

**DEMONSTRATION OF HOW HEALTHY ECOLOGICAL
INFRASTRUCTURE CAN BE UTILIZED TO SECURE WATER
FOR THE BENEFIT OF SOCIETY AND THE GREEN ECONOMY
THROUGH A PROGRAMMATIC RESEARCH APPROACH
BASED ON SELECTED LANDSCAPES**

Deliverable #5: Annual Report

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by

**Centre for Water Resources Research
University of KwaZulu-Natal**

Project K5/2354

ABBREVIATIONS

BEDS	School of Built Environment and Development Studies
CHAT	Critical Historical Activity Theory
CoGTA	Cooperative Governance and the Department of Traditional Affairs
CWRR	Centre for Water Resources Research
DBSA	Development Bank of South Africa
DEA	Department of Environmental Affairs
DEWATS	Decentralized Wastewater Treatment Systems
DUCT	Dusi uMngeni Conservation Trust
DUT	Durban University of Technology
DWAS	Department of Water Affairs and Sanitation
DWAF	Former Department of Water Affairs and Forestry, South Africa
EI	Ecological Infrastructure
EPCPD	Environmental Planning and Climate Protection Department
EWS	eThekweni Water and Sanitation
KZN	KwaZulu-Natal
LULC	Land use/land cover
PRG	Pollution Research Group
PRP	Palmiet Rehabilitation Project
SALGA	South African Local Government Association
SANBI	South African National Biodiversity Institute
SANCIAHS	South African National Chapter of the International Association for Hydrological Sciences
SASS	South African Scoring System
SIP	Strategic Infrastructure Project
TOR	Terms of Reference
UEIP	uMngeni Ecological Infrastructure Partnership
UKZN	University of KwaZulu-Natal
WESSA	Wildlife and Environment Society of South Africa
WRC	Water Research Commission

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1 INTRODUCTION

1.1 WRC Project K5/2354 - Overview

In April 2014, the Centre for Water Resources Research (CWRR) and partners were awarded a 5 year research project through a Water Research Commission (WRC) solicited call.

The project is entitled:

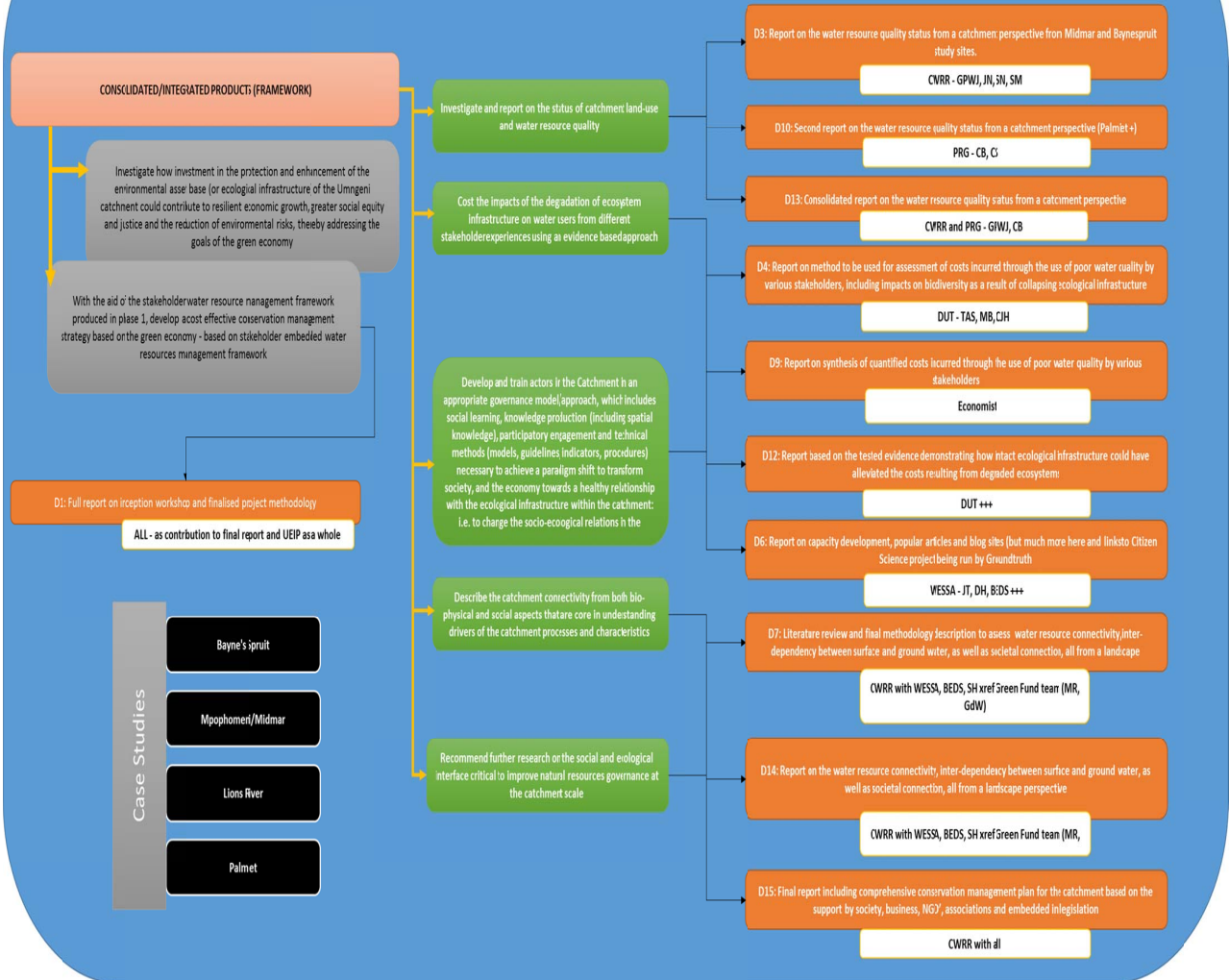
“Demonstration of how healthy ecological infrastructure can be utilized to secure water for the benefit of society and the green economy through a programmatic research approach based on selected landscapes”.

