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GAUTENG PROVINCE
AGRICULTURE AND RURAL DEVELOPMENT
REPUBLIC OF SOUTH AFRICA

Growing Gauteng Together

## COLOPHON

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# ACRONYM LIST

| | |
|---|---|
| CBD | Central Business District |
| CMA | Catchment Management Agency |
| CMP | Catchment Management Plan |
| CoJ | City of Johannesburg |
| CSOS | Community Schemes Ombud Services |
| DHSWS | Department of Human Settlements, Water and Sanitation (formerly the Dept. Water and Sanitation, DWS) |
| EAP | Environmental Assessment Practitioner |
| EIA | Environmental Impact Assessment. |
| GDARD | Gauteng Department of Agricultural and Rural Development |
| IDP | Integrated Development Plan |
| IFC | International Finance Corporation |
| MLUS | Municipal Land Use Scheme |
| MSDF | Municipal Spatial Development Framework |
| MUSIC | Model for Urban Stormwater Improvement Conceptualisation |
| OEMP | Operational Environmental Management Plan |
| RoD | Record of Decision |
| SDF | Spatial Development Framework |
| SPLUMA | Spatial Planning and Land Use Management Act 16 of 2013 |
| SuDS | Sustainable Drainage Systems |
| SWMP | Stormwater Management Plan |
| WSLUS | Water Sensitive Land Use Scheme |
| WSSDF | Water Sensitive Spatial Development Framework |
| WSSP | Water Sensitive Spatial Planning |
| WSUD | Water Sensitive Urban Design |
| WUL | Water Use Licence |
| WULA | Water Use Licence Application |

# 1 INTRODUCTION

As part of the Project Research on the Use of Sustainable (Urban) Drainage Systems (SuDS) of GDARD, the Terms of Reference (ToR) identify this report as 'Best Management Practices'. 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
5. Analysis of study areas with recommendations
6. Decision Support Tools
7. **Best Management Practices** (this report)
8. Implementation Manual

The requirements of the ToR are to create Best Management Practices for successful implementation of the SuDS in the CBD, suburban and township environments, within Gauteng. The recommendations for monitoring and evaluation should be included.

**Methodology**

The team has been challenged to derive lessons learned from the research project. Thus, these lessons are mainly learned from the Literature Review, Data collection on SuDS installations in Gauteng, Analysis of study areas, Decision Support Tools development, including the site visits and the five stakeholder workshops. These lessons are not seen to be exhaustive but reflect conditions relevant to Gauteng. The implementation of SuDS is interdisciplinary and needs adjustments in the land development and retrofitting process. First an introduction is given on the multi-disciplinary expertise needed for SuDS, and insights in the SuDS planning and design, then the report is set up per discipline, with the chapters as follows:

- Urban Planner
- Urban Designer
- Stormwater Design Engineer / Hydrologist
- Ecological advisor to land development process, in particular WULA and EIA processes
- Community Liaison Facilitator / Stakeholder consultation specialist

Although a landscape architect is also a key discipline for SuDS, because a landscape architect was not represented in the Consultancy team (as per ToR), this discipline is not represented with a separate chapter in this report. The final chapter explains the connections between the different disciplines.

# 2 MULTI-DISCIPLINARY EXPERTISE

SuDS solutions can provide multiple services and part of Best Practice will be to review the structure of the project team for a SuDS project. This will vary from site to site and will depend on the priorities and performance targets in each case.

Typically, the services include runoff and stream flow regulation (runoff quantity), water quality treatment, habitat and associated ecological services. SuDS systems usually integrate well in open space areas and so support the amenity value of a site. Expertise in these aspects is considered the core of a typical SuDS design project team (**Table 1**). They will also be represented in most development project teams and are therefore not extra expertise. The outlined types of expertise are not standard for all SuDS projects as the types of expertise used will also be influenced by the area where the SuDS options are implemented and the types of SuDS facilities considered.

