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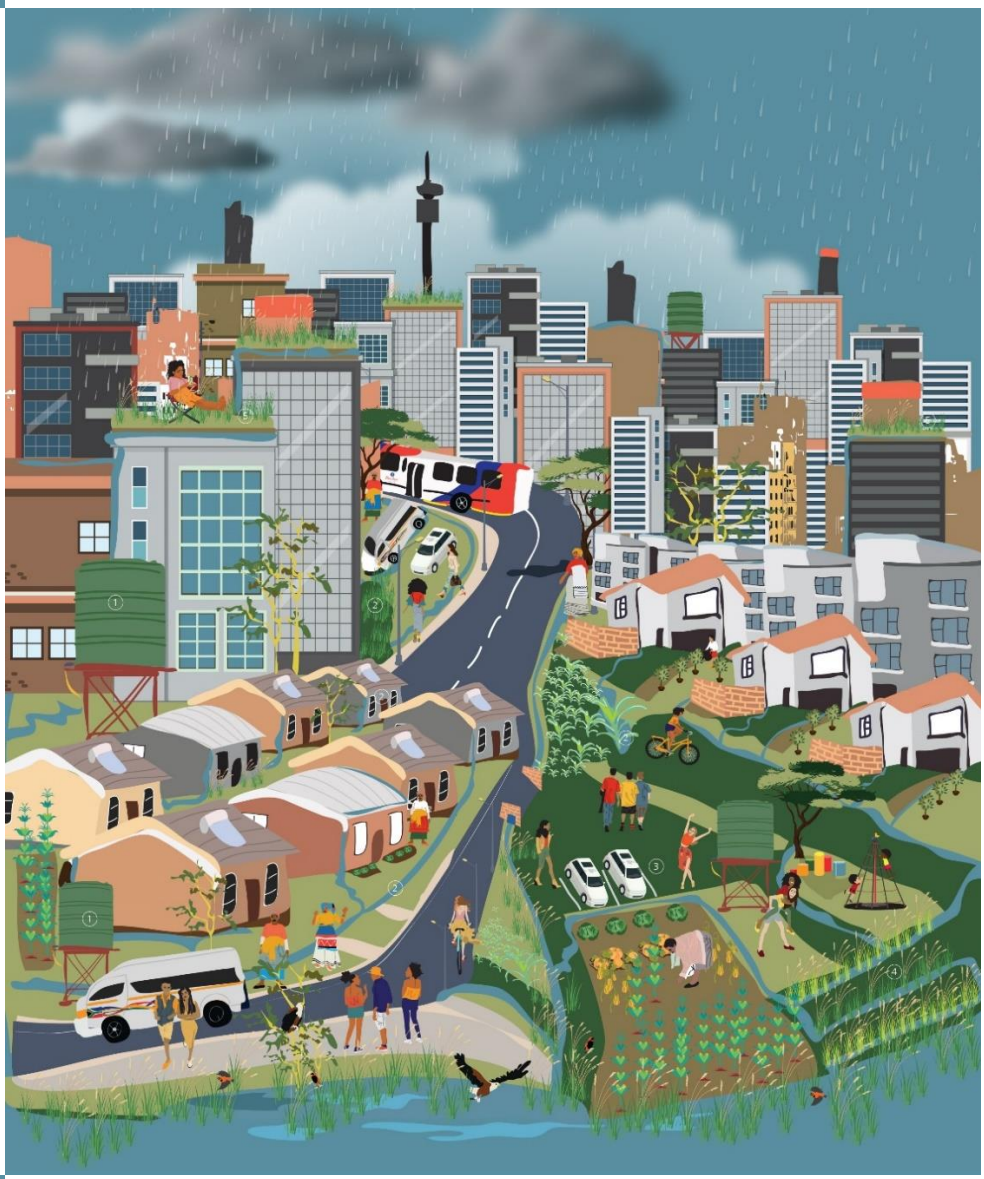

GAUTENG PROVINCE
AGRICULTURE AND RURAL DEVELOPMENT
REPUBLIC OF SOUTH AFRICA

Growing Gauteng Together

COLOPHON

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AGRICULTURE AND RURAL DEVELOPMENT
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Gauteng Department of Agriculture and Rural Development

CLIENT CONTACT PERSONS:

Ndivhudza Nengovhela (Project Manager), Rina Taviv (Project Leader), Neggie Bakwunye, Dakalo Phaswa (further members Project Management Committee)

AUTHORS:

Marieke de Groen

Aa'isha Dollie

Ntseketsi Lerotholi

Stuart Dunsmore (Internal Review and additions)

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ACRONYM LIST

CBD	Central Business District
CPD	Continued Professinal Development
EIA	Environmental Impact Assessment
GDARD	Gauteng Department of Agriculture and Rural Development
JRA	Johannesburg Road Agency
GPS	Global Positioning System
PSC	Project Steering Committee
SuDS	Sustainable Drainage Systems

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1 INTRODUCTION

As part of the project Research on the Use of Sustainable (Urban) Drainage Systems (SuDS) of GDARD, the Terms of Reference identify this report as 'Data Collection on SuDS Installations in Gauteng'. The total list of deliverables is as follows:

1. Inception report and skills transfer plan (not public)
2. Literature review on SuDS: definitions, science, data and policy and legal context in South Africa
3. Selection of three specific study areas
4. **Data collection on SuDS installations in Gauteng** (this report)
5. Analysis of study areas with recommendations
6. Decision Support Tools
7. Best Management Practices
8. Implementation Manual

This deliverable serves to identify SuDS installations in Gauteng. The requirements of the ToR are that:

- The data collection of SuDS in Gauteng includes a distinction between CBD, suburban and township areas.
- The data is collected from the whole province.

The scope of the deliverable has been explained by the Client suggesting that learning points from already installed or planned SuDS installations and gaps in knowledge to prepare for the activities following this report, would be important. Additional interviews and consultations have been undertaken with the parties involved in developing the original projects.

This inventory has identified 46 SuDS installations. This does not cover a complete list of all SuDS installations in Gauteng, only that which could be provided by contacts and sources found.

Overview of SuDS implementation in Gauteng

At the time of this study the implementation of SuDS in Gauteng is only just starting to gain traction. Design guidelines specific to Highveld applications are not available, and a formal description of sustainable drainage in municipal policy or stormwater management requirements is only recently (last two to three years) being prepared by one or two municipalities in the province. As a result, stormwater installations in the province that are based on SuDS principles, with clear performance criteria, are very few.

However, green stormwater features have been an increasing presence in site development plans over the last decade or more. This has been led largely by landscape architects and supported by the need to mitigate environmental impacts. Some of these projects are described as having "sustainable drainage" credentials, even though the stormwater capacity of the systems is not always defined. Therefore, this study has set out to identify as many of these projects that would contribute to stormwater management. Even if they are not specifically designed to meet a given level of performance, they should be included as part of the experience and knowledge base for Gauteng.

They should be monitored, so that they could provide important information on the planning, design and management of SuDS projects going forward.

This deliverable is considered a "first pass" at identifying relevant SuDS projects in the province. More projects will be added to the list as the project progresses. It would also be in the interests of the "Community of practice" to continue to maintain a register of all such projects, preferably in coordination with the respective municipalities.