The project seeks to identify sites in the uMngeni catchment at which investment into the protection and/or restoration of EI can produce long-term and sustainable returns in terms of the delivery of water-related ecosystem services. These services could include water quality and quantity, and flood protection. In essence, the project aims to guide catchment managers when deciding “what to do” in the catchment to secure a more sustainable water supply, and where it should be done. This seemingly simple question encompasses complexity in time and space, and in the connections between different biophysical, social, political, economic and governance actors in the catchment. The project is integrated with other research initiatives in the catchment, including a recently completed project funded by the Green Fund of the Development Bank of South Africa, as well as the recently established uMngeni School of Water Resources Governance.

The uMngeni catchment has become a focus area and pilot study site through various initiatives, now becoming consolidated through the uMngeni Ecological Infrastructure Partnership (UEIP) (SANBI, 2013). Through this initiative, more than 30 government departments, academic institutions, private companies and Non-Governmental Organisations have signed a Memorandum of Understanding which documents their commitment to investing in restoring, maintaining and managing Ecological Infrastructure (EI) towards improved delivery of water-related ecosystem services. The initiative also aims to provide a suite of additional benefits such as job creation, agricultural productivity, aesthetics, cultural benefits, flood attenuation and adaptive capacity to climate change impacts, which will increase the return on investment (SANBI, 2013). The service provider partners of the UEIP are undertaking pilot studies where they are investing in EI, and these form the focus “landscapes” through which this project operates i.e. the upper-uMngeni-Midmar, the Baynespruit in Pietermaritzburg and the Palmiet River catchment in eThekweni.

The approach and deliverables adopted in this project reflect this integrated complexity. An overview of the project has been developed (Figure 1) and an intranet site with access for all team members has been created (<https://sites.google.com/site/ueipwrc2354/>). All relevant project documents (Deliverables, Sub-Contracts etc) are stored at this location.

Demonstration of how healthy ecological infrastructure can be utilized to secure water for the benefit of society and the green economy through a programmatic research approach based on selected landscapes (WRC solicited)



1.1 Report Structure

The project will produce 15 Deliverables over the next four years, all of which are linked to the various project aims. Whilst the due date for many of these is some time in the future, activities to address these Aims are ongoing and some are reported here. Thus, Section 2 provides a brief overview of progress towards achieving each Project Aim and Deliverable, Section 3 provides a report on Outreach activities, Section 4 provides an update on capacity development and Section 5 provides some concluding comments and the work plan for the forthcoming year.

2 Project Progress

Two major Deliverables were completed over the past financial year and work on all future Deliverables has been initiated.

2.1 Project Team

Mr Duncan Hay, originally a team member in his personal capacity and as an associate of the University of KwaZulu-Natal, joined the Institute of Natural Resources (INR) as Executive Director in 2015. Consequently, it was decided that his contribution to the project would be via the INR, who are now members of the project team. Sub-contracting is being finalised.

2.2 Collaboration and Co-Funding

This project collaborates closely with other projects currently being undertaken through the UEIP as well as those supported by Umgeni Water through the Umgeni Water Chair of Water Resources Management. In particular, the activities of the Development Bank of South Africa (DBSA) Green Fund project entitled "Investing in ecological infrastructure to enhance water security in the uMngeni River catchment" which was finalised in December 2015 are closely aligned. Through Green Fund project, the configuration of the uMngeni Catchment for hydrological modelling with ACURU has been achieved and thus, provides a basis for Project Aims expressed in 2.4.1, 2.4.2. and 2.4.3 below.

The project also collaborates closely with CLIMWAYS. CLIMWAYS is a multi-disciplinary research project that analyses institutional constraints on water resource management and urban climate change adaptation in the cities of Durban and Cape Town. These two cities are at the forefront internationally in promoting climate change adaptation. The research focuses on two issues and scales; the local and the multi-level dimensions of urban climate governance - with reference to how local societies and city authorities interact and respond in policy and everyday practice to the impacts of climate change as it interfaces with water resources management. The research combines the theoretical frames of multi-level governance and social mobilization to unpack governance constraints (polycentric approach). The Palmiet River catchment forms the focus of the joint activities as described below.

2.3 Activities towards Project Aims

The Deliverable structure is a direct response to the Terms of Reference published with the initial project call. Whilst the project Deliverables are standalone and may seem isolated from the integrated project Outcomes, activities undertaken by the project team are not. All components address specific project aims, but also address several other aspects, ultimately contributing to integrated outcomes reflected by Figure 1. In many ways, the ToR and the need to respond to them have compromised the research approach, resulting in a project which is not optimally designed in terms of achieving its intended Outcomes.

The stated aims of the project are as follows:

1. To investigate and report on the status of catchment land-use and water resource quality in the selected catchment(s)
2. Cost the impacts of the degradation of ecosystem infrastructure on water users from different stakeholder experiences using an evidence based approach
3. Investigate how an intact ecological infrastructure could secure and enhance the benefits provided to society and economy in the catchment.

4. Investigate how investment in the protection and enhancement of the environmental asset base (or ecological infrastructure) of the Umngeni catchment could contribute to resilient economic growth, greater social equity and justice and the reduction of environmental risks, thereby addressing the goals of the green economy.
5. With the aid of the stakeholder water resource management framework produced in phase 1, develop a cost effective conservation management strategy based on the principles of the green economy.
6. Develop and train actors in the Catchment in an appropriate governance model/approach, which includes social learning, knowledge production (including spatial knowledge), participatory engagement and technical methods (models, guidelines, indicators, procedures) necessary to achieve a paradigm shift to transform society, and the economy towards a healthy relationship with the ecological infrastructure within the catchment: i.e. to change the socio-ecological relations in the catchment to ensure greater resilience through the development of a transformative governance approach
7. Describe the catchment connectivity from both bio-physical and social aspects that are core in understanding drivers of the catchment processes and characteristics
8. Recommend further research on the social and ecological interface critical to improve natural resources governance at the catchment scale.

