

Additionally, South Africa is a signatory to the United Nations Framework Convention on Climate Change (UNFCCC) and the Kyoto Protocol, and is committed to sustainable development. Eskom is currently responsible for almost half of South Africa's carbon emissions, and has a responsibility to investigate manners in which to alleviate the negative effects that their practices are having. The use of wetlands to sequester carbon for the purpose of carbon offsetting or trading is thus an attractive option, and it is recommended that this Management Framework is used as a first stepping stone in the management of wetlands occurring in Eskom's catchments to promote soil organic carbon research with the possibility of utilizing this as carbon offsetting and trading.

The carbon stock of the wetland must be determined. These results will be used:

- in conjunction with the impact inventory and results of the health, EIS and PES assessments to assign a ranking value to the wetland.
- as a benchmark to compare carbon monitoring values to.

The process

A soil scientist, whom has had some experience in wetland work, will be best qualified to determine the carbon pool of the wetlands on site. This report should also discuss wetland type and the various impacts to the wetland – current and envisaged; and include a management plan to ensure the optimum functioning of the wetland during Eskom's activities. The report must include water level data monitoring and pH measurements as well.

A ranking value will be assigned to each wetland depending on its ability to function like a healthy wetland, wetland type, and size of the carbon pool. For example, a peatland will immediately receive the highest ranking possible as this type of system is known to sequester carbon very efficiently. A wetland driven by alluvial processes will receive a considerably lower ranking. The EIS and PES scores will be used to further guide the ranking process. Existing impacts to the system will further determine the ranking, as impacts such as drainage and tillage have a massive effect on GHG emissions. These types of wetlands will be earmarked for rehabilitation. Envisaged impacts to the wetland must also be taken into consideration. A wetland that is going to be impacted severely by Eskom's activities will attain a low ranking, but will immediately be flagged for rehabilitation and mitigation measures.

Business Plan

Ensure that all documents related to the findings of the wetland delineation, Carbon pool report, PES and EIS determinations have been made available to the business planning process, and are accounted for in this process. If intensive rehabilitation is or wetland offset required, ensure that funds are set aside from the beginning of the project for these activities.

The need

The implications that the management of the wetlands on site might have on the financial and business management sector of Eskom should be transparent and included into their business strategy

The process

All the information regarding the wetlands on site should be compiled and made available to the business planning process

Planning and Design

The ranking of the wetlands on site based on the previous sections must be used to guide the management programme that each wetland requires. A long-term monitoring plan for the carbon pool of the wetlands must be put into place.

The process

The carbon pool should be monitored twice a year, once per year in the rainy season and once per year in the dry season. The exact same plots must be sampled. A centralized database must be available where the monitoring data (raw as well as processed data) can be stored. It is important that the wetland is earmarked with a specific goal in mind, as this will give value to the monitoring data. For instance, if a wetland is earmarked from the beginning to be impacted upon, this should be reflected in the carbon pool database, as this information will be used to interpret the data gained. If a wetland is earmarked to be conserved effort should be made to enhance the carbon sequestration potential of the wetland.

Construction

It is important that the monitoring plots in the wetland not be disturbed.

If the wetland is impacted upon by construction activities a detailed report of this should be given and added into the monitoring database as this can influence the interpretation of the data. Emergency protocol must be at hand to follow in cases such as these.

Commissioning and Hand-over

Ensure that the process of wetland management and monitoring is running smoothly, effectively and streamlined during and following the hand-over phase.

Operation

The personnel on site must be trained to recognize negative impacts on the wetlands as a result of catchment activities, so that they may report on any unwanted incidences or – impacts to the wetlands; as well as be familiarized with emergency protocol. This does not only refer to Eskom's activities, but also other potentially detrimental activities elsewhere in the catchment.

Close out

Ensure that the process of wetland management and monitoring is running smoothly, effectively and streamlined during and following the hand-over phase.

Evaluate

Following the project life cycle the monitoring data should be compiled into a scientifically defendable report. As this type of long-term research into carbon pools is rare in South Africa, the potential exist of contributing to wetland and soil science. The project should also be evaluated for its efficiency and shortcomings in the project in order to better the strategies and management during the next project.

4 SELECTED CASE STUDIES TO TEST THE ROBUSTNESS OF THE WETLAND MANAGEMENT FRAMEWORK

4.1 PILOT SITE SELECTION

Introduction

The Research Team recognized the need for a justifiable methodology in the selection of pilot sites for the purposes of testing the Wetland Management Framework (WMF). For this reason a cooperative and transparent approach involving relevant personnel from Eskom was followed.

Based on this recognition, two joint workshops were held. The first took place on 24 May 2013, and the second on 26 July 2013. The main points of these meetings are provided below.

Meeting held on 24 May 2013

Overview of meeting

The meeting agreed that and the study done on Adaptive Management Frameworks by Kotze (2004) is suitable for application by Eskom and that the WMF should be based on Eskom's Project Lifecycle Model (PLCM).

Consensus was reached to include one Eskom project from each Phase of the PLCM (if possible and including different renewable projects). Eskom also indicated that Mpumalanga needs to be prioritised in site selection as most of their Power Stations are situated in this region.

The following Guiding Principles were agreed upon in terms of selection of pilot sites:

1. What is practical
2. What is achievable within the time frames
3. Where are the main challenges/gaps that are being experienced by the specific site and how relevant are they to the WMF
4. What is cost effective
5. Travelling time and distance from Gauteng
6. Availability of assistance on site
7. Eskom must be the owner of the site.

Overview of proposed methodology

EON Consulting developed a site selection methodology including a scoring tool developed as per Eskom PLCM phase (Pre-planning to Project Closure).

Eskom's assets were divided into eight broad categories, namely

1. Coal-fired Power Stations
2. Nuclear Power Stations
3. Pumped storage
4. Hydroelectric Power Stations
5. Open cycle gas turbine Power Stations
6. Renewable Energy
7. Transmission and sub-stations
8. Mines

The activities and associated environmental impacts of each category of asset were identified with a view to prioritise those with the highest potential for wetland impacts.

Sites are then to be scored based on the following criteria:

1. Whether it is existing facilities
2. Whether it is existing facilities with plans for extensions
3. The nature of ecosystem services rendered by wetlands onsite
4. The nature of other ecosystem services of importance associated with the site, such as biodiversity corridors
5. The dependence of communities on wetlands for their livelihoods
6. Availability of data and information related to the site and its wetlands
7. Uniqueness of site/surrounding area
8. Position in the landscape – physical
9. Position in the landscape – societal
10. Supply lines
11. Extent of waste disposal – solid
12. Extent of waste disposal – liquid
13. Extent of waste disposal – airborne
14. Opportunities for wetland rehabilitation.

Agreement of the site selection committee

After much debate, Eskom advised a simpler process than the selection methodology proposed by EON Consulting (The original proposed site selection methodology is included as Annexure A to this document). The meeting concluded that a focus on a Systems and Phases Approach is advisable:

1. Focus on a Systems Approach – this will be wetland focused and based on national priorities.
2. Phases Approach where one project within each of Eskom PLCM phase will be selected.

The meeting then advised that the following projects should be focused on for final site selection:

1. Kusile (execution phase) and Ingula (have good wetlands for comparison)
2. Medupi (execution phase)
3. Koeberg
4. Matla and Kriel – both still operational (cumulative impacts as are close to each other)
5. Majuba – due to the presence of hillslopes that feed into the wetlands on site.

Meeting held on 26 July 2013

Overview of meeting

After some deliberation, it was agreed that due to budget limitations only 3 sites would be chosen.

The sites would need to cater for broad applications and studies. It was agreed that the sites would fall under each one of the following sub-sections of the Eskom PLCM:

1. Construction

2. Operational
3. Closure

In choosing the sites the team agreed to keep in mind:

1. The presence of on-site multiple wetlands
2. Eskom's existing work in the area and the possibility of collaboration or duplication of work
3. Prevalence of both natural and artificial sites
4. Gaining a broad spectrum of understanding/learning from individual sites.

The sites as indicated in Table 24 were consequently recommended as potential options and Eskom will draw up a generation matrix and decide on the final site selection.

Table 24: Recommended site selection options

Section	Proposed options
Construction	**Kusile** • Numerous wetlands • Class B river in immediate surroundings
Operational	**Matla** **Kriel** **Arnot** • Linked to a coal mine so all scenarios are likely to be catered for. • Ash dam situated in flood line
Closure	**Kilbarchan** – Newcastle (Ingagane power station) • Going through closure • SASS/Fish and toxicology study currently been performed • Closure and rehabilitation report **Return to service plant – Grootvlei**

It was agreed that Eskom will have an internal review of the suggested sites and confirm with EON which of the sites have been selected for the pilot study. The EON research team will then review information supplied and/or visits the suggested sites to confirm suitability of the selection.

Agreement of the site selection committee

Eskom confirmed via e-mail that the three final sites are:

1. Operational phase: Matla and Kriel Coal Fired Power Stations
2. Construction phase: Kusile Coal Fired Power Station
3. Decommissioned and re-commissioned phase: Grootvlei Coal Fired Power Station.

Kilbarchan could not be selected because the land, as per Eskom feedback received, no longer belongs to Eskom. Matla and Kriel were selected in favour of Arnot due to the recent challenges

being experienced by Matla and Kriel. Matla and Kriel are also in close proximity to each other and would present an opportunity in terms of cumulative impacts (both positive and negative).

The map below indicates the locations of the final four sites that were selected for the pilot phase.

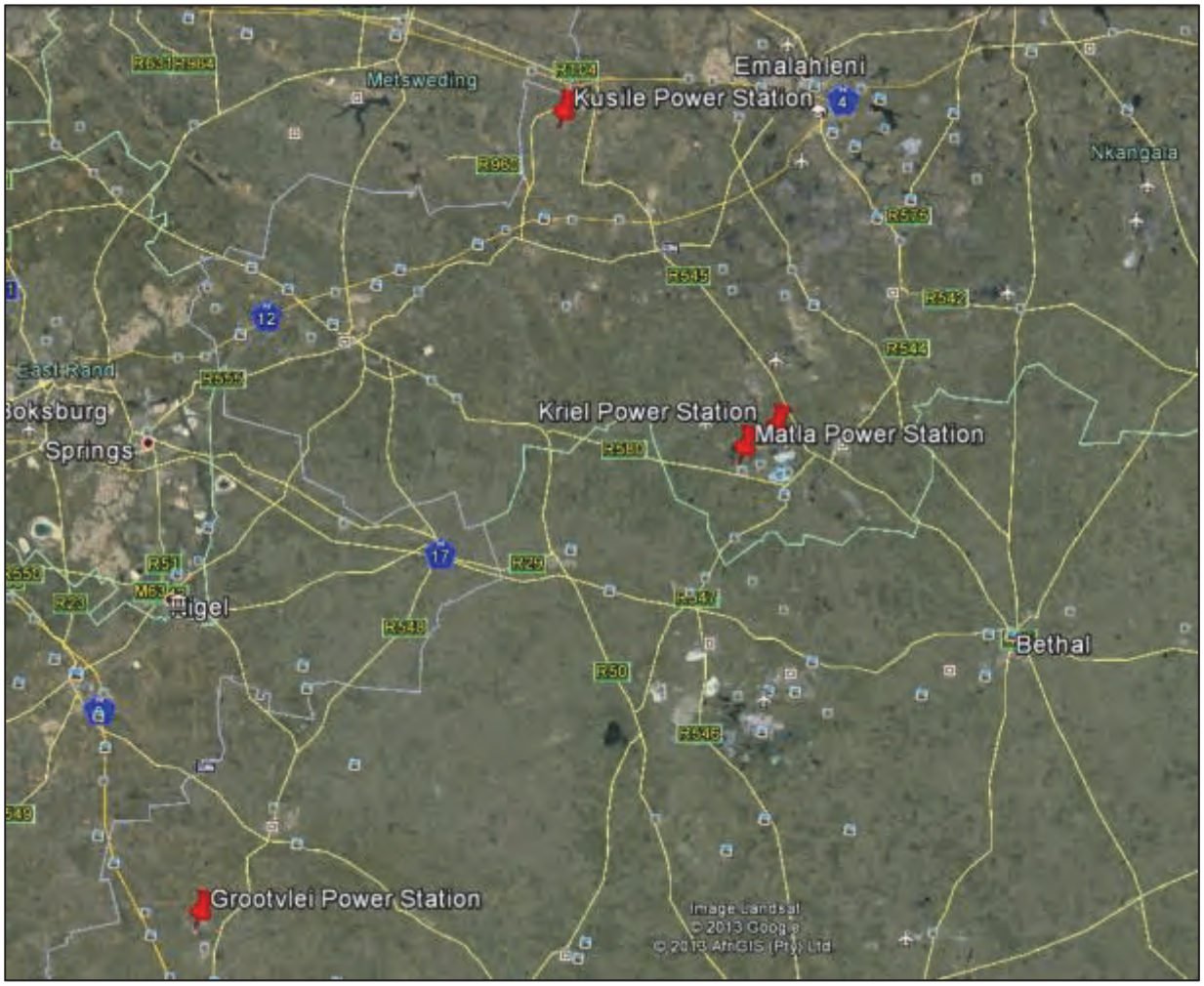


Figure 27: The location of the four sites selected for the pilot study.

Kusile, Kriel and Matla are situated in the Olifants River catchment, whilst Grootvlei is situated in the Vaal River Catchment.

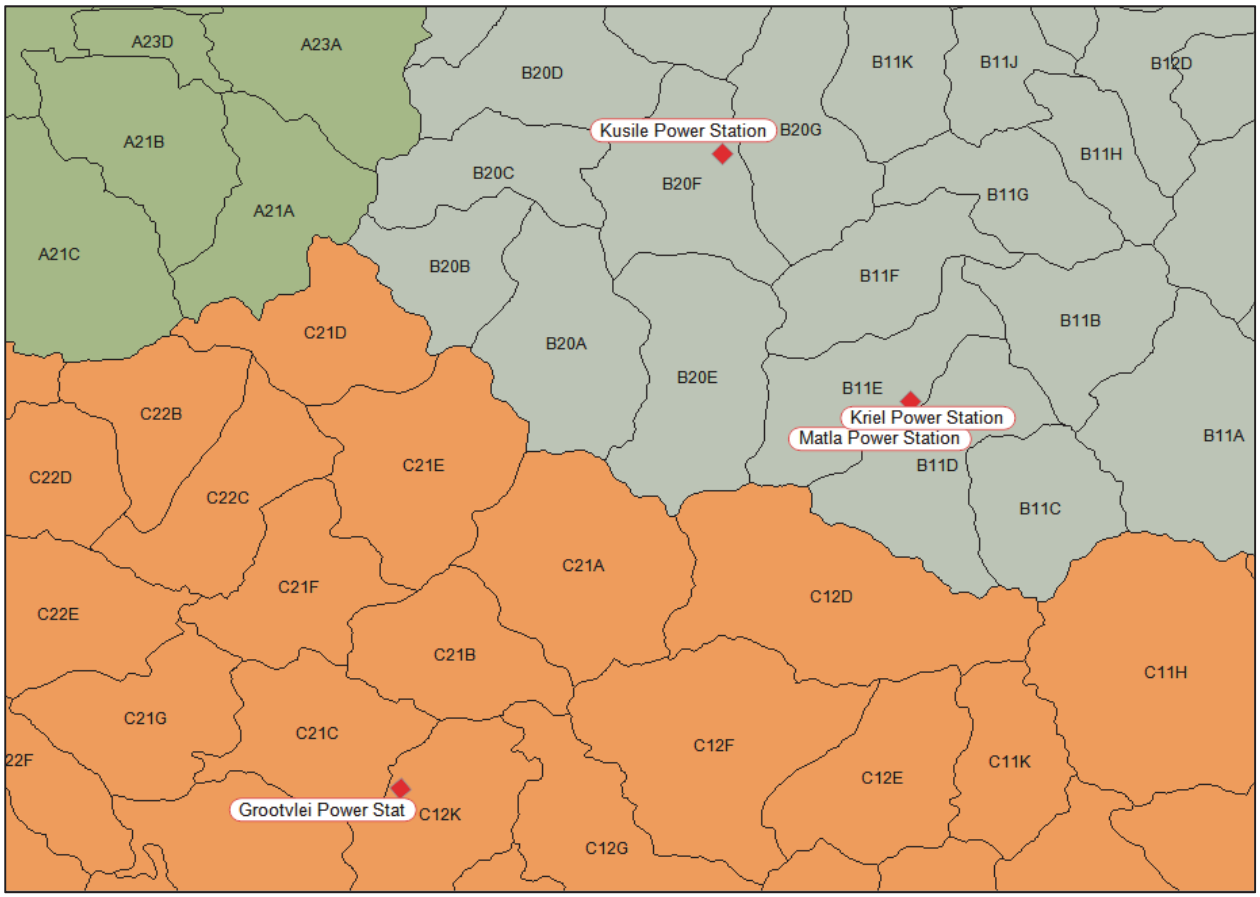


Figure 28: The primary and quaternary catchments associated with the 4 power stations selected for the pilot study

4.2 PILOT SITE SITUATION ANALYSIS

Introduction

Following on the selection of the four pilot sites as indicated above, the EON team arranged to visit each of the sites. Visits took place on:

1. Matla: 4 September 2013
2. Kriel: 4 September 2013
3. Grootvlei: 5 September 2013
4. Kusile: 16 September 2013

Overview of the findings of the site visits

Table 25 below provides an overview of the main findings of the site visits with reference to the legends contained and described below.

Table 25: Summary of findings of the site visits

General Facts	Description of site issues relevant to wetland management	Reference to the WMF	Conclusion
Matla: Operational Phase			
Upper Olifants Catchment Installed Capacity: 3 600 MW In operation since July 1983 (22 years)	– The ash dam is situated in the pit of an old open cast coalmine. This old open cast mine was sited over an existing drainage line with wetlands. – A leaking water pipe has been releasing approximately 25 m^3 of water per day for the past 3 years. Fixing the leak would mean undertaking of an excavation in a wetland and uncertainty as to requirements by DWA has left the issue unresolved. It is possible that the water leak created or contributed to the formation of the wetland in the first place. If indeed the case, the maintenance gap created the problem – A road runs through a hill slope seep and wetness is observed on the road. Personnel are unsure of the origin of the water, which could be from natural causes or emanating from the wet storage dam uphill. – Several artificial wetlands were observed on site – Hydrology of storm water run-off has been altered by related infrastructure, with the ash dam having the largest impact and have impacts both on- and	– Wetlands have not been delineated (The research team has been informed recently that a wetland specialist is in process of being appointed to delineate one of the wetlands on site) – No objectives and targets related to wetland management have been set – No investigations with reference to wetland ecology and functioning by identifying and describing the range of natural variability in wetland ecological systems in the areas where Eskom and its suppliers operates. – Several legacy issues – The creation and management of artificial wetlands are causing uncertainty with respect to the management of the wetlands onsite.	 Main focus of personnel, but room for improvement  No focus  No focus  No Focus

General Facts	Description of site issues relevant to wetland management	Reference to the WMF	Conclusion
	offsite – The coal mines supplying Eskom with coal, does not belong to Eskom and personnel were hesitant to include these sites in the site visits		
Kriel: Operational Phase			
Upper Olifants Catchment Installed Capacity: 3 000 MW In operation since 1979 (26 years)	– A trench was dug through a wetland (with water draining into the trench) without the knowledge of the environmental personnel on site – Several artificial wetlands were observed on site – Hydrology of storm water run-off has been altered by related infrastructure and have impacts both on- and offsite. – Local people were observed close to the site utilizing wetland areas as grazing for a few cattle – The coal mines supplying Eskom with coal, do not belong to Eskom and personnel were hesitant to include these sites in the site visits	– Wetlands have not been delineated – No objectives and targets related to wetland management have been set – Several legacy issues – The creation and management of artificial wetlands are causing uncertainty with respect to the management of the wetlands onsite.	 Main focus of personnel, but room for improvement  No focus  No focus  No Focus
Grootvlei: Closure phase (and re-opened)			
Vaal Catchment Installed Capacity: 1 200 MW	– Environmental personnel were not available on the day to assist the research team	– Wetlands have not been delineated – No objectives and targets related to wetland management have	 Main focus of personnel, but room for improvement

General Facts	Description of site issues relevant to wetland management	Reference to the WMF	Conclusion
In operation since 1969 and mothballed in 1990 (32 years)	– The ash dams at Grootvlei have been constructed on both sides of a valley bottom wetland system. The presence of the dams has changed the hydrology to some extent and is potentially contributing to inflows into the system. – A railway line is being constructed just outside the boundaries of Grootvlei, and the excavations run through wetlands. – No environmental closure plan could be provided. Closure plans were mainly focused on asset management and maintenance. – The re-commissioning EMP (Ninham Sham, 2004) made no significant referrals to impacts and rehabilitation associated with wetlands – Several artificial wetlands were observed on site – Hydrology of storm water run-off has been altered by related infrastructure – The coal mines supplying Eskom with coal, do not belong to Eskom and personnel were hesitant to include these sites in the site visits	been set – Several legacy issues	 No focus  No focus  No Focus
Kusile: Construction phase			
Upper Olifants Catchment 6000 hectares	– Presence of wetlands on site was characterized by differences of opinion	– Wetlands have been delineated and are being protected – Wetland Management Strategy	 Main focus of personnel, but room

General Facts	Description of site issues relevant to wetland management	Reference to the WMF	Conclusion
Capacity: 4 800 MW	– Some incidences were reported of contractors damaging wetlands – Issuing of Water Use Licenses has led to delays – Their Water Use License is one of the first to be issued with offsets, but there are not a lot of options as the offsets have to be in the same quaternary catchment, which is small – Kusile developed a wetland management strategy to help them manage the difficulties that they are having with their wetlands, which make up about 17% of their area. – The co-disposal site has a small pan in the middle, with the result that the site is now kidney-shaped. – Kusile is the first power station with a wetland strategy. The strategy is mainly focused on construction-related impacts	has been compiled with a focus on management of construction impacts and offsetting	for improvement  Wetland management strategy developed  No focus  Some focus here; especially in recognition that the Wilge River is to be maintained in Class II, but all the components of the WMF have not been addressed.

Conclusion

With reference to the respective phases of the pilot sites, the following was found:

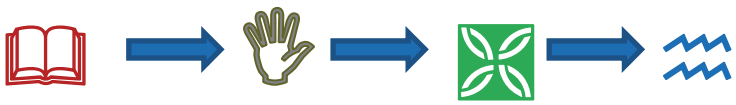
Table 26: Summary of findings of the site visits

Pilot Site and PLCM phase	Site visit findings	Conclusion
Operational phase: Matla and Kriel Coal Fired Power Stations	Matla and Kriel are not adequately prepared for the operational phase of the WMF, because wetlands have not yet been delineated. No other components of the WMF have been addressed.	As a way forward it was agreed that a detailed wetland management plan (WMP), based on the WMF will be developed for the Matla Power Station (based on the needs of the staff and their eagerness to get involved). Both Kriel and Grootvlei will benefit from the WMP
Construction phase: Kusile Coal Fired Power Station	Kusile is prepared for wetland impacts related to the construction phase, with a focus on legal compliance. Although much work has been done on the wetlands of Kusile, there are aspects of the WMF that have not yet been addressed.	Kusile will benefit from certain components of the WMP that is being developed for Matla
Decommissioned and re-commissioned phase: Grootvlei Coal Fired Power Station	Grootvlei was not adequately prepared for the closure phase nor prepared for the operation phase of the WMF, because wetlands have not yet been delineated. No other components of the WMF have been addressed.	Grootvlei will benefit from the WMP that is being developed for Matla

Conclusion of the Pilot Studies

The main conclusion reached is that the Draft Wetland Management Framework is relative to the status of Eskom's wetland management, somewhat ambitious at this stage. However, the WMF represents best practice and it is advised that a phased approach to the rollout of the WMF be taken. The creation and management of artificial wetlands are a further matter identified during the pilot studies and the WMF should be updated to provide guidelines in this regard.

