Adapting Sustainable Urban Drainage Systems to Stormwater Management in an Informal Setting

ABSTRACT

A major problem in the informal settlement of Monwabisi Park, Cape Town, is flooding caused by the low-lying topography and lack of stormwater management systems. Conducting a case study and working with local residents, we created a guidebook that analyzed the physical and social conditions underlying flooding problems, and the current interventions used by residents. In addition, the guidebook demonstrates specific Sustainable Urban Drainage System methods that we have adapted to an informal community setting.

This project report is part of an ongoing research program by students and faculty of the WPI Cape Town Project Centre to explore and develop options for sustainable community development in the informal settlements of South Africa. For more information please go to:
http://wp.wpi.edu/capetown/

The following is an executive summary of a set of project reports that has been implemented as a website available at:
wp.wpi.edu/capetown/homepage/projects/p2010/stormwater-management/

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Problem Statement

After the apartheid era in South Africa ended, many people, seeking new opportunities in urban areas, settled in informal settlements that grew largely unplanned and minimally serviced on the outskirts of many cities. These settlements are characterized by a lack of proper infrastructure (shacks), unsteady and unsafe housing, poor sanitation, and few job and educational opportunities (Parkinson, 2007). Without adequate public funding to improve public services, residents of informal settlements are faced with challenges to address basic needs. Monwabisi Park, an informal settlement located outside Cape Town, South Africa, has been experiencing many of the same problems as other informal settlements. However, the city has designated Monwabisi Park to be a pilot settlement for *in situ* urban upgrading, and has focused their attention on improving basic infrastructure and standards of living.

One major problem in this area is stormwater-related flooding and accumulation of stagnant water, which is created by the low-lying topography, the closeness of shacks along dirt roads, the paucity of proper infrastructure and poorly developed stormwater management systems found in this area (Butler, 2009). Water seeps into shack houses, causing property and infrastructure damages, such the degradation of floors, wall, and personal belongings, including mattresses and clothes. Standing water becomes a health hazard exacerbated by high levels of ground contaminants mixed with

stormwater (Winter, 2010). To tackle this issue, residents of Monwabisi Park have already implemented several simple stormwater management solutions that help alleviate flooding damages; but problems persist. Therefore, an adequate, yet sustainable, stormwater management system that combines local initiative with government action is needed.

Background

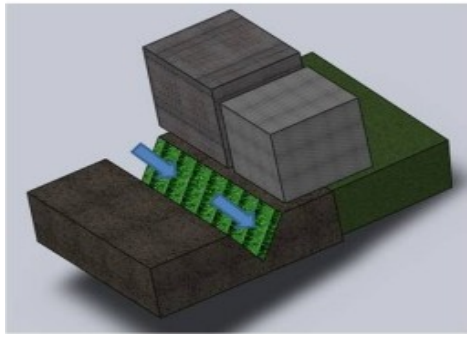
Excessive flooding in Cape Town, especially in informal settlements in the Cape Flats, has left over 32,000 people homeless during the past three years (Ziervogel, 2009). As a result, the city has established two main objectives regarding the management of stormwater runoff, which includes "reducing the impact of flooding on community livelihoods and regional economies", and "safeguarding human health, protect natural aquatic environments, and improve and maintain recreational water quality" (City of Cape Town, 2009). By clearly identifying these goals, the city is looking for simple and practical steps towards better stormwater management (City of Cape Town, 2009).

Sustainable Urban Drainage Systems (SUDS), is a philosophy used around the world to help reduce the excess flow of stormwater from spreading into unwanted areas. The major goals of the SUDS philosophy are to manage stormwater runoff, to rid the water of any pollutants and to encourage community involvement. When local community members participate in implementing and managing stormwater solutions, it increases the likelihood that community members will take care of the stormwater management systems, making said solutions more successful in the long-run (SUDS: Background, 2005).

SUDS Techniques

This project focused on integrating basic SUDS methods with the unique conditions and informal household stormwater management strategies found within an informal settlement. Using one road as a case study, this project detailed both physical and social aspects of stormwater management.