Methodology

The approach has been to first start with examples of SuDS already reported on by academic institutions. Some of the SuDS are referred to several times by different authors. To identify less documented SuDS, the PSC members of the project were asked for inputs, in particular those representing the three Metros, but this resulted in no additional new SuDS. Also, all stormwater and roads departments of all District Municipalities and local municipalities were phoned or approached by e-mail, which resulted in no additional SuDS and the insight that SuDS and related terms are still unchartered territory in the smaller municipalities.

As a result, the search was widened to include land development practitioners. Landscape architects, stormwater engineers and sustainable building experts were actively approached by e-mail or phone. This resulted in many additional projects and references to other experts with experience in SuDS in Gauteng. It also served to identify key participants of the first large workshop with a wide community of experts.

For each site in this inventory, we collated the information available on: location, year of implementation, investment required, knowledge on maintenance and operation, monitoring of performance, impacts on ecology, impacts on economy/ people, stakeholders (funder, land owners), process learning points. However, it was found that most of this information was not well documented or not documented at all.

The experts were generally willing to pinpoint where and when they had worked, but most were not willing to submit by phone or e-mail further details by filling in a questionnaire. The returned questionnairs are included in the Appendix A.

An additional effort was made to derive learning points from Environmental Impact Assessments of the projects that contained SuDS, but only Environmental Authorisations could be retrieved of projects which mentioned measures that were SuDS measures. These Authorisations studied are summarised in Appendix B.

The learning points derived while doing the inventory are summarized in this report, but do not always refer back to a certain site location, as we considered this sensitive for the sources or where explicitly asked not to do so.

Beyond the scope of the project, AquaLinks made an effort to make the site locations more publicly available as well as additional background information. This has been uploaded in www.climatescan.nl. This site is open source mapping for SuDS and other climate change adaptations, mainly in Europe and Australia, but also now considered for South Africa by the UCT knowledge centre.

The https://www.climatescan.nl/ website gives awareness on how many SuDS Gauteng already has, and information available on companies involved in the development has been included. The website gives the option to use GPS locations directly to the phone, to direct a person to the site if interested. As many SuDS in Gauteng are 'hidden' behind fences, or not easily visited otherwise, with its Google functionality the site can be visited behind the desk.

2 STARTING POINTS AND ASSUMPTIONS

To re-iterate the methodology, these are the starting points and assumptions related to the SuDS data collection:

- The inventory list focuses on deriving learning points from SuDS installations thus it does not cover a list of all the SuDS installations in Gauteng, as much as could be gathered was compiled and added;
- Professionals also shared learning experiences of projects that never became SuDS installations or where something went wrong. These learning experiences have been shared, and the source is mentioned, but the specific context has been removed to not offend anybody not interviewed and because the stories could neither be verified;
- The information was gathered without conducting any site visits, as that was not part of the scope, therefore is limited to the knowledge of the persons contacted, and their availability and permission to share information, as well as the information in the written sources;
- Learning points are often personal learning points from people who tried, which are shared in this report, as many professionals have not yet tried the route of SuDS or might benefit from the experience of others.

3 LEARNING POINTS

3.1 Introduction

The learning points derived from the inventory and interactions with specialists and workshop held on the 5th February 2019 are grouped into sections below:

- Lack of awareness / prioritization / integration at municipalities
- Coordination between stormwater management plans, EIA's and environmental monitoring plans
- Making use of opportunities in project developments
- The merits and challenges of multi-disciplinarity
- The importance of correct maintenance
- The risk of local social dynamics
- Gauteng / Highveld climate conditions
- Suggestions for how learning points could be shared within Gauteng

3.2 Lack of awareness / prioritization / integration at municipalities

Understanding of SuDS design requirements at municipalities is limited.

Even where there is awareness of SuDS there is insufficient knowledge in government institutions to direct developers towards the appropriate solutions. Therefore, developers and engineers presenting SuDS based stormwater management plans are not confident the municipal officials will be able to approve them. There is also reservation by stormwater government officials that SuDS solutions and design procedures are not yet fully defined and tested for highveld conditions. Where green systems are promoted by the municipalities, this may not be by stormwater departments themselves and emphasis may be given to vegetated solutions rather than stormwater capacity. (This learning point is based on previous experience of Fourth Element with SuDS introduction in Gauteng, rather than information collated for this project, although some of it was mentioned in an interview with Johan Barnard.)

The average stormwater contact person at smaller municipalities does not yet know what SuDS are.

As mentioned in the introduction, in contrast to the Metropolitan Municipalities (City of Johannesburg, City of Ekurhuleni, City of Tshwane) the civil servants contacted in the District and Local Municipalities did not seem to be familiar with the concept of SuDS, even when explained related measures and terminologies. This is not really unexpected; due to their limited capacity. There is more specialisation possible in larger municipalities and climate change adaptation teams are available in bigger municipalities to stress the need for transition.

Municipalities have a backlog in infrastructure upgrades.

This is a barrier to implementation, but it is also an opportunity, as when infrastructure is replaced then SuDS based solutions can be implemented. (Workshop 5 February 2019, CBD discussion).

The required interlinkages between different departments in a municipality might prevent implementation.

The multiple benefits of SuDS and its contribution to the urban open space means that it touches on the functions of more than just the stormwater department within a municipality. Departments dealing with urban planning, parks, roads, sanitation and solid waste are among the departments that have a role to play. The best SuDS solutions are developed with input from all departments (Workshop 5 February 2019). Current institutional structures make it more challenging to implement these kinds of projects and therefore acts as a barrier (Workshop 5 February 2019). Smaller municipalities may have an advantage here but it will be a challenge for all municipalities to address. In preparing this inventory it was also noticed that in smaller municipalities some inter-departmental collaboration took place on a personal level. There is also anecdotal evidence that this is a lesson learned by experience in Europe on SuDS; smaller municipalities have less programmes on Climate Change Adaptation but working multi-disciplinary is sometimes easier in smaller units, and quicker decisions can be reached, if the resources can be made available (Thomas Klomp, 2019).

The municipalities do not have the capacity to check on maintenance of attenuation ponds or other SuDS measures on private property.

There is just a lack of personnel to do this and it does not have priority in any one department's mandate. (F Letsoko 2019, personal communication, 5 February 2019). This has important consequences. Firstly, the long-term presence of stormwater interventions (and their contributions to catchment management) is uncertain. Downstream properties may then have increased flood risk. Secondly, as a consequence of this, municipalities may adopt a 'worst case'-scenario whereby all upstream stormwater measures are assumed to be ineffective (e.g. in Ekurhuleni, Workshop 5 February 2019). The cost benefits of stormwater interventions are then lost, the optimum downstream land development will be affected (with impact on land values). The development of a comprehensive asset register is one of the proposals to address this.

3.3 Coordination between stormwater management plans, EIA's and environmental monitoring plans

The municipalities approve stormwater management plans and the province approves EIA's, which result in decisions that feed into the environmental monitoring plans.

