Revision of the Pricing Strategy for Water Use Charges: Implementation of the Waste Discharge Charge System (WRCWD)

Report no. 3016/1/22 **May 2022**

Report to the
Water Research Commission

by

Traci Reddy and Thabile Mgwebi
Pegasys Strategy and Development (Pty) Ltd

Obtainable from
Water Research Commission
Private Bag X03
Gezina
PRETORIA, 0031

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

This is the final report pertaining to WRC project no. C2021-2022-01042.

ISBN 978-0-6392-0400-0

Cover Image: Image of eutrophication of Hartbeespoort Dam, August 2021 ©Traci Reddy

EXECUTIVE SUMMARY

Introduction

South Africa continues to face water scarcity and climate change pressures within a constrained national fiscal and economic context. The reduction in water quality increases the cost of water, threatens human health, limits food production, reduces ecosystem functions, and hinders economic growth. Acid mine drainage, municipal wastewater discharge, industrial activities, urban washoff, and irrigation return flow continue to be the main sources of water quality problems.

In recognising that impacts of water quality deterioration posed a significant threat for the country's economy, society, and environment, the 1997 White Paper on a National Water Policy for South Africa stated that the "*use of rivers and other water resources to dispose of wastes will also be made subject to ....a resource conservation charge where there are competing beneficial uses for such use and/or such use significantly affects other users*". This reflected the intent of Principle 16: "***Water quality management options shall include the use of economic incentives and penalties to reduce pollution***".

Following these policy positions, the National Water Act of 1998 enables the Minister to establish a Pricing Strategy for charges on water use that may (Section 26) *provide for* a differential rate for waste discharges.

The Integrated Water Quality Management (IWQM) Policy for South Africa (DWS, 2016) also recognises that water quality management is a complex and confounding challenge due to incomplete, contradictory, and changing requirements that are often difficult to recognise. Often, there are a multitude of interacting factors, including incomplete information, political interference, institutional instability, and changes outside the control of managers. Unfortunately, it is an operational reality that the water quality management approach used to date has not adequately addressed the challenge. The current penalties for non-compliance are not effectively implemented, but also not sufficiently priced to change behaviour and must be reviewed. Consequently, the IWQM Policy identifies the Waste Discharge Charge System (WDCS) as an economic incentive mechanism, in support of other regulatory tools, to improve WQM.

The National Water and Sanitation Master Plan reflects that between 1999 and 2011 the extent of main rivers in South Africa classified as having a poor ecological condition increased by 500%, with some rivers pushed beyond the point of recovery (DWS, 2018).

In response to the country's poor water quality in strategic catchments, the Waste Discharge Charge System (DWA, 2014) has been developed as a key instrument in supporting water quality management of the country, with the Waste Mitigation Charge (WMC) being a critical financial resource to support catchment water quality management. This Strategy has been in development for over a decade, and implementation is critical to realising success and improvement in the quality of our water resources.

The Pricing Strategy

In setting water use charges, incentives, and disincentives to promote the efficient and beneficial use of water, to reduce the detrimental impacts on water resources and to prevent the waste of water (Section 56(6) of the Act) may be introduced. When setting these charges, the class and resource quality objectives of the water resource should be considered.

The Pricing Strategy for Raw Water Use Charges provides a framework for implementing the charge system for water use. The Pricing Strategy addresses the following two charges allowed for in the Act, namely:

1. the **water resource management charge,** for funding water resource management; and
2. the **water resource development charge** for funding water resource development and use of waterworks.

These charges focus mainly on water use in terms of volumes abstracted or discharged and not on the impact caused by the associated discharge or the waste conveyed in the discharge. The **Waste Discharge Charge System (WDCS)** will address the latter by introducing financial and economic instruments such as the *polluter pays* principle, designed to internalise costs associated with waste and to encourage the reduction in waste and the minimisation of detrimental impacts on water resources.

While the Water Resource Management Charge is aimed at providing financial support to 11 identified water resource management functions, the activities funded by the WRMC specifically related to waste discharge activities are:

1. Water quality management plan
2. Waste discharge activities authorisation
3. Waste discharge control
4. Pollution incident planning and response (management)
5. Implementation of water management strategies (cleaner technology, dense settlements, waste discharge strategies)

The WDCS and its charge, The Waste Mitigation Charge, should be differentiated from the Water Resource Management Charge (WRMC) – which is a payment for the day-to-day management of water quality such as penalties for pollution incidents and the authorisation of waste discharge activities. The WDCS, through the Waste Mitigation Charge, aims to finance strategic interventions to address specific targeted pollutants in threatened areas.

The Waste Discharge Charge System and the Waste Mitigation Charge

The Waste Discharge Charge System (WDCS) has been identified as an economic incentive mechanism, in support of other regulatory tools, to improve water quality management. The WDCS aims to collect revenue to finance mitigation interventions and strategies.

The following **principles** apply:

1. The WDCS will be applied at a catchment scale. The catchment area will be defined as those areas that have a significant impact on water quality or are impacted by the specific problem.
2. The WDCS will be based on load discharged. This approach (1) avoids dilution of effluent to achieve cost reduction, (2) is more equitable, as it does not disproportionately penalise small dischargers with relatively higher effluent concentrations and (3) it is simple to implement.
3. A constant charge rate will be applied to the waste discharge load and will not vary against concentration.

4. The WDCS applies to both surface and groundwater resources, where water quality planning limits (WQPLs) may be defined for the resource. A single approach applies to the calculation of the WDCS in both surface and groundwater.
5. Only registered waste discharge related water use in terms of Sections 21(e), (f), (g), and (h) of the NWA will be liable for waste mitigation charges.
6. Government will be responsible for the costs associated with load that cannot be charged to registered water users.
7. The water quality load or concentration associated with water supplied to the discharger must be deducted from the load of water quality constituent that is discharged to get an accurate assessment of contribution of the discharge to the water quality load, and then the calculation of the waste discharge charge.
8. The WDCS may be applied to all discharges contributing to the load in an upstream catchment where downstream resource quality objectives are threatened or exceeded, even where incremental upstream resource quality objectives are met.
9. The mitigation measures and thus the associated waste discharge charges may be phased-in to enable planning by dischargers and to allow adaptive setting of charges as conditions change.
10. Minimum load thresholds for charging may be specified based on administrative cost considerations.

The WDCS may include, **but not be restricted to**, any of the following water quality variables:

- *Nutrients*: phosphate, nitrate & ammonium
- *Salinity*: Total Dissolved Solids, Electrical Conductivity, chloride, sodium & sulphate
- *Heavy Metals*: arsenic, cadmium, chromium, copper, mercury, lead, nickel & zinc
- *Organic material*: Chemical Oxygen Demand

Water quality indicator variables will be selected based on a ***systemic water quality problem*** and its ***cumulative impact*** identified in terms of the WQPLs and a catchment assessment. Isolated localised impacts, with limited cumulative impact may be addressed through other regulatory tools. Selection and definition of a particular indicator variable will consider the type of waste discharge sources in the catchment, the nature of the waste typically discharged, and the cost-effectiveness of monitoring different variables.

There are **four scenarios for which the Waste Mitigation Charge** may be considered:

a) *Removal of load from the water resource* – enables the recovery of costs for developing and operating regional mitigation schemes, initiatives, or projects for the reduction of water quality loads within the water resource.

b) *Water resource system operation for water quality management* – enables the recovery of costs associated with reduced system yield associated with the management of river-reservoir systems to reduce the impact of water quality problems.

c) *Treatment for downstream water users* – enables the recovery of costs incurred in developing and operating additional treatment requirements for downstream users, particularly where water quality does not meet specified resource quality objectives.

d) *Treatment at source* – enables a group of dischargers to contribute directly to the costs of reducing waste load from a specific source, including regional schemes to collect and treat waste from several sources before it enters the water resource.

Application of the Waste Mitigation Charge is based on the identification and assessment of feasible mitigation measures to reduce the catchment load or its impacts. Mitigation measures need to be evaluated in terms of their unit cost of mitigation and only those measures with lower unit cost of mitigation than the cost of treating the same load at source should be considered (the other measures represent economically inefficient options).

For feasible mitigation measures, the capital and operating costs of the mitigation measure must be calculated. The total load discharged into the resource must be estimated and the unit Waste Mitigation Charge rate per load discharged may be calculated. All point source discharge is included, and both registered and non-registered nonpoint source contributions must be estimated. Natural background water quality loads are not included in this calculation.

The mitigation cost is then distributed to the registered waste discharges according to the charge rate and individual discharge loads (discharge concentration multiplied by volume of discharge). The following equation is proposed for calculating the user charge to a specific discharger (k) for a mitigation measure in a catchment area:

Mitigation Charge Rate Formula
e) CMxik = RMxiy.[(Cdik. Vdk) - (Caik. Vak)]
f) CMxik = Waste Mitigation Charge for discharger k, mitigation measure x and water quality variable i
g) RMxiy = constant charge rate for mitigation measure x and variable i for a period y
h) Cdik = discharge concentration of variable i (registered) from discharger k
i) Caik = abstraction concentration of variable i (registered) for discharger k
j) Vdk = discharge volume (registered) from discharger k
k) Vak = abstraction volume (registered) for discharger k

The determination of the charge rate will be specific to the locality where it will be applied. Therefore, the charge rates will not be the same across the different catchments. The charge rates are also dependent on the water quality variable/s to be addressed.

A case study of the Hartbeespoort Dam indicates that short-term interventions alone are not sufficient in preventing the deteriorating water quality situation. The cost of implementing the WDCS may seem significantly higher, but this is because the WDCS proposes a full suite of interventions and mitigation actions that will have a greater impact on nutrient load reduction in a sustainable manner.

The collaborative and potentially long-term implications of implementing the WDCS requires clear institutional roles and responsibilities, in terms of both the financing and operation of the measure. Therefore, it is critical that the proposed mitigation measure is consulted with all dischargers who may be liable for charges. It is planned that the WDCS will be implemented in a phased manner, after testing and piloting the system prior to implementation. The WDCS will be applied in suitable priority catchments throughout South Africa, in line with the IWQM Policy and as identified in the National Water and Sanitation Masterplan (DWS, 2018).