The four major SUDS interventions considered were artificial swales, soakaways, infiltration trenches, and wetlands. Artificial swales are narrow culverts dug into the ground, often into a low-lying area, with a shallow, dish-shaped depression. They are covered with vegetation and are used to redirect the flow of water away from unwanted areas, such as yards and houses. Soakaways and infiltration trenches are similar to one another in that each help to redirect and cleanse run-off water through a filtration process involving rocks that are strategically layered. Soakaways incorporate a layer of biofilters - plants used to absorb excess nutrients and minerals - on top of the rocks. In both systems, filtered water is redirected into a wetland - an open depression that is often found in low-lying areas that is rich with biological variety.



Stakeholders

Our premise is that a proper stormwater drainage system will use a combination of informal interventions and SUDS methodologies, and involve collaboration across many stakeholders. This project's specific goal was to analyze and create a plan for one area of Monwabisi Park that would produce lessons applicable throughout other sections of the settlement. Stakeholders include:

CITY OF CAPE TOWN: The City of Cape Town has created a new Informal Settlement Upgrading Programme (ISUP) program, with the Violence Prevention through Urban Upgrading Programme (VPUU) as lead agency. The VPUU requested this project, as they are dedicated to upgrading informal settlements through infrastructure planning, such as road development and stormwater management systems.

DR. KEVIN WINTER: Dr. Winter, a professor of Environmental and Geographical Studies at the University of Cape Town, assisted both the team and the city in developing a plan that will minimize flooding in Monwabisi Park. He provided valuable insights into working with the residents of Monwabisi Park, translating formal stormwater management systems to an informal setting, and organizing the overall presentation of the project in a way that is understandable to a variety of audiences ranging from city governments to academic scholars.

THE WPI CAPE TOWN PROJECT CENTRE: IQP projects from previous years have helped gather background information on water sanitation issues and community involvement in Monwabisi Park. This helped the team understand the complexities of working in the Park and helped them prepare for these obstacles.

RESIDENTS OF MONWABISI PARK: Residents contributed to this project tremendously by offering their feedback and suggestions on different stormwater management systems that are already in place and those they would like to see. They are also key participants in the project's community-based approach to flooding management, as they are the ones who will build and manage many implemented systems.

CO-RESEARCHERS: The Cape Town Project Centre enlisted the help of six local Monwabisi Park residents who served not only as language translators, but also as cultural translators. They offered invaluable insights into working within the settlement, interacting effectively with the locals, collecting data, and appropriately addressing the different issues related to current and proposed solutions.

Methods

The main goal of our project was to create a guidebook that would help the VPUU and the residents of Monwabisi Park implement simple, yet efficient, stormwater management systems. We created a poster and brochure that the VPUU could use to set up community stormwater management plans. The stormwater interventions that our team recommended employ modified SUDS methods adapted for implementation in informal settlements. The VPUU chose the main road in Monwabisi Park's C-Section as the pilot site.

Five main objectives guided our project:

- Identify and categorize flooding hot spots
- Analyze Impact of Flooding
- Measure and model the spatial conditions of the hot spots
- Generate designs for stormwater management systems for informal settlements
- Create a guidebook, brochure, and poster

To start our project, we walked along the main road to get accustomed to the people who live alongside the road, to observe the different conditions of the road, and to study and take note of the existing stormwater interventions. We were able to conduct quick and informal interviews to better understand where the residents experienced the worst flooding. Preliminary analysis determined that there are seventeen main areas that experience extensive flooding. When we walked on the road and interviewed more residents, we grouped some of the areas together into four "hot spots," which are the sections of the road most prone to flooding problems.

Two members of our team revisited the four hot spots and conducted formal interviews. The questions of the interviews focused on the physical aspects of stormwater management, such as interventions that the residents had been using, and the social aspects, which included assessing levels of cooperation and tension among neighbours related to stormwater interventions. The co-researchers introduced our team to the different homeowners and translated into English what the residents said.