Searching EIAs or stormwater management plans for a certain property or project is still a challenge. Property owners who would like to retrieve the stormwater management plan the developer submitted for their property, to be able to maintain and rehabilitate, may have a hard time getting it back in municipal archives, if the code of filing is not available. (Project member tried at Johannesburg Municipality on behalf of Home Owners Association. Also, the project team, with GDARD support, tried to search for EIAs for developments with SuDS components. This proved difficult without having the original EIA code, as the names of the property had changed from the name before development.)

The Environmental Impact Assessments Sustainable development guidelines of Gauteng Province approved in 2017 mention the importance of SuDS. EIAs before 2016 are unlikely to refer to SuDS measures in the Environmental Authorisation (R Taviv 2019, personal communication, January). The

EIA's we consulted though did have references to specific SuDS type of measures, see Appendix B. However, the Environmental Authorisations did not mention any specific requirements for the environmental monitoring plans. From the EIAs review, it is evident that there are SuDS measures mentioned in EIAs, but nowhere in the reviewed documents the actual SuDS term used. This may imply that SuDS does not yet attract any particular requirements or conditions by GDARD. This could point to the need for skills and experience development within GDARD to help promote the role of SuDS as an environmental impact mitigation and a climate adaptation measure.

The Environmental Monitoring Plans connected to EIAs could give an opportunity to monitor the performance of SuDS. However, all the Records of Decision reviewed (See Appendix B) only required monitoring during construction and it seems there is no further monitoring required during operational phase of these structures. Authorisation could, for example, require that the multi-disciplinary functions of the stormwater facility be specified, along with monitoring and inspection criteria, and included in a municipal asset register.

3.4 Making use of opportunities in project development

Designers need to engage with property owners / developers to explain the added value of a SuDS installation. The arguments used to convince property developers were not so much only in the environmental benefit, but in for example what would be saved on the water bill (for irrigation, for toilets), what a green look would do to sales/rental values, what the by-laws demanded on attenuation. In one example, a distribution centre had a certain budget for landscaping and it was perceived that involving SuDS would be more expensive. However, analysis showed that harvesting rainwater would enable a saving of R750 000 per year in their water bill, thus the Client became convinced. In another example, capital expenditure costs (CAPEX) for stormwater infrastructure was the limiting factor not to include SuDS, but when the line items of both landscaping and stormwater infrastructure were added together and a more holistic approach was used, the budgets appeared sufficient. (N Toy 2019, personal communication, February; J Barnard 2019, personal communication, 24 January; Workshop 5 February 2019)

On the other hand, motivated project owners do not always feel supported. The Vleihuis development project owner shared his disappointment in the support for his project to create a constructed wetland, based on an indigenous wetland, which would treat grey water to potable water standards in Linden, Johannesburg (See Appendix A2).

The Green Star Rating for buildings looks mainly at the harvesting and greening aspects, not so much at the bigger stormwater impacts. For example, to obtain a green star rating, a building might choose to harvest rainwater without the intention of managing stormwater and a stormwater management plan might not have been required. Rainwater harvesting is one of the SuDS measures as it can reduce stormwater runoff. However, its contribution to stormwater management needs to be specifically designed if it is to become a formal part of the stormwater management plan for a site. This will typically lead to additional storage for stormwater purposes, and potentially specific operational requirements, which may not be required for a Green Star Rating.

Stormwater management plans are often done before other designers come in, which creates missed opportunities. Landscape architects or sustainability consultants mentioned they are regularly only involved in the project after the stormwater management plan has been completed, which they consider a missed opportunity (M Reinink 2019, personal communication, 16 January 2019; D Rebel 2018, personal communication, November; Workshop 5 February 2019). At the core of the problem

is that stormwater management is still treated as a waste product and stormwater solutions are left until late in the project development process. Specialist stormwater engineers are seldom involved in this process, and traditional piped stormwater networks are left to inexperienced engineers. As SuDS design needs multi-disciplinary inputs and careful use of space which needs to be set out in the concept stages of the development. Bringing stormwater management into the early stages of site development planning is key to the successful implementation of SuDS.

Approving municipal authorities are not always in favour of SuDS, because of maintenance, flood or liability concerns. This seems to be a perception, not always much grounded on studying the specific site. The examples given (J Barnard 2019, personal communication, 24 January) were however a few years old, so these perceptions might have started to change, and in some cases the argument for traditional grey infrastructure might have been valid.

3.5 The merits and challenges of multi-disciplinarity

More than with traditional infrastructure, green infrastructure and its components like SuDS require the collaboration of multi-disciplines working together in order for it to be successful. A wide range of experts is required since it is a different approach to dealing with stormwater that involves a wide variety of engineers, landscape architects, hydrologists, sustainability consultants, etc. Examples were given of unnamed experts who have an aversion to changing their design paradigm (J Barnard 2019, personal communication, 24 January). Those who are not in favour of SuDS have not been engaged in this project, but could give good learning points.

Multi-disciplinarity can go well, if individuals understand the added value of the other discipline. For example, Newtown Landscape Architects got involved in SuDS in early 2000 when in the Thokoza Park project in Soweto, the stormwater engineer was Chris Brooker. This became a mutually beneficial relationship, with many SuDS projects following. (J Barnard 2019, personal communication, 24 January). Attention is currently being given to informing the engineering profession through, for example, the development of the CoJ Stormwater Manual. However, it is also important that landscape architects, ecologists and environmental practitioners have the necessary experience to plan and design urban stormwater systems.

Multi-disciplinarity needs very coordinated communication. For example, in a certain project a multi-disciplinary team had been working on SuDS concepts and designs, but the stormwater engineer did not communicate with the other team members that the authorities had refused SuDS and the stormwater design had been changed into a traditional hard infrastructure design (J Barnard 2019, personal communication, 24 January).

A stormwater engineer has to sign off on a stormwater design and accept a certain amount of liability, while the landscape designer thinks holistically and more creatively about the landscape. The unknowns of SuDS make it difficult for the stormwater engineer to take this more unknown road, so sometimes the initiative to develop SuDS ends with “I have designed stormwater systems for 30 years like this, and am not going to change it”. (J Barnard 2019, personal communication, 24 January).

Involving expertise on the soils is important. SuDS are designed either to infiltrate or to attenuate therefore the properties of the soil are critical to SuDS and often requires the expertise of a soil scientist. An example was mentioned where a SuDS measure was almost designed for which proved completely inappropriate once the soil specialist got involved (J Barnard 2019, personal communication, 24 January). In another example, the design of a retention pond failed as the

contractor did not manage to compact the soil sufficiently, and lining had to be applied, reducing the ecological value of the retention pond (C Brooker 2019, personal communication, January).

3.6 The importance of correct maintenance

The maintenance of SuDS is critical to the effective functioning of the system. Green infrastructure has to be cared for and maintained "at least as much" as traditional infrastructure is the opinion of some, while others state that maintenance costs will be less. We recommend to check on a case by case basis, dependent on the measures proposed and the sites (and this will be part of the Cost Benefit Analysis later on in this project). Urban rivers and SuDS cannot be rehabilitated and left without a maintenance and operations plan in place that is supervised and adhered to (J Barnard 2019, personal communication, 24 January).