ACKNOWLEDGEMENTS

Authors

Lead author:	Traci Reddy	Pegasys
Contributing author:	Thabile Mgwebi	Pegasys

We, the authors, would like to express appreciation to the Water Research Commission for initiating and funding this project and to the Department of Water and Sanitation (DWS) and National Treasury for their time, strategic insights and participation on this project and other colleagues for their strategic inputs. A list of the colleagues is presented below:

Sizani Moshidi	Department of Water and Sanitation
Raquel Nosie Mazwi	Department of Water and Sanitation
Dikeledi Baloyi	Department of Water and Sanitation
Caroline Shai	Department of Water and Sanitation
Samkeliswe Tengwe	Department of Water and Sanitation
Kgomotso Mohlodini	Department of Water and Sanitation
Asiphe Sibango	Department of Water and Sanitation
Petrus Venter	Department of Water and Sanitation
Sharlin Hemraj	National Treasury
Memory Machingambi	National Treasury
Marissa Moore	Public Finance Consulting Services
Martin van Veelen	Iliso Consulting
Derek Weston	Pegasys
Guy Pegram	Pegasys

The positive support of everybody who was involved in the successful completion of this project is appreciated.

CONTENTS

LIST OF FIGURES

LIST OF TABLES

LIST OF ACRONYMS

Acronym	Definition
CMA	Catchment Management Agency
CMS	Catchment Management Strategy
DWS	Department of Water and Sanitation
HDRP	Hartbeespoort Dam Remediation Programme
IWQM	Integrated Water Quality Management
NWA	National Water Act
RQO	Resource Quality Objectives
WDCS	Waste Discharge Charge System
WMA	Water Management Area
WMC	Waste Mitigation Charge
WQM	Water Quality Management
WQPL	Water quality planning limits
WRMC	Water Resource Management Charge
WWTW	Wastewater Treatment Works

1. INTRODUCTION

1.1 Background

South Africa is a water scarce country and the equitable, efficient, and sustainable management of its water resources in the national interest is critical to supporting further economic growth and development. Even with the national water quality challenges being identified and comprehensive policy and management frameworks being formulated as early as the early 1990s, there has continued to be widespread water quality deterioration in many of the country's key catchments. Acid mine drainage (AMD), municipal wastewater discharge, industrial activities, urban washoff, and irrigation return flow continue to be the main sources of water quality problems.

In recognising that impacts of water quality deterioration posed a significant threat for the country's economy, society, and environment, the 1997 White Paper on a National Water Policy for South Africa stated that the "*use of rivers and other water resources to dispose of wastes will also be made subject to . . . a resource conservation charge where there are competing beneficial uses for such use and/or such use significantly affects other users*". This reflected the intent of Principle 16: "***Water quality management options shall include the use of economic incentives and penalties to reduce pollution***".

Following these policy positions, the National Water Act of 1998 enables the Minister to establish a Pricing Strategy for charges on water use that may (Section 26) *provide for a differential rate for waste discharges, taking into account:*

(a) the characteristics of the waste discharged

(b) the amount and quality of the waste discharged

(c) the nature and extent of the impact on a water resource caused by the waste discharged

(d) the extent of permitted deviation from prescribed waste standards or management practices; and

(e) the required extent and nature of monitoring the water use.

The Integrated Water Quality Management (IWQM) Policy for South Africa (DWS, 2016) also recognises that water quality management is a complex and confounding challenge due to incomplete, contradictory, and changing requirements that are often difficult to recognise. Often, there are a multitude of interacting factors, including incomplete information, political interference, institutional instability, and changes outside the control of managers. Unfortunately, it is an operational reality that the water quality management approach used to date has not adequately addressed the challenge. The current penalties for non-compliance are not effectively implemented, but also not sufficiently priced to change behaviour and must be reviewed. Consequently, the IWQM Policy identifies the Waste Discharge Charge System (WDCS) as an economic incentive mechanism, in support of other regulatory tools, to improve WQM.

The National Water and Sanitation Master Plan reflects that between 1999 and 2011 the extent of main rivers in South Africa classified as having a poor ecological condition increased by 500%, with some rivers pushed beyond the point of recovery (DWS, 2018).

South Africa continues to face water scarcity and climate change pressures within a constrained national fiscal and economic context. The reduction in water quality increases the cost of water, threatens human health, limits food production, reduces ecosystem functions, and hinders economic growth.

In response to the country's poor water quality in strategic catchments, the Waste Discharge Charge System (DWA, 2014) has been developed as a key instrument in supporting water quality management of the country, with the Waste Mitigation Charge (WMC) being a critical financial resource to support catchment water quality management. This Strategy has been in development for over a decade, and implementation is critical to realising success and improvement in the quality of our water resources.

1.2 Purpose

The purpose of this report is to relook at the assumptions and principles used in the development of the Waste Discharge Charge System and test the Mitigation Formula for its robustness in catchments and application.

1.3 Structure of the Report

Section 2 describes how the Pricing Strategy has been established and provides a framework for implementing a charge system for different water uses. The section lists the legislation and laws that advocate the objectives and principles of a pricing system for waste discharge. It also differentiates the WDCS and its charges from the Water Resource Management Charge (WRMC).

Section 3 provides an overview, as well as the basis and principles of the WDCS. It also defines the situations and variables that the WDCS, as an economic tool, is meant to address.

Section 4 describes the establishment of the WMC and details the four scenarios for which the WMC may be considered. It also details the considerations that are to be made when calculating the charge.

Section 5 goes through the four practical steps for determining the WMC rate, using the Hartbeespoort Dam as a case study. The development of the mock charge rates that will be borne by the dischargers is used to illustrate the methodology used to determine a WMC in an engaged process with impacted and affected stakeholders.

Section 6 reviews the implementation and impacts of the Hartbeespoort Dam Remediation Programme. It also estimates the impacts of the proposed Waste Mitigation Charge by performing a qualitative cost-benefit analysis.

Section 7 outlines the institutional roles and responsibilities for the setting, collection, and disbursement of the WMC and implementation of the mitigation measures in consultation with all dischargers who are liable for the charge.

Section 8 sets out the phased implementation approach of the WDCS in suitable priority catchments throughout the country.

2. WATER USE CHARGE FOR IMPACT

Section 56(1) of the Act instructs the Minister of Water and Sanitation to establish a Pricing Strategy for charges for any water use described in Section 21 of the Act, namely:

a) **taking water** from a water resource

b) **storing** water

c) **impeding or diverting the flow** of water in a watercourse

d) engaging in a **stream flow reduction** activity

e) engaging in a **controlled activity**

f) **discharging waste** or water containing waste into a water resource

g) **disposing of waste** in a manner which may detrimentally impact on a water resource

h) **disposing of water which contains waste** from any industrial or power generation process

i) **altering the bed, banks, course, or characteristics** of a watercourse

j) **removing, discharging, or disposing of water found underground**; and

k) using water for **recreational purposes**.

Water use charges may be set for (Section 56(2) of the Act) funding water resource management, including monitoring and controlling of water resources and its use and gathering of information, as well as water conservation; funding water resource development and use of waterworks; and achieving the equitable and efficient allocation of water.

Apart from the National Water Act and the Water Services Act, 1997 (Act 108 of 1997), no other legislation refers directly to a WDCS. There are, however, several laws that refer to the principle that the polluter should wholly, or at least in part, pay for relevant impact caused to the environment, as opposed to the State or society carrying the total expenditure of rehabilitation acts. Nearly all laws concerned with environmental protection have regulations stating that any expenditure for rehabilitation work by the State can be recovered from the responsible parties.

The legislation listed below refers to the principle of the polluter pays or advocates the objectives and principles of a possible pricing system for waste discharge:

1. Constitution of the Republic of South Africa, 1996 (Act 108 of 1996)
2. Environment Conservation Act, 1989 (Act 73 of 1989)
3. National Environmental Management Act, 1998 (Act 107 of 1998)
4. Minerals and Petroleum Resources Development Act, 1991 (Act 50 of 1991)
5. Atmospheric Pollution Prevention Act, 1965 (Act 45 of 1965)
6. Local Government Transition Act, 1993 (Act 209 of 1993)

Further, differential rates for waste discharges may be set depending on the geographical area, characteristics and amount of waste discharged, and the nature and extent of the impact on a water resource and its users (Section 56(5) of the Act). The latter should take cognisance of the class and resource quality objectives of the water resource in question. The benefit of a specific water use and the economic circumstances, as well as the monitoring requirements associated with the waste discharge should also be considered.

In setting water use charges, incentives, and disincentives to promote the efficient and beneficial use of water, to reduce the detrimental impacts on water resources and to prevent the waste of water (Section 56(6) of the Act) may be introduced. When setting these charges, the class and resource quality objectives of the water resource should be considered.

The Pricing Strategy for Raw Water Use Charges provides a framework for implementing the charge system for water use. The Pricing Strategy addresses the following two charges allowed for in the Act, namely:

1. the **water resource management charge,** for funding water resource management; and
2. the **water resource development charge** for funding water resource development and use of waterworks.

These charges focus mainly on water use in terms of volumes abstracted or discharged and not on the impact caused by the associated discharge or the waste conveyed in the discharge. The **Waste Discharge Charge System (WDCS)** will address the latter by introducing financial and economic instruments such as the *polluter pays* principle, designed to internalise costs associated with waste and to encourage the reduction in waste and the minimisation of detrimental impacts on water resources.

There are five categories of charges, two of which apply to waste discharge: namely The Water Resource Management Charge and the Waste Mitigation Charge.

The **Water Resources Management Charge** funds the water resource management activities related to the protection, allocation, conservation, management, and control of all the nation's water resources. It consists of two components the abstraction water use charge and the waste discharge related water use charge. While the Water Resource Management Charge is aimed at providing financial support to 11 identified water resource management functions, the activities funded by the WRMC specifically related to waste discharge activities are highlighted in Table 1 below and include (Department of Water and Sanitation, 2015):

1. Water quality management plan
2. Waste discharge activities authorisation
3. Waste discharge control
4. Pollution incident planning and response (management)
5. Implementation of water management strategies (cleaner technology, dense settlements, waste discharge strategies)

Table 1: Water Resource Management Charge activities

	Activities	Abstraction activities	Waste discharge activities
1	Catchment management strategy and Water resources planning	Resource studies, investigations, and integrated strategy development	
		Allocation plans	Water quality management plan
2	Resource directed measures	-Implement programmes to monitor Resource Quality Objectives (RQOs) -Implement source-directed controls to achieve resource quality objectives -Report against the achievement of the Class and RQOs -Report on the water balance per catchment (i.e. water available for allocation after consideration of ecological requirements)	
3	Water use authorisation	Registration of water use	
		Abstraction & stream flow reduction activities Authorization	Waste discharge activities Authorization
4	Control and enforcement of water use	Control Monitoring and enforcement of Water Use	
		-Abstraction & stream flow reduction activities -Dam safety control (private dams)	Waste discharge control
5	Disaster management	Planning and management of disaster (Administration)	Pollution incident planning and response (management)
6	Water resources management programmes	Integrated water resources programmes	
		Implementing of water management strategies (e.g. water conservation and water demand management)	Implementing of water management strategies (e.g. cleaner technology, dense settlements, waste discharge strategies)
7	Water related institutional development (Stakeholder Management empowerment)	Stakeholder participation, empowerment, institutional development & coordination of activities - Establishment and regulation of water management institutions - Stakeholder consultations - Capacity and Empowerment of stakeholders	
8	Water weed control	Aquatic weeds control	
9	Maintenance and Restoration of Ecosystems to improve water resources	- Planning and implementation of ecosystem maintenance and rehabilitation programs, required for water resource protection, e.g. sediment control, nutrient trapping, riparian rehabilitation - Control of invasive alien plants with acknowledged negative impacts on water resources, e.g. riparian zones, mountain catchment areas, wetlands and in areas where there could be an impact of aquifers	
10	Geo-hydrology and hydrology	- Groundwater and Surface water Monitoring - Compiling of maps and yield information - Extending and maintaining the hydrological database & compilation of information	
11	Administration & Overheads	Administrative, institutional & overheads for regional office or CMA	

The WDCS and its charge, The Waste Mitigation Charge, should be differentiated from the Water Resource Management Charge (WRMC) – which is a payment for the day-to-day management of water quality such as penalties for pollution incidents and the authorisation of waste discharge activities. The WDCS, through the Waste Mitigation Charge, aims to finance strategic interventions to address specific targeted pollutants in threatened areas.