Based on the categories of focus as set out in the WMF, it is advised that implementation starts with a focus on legal compliance, followed by livelihoods, ecosystem services and a catchment perspective.



The following phase of the pilot project consisted of the development of a detailed Wetland Management Plan (WMP) for Matla Power Station. The plan is based on a workshop with personnel from the Matla Power Station, held on 19 September 2013.

4.3 WETLAND MANAGEMENT PLAN FOR MATLA POWER STATION (PS)

Situation analysis of Matla PS

Matla Power Station and its associated land are situated in the Upper Olifants catchments and straddle two quaternary catchments (B11E and B11D) (Figure 29).

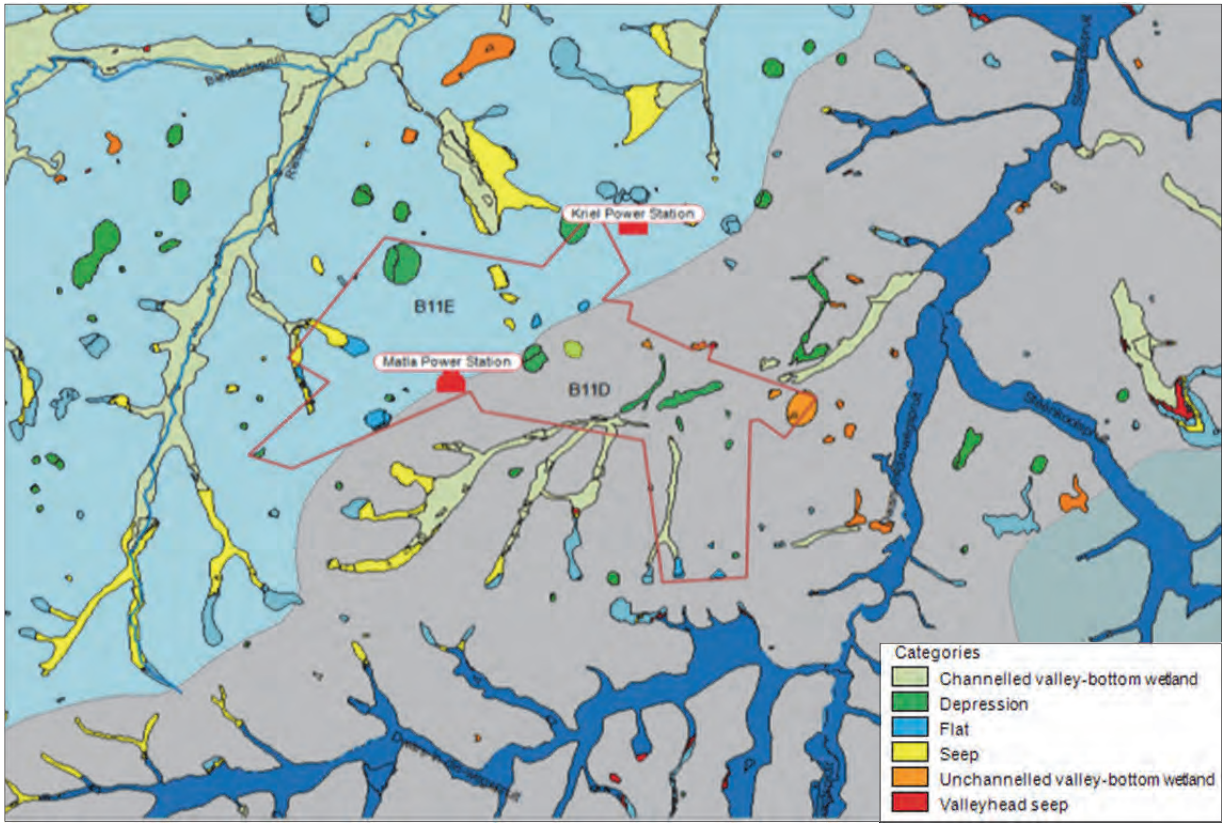


Figure 29: An overview of the NFEPA wetlands associated with the Matla Power Station area (SANBI, 2012)

Eskom provided the boundaries for the map illustrated by Figure 29 above. The map below was obtained from SANBI's website (www.sanbi.org) (Figure 30A) in which the NFEPA wetlands have been overlaid over an image of the power stations' (left-hand side) infrastructure. The figure also provides the same image of the Matla Power Station, but with the wetland layer turned off, in order to be able to see the water bodies beneath the wetland layer (Figure 30B). As can be seen from the image, some of the wetlands are artificial and associated with man-made holding structures, or were in existence prior to the ash dams being built. The ash dam was built across the path of the unchanneled valley bottom system.

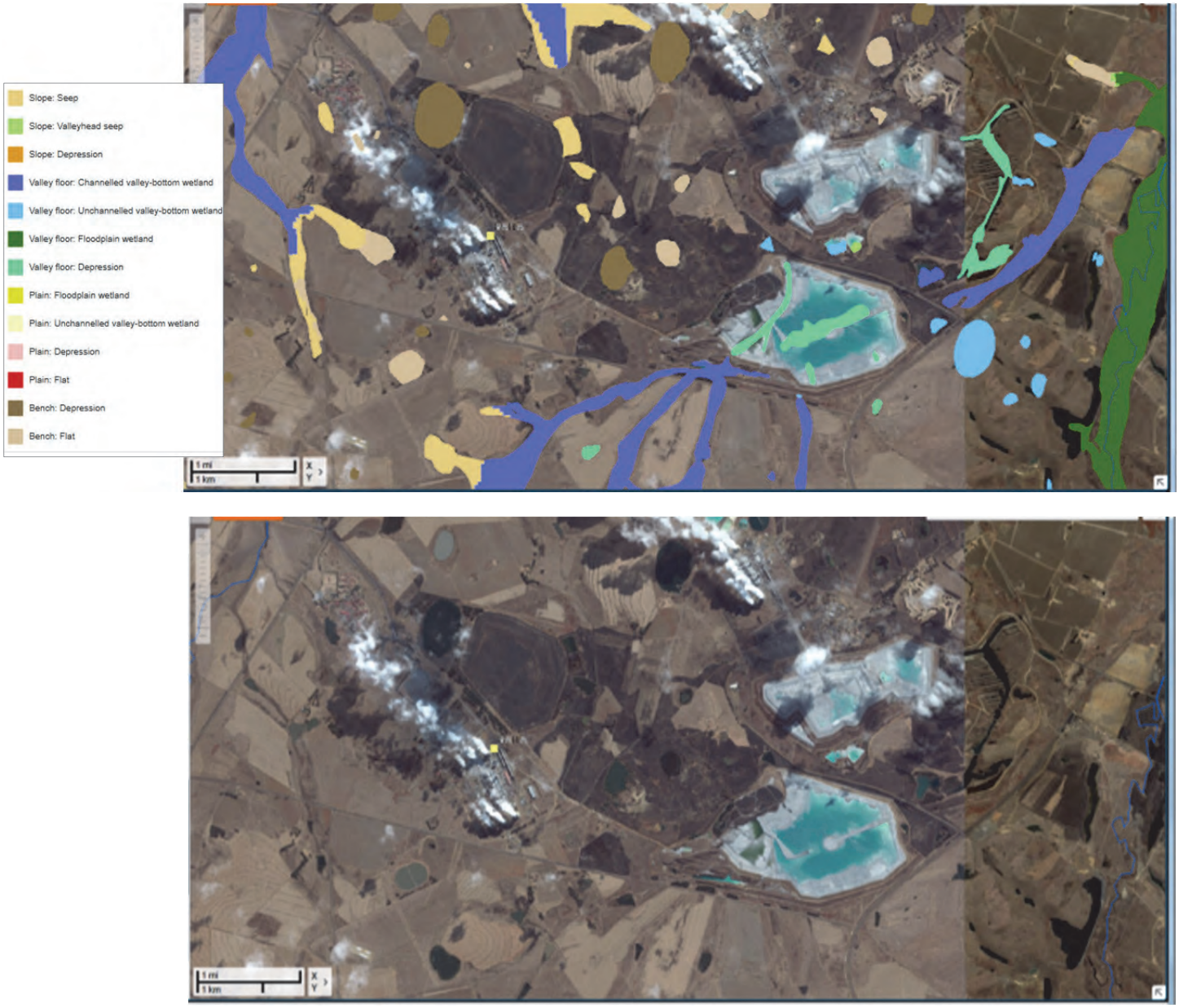


Figure 30: Images associated with Matla PS with reference to the National Wetland Inventory (SANBI, 2013) (Figure 30A: Wetlands on the Matla Power Station property with the NFEPA overlay and Figure 30B: Wetlands on the Matla Power Station property without the NFEPA overlay)

4.4 ANALYSIS OF WETLANDS ASSOCIATED WITH MATLA PS WITH REFERENCE TO ITS CATCHMENT

This section of the document presents the results of an analysis of wetland types associated with the Matla PS property and its associated 2 quaternary catchments. Table 27, Table 28 and Table 29 provide an overview of the respective surface areas and the results.

Table 27: Surface area associated with Matla property and the two associated quaternary catchments

Catchment	Size (km^2)	Total size (km^2)
B11D	551	1017.7
B11E	466.7	
Matla		39

Table 28: Surface area of wetlands in the total catchment

Total Catchment (B11D and B11E)		
Wetland category	**Size (km^2)**	**Density‡**
Natural	136	0.13
Artificial	13	95.75
Total	149	95.89
Natural Wetlands		
Wetland type	**Size (km^2)**	**% of catchment**
Channelled Valley bottom	47.81	4.70
Depression	5.71	0.56
Flat	11.79	1.16
Floodplain wetland	45.26	4.45
Seep	22.41	2.20
Unchannelled valley bottom	2.08	0.20
Valleyhead seep	0.88	0.09
Artificial wetlands		
Wetland type	**Size (km^2)**	**% of catchment**
Unchannelled valley-bottom wetland	0.91	0.001
Seep	4.22	0.004
Floodplain wetland	1.70	0.002
Flat	1.44	0.001
Channelled valley-bottom wetland	4.46	0.004

‡ Density: Number of Wetlands per km^2 of a Quaternary Catchment

Table 29: Surface area of wetlands within the Matla PS boundaries

Matla		
Matla surface area	39	
Wetland category	**Size (km^2)**	**Density‡**
Natural	4.2	0.11
Artificial	0.5	0.12
Total	4.7	0.23
Natural wetlands		
Wetland type	**Size (km^2)**	**% of total catchment**
Depression	1.54	27.0
Flat	0.47	4.0
Seep	0.40	1.8
Unchanneled valley bottom	0.39	18.6
Valley head	0.01	1.5
Artificial Wetlands		
Wetland type	**Size (km^2)**	**% of total catchment**
Channelled valley-bottom wetland	0.07	6.9
Flat	0.15	5.3
Seep	0.23	0.0
Unchanneled valley-bottom wetland	0.06	10.3

‡ Density: Number of Wetlands per km^2 of Matla PS's surface area

Table 30 below provides an overview of the average wetland situation in South Africa (SANBI, 2012). It is useful to compare the figures with the situation in the catchments where Matla PS operates. Based on a comparison between number of wetlands per quaternary catchment and density, it appears as if wetlands in B11 E and D tend to be smaller in size.

Table 30: Overview of the average wetland situation in South Africa

			B11E and B11D
Total Surface Area of Wetlands in S.A (km^2)	196 545.76		149
Percentage Coverage of Wetlands Area in S.A	15.30		13.36
Density: Number of Wetlands per km^2 of a Quaternary Catchment	0.10		95.89
Average number of wetlands per Quaternary	62.7	125 (for two catchments)	1504

The graph below illustrates the relative contribution from the different wetland types (natural) contained within the boundaries of Matla PS to the two quaternary catchments. It is important to acknowledge that these figures would change significantly if Matla PS were positioned in one catchment only. The finding of this analysis then underlies the importance of the Matla PS wetlands as containing a significant portion of depression and unchanneled valley bottom wetlands from a representivity point of view.

Note that the X-axis refers to two units of measure, namely percentage and surface area in km^2.

The analysis of the wetland types as illustrated by the tables (29, 30 and 31) above is that the distribution of the different wetland types is dependent on the geomorphology of quaternaries. For instance, depression wetlands are only found in areas with very low gradient (normally less than 1%) so tend to occur on watershed areas, and comprise 27% of the wetland, by area, of the wetlands occurring on the Matla property as opposed to 0.56% of the wetland types in the two quaternaries. In the same way, unchannelled valley-bottom wetlands occur more frequently in the upper reaches of a watercourse, with 18.6% of the wetland area on the Matla property, as opposed to 0.2% of the wetland area in the two quaternaries. This makes the management of these wetland types on the Matla property all the more important, as they represent a substantial part of the land surface suitable for the formation of these wetland types. The absence of channelled valley bottom wetlands and floodplain wetlands from the Matla site indicates that these occur lower down in the catchment where the watercourses are generally larger and likely to carry higher flows during flood events. This spatial separation of wetland types based on the geomorphology, which tend to be related to position of the site in the catchment, should be noted in the delineation of wetlands on site and related to the wetlands in the surrounding area in order to develop a plan for conserving the diversity of wetland types.

Table 31 below indicates measures to be taken to protect these wetlands. Definition of the wetland types is provided by SANBI (2012). In addition, note should be taken of the level of threat to which each wetland type is exposed when planning conservation measures. Figure 31 illustrates this level (from Nel and Driver, 2011). In all cases, wetlands on Eskom property should not be seen in isolation, but should be reviewed and managed together with those upstream and downstream as part of the whole ecosystem. This is particularly important when the wetlands are continuous with those on neighbouring properties.

Table 31: Measures that are to be taken to protect the Matla wetlands

Wetland type	Measures to conserve/protect the specific type
Depression	– The catchment area of depression wetlands is normally local and, as far as possible, this should not be disturbed by developments that will change the hydrology‡. In some cases, the catchment may extend beyond the immediate vicinity and this should be taken into account. – Sediment-generating activities should be avoided as far as possible, but where these cannot be avoided, sediment generation should be controlled. – Buffer zones should be respected. – Where depression wetlands are important to the biodiversity of the general area, such as loafing areas for waterfowl, disturbance around the wetland should, as far as possible, be minimised.
Flat	– Ensure that channels do not form in the wetland. Possible causes of channels may be cattle paths or vehicle tracks. This is particularly important near their edges as the formation of such a channel could drain the wetland, causing the erosion of the wetland. – Maintain the hydrological regime. ‡ – Avoid cultivation of flats.
Seep	– Hillslope seeps provide better grazing than surrounding areas and care should be taken to avoid the development of paths which may lead to erosion. – Care should be taken not to interrupt the passage of the interflow which feeds the seep. ‡ – Care of the upslope areas will ensure that the seep continues to deliver ecosystem service benefits. – Diffuse flow of water through the wetland should be maintained. ‡
Unchannelled valley bottom	– Care should be taken not to disrupt the hydrology. In particular, roads or paths constructed across unchannelled valley bottoms should be designed to maintain the diffuse flow of water through the wetland and avoid channelling of the flow. ‡ – Any interventions in unchannelled valley bottom wetlands should be designed to allow for the passage of migrating fauna.
Valley head	– Diffuse flow of water through the wetland should be maintained. ‡ – Avoid disturbance of the surface both within and upslope of the wetland ‡ – Care should be taken not to interrupt the passage of the interflow which feeds the seep. ‡

‡ Some examples of interventions which may change the hydrology. Culverts under a road concentrate the flow and may cause channels to develop with associated erosion problems. Cattle paths or vehicle tracks can channel water which may give rise to erosion. Cultivation destabilises the wetland and alters the hydrological characteristics.

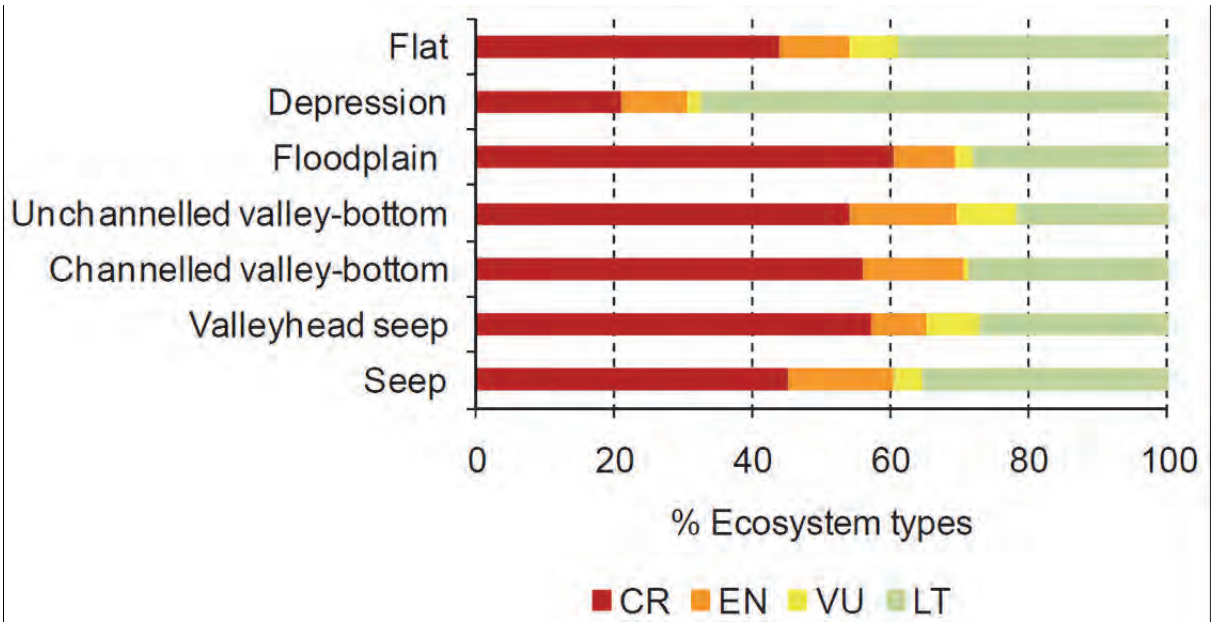


Figure 31: Level of threat to which various wetlands are exposed in South Africa (Nel and Driver, 2011). CR = critically endangered; EN = endangered; VU = vulnerable; LT = least threatened.

4.5 WETLAND ECOSYSTEM SERVICES

For the purposes of the catchment perspective, it is important to note that the wetlands identified above provide specific ecosystem services and that the protection of these services should be incorporated in to the WMP for Matla PS.

Brief background that will lay the basis of integrated wetland management from a catchment perspective

Wetlands are an important part of the aquatic ecological infrastructure which, in turn, is part of the landscape which delivers the basket of ecosystem services to the socio-economy. For the purpose of the benefits derived by the socio-economy they should be viewed and managed as an integrated whole, not be viewed 'piecemeal' from other wetlands (or ecosystems) in the catchment, but should be seen as a whole system delivering a complete set of services. Three of the four power stations selected for case studies are situated in the Olifants catchment. The following paragraph is extracted from the Kusile Wetland Management Strategy (Harris et al., 2013), who also undertook the economic component of the DWA study for the Water Resource Classification of the Olifants Water Management Area.

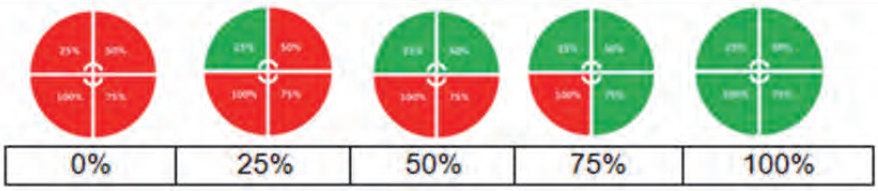
Wetland habitat in the Wilge Catchment (a tributary of the Olifants River) is important because it is a component of the ecological infrastructure comprising the aquatic ecosystem of the Olifants River Catchment. DWA (2012) estimated that the value of aquatic ecosystem services (within which wetland ecological infrastructure plays an important role) was approximately R3 billion per year. Moreover, more than 55% of the GDP contributing sectors in the Olifants River Catchment are directly dependent on water use licenses. The economy and people of the Olifants River Catchment are thus highly dependent upon the water resources of the catchment.

4.6 STATUS OF WETLAND MANAGEMENT AT MATLA PS

The following section provides an overview of the current status of wetland management at Matla PS. The information is based on findings of the site visit as well as discussions and a workshop with relevant personnel of the PS.

The research team compiled a checklist of critical points in order to evaluate the status quo. The checklist and the findings of the application of the checklist are provided below in Table 32.

Table 32: Findings of the Matla PS site visit with reference to critical elements of the WMF

Focus area	Criteria	Status
General	A Wetland management strategy/plan is in place	
	Wetlands have been delineated; buffer zones assigned and demarcated as no-go zones. . Relevant legal requirements are adhered to (e.g. water use license conditions)	
	Wetland health has been assessed and an understanding is in place with regards to ecosystem services. Measures are taken to protect/restore wetland health. Measures have been put in place to safeguard wetlands to protect Eskom's water resources Wetlands are monitored based on a predefined set of risk indicators	
	An analysis has been done to understand livelihood dependency	
	Wetlands from a catchment perspective have been analyzed in order to understand the relative importance of wetland on site. Active measures are put in place to promote wetland conservation in the catchment	
		

Based on the aforementioned it became evident that a wetland management plan, based on the WMF, for Matla would need to be developed. The environmental staff at Matla have limited expertise related to wetlands and have expressed a need for such a document.

The suggested vision for Matla PS is related to Figure 32 below, viewing wetlands as a continuum of ecosystem services, with Eskom on the receiving end as well as fulfilling its obligations to downstream users to continue receiving ecosystem services from wetlands.

Essentially, the WMP should address the following fundamental questions:

- Where are the wetlands on Matla's property and what is their health status? How do Matla's activities impact on the flow of ecosystem services?
- Is Matla compliant with all wetland related legislation?
- What is the broad picture with reference to wetlands in the catchment within which Matla operates? How does the status of these wetlands impact on ecosystem services received by Matla? And how do Matla's activities impact on the status of wetlands in the catchment?
- How might the situation change and values be lost (what threats apply)?
- What are the priority areas for intervention?
- What is the plan of action to manage, restore, improve and/or sustain wetlands?
- Who are the role-players that should be involved and how will progress be measured?