Maintenance personnel often lack the knowledge of how to maintain SuDS systems. This point was raised by municipal services responsible for maintenance (JRA in workshop 5 February 2019) as well as by landscape architects interviewed for this and other projects. The landscape architects are typically contracted for one to two years after construction, but are not necessarily in direct contact with the contractors who do maintenance. Examples were mentioned of trees not being watered for the first two years, filter substrates in permeable paving not being cleaned, grass being cut where it should not be cut, flower beds in a park completely mowed away. Johan Barnard said the landscape architect can provide the service of a 'landscape audit' where it can advise property owners on what needs to be done in this time of the season, and how to phase it between different parts. For example, field burns should be done in part of a property (GCRO, 2019). A requirement of the Client could be that the consultants of the project are required to train the maintenance team and whoever is going to be in charge of upkeep of the development as to what they are supposed to do, why they have to do it a certain way and how they should go about doing it to ensure the success of the SuDS installations.

The budgets for maintenance are not necessarily available. In the first large workshop, Johannesburg Roads Agency mentioned the large backlog in maintenance therefore not being keen to introduce measures that potentially require more maintenance to be able to function.

Local ownership of maintenance comes with benefits and challenges. The maintenance of public open space is a challenge. The involvement of a local community can be beneficial but also comes with risks. There is a precedent in Johannesburg where local community members in Johannesburg were paid for maintenance activities and threatened to vandalize as soon as the project funding was finalized (First large Workshop 5 Feb 2019).

Residential estates or office parks are often led by property owners / home owners' association with limited priority and interest in the water system functioning. Once developers have completed projects, they hand over the operations and maintenance to the home owners' associations. In some cases, these associations either do not know what to do or they choose to ignore the advice from experts who were involved in the project. Without the correct information and actions, SuDS installations are likely to fail.

SuDS measures in individual private houses / buildings are not maintained. Examples were mentioned of rainwater harvesting systems not used, underground storage facilities for rainwater harvesting not being maintained, increased amounts of non-permeable paving not in the original stormwater management plans. (Personal experiences of Johan Barnard and project team member).

3.7 The risk of local social dynamics

Littering and vandalism thrive in certain areas of Gauteng. That this will be done and should be taken into account when deciding between traditional grey infrastructure and SuDS.

The blocking of sewerages and stormwater systems happens sometimes on purpose. In Johannesburg CBD the risk of the blocking of sewerage systems was emphasized, not just by litter but because desperate people were looking for valuables in sewerage systems. The risk of pollution when implementing certain SuDS then would increase.

Involving the public can be a challenge. JRA mentioned (Workshop 5 February 2019) the challenges of involving the public, as most people who show up for public meetings are really those interested in the project, not those influencing its success after implementation. Awareness campaigns seem to only have a limited time effect.

3.8 Gauteng / Highveld climate conditions

Sudden frost in winter in wet detention ponds / swales can cause trees to freeze. With respect to the climate in Gauteng, a wet Highveld and an extreme drop in temperature results in vegetation dying therefore the planning of SuDS must be done according to the climate conditions, soil properties, topography etc. (J Barnard 2019, personal communication, 24 January).

Studying the original ecology of a location can help to get the right ecological conditions in place. This was a starting point for the design of the Vleihuis in Linden – still to be constructed (Sherratt, 2019).

A green roof concept is often misunderstood. One site visited by project team members has a dead green roof. It appears as if normal soil and normal highveld grasses are used, instead of substrates and succulents. The green grass has not survived. Other people put some pot plants and expect it to function as green roof.

3.9 Suggestions for how learning points could be shared within Gauteng

In the submissions for contributions to this workshop the following suggestions came in, on how to share learning experiences (Craig, 2019):

- Organise site visits to installed projects through professional membership organisations
- Provide Continued Professional Development training on SuDS to registered professionals
- Feature SuDS projects in popular magazines

With this report, www.climatescan.nl has been used as a means of learning about Gauteng SuDS, with project information being available by maps.

4 LIST OF SUDS INSTALLATIONS IN GAUTENG

The following data were collated on SuDS Installation in Gauteng. To keep the report concise, most background information is provided via the link to www.climatescan.nl. While many of these SuDS examples are realized, we could not find evidence that they were planned as SuDS in the stormwater management plans. The drivers behind many of them seemed water harvesting or amenity value reasons.

Table 1 List of identified SuDS installations in Gauteng

Nr	Name of project	SuDS measure	Location	Lati-tude	Longi-tude	Municipality	Owner-ship	Land-use	Further information (inputs climatescan by AquaLinks or otherwise)
1	15 Alice Lance	Rainwater harvesting	Sandton	-26.11	28.05	City of Johannesburg	Private	CBD - Commercial	https://www.climatescan.nl/projects/2899/detail
2	22 Fredman Drive	Green roof	Sandton	-26.10	28.05	City of Johannesburg	Private	CBD - Commercial	https://www.climatescan.nl/projects/2914/detail
3	44 on Grand Central	Rainwater harvesting	Midrand	-26.00	28.13	City of Johannesburg	Private	Suburb - Commercial	https://climatescan.nl/projects/2894/detail
4	Alexandra (15 schools) Rand water RWH pilot study	Rainwater harvesting	Alexandra			City of Johannesburg	Municipal	Township - Educational	Primary schools: Emfundisweni, Carter, Ikage, Dr Knak, Bovet, Ekukhanyisweni, Zenzeleni, Gordon, Ithute Secondary Schools: Iphutheng, Minerva, Eastbank, Realogile, Kwabhekilanga, MC Weiler
5	Anslow Park Phase II	Rainwater harvesting	Bryanston	-26.06	28.02	City of Johannesburg	Private	Suburb - Commercial	https://climatescan.nl/projects/2891/detail
6	Atholl Towers	Rainwater harvesting	Sandton	-26.11	28.07	City of Johannesburg	Private	CBD - Commercial	https://www.climatescan.nl/projects/2895/detail
7	Atlasville Flood Relief Scheme	Canal Rehabilitation	Boksburg	-26.16	28.29	City of Ekurhuleni	Municipal	Suburb - Residential	https://climatescan.nl/projects/2862/detail
8	Booysens Attenuation Facility	Detention pond	Booysens	-26.23	28.02	City of Johannesburg	Municipal	Suburb - Recreational	https://climatescan.nl/projects/2881/detail
9	Bothlabela Village	Rainwater harvesting	Alexandra	-26.11	28.12	City of Johannesburg	Private	Suburb - Residential	https://www.climatescan.nl/projects/2912/detail