3. THE WASTE DISCHARGE CHARGE SYSTEM

3.1 Overview

The National Water Act (NWA) defines water use to include activities that contribute point or diffuse waste into water resources. Regulatory and cooperative instruments have been applied in managing waste from these sources, but problems can occur even where there is compliance with the relevant standards. There is a need in many catchments to collect money from polluters to mitigate or rehabilitate the impacts that their discharge has on other users of the water resources, as well as to efficiently incentivise the reduction of cumulative waste loads into those water resources and thereby reduce the impacts on these other water users and the aquatic environment. The implementation of economic instruments to assist the achievement of water quality management objectives has been considered over the past decade in the development of the WDCS (DWS, 2016).

An economic instrument is "a Policy, tool or action which has the purpose of affecting the behaviour of economic agents by changing their financial incentives in order to improve the cost-effectiveness of environmental and natural resource management" (EPA, 2022). Economic instruments often work best when they complement other approaches such as regulation, information and communications measures. While traditional regulatory approaches are valuable policy tools, market-based approaches create an incentive for society to incorporate pollution abatement into production or consumption decisions and to innovate in such a way as to continually search for the least costly method of abatement (EPA, 2022). Economic instruments include water pricing, charges, penalties, and incentives to be used as an incentive to reduce pollution of water sources.

The WDCS is the most important tool that will be implemented in this regard. It is based on the polluter-pays principle and aims to promote the sustainable development and efficient use of water resources; internalise the environmental and social costs of using water; create financial incentives for water users to reduce waste and use water resources more optimally, and recover costs associated with impacts of waste discharges.

The WDCS is designed to reflect the financial and economic costs imposed on society and the environment from discharging wastes and pollutants into water bodies – enshrined in the widely accepted Polluter Pays Principle. The Polluter Pays Principle helps to link causes to solutions and create common ownership and should not be viewed as an entirely punitive measure.

The WDCS as an economic incentive mechanism is therefore most appropriate for water quality problems for which the **primary impact is associated with the cumulative impacts from a single or a number of dischargers** in a catchment, rather than localised pollution events from a single discharger (which is better managed through regulatory directives under Section 19 of the NWA), and **the primary sources are authorised water users**, which require authorisation or registration, rather than diffuse sources that are not defined as water users (in terms of Section 21 of the NWA). The WDCS is therefore applicable to all dischargers but will only be implemented where identified interventions are to be affected.

The **Waste Discharge Charge System** aims to collect revenue to finance mitigation interventions and strategies. The assumption is that the costs of pollution can be:

1. Fully assessed and
2. That restitution of the original environmental quality can and will be done.

The **WDCS will be applied at a catchment level**, not necessarily at a Water Management Area (WMA) scale. The catchment area will be defined as those areas that have a significant impact on or are impacted by the specific water quality problem. This may therefore be an entire catchment in which a wide-spread water quality problem exists or may be a sub-catchment within a larger basin, which is bounded by reservoirs and/or sub-catchments with insignificant contaminant loading. The potential impact of waste disposal on groundwater resources is recognised.

The WDCS may be implemented in catchments for which Resource Quality Objectives (RQOs) are either exceeded or threatened but may also be implemented in areas where identified water quality challenges are prevalent and require redress. In the absence of a class and associated resource quality objectives (RQO), Water quality planning limits (WQPLs) (previously referred to as Resource Water Quality Objectives) are developed to guide the management water quality. The setting of these WQPLs must be through a process of consensus-seeking amongst waste dischargers, water users and other relevant stakeholders, with the public trust placing the responsibility on Government to make sure that environmental interests are represented. These WQPL's can then also be used to guide where the WDCS is implemented.

It is important to **link the waste discharge charge to a water quality management plan wherever possible to provide a consolidated approach that results in improved and sustainable water resource quality. These more comprehensive approaches, that link planning approaches with the operational management and the use of various regulatory instruments will support the attainment of** objectives within a catchment through an **adaptive management process**. Encapsulating these within a Catchment Management Strategy (CMS) [in terms of Section 8 of the NWA] provides a strategic and integrated basis for mitigation actions within a water management area and provides an instrument for ongoing adaptive management.

It is also important to note that the WDCS can also be utilised as a vehicle to address very specific water quality management challenges associated with Court Orders that are instructive in terms of interventions to address specific issues.

3.2 Principles of the Waste Discharge Charge System

The WDCS defines two charges – an incentive charge (Waste Discharge Levy) and a mitigation charge (DWA, 2013). Either or both could be applied to a catchment. The Waste Discharge Levy is not considered during the current revision phase. The mitigation charge aims to cover the cost of mitigation measures in the catchment, where it is economically more viable to do so (de Waard, 2012).

The following principles apply to implementation of the Waste Mitigation Charge in terms of the WDCS.

1. The WDCS will be applied at a catchment scale. The catchment area will be defined as those areas that have a significant impact on water quality or are impacted by the specific problem.
2. The WDCS will be based on load discharged. This approach (1) avoids dilution of effluent to achieve cost reduction, (2) is more equitable, as it does not disproportionately penalise small dischargers with relatively higher effluent concentrations and (3) it is simple to implement.

3. A constant charge rate will be applied to the waste discharge load and will not vary against concentration.
4. The WDCS applies to both surface and groundwater resources, where WQPLs may be defined for the resource. A single approach applies to the calculation of the WDCS in both surface and groundwater.
5. Only registered waste discharge related water use in terms of Sections 21 (e), (f), (g), and (h) of the NWA will be liable for waste mitigation charges.
6. Government will be responsible for the costs associated with load that cannot be charged to registered water users.
7. The water quality load or concentration associated with water supplied to the discharger must be deducted from the load of water quality constituent that is discharged to get an accurate assessment of contribution of the discharge to the water quality load, and then the calculation of the waste discharge charge.
8. The WDCS may be applied to all discharges contributing to the load in an upstream catchment where downstream resource quality objectives are threatened or exceeded, even where incremental upstream resource quality objectives are met.
9. The mitigation measures and thus the associated waste discharge charges may be phased-in to enable planning by dischargers and to allow adaptive setting of charges as conditions change.
10. Minimum load thresholds for charging may be specified based on administrative cost considerations.

3.3 Water Quality Variables

The WDCS may include, but not be restricted to, any of the following water quality variables:

- *Nutrients*: phosphate, nitrate & ammonium
- *Salinity*: Total Dissolved Solids, Electrical Conductivity, chloride, sodium & sulphate
- *Heavy Metals*: arsenic, cadmium, chromium, copper, mercury, lead, nickel & zinc
- *Organic material*: Chemical Oxygen Demand

Water quality indicator variables will be selected based on a ***systemic water quality problem*** and its ***cumulative impact*** identified in terms of the WQPLs and a catchment assessment. Isolated localised impacts, with limited cumulative impact may be addressed through other regulatory tools. Selection and definition of a particular indicator variable will consider the type of waste discharge sources in the catchment, the nature of the waste typically discharged, and the cost-effectiveness of monitoring different variables.

4. THE WASTE MITIGATION CHARGE

4.1 Waste Mitigation Charge

The WMC is related to the recovery of costs associated with mitigation and abatement measures employed in the water resource to achieve WQPLs. This user charge is established in terms of the Pricing Strategy under the NWA, and therefore it should be **focused on the recovery and disbursement of quantifiable costs incurred in the mitigation** of direct impacts of waste discharge. To be a user charge, it is important that **all dischargers only pay according to their proportional contribution to the problem**. Accordingly, while the Waste Mitigation Charge may influence dischargers to reduce their discharge loads, it must be defined around the cost of mitigation.

To set charges in accordance with the *polluter pays* principle in mind, there must be a direct correlation with actual costs associated with impact caused by the discharge/disposal of waste. In order to set appropriate charges, the following must be developed or identified:

1. Key representative pollutants
2. The direct impact costs of the discharge/ disposal of waste
3. Abatement costs for categories of pollutants
4. Costs for the administration and oversight of mitigation interventions; and
5. Charge estimation and distribution models.

4.2 Scenarios for the Waste Mitigation Charge

There are four scenarios for which the Waste Mitigation Charge may be considered:

a) *Removal of load from the water resource* – enables the recovery of costs for developing and operating regional mitigation schemes, initiatives, or projects for the reduction of water quality loads within the water resource.

b) *Water resource system operation for water quality management* – enables the recovery of costs associated with reduced system yield associated with the management of river-reservoir systems to reduce the impact of water quality problems.

c) *Treatment for downstream water users* – enables the recovery of costs incurred in developing and operating additional treatment requirements for downstream users, particularly where water quality does not meet specified resource quality objectives.

d) *Treatment at source* – enables a group of dischargers to contribute directly to the costs of reducing waste load from a specific source, including regional schemes to collect and treat waste from several sources before it enters the water resource.

In thinking about the above, potential actions and interventions that can reduce the load or impact in the resource will include a range of solutions:

- **Physical Solutions**: such as upgrade of facilities on a plant, new infrastructure
- **Technical Solutions**: look at new technologies for treatment such as desalination
- **Management Solutions**: such as fix existing technology, enforce current regulatory laws.