*Table 1: Core expertise for SuDS projects (concept development through to detailed design)*

| Expertise | Key aspects of SuDS |
|---|---|
| **Stormwater engineer** | Understanding wider water resource objectives. Planning and design of hydrological performance (quality and quantity) of SuDS treatment train to achieve these objectives. Hydrology and hydraulics of receiving systems. Flood risk management. SuDS soils specification (in association with Landscape Architect). |
| **Landscape architect** | Design and layout of SuDS treatment train in the landscape of the site. Plant selection, soils specification, maintenance plan. |
| **Urban designer** | SuDS integration with the urban space. Critical for retrofit projects. Use-value determination. Expert support in community consultation. |
| **Aquatic ecologist/ wetland specialist** | Direction on design for biodiversity objectives. Instream and riparian habitat planning and design. Input to stream flow (stormwater flow) regulation by SuDS. Input to plant selection. Particularly important on sites where ecological rehabilitation is required, as well as sites where larger SuDS treatment trains are planned and integrated with conservation plans. |
| **Community liaison facilitator / Stakeholder consultation specialist** | Critical for projects where engagement with, and education of communities is needed to ensure the most appropriate design and adoptability of the SuDS project by the local community. This may form part of the EIA process if timing is suitable. |

The stormwater engineer is best placed to lead the technical design process if the priority objectives are stormwater quantity and quality control. Other members of the project team could take the lead if other objectives take priority, and stormwater is a secondary function which is not the focus of SuDS. In this case the system will be designed more along the lines of green infrastructure and in these

situations a design may not necessarily be incorporated into an approved Stormwater Management Plan as the hydraulic performance of the system may be undefined or uncertain in the long-term.

Expertise necessary for the inclusion of SuDS in urban planning, and in particular its incorporation into Integrated Development Plans (IDPs) and Spatial Development Frameworks (SDFs) are summarised in **Table 2**. In this case the Urban Planner is best placed to lead the process with the technical support of some of the experts listed.

*Table 2: Water Sensitive Planning (after Fourie, et al, 2019)*

| Expertise | Key aspects of SuDS |
|---|---|
| **Urban Planner** | Strategic land use planning, rezoning. Allocation of space to achieve sustainable drainage and water resource management objectives. Integration with urban green infrastructure objectives. |
| **Water resource specialist** | Hydrologist or engineer with experience in water resources analysis. Experience in planning at a CMA (Catchment Management Agency) level (in terms of the National Water Act.) would be an advantage, but a sound understanding of hydrological processes is also important. |
| **Water sensitive modeller** | Hydrologist or engineer with experience of modelling urban catchment systems and urban water resources assessments including SuDS systems. |
| **Biodiversity specialist** | Assess and integrate regional biodiversity and conservation objectives. |
| **Urban designer** | Undertake a build environment analysis |

This study has also shown that other benefits may accrue from direct association with SuDS projects. These include food gardens and local agricultural projects, water harvesting, and land value improvements. Optimising these benefits requires expert multi-disciplinary input. Some of these may require additional expert input (**Table 3**).

Depending on the scale of the project and the expertise of the practitioners, the team size may vary between projects. The more common kinds of expertise are presented here in **Table 1** and **Table 3** as a best practice guide. Normally, experts in **Table 1** would advise if experts in **Table 3** are needed to be added to the team. Such experts can also be referred to by the authorities evaluating the projects (e.g. in the EIA or WULA processes), who would also have the task to check if the experience and qualifications of the practitioners involved in the team is sufficient for the level of complication of the project. The total team needed depends on the complexity of the project. As Armitage et al. (2013)

also point out, “the Client” is also important in the interdisciplinary partnership, in terms of conceptual specifications and appointments of the specialists.

*Table 3: Optional additional relevant expertise for SuDS projects*

| Expertise | Key aspects of SuDS |
|---|---|
| **Hydrologist** | Assessment of hydrology of receiving systems. |
| **Hydropedologist** | Assessment of vadose zone soil hydrology (important for some infiltration and shallow aquifer or hillslope recharge). |
| **Agriculture specialist** | Food gardens and agriculture projects in the SuDS project area or benefitting from water harvested from the SuDS project. |
| **Constructed wetland specialist** | Planning and design of treatment wetlands (if not covered by one of the other project team members). |
| **EAP and/or WULA specialist** | Integrating the planning and design of the SuDS treatment train with the environmental and water use licencing processes. |
| **Other disciplines** | Armitage et al. (2013) suggest considering also (in alphabetical order): architects, botanists, civil engineers, climatologists, economists, engineering geologists, environmentalists, epidemiologists, freshwater ecologists, geohydrologists, geomaticians, historians / heritage experts, social anthropologists, zoologists.<br><br>Other suggestions given by stakeholders during this project were: river health specialists (probably close to freshwater ecologists), water quality specialists and environmental educators for awareness raising in the communities. |