Based on the aforementioned starting point, the WMP for Matla PS is unpacked in the sections below and indicated relevant actions that must be taken by Matla PS's personnel.

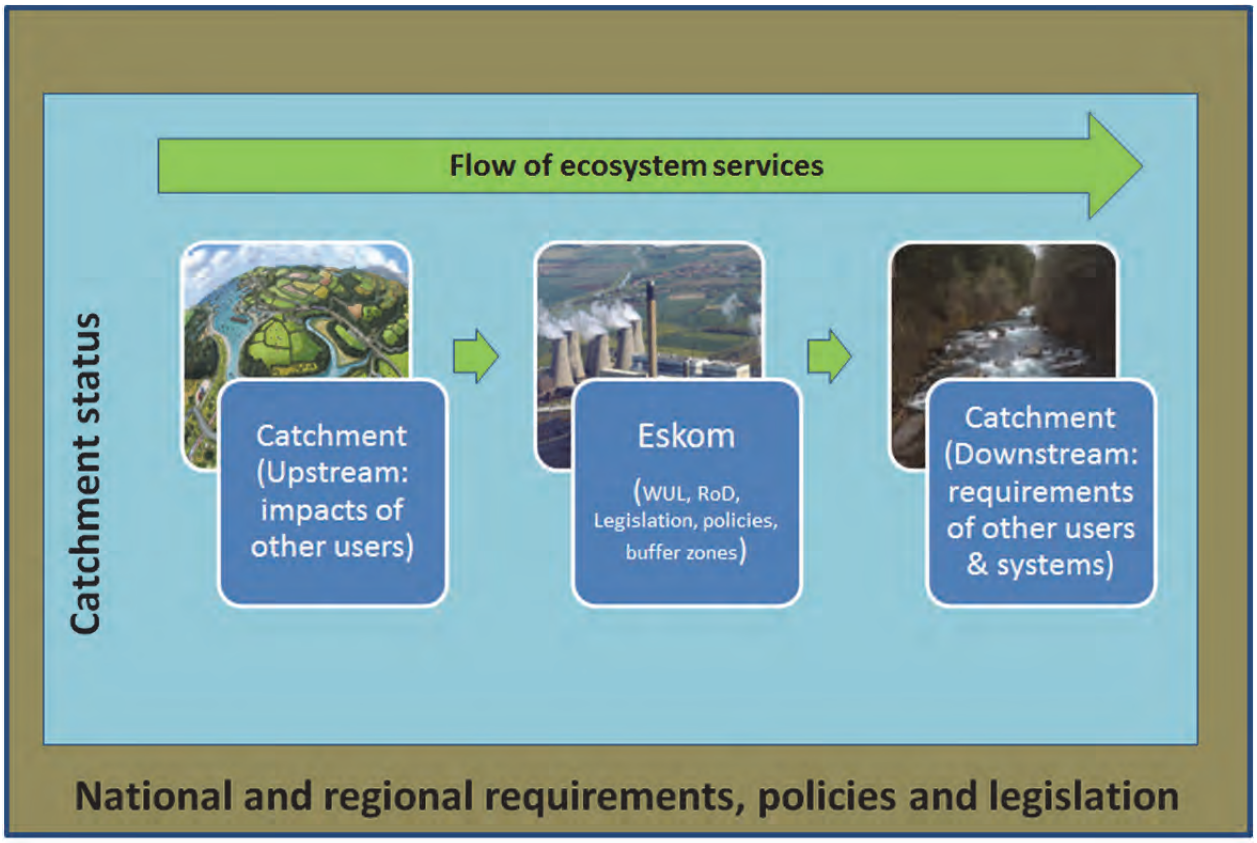
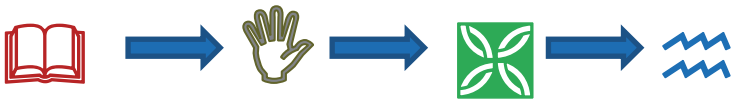


Figure 32: A conceptual overview of the approach to the WMP for Matla PS

Based on Figure 32, a process flow for the compilation of a WMP for Matla PS is provided below.

The process has to start off with wetland identification and delineation in order to compile a wetland inventory. Based on the proposed implementation sequence (as indicated below), actions has been set based on a phased approach.



*RWQO = Resource Water Quality Objectives

Figure 33: Step by step development of generic wetland management plan for Matla PS (Starting at the bottom and being influenced by the WMF from the top)

Table 33: The WMP for Matla PS

	Category of action	Sub actions	Description/Remarks	Relevant organisational element	Indicator
	Phase 1: Preparation, Status Quo Analysis on site and Action Plan #1 ***Outcome: Preserve the status quo on site***				
1	Vision		Compile a suitable vision and obtain the buy-in from top management at the PS. A draft vision has been included in the WMF which could be considered.	Communication Corporate reporting	Signed vision certificate by the general manager displayed at the entry point
2	Delineate wetlands on site	Determine boundaries of proposed assessment area (e.g. transmission related infrastructure) Delineate all wetlands and their hydrological zones. Understand and describe the flow of water through the landscape on which wetlands are dependent to ensure that flows can be maintained. Allocate appropriate buffer zones Comprehensively describe ecosystem services, including those provided by artificial wetlands Determine wetland health status Identify risks and threats including those originating from nearby properties	Ideally, wetlands should be delineated and assessed by a wetland management specialist. Obtain a GIS supported map of the site (including the shapefile data)	Supply chain management Financial systems Data and Information management Skills development Communication Corporate reporting	Detailed wetland map indicating wetland hydrological zones, types and buffer zones Markers set out on site to indicate the buffer zone boundaries Wetland health chart for each individual wetland

	Category of action	Sub actions	Description/Remarks	Relevant organisational element	Indicator
		Understand the range of sensitive plant and animal species associated with wetlands on site Investigate any opportunities to reinstate/maintain connectivity with adjacent natural areas Identify the need for rehabilitative actions Investigate and describe carbon sequestration and carbon management potential			
3	Wetland Inventory		Compile comprehensive wetland inventory including HGM type, health status, ecosystem services, buffers, impacts, risks as well as livelihood dependency, carbon storage potential and surface area requiring rehabilitation	Environmental Management Systems	Wetland inventory supported by GIS functionality
4	Legislative review		Review all wetland related conditions and requirements with reference to: Water use license Records of decision Provincial and national legislation and policies	Environmental Management Systems	Legal register with a focus on wetlands compiled
5	Interim site specific objectives and targets		Set site-specific objectives and targets to ensure the immediate demarcating of wetland areas and required	Environmental Management	Interim action plan

	Category of action	Sub actions	Description/Remarks	Relevant organisational element	Indicator
			management actions, including a planned and regular review of progress. It is also suggested that a specific wetland management document control system and management-tracking tool be developed to keep track of progress and required as well as outstanding actions.	Systems Communication systems	
6	Operational fast tracking		Compile a best practice generic wetland management and incident management plan to enable maintenance of infrastructure onsite and cleaning-up spills, e.g. leaking water pipes, ash spillages	Communication Environmental Management Systems Governance Systems	Generic wetland management plan approved by DWA
7	Operational analysis	Illegal activities in wetlands Spillages and leakages Current operational procedures impacting routinely on wetlands	Analyse past records to understand the extent of the problem as well as the root causes. Analyse current procedures impacting on wetlands with a view to update these to avoid routine impacts	Environmental Management Systems Governance Systems Skills development	Root cause analysis of past incidences affecting wetlands Updated operational procedures
8	Training and awareness	Define target groups and training needs Develop training material Compile training plan	Ensure that all personnel on-site are aware of their responsibilities with respect to wetlands and the procedures that were created to manage and protect wetlands	Skills development	Training plan Training attendance register Training programs Training evaluation

	Category of action	Sub actions	Description/Remarks	Relevant organisational element	Indicator
					and feedback loop
9	Rehabilitation and mitigation		Compile a wetland rehabilitation strategy and plan Legal review of obligations related to rehabilitation. Agreement with DWA on rehabilitation procedures Commence with rehabilitation and mitigation of impacts		Wetland rehabilitation plan
Phase 2: Looking beyond the fence line ***Outcome: Integrated wetland management***					
10	Livelihood impacts		Understand which communities and individuals in the vicinity are reliant on wetlands for their livelihoods. Determine whether Eskom impacts in any way on the sustainability of their livelihoods Compile an action plan with mitigation measures Compile a proactive plan for the controlled use of resources on Eskom property where relevant	Governance Systems Supply chain management Financial systems Communication systems Stakeholder management	Livelihood action plan with mitigation measures
11	Catchment analysis: Total view		Review catchment wetland data and compare wetland surface areas and numbers with those under the control of	Supply chain management	Strategic analysis

	Category of action	Sub actions	Description/Remarks	Relevant organisational element	Indicator
			Matla PS. Understand the importance of Matla PS wetlands and the potential impact of wetland alteration at Matla on the flow of ecosystem services to and from the catchment Understand the RQO's and the role of wetlands	Financial systems Data and Information management	
12	Catchment profile upstream		Review threats to wetland integrity upstream of wetland PS, e.g. coal mining, erosion. Investigate potential impacts beyond the fence line which could disturb the hydrological regime of wetlands on Eskom's site and create the required partnerships and communication channels to ensure preventive actions.	Supply chain management Financial systems Data and Information management	Strategic analysis
13	Catchment profile downstream		Understand the needs of downstream users and the impact of Eskom activity on the flow of ecosystem services, e.g. altering the hydrological regime, creating artificial wetlands	Supply chain management Financial systems Data and Information management	Strategic analysis
14	Connectivity		Review ecological corridors to determine in which way site wetlands can serve as a connecting point. Take cognizance of neighbouring	Supply chain management Financial systems	Strategic analysis Action plan, targets and objectives.

	Category of action	Sub actions	Description/Remarks	Relevant organisational element	Indicator
			disturbances, such as mining activities, Compile action plan and demarcate the relevant zones as no-go areas.	Data and Information management	Demarcated areas
15	Prioritize site wetlands and interventions	Prioritise wetlands for protection based on the wider catchment picture, livelihood dependency and post-closure ecosystem services. Rehabilitation of degraded wetlands based on urgency.	Based on the following criteria, prioritise wetlands for intervention: – Illegal activities – Wetlands of importance from a representivity and biodiversity point of view – Degraded wetlands – Wetlands that might be affected by future expansions – Wetlands providing critical ecosystem services to Eskom in terms of water quality – Wetlands providing livelihood services to communities – Wetlands providing ecosystem services to attenuate externalities from Eskom's operations – Carbon sequestration and carbon management	Supply chain management Financial systems Data and Information management	Action plan, targets and objectives.
16	Prioritize catchment wetlands and interventions		Prioritise wetlands that could positively influence the quality of Eskom's water supply. Create partnerships to ensure ongoing protection and rehabilitation if	Data and Information management Communication	Action plan, targets and objectives. Partnerships

	Category of action	Sub actions	Description/Remarks	Relevant organisational element	Indicator
			required. Carbon sequestration and carbon management	systems Corporate reporting	created.
17	Wetland management plan update to include integrated wetland management actions		Set catchments specific objectives and targets to ensure protection and rehabilitation of wetland areas and livelihoods and the associated management actions Create the required partnerships	Environmental Management Systems Communication systems	Updated action plan reflecting a catchment and livelihood perspective Partnerships
Phase 3: Taking it a step further **Outcome: Engaging the supply chain, implement best practices and planning for closure**					
18	Supply chain interventions		Compile a list of critical suppliers in the procurement value chain with a view to include wetland management measures in contractual obligations	Supply chain management	Standard measures defined and incorporated in a generic contract
19	Planning for closure	Identify natural and artificial wetlands that may be affected once operations cease (e.g. reduced water flows to artificial wetlands) Define ways in which communities	Determine what the residual impacts will be on wetlands both on- and off-site. Review options for passive treatment (constructed wetlands for seepage	Financial systems Data and Information management Skills development	Inputs into closure planning

	Category of action	Sub actions	Description/Remarks	Relevant organisational element	Indicator
		can become involved in wetland management and job creation Residual risk Concurrent rehabilitation Carbon sequestration	control and water quality improvement Ensure that the creation of artificial wetlands is done purposefully and that a measure of sustainability is incorporated into its creation. Deposits sites are constructed with the end landform in mind in order that they can be concurrently rehabilitated without needing to reshape them at closure.	Measurement systems	
20	Alternative technologies	Constructed wetlands	Investigate options to install constructed wetlands to attenuate pollution from ash dams, seepage zones, contaminated run-off, sewage works, etc.	Supply chain management	Strategic analysis
	Do not forget the basics as part of every phase: ***Outcome: Ensuring data management, monitoring, consistency, evaluation and updating the WMF***				
A.	Data and Information management		Create a repository for data in order to abstract meaningful information related to wetland management	Data and information management	Data and information plan and procedures
B.	Audit protocols and checklists		Compile audit protocols and checklist to ensure that wetland monitoring are comprehensive and effective Ensure that risk based measures are included	Environmental Management Systems Governance Systems Skills development	Audit protocols and checklists

	Category of action	Sub actions	Description/Remarks	Relevant organisational element	Indicator
C.	Training and awareness	Define target groups and training needs Develop training material Compile training plan	Ensure that all personnel on-site are aware of their responsibilities with respect to wetlands and the procedures that were created to manage and protect wetlands Ensure that communities are educated with respect to wetland protection and management	Skills development Supply chain systems	Training plan Training attendance register Training programs Partnerships with NGO's to provide community awareness
21	Monitoring	Targets and objectives Roles and responsibilities Time frames Budgeting and procurement Skills development Indicators for monitoring purposes Feedback loops to update WMP and WMF as well as effectiveness of training	Compile a comprehensive SMART action plan to monitor identified priorities and interventions	Environmental Management Systems Governance Systems Skills development	Completed action plan communicated to and accepted by role players

4.7 PILOT PHASE: CONCLUSION AND RECOMMENDATIONS

The pilot phase of the project found that the selected sites for implementation of the WMF are not ready to adopt the plan in full, due to the absence of basic information, such as the delineation and demarcation of wetlands in site.

Eskom personnel are positive in their support for the WMF. During our communication with the various personnel on site, the main problems conveyed to the research team are:

1. Uncertainty with respect to the distinctions between natural and artificial wetlands and the management of these
2. Legislative uncertainty and the best way to solve operational problems associated with wetlands are hampering progress

With respect to the WMF, it was found that the framework is mostly comprehensive but that a few matters are to be included or strengthened in the WMF:

1. Addressing of legacy issues
2. Management of artificial wetlands
3. Closure management
4. Ease of implementation (for which purpose the WMP developed for Matla PS will be of assistance)
5. An overview of best practice tools to ensure effective wetland management.

5 THE CATCHMENT PERSPECTIVE

As described in Chapter 1, Eskom has a national footprint. Figure 2 shows the distribution of Eskom's infrastructure. The coal-fired power stations are concentrated on the Mpumalanga Highveld, and area rich in wetlands. Eskom also has approximately 30 000 km of power line servitudes covering the country. In addition to Eskom's own infrastructure, there is also other infrastructure which contributes to or supports the generation of power by the coal-fired power stations such as coalmines, some of which belong to Eskom, and interbasin transfers to provide the power stations with the water that they require.

Figure 3 shows the volumes of water moved between water management areas by interbasin transfers (IBT) in the Northeastern part of South Africa. These IBTs are managed by the Department of Water and Sanitation. Eskom is one of the beneficiaries of these IBTs, being a principle beneficiary in the areas which supply the coal-fired power stations.

The Department of Water and Sanitation are currently developing the water resource classification system (WRCS) for both the Olifants and the Upper Vaal WMAs. The role of the WRCS within the IWRM environment 'is to facilitate finding a balance between resource protection and resource development and utilisation. A complex institutional environment surrounds this process, both in terms of the systems and procedures of Integrated Water Resource Management (IWRM), and the division of roles and responsibilities between DWS and the Catchment Management Agencies (CMAs)'. This process will evaluate the trade-offs between the economic, social and ecological requirements for water in the river basin and will lead to the development of the allocation schedule, including the management class, the reserve, the resource quality objectives and the catchment management strategy. The WRCS forms part of the compulsory licensing process and the management class has significant implications for the allocation schedule.

Within the WRCS process and in addition to straddling more than a single WMA, Eskom's interests are both WMA-wide in catchments where there are a number of power stations and related activities such as coal mining as well as a local interest where the footprints of the individual power stations and other related activities are concerned. The sustainable environmental planning framework developed below takes these scales into account.

5.1 THE FRAMEWORK

The use of the frameworks

Two frameworks have been used to provide a basis for the development and testing of a sustainable environmental framework within the catchments where Eskom operates. The overarching framework employed is that developed by Anderies et al. (2004) which provides a structured process for assessing the robustness of the social-ecological system (SES) under consideration (Figure 34). The framework needs to address the robustness of the socio-ecological system. It also needs to be scale independent so that it may be used at scales varying between the local, on site, through the catchment and WMA scales to the scale of multiple WMAs. The framework developed by Anderies et al. (2004) meets these conditions. A description of the components of the framework is provided as well as a series of questions which will guide the user in using the framework.

In this case, the Resource (Box A, Figure 34) is bounded in terms of the ecosystem services it delivers from which the SES derives benefit as defined by the Millennium ecosystem Assessment (Figure 34).

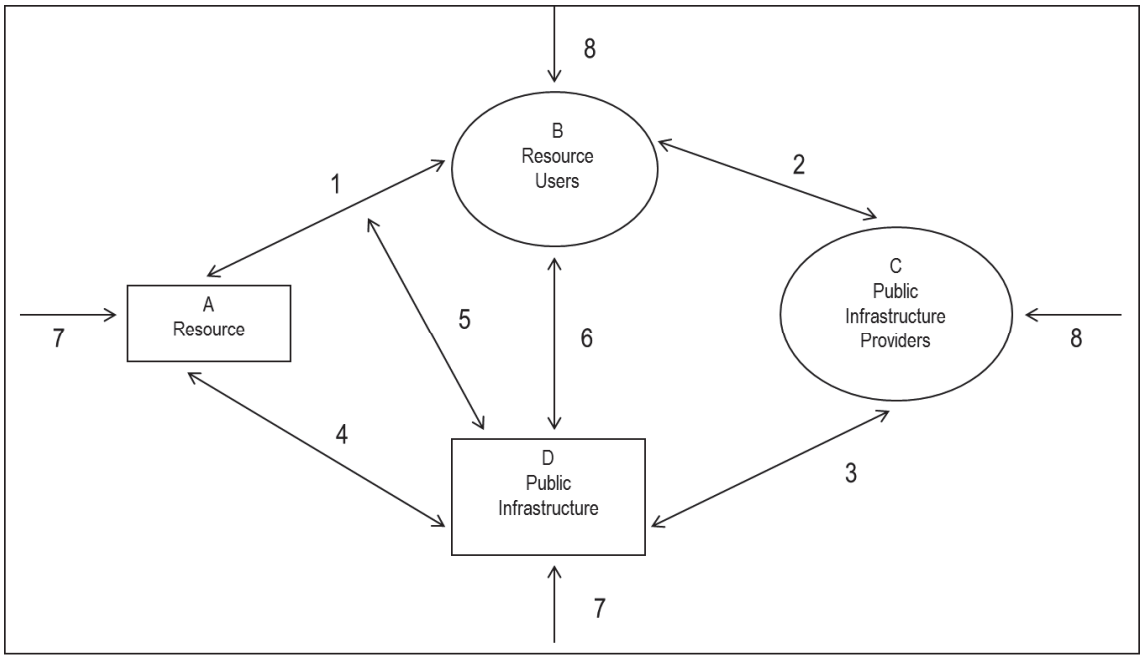


Figure 34: A Framework illustrating a social-ecological system as conceptualised by Anderies et al. (2004)

Description of the components for the Anderies et al. (2004) framework

(Taken from Hay et al., 2012): For ease of reference, this framework will be referred to as the Anderies Framework.

The arrows indicating the relationships between the entities of the framework are bi-directional, which takes account of the feedback from the interactions between the components of the framework.

Figure 34 explains the components involved in social ecological systems and in Table 35 the links between the entities.

Table 34: The entities involved in social ecological systems (from Anderies et al., 2004)

Entities	Examples	Potential problems
A. Resource	Water source Fishery	Uncertainty Complexity/Uncertainty
B. Resource users	Farmers using irrigation Fishers harvesting form inshore fishery	Stealing water, getting a free ride on maintenance Overharvesting
C. Public infrastructure providers	Executive and council of local users association Government bureau	Internal conflict or indecision about which policies to adopt Information loss
D. Public infrastructure (Physical)	Engineering works	Wear-out over time
D. Public infrastructure (Social – institutional rules)	Laws, conventions, etc.	Memory loss over time, deliberate cheating
External environment	Weather, economy, political system	Sudden changes as well as slow changes that are not noticed.

Table 35: The links between the entities of a social-ecological system (from Anderies et al., 2004)

Link	Examples	Potential Problems
(1) Between resource and resource users	Availability of water at time of need/availability of fish	Too much or too little water/too many uneconomic fish – too many valued fish
(2) Between users and public infrastructure providers	Voting for providers Contributing resources Recommending policies Monitoring performance of providers	Indeterminacy/lack of participation Free riding Rent seeking Lack of information/free riding
(3) Between public infrastructure providers and public infrastructure	Building initial structure Regular maintenance Monitoring and enforcing rules	Overcapitalization or undercapitalization Shirking disrupting temporal and spatial patterns of resource use Cost/corruption
(4) Between public infrastructure and	Impact of infrastructure on the resource level	Ineffective

Link	Examples	Potential Problems
resource		
(5) Between public infrastructure and resource dynamics	Impact of infrastructure on the feedback structure of the resource – harvest dynamics	Ineffective, unintended consequences
(6) Between resource users and public infrastructure	Coproduction of infrastructure itself, maintenance of works, monitoring and sanctioning	No incentives/free riding
(7) External forces on resource and infrastructure	Severe weather, earthquake, landslide, new roads	Forces a change of state in the resource and destroys infrastructure
(8) External forces on social actors	Major changes in political system, migration, commodity prices, and regulation	Conflict, uncertainty, migration, greatly increased demand

Questions to the components informing the Anderies framework

(Modified from Hay et al., 2012).

The questions are designed to help users of the framework to include the full complexity of the socio-ecological system (SES) in their assessment of the system with which they are working. All questions will not necessarily apply in every instance, but they are designed to provide insight into the dynamics of the system under consideration.

The resource (A)

- What are the ecosystem services of relevance to the SES?
- What are the asset base/ecological infrastructure that are providing these ecosystem services?
- What does it comprise? (What are its key biophysical features?)
- How big is it?
- How does it connect to other resources?
- What are its history and its significance to people living at or around it?
- Are there any obvious trends (focus on the resource)
- What is the status of the resource in terms of ecological integrity?

The users (B)

- Who makes use of the aquatic ecosystem services?
- Where are they from?
- What is the state (or states) of well-being of people using these services, how does the particular use affect the state, and are there any obvious trends?

The public infrastructure providers (C)

- Who is responsible for governing the system?