4.3 Calculation of the Waste Mitigation Charge

The Waste Mitigation Charge is a user charge established in terms of the pricing strategy to recover the costs of mitigating the impacts of waste discharge on the surface water resources. It is intended for application **where mitigation measures provide an economically efficient approach** to support the achievement of WQPLs in a catchment, in comparison to the costs of waste discharge reduction at source. It must be planned, developed, and implemented in terms of a water resources management (and rehabilitation) plan developed to address a water quality problem in a catchment.

During the calculation of the waste discharge charge, the following should be considered:

- **Related to the impact cost:** The waste discharge charge should be related to the direct impact cost of the impact caused by the discharge/ disposal of waste. The charge should therefore be proportional to the impact experienced by the affected parties. In circumstances of uncertainty, one could resort to the use of a cost-benefit analysis. If direct impact costs are difficult to estimate, then abatement costs could be used where abatement is viable and feasible. If both costs exist (abatement cost and impact cost), the lessor of the two should be used. The system should be clear on how both the direct impact and abatement costs will be calculated.
- **Basis for calculation:** Distinctions should be made between different pollutants or groups of pollutants according to their toxicity and potential impact. The charge of certain pollutants (salinity) could be based on the total load associated with the discharge/disposal of waste, while that of others (potentially hazardous pollutants) could be based on maximum allowable concentrations. Certain hazardous pollutants or groups of pollutants could be totally banned and should therefore not be regulated through or form part of the WDCS.
- **Site-specific:** The charge should be calculated on a site-specific basis for each catchment or WMA, based on the circumstances and the optimal level of utilisation of the water resources within the WMA. Aspects that should be recognised are the resource quality objectives and requirements of the receiving water resource, as well as the direct impact cost associated with the discharge/disposal of waste in the specific WMA.
- **Double-charging:** No double-charging should transpire from the charges levied, and the system should address mechanisms that will ensure that double-charging is prevented.
- **Cross-subsidisation:** The system should be clear on the aspect of cross-subsidisation, if and when applicable, and to what degree. The system should also include control systems to manage this effectively.

Application of the Waste Mitigation Charge is based on the identification and assessment of feasible mitigation measures to reduce the catchment load or its impacts. Mitigation measures need to be evaluated in terms of their unit cost of mitigation and only those measures with lower unit cost of mitigation than the cost of treating the same load at source should be considered (the other measures represent economically inefficient options).

For feasible mitigation measures, the capital and operating costs of the mitigation measure must be calculated. The total load discharged into the resource must be estimated and the unit Waste Mitigation Charge rate per load discharged may be calculated. All point source discharge is included, and both registered and non-registered nonpoint source contributions must be estimated. Natural background water quality loads are not included in this calculation.

The mitigation cost is then distributed to the registered waste discharges according to the charge rate and individual discharge loads (discharge concentration multiplied by volume of discharge). The following equation is proposed for calculating the user charge to a specific discharger (k) for a mitigation measure in a catchment area:

Box 1: Mitigation Charge Rate Formula
CMxik = RMxiy.[(Cdik. Vdk) - (Caik. Vak)]
CMxik = Waste Mitigation Charge for discharger k, mitigation measure x and water quality variable i
RMxiy = constant charge rate for mitigation measure x and variable i for a period y
Cdik = discharge concentration of variable i (registered) from discharger k
Caik = abstraction concentration of variable i (registered) for discharger k
Vdk = discharge volume (registered) from discharger k
Vak = abstraction volume (registered) for discharger k

The determination of the charge rate will be specific to the locality where it will be applied. Therefore, the charge rates will not be the same across the different catchments. The charge rates are also dependent on the water quality variable/s to be addressed.

It is important that dischargers are not charged for the load of water quality constituents that the user receives. This would then consider the quality of receiving water quality whether from reticulated water supply or directly from the resource. Therefore, the intake concentration is taken at the point of abstraction with the intention to be focusing on the additional load that is added by the user. *RMXiy* is estimated as the annual cost of the mitigation including operation and debt repayment divided by the total discharge load in over a period *y*. In the event of concentrating, should the intake load be larger than the discharge load, the above equation is equated to 0 such that there is no negative charge.

The Waste Mitigation Charge for:

- *Registered point source dischargers* will be calculated as the product of the Waste Mitigation Charge rate and the monitored (or registered) waste load from that point source.
- *Registered discharge or disposal to land or facilities* (representing non-point sources) will be calculated as the product of the charge rate and the total monitored (or estimated) discharger charge load – related to the source management system.
- *For the (DWS) government contribution* related to other non-registered nonpoint sources will be the product of the charge rate and the total remaining nonpoint sources load in the catchment. **DWS together with other stakeholders are also obliged to implement regulatory and/or non-regulatory approaches to reduce the load from these nonpoint sources.**

5. PRACTICAL DEVELOPMENT OF THE WASTE MITIGATION CHARGE RATE

5.1 Steps for charge rate development

There are four steps to determine the charge rate, noting that there is consultation with the impacted and affected stakeholders. This is presented in the figure below:

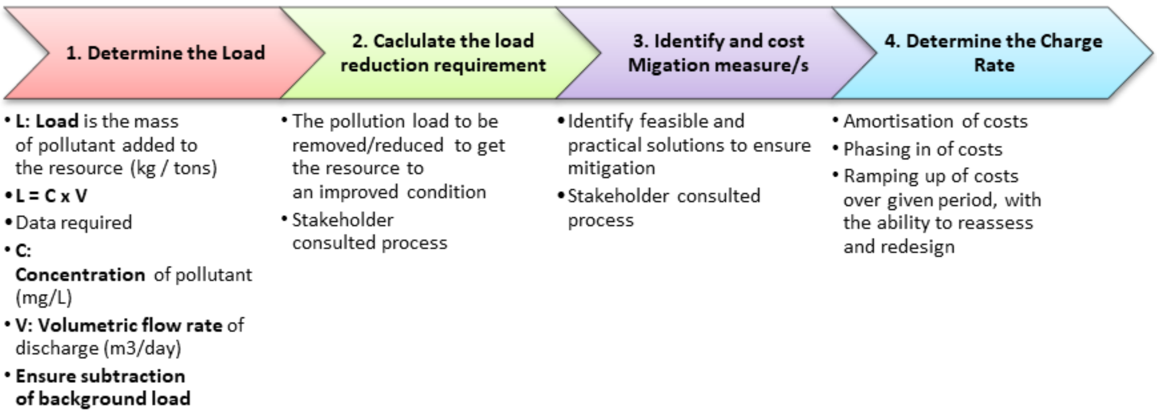

Figure 1: Charge Rate Determination

5.2 Case Study: Hartbeespoort Dam

To illustrate the charge rate development methodology, data, and information from the Hartbeespoort Waste Discharge Charge System Business Plan of 2014 (DWA, 2013) will be used. It should be noted that this is the most complete set of data available currently and provides the starting blocks to demonstrate the charge rate development. Therefore, these are mock charges and should not be read as final. The Upper Vaal and Upper Olifants catchments still require consensus on the load determination and will not be used in this illustration.

5.2.1 Step 1: Determine the Load

Based on the situation assessment done at the time (2014), the following results are available.

Overview of the Catchment

The Hartbeespoort Dam catchment is a sub-unit of the Crocodile-Marico West catchment and is situated in the North West Province in a valley south of the Magaliesberg mountain range. It lies approximately 35 km west of Pretoria and approximately 70 km northwest from Johannesburg. The dam was constructed in 1921 as an irrigation dam. There are three large rivers that drain towards the Hartbeespoort Dam, namely, Jukskei, Hennops and Magalies (refer to Figure 2). The characteristics of the dam are summarised in Table 2.

Table 2: Characteristics of the Hartbeespoort Dam

Characteristic	Value
Catchment area	4 112 km^2
Mean Annual Rainfall	670 mm
Mean Annual evaporation	1 690 (S) 1 246 (D)
Surface area	2 034 ha
Natural Mean Annual Runoff	163 million m^3
Full Supply Capacity	196 million m^3
Firm Yield (1990)	159 million m^3
Wall height	95
Crest length	101

The catchment area of the Crocodile (West) River is one of the most developed in the country. It is characterised by the widespread urban and industrial areas of northern Johannesburg and Pretoria, extensive irrigation downstream of Hartbeespoort Dam and large mining developments north of the Magaliesberg. As a result, the Crocodile River is one of the rivers in the country that has been most influenced by human activities, and where more specific management strategies are of paramount importance. There is also a strong inter-dependence between the Crocodile River catchment and neighbouring catchments due to the large-scale inter-basin transfer of water, as well as the complex water situation within the Crocodile River catchment.

Most of the water used in the catchment is supplied from the Vaal River system via Rand Water, mainly to serve the metropolitan areas and some mining developments. This in turn results in large quantities of effluent from the urban and industrial users, most of which is discharged to the river system after treatment, for re-use downstream. In many of the streams and impoundments, water quality is severely compromised by the proportionate large return flows resulting in the unmanageable nutrient pollution.

The Hartbeespoort Dam Irrigation Board supplies irrigation water through a network of canals to farmers cultivating a wide variety of produce including wheat, lucerne, fruit and flowers. The area used to be a major producer of tobacco, but due to increased quality requirements for the tobacco itself and an ever-increasing chloride concentration in the dam water, tobacco could no longer be produced commercially and has mostly been phased out.

The key pollutant of interest in the Dam was phosphate.