# 3 SUDS – PLANNING & DESIGN

## 3.1 Introduction

SuDS should ideally be implemented in a manner that supports and enhances land development objectives, rather than imposing unnecessary additional constraints. Implementation of SuDS in synergy with land development objectives is the ideal outcome. In these situations, the objectives of sustainable drainage are convergent with the wider land development objectives, and there is little need for compromise between the two. SuDS need space, but it is ideally suited to existing in a shared space providing multiple benefits (e.g. ecological services and amenity). On the one hand this requires forward thinking and the introduction of stormwater management early in the planning stages. On the other, it needs a baseline land-use framework on which to start.

## 3.2 Integrating SuDS with SPLUMA

Making space for SuDS is best provided within the urban planning process. This sets out the land use parameters that guide land development projects (**Figure 1**).

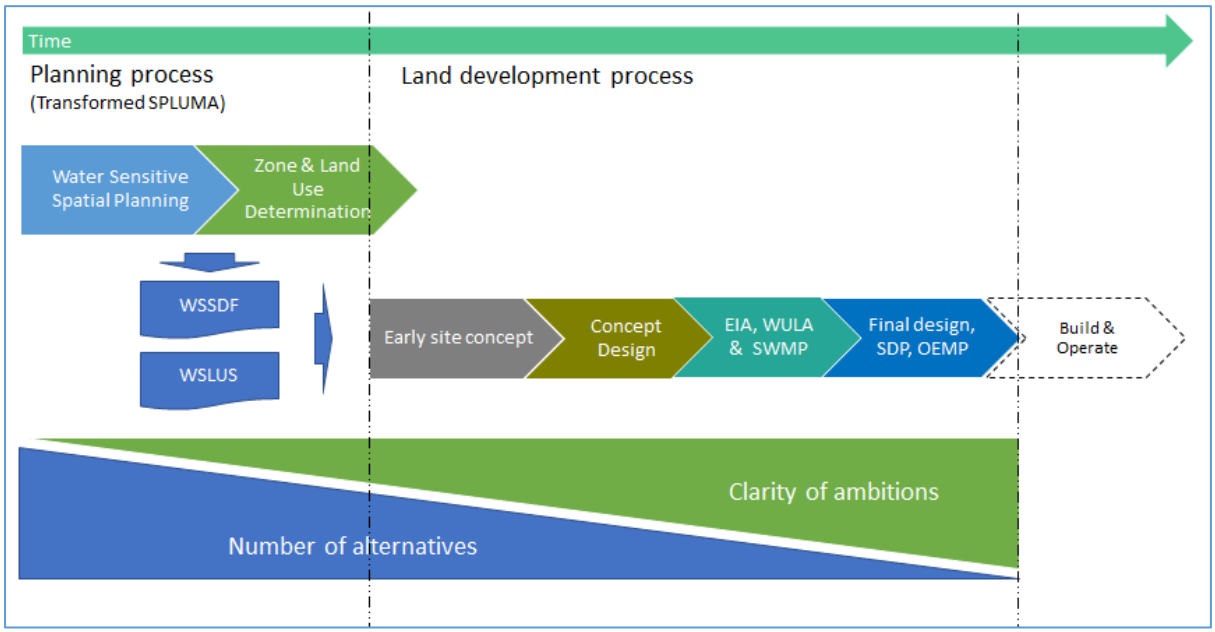


*Figure 1: Land use planning and development processes, adopting the Water Sensitive Spatial Planning process proposed by Fourie, et al (2019)*

The Municipal Spatial Development Framework (MSDF) and Municipal Land Use Scheme (MLUS) are the current municipal planning instruments mandated by the Spatial Planning and Land Use Management Act 16 of 2013 (SPLUMA), with the following roles:

- The MSDF provides the baseline of the land development objectives across a municipality (and is therefore an important reference for developers in advance of preparing site development layouts).

- The MLUS is the legal enforcement of land development conditions. Initial site-level development parameters are outlined in the MLUS and include details of acceptable coverage, open spaces and any additional controls.