- What government departments, systems of traditional leadership and other agencies are involved?
- Who makes the rules or laws that dictate how people use the resource under consideration?
- Who supplies the infrastructure, services and equipment that allow the use of the resource under consideration?

The public infrastructure (D)

- What are the rules, conventions and norms that **govern use?**
- Are there formal rights of access that govern use?
- What infrastructure and services are in place to support use of the resource under consideration?
- The relationship between the users and the resource (Arrow 1)
- Who is using the resource?
- What is being used and what is it being used for? (What ecosystem services are being supplied by the system?)
- How important are the uses? (What is the contribution of various ecosystem services to the well-being of people in and beyond the system and at what scale?)
- How are the various uses changing over time and what is causing these changes?
- How are the various uses organised and allocated to people? (What property rights regime is in place for each ecosystem service?)
- How does one use of the system affect another use or other uses of the system? (Are there conflicting or contradictory property rights regimes in place?)
- How are the uses of the system affecting its health? (What is the impact of use on the ecosystem?)
- Are there potential uses that have been thought of that would benefit people but are not being used?
- How would these potential uses benefit people?
- What is the trajectory of change? (rapid, slow, gradual, erratic, large spatial scale, small spatial scale)

The relationship between users and public infrastructure providers (Arrow 2)

- How are rules of use made?
- How is infrastructure and service delivery planned and implemented?
- How are decisions recorded and circulated?
- Do the users play a role in making decisions? If so, how does this happen?
- Does the system work?
- What are the problems that are encountered?
- How might these problems be solved?

The relationship between public infrastructure providers and public infrastructure (Arrow 3)

- How do the governors make the rules?
- How do the service providers plan the infrastructure and service delivery?
- Are rules monitored and regulated? If so, how?
- How does maintenance of infrastructure and services take place?

The relationship between public infrastructure and the resource (Arrow 4)

- What impact are the rules having on resource levels/condition?
- What impact are the physical infrastructure and services having on resource levels/condition?

The relationship between public infrastructure, and the resource and the users (Arrow 5 and 6)

- Do the users think that the rules of use are fair?
- Do the users think that the infrastructure and services are adequate?
- Are the users involved in making the rules, and managing and governing the system?
- Are the users involved in developing and maintaining infrastructure and services?

The impact of external driving forces on any component or any relationship within the system (Arrows 7 and 8)

- What are external forces impacting on the system?
- How are they impacting on the system?
- How are they affecting people's well-being?

The Millennium Ecosystem Assessment Framework

The Millennium Ecosystem Assessment (2005) provides insight into how ecosystem services contribute to human well-being (Figure 35). In this case study the Resource is defined in terms of the ecosystem services it delivers. This definition integrates the ecosystem services from which the SES derives benefits with the health of the ecological infrastructure which provides these benefits. While this approach is still being developed, the concept is helpful because it relates easily to the way in which people interpret their use of resources. The relationship between ecosystem services and human wellbeing is illustrated in Figure 35.

The framework illustrated in Figure 35 is useful in that it attempts to explicitly link ecosystem services to the various constituents of well-being. However, the starting point in this framework is the ecosystem service supply, not the well-being of the resource users. To quote Fish (2011) "*Advocates of the ecosystem services framework need to develop a more elaborate understanding of how a rich and variegated term such as 'well-being' maps back onto the services that nature provides."* There is a need to appreciate the demand for the ecosystem services and understand how the demand will influence the development of the resource.

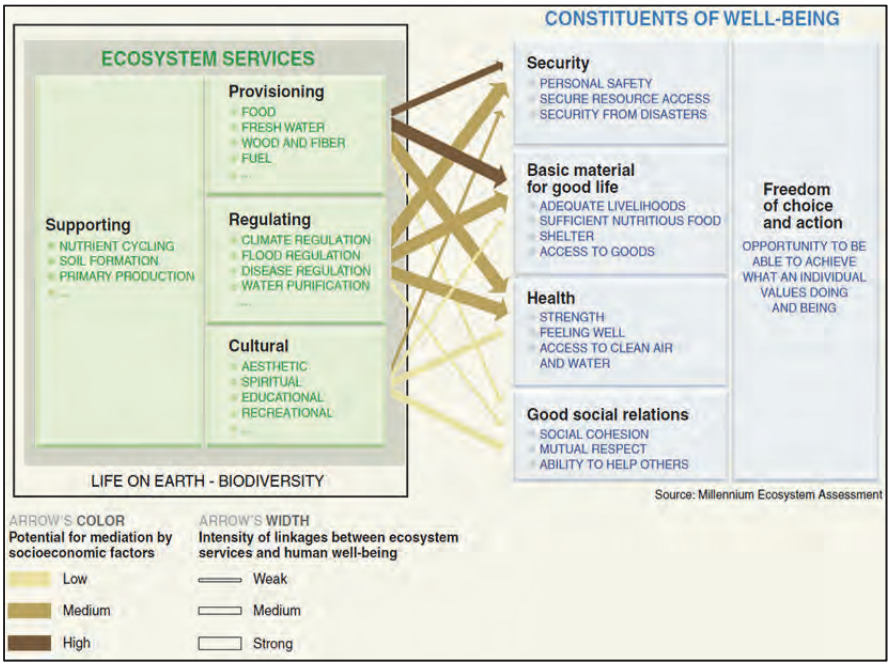


Figure 35: The relationship between ecosystem services and well-being as conceptualised in the Millennium Ecosystem Assessment (from MA, 2005:vi)

A description of ecosystem services is given in Section 3.9 above.

- **Eskom's input into the Frameworks**

This section provides information on how Eskom's activities will impact each of the four components of the Anderies Framework. When populating the framework, this information needs to be considered in conjunction with the answers to the questions (Section 29.2 above) which will provide input on the activities of other users in the catchment in addition to Eskom. Eskom's interaction with the resource component (Figure 37, Box A) is addressed in Table 36-Table 40 below. Eskom's position as a resource user (Figure 37, Box B) is addressed in Table 41. Eskom's relationship with the public infrastructure providers (Figure 37, Box C) is addressed in Table 42 and the interactions with the public infrastructure (Figure 37, Box D) is addressed in Table 43.

Below each of Table 36-Table 43 is a brief explanation of the activities identified in the table. This explanation provides direction for each of the activities together with references where these are relevant and helpful.

The components of the socio-ecological system have been colour coded for ease of use in the tables below

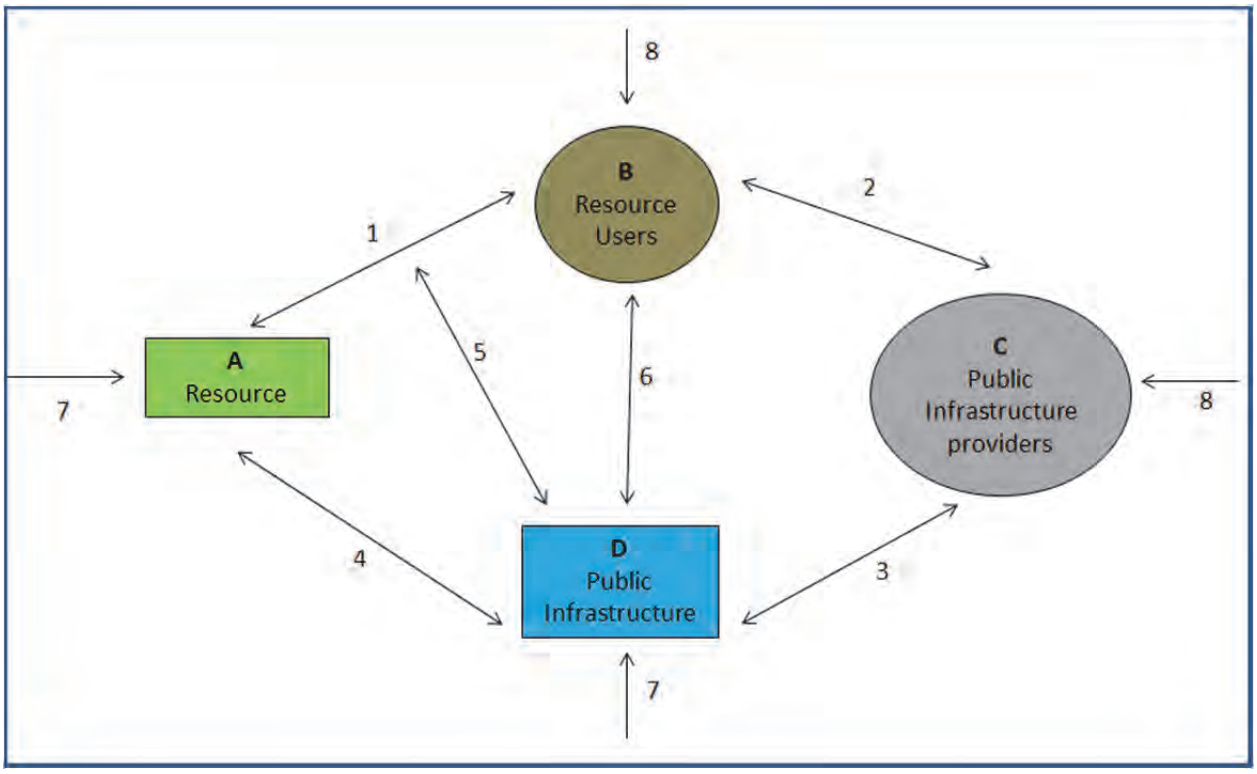


Figure 36: The colour coded elements of the SES for ease of reference

5.2 THE RESOURCE – DEFINING ESKOM'S INTERFACE

Table 36: Eskom responsibilities for planning sustainable management of the water resource upstream of the power station

Geographical Position **Upstream**		
Issue	**Eskom Head Office responsibilities**	**On-site responsibilities**
A. Inter-Basin Transfers	• Through the activities of the DWA ensure that the water quality and quantity of the donor catchments, wetlands in particular, are protected • Ensure there is adequate protection against the import of invasive flora and fauna	• Implement water conservation and water demand management measures to reduce water use
B. Mining operations	• Ensure that Eskom's water management policy is given effect as appropriate • Work with the upstream stakeholders through the DWA structures (CMF, WUA) to ensure that the RWQOs (and RQOs when promulgated) are met	• Ensure that the supply chain (mines supplying power stations with coal) comply with their environmental authorisations and conditions of their water use licence • Acid mine drainage (AMD) is a widespread cause of water quality deterioration in coal mining areas. AMD should not be released into the environment. o In cases where a mine in the Eskom supply chain has closed and is releasing AMD, *measures should be instituted to prevent decanting and/or institute water treatment technology. The treated water should ideally be used to supplement water used in Eskom's operations, thereby reducing the water demand on other catchments from which water is transferred.*
C. NFEPA wetlands and key ecological infrastructure	• Are there any NFEPA wetlands/rivers or other important or sensitive water resources in the catchment? • What is the ecological status of these wetlands and how do they contribute to water quality and the	• Develop management plans for wetlands on Eskom properties to improve system functionality

Geographical Position Upstream		
Issue	**Eskom Head Office responsibilities**	**On-site responsibilities**
	provision of other ecological services in the catchment? If required, assist with wetland protection and rehabilitation.	
D. Maintain habitat continuity	• Look at and align activities with biodiversity conservation plans and other GIS layers highlighting strategically important and sensitive water resources.	• Maintain continuity and water and biodiversity corridors linking with neighbouring wetlands

Geographical Position

Upstream

A. Inter-basin transfers

Eskom Head Office responsibilities

Make input into the WRCS of the donor catchments to ensure that the water resource (both quality and quantity) is assured. In particular, make sure that the ecological infrastructure, wetlands in particular, are adequately protected so that they may sustainably provide the ecosystem services required of them in the face of future developments.

Do what is possible to minimise the transfer of undesirable flora and fauna by means of the inter-basin transfer.

On-site responsibilities

Water conservation and water demand management measures should be implemented in order to reduce the volume of water used by the PS.

B. Mining operations

Eskom Head Office responsibilities

Eskom's water management policy lists a number of areas where Eskom's activities interact with the environment. The policy should give guidance to these interactions.

Seek to influence upstream stakeholders, in terms of the UN CEO Water Mandate, to work together through the structures provided by DWA and others as relevant to ensure that the water resource is

protected for the long term in the face of current mining developments as well as those which may occur in the future.

On-site responsibilities

Work together with the environmental managers of the mining houses in the power station's supply chain to ensure that the necessary environmental authorisations and water use license are in place and that the mines are complying with them. This should be done both with Eskom-owned mines as well as those owned by other companies but which supply Eskom.

Acid mine drainage (AMD) is a widespread cause of water quality deterioration in coal mining areas. With mines that are active, effective steps should be taken to prevent the release of AMD into the environment (there are technologies to treat AMD). Eskom should investigate and implement combined active and passive treatment of AMD. The possible re-use of treated AMD either on the coal mine or power station should be investigated.

Eskom should ensure through their contract with their suppliers that the mine abides by its environmental authorisations and water use license during its life and that, upon closure, there is adequate financial provision for rehabilitation and post-closure management.

C. NFEPA wetlands and key ecological infrastructure

Eskom Head Office responsibilities

Ensure, working through the stakeholder structures provided by DWA, that NFEPA wetlands are identified and adequately protected.

Determine the contribution of wetlands in the donor catchment to water quality and hydrology. Where necessary, assist with the conservation and rehabilitation of wetlands in donor catchments. As not all land is government owned there is an opportunity for Eskom to enter into arrangements with landowners for the payment of ecosystem services through which landowners are assisted for maintaining ecological infrastructure in a healthy state.

On-site responsibilities

Where wetlands identified through the NFEPA process occur on Eskom property, these should be noted in the particular management plan for the power station.

D. Maintain habitat continuity

National office responsibilities

Ensure the protection of ecological and water corridors linking water resources to ensure ecosystem process and patterns are maintained.

On-site responsibilities

Maintain continuity of habitat in the linear drainage lines through buffer zones and biodiversity corridors.

Resources

Driver et al., 2011.

Kotze et al., 2009.

Table 37: Eskom responsibilities for planning sustainable management of the water resource on the power station site

Geographical Position **On-site**		
Issue	**Eskom Head Office responsibilities**	**On-site responsibilities**
A. Protection/ rehabilitation of wetlands on-site	• Pro-actively develop and implement a suitable EMS as an avenue for water resource management • Recognise that all the power stations in a particular catchment are subject to the same overarching DWA requirements and structures o Need to provide effective representation at WUA and CMF level o Need to ensure compliance with the WRCS of the catchment o Need to provide training for on-site personnel where required • Focus activities on wetlands that are in a poorer condition (harder working)	• Assess wetlands through the lens of the ecosystem services they provide Wetland specialist – to be contracted to perform the following functions • Wetland delineation • Buffer zone delineation o Demarcate the edges of the wetlands and buffer zones so that operations personnel can avoid these areas • Biodiversity corridor where necessary • Assess the wetland health • Determine present ecological state (PES) and ecological importance and sensitivity (EIS) • Identify the presence of NFEPA wetlands on site and in the quaternary catchment • Assist in identifying the ecosystem services provided by wetlands on site

Geographical Position On-site		
Issue	**Eskom Head Office responsibilities**	**On-site responsibilities**
		Working for Wetlands • Lead/help with the identification and planning of rehabilitation and the rehabilitation itself. This will probably need to be funded by Eskom. Environmental Manager • Plan and budget for on-going maintenance of ecological infrastructure • Conduct routine monitoring within the framework of strategic adaptive management (SAM) to monitor the following: o The condition of wetlands on site. The condition of these wetlands should not be allowed to deteriorate, but should preferably improve to the level stipulated in the WRCS. The indicators given in the Oberholster et al. (2014) health and risk assessment guide should be used for this. o The monitoring should indicate the level of compliance with authorisations o Ensure that other activities do not compromise wetland integrity

Geographical Position **On-site**		
Issue	**Eskom Head Office responsibilities**	**On-site responsibilities**
		• Identify opportunities for improving wetland services on site (such as constructed wetlands)
B. Buffer zones & biodiversity corridors	• Identify biodiversity corridors linking water resources in terms of process and pattern and set appropriate buffers to protect these processes. • Biodiversity buffer zones and corridors need to be included in the planning of new infrastructure.	• During site development biodiversity buffer zones and corridors need to be included in the planning • Ensure that the integrity of buffer zones and biodiversity corridors are not compromised through construction or any other activities
C. Livelihood opportunities	• Identify livelihood opportunities in the catchment and how Eskom holdings may contribute to these	• Are there opportunities for contributing to the livelihood of rural people?
D. Comply with requirements of the WUL and EA	• Ensure that the Eskom water management policy is actioned on all sites • Provide training and other support as required	• Ensure that all personnel and contractors know and understand the conditions of the WUL and abide by these • Ensure that the required monitoring of ground and surface water is in place and that the reporting procedures are complied with
E. Zero liquid effluent discharge (coal stockpiles and ash dam	• Give effect to the water management policy • These aspects are to be included in the planning of new infrastructure	• Ensure that runoff from hard surfaces of the power station are appropriately contained and treated for reuse in terms of the policy of Zero Liquid Effluent Discharge

Geographical Position **On-site**		
Issue	**Eskom Head Office responsibilities**	**On-site responsibilities**
discharge)		• Hydrocarbons, from whatever source, should not be released into the environment
F. Incident reporting procedure	• Analyse incidence data in order to identify underlying cause and effect and institute corrective measures • Ensure that training is provided on reporting procedures	• Ensure that incident reporting procedure is in place and that the relevant staff understand and comply with it as required by the WUL and other authorisations
H. Eskom's position	• As signatory to the UN CEO Water Mandate and as a major water user in the area, Eskom is in a position to take the lead in the management and protection of ecological infrastructure • Give effect to the Eskom water management policy • Review relevant catchment reports to monitor trends and identify opportunities for positive interventions	• Find ways to practice the UN CEO mandate aims and objectives on site • Give effect to the water management policy

Geographical Position

On-site

A. Protection/rehabilitation of wetlands on-site:

Eskom Head Office responsibilities

All the power stations in a particular catchment are subject to the same overarching water resource management requirements and structures. Eskom Head Office should develop and implement an environmental management strategy for their holdings to ensure that there is consistency in environmental management across all their activities.

A key change introduced in the National Water Act (Act 36 of 1998) is the change to Integrated Water resource Management (IWRM). *'A key aspect of IWRM transformation in South Africa is the progressive decentralisation of many of the responsibilities and authority for water resources management to CMAs and assisted by, at a local level, Catchment Management Committees, Water User Associations and Catchment Management Forums. These responsibilities relate mainly to allocatable water within the WMA'* (DWAF, 2007:16).

The water quality and quantity requirements are spelt out for each water management area (WMA) in the Water Resource Classification Process (WRCS; Described above under Section 2 XY. National Policy and Legislation).

The catchment management agency (CMA) is tasked with developing the catchment management strategy (CMS) for each WMA and the WRCS is developed by DWA.

As the CMS and the WRCS for any one WMA will apply to the entire WMA it is in the interests of the Eskom Head Office to provide effective representation in these processes and to ensure that on-site personnel are familiar with what is required of them.

DWA recognise that some wetlands are in a poorer condition (harder working) than others. The focus of activities on these will maintain the overall quality of the ecological infrastructure in better condition and also mean that mitigation or offset interventions will be more cost effective.

On-site responsibilities

Wetlands should be assessed through the lens of the ecosystem services that they provide. The wetland specialist will be able to assist with this. As far as is possible, the cumulative effects of the impacts on wetlands and the services they deliver should be assessed.

Wetland specialist: One of the conditions routinely required in the water use license applications are that wetlands are delineated. The task needs to be undertaken by a consultant specialising in wetland

delineation, often in conjunction with a soil specialist. It is a requirement of wetland conservation that buffer zones around the wetlands are also demarcated. During the construction phase it is necessary to mark the edge of the wetlands/buffer zones to prevent accidental disturbance of the area. One of the many functions of the buffer zone is to protect biodiversity. Where necessary, the on-site protection of biodiversity may also require corridors of undisturbed habitat through which to move between wetlands. While the wetlands specialist is on site they should assess the health of the wetlands following the methods of MacFarlane et al. (2008). Oberholster et al. (2014) should be used by the environmental manager to monitor for changes in the wetlands. If the Present Ecological State (PES) and the Ecological Importance and Sensitivity (EIS) have not been determined, this should be done by the wetland specialist while on site as this is a requirement of the WUL application process. The wetland specialist should also identify any NFEPA (National Freshwater Ecosystem Priority Area) wetlands that are on site and in the quaternary catchment. These areas require special conservation. The wetland specialist can also assist in identifying the ecosystem services which the wetlands on site are delivering.

Working for Wetlands: If there are wetlands which need to be rehabilitated, plans should be made to do this. This should ideally be done in conjunction with Working for Wetlands. Working for Wetlands is mandated to do wetland rehabilitation and so with their help the necessary environmental authorisations will be more easily obtained. Neighbouring landowners with wetlands to be rehabilitated may be approached. In this way the area of wetlands to be rehabilitated may be increased.

Environmental manager:

The environmental manager should plan and budget for the on-going maintenance of ecological infrastructure.

On-site monitoring: Through the process of strategic adaptive management (SAM) the environmental manager should ensure that the condition of wetlands on-site does not deteriorate, but preferably improves. The indicators in Oberholster et al. (2014) should be used and be guided by the WRQO or REC of the reserve used during the WUL authorisation. The monitoring done within the SAM process should indicate the level of compliance with wetland management requirements and that construction or any other activities do not compromise wetland integrity. If there is an opportunity for constructed wetlands to enhance the ecosystem services, the feasibility of this option must be investigated.

B. Buffer zones & biodiversity corridors

Eskom Head Office responsibilities

Ensure the protection of ecological and water corridors linking water resources to ensure ecosystem process and patterns are maintained.

Planning for the protection of ecological and water corridors linking water resources to ensure ecosystem process and patterns should be included in the planning of new infrastructure.

On-site responsibilities

While the wetland specialist is on site delineating the wetlands, ensure that the correct buffer zones are also delineated for the appropriate objectives. Buffer zones are currently the subject of a DWA/WRC research project and the guidelines from this should be followed. Buffer zones need to be included in the initial planning.

In certain instances it may be necessary to delineate and protect biodiversity corridors. It is recommended where there is a need for this that it be done at the same time as the wetland delineation by the wetlands specialist. The biodiversity corridor should then be marked in the same way as the wetlands and construction/operations personnel should be informed of its presence and should avoid disturbing it.

C. Livelihood opportunities

Eskom Head Office responsibilities

In conjunction with other stakeholders and through the existing structures, livelihood opportunities from wetlands may be identified and where feasible these may be developed and/or supported.

On-site responsibilities

Where wetlands on Eskom property provide the opportunity for livelihood provision, these should be identified and the feasibility of developing the opportunities be investigated.

D. Comply with requirements of the WUL

Eskom Head Office responsibilities

Ensure that environmental officers are up to speed with the requirements of water use licence and that they are adequately supported in their efforts to comply with the WUL.

On-site responsibilities

All personnel and contractors on site need to abide by the requirements of the WUL in order to ensure the power station's compliance.

The environmental officer needs to design and implement monitoring of the surface and groundwater as required by the WUL. The results should be submitted to the DWA in terms of the WUL.