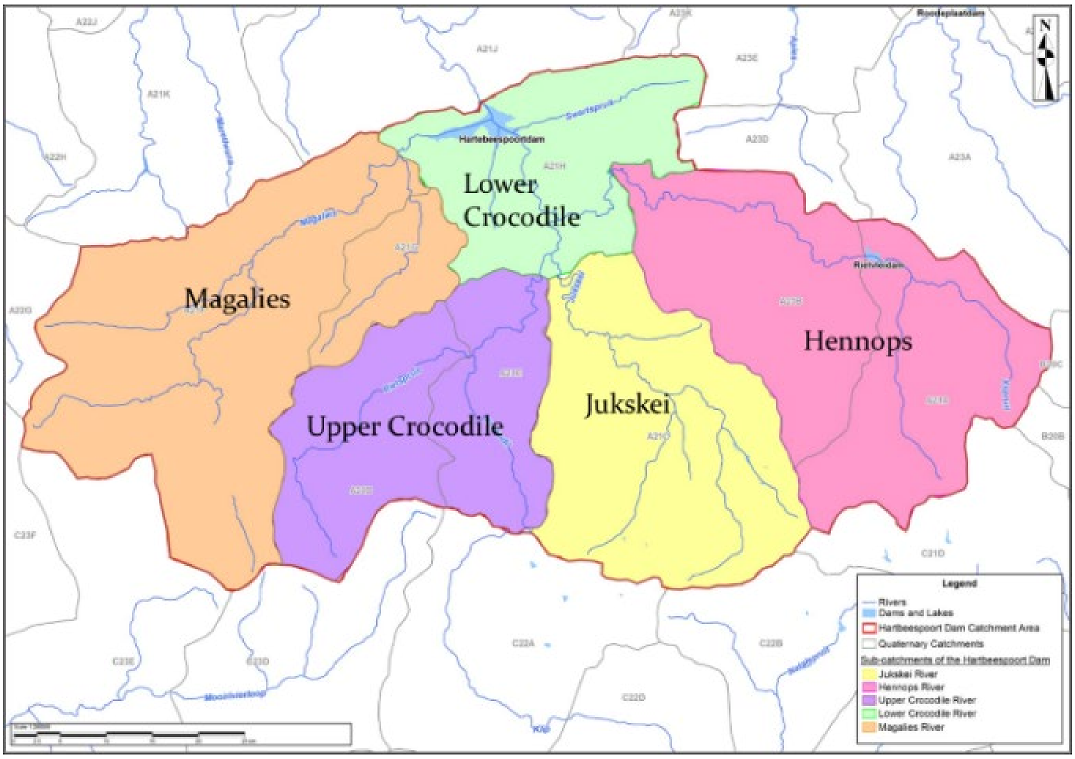

Figure 2: Upper Crocodile (West) Catchment

Dischargers in the catchment

The main contributors to the **nutrient load** in the Hartbeespoort catchment are the nine wastewater treatment works (WWTWs) that are discharging sub-standard treatment loads to the resource:

- Driefontein WWTW
- Northern WWTW
- Sunderland Ridge WWTW
- Randfontein WWTW
- Percy Steward WWTW
- Magalies WWTW
- Olifantsfontein WWT
- Hartbeesfontein WWTW
- Esther Park WWTW

Presented in Figure 3 below is the location of the WWTWs in the catchment, providing more detail regarding the dischargers of phosphate in the catchment.

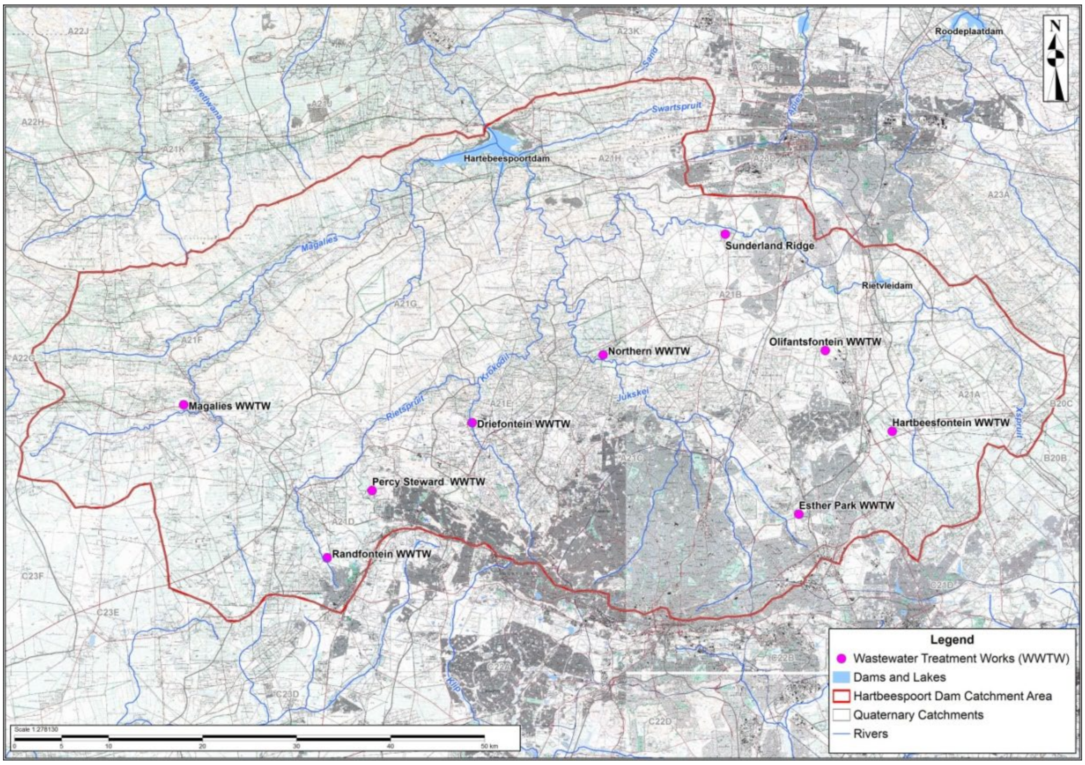

Figure 3: Location of WWTWs in the Hartbeespoort Catchment

Of the nine treatment works in the catchment, the Northern WWTW in Johannesburg is the largest WWTW in the Hartbeespoort Dam Catchment and performs efficiently in terms of nutrient removal, discharging approximately 0.3 mg/L PO_4 to the Jukskei River. The remaining WWTWs are in a poor state and are not being operated efficiently. Some of the WWTWs, such as the Hartbeesfontein WWTW are overloaded, with the operating capacity exceeding the design capacity. There is little spare capacity left for most of the WWTWs and this should be considered.

Sources of Phosphate in the Catchment

The origin of the phosphate load into the Hartbeespoort catchment emanates from three categories:

- **Natural background** – this refers to the phosphate that occurs naturally in the resource.
- **Point sources –** refers to any discernible, confined, and discrete conveyance, including but not limited to any pipe, ditch, channel, tunnel, conduit, well, discrete fissure, container, rolling stock, concentrated animal feeding operation, or vessel or other floating craft, from which pollutants are or may be discharged.
- **Non-point sources (diffuse loads) –** refers to sources that have no specific or discernible point of discharge.

Figure 4 shows that the natural background contribution of phosphate in the Hartbeespoort catchment is negligible and is therefore not discussed further. The point sources contribute 53.2% of the total load in the Hartbeespoort catchment, with the non-point sources contributing 46.4%. The non-point load is significant in this catchment and must be included in the management objectives to reduce the overall phosphate load. The point source and non-point loads are discussed in detail below.

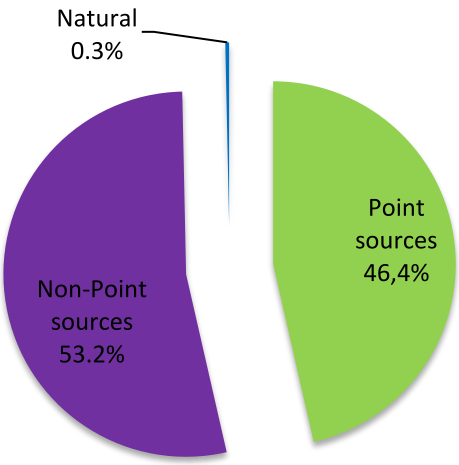

Figure 4: Discharge load per category

The study also showed that most of the phosphate load generated in the Hartbeespoort Dam Catchment emanates from two sub-catchments, namely the Jukskei and the Hennops (Figure 5) which together represent 91% of the load. The other significant sub-catchment is the Upper Crocodile, which contributes 7.2% of the load. Together these three sub-catchments contribute almost 99% of the load. This indicates that there should be focussed interventions in these three sub-catchments.

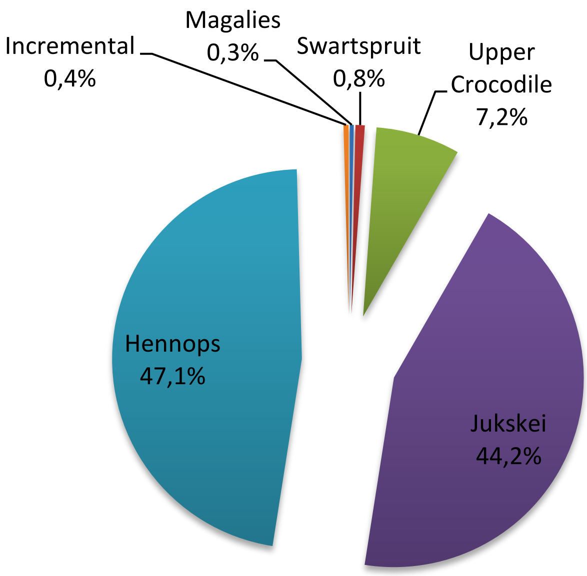

Figure 5: Load distribution (%) from the sub-catchments

On further inspection of the main sub-catchments (Figure 6), it is interesting to note that in the Hennops and Upper Crocodile sub-catchments, point sources dominate whereas in the Jukskei sub-catchment non-point sources dominate.