Nr	Name of project	SuDS measure	Location	Lati-tude	Longi-tude	Municipality	Owner-ship	Land-use	Further information (inputs climatescan by AquaLinks or otherwise)
10	Broadacres Academy	Permeable paving, attenuation pond	Broadacres	-26.00	27.99	City of Johannesburg	Private	Suburb - Educational	https://www.climatescan.nl/projects/2910/detail
11	Bruma Lake	Constructed Wetland	Bruma	-26.18	28.11	City of Johannesburg	Municipal	Suburb - Recreational	https://climatescan.nl/projects/2877/detail
12	Cedar Lofts Development	Wetland rehabilitation, bioswales, attenuation ponds	Fourways	-26.02	28.00	City of Johannesburg	Private	Suburb - Residential	https://climatescan.nl/projects/2861/detail
13	Department of Environmental Affairs	Rainwater harvesting, green roof	Arcadia	-25.74	28.20	City of Tshwane	Municipal	Suburb - Government	https://www.climatescan.nl/projects/2909/detail
14	Development Bank of South Africa	Green roof	Midrand	-25.94	28.14	City of Johannesburg	Municipal	Suburb - Commercial	https://www.climatescan.nl/projects/2915/detail
15	Diepsloot SuDS research project	Permeable paving, semi-vegetated channels, soakaways, bio-retention area	Diepsloot	-25.94	28.01	City of Johannesburg	Private	Township - Residential	https://climatescan.nl/projects/2697/detail
16	Diepsloot SuDS research project	Bioswale	Diepsloot	-25.94	28.01	City of Johannesburg	Municipal	Township - Residential	https://www.climatescan.nl/projects/2920/detail
17	Diepsloot SuDS research project	Bioswale	Diepsloot	-25.92	28.01	City of Johannesburg	Municipal	Township - Residential	https://www.climatescan.nl/projects/2919/detail
18	Eastgate 20	Rainwater harvesting	Sandton	-26.10	28.07	City of Johannesburg	Private	CBD - Commercial	https://climatescan.nl/projects/2890/detail
19	EY building	Rainwater harvesting	Sandton	-26.11	28.06	City of Johannesburg	Private	CBD - Commercial	https://climatescan.nl/projects/2863/detail

Nr	Name of project	SuDS measure	Location	Lati-tude	Longi-tude	Municipality	Owner-ship	Land-use	Further information (inputs climatescan by AquaLinks or otherwise)
20	Fourways Garden Stream	Stream rehabilitation	Fourways	-26.00	28.01	City of Johannesburg	Municipal	Suburb - Residential	https://climatescan.nl/projects/2870/detail
21	Fourways Golf Park	Rainwater harvesting	Fourways	-26.02	28.00	City of Johannesburg	Private	Suburb - Commercial	https://climatescan.nl/projects/2887/detail
22	Group Five Head Office	Rainwater harvesting	Midrand	-26.02	28.09	City of Johannesburg	Private	Suburb - Commercial	https://www.climatescan.nl/projects/2903/detail
23	Grundfos Office Block	Underground detention tanks	Kempton Park	-26.16	28.16	City of Ekurhuleni	Private	Suburb - Commercial	https://climatescan.nl/projects/2889/detail
24	Inanda Greens	Rainwater Harvesting	Sandton	-26.11	28.06	City of Johannesburg	Private	Suburb - Commercial	https://climatescan.nl/projects/2893/detail
25	Kaalspruit	Constructed Wetland	Olifantsfontein	-25.94	28.21	City of Ekurhuleni	Municipal	Suburb - River	Not yet realized
26	Lord's view industrial park	Retention pond, treatment trains	Clayville	-26.05	28.17	City of Ekurhuleni	Private	Suburb - Industrial	https://www.climatescan.nl/projects/2916/detail
27	Mapetla Regional Wetland Park	Wetland rehabilitation	Mapetla	-26.27	27.84	City of Johannesburg	Municipal	Township - Residential	https://www.climatescan.nl/projects/2918/detail
28	Melrose Arch Precinct	Rainwater harvesting	Melrose	-26.13	28.07	City of Johannesburg	Private	Suburb - Mixed Use	https://www.climatescan.nl/projects/2917/detail
29	Menlyn Maine	Treatment trains	Menlyn	-25.79	28.28	City of Tshwane	Private	Suburb - Mixed-use	https://www.climatescan.nl/projects/2901/detail
30	Mining Industry Study Centre	Swales, retention ponds, constructed wetland	Hatfield	-25.75	28.23	City of Tshwane	Private	Suburb - Educational	https://www.climatescan.nl/projects/2906/detail
31	Moroka Dam and Thokoza Park	Bioswale, stream and wetland	Soweto	-26.26	27.88	City of Johannesburg	Municipal	Suburb - Recreational	https://climatescan.nl/projects/2878/detail

Nr	Name of project	SuDS measure	Location	Lati-tude	Longi-tude	Municipality	Owner-ship	Land-use	Further information (inputs climatescan by AquaLinks or otherwise)
		rehabilitation							
32	Oxford Parks	Rainwater harvesting, swales, permeable ground surfaces, rooftop gardens	Dunkeld	-26.14	28.04	City of Johannesburg	Private	Suburb - Commercial	Not yet realized
33	Paterson Park	Bioswale	Orange Grove	-26.24	28.08	City of Johannesburg	Municipal	Suburb - Recreational	https://climatescan.nl/projects/2864/detail
34	Rainbow Junction	Green roofs, permeable surfaces, detention pond, swales etc	Pretoria	-25.67	28.19	City of Tshwane	Private	Suburb - Mixed-use	https://www.climatescan.nl/projects/2902/detail
35	Sandton Attenuation Facility	Retention pond	Sandton	-26.11	28.06	City of Johannesburg	Municipal	CBD - Commercial	https://climatescan.nl/projects/2880/detail
36	SANRAL Head Office	Green roof	Pretoria	-25.75	28.29	City of Tshwane	Municipal	Suburb - Government	https://www.climatescan.nl/projects/2908/detail
37	St Stithians College	Bioswales, wetland, attenuation dams	Sandton	-26.08	28.02	City of Johannesburg	Private	Suburb - Educational	https://climatescan.nl/projects/2879/detail
38	Sunnypark Holiday Inn Express	Green roof	Sunnyside	-25.75	28.20	City of Tshwane	Private	Suburb - Commercial	https://www.climatescan.nl/projects/2913/detail
39	The Falls Pick n' Pay	Swales, detention pond	Roodepoort	-26.11	27.88	City of Johannesburg	Private	Suburb - Commercial	https://www.climatescan.nl/projects/2905/detail

Nr	Name of project	SuDS measure	Location	Lati-tude	Longi-tude	Municipality	Owner-ship	Land-use	Further information (inputs climatescan by AquaLinks or otherwise)
40	Tshedimosetso House	Rainwater Harvesting	Hatfield	-25.75	28.23	City of Tshwane	Private	Suburb - Government	https://www.climatescan.nl/projects/2896/detail
41	Vleihuis development	Wetland rehabilitation	Linden			City of Johannesburg	Private	Suburb - Residential	See Questionnaire submitted in Appendix B
42	Vodacom Site Solution and Innovation Centre	Underground detention tanks, treatment wetland, indoor pond	Midrand	-25.97	28.13	City of Johannesburg	Private	Suburb - Commercial	https://www.climatescan.nl/projects/2904/detail
43	Warehouse in lanseria business park (cash crusaders)	Attenuation tank	Lanseria	-25.95	27.92	City of Johannesburg	Private	Suburb - Commercial	https://www.climatescan.nl/projects/2911/detail
44	Wits Parking lot	Permeable paving	Braamfontein	-26.19	28.03	City of Johannesburg	Private	CBD - Educational	https://www.climatescan.nl/projects/2900/detail
45	Woolworths Distribution Centre	Rainwater harvesting, retention pond	Centurion	-25.92	28.17	City of Tshwane	Private	Suburb - Commercial	https://www.climatescan.nl/projects/2907/detail
46	Zola Wetlands	Swale	Soweto	-26.24	27.81	City of Johannesburg	Municipal	Suburb - Recreational	https://climatescan.nl/projects/2865/detail

