

**Contract Details**

**KSA** Research & Development (Branch)  
**Thrust**  
**Programme**

**Title** Urban Drainage Hydrological Processes K1 T2 P3  
**Proposal Number** 2022/2023-00981  
**Start Date** 01/Apr/2022 **End Date** 31/Mar/2024

**Lighthouses**  
 Sustainable Water Behaviours  
**Knowledge Tree**  
 Empowerment of Communities  
 Human Capital and Development in Water and Science Sectors  
**Research Location**  
 Gauteng

**Abstract**

While the development of urban drainage simulation models and of Sustainable Urban Drainage Systems designs have improved immensely over the past few decades, useful observations of urban drainage water and quality responses are seriously lacking. An opportunity exists to make such observations in the headwaters of the Jukskei river in the suburbs of Johannesburg. A station has been established with comprising automatic meteorological measurements, automatic water level and water velocity measurement and associated flow-rated automatic water sampler in the channeled Jukskei river at Victoria Yards, Lorentzville. Runoff from the suburbs of New Doornfontein, Bertrams, Troyville, Highlands and Lorentzville are monitored at this station. Rapid reposes have been observed, but not quantified and sporadic water quality sampling reveals the very poor condition of the river at the station location. An opportunity now exists to gather a continuous record of meteorological variables, runoff and water quality responses to provide the much-needed understanding of the response mechanisms and sources of runoff and water quality. This understanding will be included in model parameterization and model development to improve our ability to estimate high and low flow responses. Moreover, an NGO, Water for the Future (WFTF), has been established at the Victoria Yards and it has recognized the value of interaction with the local community where improvements to the water quality and flood events are desired. WFTF’s interaction involve education of the local community in various aspects of cleaning up the catchment, water quality understanding and the value of reducing runoff peak flows. WFTF are in the process of developing a WiFi network to allow for access to the station data, which will bne used for further education of the local and visiting communities.

This proposal seeks to provide for two wet seasons of observations at the station, assessment of the responses to provide for identification of sources and pathways, the development of a conceptual model and the simulation of the responses in a mathematical model, together with supporting the community training with technical evaluations. The outputs will provide support to efforts to quantify urnab drainage responses and to the evaluation of catchment based efforts to reduce peak flows and improve the water quality. It is envisaged that the viable station will then be handed over to a permanent operator to continue monitoring the responses to catchment improvements.

**Rationale**

**Motivation**

While the development of urban drainage simulation models and of Sustainable Urban Drainage Systems designs have improved immensely over the past few decades, useful observations of urban drainage water and quality responses are seriously lacking. This has become particularly evident in the findings of the recent WRC project

**ANNEXURE A**

K5/2747, Design Flood Estimation in Urban Areas in South Africa: Preliminary Results from Tshwane Case Studies. A. unique opportunity exists to provide much-needed observations of urban runoff and water quality responses in a heavily urbanised environment in the headwaters of the Jukskei river. A station has been established in the Jukskei channel at Victoria Yards, where automatic meteorological, channel flow and flow-rated water quality sampling are possible. If this station is supported and maintained for two seasons, valuable information, conceptual model and simulation techniques can be developed. The station comprises meteorological instrumentation and a water quality sampling device with integrated flow measurement instrumentation. A concurrent record of flow and water quality dynamics, particularly during rainfall event responses will be assembled. Examination of these parameters, together with associated stable isotopes of water, will allow us to deduce the sources and possible pathways of the discharge and water quality species. This is an essential first step for evaluating rehabilitation measures; Concurrent observations of the water quality concentrations, together with a flow time series, allows us to:

- Calculate mass loading, which is often more important than peak concentrations, particularly in assessing downstream impacts;
- Assess seasonal variations in mass loading with similar discharge rates;
- Assess the immediate effects of any changes to the stormwater reticulation or implementation of remediation measures to sewers or water reticulation networks;
- Allow for a local instruction station for local communities to be trained in catchment care and subsequent improvements to the Jukskei headwaters.

**i) Contextualisation**

The understanding and the time series generated from this station will prove invaluable to the City of Johannesburg, hydrological consultants and University research efforts. Furthermore, efforts are already underway to empower the local communities of these low income suburbs in aspects of catchment management and improvement. It is envisaged that the proper running of the station at Victoria Yards will allow for further training and instruction of the local communities. It is envisaged the WiFi connection to the station will be used to communicate catchment responses to the local communities and increase their appreciation of their efforts as individuals in improving catchment conditions particularly aimed at reducing peak flows and reducing water quality impacts.