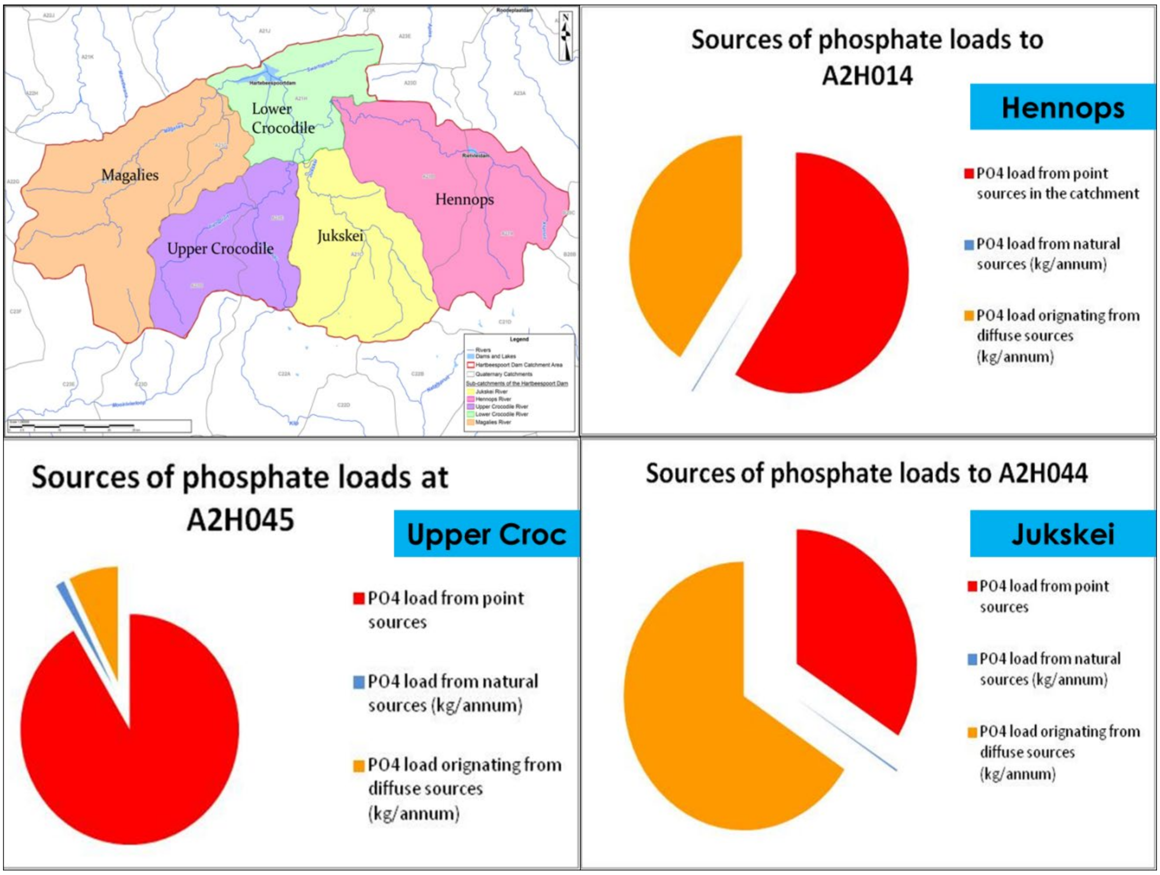

Figure 6: Source distribution in sub-catchments

Summary of phosphate load in the catchment

The phosphate loads entering the Hartbeespoort Dam is mainly due to anthropogenic activities that emanate from the urban areas in the upper reaches of the catchment, with a small contribution from the natural background runoff. Of the load emanating from anthropogenic activities, approximately half of the load is attributed to point sources, with the remaining load stemming from non-point sources. Table 3 provides a summary of the distribution of load in the Hartbeespoort catchment.

Table 3: Distribution of load into the Hartbeespoort Catchment

Catchment	Wastewater Treatment Works		Non-point Load	Natural load	Total Load	% Contribution
	Name	Load (kg/a P)	(kg/a P)	(kg/a P)	(kg/a P)	
Magalies	Magalies	830	88	386	1 305	0.37
Swartspruit			2 757		2 757	0.79
Upper Crocodile	Randfontein	9 610				
	Percy Steward	11 389				
	Driefontein	1 854				
	Total	22 853	1 837	325	25 015	7.17
Jukskei	Esther Park	166				
	Kelvin P/S	2 500				
	Northern Works	42 142				
	Total	44 808	108 830	324	153 962	44.15
Hennops	Hartbeesfontein	5 969				
	Olifantsfontein	42 243				
	Sunderland Ridge	48 753				
	Rietvlei Dam	-3 606	3 609			
	Total	93 359	70 570	248	164 177	47.08
Lower Crocodile Increment catchment estimate					1 500	0.43
TOTAL PHOSPHATE LOAD		161 850	184 081	1 284	348 715	100

The main source of the point source loads emanates from two sub-catchments, namely the Jukskei and the Hennops River Catchments. Together, these catchments generate 91% of the point load. The Upper Crocodile contributes only 7.2% of the load. Collectively, these three urban dominated sub-catchments contribute approximately 99% of the phosphate load to the Hartbeespoort Dam and will be the focus of the mitigation interventions. Northern Works, Olifantsfontein and Sunderland Ridge are the dominant dischargers of the phosphate load to the catchment.

The main source of the non-point sources is failing or broken pump stations that have not been fixed or maintained in the last few years resulting in overflowing and leaking sewer systems, which will be more difficult to address than the point sources.

Increases in the phosphate load due to increased economic activity and population growth should also be considered. Sunderland Ridge is looking to expand capacity to 95 ML/d by 2015, Northern Treatment Works is expected to increase their treatment capacity by a further 100 ML/d to 550 ML/d within the next 30 years and Driefontein WWTW will be upgraded in stages with an additional 80 ML/d on completion.

5.2.2 Step 2: Calculate the load reduction requirement

The threshold phosphate concentration defining the boundary between the mesotrophic and eutrophic conditions in South African reservoirs has been determined as 55 µg/L of phosphate. To achieve this condition in the Hartbeespoort Dam, the estimated required load reduction would be eighty-one percent (81%) of the current aggregate load of 349 tons/year. This translates into an allowable discharge load of 68 tons/year of phosphate, which is not practical in the short term.

Since a reduction of 80% is not achievable as part of this business planning process, it is proposed that an interim phosphate target of 85 µg/L P be set. This target represents the cut-off between mesotrophic and hypertrophic conditions and is the median for eutrophic conditions. It is not ideal, but the interim target would result in definite improvement of water quality in the dam, with less frequent and intense algal blooms.

Therefore, the interim management objective for the Hartbeespoort Dam would require a maximum load of 110 tons of phosphate per annum to be discharged, requiring a reduction of 238 tons. Currently, the point sources contribute 165 tons/year while the non-point load contributes 184 tons/year. A preliminary calculation has shown that a 55% reduction in the load (90 tons) from point sources can be achieved, while a reduction of 71% in the non-point sources (130 tons) is achievable. This will result in an overall load reduction of 219 tons of phosphate per annum. This represents 92% of the short to medium term target.

It is therefore proposed that an interim reduction of ***55% in the point source*** load and a ***71% reduction in the non-point source*** load are accepted as the goal for the Rehabilitation and Water Quality Management Plan. The reduction targets are summarised in Table 4 below.

Table 4: Phosphate reduction targets for point and non-point sources

	Unit	Point Sources	Non-point Sources	TOTAL
Current load	tons	165	184	349
Ideal target (55 µg/L)				
Load	tons			238
Interim target (85 µg/L)				
Load	tons	90	130	220
Percentage reduction	%	55	71	63

5.2.3 Step 3: Identify and cost the mitigation measure/s

It is clear from the analysis of the region, that the WDCS system alone will not solve the problem of eutrophication in this catchment. Therefore, in constructing the Waste Discharge Charge System Rehabilitation and Water Quality Management Plan to mitigate the phosphate loads in the Hartbeespoort catchment, a range of interventions were considered:

- Reducing the current discharge standard from 1 mg/L to 0.3 mg/L for all Wastewater Treatment Works and sewer maintenance over an achievable period of 3 to 5 years. This will greatly reduce the load going into the resource.
- Targeting (ring-fencing) the Upper Crocodile catchment and proposing a clear management and financial plan to National Treasury requesting funds to be allocated to the catchment for the rehabilitation of the catchment with regards to sewer maintenance and fixing/replacing of failing pump stations.
- Applying the Waste Mitigation Charge such that the revenue generated is used to improve monitoring, control, and enforcement in the catchment as well as existing rehabilitation measures. WDCS must be applied to all dischargers in the area, including municipalities.
- Improving monitoring systems, with increased monitoring sites, increased sampling, and an improved regulatory capacity through the appointment of a WDCS funded pollution control officer in order to correctly attribute the loads from the non-point sources in the area.
- Clearly defining the goals and objectives through on-going municipal engagement to monitor the achievement of these goals and to avoid municipalities from just transferring the costs from the WDCS charges upstream, through the trade effluent and municipal charges.
- Payment of a portion of the collected charges to the downstream users for the addition of load to the system, in the absence of any mitigation measures.

The actions and interventions that will be implemented to reduce the load of phosphate and mitigate the impact of the pollution are presented below together with a high-level cost estimation for each intervention. The management actions and interventions will focus on:

- Dam mitigation
- Point source load reduction
- Non-point source load reduction

This study proposes interventions that together will significantly reduce the load or improve the overall monitoring/regulation of the Hartbeespoort Dam. Table 5 summarises the total estimated costs for the implementation of those actions/interventions to reduce the phosphate load in the Hartbeespoort catchment over a 15-year timeframe.

Table 5: Total cost and load reduction as a function of the action/intervention over a 15year timeframe

No.	Management Action	Interventions	Costing (ZARm)	Potential Total Load Reduction
			once-off	*tonnes*
1	Mitigation	Rehabilitation Plan for improved maintenance and prioritised actions	5	
2		Integrated monitoring and regulatory system	5	
3		Dam Mitigation *(hyacinth removal, sediment removal, wetland remediation, shoreline rehab, implementation of policy & eco-system rehab)*	30 (over a few years)	(96 equivalent)
4		Mitigation to downstream users	3	(5 equivalent)
5	Point Source management	Upgrade works to 1 mg/L	1050	52
6		Improve works to 0.3 mg/L	275	42
7		Improve works to 0.15 mg/L	760	33
8	NPS Management	Rehabilitation of pump stations	275	70
9		Refurbishment & Urban Development	unknown	unknown
10		General sewer maintenance	unknown	unknown
		TOTAL COSTS	2403	197 (101 equivalent)

5.2.4 Step 4: Determine the Charge Rate

The costs associated with mitigating the impact of pollution in the Hartbeespoort Dam catchment can be categorised as follows:

- **Capital Costs:** The actions and interventions presented in Section 5.2.3 indicate that there is a large capital expenditure cost associated with the implementation of the WDCS in the Hartbeespoort Dam catchment. The estimated capital costs are R2 403 million over a 15-year period.
- **Operational and Maintenance Costs:** Funding is also required for the operation and maintenance of the additional infrastructure in the Hartbeespoort Dam. This has not been included but should be considered by local government in their budgeting processes.
- **Administrative Costs:** The administrative costs cover the cost of administrating the WDCS system in the catchment and employment of a pollution officer. The pollution officer will need both managerial and technical skills and has been costed at R500 000 a year. The overhead costs associated with administering the WDCS has been estimated at an additional R300 000. The responsibilities associated here do not necessarily require an additional employee The responsibilities can form part of existing administrative duties.

The proposed rehabilitation and water quality management plan for the Hartbeespoort Dam catchment is envisaged to be implemented in a phased approach over a 15-year period. The Jukskei, Hennops and Upper Crocodile sub-catchments have been identified as priority areas and therefore there will be targeted actions in those areas based on the outcomes of the rehabilitation plan.

The **calculation of the charge rates was determined over a five-year period**, with the view to reassess and re-negotiate the charge rates. The objective of the WDCS is to improve the situation and to generate income for mitigation of the eutrophication problem. **The basis for the calculation of the charge rates will be kg of phosphate discharged to the resource.**

The charge rate was simplified to be the total annual cost of the interventions for the year divided by the total load reduction of phosphate required on the catchment (349 tons). It should be noted that the discharger charge load will be reduced by the quantity that the mitigation has impacted and therefore, over time, their individual mitigation charges (charge rate multiplied by charge load) is reduced. Should the discharger employ additional measures to reduce the charge load, the mitigation charge will be reduced accordingly.