5 SELECTED CASE STUDIES

Table 5.1: TOWNSHIP CASE STUDIES

Name of project	Learning points
Diepsloot Bioswale Research Project (Craig, 2019) (See Appendix A1)	• The intention for the bioswales was only to capture the overflow from the municipal stormwater infrastructure. However, the municipal system has been blocked for almost the entire project period and the swales have to deal with larger quantities than they were designed for. • Sedimentation is much more than originally expected which is worsened by the deterioration of upstream grey infrastructure. • Lawn planted in the surrounding areas has helped to prevent erosion around the swales. • Projects are less likely to be successful if done in isolation, the larger catchment area needs to be considered • Even after extensive community awareness campaigns, the wider community does not realise the role of the project. Areas identified by the community should be considered if possible. This project was identified based on municipal recommendation and approval • Construction work had to be repeatedly corrected because the site managers did not understand the SuDS principles and deviated from the construction details provided. Therefore, in addition to consultants, construction companies will also have to be trained on SuDS.

Table 5.2: SUBURB CASE STUDIES

Name of project	Learning points
Vleihuis Development (Sherratt, 2019) See Appendix A2	• The overall cost was much higher than expected • There is little to no support from local communities or government for this kind of project. We are far behind the rest of the world in terms of innovation.
Fourways Golf Park (Brooker, 2019)	• Limited ecological value because the pond was originally designed with the specification that it would be waterproofed using bentonite modified soil which would have allowed for the development of some sort of natural ecosystem. However, during construction, the Contractor did not handle the bentonite correctly, nor did they compact the modified soil thus the pond leaked on the first filling. Instead of rebuilding to the original specification, it was agreed that a Viaseal membrane would be applied. • The high water table at the top of the hill caused difficulty in the curing of the Viaseal.

Table 5.3: CBD CASE STUDIES

Name of project	Learning points
Ernst & Young Building (Dollie, 2018)	• Even though a stormwater management plan was not necessary for the building, the designers were being environmentally responsible by limiting the stormwater runoff in the area through the installation of a rainwater harvesting system. This earned them credits in their green star rating. • The rainwater harvesting system was installed during the construction (2013) of the building however, post-construction it did not function as intended. The building was still using potable water for all its needs (at least 5 years) because there was only a filtration system installed but no secondary treatment. The building targeted the New Buildings Green Star Rating and obtained their credits based on the installation of the system however because they did not target the Existing Building Performance Rating it did not matter that the systems did not function correctly during operation and maintenance.
General	All other developments identified in the CBD are owned by Property developer Growth Point. It was commonly observed that the motivation for installing SuDS in the CBD area is primarily for buildings that target a Green Star rating.

6 CONCLUDING REMARKS

The list of SuDS projects in Gauteng shows that a step is made towards a transition to more sustainable drainage systems. As mentioned, while many of these SuDS examples are realized, we could not find evidence that they were planned as SuDS in the stormwater management plans. The drivers behind many of them seemed water harvesting or amenity value reasons.

While not many learning points were shared on the individual projects, the persons experiences with SuDS projects in Gauteng have a lot of learning points to share.

This report is a draft of learning points, based on the first investigations for this project. The literature review and the research on the study areas, which follow this first deliverable will contribute to further insights and possibly to corrections in learning points.

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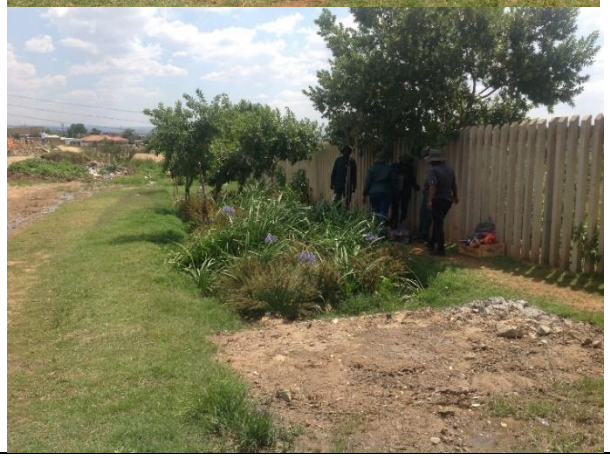
APPENDIX A RETURNED QUESTIONNAIRES

APPENDIX A1: Diepsloot Bioswale Research Project (Craig, 2019)

Questionnaire on Sustainable (Urban) Drainage Systems in Gauteng	
Project:	**Diepsloot Bioswale Research Project**

NAME	ORGANISATION	POSITION	EMAIL
Mrs Liezl Craig-Swart	Unisa	Lecturer	craigl@unisa.ac.za

Table 0.1: Project details

General project information	Answer
Type of SuDS	bioswales
Photos	 
Purpose of SuDS (flood alleviation, ecology/amenity improvement, water quality)	Water quality & flood alleviation.
Brief background/history that lead to SuDS installations	This is a research project towards my PhD in Development and Management (Water Studies) with North-west University. It follows my earlier research for my MPhil Integrated Water Management (Monash South Africa) which investigated the viability of bioswales in the informal settlement context. This is

	a pilot project to test the performance of three different prototypes for the informal settlement context.
Motivation for SuDS (why SuDS instead of traditional infrastructure (concrete channels, pipes, culverts etc.))	Traditional stormwater infrastructure requires large financial investment and are usually one of the last priorities on the development agenda. They further require right angles and certain inclines and informal settlements often have a hap-hazard layout and are located within drainage areas which means there are steep inclines. There are increased sedimentation and regular sewerage leaks which are not treated by traditional infrastructure. The reasoning was also that bioswales have a simple construction method which meant that unemployed residents could be employed for the construction and maintenance of the systems.
CBD/Suburban/Township	Township
Location	Site 1 (25°56'21.80"S, 28° 0'34.47"E) Orange Street, Diepsloot Site 2 (25°55'27.84"S, 28° 0'44.86"E) Fourth Cabbage Tree Crescent, Diepsloot
Land-use	Mixed / residential
Public/Private ownership	Public – Municipal open space
Year of completed design	2015
Year of completed construction	2016
Reference nr of EIA (GDARD)	n/a
Reference nr of stormwater management plan (Municipality)	n/a
Capital expenditure (CAPEX) amount	R 417,000.00 for 3 swales of 25m long, 3m wide with sedimentation tanks (incl. community worker training & 3 month post-completion maintenance)
Who are the stakeholders involved? (Funders, Owners, Consultants, Civil Society etc.)	JCPZ – Cebo Mhlongo (cmhlongo@jhbcityparks.com) Unisa – Prof WAJ Nel (Nelwaj@unisa.ac.za) North-west University - Prof Tempelhoff (Johann.tempelhoff@nwu.ac.za) BMW Seed Programme – Bongani Mshibe (Bongani.mshibe@bmw.co.za) National Research Foundation Diepsloot community members
Operation and maintenance	
Operational and maintenance expenditure per annum	Not provided
Who is in charge of maintenance?	The site is currently being maintained by 5 (five) Diepsloot community members, paid by Unisa with funding from BMW Seed Programme
What does the maintenance plan entail?	Weeding, removal of sediments, litter removal, splitting and replanting, maintenance of lawn areas surrounding implementation, watering in winter months if needed, cleaning of reno-mattress litter trap from litter and sedimentation, cleaning of sedimentation tank.
Evaluation and monitoring	
In the initial design discussions, was an evaluation method used (like Cost Benefit Analysis) to compare between different ways of designing (including traditional	N/A

infrastructure)? If yes, please explain.	
Is performance being monitored in terms of stormwater management? If yes, what are the monitoring results?	Water quality sampling (to be published) Plant survival rate
What are the estimated/monitored ecological impacts?	Improved water quality of effluent released in downstream wetland and river.
What are the estimated/monitored economic impacts?	Job creation and amenity value
What are the estimated/monitored social impacts?	Reduced E. coli levels in discharged stormwater and reduced peak stormwater flow.