Incidents on site should be reported as required by the WUL.

E. Runoff from hard surfaces, coal stockpiles and ash dam discharge (Water quality leaving the site)

Eskom Head Office responsibilities

Eskom's water management policy gives guidance to the management of water on-site.

On-site responsibilities

Hard surfaces alter the hydrology of an area, causing the peak discharge from a rainfall event to be more intense and of shorter duration than would be the case from a natural area. Runoff from power station premises should be managed in terms of the zero liquid effluent discharge policy. Runoff should be contained and treated to a quality suitable for recycling.

Potential sources of sediment should be treated to prevent, or at least substantially reduce, erosion. This will make the treatment for recycling more cost effective.

F. Incident reporting procedure

Eskom Head Office responsibilities

The incidents should be analysed to identify and then correct the underlying causes. It must also be reported to authorities and handled according to the authorised protocols and procedures.

On-site responsibilities

Ensure that incident reporting procedure is in place and that the relevant staff understand and comply with it.

H. Eskom's position

Eskom Head Office responsibilities

As signatory to the UN CEO Water Mandate and as a major water user, Eskom is in a position to take the lead in the management and protection of ecological infrastructure. Certain functions of this may be delegated to personnel on site while other functions may be better retained at the Eskom Head Office.

Give effect to Eskom's water management policy which lists a number of areas where Eskom's activities interact with the environment. The policy should give guidance to these interactions.

Catchment reports should be reviewed to identify trends in the catchment and where possible positive interventions may be implemented.

On-site responsibilities

Where aspects of the UN CEO Water Mandate have been delegated to PS personnel, they should seek opportunities to implement these.

Resources:

Cox and Kotze, 2008.

DWAF, 2007.

Ellery et al., 2009.

Eskom (Undated) Wetland classification and risk assessment index. Published by Eskom

Kotze et al., 2009.

Macfarlane .2008.

SANBI and DWS, 2014.

Millennium Ecosystem Assessment, 2005.

SUDS – e.g. *http://www.sepa.org.uk/water/water_regulation/regimes/pollution_control/suds.aspx*

Turpie et al., 2009.

Table 38: Eskom responsibilities for planning sustainable management of the water resource downstream of the power station

Geographical Position **Downstream**		
Issue	**Eskom Head Office responsibilities**	**On-site responsibilities**
A. Water quality	• Ensure that personnel on site are familiar with the RWQOs for the catchment in which they operate • Ensure compliance with the zero liquid effluent discharge policy of Eskom	• Ensure compliance with the zero liquid effluent discharge policy of Eskom
B. Maintain habitat continuity	• Take buffer zones and biodiversity corridors to adjacent wetlands into account when planning developments	• Maintain continuity with neighbouring wetlands by active monitoring and management

Geographical Position

Downstream

A. Water quality

Eskom Head Office responsibilities

Ensure that environmental managers on site are supported in their duties to meet the RWQOs set for the catchment in which the power station is situated.

On-site responsibilities

Ensure that water leaving the site complies with the RWQOs (and the RQOs once set). Particular attention should be given to Persistent organic pollutants (POPs) and other power station-specific pollutants as certain of these are known health risks.

Maintain habitat continuity.

Eskom Head Office responsibilities

On-site responsibilities

Ensure that the planned buffer zones and biodiversity corridors are implemented.

B. Maintain habitat continuity

Eskom Head Office responsibilities

Habitat continuity, through buffer zones and biodiversity corridors, should be planned to link with similar habitats on neighbouring properties in order to preserve the attributes of the landscape.

On-site responsibilities

Maintain continuity of habitat in the linear drainage lines through the demarcation and protection of buffer zones and biodiversity corridors as appropriate.

Table 39: Eskom responsibilities for planning sustainable management of the water resource on transmission servitudes

Geographical Position **Transmission**		
Issue	**Eskom Head Office responsibilities**	**On-site responsibilities**
A. Crossing wetlands	• Limit crossings of sensitive water resources by avoidance or specific mitigatory measures must be implemented to reduce footprint impacts	• Ensure compliance with Eskom guidelines for crossing wetlands and water courses
B. Alien invasive plants	• Prevent and manage the spread of alien invasive species	• Remove alien invasive plants following the procedures of the relevant Eskom guidelines
C. Buffer zones and biodiversity corridors	• Ideally planning for distribution networks should be done jointly with conservation authorities leading to mutually supportive conservation opportunities • Commissioning of new distribution systems should (where possible) be aligned with provincial open space/biodiversity planning in an effort to supplement biodiversity corridors with power line servitudes. • The maintenance of power line servitudes serving as supplementary biodiversity corridors should take account of the migratory aspects associated with such a corridor, e.g. time of year when migration is taking place or escape routes during fires are provided	• Ensure that buffer zones identified are properly maintained and managed in terms of the objectives that they were set out to achieve

Geographical Position

Transmission

Eskom has developed best practice guidelines for maintaining transmission servitudes. The appropriate guidelines should be followed by teams working on servitudes.

In cases where areas of high ecological importance and sensitivity are present, the planning of distribution infrastructure should be aligned with conservation interests as well as provincial open space planning in order to supplement biodiversity corridors with Eskom servitudes. These servitudes should cater for the needs of the fauna which will use them.

Resources

Eskom's best practice guidelines as updated from time to time.(Anon,. 2010).

Table 40: Eskom responsibilities for planning sustainable management of the water resource in Eskom owned or managed mines

Eskom owned mines and Eskom purchase agreements		
Issue	**Eskom Head Office responsibilities**	**On-site responsibilities**
ESKOM-OWNED MINES A. Ensure compliance of mining activities with authorisations, e.g. WUL, EMP, etc.	• Give effect to the Eskom water management policy for both Eskom-owned mines and through the value chain • Advise on, and ensure that the necessary authorisations are applied for timeously. • Ensure that personnel are adequately trained in the implementation of government and Eskom's policies.	• Ensure that the necessary authorisations are in place following the procedure outlined in, for instance, Table 4 (impacts on wetlands are either avoided, mitigated or offset). • Ensure areas designated for conservation are protected and that operational staff respect this. • Implement a monitoring programme to gauge changes to wetlands during the operation of the mine.
ESKOM PURCHASE AGREEMENTS A. Expect and ensure compliance of suppliers in the supply chain	• Ensure that contracts with suppliers require that businesses in the Eskom supply chain comply with relevant legislation and authorisations. • Ensure that contracts with suppliers require that businesses in the Eskom supply chain comply with relevant Eskom policies, in particular the Eskom water management policy	• Ensure that businesses in the Eskom supply chain comply with conditions in their contract • Ensure that contracts with suppliers require that businesses in the Eskom supply chain comply with relevant Eskom policies, in particular the Eskom water management policy

Eskom owned Mines

Eskom Head Office responsibilities

Give effect to the water management policy at both Eskom-owned mines and throughout the value chain.

Ensure that the necessary authorisations (environmental and water use, etc.) are applied for timeously and that personnel who are to work on the mines know what is expected from them in terms of the legislation.

On-site responsibilities

Working with the relevant section in the head office monitor on-site operations to ensure that conditions set in the authorisations are complied with and that wetlands marked for conservation are not impacted.

Implement a monitoring programme to ensure that any changes to wetlands on the site will be picked up and managed.

Eskom purchase agreements

Eskom Head Office responsibilities

Contracts entered into between Eskom and their suppliers should require the suppliers to be fully compliant with the relevant legislation and authorisations.

On-site responsibilities

Environmental mangers should monitor, as far as possible, that Eskom suppliers comply with conditions of their contract.

Resources

Department of Environmental Affairs, Department of Mineral Resources, Chamber of Mines, South African Mining and Biodiversity Forum, and South African National Biodiversity Institute. 2013.

5.3 ESKOM AS A RESOURCE USER

Table 41: The CEO Water Mandate, with the focus on the goals for the period 2014-2015

<table>
<tr><td colspan="3">UN CEO Water Mandate
Strategic Plan 2014-2015</td></tr>
<tr><td>Mission Statement
(Extracts)</td><td colspan="2">• Mobilize a critical mass of business leaders to advance water sustainability solutions
• Forge multi-stakeholder partnerships to address the problems of access to water and sanitation.</td></tr>
<tr><td>Broad focus areas (2014-2015)</td><td colspan="2">• Overseen by the Mandates governance and accountability framework
• Supported by:
o Sustainable funding model
o Technology and communications</td></tr>
<tr><td colspan="3">Goals of the UN CEO Water Mandate for the period 2014-2015</td></tr>
<tr><td>Goal 1</td><td colspan="2">Growing to Greater Scale and Effectiveness Through Endorser and Key Stakeholder Recruitment and Engagement</td></tr>
<tr><td>1.1</td><td>Introduce effective recruitment strategies to achieve greater scale, especially via UNGC Local Networks (cross-referenced under Overarching Goal 2)</td><td rowspan="2">Expected Outcomes & Impacts
• Increased number of endorsers (for example, to 125 by end of 2014; to 150-200 by close of 2015) –
• Increased number of companies joining the UN CEO Water Mandate from underrepresented region, especially Africa, Latin America, and Asia –
• Improve number and quality of Mandate</td></tr>
<tr><td>1.2</td><td>Improve endorser and key stakeholder engagement capacity by enhancing internal operating capacity (i.e. Secretariat), further developing effective technology infrastructure (e.g. Mandate Website; Water Action Hub), and enhancing communication with endorsers and</td></tr>
</table>

	stakeholders (e.g. e-newsletter, etc.	Communications on Progress (COP), the primary accountability instrument for the initiative – • Increased number of non-business stakeholders involved in events, workstreams, and action areas (e.g. Water Action Hub) – • Convene annual events – e.g. Peru (April 2014), Stockholm (August 2014); Tel Aviv (2015), Stockholm (2015) – in addition to specialty convening and participation and other key water-related fora – e.g. U.S. Nexus event (Q1 2014)
1.3	Increase number of non-business stakeholders (e.g. civil society, UN agencies, governments, bilateral aid agencies, investors, foundations, universities, etc.) engaged in the initiative	
Goal 2	**Engaging UNGC Local Networks to Improve the Initiative's "Global-to-Local" Effectiveness/Impact**	
2.1	Actively work with UNGC Local Networks to incorporate Mandate in country-level activities (especially policy dialogues and working conferences) focusing on water and sanitation challenges	**Expected Outcomes & Impacts** • Increased number of Local Network convenings on the UN CEO Water Mandate and water stewardship, leading to implementation of best practices with positive local impacts • Increased number of organization registrations and project postings on Water Action Hub, facilitated and supported by individual Local Networks • Increased number of endorsers joining the Mandate from under-represented • countries and markets (cross referenced under Overarching Goal 1)
2.2	Encourage Local Networks to mobilize and facilitate the posting of projects on the Water Action Hub within their regions and countries	

Goal 3	**Advancing and Launching Priority Workstreams**	
3.1	Further advance work in existing UN CEO Water Mandate priority workstreams, with associated release and dissemination of key deliverables	**Expected Outcomes & Impacts** • Increased engagement in Mandate via relevant and useful resources, guidance and tools (reinforcing Overall Goal 1) • Dissemination of resources and tools to Local Networks (reinforcing Overarching Goal 2) • Increased understanding by policy makers of importance of corporate water stewardship and effectiveness of related resources and tools (reinforcing Overarching Goal 4) • In Q2 2014: launch of Mandate's Global Guidance on Water and Human Rights (links to Mandate's recognition of the human right to water and sanitation; also links to 5th core element of Mandate, i.e. Community Engagement) • In Q2 2014: publication of white paper on corporate practices in relation to sanitation, supporting the DSG's special call-to-action • In Q3 2014: launch of Mandate's Global Guidelines on Corporate Water Disclosure (links to 6th core element of Mandate, i.e. Transparency and Disclosure) • In Q4 2014: launch of Guide to Integrity in Water Stewardship Partnerships (links to 3rd and 4th core
3.2	Launch 1-3 new workstreams in areas deemed critical by endorsers for the advancement of corporate water stewardship, especially in frontier issue areas – e.g. Collective Action impact measurement; Supply Chain water stewardship/sustainable agriculture	

		elements of Mandate, i.e. Collective Action and Public Policy) • Dissemination and utilization of above-mentioned guides by endorsing companies and stakeholders (esp. in 2015) • Scope/advance work on collective action impact measurement within Collective Action Working Group • Creation of new Supply Chain Working Group to advance best and frontier practices (links to 2nd core element of Mandate, i.e. Supply Chain/Watershed) • Greater incorporation of Mandate resources and other assets by Local Networks (cross-referenced under Overarching Goal 2) • Improved consistencies and synergies across other UNGC portfolio issues and workstreams (e.g. climate/energy and food/ag ("Nexus"); women; anticorruption)
Goal 4	**Engaging in UN Post-2015 Development Agenda**	
4.1	Continue to lobby/promote importance of water and sanitation within UN Post-2015 Sustainable Development Process, via Mandate annual events and activities, communications, and continued involvement in related UN processes and partnership with key UN Offices and Agencies (e.g. Deputy SG; UNICEF; UNDP; UNEP; UN-Habitat; UN-Water)	**Expected Outcomes & Impacts** - Understanding by policy makers of importance of water and sanitation in any new development framework - Increase number of endorsing companies and stakeholders in partnership activities in support of UN goals and activities in relation to water and sanitation

4.2	Position UN CEO Water Mandate and especially Water Action Hub as implementation platforms in future actions related to realization of water-related global development goals (i.e. possible SDG on water and sanitation; see Appendix 3)	- Greater adoption and use of Guide to Responsible Business Engagement in Water Policy - Increased number of organizations registered and projects posted on Water Action Hub (for example, number of project locations to 500+ by end of 2014; between 500 and 1000 by end of 2015)
4.3	Orient specific Mandate-Local Network collaborations and activities around Post-2015 agenda to partner more effectively with the private sector	
4.4	Encourage Mandate endorsers to directly engage with policy makers and Governments on post-2015 agenda, through bi-lateral or collective action efforts	

UN CEO Water Mandate

About the UN CEO Water Mandate:

Water poses one of the greatest sustainability challenges of the 21st Century. Water scarcity and pollution, among many other issues, threaten our ability to grow strong and stable economies, meet basic human needs, and protect healthy ecosystems (and the services they provide), while also posing severe human health problems.

Business organizations are greatly affected by – and also often contribute to – these important issues. Because of this, they are increasingly seeking more information and trying to understand how to address these challenges.

Launched in July 2007 by the UN Secretary-General, the UN CEO Water Mandate is a unique public-private initiative designed to assist companies in the development, implementation, and disclosure of water sustainability policies and practices

Mission Statement:

The UN CEO Water Mandate seeks to make a positive impact with respect to the emerging global water crisis by mobilizing a critical mass of business leaders to advance water sustainability solutions – in partnership with the United Nations, civil society organizations, governments, and other stakeholders.

Eskom's position:

Eskom is one of a small number of South African companies that have endorsed the UN CEO Water Mandate and so has undertaken to advance water sustainability solutions in areas where it has influence.

The Eskom water management policy supports the UN CEO Water Mandate.

Resources

http://ceowatermandate.org/

http://ceowatermandate.org/files/Mandate_Brochure.pdf

http://www.unglobalcompact.org/

5.4 ESKOM AND THE INFRASTRUCTURE PROVIDERS

Table 42: The infrastructure providers

Infrastructure providers
Government Departments and The Mandated Structures Such as the CMA, WUA (Irrigation Boards), Stakeholder Forums, etc.
Eskom, as a national energy provider, has its specific structures and requirements.

Infrastructure providers

Resources

Armstrong, 2009.

Cox and Kotze, 2008.

Department of Water Affairs. *http://www.dwa.gov.za/* There is a lot of material on this site. The search facility is effective in finding documents on the required subjects. DWA is actively implementing the NWA so the situation is not static. Up-to-date information should be obtained from DWA offices.

Department of Environmental Affairs. *https://www.environment.gov.za/*There is a lot of material on this site. The search facility is effective in finding documents on the required subjects.

SANBI. *http://www.sanbi.org.za/* On this site is a document addressing wetland mitigation banking.

The β-version of the Wetland Offset Guideline is available on request from *sholness@nmmu.ac.za*or from *steve.mitchell@eon.co.za*

5.5 ESKOM AND THE PUBLIC INFRASTRUCTURE

Table 43: National Policy and legislation concerning the management of the water resource, with a focus on wetlands

Public Infrastructure		
Social-Institutional Rules – National Policy and Legislation		
Issue	**Eskom Head Office responsibilities**	**On-site responsibilities**
A. National Water Act	• A number of best practice guidelines are available on the website of the Department of Water Affairs. Relevant documents should be brought to the attention of environmental managers • Catchment Management Agency (CMA) • Water Use License (WUL) o Develop 'Industry Specific' General Authorisations o Develop a Risk-Based Approach to wetland management • WRCS o Through a subject matter expert make input into the WRCS in each of the water management areas relevant to Eskom o Ensure that on-site environmental managers get the necessary support be	• WUL o Adherence to mitigation hierarchy during the impact/risk assessment phase of WULA's o Arrange for contractor and contract o Ensure inclusion of maintenance and emergency procedures o Compliance with WUL requirements o Protect water quality in the catchment – e.g. runoff from ash dams and hard surfaces o Ensure that other personnel are aware of wetlands and the requirements of the WUL o Ensure that wetlands are protected in terms of the WUL requirements • WRCS o Be aware of the environmental reserve (quality

	able to comply with and implement requirements of the environmental reserve (quality and quantity) and the resource water quality objectives (RWQOs)	and quantity) and the preliminary resource classification, the RWQOs o Be aware of the resource water quality objectives
B. National Environmental Management Act (NEMA)	• Coordinate the applications of the necessary authorisations o EIA o EMP	• No net loss of wetlands – how is this to be implemented? o Avoid; mitigate; offset • Apply for the necessary authorisations o EIA o EMP
C. National Environmental Management: Waste Act	• Compile corporate best practice guidelines on dealing with waste and contaminated land, thereby minimising impacts on water quality across the catchments within which Eskom operates • Coordinate the applications of the necessary authorisations	• Incorporate conditions related to any waste management licence into the environmental management system of the operation. • Commit to best practices related to avoidance, minimisation, re-use and recycling.
National Environmental Management: Air Quality Act	• Understand the impact of Eskom's stack emissions on water quality due to dry fall-out and wash-out • Understand the impact of airborne particulate matter/aerosols originating from ash dams and coal stock piles on water quality	• Implement required actions as dictated by relevant authorisations and guidance from head office • Ensure operational efficiency

Conservation of Agricultural Resources Act, 1983 (Act No 43 of 1983)	• Understand he drivers and pressures of Eskom operations related to the dispersion and/or creating of conditions that allow alien invasive species to flourish in catchments, e.g. changing hydrological flow patterns due to large scale abstraction might favour alien species due to disturbance of the flow regime	• Implement weed management programs • Ensure that disturbed areas have been rehabilitated to avoid providing a competitive advantage to alien species
National Environmental Management: Biodiversity Act and National Environmental Management: Protected Areas Act	• Understand the **cumulative** impact of Eskom's water footprint on protected and vulnerable areas due to: o Habitat/wetland destruction o secondary impacts related to operations such as pollution and disturbances to wetland associated species	• Monitoring and management of impacts

Public Infrastructure		
Physical Infrastructure		
Issue	**Eskom Head Office responsibilities**	**On-site responsibilities**
A. Water supply provision (IBTs, dams, canals,)	• Liaise with responsible authorities over planning and maintenance issues	• Proper maintenance of infrastructure. Maintenance should be done in line with approved environmental procedures.

		• Future Water Use Licence Applications should include procedures for the maintenance of infrastructure (e.g. water pipes through wetlands) to ensure that immediate action can be taken to respond to infrastructure failures

Public Infrastructure

Social-Institutional Rules – National Policy and Legislation

Eskom Head Office responsibilities

DWA: There are a number of best practice guidelines on the DWA website. Relevant documents should be brought to the attention of environmental managers.

Give input into the DWA procedures where relevant. This may be done through a subject matter expert who is able to work nationally.

Ensure that the environmental managers get the necessary support, including training, to be able to comply with DWA requirements.

DEA: Coordinate the necessary applications for the EIA and EMP as required.

National Environmental Management: Waste Act (Act 59 of 2008): Compile corporate best practice guidelines on dealing with waste and contaminated land, thereby minimising impacts on water quality across the catchments within which Eskom operates and provide training of on-site personnel as necessary.

Coordinate applications for the necessary authorisations.

National Environmental Management: Air Quality Act (Act 39 of 2004): Understand the impact of the dry fall-out and wash-out of emissions as well as the impact of particulate matter and aerosols originating from Eskom activities on the catchment SES, including human, animal and ecosystem health.

Conservation of Agricultural Resources Act, 1983 (Act No 43 of 1983): Understand and manage nationally the influence of Eskom activities on the conditions which may favour the infestation and dispersion of alien invasive species

National Environmental Management: Biodiversity Act (Act 10 of 2004) and National Environmental Management: Protected Areas Act (Act 57 of 2003): Be aware of the **cumulative** impact of Eskom's water footprint and the effect of this on the cumulative water resource and aquatic ecosystem services in the catchment when the impacts of other users are taken into account. Cumulative impacts should be managed at the catchment level.

On-site responsibilities

DWA: Arrange for the WULA to be developed. It is important that the WULA includes maintenance and emergency procedures as they apply to wetlands to avoid having to apply for a new WUL when maintenance requirements arise in a wetland. In case where a WUL is already in place then it is advisable to apply for amendment together with an EMP to permit rapid access to a site requiring maintenance.

The environmental manager should be aware of the R(W)QOs and comply with these.

DEA: Ideally, there should be no net loss of wetlands. Where possible activities impacting on wetlands should be avoided. Where this is not possible impacts should be mitigated and only as a last resort will an offset be considered.

Ensure that EIA and EMP are in place as may be required.

National Environmental Management: Waste Act (Act 59 of 2008): Conditions of waste management licenses/authorisations should be incorporated into the environmental management system of the site under consideration.

Develop appropriate standard operating procedures based on the best practice for waste avoidance, minimisation, re-use and recycling, as laid out in the Eskom guidelines,

National Environmental Management: Air Quality Act (Act 39 of 2004): Implement the actions required by relevant authorisations as well as the guidance from head office, ensuring efficiency of operation where possible.

Conservation of Agricultural Resources Act, 1983 (Act No 43 of 1983): Implement alien invasive management programmes in conjunction with Working for Water and Working for Wetlands. A part of this intervention should be to ensure that disturbed areas are rehabilitated using vegetation indigenous to the area under consideration.

National Environmental Management: Biodiversity Act (Act 10 of 2004) and National Environmental Management: Protected Areas Act (Act 57 of 2003): Implement a monitoring system that will effectively measure the impact that Eskom activities are causing. Where possible, the results of the monitoring programme may be fed into a catchment-wide system.

Public Infrastructure

Physical Infrastructure

Eskom Head Office responsibilities

Liaise with the responsible authorities over the planning and maintenance of the infrastructure delivering water to power stations.

Liaise with transport authorities on the construction and maintenance of road and rail infrastructure, especially where wetlands are affected.