The Waste Mitigation Charge will be used to fund and implement the interventions listed under Management Actions as well as cover the administrative costs. The annual Waste Mitigation Charge rate is presented in Table 6.

Table 6: Draft Annual Charge Rates for the Waste Mitigation Charge

Timeframe	Action/Intervention	Cost (Rm)	Waste Mitigation Charge
Year 1	Construct Rehabilitation Plan	5	
	Payment to downstream users – Institutional arrangements	3	
	Dam Mitigation	5	
	Administration	0.3	
	Cumulative	**13.3**	**R38/kg**
Year 2	Payment to downstream users	3	
	Dam Mitigation	10	
	Integrated Monitoring and Regulatory Plan	2.5	
	Administration	0.3	
	Cumulative	**15.8**	**R45/kg**
Year 3	Payment to downstream users	3	
	Dam Mitigation	15	
	Integrated Monitoring and Regulatory Plan	2.5	
	Administration	0.3	
	Cumulative	**20.8**	**R60/kg**
Year 4	Payment to downstream users	3	
	Dam Mitigation	20	
	Administration	0.8	
	Cumulative	**23.8**	**R68/kg**

Timeframe	Action/Intervention	Cost (Rm)	Waste Mitigation Charge
Year 5	Payment to downstream users	3	
	Dam Mitigation	25	
	Administration	0.8	
	Cumulative	28.8	R83/kg

The charge rate is ramped up over the five-year period (Figure 7) to ensure that the dischargers have sufficient time to plan as well as ensure that the WMC meets the requirements of being economically feasible.

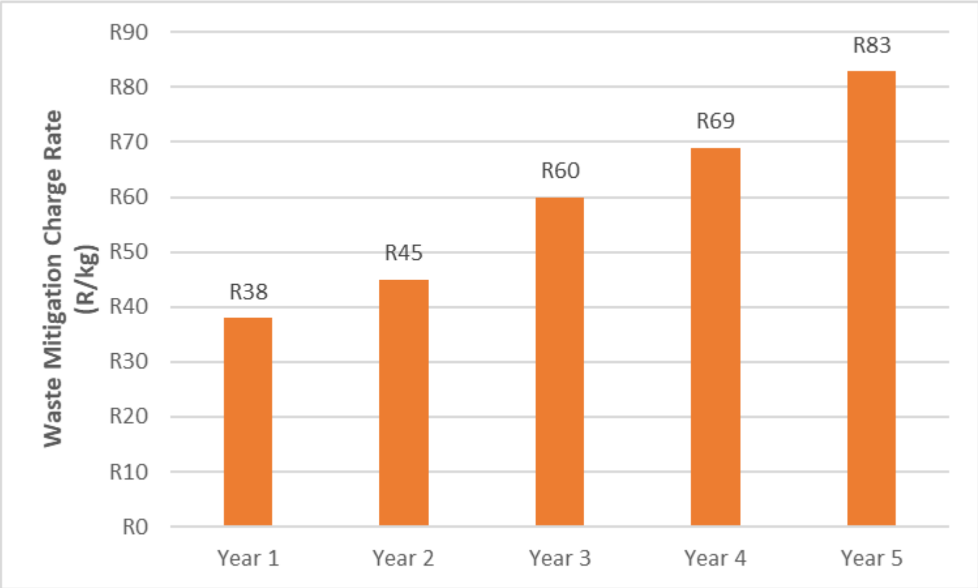

Figure 7: Projected Waste Mitigation Charge rates over a five-year period

It should be noted that, as part of the monitoring and evaluation framework that was designed as part of the overall project, the Waste Mitigation Charges will be reviewed and re-calculated on an annual basis taking into consideration the changing environment in the catchment and the above values should be used as estimates.

5.3 Actual charges borne by the dischargers

The section above proves the charge rate for years one to five of the WDCS Implementation. This allows the dischargers to calculate the financial impact to be borne over the five-year period. Therefore, using the Jukskei sub-catchment as an example, the following mock charges in Table 7 are applicable.

Table 7: Draft charges applicable to the dischargers in Year 1

Jukskei Dischargers	Load (kg/a P)	Year 1 charge rate	Costs to the dischargers in Year 1
Esther Park	166	R38/kg P	R6 308
Kelvin P/S	2 500		R95 000
Northern Works	42 142		R1 601 396

5.4 Concluding Remarks

A robust situation assessment of the area of interest is the first step in implementing WDCS system. It is important to note that in the design of the charges, a step-by-step process is followed that is highly dependent on an accurate assessment of the water quality situation in the area of interest, and this is discussed with the impacted and affected stakeholder to find a common and shared solution to the problem. The success of the WDCS lies in the engaged process, and not an authoritarian process. Buy-in and ownership is crucial to the success of not only setting the charges, but the ability to collect the revenue once these charges are established.

6. CASE STUDY FOR COST-BENEFIT ANALYSIS: HARTBEESPOORT DAM

Hartbeespoort Dam is situated north of South Africa's largest economic hub and is one of the most significant dams in the country which has also been severely impacted by eutrophication. The high prevalence of cyanobacterial blooms is cause for immediate concern for potable, recreational and agricultural uses. The implementation of the 10-year long Hartbeespoort Dam Remediation Project presents an opportunity to assess the impact of the intervention and gain insight that may contribute to the implementation of the WDCS.

6.1 Harties Metsi a Me

The Department of Water and Sanitation (DWS) implemented the Hartbeespoort Dam Remediation Programme (HDRP), Harties Metsi a Me, to address the imbalances and unhealthy biological conditions in the dam. The programme was planned to be rolled out in two phases. The development of Phase 1 began in July 2006 following the appointment of an implementing agent. Remediation of the dam began in 2008. Phase 1 focused on establishing biological processes and the mechanical harvesting of algae and hyacinths (Dennis & Dennis, 2019). The programme ended in April 2016 prior to the implementation of Phase 2. Phase 2 would have focused on the treatment and bulk removal of phosphates.

6.2 Present state of the Hartbeespoort Dam

Information gathered during Phase 4 of the WDCS project from the Situation Assessment Report (DWA 2013), show that there has been little improvement in the water quality situation at the Hartbeespoort Dam. Although there were localised improvements in terms of wildlife habitat, clearing of water hyacinth to allow water-based activities, and water quality due to the bioremediation interventions that were implemented during Phase 1, there has been minor contribution to the overall nutrient load removal from the dam. The rate of accumulation in the dam is almost an order of magnitude greater than that removed through the interventions (Carroll & Curtis, 2021).

Following the end of the HDRP and other private initiatives to remove water hyacinth and litter, pollution in the dam has increased. In April 2017, it was estimated that over 30% of the dam's surface area was covered in water hyacinth (VUT, 2017). The situation has worsened following the introduction of a new aquatic invader, the common Salvinia plant (shown in Figure 8). The Hartbeespoort Dam has reached over 35% cover of water hyacinth and Salvinia, nearing the extent of the surface area covered by water hyacinth in the past (Kormorant, 2021).

Figure 8: Water hyacinth and common Salvinia in the Hartbeespoort Dam (source: For Anglers, 2021)

6.3 Approach

The HDRP and the WDCS share a similar objective – to improve the situation in the Hartbeespoort Dam. The HDRP represents the status quo, outlining the remediation efforts that have been undertaken to date, whereby the current eutrophication situation persists, and no further intervention measures have been implemented.

The impact of the HDRP and the estimated impact of the proposed WDCS will be expressed allowing the economic costs and ecological and social impacts to be assessed. This will enable a comparison between the status quo and the expected future impacts and benefits.

A full cost-benefit analysis would be able to better determine a course of action. However, this would require a comprehensive analysis, including indirect, intangible, and opportunity costs and assigning them a monetary value. Monetising the full range of impacts is beyond the scope of this project. Accurate data would be critical to producing reliable results.

The impacts of the proposed Waste Mitigation Charge will be estimated by performing a qualitative cost-benefit analysis which involves monetising as many of the project's impacts as possible. The other impacts that cannot be evaluated in quantitative terms will be estimated in qualitative terms.

6.4 Costs

The qualitative assessment looked at the direct costs, which are expenses directly related with the implementation of the project.

6.4.1 Harties Metsi a Me costs

The total costs of implementing the HDRP until July 2015 was ZAR167.66 million (shown in Table 8).

Table 8: HDRP yearly expenditure (DWS, 2015)

Year	06/07	07/08	08/09	09/10	10/11	11/12	12/13	13/14	14/15	15/16	TOTAL
Cost (ZARm)	0.998	9.518	24.999	20.500	20.552	18.447	26.837	28.331	17.473	5.580	167.660

*up to July 2015

Year on year, the administration costs far exceeded the operational costs, indicating a programme characterised by large overheads. For the Phase 1 HDRP period ending 2013/14, administration costs made up 68% of total overall expenditure. The technical governance of the HDRP was inadequate. The technical committee that was intended to implement a monitoring programme either did not exist or did not meet. The monitoring programme stopped in 2011 and is an indication that the Project Management Committee was not exercising its oversight (Mitchell & Crafford, 2016).

6.4.2 Other economic costs

The quality of water affects the Hartbeespoort dam area economy (Mokoena et al., 2017).

- The Carp and Catfish occur in large number and are undesirable fish species because they have a negative impact on the entire dam ecosystem. They dominate the other more valuable indigenous species like Talapia (Blue Kurper) and others. It is estimated that a healthier dam ecosystem could produce a sustainable income of ZAR12 million per annum for commercial fisheries based on SMME development (Rand Water, 2012).
- Revenue from maize and sunflower farming has declined due to lower market demand as retailers such as Woolworths have stopped sourcing products from the area because of the presence of *E. coli* and toxins in the crops. The monthly revenue generated from agriculture is less than ZAR1.1 million. This figure is lower than the cost of water treatment for irrigation, highlighting the high input costs for the agricultural sector in the region.
- Hartbeespoort Dam is a major tourist attraction, between 19,000 to 20,000 vehicles per weekend drive over the Hartbeespoort dam wall. It is the most popular destination in the municipality and has the largest share of all tourism facilities accounting for 71% of tourism (DRDLR, 2014). The state of the dam is negatively impacting the tourism sector which generates ZAR1.4 billion annually.
- The Hartbeespoort Dam area contributes ZAR6.6 million to municipal revenue however houses near the shoreline of the dam are affected by the smell of dying cyanobacteria cells which could negatively influence the growth of business such as property development.