**ii) Outcomes and Expected Impacts**

This project is aimed at

- providing technical understanding of rainfall-runoff and water quality responses in highly urbanised environments for urban developers, researchers and consultants;
- providing the communication of technical hydrological and water quality responses in simplified formats to local communities;
- supporting local communities in realising the responses to their efforts in improving catchment conditions;
- supporting efforts currently underway to instruct and support the local community in improving catchment conditions.

**Aims**

No	Aim
1	Monitor and evaluate the automatic collection of meteorological parameters, continuous discharge and flow rated water quality sampling in the headwaters of the Jukskei river
2	Develop an understanding of the sources and pathways of urban drainage responses in the upper Jukskei; develop a conceptual model of the water and water quality responses and include this understanding in SWMM modelling of the catchment
3	Provide simplified information for supporting efforts to communicate catchment responses and improvements to catchment conditions to local communities.
4	Provide technical evaluation and simulation of the catchment runoff and water quality responses for better understanding by urban catchment managers, researchers and consultants

**Methodology**

The methodology comprises the following tracts of work:

1) ESTABLISH OBSERVATIONS

The station currently comprises:

- o A Campbell Scientific (CS) automatic Weather station

**ANNEXURE A**

- o A Campbell Scientific water level sensor mounted on a footbridge over the Jukskei channel
- o An ISCO water depth and velocity sensor mounted into the base of the channel
- o An ISCO automatic sampler that is triggered by information collected on the channel discharge volume, thus allowing for period sampling during low flows and multiple samples during a runoff event
- o All the CS observations will be automatically disseminated on a WiFi link, while the associated water quality results will be included manually to the same linked data base

The first task will require establishing a viable flow depth-discharge relationship using the dimensions of the channel together with the recorded velocity and flow depths. The ISCO sampler will then be programmed to extract one sample per week during low flows and at least six samples per runoff event resulting from rainfall of over 20 mm. The local assistants will be trained to extract the samples and prepare them for delivery to the labs.

**2) DATA COLLECTION and ANALYSIS**

The following data will be collected from May 20022 to February2024, focusing on the wet season of 2022/23. Meteorological variables (rain, temperature, humidity, wind speed, solar radiation), channel water level and discharge velocity, water samples at low and event scales, analysed for:

- o Nutrients (nitrate and phosphate), EC, pH, ORP at the Bureau Veritas Laboratories. Occasionally batches will be further analysed for nitrites, ammmonia, sulfates and other species to be established, also at the Bureau Vertas labs
- o Pathogen species and Covid-19 markers at the WATERLAB laboratory in Pretoria;
- o Stable isotopes of water, 18O and 2H ratios, analysed at the UKZN Centre for Water Resources Research, Soil and Water laboratory in Pietermaritzburg.

**MODEL DEVELOPMENT**

The observed data will be analysed. Rainfall runoff relationships, water quality responses and isotope variations will be used in end-member mixing models and time series analyses to identify sources and evaluate flow paths and contributions. In particular, the following sources, their pathways and relative contributions will be the subject of analysis:

- o Recent rainfall - runoff generation;
- o Subsurface or stored catchment water;
- o Groundwater contributions;
- o Leaky reticulation (sewerage or water supply networks).

An illustrated conceptual model of these sources, pathways and contributions will be developed.

The SWMM urban drainage model (already set up in the ICLEI: Local Governments for Sustainability, Africa Secretariat project: Upper Jukskei Catchment Management Plan: Hydrological Model) will be parameterised with using the observed responses and the conceptual model as a guide. Simulations will be performed and outcomes compared with observed responses. Learnings from the differences between simulated and observed discharge and water quality will be used to further refine the model structure and parameterisations, with learnings recorded.

**COMMUNITY EMPOWERMENT**

Develop simple charts and instructions to allow the community to understand catchment responses and the likely improvement to these responses by implementing SUDS, cleaning the catchment and improving the hygiene of sewerage systems. A dedicated member of the WFTF will be engaged to liaise with the community and include the findings of the study in educating and training of local community members. The community will be instructed in the merits of keeping the catchment clear of debris and loose trash, in the merits of localised retention of runoff, of increasing permeable areas and in maintaining sewage systems. Data generated at the station will be used to provide illustrative examples of improved catchment status. A workshop will be conducted in order to record feedback from the community.

**COMMUNICATE FINDINGS**

All data, analyses, conceptual model development and simulations will be reported in progressive reports.