Resources:

SANBI and DWS, 2014.

WRCS – *http://www.dwaf.gov.za/RDM/documents/vol01complete.pdf*

5.6 USING THE FRAMEWORKS

The information contained in Table 36 to Table 40 (The resource), Table 41 (The resource users), Table 42(The Infrastructure providers) and Table 43 (The public infrastructure;) provides guidance into the contribution that Eskom may make to the sustainable planning and management of a socio-ecological system (SES), be it catchment-wide or confined to a more limited area.

Notes on populating the Framework

Define the boundaries of the SES which is to be assessed. This may be a single wetland, a sub-catchment or it may be a larger area.

Once the system has been bounded, then the **resource** should be defined in terms of the ecosystem services provided by the wetlands within the bounded area. Those services either used by Eskom or which Eskom's activities can influence need to be noted.

The **resource users** in the SES need to be identified. The **public infrastructure providers** make the rules which govern the resource users. A point to be noted is the opportunity for input by the resource users to the governance process.

The **public infrastructure** consists of two components. The social-institutional rules (laws and conventions) may be mandated by government departments or stakeholder organisations (such as the Olifants River Forum). The physical infrastructure consists of the IBTs, dams, canals and other physical infrastructure related, in this case, to water supply and distribution. Both components of the public infrastructure need to be identified.

Having identified the component parts of the SES the relationships between them may be defined.

The quantity of ecosystem services that can be provided by an ecosystem is finite, but the services may be distributed in different ways. Thus, increasing the use of some services will decrease the availability of others. The questions probing the relationship between the resource and its users (**Arrow 1**) will highlight these options and provide some insight into which services are more important within the SES under consideration. While the public infrastructure may alter the resource (**Arrow 4**) and impact the resource users directly (**Arrow 6**), the relationship between the resource and resource users is influenced by the way in which the public infrastructure is managed (**Arrow 5**).

The role played by Eskom should be noted for each part of the framework. From this it will be possible to assess the role of Eskom within the SES being assessed and to see how this may be changed as required.

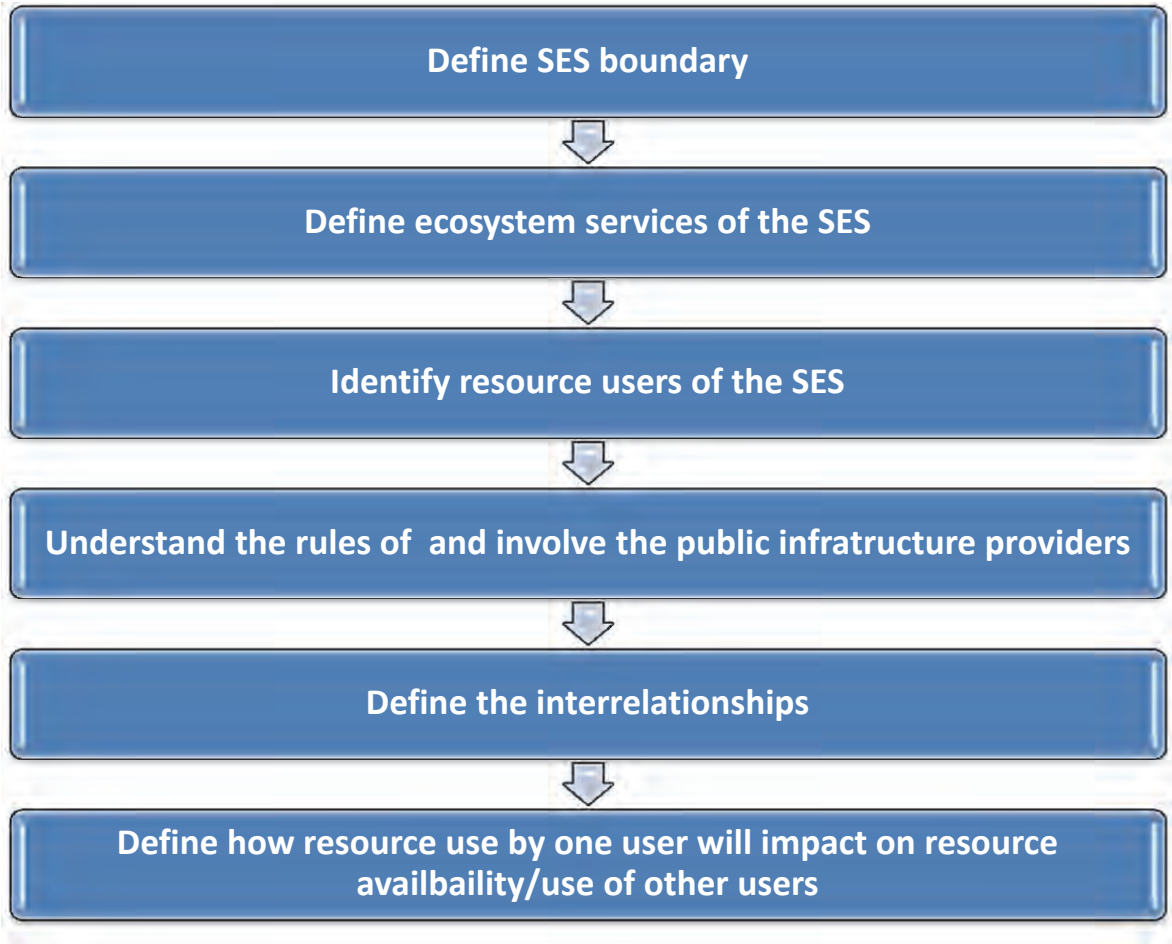


Figure 37: An overview of the steps involved in using the Framework

5.7 CASE STUDY: POPULATING THE ANDERIES FRAMEWORK FOR MATLA PS AND ESKOM

Introduction

The Anderies framework (Figure 38) has been used in order to identify and link all the activities within a social ecological system (SES). This framework will enable users to locate themselves within the web of relationships of a SES and so understand the role(s) that they play in the efficient functioning of the SES. This case study has been developed as a desk-top exercise to illustrate how the Anderies framework (Figure 38) and the MEA framework (Figure 39) may be used to locate an entity (in this case the wetlands on Matla Power Station property and Eskom) in the SES within which in operates.

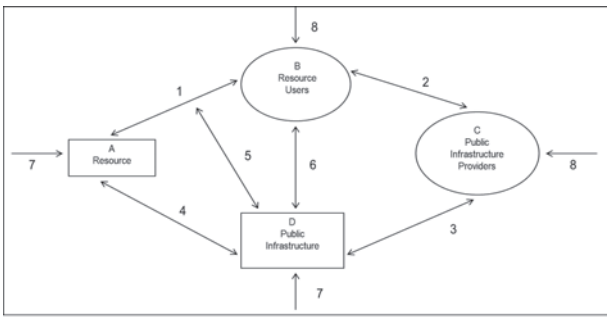


Figure 38: The Anderies Framework

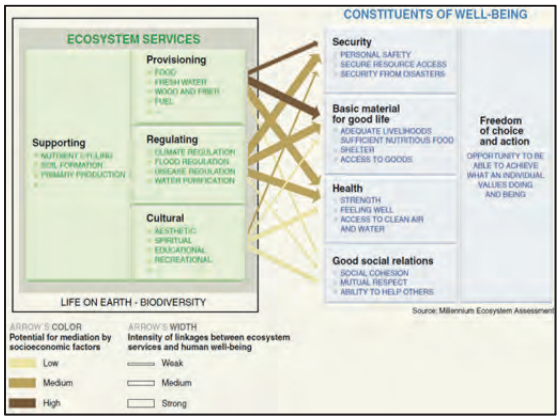


Figure 39: The Millennium Ecosystem Assessment Framework

Documents used in this study

The following documents from this project have been used to provide the basic material for this case study:

1. Chapter 3 – Sustainable Environmental planning framework with a catchment perspective (Operational stage).
2. Chapter 4 – Reports of selected case studies where the robustness of the environmental conservation framework was tested – Wetland management plan for Matla Power Station.

3. Chapter 5 – the interactions described in the earlier sections of this chapter. It should be recognised that while some of the responsibilities will apply to all Eskom properties, others will be site specific.

The primary focus of this case study is on wetlands with a secondary focus on the water resource. The resource is defined in terms of the ecosystem services (ES) that are delivering benefits to the SES as bounded below. The level of detail for the Matla PS is much higher than that for the surrounding SES.

A full study would require on-the-ground knowledge of the SES at a sufficient level to assess the relative influences of the wetlands on the SES. This case study has been done without communication with the stakeholders of the wider SES and is given as an example only.

Summary of findings of the case studies

Defining the boundary of Matla Power Station

Matla Power Station is bounded by quaternary catchments B11E and B11D as shown in Figure. Key points of the report are summarised below.

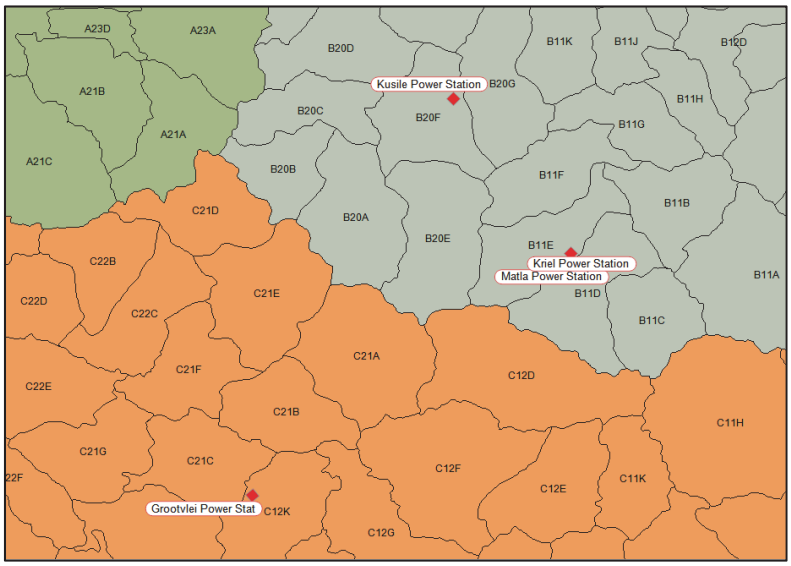


Figure 40: The primary and quaternary catchment associated with Matla PS and the neighbouring power stations

Matla PS is situated at the very top of the Olifants catchment close to the watershed between the Olifants and the Vaal (Figure 40). Runoff from Matla drains into the Rietspruit, a tributary of the Steenkoolspruit which in turn drains into the Olifants River upstream of Witbank Dam.

In this area, the main socio-economy activities are 2 Power stations (Matla and Kriel), open-cast coal mines, urbanisation and agriculture (taken from Google Earth imagery).

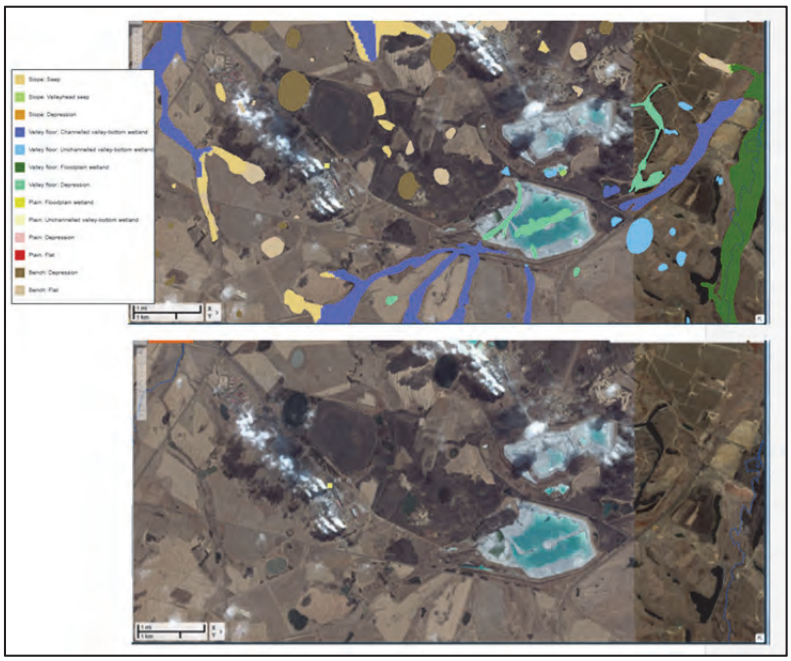


Figure 41: Images associated with Matla PS with reference to the National Wetland Inventory (SANBI, 2013)

Figure 41A. Wetlands on the Matla Power Station property with the NFEPA overlay.

Figure 41B. Wetlands on the Matla Power Station property without the NFEPA overlay

Wetlands of Matla PS and the SES

Table 44: Respective sizes of associated quaternary catchment and Matla PS

Catchment	Size (km^2)	Total size (km^2)
B11D	551	1017.7
B11E	466.7	
Matla	39	

Table 45: Surface area of wetlands in the SES and on the Matla property

Wetland category	Area in SES (km^2)	Area on Matla (km^2)
Natural wetlands		
Channelled Valley bottom	47.81	
Depression	5.71	1.54
Flat	11.79	0.47
Floodplain wetland	45.26	
Seep	22.41	0.4
Unchannelled valley bottom	2.08	0.39
Valleyhead seep	0.88	0.01
Total	**135.94**	**2.81**
Artificial wetlands		
Unchannelled valley-bottom wetland	0.91	0.06
Seep	4.22	0.23
Floodplain wetland	1.70	
Flat	1.44	0.15
Channelled valley-bottom wetland	4.46	0.07
Total	**12.73**	**0.51**
Wetlands as a percentage of the total area	**14.61**	**8.51**

The bar chart (Figure 42) compares the distribution of the various wetland types between the Matla PS and the SES. The Matla PS is in the Olifants River basin close to the watershed with the Vaal River basin. The SES includes some larger drainage lines which accounts for the differences in occurrence as the floodplains and channelled valley bottom wetlands tend to occur on the larger drainage lines while depressions (or pans) occur only where the gradient is less than 1% (i.e. areas that are almost level). This clearly illustrates the importance of the upper catchment area in providing the depressions and unchannelled valley bottom wetlands.

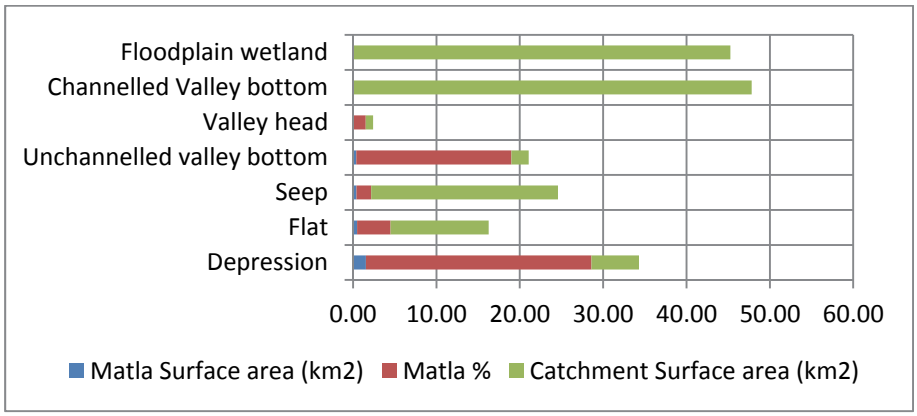


Figure 42: A comparison of relative wetland surface area between the Matla PS property and the SES (Quaternary catchment B11D and B11E)

Note for Figure 42: Matla surface area – Area of the wetland type which occurs on Matla PS property; Matla % – The percentage of the total area of the particular type of wetland (for the SES) occurring on Matla property; Catchment surface area – the total area of the wetland type occurring in the SES.

The different types of wetlands offer different levels of ecosystem services, and wetlands in healthy condition provide more benefits than those in poor condition. For a brief description of 17 common ecosystem services see Appendix A to this document.

The population of the framework below is guided by the questions as given in Appendix B of this document.

Populating the Frameworks

This section needs to be developed in conjunction with the list of questions which give guidance on what should be considered during the population of each section of the framework. Figure 43 illustrates possible areas where Eskom may become involved in the Framework with specific reference to Matla PS where relevant.

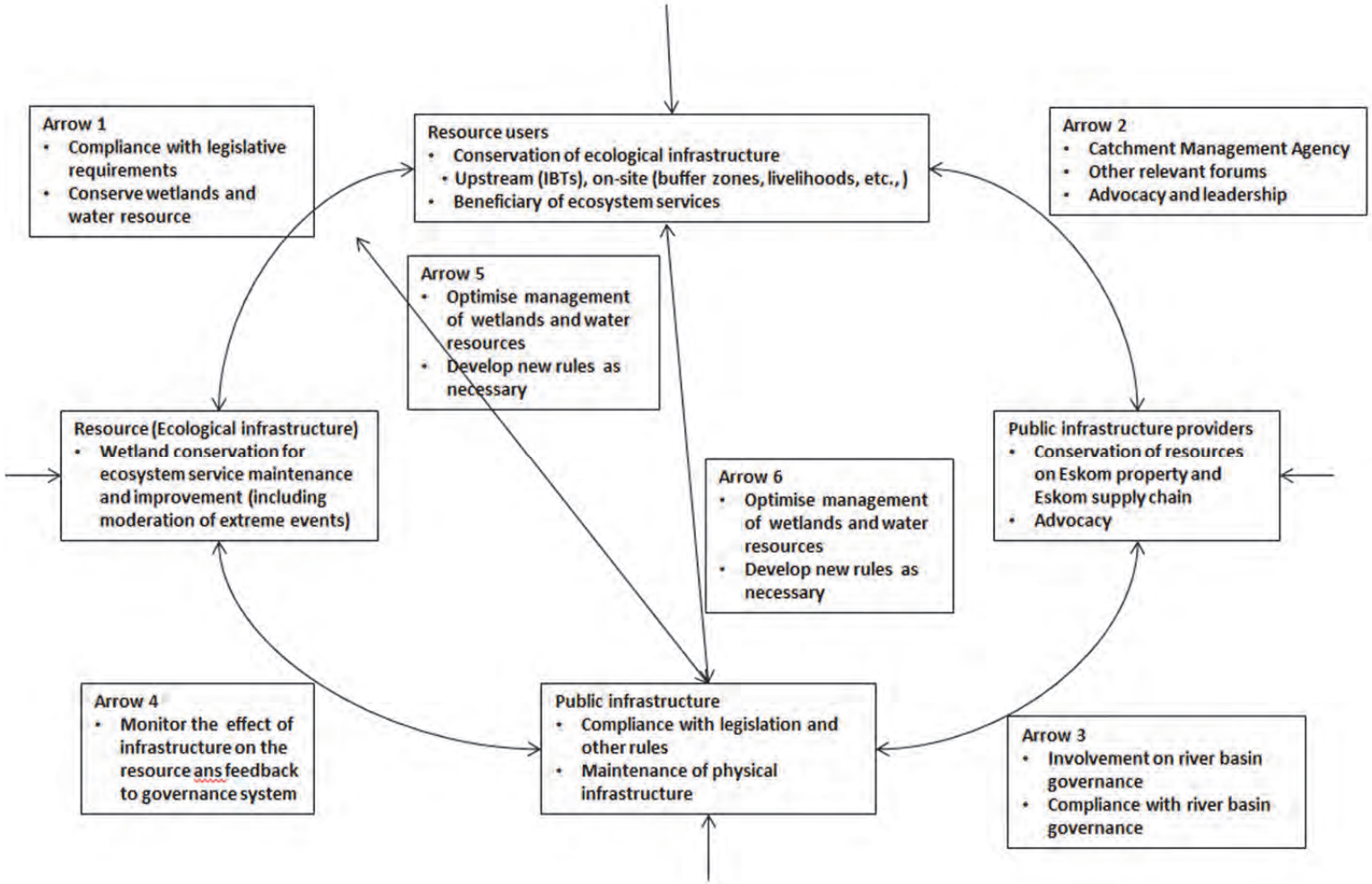


Figure 43: Possible areas of involvement for Eskom in the Matla Wetlands case study, as defined by the Anderies Framework

Box A – The resource

The resource on Matla property is wetlands. The area of wetlands is small compared to the area in the SES, but the uniqueness is that large percentages of unchannelled valley bottom and depression wetlands in the SES occur on the Matla property. Unchannelled valley bottom wetlands are very effective in removing pollutants and nutrients from the water, as well as in the moderation of extreme events especially flood attenuation, as water does not pass through these wetlands rapidly and is released more slowly over a period after high flow. These wetlands, apart from the depressions, are part of the larger Olifants River system. The ES of improved water quality and flood attenuation benefit all users in the SES.

The status of the resource is not known.

Eskom's role in the SES is the conservation of wetlands important for the maintenance of good water quality as well as the moderation of extreme events in the SES.

Box B – The resource users

The ES are used by all residents in the SES. Flood attenuation benefits water quality, soil fertility, agriculture, urban and mining investments. The influence of the IBT from the Vaal should be taken into consideration at this point.

Eskom has a dual role in the SES, that of the conservator of ecological infrastructure and that of a beneficiary of the ES.

Box C – Public infrastructure providers

National government departments are largely responsible for governing resource use in the SES, although local government has the important role of maintaining environmental quality in their areas of jurisdiction. Large industries such as Eskom and the mining houses also play a role through their in-house policies on resource management. An important role that large industries can play is that of advocacy to ensure that the wetlands and water resource in the catchment are managed sustainably.

The role of Eskom in this section is, in part, conservation of the resources on Eskom property. It could also address the activities in the supply chain to ensure that their activities considered the sustainability of their operations. Eskom is also in a strong position to provide advocacy to national and local government to ensure that the wider catchment is maintained in the desired condition.

Box D – Public infrastructure

Institutional

Wetland and water users and those whose activities impact on wetlands need to be aware of the various pieces of legislation with which they need to comply.

From the Eskom point of view Kusile PS has had to work closely with the relevant legislation and policies and the Kusile Power Station Wetland Management Strategy (Harris et al., 2013; Document No. MTPB-ESK031-0013) gives guidance in this regard (See Section 8.4 and Table 10 of the document title 'Report on the outcome of testing the sustainable environmental planning framework within a catchment perspective').

Physical infrastructure

The category 'Physical infrastructure' covers such infrastructure as dams, canals and pipelines. These may be on- or off-site and may serve one or more users. The physical infrastructure should be maintained in good condition to keep water loss at a minimum.

The role that Eskom could play is to ensure compliance with the institutional infrastructure as well as to ensure compliance of the organisations in its supply chain with relevant institutions. Eskom could also ensure that physical water supply infrastructure is maintained in good condition.

A point that has come to the fore with PS that have been operating since before the enforcement of the current legislation is that the water use License (WUL) for any infrastructure should include a clause permitting the repair of infrastructure without the necessity of re-applying for permission to do so. This will ensure that emergencies can be dealt with immediately.

Arrow 1 – **The relationship between the users and the resource**

Who else, apart from Eskom, is using the resource? In situations where an inter-basin transfer of water is occurring, users in the donor basin should also be considered. Where the resource use has changed over time, this needs to be assessed in the light of possible changes to priorities in resource use. The rights of the various users need to be considered.