The HDRP remediation costs indicated above in Section 6.4.1 do not include the costs incurred by other stakeholders such as the research consortium, Centre for Biological Control, which was implementing biological control at Hartbeespoort Dam at a cost of ZAR1.8 million/ year between 2018 and 2020 (Kormorant, 2021).

6.5 Impacts

The deteriorating water quality in the Hartbeespoort Dam has ecological and social consequences that are expressed here in qualitative terms.

6.5.1 Ecological

A fish health assessment confirmed that water from the Hartbeespoort dam was adversely affecting the health of freshwater fish. Aluminium, silicon, and chromium were detected in the water and muscle tissue (Wagenaar & Barnhoorn, 2018).

Water bird numbers had crashed from 11,860 in 2016 to 3,462 in 2017, the lowest count since 2010. Hyacinth has taken away shallower water habitats for birds like the Greater Flamingo, Pied Avocet, and Black-winged Stilt. Even the Red Knobbed Coot who feed on water hyacinth has crashed in numbers from an estimated 7 000 plus in July 2016, to 252 in the recent count (Caxton News Service, 2017).

6.5.2 Social

The HDRP did not create sustainable employment opportunities. The different activities constituted in the HDRP were achieved with a professional specialist team and created an average annual labour force of 110 employees appointed as semi-permanent over 9 years (Department of Water and Sanitation, 2015).

Sampling from different settlements located around the Hartbeespoort Dam indicated that communal tap water samples were contaminated with cyanobacteria toxins even after treatment at the Schoemansdal water treatment plant (Mokoena & Mukhola, 2019). The Hartbeespoort Community Development Initiative reports how residents must resort to buying water, and how vulnerable communities have no option but to drink what comes from the taps. Aside from the unpleasant taste, there are real health concerns. Once the toxic by-product of eutrophic water – microcystin is released it becomes part of the water and cannot be filtered out, meaning that communities are increasingly exposed to microcystin (Bega, 2020). Cyanobacteria toxins in drinking water pose health risks to the immune compromised, the elderly and children younger than 5 years old. Long term exposure is associated with chronic health problems.

6.6 Summary

Water from the Hartbeespoort Dam is used for the irrigation of 160 km^2 of farmland, on which tobacco, wheat, lucerne, fruit and flowers are produced. It is used for drinking in the towns of Hartbeespoort, Schoemansville, Kosmos and Ifafi. The water is also used as industrial water and for aquaculture (Atta, et al., 2020). If the poor water quality situation is allowed to persist it could drive the region into decline and destroy the ecological functioning of the river which is a crucial part of the region's economy.

Although there have been some successes during the implementation of Phase 1 of the HDRP, the bioremediation interventions alone are not sufficient to prevent the deteriorating water quality situation in the dam as shown in Figure 9.

Figure 9: Eutrophication in the Hartbeespoort Dam in 2021

The HDRP program was not successful in the long run due to poor project management and the failure to address the WWTW upstream of the dam before mitigation activities commenced (Dennis & Dennis, 2019).

Regulatory tools for water quality management have been developed and are available. Effective water quality management means that administrative systems need to work, by collecting and interpreting data and the enforcement of water quality laws. Limited capacity and limited appropriate data and information to support Department in its regulatory role needs to be strengthened and is also a crucial first step in improving resource water quality.

The WDCS is an economic instrument that is meant to complement and support existing regulatory approaches. However, this has not been a priority for DWS because only ZAR1,200 was spent on the implementation of the WDCS whereas ZAR2.2million was budgeted during the period 2006 to 2014 (Mitchell & Crafford, 2016).

Reducing the nitrogen and phosphorus flux to Hartbeespoort from leaking and overflowing sewers and WWTWs is the only long-term solution to controlling the eutrophication problem at Hartbeespoort. The WDCS aims to address the root cause of the water quality challenge in the catchment by removing 197 tonnes of load in a 15-year period at a cost of ZAR2.4 billion (refer to Table 5 in Section 5.2.3 above). This presents a real reduction in dam pollution load in comparison to the ZAR166.7m spent over a 10-year period for the HDRP programme, which has had limited load removal.

The cost of implementing the WDCS may seem significantly higher, but this is because the WDCS proposes a full suite of interventions, including technical infrastructure solutions. These mitigation actions will have a greater impact on load reduction in a sustainable manner. The cost of not addressing the water quality challenge may be high with the full cost of pollution being borne by the environment, economy, and society.

There is a need to get a comprehensive understanding of the true cost of poor water quality to livelihoods and business. Beyond the provisioning services that the dam provides, there are other ecosystem services such as regulating, cultural and supporting services that can be leveraged to drive sustainable economic growth and improvements in social welfare. Particularly because the dam is popular for angling, water sport and recreational activities. There is a lack of frameworks and methods to identify, assess and measure the range of intangible benefits associated with cultural ecosystem services (Mowat & Rhodes, 2020). Therefore, not all the costs have been detailed in this report and there is a need to consider other values as part of a full cost-benefit analysis.

The report does not consider the costs to ecological infrastructure, the birds and fish species and the impacts on biodiversity due to poor water quality. The cost that pollution has on the ZAR1.4 billion tourism and other economic sectors in the region have also not yet been determined.

Decision-making should not focus solely on the costs because this will ignore the various benefits that the implementation of the WDCS can provide. There is a possibility that the cost associated with a declining economy and social instability due to poor water quality will outweigh the cost that will be needed for the rehabilitation of existing WWTWs.

7. INSTITUTIONAL ARRANGEMENTS

The collaborative and potentially long-term implications of implementing a mitigation measure in this manner requires clear institutional roles and responsibilities, in terms of both the financing and operation of the measure.

Setting, collection and disbursement of Waste Mitigation Charges: are the responsibility of the catchment management agency (CMA) in terms of the WDCS business plan to be developed in consultation with stakeholders. The DWS acts as the proto-CMA in water management areas in which the CMA is not yet established and functional. This must comply with the requirements of the Public Finance Management Act and this Pricing Strategy, and should align with the Catchment Management Strategy, where this has been established.

Intervention implementation: The CMA/proto-CMA will not necessarily directly implement the measure, but rather this may be done by service providers, infrastructure operators or an independent implementing agent. The CMA will clarify (and establish) the institutional responsibilities through the business plan, in consultation with the waste dischargers. In some cases, an agreement may be required between the implementing agent and the dischargers, while the project funders may require the CMA to enter an agreement in terms of the collection and disbursement of funds.

Depending upon the design life and capital repayment schedule for the mitigation measure, these agreements may be in force for several years. **This characteristic makes it critical that the mitigation measure is consulted with all dischargers who may be liable for charges.**

8. IMPLEMENTATION OF THE WDCS

The Waste Mitigation Charge will be implemented as a priority, after testing and piloting the system prior to implementation. The WDCS will be applied in suitable priority catchments throughout South Africa, in line with the IWQM Policy and as identified in the National Water and Sanitation Masterplan (DWS, 2018). The WDCS will be implemented in a phased manner.

References

Atta, K. P. et al., 2020. Chemical phosphate removal from Hartbeespoort Dam water, South Africa. *Water SA,* 46(4), pp. 610-614.

Bega, S., 2020. *Fears of long term damage to SA's water supply as eutrophication strangles rivers and dams.* [Online] Available at: https://www.iol.co.za/saturday-star/news/fears-of-long-term-damage-to-sas-water-supply-as-eutrophication-strangles-rivers-and-dams-50491546[Accessed 25 February 2022].

Carroll, A. S. & Curtis, C. J., 2021. Increasing nutrient influx trends and remediation options at Hatbeespoort Dam, South Africa: a mass-balance approach. *Water SA,* 47(2), pp. 210-220`.

Caxton News Service, 2017. *Hartbeespoort water birds in crisis.* [Online] Available at: https://kemptonexpress.co.za/lnn/248626/hartbeespoort-water-birds-crisis/ [Accessed 26 February 2022].

Dennis, I. & Dennis, S. R., 2019. Social paradigm shift required to counter the eutrophication of the Hartbeespoort Dam in South Africa. *Water and Society V,* Volume 239, pp. 159-172.

Department of Water and Sanitation, 2015. *National Pricing Strategy for Water Use Charges,* Pretoria: DWS.

Department of Water and Sanitation, 2015. *Written Reply: Question No 2936,* Cape Town: National Assembly.

Department of Water Affairs, 2014, Waste Discharge Charge System Strategy, Pretoria,

Department of Water Affairs, 2013, Waste Discharge Charge System – Situation assessment Report for Hartbeespoort Bam, Upper Olifants and Upper Vaal), Pretoria,

DRDLR, 2014. *Hartbeespoort Area Precinct Plan,* s.l.: Madibeng Local Municipality.

DWS, 2018. *National Water and Sanitation Master Plan Volume 1: Call to Action,* Pretoria: Department of Water and Sanitation.

For Anglers, 2021. *Harties: A new invader has taken over, Salvinia minima.* [Online] Available at: https://foranglers.co.za/harties-a-new-invader-has-taken-over-salvinia-minima/ [Accessed 27 February 2022].

Kormorant, 2021. *Pollution of Hartbeespoort Dam shocking.* [Online] Available at: https://kormorant.co.za/2021/07/22/pollution-of-hartbeespoort-dam-shocking/[Accessed 26 February 2022].

Mitchell, S. A. & Crafford, J. G., 2016. *Review of the Hartbeespoort Dam Integrated Biological Remediation Programme (Harties Metsi a Me),* Pretoria: Water Research Commission.

Mokoena, M. M. & Mukhola, M. S., 2019. Current effcts of cyanobacteria toxin in water sources and containers in the Hartbeespoort Dam area, South Africa. *International Journal of Environmental Research and Public Health,* 16(22), p. 4468.

Mokoena, M., Mokgobu, M. I. & Mukhola, M. S., 2017. *The Economic Effect of Hartbeespoort Dam Areas.* s.l., Global Business and Technology Association, p. 9.

Mowat, S. & Rhodes, B., 2020. Identifying and assigning values to the intangible cultural benefits of ecosystem services to traditional communities in South Africa. *South African Journal of Science,* 116(7/8), p. 6.

VUT, 2017. *Hartbeespoort hyacinth crisis continues.* [Online] Available at: https://www.vut-research.ac.za/hartebeespoort-hyacinth-crisis-continues/[Accessed 27 February 2022].

Wagenaar, G. M. & Barnhoorn, I. E., 2018. Health and chemical burdens of fish species from polluted and hyper-eutrophic freshwater ecosystems in South Africa. *African Journal of Aquatic Science,* 43(3), pp. 271-280.