Both the MSDF and MLUS are required by law but neither of these currently address the requirements of water resources management, or the potential negative impacts of land development on water resources. Instead it is left to the municipalities themselves as to whether they want to include any environmental, water or climate related criteria.

Fourie, et al (2019 a, b) adopted the term Water Sensitive Spatial Planning (WSSP), and provided recommendations for transforming the current Municipal Spatial Development Framework (MSDF) and the Municipal Land Use Scheme (MLUS) to a Water Sensitive Spatial Development Framework (WSSDF) and a Water Sensitive Land Use Scheme (WSLUS) respectively (**Figure 1**). The transformation of the MSDF and MLUS to the WSSDF and WSLUS respectively will provide critical support for the implementation of SuDS for the reasons highlighted by Fourie, et al (2019), and is therefore recommended as part of the Best Management Practices for SuDS implementation.

Another important observation by Fourie, et al (2019 a, b) is that town and regional planners generally do not have the skill set to address matters relating to water sensitivity. Hence, they point to the need for a multidisciplinary team to support the preparation of the municipal WSSDF and WSLUS. This is in line with the general requirement for multidisciplinary expertise for SuDS in Section 2 (see **Table 2**)

## 3.3 Integrating SuDS with the Project Development Process

Introducing SuDS into the early planning of a development project is considered a critical success factor in gaining momentum in the implementation of SuDS. This is a distinct departure from current practice where stormwater infrastructure is largely considered after the site layout is confirmed.

**Figure** 2 sets out the principal stages in the planning and design of a development. Stormwater management is often first introduced as part of the EIA and WULA processes, just before final design. At this stage, the available space for stormwater is usually very constrained and SuDS system performance will be limited.

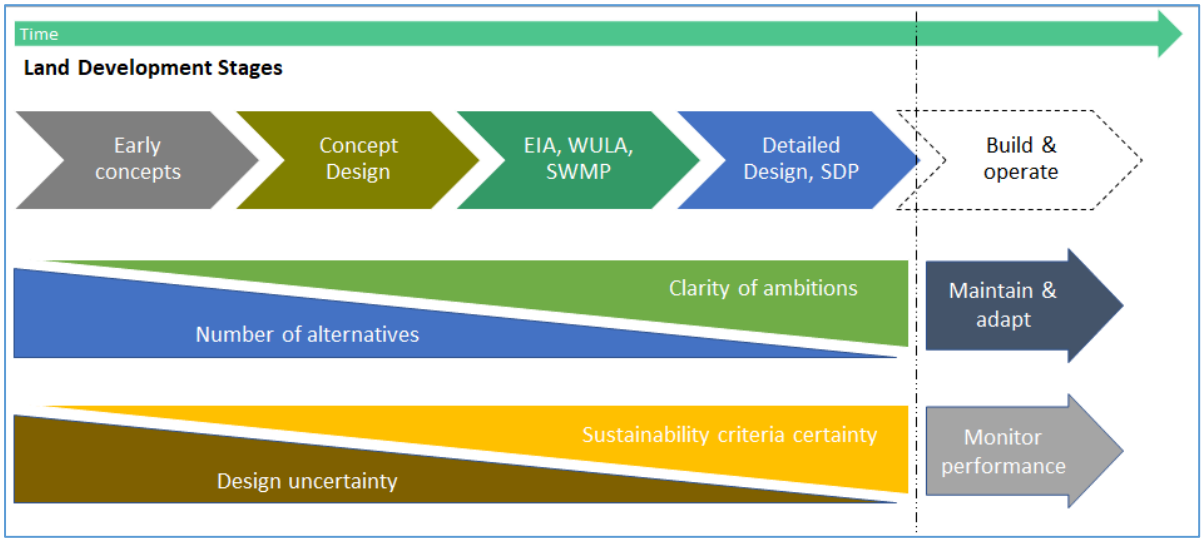


*Figure 2: Land development design process*

SuDS offer a range of solutions and these should be explored with the wider alternatives during the start of the planning process, ideally during early concept design stage at the very latest *(***Figure 2***)*. This is also a critical stage in the stakeholder engagement programme where the likely adoption of the SuDS solutions begin to be tested (Figure 3).