In the case of Eskom the wetlands on the Matla site are not used by Matla PS to any great extent, but provide ES to other users in the basin. It is required by the legislation that these be conserved.

Arrow 2 – The relationship between users and public infrastructure providers

Do the users (Eskom included) play a role in the decision-making on the use of wetlands and the water resource on Matla PS? If not, how are the rules made?

In Eskom's place, is there opportunity for Eskom to get involved in the activities of the Catchment Management Agency or other forums where wetland and water resource use is discussed/decided?

Arrow 3 – The relationship between public infrastructure providers and public infrastructure

Eskom could monitor the performance of infrastructure on which it depends and ensure its maintenance as necessary. Where possible, Eskom may get involved in the governance of the river basin, so having the opportunity to make input into the rules governing the service delivery.

Arrow 4 – The relationship between public infrastructure and the resource

The monitoring programme should be designed in such a way as to be able to measure changes in the resource that could result from the rules and physical infrastructure. This data may then feed back into the governance system with a view to optimising the system.

Arrow 5 and 6 – The relationship between public infrastructure, and the resource and the users

Are the rules of use fair to all users? If they are not, then how may the situation be addressed.

Eskom, as a major stakeholder in the catchments where it is active, may be able to lead the way in optimising the management of wetlands and the water resource, guiding the development of new rules where necessary for improved wetland and water resource management.

Arrows 7 and 8 – The impact of external driving forces on any component or any relationship within the system

The risks of external factors such as floods and droughts or climate change in the longer term (Arrow 7) or a downturn of the economy (Arrow 8) to activities within the catchment need to be taken into account, and a role that Eskom might play in this situation would be to lead the planning of contingencies to cope with these risks.

5.8 CONCLUSIONS

Eskom Holdings makes an absolutely critical contribution to the socio-economy of South and southern Africa. The footprint of Eskom's generation and transmission infrastructure covers the entire country. Eskom is the largest single industrial water user, accounting for in the order of 1.5% of the total South African water consumption (http://www.eskom.co.za/OurCompany/SustainableDevelopment/Pages/Reduction_In_Water_Consumption.aspx). Through mechanisms such as the inter-basin transfer of water, the geographical extent of the water footprint is much greater than just the river basins in which power stations are sited. In addition, atmospheric circulation spreads the impact of the coal-fired power stations on air quality beyond the catchments in which the power-generating infrastructure is sited. Although Eskom anticipates that its water use will increase in coming years as a result of increasing demand, it is committed to reducing the volume of water required for power generation per kWh. Eskom aims to bring down water consumption per unit of electricity produced from the current 1.35 litres per kWh to 0.99 litres per kWh in 2030, representing a reduction of approximately 26%.

Eskom is signatory to the UN CEO Water Mandate and this document seeks to clarify how the commitment to use water more efficaciously may be implemented within the Holdings and within the wider socio-economic community with which it interacts. In Table 36 to Table 43 above, the document indicates how Eskom head office may provide structure to their pro-active leadership both within the Holdings and in its interactions with the other water users in the river basin active in the conservation and sustainable management of natural resources as well as water conservation and demand management. This will sanction the activities of the environmental personnel on site in the performance of their duties.

This document provides some insight into how Eskom may mesh its activities with other water users in order to improve, or at least maintain, the quality of the ecosystem services that the ecological infrastructure provides to the socio-economy. Two frameworks are provided in order to do this, and guidance is given on how to determine how Eskom's activities fit into the frameworks as well as how to determine how the activities of the other users fit into the frameworks. This enables planners to take account of the needs of all the users in the river basins under consideration.

The water shortages projected for the country (NWRS 2, 2012) demand that South Africa implements water conservation and demand management interventions. Eskom has set the

ambitious target of reducing water us to 1.201 ℓ kWh^{-1} by 2017. As a large user of water the strict management of its water use will contribute to national water savings.

6 FUTURE RESEARCH NEEDS WITHIN THE WATER-ENERGY NEXUS With recommendations for further research within the green economy context, including impacts of and adaptation to climate change

6.1 FUTURE RESEARCH

Introduction

As described in the Introduction to this report (Chapter 1), the water supply crisis is ranked amongst the top five global risks both in terms of its likelihood to happen as well as its impact by the World Economic Forum 2013 report. Global freshwater demand is projected to exceed current supply by 40% by 2030. To quote the WWF (2014), '*South Africa is a chronically water stressed country with huge economic development pressures and social upliftment challenges.*

The Johnson Foundation (Johnson, 2014) report covers the result of a think tank which involved 400 water professionals and experts over a six year period to review the freshwater situation in the United States of America in recognition of the fact that *'without significant changes, existing water systems will soon no longer be able to provide the services that citizens have come to expect'*. They developed the following guiding principles for the future of US freshwater resources:

- Forge partnerships and collaborate to solve problems
- Develop integrated solutions
- Incentivise and promote innovation
- Highlight multiple benefits
- Recognise the value of water
- Plan for adaptation to and mitigation of climate change impacts
- Balance human and environmental needs
- Design infrastructure to restore ecosystem function
- Prioritize local water sources
- Redefine "waste" as valuable resources
- Right-size water systems and services
- Tap into sustainable financing streams
- Ensure accountability.

Within these guiding principles there are five key areas of recommendations changes or improvements need to be made to ensure sustainability of freshwater:

1. Optimize the use of available water supplies
2. Transition to next-generation wastewater systems
3. Integrate the management of water, energy and food production
4. Institutionalize the value of water
5. Create integrated utilities.

Each of these key areas has a number of subsections outlining actions which will contribute to the sustainability of water resources.

These guiding principles and key areas apply equally well to the South African situation. Where appropriate for Eskom, the guiding principles and key areas for change have been included in the recommendations for future research below.

- National Water Resource Strategy (NWRS) 2

South Africa's water scarcity creates the imperative for increasing the efficiency of water use. Eskom is proactive in this and, in addition to being signatory to the UN CEO Water Mandate, has formed water management task teams to improve the efficiency of water usage. The current target for water use, utility-wide, is 1.32 ℓ kWh^{-1}. The target set for 2017 is 1.20 ℓ kWh^{-1} (Divisional Report Key indicators, 2012). This target puts pressure on Eskom Holdings to implement effective water conservation and water demand management across all their activities. However, dry cooling power stations use considerably less water, with Matimba Power Station, the largest dry-cooled power station in the world, using 0.1 ℓ kWh^{-1}. Medupi PS and Kusile PS will both use dry-cooling technology. In the face of climate change projections, the imperative to increase the efficiency of water use may be a higher priority than is accorded by these figures.

Eskom is a strategic water user, but this does not absolve Eskom Holdings from using water responsibly. The NWRS 2 (2012) recognises the cardinal role of water in the South African socio-ecological system and has articulated a number of core strategies as given in Text Box 1. All of these are relevant to Eskom's business. It should be noted that both water quality and water quantity are seen as critically important for the sustainable growth of the country as proposed in the National Development Plan and the New Growth Plan.

Text Box 1

Core strategies (NWRS 2, 2012)

1. Implementation of Equity Policy;
2. Putting water at the centre of integrated development planning and decision-making;
3. Ensuring water for equitable growth and development;
4. Contributing to a just and equitable South Africa;
5. Prioritising and ensuring the implementation of water conservation and demand management;
6. Optimizing and stretching of our available water resources (groundwater, water re-use, desalination (including seawater), water systems optimization and rainwater harvesting);
7. Committing to the protection of our water resources and ecosystems;
8. Achieving effective and smarter water governance;
9. Embedding sustainable business principles and practices in water resources and systems management;
10. Implementing a water sector investment framework for infrastructure, human resource capacity and institutions;
11. Engaging the private and water use sectors.

Collectively, wetlands in a catchment can have a positive impact on water quality, with the degree of impact varying with the type of wetland. Bullock & Acreman (2003), in a review of published results from 439 wetlands in 169 studies found that while wetlands had a strong influence on the hydrology of the drainage, the actual effect depended on factors such as the type of wetland and its position in the drainage line.

The extent of wetland surface area required to maintain or improve water quality in a catchment is dependent on a large number of variables, such as:

a) The nature of the water quality problems experienced in the catchment

b) The hydro-geomorphic position of wetlands in the landscape

c) The relative position of wetlands with reference to any pollution sources in a catchment.

The Resource Quality Objectives set for a catchment can also provide further guidance as to the critical extent of wetland surface area that will be required. It is acknowledged that at this stage, the matter of required wetland surface area vs. catchment surface area with respect to the delivery of ecosystem services is “blue sky” and that each catchment being unique and dynamic, will require dedicated studies.

An observation of the levels of development in a catchment as well as the temporal and spatial nature of water quality constituents is an important starting point. Should any of the aforementioned criteria have a significant negative trend, a joint investigation with suitable stakeholders should be undertaken to determine the optimal wetland surface area, wetland types as well as levels of wetland health that will be required to sustain or improve water resource quality in a catchment.

A useful method in this regard is to link wetland health and the provision of ecosystem services to national land cover change data sets, which are readily available. Land cover is used as an indicator of impacts on hydrological functioning and through consulting numerical metrics predefined by Ellery et al., loss of wetland functionality can be deduced. Using coarse-resolution land cover categories as a basis to assess impacts to wetlands is a very basic tool, however given the broad scale at which it will be applied, it will generally be sufficiently accurate for the purpose of strategic assessments (Ellery et al., 2009).

The matter of surface water pollution is by default a critical issue in catchments such as the Upper Olifants, Inkomati and Upper Vaal, given the extent of both point and non-point sources of pollution. Mitch and Gosselink (2000) stated that on average at least 5% of temperate-zone watersheds should consist of wetlands in order to optimise ecosystem services derived from wetlands (This figure will vary, however, depending on wetland type, catchment characteristics and water resource objectives). Palmer et al. (2002) estimated that 9.9% of land surface of the upper Olifants (Mpumalanga) is covered by wetlands. Bullock and Acreman (2003) state that, globally, wetlands cover about 6% of the land surface.

Whilst several authors have indicated the importance of the integration of wetlands into catchment planning (see, for instance, Dickens et al., 2003), an explicit methodology linking the Resource Directed Measures (RDM) or Resource Quality Objectives (RQO) to a percentage of wetland surface area in a catchment is largely lacking. The same can be said of other ecosystem services provided by wetlands, such as flood attenuation in urban

catchments with extensive hard surfaces that have replaced permeable surfaces for ground water infiltration.

A range of land cover classes based on the National Land Cover database for South Africa have been identified with respect to their impacts on water inputs to, and retention of water within, wetlands. If present in the catchment, these land cover classes can either increase or decrease water inputs to a wetland, or if present in a wetland itself, they can increase direct water losses from the wetland, reduce surface roughness, impede the flow of water in a wetland or enhance the flow of water in a wetland. The effect of each category of land cover change from the natural condition on each of these parameters has been assigned an intensity of impact score. The loss of function metric (Ellery et al., 2009) describes the relationship between the magnitude of impact score and wetland functionality for a total of 6 ecosystem services: flood attenuation, stream-flow regulation, sediment trapping, nitrogen removal, phosphate removal and toxicant removal. The authors determined numerical relationships between intensity of impact scores and impact on wetland services which are consulted in order to determine the loss of function metric.

6.2 IDENTIFICATION OF FUTURE RESEARCH NEEDS

> It has been said there are two ways to achieve change — through crisis or through leadership. Freshwater is too important to our ecosystems, communities and national security to wait for a crisis.
>
> Johnson Foundation, 2014

Gone are the days when individual economic sectors could plan their developments in isolation from other sectors. Pressure on the resources has reached the point where the use by one activity will impact on the availability of the resource to others.

There is a need to investigate ways in which economic growth may be decoupled, at least partially, from resource availability.

In recognition of the projected water shortages in the USA the Johnson Foundation convened a series of working conferences in which they brainstormed the challenges facing the social-ecological system and how these may be addressed. The report lists a number of guiding principles as well as a number of specific recommendations (Text box 2). It would be worthwhile for South Africa to benchmark against these principles and recommendations. The legislation and the institutions are in place but the implementation is not yet complete.

Text box 2

Recommendations to catalyse change and Key Ideas for improving water management (Johnson Foundation, 2014)

Each of these recommendations to catalyse change and key ideas is described in detail in the Johnson (2014) report.

1. Optimize the use of available water supplies
    a. Increase the Efficiency of Water Distribution Systems

b. Establish Water Rates and Other Fees that Drive Conservation and Efficiency
c. Implement Policies and Programs to Stimulate Efficient Water Use
d. Expand Adoption of Water-Wise Agricultural Practices
e. Diversify Supply Portfolios with underused Water Sources
f. Reclaim and Reuse Water from Wastewater
g. Match the Right Quality Water to the Right Use

2. Transition to next-generation wastewater systems
    a. Prevent Clear Water from Entering Sewer Systems
    b. Complement Centralized Wastewater Infrastructure with Distributed Systems
    c. Maximize Resource Removal and Recovery from Wastewater
    d. Develop Energy-Positive Wastewater Treatment Facilities
3. Integrate the management of water, energy and food production
    a. Improve Energy Management at Water and Wastewater Utilities
    b. Prioritize Water-Smart Electric Power
    c. Recover nutrients and energy from agriculture
    d. Plan for sustainable rural water supplies
4. Institutionalise the value of water
    a. Tap New Sources of Capital and Use Innovative Financing Mechanisms for Infrastructure Upgrades
    b. Institute Sustainable Pricing for Water Services
    c. Leverage Market Mechanisms to Account for the Value of Ecosystem Services
    d. Create a Culture in Which Water Services Are Highly Valued
5. Create integrated utilities
    a. Create New Design Principles and Evaluation Criteria
    b. Transform Utilities from Service Providers into Resource Managers
    c. Develop New Business Models and Regulatory Schemes
    d. Cultivate Resource Management Partners and Customers of the Future

Some of the ideas below will require new research, others will require the repackaging (data mining) of existing research and presentation in a way that enables their implementation. Both of these are valid. Again, some of the research needs presented below would be implemented within Eskom while others will entail Eskom working with other stakeholders. Although the ideas have been listed and introduced separately, it may well be pragmatic to combine some of them.

6.3 ON ESKOM PROPERTY

The role of ecological infrastructure

What is the actual and potential role that ecological infrastructure can play in supporting, enhancing and sustaining Eskom's built infrastructure for energy generation? Such an approach should look all the way along the supply chain. Water quality is one aspect, together with topics such as the impact of sediment on hydropower generation, the management of servitudes, etc. The costs and benefits of maintaining ecological infrastructure and the potential costs of not addressing the risks posed by degraded ecological infrastructure should form part of the study. This study should consider how maintaining ecological infrastructure can contribute to the transition to a green economy.

Soil carbon

Wetlands are important agents of carbon sequestration. As an example, carbon sequestration is one ecosystem service provided by wetlands and Euliss et al. (2006) found that wetlands in the prairie regions of North America sequestered twice the carbon as no-till cropland on 17% of the area. Also, carbon may be released when wetlands are disturbed. Eskom's emissions account for nearly half South Africa's total carbon emissions. The role of South African wetlands in carbon sequestration is not known, although international literature informs us that it is important, with peatlands being the most important of all.

The need is for knowledge of the carbon content of wetland soils on Eskom sites, and how this needs to be managed so that the sequestration capacity is improved, not lost.

The benefits and costs of rehabilitation

Ecological restoration is becoming regarded as a major strategy for increasing the provision of ecosystem services as well as reversing biodiversity losses and the benefits of restoration can outweigh the costs (Bullock et al., 2011).

What are the benefits and costs of rehabilitation/restoration of wetlands, and is there a case for making the rehabilitation/restoration of wetlands (and the wider environment) not negotiable?

(I ask this question because a common response to the need to rehabilitate environmental impacts (including treating waste before discharge to the environment) is that it is not cost effective).

Impacts on Ramsar sites

Eskom has a national footprint. Most of the coal-fired power stations are situated on the Mpumalanga Highveld, but the distribution system is national, with approximately 30 000 km of power line servitudes as well as strategically placed substations. The most efficacious route for the servitudes to follow is the direct route. This means that servitudes will cross any rivers or wetlands that may lie in their path.

South Africa has 21 Ramsar sites totalling 554 136 ha (2014). South Africa's policy regarding development in or around wetlands is firstly to avoid impacts, secondly, to mitigate impacts and thirdly, to offset impacts where either of options 1 or 2 are unachievable. The Ramsar Convention offers a number of guidelines on wetland management and the management of impacts.

Best practice guidelines need to be developed for addressing this situation when and where it arises. These guidelines should consider both the requirements of the Ramsar Convention and the national policy and legislation.

Consideration of possible future changes in wetland or water policy and legislation

Water policy, legislation and management is dynamic and evolving. In relation to wetlands there are currently WRC projects that are potentially leading into ways of managing the challenges that we recognise. The projects **K5/2200** *(Development of a methodology to determine the appropriate buffer zone width and type for developments associated with wetlands, watercourses and estuaries (Short Title: Wetland Buffer Zones)*), **K5/2269** *(Development of a national wetland monitoring programme (Phase 1))* and **K5/2281** *(Develop and test a landscape-based multidisciplinary and multi-sectoral decision support system to support Integrated Water Resource Management in Mpumalanga)*, amongst others, are likely to influence the way wetlands and water are managed, and these new ideas will need to be actioned in a way that is practical and will achieve the desired end as efficiently as possible.

In terms of national instruments for managing water the progressive implementation of, for example, the environmental reserve and the waste discharge charge system are likely to influence Eskom activities.

Research will foresee the challenges that need to be addressed and develop methods to address these. These ideas will, however, need to be developed into ways in which they can be practically applied by resource users.

There is a need to conduct a strategic review of the challenges in water resource management as these affect Eskom. This would include a review of the research needs and the ongoing research that is addressing these needs. It should also take the identified needs to a point that addresses implementation challenges within Eskom and the social-ecological system.

Eskom water strategy

Eskom's water strategy outlines the planned reduction of the volume of water to generate 1 kW of electricity from 1.32 ℓ kWh^{-1} in 2012 to 1.20 ℓ kWh^{-1} in 2017 (Divisional Report Key indicators, 2012). In addition, the Water Management Policy states that all coal-fired power stations shall comply with the Zero Liquid Effluent Discharge (ZLED) policy.

There are two aspects to this research need. The first is the on-going improvement of on-site water conservation and water demand management and the second is the treatment and reuse of effluents. While both of these are already embedded in Eskom policy, the refinement and implementation of the activities to achieve these two goals should be

addressed. As the dynamics of each power station differ, this will require the development of generic as well as site-specific guidelines.

Water conservation and demand management

Water conservation and demand management was a priority strategy in the NWRS (2004) and in the NWRS 2 (2012) its importance has been elevated to one of the core strategies of water management policy. There needs to be an on-going drive to improve water conservation and demand management. This drive will start with a thorough audit of water use on site at power stations as well as in the supply chain and will then need to examine methods and behaviours that could or should be changed and how these changes may be brought about cost-effectively. The priority would be the areas of the power generating process where a lot of water is used such as the selective catalytic reducing process (SCR) or flue gas desulphurization.

Improvements in water conservation and demand management would both help Eskom to achieve the aim of reducing the volume of water per unit of electricity generated and would also free up more water for growth, development and the environment.

Wetland responsibilities on mines

The responsibilities of mines with regard to wetlands should comply with national policy and legislation. However, more than this, in the past it has been the practice to mine opencast in the bottom of valleys, as the coal seams are closer to the surface at these localities. With the new emphasis on wetland conservation, this practice should change. In addition, the DEA, the DMR, the Chamber of Mines and SANBI have published the Mining and Biodiversity Guideline (2013).

The various sources of knowledge need to be brought together into a single guideline document that is accessible and useable by environmental staff on site while at the same time providing guidance to policy formation to the Eskom policy makers.

Procurement chain of Eskom-owned mines

The increasingly rigorous implementation of water and environmental legislation at national and provincial level makes it important that Eskom, mining houses and other activities that take place in the landscape are aware of their allocated responsibilities.

Guidelines need to be developed which address these allocated responsibilities in a way that will enable planners and decision makers to understand how enacting these responsibilities will influence the on-the-ground operation of, for instance, operational imperatives, purchasing agreements and the environmental assurances that are required by the policy and legislation. This should be developed in such a way as to enable the planners and decision makers to gauge the funding requirements of addressing the increasingly rigorous implementation of water and environmental legislation.

New agreements with mines

New agreements with mines should use the Eskom Project Life Cycle Model (PLCM). The Wetland Management Framework (Deliverable 3 of this project) may then be implemented within the PLCM.

There is place for guidelines on how wetlands, water and environmental management issues should be addressed in new agreements with mines. The format followed by the recently published 'Mining and Biodiversity Guideline: mainstreaming biodiversity into the mining sector' (DEA et al., 2013) may give guidance on how this may be developed.

Decommissioning of mines and power stations and their impacts on wetlands

Guidelines for the decommissioning of power stations and mines need to be developed. The guidelines should include the control of acid mine drainage as well as any sources of leachate from the sites. They should include methods of ensuring ash dams/spoil dumps are stable and rehabilitated as far as possible in the time available. Employing constructed wetlands as part of the strategy to achieve this is an option, but a precautionary note is that the capacity of wetlands to sequester pollution is not unlimited and so needs to be monitored and managed. If the pollutants reach a point where they break through the capacity of the wetlands to absorb them, then a situation similar to what happened in the town of Carolina recently may arise.

The guidelines should also provide for a follow-up programme which includes monitoring (within an adaptive management framework) and management of the technologies employed. The duration and intensity of the follow-up programme should be outlined, although there would need to be some flexibility to allow for the feedback of the results to be incorporated into the programme. This is particularly relevant when facilities such as the water and wastewater treatment works remain active to provide services to surrounding settlements.

Constructed wetlands

There is a need for guidelines on the construction and management of constructed wetlands. These guidelines need to cover topics such as when they may be employed and what are the legal and permitting requirements to implement them. They should also address the structure and functioning of the wetland itself, as some types of constructed wetlands are more efficient than others in certain circumstances, adding value to the existing ecological infrastructure.

Monitoring programme

A monitoring programme should be developed within the framework of adaptive management (learning by doing). While the initial focus of the monitoring programme should be on wetlands, the programme should be developed in such a way that it can be expanded to include all aspects of environmental management as well as water use on the site.

It is seen that the monitoring programme will have a core of generic activities, but that there will also be sufficient flexibility to allow for the individual needs of each power station, transmission line servitude and substation to be accommodated.

Recovery of water vapour from Eskom cooling towers

A large quantity of water is lost to the atmosphere through the cooling towers on coal-fired power stations. South Africa is a water scarce country and the demand for the existing water is increasing. The recovery of all or a portion of the water evaporated from cooling towers will help Eskom meet the target of reducing the volume of water required to generate a unit of electricity. It will also release some of the water currently allocated to Eskom for growth, development and the environment. This additional water will contribute to increasing national water security.

There is an international project entitled 'Capture of evaporated water with novel membranes', acronym CapWa, investigating the possibility of recovering evaporated water from industrial processes (*http://www.watercapture.eu/*).