2.3.1 Deliverables Completed

Two Deliverables were completed over the past year i.e.

Deliverable No.	Title	Due Date
3	Report on the water resource quality status from a catchment perspective from Midmar and Baynespruit study sites	31 July 2015
4	Report on method to be used for assessment of costs incurred through the use of poor water quality by various stakeholders, including impacts on biodiversity as a result of collapsing ecological infrastructure	30 November 2015

Deliverable 3 was completed in July 2015. The report provides an overview of water quality in these sub-catchments of the river and highlighting the potential role for EI.

Deliverable 4 provides a comprehensive literature review of aspects of evaluation in the context of a Green Economy and a suggested approach to be developed further through this project.

These Deliverables are available on the WRC FMS system and on the project intraweb at <https://sites.google.com/site/ueipwrc2354/documents>

The ongoing research in the Case Study sites seeks to address multiple aims as detailed in the progress at each site provided below.

2.3.2 Upper-uMngeni-Midmar Case Study

Much research has taken place in the upper-uMngeni over the past year. This has covered several aspects, including assessing the water quality of the infows to the Midmar and Albert Falls Dams, the role of the Lions River wetland in mitigating pollution flows to Midmar Dam and the potential role for citizen science in influencing how society and authorities can influence and respond to water quality issues in the catchment. This research has resulted in the preparation of 7 academic research papers, one of which has been submitted. Another four will be submitted to journals by April 2016 and the final two by June 2016. The abstracts to these papers are included below.

OPPORTUNITIES FOR CITIZEN SCIENCE TO IMPROVE CATCHMENT WATER QUALITY

Sesethu Matta, Jim Taylor and Graham Jewitt

Abstract

South Africa is a water scarce country faced with a water delivery crisis, which is further exacerbated by deteriorating water quality. With human activities at the root of the problem, it has been suggested that, for a realistic solution, community integration into a multi-stakeholder collaboration is imperative. Citizen Science, defined as the partnerships between scientists and non-scientists where, data are collected, shared and analysed, encourages such community integration. The initial step towards understanding and ultimately solving the problem of declining water quality can be seen as requiring the expansion of water quality monitoring, facilitated by citizen science tools. The aim of the study is to understand the applicability of citizen science in South Africa, through an investigation of how the involvement of community members in water quality monitoring contributes towards water quality conservation in South Africa. To understand the challenges and opportunities that face a community-based water quality monitoring initiative in South Africa, the Mphohomeni Sanitation Education Project (MSEP) and Msunduzi Municipality-miniSASS outreach initiative, were used as case studies, where participant observation and key informant interviews were conducted. Results indicate that citizen science tools empower and encourage social learning amongst participants and improve relationships between citizens and service providers for inclusive decision-making. However, the lack of education, awareness, adequate interest, support from service providers and poverty are major challenges that threaten the progress of these citizen science initiatives. It is concluded that Citizen Science may be the key to solving the problem of declining water quality and improving catchment water quality; however, solutions should be derived from a greater engagement with, and a clearer understanding of, the South African context.

Key words: citizen science, water quality, miniSASS, monitoring, stakeholder participation

IS THERE A RELATIONSHIP BETWEEN MINISASS SCORES AND CONVENTIONAL WATER QUALITY PARAMETERS?

Sesethu Matta, Graham Jewitt and Jim Taylor

Abstract

Community-based water quality monitoring initiatives, internationally and in South Africa, face a number of challenges. One of these is the nature and quality of data collected by citizens. Traditionally, service providers and scientists use advanced technical instrumentation and methods of water quality monitoring, whilst citizens often use inexpensive, less technical methods. This can result in service providers and scientists failing to recognize the efforts of citizens, thus jeopardizing the potential role that citizens can play in decision making, support provision and the generation of new hydrological knowledge, particularly in remote areas. In KwaZulu-Natal, community members around Midmar Dam have been using the miniSASS toolkit as a means of monitoring river health, which gives an indication of water quality. This study aims to relate miniSASS scores with conventional water quality monitoring parameters as analysed by service providers. The study was conducted in the upper uMngeni catchment, where miniSASS analysis was conducted at various sites, with diverse characteristics, to complement conventional water quality monitoring undertaken for related research projects. Regression analysis was undertaken to relate miniSASS scores to laboratory results of Ammonia and Phosphates, which are both chemical indicators of pollution. Results reveal a moderate negative correlation of 0.42 between miniSASS scores and ammonium concentrations. A similar negative and moderate correlation of 0.51, was noted between miniSASS and phosphorus concentrations. Comparison of the two correlations indicates that ammonium had a higher influence on miniSASS scores in when compared to phosphorus. Statistical analysis of the relationship between miniSASS and streamflow, revealed a correlation of 0.56. Suggesting that an increase in streamflow was

generally accompanied by a greater variety of macroinvertebrates. However all the relationships between miniSASS and conventional water quality parameters were insignificant. An indication that the two methods, citizen science tool and conventional water quality monitoring, are not interchangeable but can both provide useful information that can go a long way into understanding water quality issues.