Table 0.2: Learning points

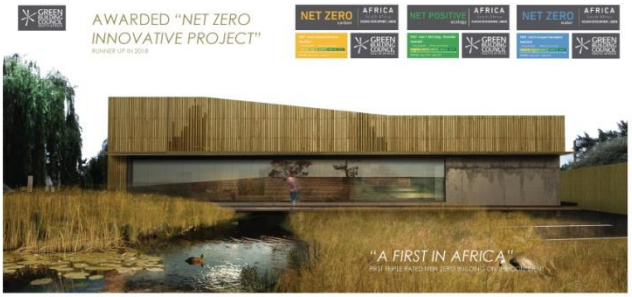
Question	Answer
What was your role in this project?	Project leader, researcher, monitoring and evaluation
Would you do anything differently in a similar project? If yes, what and why?	The aim was to install prototypes to see how well they function in an informal settlement context. The intent was to only capture the overflow from the municipal stormwater infrastructure. The municipal system across from the site has however been blocked for almost the entire project period and the swales have had to deal with larger quantities than what it was designed for. The sedimentation is also much more than originally expected and infrastructure in the area has deteriorated over the past three years, increasing the sedimentation further. We only had extra funds to plant the surrounding area with lawn in 2018. This has prevented erosion around the swales. Projects are less likely to be successful if done in isolation, the larger catchment area needs to be considered.
What would you like other stakeholders involved to do differently?	n/a
Were Costs and Benefits (not just financial investments but also in terms of impact on society or ecology of the costs of maintenance) as expected, or did you learn a lesson there?	The wider community don't realise the role of the project even after extensive community awareness campaigns. Areas identified by the community should be considered if possible. We went on municipal recommendation and approval.
What did you learn from the project / process that would constitute important learning points for a transformation towards applying SuDS in Gauteng?	We did the implementation through a landscape construction company which had to employ and train the community workers. It became apparent that the site managers didn't understand the SUDs principles and deviated from construction details provided. Work had to be corrected repeatedly. The construction companies will also need to be trained on SUDs.
Do you have views on how learning points on SuDS should be shared within Gauteng?	Site visits to installed projects through professional membership organisations. CPD training on SUDs to registered professionals. Project features in popular magazines too.

APPENDIX A2: VLEIHUIS DEVELOPMENT (Sherratt, 2019)

Questionnaire on Sustainable (Urban) Drainage Systems in Gauteng	
Project:	**Vleihuis Development**

NAME	ORGANISATION	POSITION	EMAIL
Marc Sherratt	MSSA	Managing Director	marc@marcsherratt.com

Table 0.3: Project details

General project information	Answer
Type of SuDS	Rainwater water harvesting and indigenous wetlands which store that water that is then purified to potable
Photos	
Purpose of SuDS (flood alleviation, ecology/amenity improvement, water quality)	Water storage and drinking water
Brief background/history that lead to SuDS installations	Targeting NET ZERO water certification from GBCSA. Discovered by restoring an indigenous landscape such as a wetland water could be stored in an environment that can have multiple purposes, i.e. evaporative cooling, aquaculture biophilia etc.
Motivation for SuDS (why SuDS instead of traditional infrastructure (concrete channels, pipes, culverts etc.)	As above these are mono purpose
CBD/Suburban/Township	Linden, Johannesburg
Location	Private
Land-use	Residential.
Public/Private ownership	Private
Year of completed design	2018
Year of completed construction	Planned for 2020
Reference nr of EIA (GDARD)	N/A
Reference nr of stormwater management plan (Municipality)	
Capital expenditure (CAPEX) amount	
Who are the stakeholders involved? (Funders, Owners, Consultants, Civil Society etc.)	Marc Sherratt, Sustainability Architects (MSSA)
Background reports	
Operation and maintenance	
Operational and maintenance expenditure per annum	Not provided
Who is in charge of maintenance?	Body Corporate
What does the maintenance plan entail?	To be developed

Evaluation and monitoring	
In the initial design discussions, was an evaluation method used (like Cost Benefit Analysis) to compare between different ways of designing (including traditional infrastructure)? If yes, please explain.	No
Is performance being monitored in terms of stormwater management? If yes, what are the monitoring results?	Not yet, only when built
What are the estimated/monitored ecological impacts?	Increase of biodiversity for the area
What are the estimated/monitored economic impacts?	Increase of selling price in the area
What are the estimated/monitored social impacts?	N/A

Table 0.4: Learning points

Question	Answer
What was your role in this project?	Architect, Head Designer, Project Manager
Would you do anything differently in a similar project? If yes, what and why?	Yes, every project is unique but the approach would be the same.
What would you like other stakeholders involved to do differently?	More funders for similar projects
Were Costs and Benefits (not just financial investments but also in terms of impact on society or ecology of the costs of maintenance) as expected, or did you learn a lesson there?	No overall cost was much higher, maintenance expenses are still to be clarified
What did you learn from the project / process that would constitute important learning points for a transformation towards applying SuDS in Gauteng?	There is little to no support from local communities or government for this kind of project. We are far behind the rest of the world in terms of innovation.
Do you have views on how learning points on SuDS should be shared within Gauteng?	Yes based on historic research into the ecological system of previous indigenous landscapes.