The need is for an investigation into innovative technologies which may be retrofitted to Eskom coal-fired power station cooling towers to condense the water vapour which currently is being lost to the atmosphere. For each potential technology the investigation should develop estimates of the benefits and costs of the technology. The estimates of the benefits and costs to be investigated for envisaged innovative technologies should include, but not be limited to, the following:

- The percentage of water that may be recovered,
- The cost per litre of water recovered,
- Changes to the efficiency of the functioning of the cooling towers.

Waste as a resource

There is need for a thorough audit of the waste streams emanating from Eskom with a view to investigating what resources may be recovered and what waste streams may be reduced.

- Data mining of existing research

Eskom organisational responsibilities

The organisational responsibilities of Eskom have been broadly outlined in Deliverable 5 of this project. Responsibilities range from the generation of company policy to on-the-ground implementation of this policy as well as national and provincial legislation, including training to enable personnel at the various levels to carry out their duties effectively. The increasing realisation of the importance of the role of water and the environment is leading to increasing rigour of implementation of water and environmental legislation.

There is a need for the organisational responsibilities to be reviewed. The review will need to take account of projected changes in national policy and legislation, global (climate, economic, demographic) change and the needs of new technologies which may be

employed by Eskom. The review should examine the effect that these changes are likely to have on Eskom and its functioning.

Wetland indicators

Indicators of wetland health and the contribution of wetlands to the socio-economy are available from a number of sources. The Water Research Commission has funded the development of specific indicators, particularly those by Pollard and Cousins (2008) and Pollard and du Toit (2009; 2010). Ramsar have also developed indicators for wetlands. In addition, the Water Research Commission is currently funding a project entitled 'Development of a national wetland monitoring programme (Phase 1)' (WRC Project Number K5/2269) which is developing a suite of indicators which cover the position of wetlands in the socio-ecological system. This project is due to finish after the current project.

Once the WRC project K5/2269 has been completed it will be necessary to incorporate indicators relevant to wetlands under Eskom's jurisdiction into an adaptive management framework which will then feed into the Wetland Management Framework developed in this project.

Presentation and training of the WRC wetlands framework to Eskom managers and staff

During the current project training in the application of the Wetland Management Framework has been developed. This needs to be incorporated into the electronic courseware system of the Eskom Learning Academy. Once this is available online the course will need to be presented to relevant managers and staff to empower them to use the WMF.

Guidance for Eskom policy makers

Eskom is faced with the need to generate more power in a socio-economic environment where there is an increasing demand for resources. There is also a swing, internationally and nationally, towards a sustainable green economy. This increasing demand for resources leads to an increase in the need to comply with policies and legislation designed to ensure the sustainability of these resources. In the face of this Eskom needs to develop policies which will ensure the sustainability of its operations while at the same time complying with the changing landscape of national management of natural resources, particularly water.

Guidelines need to be developed, drawn from international and national experience, to guide Eskom policy makers in the formulation of policy which will ensure the sustainability of Eskom's activities.

Fast tracking of best wetlands management practices

There is a considerable bank of local knowledge on wetland management which has been developed over the years by the Department of Water Affairs, the Department of Environmental Affairs, the Water Research Commission and postgraduate research in various universities. Equally, there is a large bank of knowledge on wetland management

internationally. The management of wetlands is addressed in various Eskom policies and the wetland management strategy has been developed for Kusile Power Station. The Wetland Management Framework developed in this project provides a step-by-step guide to the management of wetlands during the various phases of the Eskom Project life Cycle Model.

Collation of this bank of knowledge into a resource that will make it readily accessible to Eskom managers and staff, accompanied by training, will be a step towards the fast tracking the implementing of best practice in wetland management.

Such a resource has the potential to be widely used by all stakeholders in a catchment, bringing best practices to agriculture, mining, urban and industrial land users.

6.4 RESEARCH NEEDS IN THE CATCHMENTS WHERE ESKOM IS ACTIVE

Eskom is one of a community of resource users within a catchment, and the resilience of natural resources is enhanced when the area under good management is increased.

Hierarchy of conservation targets

Given the varied nature and role of wetlands in the landscape, it is necessary to take cognisance of and set conservation targets for each type of wetland affected by Eskom's operations. Conservation targets need to be aligned with provincial and national biodiversity conservation plans and other strategic planning documents highlighting sensitive and important water resource areas while recognising Eskom's particular needs at the same time.

Conservation targets need to integrate 'land health' (land use including urbanisation) and 'aquatic ecosystem health', so linking terrestrial and aquatic activities.

Wetland connectivity

Habitat corridors are considered an important feature of biodiversity conservation because they facilitate movement of organisms between patches, thereby increasing species richness in those patches. Biodiversity corridors allow species to traverse habitat that is not necessarily suitable for permanent residency. Species often rely on biodiversity corridors to disperse from the area from which they originated, escape predation, locate better habitat, find a mate, or access habitat they need at a specific life history stage. Without the connectivity provided by corridors, many species cannot perform their essential life functions and thus eventually become locally extinct. Separation of previously connected natural habitats resulting from anthropogenic land use changes is one of the most important drivers behind biodiversity loss (Bergsten, 2012).

Resource Quality Objectives (RQO) of feeder catchments

The water resource classification system (WRCS) is in process of being developed for some of the catchments in which Eskom is active and will eventually cover the entire country. The WRCS sets the water resource management targets, including the resource quality objectives (RQO) and at a finer scale the water resource quality objectives (WRQO) for each IUA in the catchment.

Based on the pollution attenuation potential of wetlands on Eskom property, Eskom can set strategic conservation and rehabilitation targets to manage or improve catchment water quality. This will require knowledge of the pollution attenuation potential of different types of wetland for different pollutants. Some of this knowledge exists but it is likely that some may need to be developed.

Hydrological integrity

It is vital to understand water use by different role players within a catchment to ensure that the hydrological integrity of wetlands is maintained. In order to set realistic conservation targets, an understanding of current and future water use in the catchment is required. This will require modelling projections of changes to the demographics and economic activities. In view of the water scarcity in the region, the modelling should provide clear decision support capability.

Greenhouse Gas (GHG) sinks

Wetlands are considered to be important sinks for GHG. Wetlands under Eskom's jurisdiction may be ranked in terms of their GHG attenuation potential. This will ensure that the criteria and targets related to wetland conservation take cognisance of this wetland function. The capacity of wetlands to attenuate pollution may be employed is to be one of the suite of technologies towards realising a clean development mechanism (CDM), or the development of cleaner technologies as is currently being implemented by industry.

The effectiveness of wetlands to perform the functions of carbon sequestration (WRC project K5/2346: Investigation of peatland characteristics and processes as well as understanding of their contribution to the South African wetland ecological infrastructure) and to be employed as a CDM needs to be researched and where practical, the pathway to implementation should be developed.

Ecosystem services for communities

Develop a process (a framework) for identifying and evaluating the value of the ecological services used by communities and how these will be affected by Eskom activities. Where the impact may be negative, the framework should include feedback loops to assess mitigation measures where these are appropriate. At the same time, opportunities will be identified to promote access to wetland services by surrounding communities, in support of Eskom's social responsibility initiatives.

Integrated natural resource management for the benefit of ecosystem services

Water quality cannot be effectively managed if the sources of diffuse pollution are not addressed. As part of the overall strategy to improve the IWRM in a catchment it is necessary to assess the contribution of activities contributing to diffuse pollution together with those point sources which may be more easily managed. Mining, agriculture and urban runoff are land-based contributors to diffuse pollution, affecting the catchment in which they are situated. Quantification of the relationship between land-based activities and aquatic

ecosystem services will guide the management of land use in order to improve the flow of ecosystem services from the wetlands on Eskom properties.

Diffuse pollution from aerial discharges is more complex as the impact has the potential to go beyond the catchment of origin. Knowledge of how aerial discharges affect the terrestrial and aquatic ecosystems and the services they deliver exists internationally, but specific knowledge of the extent and effect of Eskom's aerial discharges on ecosystem services will guide policy and management decisions on aerial discharges.

Management of the water quality in a catchment ultimately will require a holistic initiative involving the management of point and diffuse sources of pollution. This requires, firstly, knowledge of the sources of pollution and how existing instruments of national policy, such as the Waste Discharge Charge System, may be brought to bear on the situation. Secondly, it will require an integrated effort from all stakeholders involved if it is to be fully implemented. The possibility of rolling out the existing strategy into the catchments in which Eskom operates should be investigated.

Differing baskets of ecosystem services

Improved understanding of the differences in the baskets of ecosystem services offered by different types of wetlands will guide the prioritisation of wetland management and rehabilitation. For instance, unchannelled valley bottom wetlands are better at upgrading water quality than channelled valley bottom wetlands. This understanding would also guide the design of constructed wetlands where they are to be used.

One specific question which may be answered is 'What is the benefit/cost ratio of rehabilitating an unchannelled valley bottom wetland into which a channel has been eroded through the presence of, for instance, flow being concentrated through a culvert?'

6.5 IN THE SOCIAL ECOLOGICAL SYSTEM

Benefits and costs to power generation, water use and food production

The costs of the use of coal for energy production in terms of water use and impact on quality, impact on the environment and impact on food production are known. What is less clear is the costs and benefits of alternate energy production technologies on water use and impact on quality, impact on the environment and impact on food production for different regions and under varying degrees of water scarcity.

There is a need to develop a decision support system based on costs and benefits to power generation, water use and impact on quality, impact on the environment and impact on food production for different technologies (e.g. solar, wind, biomass – where biomass may be seen as virtual water) for regions of differing water availability, using figures for coal as the benchmark. The development of a model should serve as a decision support system for policy makers and decision makers.

This may become one of the determining factors guiding future decisions and of transitioning towards a green economy.

The water energy food nexus

The triple challenge of energy supplies, water stress and food security is becoming increasingly important at a global level. In a recent live chat on the water-energy-food nexus, experts from the World Economic Forum shared positive, practical examples of policy and on-the-ground projects and commented on what the future holds. Williams and Pittock (undated) presented the following quotes:

In 1911, John Muir observed, 'When we try to pick out anything by itself in nature, we find it hitched to everything else in the Universe.'

A century later, a gathering of the World Economic Forum discovered the same phenomenon. Four hundred top decision-makers listed the myriad looming threats to global stability, including famine, terrorism, inequality, disease, poverty, and climate change. Yet when we tried to address each diverse force, we found them all attached to one universal security risk: fresh water. (Margaret Catley-Carlson, Patron, Global Water Partnership, 2008-2010, Chair of World Economic Forum Global Agenda Council on Water Security) (quoted from Williams and Pittock, undated).

As a major and strategic user of water, Eskom should be in a position to contribute to the development of strategy to address the management of this nexus in a country that is subject to water scarcity and where the demographics and growth projections indicate a growing demand for water, food and energy.

The energy, agriculture and water nexus

A valid research question is 'On the one hand, how does the availability of electricity influence agriculture and how does Eskom's use of water influence agriculture and on the other hand, how does the use of water in agriculture impact Eskom's activities?' This should consider both water quantity (including the timing of flow) and water quality. Ecosystem-based adaptation to climate change

Ecosystems in good condition are resilient and better able to resist shocks than built infrastructure. While the natural variability of the climate in southern Africa tends to mask trends, any initiatives to address the adaptation to climate change will assist in the coping with the inherent climate variability. Wetlands are key providers of aquatic ecosystem services and maintaining them in good condition will increase the sustainability of the socio-ecological system (SES), but they need to be managed at the catchment level. The benefits of improved resilience and sustainability will be realised by the whole catchment SES, not just Eskom. Subsistence users, the "voiceless", who depend directly on the ecosystem services for their livelihoods will be amongst the first to benefit from this improvement in sustainability. Improving the resilience of ecosystems will also contribute to the transition towards a green economy.

The question is: 'What form could Eskom's input into catchment-wide wetland management take?' Aspects to be considered when answering this question would be the projected changes in wetlands under the climate change projections and how the projected changes would work out into changes in wetlands in the landscape and how these changes would

influence the ecosystem services currently realised from wetlands. This would then need to be worked into the catchment management strategy of the relevant CMA.

Use of reclaimed water

In a situation of water scarcity, what are the benefits and costs of using reclaimed water from a source external to the power station itself (e.g. municipal effluent) for power generation? Currently, for instance, the Kleinkoppie coal mine is treating AMD as required in its water use license and then selling the treated water to Emalahleni Municipality. Duvha PS is not far from Emalahleni, which has a serious problem with its WWTW, could there be some form of cooperation here? And similarly elsewhere? It would also save untreated sewage from being discharged into the environment, so releasing the wetlands downstream to polish the water in an already overused catchment and in the longer term, helping to protect the water quality used in the Groblersdal irrigation scheme downstream from Loskop Dam. Questions that could be addressed in this regard are:

- What is the feasibility and what are the limitations (geographic, technological, economic) to implementing the recycling of reclaimed effluent from a non-Eskom service provider;
- What are the sustainability issues that would need to be addressed, and how could these be addressed;
- How could the findings of the WRC research programme on the use of primary sewage sludge to sequester sulphur from effluents (under Prof P Rose, Rhodes University, patents held in conjunction with ERWAT) be implemented in such a situation.

This has the potential to improve the delivery of ecosystem services in the catchment

- Addressing International Questions

Projections of the use of energy and water into the future

At a global level, it is critical to remain aware of future projections concerning water supply alternatives that could shift overall energy consumption. For instance, between 2006 and 2011 global desalination production (an energy intensive technology) increased from 25 million m^3 to 72 million m^3 per day. By 2015, the projection stands at 100 million m^3 (Olsson, 2012).

What are the longer term projections for (A) the use of power in water management and (B) the use of water in power generation in South Africa?

- Alternate technologies

What is the cost and lead time of viable energy alternatives which may use less water, leaving more for the environment and other uses such as food production. And what is the impact of these alternate energy sources on the long term sustainability of the environment (i.e. once the technology has been decommissioned)? There is an urgent need for R&D to investigate alternate technologies which will reduce the volume of water used and the volume of waste generated by the suite of technologies currently used in South Africa.

Shale gas

Natural gas extraction: South Africa has extensive fields of shale gas and the process of investigating the development of these is underway. Apart from the concerns around the availability of sufficient water for the extraction process and the contamination of shallow aquifers, the handling of the effluent from the wells will need to be addressed. Where fracking is practised in water-rich areas the effluent is stored in large, open, surface reservoirs. If this practice is followed in the semi-arid areas of South Africa it will result in the creation of wetlands where none existed previously. The reservoirs containing the water of poor quality will attract wildlife which will become affected by the toxins in the effluent.

This aspect also needs to be addressed in the planning for the process.

Nuclear energy

Nuclear energy has had bad press following accidents from the early-generation technologies. Newer generation technologies are safer. What is the relative efficiency and reliability of nuclear energy, and what is the cost per KWh? There is a need for a review of the experience from elsewhere in the world. Water use and greenhouse gas emissions must be taken into consideration. The costings need to be benchmarked against South African standards so that accurate and unbiased comparisons may be drawn. This will help decision makers to choose the most cost effective technologies. Off grid technologies

There is a need to look at off-grid technologies. This is relevant for rural areas as well as urban areas. Of particular importance is the understanding of the social aspects. Rural people may regard off-grid technologies as ‘second best’, and where this perception exists it needs to be managed. In the wealthier urban areas these technologies may be more readily accepted as the people may be more ready to accept the need for adopting off-grid technologies.

Some examples of off-grid technologies follow:

Solar energy

South Africa is richly endowed with solar energy, particularly in the arid West. What is the relative water use efficiency of solar energy compared to, for instance, coal which is currently the main source of energy? Are there other costs to the social-ecological system which are not currently recognised?

Wind energy

What is the relative efficiency and reliability of wind energy, and what is the cost per KWh? There is a need for a review of the experience from elsewhere in the world. Water use and greenhouse gas emissions must be taken into consideration. The costings need to be benchmarked against South African standards so that accurate and unbiased comparisons may be drawn. This will help decision makers to choose the most cost effective technologies.

Energy from biomass

What is the relative efficiency and reliability of energy from biomass, and what is the cost per KWh? There is a need for a review of the experience from elsewhere in the world. Water use and greenhouse gas emissions must be taken into consideration. The costings need to be benchmarked against South African standards so that accurate and unbiased comparisons may be drawn. This will help decision makers to choose the most cost effective technologies.

Energy generated from gas.

There are large fields of natural gas being developed in the SADC region and this is coming available for use in South Africa. What is the relative efficiency and reliability of energy from natural gas, and what is the cost per KWh? There is a need for a review of the experience from elsewhere in the world. Water use and greenhouse gas emissions must be taken into consideration. The costings need to be benchmarked against South African standards so that accurate and unbiased comparisons may be drawn. This will help decision makers to choose the most cost effective technologies.

Beneficiation of waste

Are there technologies which could reduce the footprint of power generation? Would, for instance, the re-working coal discard dumps to produce coal pellets for coal fired power generation be an option? And can any of the pollutants (e.g. sulphur) be recovered for recycling? Are there other waste streams which could be beneficiated, so reducing the overall volume of waste generated by the power station?

The principle of cleaner production is that resources are used more efficiently and so the waste stream is reduced. Using the principles of cleaner production as implemented in other industries, how can Eskom improve its efficiency in the use of the resources necessary for energy generation while at the same time reducing its footprint

The Water Research Commission has, over the years, funded research to develop cleaner production guidelines for industry (TT 139/00; 1898/1/11), petroleum industry (1673/1/08), the mining industry (TT 485/11; 1553/1/11) and industrial complexes (TT 544/12; TT 545/12; TT 546/12; TT 547/12; TT 548/12), amongst others. Where cleaner production principles have been implemented there has been an improvement in efficiency and a decrease in waste generated.

There is a need for a similar guide for the power generation industry. This would not be limited to the coal-fired power generation, but should address all the technologies used in South Africa.

6.6 PRELIMINARY ASSESSMENT OF RESEARCH PRIORITIES

- Technical Research
    - Soil carbon (paragraph: Soil carbon)
    - Water conservation and demand management (water use efficiency) (paragraph: Water conservation and demand management)
    - Development of a generic monitoring programme for use on Eskom properties (paragraph: Monitoring programme)
    - Integrated natural resource management (paragraph: Integrated natural resource management for the benefit of ecosystem services)
- Social/economic research
    - The benefits and costs of alternate technologies available to power generation, water use and impact on quality, impact on the environment and impact on food production (paragraph: Benefits and costs to power generation, water use and food production)
    - Ecosystem-based adaptation to climate change for Eskom-specific activities (paragraph: The energy, agriculture and water nexus)
- Legal/policy research
    - Possible future changes in in wetland or water policy and legislation (paragraph: Consideration of possible future changes in wetland or water policy and legislation).

7 CONCLUSION

South Africa is a water-stressed country and the water resource will potentially limit the economic growth if it is not well managed. Society relies on the benefits that ecosystem services provide and when ecosystems become degraded they are no longer able to provide the services at the level of their potential. Table 3 (Page 34) gives the mean global values of the ecosystem services per the world's biomes (De Groot et al., 2012). These were derived from a number of published studies (see 'Sample Size' in the table). These figures show that, of the inland systems, inland wetlands deliver the highest value per hectare. The regulating services are difficult to value but provide the resilience to the system, and these form a major part of the contribution to the value of inland wetlands.

Wetland habitat in the Olifants River catchment is important because it is a component of the ecological infrastructure comprising the aquatic ecosystem of the Catchment. DWA (2012) estimated that the value of aquatic ecosystem services (within which wetland ecological infrastructure plays an important role) was approximately R3 billion per year. Moreover, more than 55% of the GDP contributing sectors in the Olifants River Catchment are directly dependent on water use licences. The economy and people of the Olifants River Catchment are thus highly dependent upon the water resources of the catchment (quoted from Harris et al., 2013). This catchment has a number of coal-fired power stations as well as coal mines and other economic activities. Thus, the loss of aquatic ecosystem services in this catchment would have a severe impact on the economy of the catchment. The Olifants River catchment (in Gauteng, Mpumalanga and Limpopo Provinces) provides an example of the value of aquatic ecosystem services to the country. For this reason it is important that aquatic ecosystems are maintained in good condition.

The wetland management framework was developed with the importance of the aquatic ecosystem services in mind.

The wetland management framework (WMF) has been developed as a practical, 'how to', guide for on-the-ground wetland management. It is designed to provide detailed guidance to environmental managers, but also to provide the knowledge needed by managers and planners on the legal and ecological aspects of managing wetlands on Eskom properties. It gives insight into the complexity of managing wetlands under the current legal requirements while at the same time working into the maintenance of the ecosystems that provide the benefits on which society relies, both on Eskom property as well as in the catchments in which Eskom is active.

The WMF has been structured to mesh with Eskom's Project Life Cycle Model (PLCM). This informs the planning and management teams about the relevant wetland management tasks that need to be included at each stage of the process to ensure compliance with the requirements of legislation as well as the conservation of the desired ecosystem services. It also includes the corporate responsibility to the wider community where relevant.

Although the WMF focuses on Eskom's business processes, it will also serve to guide other organisations which are working in and around wetlands such as mining activities and municipal developments. It addresses the essentials of wetland management in a way that will provide the essential guidance to how to interact with wetlands.

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APPENDIX

Figure 44: Pathways and milestones for the period 2009 to 2015 related to water (Eskom, 2009b)

Figure 45: Pathways and milestones for the period 2016 to 2030 related to water (Eskom, 2009b)

PILOT SITE SELECTION

The Research Team recognized the need for a justifiable methodology in the selection of pilot sites for the purposes of testing the Wetland Management Framework (WMF).

Tables 46 and 47 provide the names and organisations of the persons attending two such meetings as well as those from whom an apology was received.

Table 46: Attendees of the site selection meeting on 24 May 2013

Attendees	Name	Organisation/Business Unit	Contact Details
Present	Wietsche Roets	DWA	082 604 7730
	Kaajial Durgapersad	Eskom	082 389 2350
	Felicia Tiba	Eskom	083 297 4328
	Tefo Tshabidi	Eskom: Sustainability	082 879 9286
	Siven Naidoo	Eskom: TS & RM	083 258 3786
	Florence Radebe	Eskom: Construction	082 389 2233
	Michael Michael	Eskom: RT & D	084 664 0747
	Daphney Ramaphosa	Eskom: Construction	073 315 1117
	Levania Moodley	EON Consulting	081 270 9328
	Adri Venter	EON Consulting	082 372 8186
Apologies	Meera Ormea	Eskom: PED	083 2700 659
	Esther Appleyard	Eskom: PED	
	Steve Mitchell	EON Consulting	

Table 47: Attendees of the site selection meeting on 26 July 2013

Attendees	Organisation/ Business Unit	Contact details
Kaajial Durgerpaersad	Eskom	082 389 2350
Felicia Tiba	Eskom	083 297 4328
Tefo Tshabidi	Eskom: Sustainability	082 879 9286
Michael Michael	Eskom: RT & D	084 664 0747
Adri Venter	Eon Consulting	082 372 8186
Steve Mitchell	Eon Consulting	
Michillay Brown	Student accompanying Eskom	
Kishaylin Chetty	Eskom	
Theresa Ferguson	Eon Consulting	
Apologies		
Wietsche Roets	DWA	082 604 7730