Key words: miniSASS, ammonium, water quality, river health, citizen science

NUTRIENT LOAD DETERMINATION TO THE MIDMAR DAM, KWAZULU-NATAL, SOUTH AFRICA: 1987-2013

S Ngubane, GPW Jewitt and NE Nsibirwa

Abstract

There is increasing concern over the quality of water flowing into Midmar Dam, upper uMngeni Catchment, KwaZulu-Natal Province, given its status as a critical water supply impoundment for the cities of Pietermaritzburg and Durban. The aim of this study was to estimate nutrient loads entering the Midmar Dam from three major tributaries, viz. the Lions River, the uMngeni River and the Mthimzima Stream. The Lions and uMngeni River catchments drain predominantly commercial agricultural areas whilst the Mthimzima stream drains the rapidly developing township of Mpophomeni. Measured daily streamflow and weekly, fortnightly and monthly nutrient concentrations were obtained from the local water service authority i.e. Umgeni Water, where available. Given that no streamflow are available for Mthimzima, the daily time-step ACRU model was used to simulate streamflow. Soluble reactive phosphorus (SRP), total phosphorus (TP), ammonia (NH₃) and nitrate (NO₃⁻) data were used to calculate nutrient loads as a product of mean monthly flow and mean monthly pollutants concentration to provide a monthly load. From the year 2000 – 2013, only one concentration value in a month was available to calculate the load. Monthly loads were estimated from the beginning of the hydrologic year (October to September) and accumulated to give annual loads. Loads for all nutrients were found to be highest in 1995 for all streams. Nitrogen loads were found to be generally higher than for phosphorus. The results showed an increase in nitrogen and phosphorus loads over the majority of the years, which ranged from 0.096 to more than 9.0 tons/a of phosphorus and from as low as 0.40 to over 90 tons/a dissolved inorganic nitrogen (DIN). They also showed that streamflow drives nutrient loads. The study concluded that this represents an increase in nutrient loads and deterioration of water quality entering Midmar over time and that these are most likely a consequence of direct sewage entering the Mthimzima and the expansion of agricultural activities upstream in the Lions and uMngeni catchments.

Key words: *Nutrient loading, uMngeni Catchment, Midmar Dam, Nutrients, Water Quality Deterioration*

SENSITIVITY ANALYSIS OF WATER QUALITY MONITORING FREQUENCY FOR THE UMNGENI RIVER AND ITS TRIBUTARIES, KWAZULU-NATAL, SOUTH AFRICA

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Abstract

Increased water quality deterioration is a global issue in both developed and developing countries. Anthropogenic activities are major sources of non-point and point source of pollution and the cost of restoration of water quality is higher compared to the cost of pollution prevention, ecosystem restoration and water treatment. Despite this, monitoring programmes are declining with fewer points and less frequent sampling taking place throughout the world. This study aims to assess the effect of water sampling frequency on water quality management decision-making in upper uMngeni Catchment. A thirteen years' time series water quality data-sets provided by Umgeni Water (1988-2000) in eleven sampling stations,

monitored on weekly basis was assessed for pH, electrical conductivity, temperature, turbidity, total suspended solids, *Escherichia coli* (*E. coli*), ammonium, nitrate, nitrite, soluble reactive phosphorus and total phosphorous. Statistical packages were used to process the data and water quality indices (WQIs) for eutrophication and recreational water to assess water quality score, as a result of different monitoring frequencies. It was found that water quality status ranged from marginal to acceptable in ten of eleven stations and poor water quality at Mthimzima River downstream of Mpophomeni Township. Furthermore, the higher the monitoring frequency, the lower the water quality index as more conclusive information is available. However, these differences were not statistically significant. Our finding showed that over 90% of sampling stations presented higher levels of *E. coli*, exceeding human contact recreational threshold making it an influential variable for water quality score in the catchment. It is concluded that the existing monitoring strategy needs to be supplemented by an automatic sequential sampling plan, combined with streamflow measurements on the major tributaries of uMngeni River as well as at inflows of uMngeni River to the large dams in the catchment.

Key words: Eutrophication, monitoring frequency, sensitivity analysis, uMngeni Catchment, water quality index

EFFECTS OF LAND USE AND LAND COVER CHANGES ON WATER QUALITY IN THE UMNGENI RIVER CATCHMENT, SOUTH AFRICA

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Abstract

Land use and land cover change (LULC) are major drivers of water quality deterioration in watercourses and impoundments. However, there is a complex relationship between LULC changes and the concentration of water quality variables from one region to another. Understanding of the spatial and temporal variability of LULC characteristics and their link to water quality parameters in catchments is limited.

This study investigates the linkages between biophysical chemical water quality parameters *viz.* electrical conductivity (EC), nitrate (NO₃-N), ammonium (NH₄-N), soluble reactive phosphorus (SRP), total phosphorus (TP), total suspended solids (TSS), temperature, turbidity and *Escherichia coli* (*E. coli*) and LULC classes in the upper reaches of the uMngeni Catchment, a rapidly developing catchment in the KwaZulu-Natal (KZN) Province, South Africa. Geographic Information Systems (GIS) tools and statistical analyses were used to correlate land use information and water quality parameters collected by the local water authority for the years 1994, 2000, 2008 and 2011. Natural vegetation, forest plantations and cultivated areas occupy 85% of the catchment. A noted increase in cultivated, urban/built-up and degraded areas by 6%, 4.5% and 3% respectively and other land uses (plantations, mines, wetlands and waterbodies) coincides with a decrease of the natural vegetation by 17%. Variability in the concentration of water quality parameters from 1994 to 2011 and a decline in water quality were observed. *E. coli* levels exceeding recommended guidelines for recreation and public health protection were noted as a major issue in six of the eight sampling points. Midmar Dam, a large water supply reservoir, retains over 20% of nutrients and over 95% of *E. coli*. Increase of urban/built-up and cultivated areas was significantly associated with high concentrations of TP, EC, NO₃-N, SRP, *E. coli*, and NH₄-N in the waterbody while a decline in forest plantations and natural vegetation resulted in an increase in TSS and turbidity ($p < 0.05$). This highlights the complexity and site specific nature of relationships between LULC types and water quality parameters in uMngeni Catchment. This information has potential for further application to address water quality deterioration and management in the uMngeni Catchment and beyond.