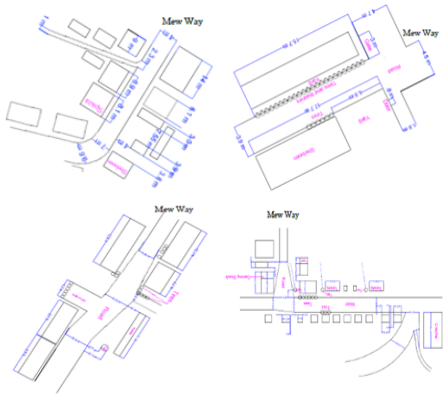
The other two members of our team focused on measuring the road and creating accurate computer-generated models of the different hot spots. They showed these models to the residents so that they could point out where the trouble areas were and where they would like to see stormwater management interventions placed. Since most of the proposed interventions require gravity as a key component, they measured the different levels of the roads using a level and a tape measure. After some

Results

After our team had gathered all of the information needed from Monwabisi Park – interviews, measurements and photos – we analyzed the data and produced three items for two different audiences: a guidebook and poster for the VPUU, and a brochure for the residents of Monwabisi Park. Through the interviews, our team was also able to explore the social dimension of flooding and how residents might behave if some of the proposed solutions were implemented. Below we discuss results particular to our case study, followed by more general findings.

Flooding Hot Spot Analysis

Hot spots A, B and D flood due to a downhill slope in the road that directs water into houses located at the bottom of a hill (one hill in each hot spot). These hot spots also have uneven surfaces that not only cause water to spread in different directions off the path of the main road and into the houses, but also cause water to accumulate and form small ponds. Hot spot C experiences flooding mainly as a result of a broken tap that leaks water into the area around the tap. When rainwater mixes with this tap water, the mixture increases the risk of flooding in the houses around the tap, and creates an unsanitary runoff containing contaminants from greywater produced around the tap.



Socially, our team noted that in hot spots A and D, there was relatively low tension between the neighbours and they were willing to work together to create a local stormwater management system that would have the potential to benefit many people. Specifically in hot spot D, the residents had developed a small water redirection system that resembled a ditch along the road. They created this system by working together in a large group, sharing tools and other resources, and by organizing a collaborative effort to ensure that it was properly implemented. This willingness to work together was not evident in either hot spot B or C, where residents experienced conflict over stormwater and were not as eager to work collaboratively to design and implement solutions.

Informal Stormwater Interventions

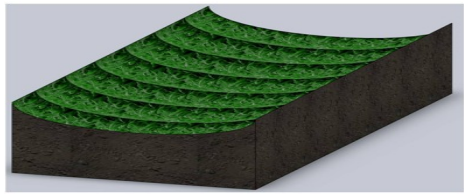
Through interviewing residents, our team learned valuable information about these local stormwater techniques and how they are used throughout the settlement. The residents were cooperative and showed the team the different interventions they had in place, as well as the different problem areas, such as the route that ground water followed. Our summary findings include:

- Many stormwater techniques are already in place and used by the local residents. Informal interventions present along the studied road include: fences; culverts and holes; accumulation of sand bordering the sides of the roads; vegetation; wooden boards and ledges; walls and sand stabilizers created by tyres. The majority of these techniques are widespread throughout the settlement, while other interventions which are more complicated to design, like raised platforms and plastics, are less commonly used by the residents.

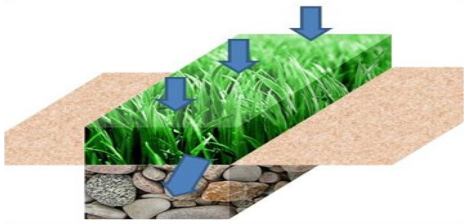
- Interventions found within Monwabisi Park serve to do three main things; create a barrier against the water, create a path of redirection for the water, and assist in the absorption of water into the ground. These three functions can all help minimize flooding in one aspect or another, but the manner in which they do this varies depending on the size, location and effectiveness of the system.
- The effectiveness of informal stormwater interventions varies widely, both by intervention type and the intention of specific applications. These depend on factors such as whether the underlying strategy of the technique is intended to prevent flooding, what level of maintenance it entails (on both a long-term and short-term basis), and what extent of construction it requires. If the intervention is relatively simple to design and install, such as the stacking of tyres or the creation of ditches, then the chance of it being built correctly and effectively is higher than if it entails a greater