Introduction of SuDS before Concept Design improves the chances for synergistic solutions (and therefore the adoption by the stakeholders). The later the consideration of SuDS in the design process the more likely the requirement for compromise and trade-off, and less likely the stakeholders and occupants of the site will understand and see value in the SuDS interventions. This is important for greenfield developments, but is also important for retrofit projects, if it is to be appropriately integrated into design.

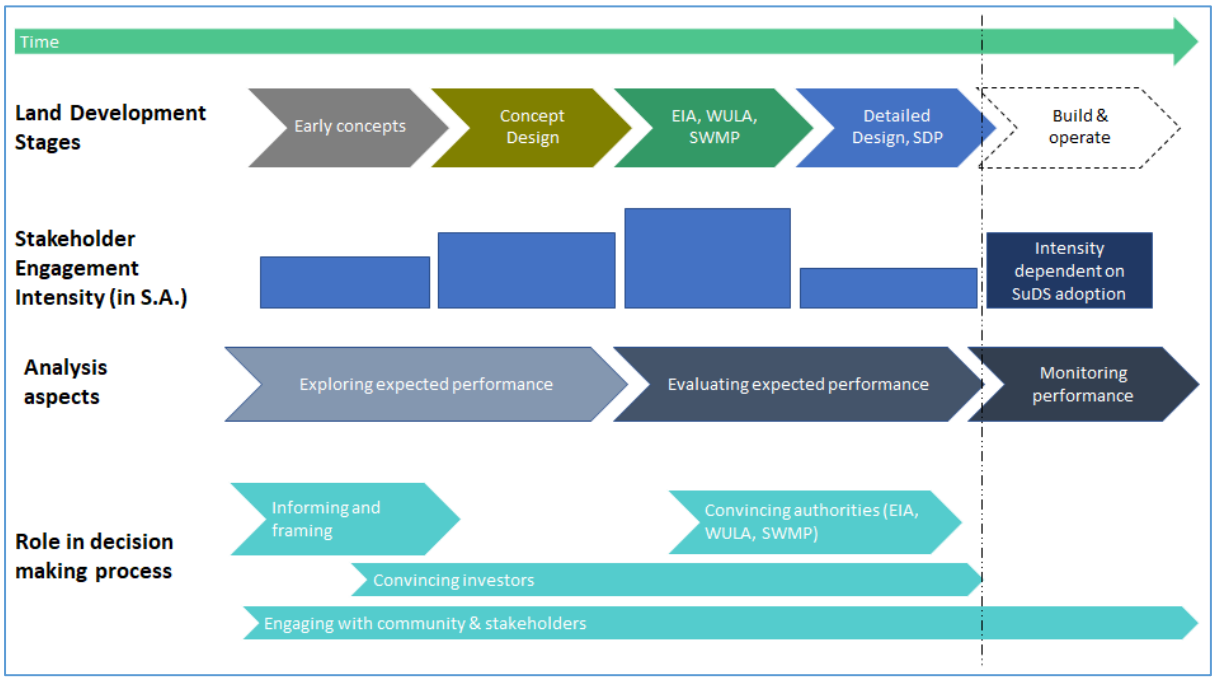


*Figure 3: Land development consultation & decision making*

# 4 URBAN PLANNER

## 4.1 Introduction to the role

Urban Planners will play an important role in planning for SuDS in local areas, helping to identify the best location and best type of intervention given the existing and / or proposed land use types, character, administrative area of jurisdiction and ownership patterns, while considering the broader spatial, social, economic and environmental objectives for the area. They will identify key actions required to unlock the potential for open spaces containing SuDS to meet these additional objectives.

Urban planners, as forward thinkers, will also play a critical role at Catchment scale, "making space" for hydrological processes, alongside other land uses.

Urban planners play a critical role prior to the SuDS implementation phase, advising and acting on land use and development rights and other land designations and cadastral issues to support the longterm management of SuDS.

Investment in certain SuDS interventions can be catalytic for more sustainable development and the urban planner can help to facilitate and formalise intended land use changes.

**Monitoring & Evaluation**

Where monitoring of interventions is undertaken, urban planners can play a role in assessing how land use patterns and activities have changed over time and identify where the changes demonstrate alignment with the broader development, spatial, social, economic and environmental objectives for the area.