Key words: Land use; land cover; Midmar Dam; uMngeni Catchment; Water quality

AN ASSESSMENT OF THE ECOLOGICAL CONDITION BASED ON SOIL AND VEGETATION PARAMETERS OF THE LIONS RIVER FLOODPLAIN, SOUTH AFRICA

Hlengiwe Ndlovu, Donovan Kotze, Craig Morris and Graham Jewitt

Abstract

Wetlands are exposed to many human activities, including agriculture and urbanisation that are increasing worldwide, resulting in wetland degradation. In South Africa, a water-scarce country, wetlands can play an important water-regulating role. This study aims to establish a baseline ecological integrity of the Lions River floodplain, an important, but degraded, wetland in the uMngeni catchment, to provide a guide for the planning and implementation of rehabilitation interventions. A comprehensive assessment of the wetland's structure was undertaken using vegetation and soil parameters, mapped and compared with an interpretation of landuse change within the wetland based on historical aerial photographs. The study concluded that the wetland's ecological integrity has decreased due to historical landuse in the floodplain. Wetness indicators of soil and vegetation can be used to indicate a transformation in the wetland's water regime, where the soil reflects the historic water regime and vegetation reflects the current water regime. A moderate to high abundance of ruderal and alien invasive species in 61% of the floodplain, particularly the drier areas of the floodplain, further indicate a reduction in ecosystem health. Soil degree of wetness emerged as the key drivers of species composition and historical landuse in the floodplain. The drier areas in the floodplain are most disturbed. This study highlighted the importance of detailed field studies and understanding for rehabilitation planning to return ecosystems to their natural function, thereby forming important ecological infrastructure for sustained water provision.

IMPACT OF THE LIONS RIVER FLOODPLAIN ON DOWNSTREAM WATER QUALITY

Hlengiwe Ndlovu, Donovan Kotze and Graham Jewitt

Abstract

The uMngeni catchment is important basin providing water to the cities of Pietermaritzburg and Durban, South Africa's second largest economic hub. However, there are rising concerns over the deterioration of water quality in Midmar Dam, a large impoundment within this important catchment. The Lions River, one of the main tributaries to Midmar Dam, transports pollutants from its catchment, as well as the Mooi River catchment through the recently implemented Mooi-Mgeni transfer scheme into the impoundment. This study therefore aims to determine what effect the Lions River Wetland, a degraded floodplain system, has on downstream water quality. An assessment of the wetland's impact on water quality was conducted by sampling water at various points through the floodplain over a period of one year. Water quality results indicate that total oxidised nitrogen decreased from upstream to downstream whilst ammonia concentrations remained stable at all the sampling points. Soluble reactive phosphorus concentrations increased, while total phosphorus concentrations decreased from upstream to downstream. It is concluded that the lack of bank overspill and low rainfall during the study period reduced the effectiveness of this floodplain to retain nutrients. Also, a deeply incised main channel with limited riparian vegetation and reduced water retention time and increased flow velocity due to the Mooi-Mgeni Transfer Scheme have also probably impacted the floodplain's ability to retain nutrients. Ongoing degradation of the wetland by overgrazing and artificial drainage is also having an impact.

2.3.3 Baynespruit Case Study

This project addresses several project aims. It is undertaken in collaboration with the uMsunduzi Municipality and provides a consolidated product for the project.

The Baynespruit research was less advanced than the upper uMngeni at the time when Deliverable 3 was completed. In this regard, a separate Baynespruit study is currently underway with the following objectives:

Objective 1: to determine the constituents that is found in the Baynespruit River and to monitor whether the levels of these constituents vary throughout the year.

- Successfully determined the constituents that are found in the Baynespruit River.
- Water quality monitoring has been successfully completed for 6 months and will continue until a period of one year has been reached. The results from the completed 6 months have been recorded and data analysis will commence once all water quality monitoring is complete.
- To supplement water quality monitoring a winter sediment analysis, for a variety of constituents, has been completed, results are recorded and will be analysed once the summer sediment analysis is complete.

Objective 2: to determine the effects on different edible crops in the Sobantu community, when irrigated with water from the Baynespruit River.

- This objective is broken-up into a winter and summer period. The entire portion of the winter period has been successfully completed. The data from this completed portion will be analysed once the summer period results have been obtained.

Objective 3: to determine in what ways the Sobantu community are currently linked/exposed to the polluted water of the Baynespruit and in essence, determine the health threat to people linked/exposed to the river.

- A preliminary workshop has been successfully completed which determined how the Sobantu community are currently linked/exposed to the polluted water of the Baynespruit River.

Overall, all objectives have been successfully achieved to date and within the expected time. Additionally, a research proposal, which comprises of a comprehensive literature review and methodology, has been produced. The study is being undertaken by MSc student Jedine Govender under the supervision of Dr Sabine Stuart-Hill and Prof GPW Jewitt.

2.3.4 Palmiet Case Study 2015/16

A range of participatory action research activities have been undertaken by the UKZN CLIMWAYS/WRC 2354 Durban team in the Palmiet catchment in the 2015/16 year to date, including:

- Three stakeholder engagement workshops
- Focus group meetings with the Quarry Road informal settlement
- Community survey - Quarry Road informal settlement
- On-going engagement with the Quarry Road community over issues that arise concerning the relationship between the river and the community
- Initial engagement to facilitate waste clearing and recycling projects in Quarry Road with Durban Solid Waste and Wildlands Conservation Trust

- Interviews with key stakeholders as part of actor mapping exercise
- Engagement with St Marys School – MiniSASS exercise
- Masters Research into relationship between New Germany industry and the river
- Engagement with the Kloof Conservancy – Take Back Our Rivers project

These activities are detailed below.

1. Stakeholder engagement process

Emerging from the uMngeni Ecological Infrastructure Partnership (UEIP), of which UKZN and the eThekweni Municipality are key partners, the Palmiet catchment was identified as a case study for researching opportunities for the enhancement of ecological infrastructure to improve water quantity and quality. Out of this was born the Palmiet Rehabilitation Project in 2014 which was initially driven by eThekweni Water and Sanitation (EWS), and which focused largely on technical solutions to improve the condition of the Palmiet and to reduce risk in the lower portion of the river that flows through the Quarry Road informal settlement. However, through the influence of the UKZN's CLIMWAYS research team, the scope and focus of the Palmiet Rehabilitation Project shifted in early 2015 to water governance along the whole Palmiet catchment. A preliminary actor mapping exercise, which had been undertaken in the second half of 2014, supported this.