- Socially, existing interventions cause numerous problems within the community. Techniques beneficial to one resident often negatively affect others, and residents expressed emotions ranging from subtle annoyance to vociferous frustration, resulting in distress and lack of trust. Our SUDS-informed recommendations to encourage cooperation among neighbours are designed to reduce these problems, and to assist in creating solutions that can benefit a large group of people all at the same time.

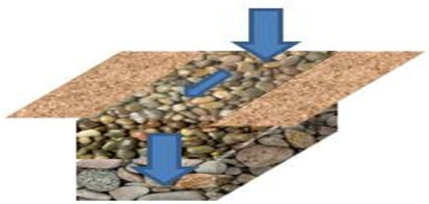
In Monwabisi Park, the preventative measures that the residents have implemented are only partially successful. To help increase the effectiveness of stormwater management plans and to work alongside these interventions, we proposed four different SUDS methods that we have adapted to work in an informal settlement. These solutions included:



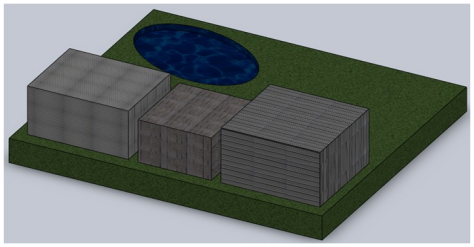
♦ Artificial swales



♦Soakaways



♦Infiltration trenches



♦and a Wetland.

One main philosophy behind SUDS interventions is obtaining community involvement. By encouraging collaboration among community members, it is possible to create a plan that can benefit a larger group of people. By promoting community-wide efforts and teamwork, the management demands, which are greater than the demands of the current interventions, will become more reasonable and easier to satisfy.

Our team put all of this information into a guidebook that the VPUU can later use to implement stormwater management plans and systems in Monwabisi Park. The guidebook includes detailed information about each intervention that was already in place and how the social conditions created by the residents affected the overall success of these preventative methods. It also discussed the importance of adapting the principles of SUDS to informal settlements, and how certain solutions were designed by our team to incorporate these philosophies into the existing conditions of Monwabisi Park. A detailed account of each proposed solution is presented in the guidebook; and, proposed management and maintenance plans are also included. This management aspect is a main focus of the guidebook, as it is intended to inform both the interested organizations, such as the VPUU, and the residents of Monwabisi Park of the time, labour and cost requirements involved with each proposed solution.

Aside from creating a formal guidebook, we also created a brochure and a poster, which provide residents useful information drawn from our project. The purpose of these two deliverables is to promote awareness and education of stormwater management throughout Monwabisi Park. The brochure is comprised of pictures and diagrams of functional current interventions, as well as explanations and recommendations of how to prevent flooding and why prevention is important. The poster was designed with the intention of providing an informative, yet aesthetically pleasing, product describing the various aspects of our research. We hope that this poster can be used by both the VPUU and local residents, through the direction of street committees, to show people how flooding can be minimized. The poster includes descriptions of both the current interventions, and diagrams and models of the proposed, SUDS inspired, solutions that our team has produced.

Future Recommendations

Our team's research and work in Monwabisi Park has resulted in a detailed proposal that has left both the VPUU and other organizations with guidelines for implementing the solutions we have suggested. This process would require obtaining more community involvement in both planning and implementing the adapted SUDS methods. This would help determine if these solutions do, in fact, work in informal settings. If the social collaboration and the physical interventions work, we recommend implementing the SUDS interventions in all of Monwabisi Park so that more people can benefit from proper stormwater management. A record of the steps of the process is crucial in understanding and analyzing the solutions. From such results, a case study can be created discussing future stormwater management systems in informal settlements.

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Acknowledgments

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