APPENDIX A3: Warehouse in Lanseria Business Park (Mujaji, 2019)

Questionnaire on Sustainable (Urban) Drainage Systems in Gauteng	
Project:	Warehouse in Lanseria Business Park

NAME	ORGANISATION	POSITION	EMAIL
Kuda Mujaji	Mariswe (Pty) Ltd	Lead Engineer: Buildings & Industrial Structures	kudam@mariswe.com

Table 5: Project details

General project information	Answer
Type of SuDS	Attenuation Tank
Photos	Refer to attachments
Purpose of SuDS (flood alleviation, ecology/amenity improvement, water quality)	Attenuation Tank to choke the post-development runoff into the municipal infrastructure as required by the relevant authorities
Brief background/history that lead to SuDS installations	It was a prerequisite requirement of the development to have an attenuation tank so as to reduce the rate of discharge of stormwater into the existing infrastructure.
Motivation for SuDS (why SuDS instead of traditional infrastructure (concrete channels, pipes, culverts etc.))	To avoid over loading the existing infrastructure and to harness and store water for grey water harvesting.
CBD/Suburban/Township	Lanseria
Location	Lanseria Business Park
Land-use	Commercial
Public/Private ownership	Private
Year of completed design	2011
Year of completed construction	2012
Reference nr of EIA (GDARD)	
Reference nr of stormwater management plan (Municipality)	
Capital expenditure (CAPEX) amount	R 2 Million
Who are the stakeholders involved? (Funders, Owners, Consultants, Civil Society etc.)	Lanseria Trust, Client,
Background reports	Lanseria Corporate Estate Design Review Package
Operation and maintenance	
Operational and maintenance expenditure per annum	0
Who is in charge of maintenance?	n/a
What does the maintenance plan entail?	n/a
Evaluation and monitoring	

In the initial design discussions, was an evaluation method used (like Cost Benefit Analysis) to compare between different ways of designing (including traditional infrastructure)? If yes, please explain.	Yes, we did preliminary designs ,details and rough order costings and submitted for comments and approvals to Lanseria Corporate Estate. We got approvals with minor comment.
Is performance being monitored in terms of stormwater management? If yes, what are the monitoring results?	We don't know, our engagement was up to construction monitoring and close out.
What are the estimated/monitored ecological impacts?	--
What are the estimated/monitored economic impacts?	--
What are the estimated/monitored social impacts?	--

Table 6: Learning points

Question	Answer
What was your role in this project?	Design Engineer
Would you do anything differently in a similar project? If yes, what and why?	
What would you like other stakeholders involved to do differently?	
Were Costs and Benefits (not just financial investments but also in terms of impact on society or ecology of the costs of maintenance) as expected, or did you learn a lesson there?	
What did you learn from the project / process that would constitute important learning points for a transformation towards applying SuDS in Gauteng?	It is easy to harness stormwater, filter it correctly and use it as greywater i.e. flushing toilets, irrigation etc. This reduces the burden and demand on water treatment plants and existing infrastructure
Do you have views on how learning points on SuDS should be shared within Gauteng?	

APPENDIX B REFERENCES TO SUDS IN ENVIRONMENTAL AUTHORISATION

Review of Record of Decision (RoDs) and the Basic assessment reports (BARs)

The team tried to get hold with the support of GDARD of the EIAs related to the list of identified projects which had SuDS. This proved to be almost impossible without the correct EIA code available. Therefore, together with GDARD (Marc Leroy) a selection of EIAs was made, with project titles that made it plausible that there would be reference to SuDS in these EIAs. The following findings were made for the selected and retrieved EIAs:

Rietfontein A.H.Wetland, Palm Ridge, near Alberton, Gauteng Province (Gaut 002/ 12-13/E0021)

- Physical Removal of litter, old pipes and rubble
- Construction of head-cut stabilization structures
- Possible formalization of human crossings to avoid widening of the system
- Construction of sediment control structures to avoid sediment loss due to bank collapsing
- Removal of berms along the wetland to allow for natural flow patterns within the wetland area
- Adherence of rehabilitation plan

The Rehabilitation of the Tsongweni Wetland, Roodekop Extension 31, Near Germiston (Gaut 002/13-14/E170)

- Raise water table and redirect water away from the trench
- Stabilise incision and raise water table and rewet location
- Removal of Earth berm and rewet the wetland area location
- Construct soil plugs to avoid soil movement from filled trench
- Removal of unused road to limit access to wetland and avoid dumping
- Raise water table, stabilise headcut upstream &
- Fill the trench and rewet the wetland area
- Construct soil plug to avoid soil movement from filled trench
- Raise water level and rewet the upstream wetland
- Fill the trench and construct soil plugs to avoid soil movement
- Raise water table and rewet upstream wetland area
- Fill the trench and rewet the wetland area
- Construct soil plug to avoid soil movement from the plug trench to downstream areas
- Removal of alien invasive vegetation

The impact assessment was carried out on the geo-morphological integrity of the wetland identified and it was found to be high without the rehabilitation plan.

Tembilisha wetland rehabilitation (Gaut 002/12-13/E0126)

- Preventing further wetland loss through erosion by the stabilisation of identified headcut erosion features

- Spread out surface flows at concentrated points such as breached dam wall, in order to rewet a larget area of wetland, prevent headcut formation and reduce the risk of future channel incision.
- A labour intensive physical removal of litter and debris within the watercourse should be effected
- Restriction of dumping of waste on the wetland must be effected
- A rotating grazing practise must be effected at the lower section of the wetland
- Adherence to Rehabilitation Plan

The impact assessment was carried out on the geo-morphological integrity of the wetland identified and it was found to be high without the rehabilitation plan.

The rehabilitation of the Boksburg Lake Downstream Wetland (Gaut 002/11-12/E0145)

- Preventing further wetland loss through erosion by the stabilisation of identified headcut erosion features
- Block drainage trenches that are located on suitably flat gradients where road networks will not be flooded or adversely affected. The in-fill of open trenches associated with the removed pipeline near the railway crossing is regarded to be an ideal rehabilitation opportunity
- Spread out surface flows at concentrated points, such as breached dam walls, in order to rewet a larger area of wetland, prevent headcut formation and reduce the risk of future channel incision.
- A designed stream flow obstruction downstream of an existing dirt road crossing at the downstream end will help to raise the water level within the channel and prevent future scour downstream of the perched pipes

Construction of Flood Management System at Norkem Park x1 PAN, Kempton Park(Gaut 002/13-14/E0295)

- Site inspections indicated that the proposed flood management system development is compatible with the surrounding land uses, considering the pan that is causing flooding to the surrounding houses.

Diepsloot wetland rehabilitation (Gaut 002/15-16/E0267)

- Installation of litter traps
- Erosion control using gabions and weirs, Reno mattress
- Placing plugs in gullies to minimise intense soil erosion that is currently taking place
- Re-vegetation of the wetland and the banks of the stream with indigenous vegetation and control of alien vegetation

Rehabilitation of Vorna Valley catchment (Gaut 002/16-17/E0289)

- The proposed activities will include installation of flood protection berms, installation of riprap groynes, repairing of existing gabions and removal of willow tree

Thokoza narrative centre (Gaut 002/17-18/E0035)

- Construction of rainwater harvesting tanks
- Installing of stilling basin with flow weirs to act as litter and sand trap
- SWMP with flood alleviation system to be submitted to JRA and CoJMM

Fourways Mall attenuation dam (Gaut 002/17-18/E0054)

- The EA entails decommissioning of the current dam and construction of a new attenuation dam downstream. This will involve installing a stilling basin with flow weirs to act as litter and sand trap. Cleaner water coming from the stilling basin will thereafter be discharged into a vegetated channel lined with Reno matrasses.
- Stormwater Management Plan with flood alleviation system for the area must be developed and approved by CoJMM and JRA.

Construction and upgrade of the Strom Water infrastructure (Gaut 002/17-18/E0087)

- Strom water retention facility during construction and operation should ideally incorporate and additional 15% to 20% capacity to cater for potential higher runoff events that area likely to occur as a result of climate change.

Expansion of existing attenuation pond (Gaut 002/17-18/E2058)

- Planting grass at the bottom of the storm water attenuation pond to filter sediments from storm water before it reaches the outlet.