The shift of focus to water governance at catchment level, led to the initiation of a stakeholder engagement process with a range of municipal, academic, civic science and community stakeholders. UKZN and eThekweni's Climate Protection Branch (CPB) initiated the process but there has been a shift towards greater leadership and engagement in the process by civic science as the process has evolved. The first Palmiet Rehabilitation Project stakeholder meeting, co-hosted by CPB and UKZN on 9 April 2015, was a technical workshop with stakeholders from eThekweni Municipality, UKZN, DUT and the founder of civic science group, Palmiet River Watch. The meeting focused on stakeholders' interest in the Palmiet, their role in the project and expanding stakeholder involvement to take the project forward. It was agreed that a participatory governance model should be used with an emphasis on action. The relationship between the state and non-state actors was discussed, with the research community (UKZN, DUT, DUCT) identified as the playing a pivotal role in connecting the community with the Municipality. The dire waste situation in the Quarry Road informal settlement was raised as a high priority issue.

The second stakeholder engagement workshop, also co-hosted by CPB and UKZN, was held on 18 November 2015 with a wider range of stakeholders including the technical stakeholders from the first meeting, representatives of the Quarry Road informal settlement, other local residents, and a good representation of civic science, including conservancies, Palmiet River Watch, WESSA and DUCT. The absence of local councillors and the business community was noted. After information sharing on the project and its context, participants discussed a range of questions relating to governance in the catchment and the governance model put forward at the technical workshop. This was followed by a groupwork exercise (mixed stakeholder groups) to identify stakeholders' critical issues concerning the Palmiet River, the opportunities for and constraints to responding to these issues, and their vision and goals for the river. The purpose of this exercise was to use the stakeholder responses to develop an action plan for the Palmiet. At the end of the meeting River Watch invited the stakeholders to attend a River Watch Meeting in January 2016, to inform on the current status of the river. CPB meanwhile summarised all of the stakeholder contributions into a draft concept note and action plan for the Palmiet.

In January 2016 the UKZN CLIMWAYS team met with CPB and River Watch to discuss and plan the next meeting. Although initially planned as a River Watch meeting, it effectively became a combined Palmiet Rehabilitation Project meeting between River Watch, CPB and UKZN, indicating an important shift in the governance process and a strengthening of the role in and commitment of civic science to the process. River Watch placed an article in the local newspaper inviting stakeholders to the meeting and UKZN/CPB invited their stakeholder list as well. The three parties co-chaired the meeting, held on 21 January 2016, with CPB and UKZN providing an overview of the project progress to date and the intention of the meeting to move towards an action plan. River Watch then provided a presentation on the context of the Palmiet in eThekweni

and the range of challenges facing the river, including multiple ways of measuring river health. UKZN added the specific challenges facing the Quarry Road community, particularly in light of the recent flood events within the context of a national drought situation. The stakeholders then reviewed the draft action plan developed by CPB in a mixed group work session. All the stakeholder inputs are in the process of being combined into a final draft action plan by CPB, UKZN and River Watch.

The next step in the stakeholder engagement process will be the setting up of a smaller stakeholder group, or Community of Innovation, to refine the action plan and take the process forward. It is intended that broader stakeholder meetings will take place about every six months.

2. Focus group meetings - Quarry Road informal settlement

Following initial engagement with the Quarry Road informal settlement in the second half of 2014, the CLIMWAYS research team hosted two focus group meetings at UKZN on 24 February 2015 with members of the Quarry Road area committee. The aim of the focus groups was to explore the governance context of the informal settlement, the key challenges faced by the community, their relationship with the Palmiet River and their perceptions around these issues. The focus groups started with a discussion of context and history of the settlement, their reasons for living there, challenges they face, including service and social facility related challenges. The discussion then shifted to the relationship between the community and the Palmiet River – how the river is used, how it benefits the community, challenges caused by the river, the history of the river and how the relationship with the river could be improved. More specifically the community was asked about flooding and how it impacts on the community, as well as their understanding of climate change. The focus group was rounded off with a discussion on governance issues including their relationship with the Municipality and the ward councillor, and the nature of community protests. These focus group meetings deepened the team's understanding of the community as well as playing a key role in building a trust relationship for further engagement.

Another focus group meeting was held on 15 January 2016 in the informal settlement when a visiting team from the 100 Resilient Cities programme was invited to meet the community. The focus group meeting explored questions on risk and resilience and was used as a means of ground truthing some of the themes that had emerged in the 100RC stakeholder engagement.

3. Community survey - Quarry Road informal settlement

More detailed household research was conducted in the Quarry Road informal settlement in March 2015 by the CLIMWAYS research team in conjunction with a visiting PhD student from the University of Amsterdam. The team administered a total of 100 surveys. The survey-included questions relating to household social and economic status, rationale for settling there, health and social networks, quality of housing, personal assets, services provision, governance relationships, and emotional well-being.

On-going engagement with the Quarry Road community

Since project inception, the CLIMWAYS team has been engaging with the Quarry Road community mainly through its area committee members, not only through the more formal research activities discussed in 2 and 3 above but also in a more ad hoc manner as specific issues arise. Regular meetings have been held with committee members to discuss issues that have arisen as a result of the relationship between the community and the river.

High risk situations related to the relationship between the community and the river have also resulted in the CLIMWAYS team/Cathy Sutherland acting with and on behalf of the community to attempt to resolve or lessen the impact of these crises, by engaging with the Municipality. For example, two flooding/storm incidents in January 2016 resulted in the loss of several homes and property and a tree falling onto one of the community ablution blocks. Cathy has been in touch with multiple departments in the Municipality to get municipal help for the community. The CLIMWAYS team is also initiating an engagement with the community to address their concerns relating to a snake in the river which has already bitten a child, and which is starting to transform in to the risk producing snake associated with cultural constructions of nature.

4. Waste clearing and recycling projects in Quarry Road

Complex governance problems concerning the relationship between the Municipality and the Quarry Road informal settlement around waste collection and illegal electricity connections has meant that waste removal in the community is limited. Consequently the majority of the waste generated by the settlement is ending up in the Palmiet River with consequent health and safety risks. The CLIMWAYS team started engaging with Wildlands Conservation Trust (WCT) in October 2015 to look into the opportunities for initiating a wastepreneur programme in the settlement. A follow on meeting was held at the informal settlement in November 2015 with WCT and DSW to discuss waste clean-up opportunities. DSW is planning a one year Expanded Public Works Programme project in the settlement to clear the waste using local community members. Once the project has been approved by the Municipal Manager, the CLIMWAYS team plans to host a meeting of the community with DSW and WCT to plan an approach going forward which can dovetail the clean-up with recycling opportunities.