Papers will be prepared for submission to journals on urban hydrology.

Simplified documents and brochures will be developed for empowerment efforts in the community.

Brief catchment management guidelines will be developed, specific to the very dense urban development in the upper Jukskei.

Communicate technical advice to CoJ in sewage and water reticulation

**Deliverables**

No.	Deliverable Title	Description	Target Date	Amount
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**ANNEXURE A**

1	Initiation report and instrumentation establishment	Introduction of the team. Refining method. A report describing the establishment and configuring of the instrumentation, including calibration of the discharge and programming of the automatic sampler.	13/May/2022	R21 280,00
2	Observation progress	A progress report detailing all observations made in the first quarter. Graphics will be prepared to gain an early understanding of rainfall-runoff responses. Equipment problems will be corrected	16/Sep/2022	R50 000,00
3	Year 1 analyses, conceptual model and community engagement report	A report on the first year of observations, conceptual model development and simulations.	23/Feb/2023	R35 120,00
4	SWMM model results	A report on the SWMM modelling including parameterisation and development	19/Jun/2023	R40 000,00
5	Year 2 observation and community engagement report	Report on the data collected and engagement with the community, including community feedback from a group workshop	13/Oct/2023	R40 000,00
6	Final report	A final report communicating all observations, conceptual model development, simulation results. Results of community engagement and feedback.	15/Mar/2024	R38 100,00

**Products**

Title/Name	Target Group	Application
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**Innovation**

**Innovation Details**

Besides the unique data sets, analyses and community engagement, no further innovations are envisaged.

Innovation	Product Name
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**Intellectual Property**

**Background Intellectual Property**

No intellectual property rights are anticipated.

Intellectual Property	Product Name
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**ANNEXURE A**

**Budget**

**a) Operational Expenses**

Operational Expense Type	Financial Year	Amount
General Maintenance	2022/2023	R12 000,00
General Maintenance	2023/2024	R12 000,00
Laboratory Tests and Analyses	2022/2023	R8 000,00
Laboratory Tests and Analyses	2023/2024	R8 000,00

**c) Capital Expenses**

Capital Expenses	Motivation	Financial Year	Amount
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**e) Dissemination/Uptake Activity Expenses**

Expense Name	Financial Year	Amount
Community Training and WiFi Maintenance	2022/2023	R6 000,00
Community Training and WiFi Maintenance	2023/2024	R6 000,00

**f) Budget Summary**

**Expenses**

Financial Year	HR	Capital	Running	Uptake	Total	Deliverables
2022/2023	R80 400,00	R0,00	R20 000,00	R6 000,00	R106 400,00	R106 400,00
2021/2023	R0,00	R0,00	R0,00	R0,00	R0,00	R0,00
2020/2023	R0,00	R0,00	R0,00	R0,00	R0,00	R0,00
2023/2024	R92 100,00	R0,00	R20 000,00	R6 000,00	R118 100,00	R118 100,00
<b>Totals</b>	R172 500,00	R0,00	R40 000,00	R12 000,00	R224 500,00	R224 500,00

**Knowledge Dissemination and Research Uptake**

Knowledge dissemination is described in the methodology and will comprise:

- Technical reports
- Journal articles
- Community training documentation and feedback
- Shared Data base

**Capacity and Competency Development**

**a) Capacity Building**

Student Full Name	Gender	Race	Qualification	Financial
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**ANNEXURE A**

Ione Loots	Female	White	Doctor's Degree	2022/2023
An Other			Master's Degree	2022/2023
An Other			Master's Degree	2023/2024

**b) Institutional Development**

Institution Name	Nature Of Development
University of Pretoria, Civil Engineering	Heavily Urbanised hydrologu data set for model development
Water for the Future	Management of urban catchment runoff station

**c) Community Development**

Community Name	Nature Of Development
Residents of local suburbs in the catchment	Basic Training in urban runoff and water quality. Training in catchment care, including runoff peak reduction and water quality improvement

**3<sup>rd</sup> Party Funding**

Organisation	Financial Year	Amount
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**General Information**

**a) Literature References**

WRC report K5/2474 Design Flood Estimation in Urban Areas in South Africa: Preliminary Results from Tshwane Case Studies  
 Dunsmore, S. 2021. UPPER JUKSKEI CATCHMENT ANAGEMENT PLAN HYDROLOGICAL MODEL PHASE 1: STATUS QUO MODEL, Fourth Element Report 472