## 4.2 Best Management Practices learned

**Planning legislation and policies**

- GDARD, ideally in conjunction with Catchment Management Agencies[1] (CMA), needs to proactively protect higher order open space and hydrological networks and systems, to ensure that sufficient space is set aside for larger "regional"[2] scale SuDS interventions servicing the catchment. This requires capacity to forward plan and coordinate with municipalities. There is currently a focus on biodiversity but less focus on hydrology, but a transformation of the planning processes in SPLUMA are proposed by Fourie, et al (2016) to incorporate Water Sensitive Spatial Planning.
- Spatial mapping is essential for effective green infrastructure forward planning at Catchment scale. To achieve this, sufficient and accurate spatial information needs to be collected and coordinated with the at least the following datasets: the natural and planted vegetation, agricultural land, open space systems, recreational areas, protected areas and hydrological

[1] As provided for in the National Water Act 36 of 1998.

[2] Armitage et al, (2013, p 49) refer to various scales of SuDS intervention and "control" points: Source, Local and Regional.

networks (Bobbins, 2015). Fourie, et al (2019 a, b), recommend that spatial planning should be carried out at catchment scale, and even integrated with Catchment Management Plans (CoJ, 2019, see **Box 1**). Oversight by GDARD in the coordination of these plans will be important.

- 'Regional scale' SuDS interventions are also essential at municipal scale. Biodiversity categorization and environmental management zones have helped the local authorities to protect the open space networks that contain critical biodiversity areas. However, natural water flows, floodplains and geo-hydrological conditions are not necessarily informing the current Spatial Development Frameworks forming an integral part of Integrated Development Plans. Stormwater Master planning (and / or Catchment planning), informed by these missing layers, undertaken by Municipalities and these can in turn inform the SDF's. In this way land can be set aside for regional scale SuDS interventions.

***Box 1: Catchment Management Planning***

In 2019 the City of Johannesburg initiated a study to prepare a pilot Catchment Management Plan (CMP) that sets out to address the fundamental requirements for planning a Water Sensitive City. The CMP will address the needs of the recent Stormwater Design Manual (CoJ, 2019) and the promotion of SuDS, but it will look at the wider opportunities and constraints in the urban hydrological cycle of a typical Gauteng metropolitan catchment. Constraints will include current land use and development densities, but it will explore opportunities for the likes of stream flow regulation and ecological recovery, flood management, water quality improvements, and stormwater harvesting. Urban land use and planning considerations will be important in the analysis of both the constraint and the opportunities.

At present the urban Catchment Management Plan (CMP) has no legal status in Gauteng, other than by association with municipal bylaws that specify Best Management Practices in stormwater management or as by association with the objectives of a Catchment Management Strategy which the Catchment Management Agency (CMAs) will need to formulate in terms of the National Water Act, but this is not done yet as CMAs are not yet operational in Gauteng.

For further reading see Catchment Planning Chapter in the Implementation Manual.

- Fourie et al (2019) are in the process of finalising guidelines for the WRC on how to compile water sensitive spatial plans which they suggest should be incorporated into the Municipal Spatial Development frameworks. These guidelines can be used as the basis for exploring how spatial planners go about planning for SuDS within a broader framework of more water sensitive cities.
- Local government holds the mandate to control building and land use change applications through which flood mitigation and SuDS can be promoted at a local scale on a site by site basis. However, there are few legislative tools and approval mechanisms available to obligate developers (whether public or private) to deliver SuDS. This is a lost opportunity and needs to be attended to as the process of applying for additional land use rights provides the perfect

opportunity to obligate land owners to deliver source and local controls[3]. Possible Legislative tools and approval mechanisms may include:

- By-laws and policy:

  New By-laws and policy (providing minimum requirements, standards and guidelines) would go a long way to providing the necessary "teeth" for municipal officials to get land owners to incorporate SuDS on site (See also workshop report Final Stakeholder Workshop July 2019). GDARD could provide guidance on how to structure a model By-law that would need to be customised to fit the respective municipality's context specific requirements. By-laws and policy should prescribe an approach and set targets and prescribe submission requirements. The municipality should have the authority to ask for flood lines, impact assessments and stormwater management plans (SWMP). The City of Tshwane's Green Building Development Bylaw (2013) is an example of a By-Law promoting SuDS implementation.