5. Interviews with key stakeholders as part of actor mapping exercise

A range of Palmiet stakeholders were interviewed in the second half of 2014 as part of an actor mapping exercise, including local conservancies, the Palmiet Nature Reserve, Palmiet River Watch and the eThekweni Environmental Health Department. Further interviews were held in 2015 with the councillor for ward 23, the eThekweni Housing Department, eThekweni Water and Sanitation (Pollution and Environment Branch) and the uThekwane Conservancy (the last two as part of research into the relationship between New Germany industry and the river – see 8 below).

6. Engagement with St Marys School

As part of the wider stakeholder engagement process, the CLIMWAYS team also worked with the St Marys School in Kloof to conduct a water quality (miniSASS) assessment in the upper part of the Palmiet catchment with the assistance of the Palmiet River Watch. Three groups of grade 11 learners from the school conducted water quality assessments on 4, 7 and 8 May 2015. The results were uploaded to the miniSASS website.

7. Masters Research into relationship between New Germany industry and the river

The CLIMWAYS project is funding the research of a Masters student, Nolwazi Ntini, into the relationship between New Germany industry and the Palmiet River, using the hydro-social cycle literature as her theoretical framework. The research started in December 2015 with two contextual interviews with EWS and the uThekwane Conservancy and further interviews are planned for February 2016. It is hoped that the research will facilitate the engagement of industry in the Palmiet Rehabilitation Project stakeholder process, which so far has been lacking at the stakeholder meetings.

8. Engagement with the Kloof Conservancy – Take Back our Rivers project

An interesting development in the latter part of 2015 is the Kloof Conservancy's proposal, in partnership with the eThekweni Conservancies Forum, to initiate a "Take Back our Rivers" project to determine the condition of eThekweni's rivers using the 'river walk' approach and then to initiate restorative action and education. The conservancy has submitted a funding proposal to the UNDP, which is strongly embedded in a climate adaptation framework and aligns with work that the Municipality and the CLIMWAYS team are doing through this and the WRC project/UEIP. The Palmiet River is one of three rivers chosen for the first phase (90 km of river) of the project. The CLIMWAYS team and CPB met with the Kloof Conservancy on 1 February 2015 to engage further on the project and to discuss synergies with the work being done in the Palmiet Rehabilitation Project and by the Municipality through other programmes like the Green Corridor project. The Kloof Conservancy will be one of the members of the Community of Innovation that is being set up to steer the Palmiet Rehabilitation Project forward.

9. Engaging with other related processes

Catherine Sutherland presented a seminar, undertook a fieldtrip and facilitated a group discussion on 11 September 2015 as part of the World Social Science Fellows Seminar Series on Sustainable Urbanization Urban governance with a focus on urban poverty and environmental sustainability Durban, South Africa. The core seminar question: What modes of urban governance are emerging across the developed and developing world to demonstrate that it is possible to tackle the underlying challenges of urban growth, urban poverty and environmental unsustainability? She participated in this seminar series as part of her commitment to MILE and sharing knowledge from the WRC project with the Municipality and its partners.

Catherine Sutherland presented a paper on environmental services in the Palmiet River as an invited speaker at the ICLEI-DAC workshop held in Durban in October 2015. This was a partnership between ICLEI – Local Governments for Sustainability– Africa and eThekweni Municipality. There were over 200 delegates at the workshop from more than 21 countries. Over 75% of the participants were from 16 countries in Africa. Local government participation along with academics, NGOs, private sector, development partners and institutions, meant that there was fruitful discussion, learning, networking and transfer of lessons across the continent.

Catherine Sutherland presented a seminar on ecological infrastructure in the Palmiet River on 03 December 2015 to a group of Town and Regional Planning students from the University of Botswana who were on a study tour to Durban

2.4 Conferences, Symposia and other Events attended

Members of the project team were active in a number of local and international events. Papers were presented at the annual SASAQS symposium, at the Society for Ecological Restoration symposium held in Manchester as well as several other local events and fora.

Team members initiated the establishment of the 'uMngeni School of Water Governance Research. This initiative builds from the reality that the source of many of the problems we face does not lie in failures of our natural or engineered systems; it resides in failures of governance – the failure of our political, social, economic and administrative systems that influence water resource planning, use and management. See Appendix 1.

3 Capacity Building

Progress on student projects has been included in the above sections. A list of students contributing to the project appears below in Table 1. Michelle Browne has joined the project team to lead the economic analysis and is registered for a PhD at Rhodes University and a further Honours students will join the project this academic year. One student successfully completed his Hydrology Honours degree in 2015. Of the MSc students, Hlengiwe Ndlovu's MSc is complete (Graduation in April 2016) and Sesethu Matta and Sanele Ngubane will soon submit.

Table 1: Students currently registered or degree complete. New students in 2015 and those who have completed degrees are highlighted (green).

Name	Year	Degree	Project
Jean Namugize	2014-	PhD	Effects of Land Use on Water Quality of Umgeni River
Catherine Hughes	2014-	PhD	The hydrological benefits of rehabilitation of critical areas catchment - land use change impacts - aliens and degradation
Simphiwe Ncgobo	2015	PhD	Appropriate spatial and temporal scales for the assessment of global change
Michelle Browne	2015	PhD	Economics
Sesethu Matta	2014-	MSc	The value of community based water quality monitoring programmes
Hlengiwe Ndlovu (degree complete)	2014-	MSc	The restoration of Lions River Wetland for improved downstream water quality and quantity
Sanele Ngubane	2014-	MSc	Assessing changes in pollutant loadings to Midmar Dam between 1974 and 2014.
Silindile Mtshali	2015-	MSc	Mapping the extent of invasive alien plants in the uMngeni Catchment
Jedine Govender	2015 -	MSc	Impact of water quality degradation in the Baynespruit on farmers in Sobantu
Nantale Nsibirwa (degree complete)	2014	Hons	Hydrological modelling to estimate water quantity and quality of the Mthimzima Stream
Nokulinga ZweZwe (degree complete)	2014	Hons	Assessment and monitoring of the water quality of inflows to Midamr Dam
Silindile Mtshali (degree complete)	2014	Hons	Estimating chlorophyll content in water bodies in the uMngeni Catchment from hyperspectral satellite imagery
Sheldon Gouws (degree complete)	2015 -	Hons	A water quality profile of the Karkloof River
Sizophila Mahlobo	2016 -	Hons	Ongoing water quality studies of the of the Karkloof River

4 Conclusions and Way Forward

In 2015/16 the project and its associated ventures has been running effectively. Deliverables scheduled for the year have been submitted and progress has been made towards several of the project Deliverables. There is strong collaboration and inter-linkage with other related projects. A particularly pleasing aspect has been the extent of student involvement in the projects and the completion of four honours and one MSc degree to date.

4.1 Work Plan

The work plan for 2015 and the rest of the project is detailed in Appendix 4. Three Deliverables are in the 2015 financial year, as listed below:

Deliverable No.	Title	Due Date
6	Report on capacity development, popular articles and blog sites	31 June 2016
7	Literature review and final methodology description to assess water resource connectivity, inter-dependency between surface and ground water, as well as societal connection, all from a landscape perspective.	30 November 2016
8	Annual Report of Activities.	31 January 2017

5 Appendices

5.1 Appendix 1: Press Release - *'uMngeni School of Water Governance Research*

Exciting Water Research Partnership Launched

9 February 2016

The uMngeni River Basin is our collective life-blood – we rely on its water for our homes and businesses; we irrigate our crops; we collect food and medicinal plants from its wetlands; we marvel at its beauty; we worship along its river banks, and we paddle, boat, fish and swim in its rivers, streams and dams.

In the river basin our understanding of the system's hydrology and ecology is good. Also, our capacity to capture water from the system, process it and harness it for our needs is considerable. And yet we find ourselves in a situation which is, quite frankly, a mess. Water quality is poor and deteriorating; water wastage is high; alien invasive plants run rampant; natural flows are disrupted; human and ecological health is compromised; regulatory enforcement is weak; rural residents are regularly deprived of equitable access to the resource, and we are inadequately prepared to deal with the current drought. In short we are constantly compromising the very life-blood that sustains us.

The source of many of the problems we face does not lie in failures of our natural or engineered systems; it resides in failures of governance – the failure of our political, social, economic and administrative systems that influence water resource planning, use and management. While our individual and collective understanding of these issues under the umbrella of water resource governance is growing and good knowledge is being generated, there is very little to indicate that this knowledge is reaching and influencing the intended users. Also, there is a need to fundamentally increase social sciences and others to engage with the issues. Finally, individual researchers in the uMngeni are currently not unified around a common research agenda.

With this in mind a group of social and natural scientists gathered recently to plot a way forward. The main aim was to get to know each other better and learn about relevant projects that currently are undertaken by the researchers. The intended outcome of the get-together was to establish a common identity and identify key research needs and key partners as well as to establish a basis for collaboration and by that to begin the process of establishing a shared research agenda.

For our first session – a one and a half day workshop - we created a 'safe space' in order to meet our aims and thus, limited participation to researchers rather than practitioners and managers. Participants included colleagues from the CSIR, the Institute of Natural Resources, Monash South Africa, South African National Biodiversity Institute (SANBI), University of KwaZulu-Natal (UKZN), Urban Earth and the Wildlife and Environmental Society of South Africa (WESSA); there were twenty people in all. While other organisations and individuals are also operating in this space the group does represent a large portion of the water research effort focused on the uMngeni River Basin.

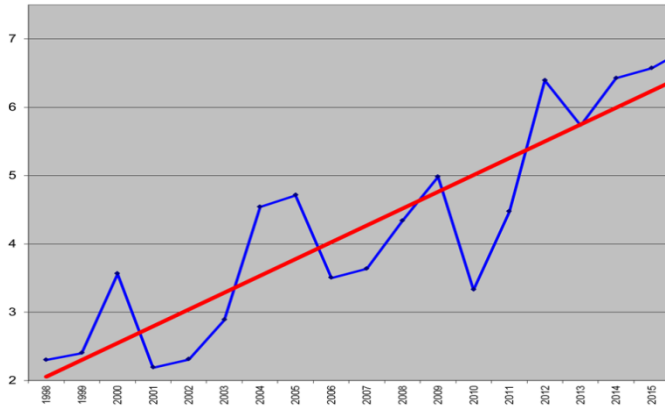
The workshop was a great success and has left the attendees with much enthusiasm, and many ideas and tasks. Researchers were able to get to know each other at a personal and professional level. Of particular interest was that at least seven participants were engaged in doctoral research. The range of interests was considerable and was not confined to research. It included direct support for management efforts, capacity development of key stakeholders such as municipal officials and traditional leaders, and a large body of research attempting to unpack the river basin as a social-ecological system.

We achieved to establish a common identity under the banner of the *'uMngeni School of Water Governance Research'* linked to the already well recognised uMngeni Ecological Infrastructure Partnership. Recognising that the creation of knowledge is an ongoing interaction between all stakeholders we were able to identify a

broad range of potential research partners and key stakeholders. These ranged from civil society, through NGOs and the private sector to various spheres of government.

Finally the uMngeni School of Water Governance Research established the foundations for a common research agenda, creating a short-term 'to-do' list, and assigning roles and responsibilities – watch this space!

No. of PMB area River Sites with >10000 E. coli per week, annualised average



Increasing pollution levels in the Msunduzi River at Pietermaritzburg – a governance failure



A woman from the Quarry Rd informal settlement washing clothes at the polluted Palmiet Stream – a governance failure

5.2 Appendix 4: Detailed Work Plan