- Pre application meetings

  Local authorities should make pre-application meetings early on the development process, mandatory. These meetings must include officials from environmental, stormwater, spatial planning, parks, land use planning departments etc. as well as the integrated team of professionals involved in the design of the overall site layout. This should only be undertaken once the environmental specialists have undertaken baselines where these are deemed necessary.

- Stormwater Management Plans (SWMP)

  Once concept proposals for the site have been finalised, SWMP's should be submitted to the local authority for scrutiny by the engineers and environmental departments. These SWMP's should be attached to the Land Use Application approval. At the same time, the SWMP's can also form part of the Environmental Management Plan that is required as part of the Environmental Authorisation.

**Protecting the role of land for SuDS**

- It is necessary to protect land parcels that have a potential for SuDS and flood attenuation, retention / detention role in perpetuity especially where regional SuDS systems cut across private land holdings. There are several mechanisms that allow government to ensure the regional scale network is protected in perpetuity including the following:
  - Rezoning: An Open Space zoning would allow the land to be utilised for green infrastructure, amenity and recreation purposes but other zoning categories can also be considered dependant on the Zoning Scheme of the authority concerned.
  - Servitudes: Servitudes can be registered in favour of the Local Authority or any other relevant government department responsible for or holding the SuDS related land.

[3] Armitage et al, 2013, p49) refer to various scales of SuDS intervention and "control" points: Source, Local and Regional.

**Ongoing management and maintenance**

- Service Level Agreements that identify the key responsible bodies and their respective responsibilities, including costs, should be compiled where regional scale SuDS interventions are located on private land or where local SuDS interventions are located within larger greenfield developments. The former condition requires agreements to be entered into between the local authority and / or other relevant government department and the land owner concerned and be included in the conditions of approval in land use applications. In large greenfield developments, agreements should be incorporated into constitutions of the homeowners' association or bodies corporate.
- Regulation through the enforcement of bylaws is critical to the success of green open spaces. Dumping, littering, polluting and vandalism require regulatory authorities to be visible, accessible and to act, timeously.
- Effective and sustainable management and maintenance arrangements are not equally as implementable across different sites and contexts. This should be taken into account when designing regional scale SuDS interventions comprising treatment trains, as each stage of the treatment train will assume upstream projects to perform and meet specific targets.

**Benefits**

- It is not conclusive that investment in SuDS results in increased property values, in particular in low income neighbourhoods. Therefore, some caution has to exercised in counting SuDS as a benefit in this regard. Instead other forms of 'use-value' should be explored for SuDS interventions in these situations. This may take the form of economic activities within the same shared space as the SuDS, with these activities directly benefiting from the SuDS facilities. Therefore, caution is required in counting SuDS as a benefit in public spaces. (See Deliverable 6 Decision Support Tools for further information on how this caution was derived from desktop research)
- Increases in property values, as a result of investment in green open spaces, are usually related to the use value of the green open space. The use value will differ across environment types and locations.
- Fiscal Impact Analyses which assist municipalities in evaluating their returns on investment are determined by general municipal valuations' principles. In other words, where municipalities make investments in public infrastructure to improve local areas, there is an expectation that the investment is recouped through land and property rates and taxes. This does not necessarily reflect the residents' perception of the value that the open space / SuDS intervention adds to their properties.
- Many of the social and economic benefits arising out of investment in green open spaces cannot be measured or quantified. The traditional forms of assessment such as cost benefit analysis or general property valuations may therefore not be appropriate.
- SuDS are part of the design to become water sensitive urban settlements; rainwater harvesting is a SuDS application, but also treatment processes by SuDS can make water suitable for certain use of stormwater. The overall objective of SuDS is to mimic natural river flow and groundwater fluctuations. In the urban situation there is usually more net runoff

than would occur from the natural catchment and thereby creates opportunity for provision of some of the surplus water for other uses (see interconnectivity with other disciplines). Given Gauteng's location on the continental watershed of the Orange-Senqu and Limpopo catchments, and a concern of increasing water insecurity, looking at the reallocation of stormwater makes particular sense.

**Incentivisation**

- Incentive schemes such as that referred to in the City of Tshwane Green Building Development Incentive Scheme in Green Building Development Policy contained in the Green Building Development By-Law (CoT, 2013) can be considered as a means to encourage the private sector to adopt more sustainable approaches to handling stormwater.

**Monitoring & Evaluation**

- Monitoring of completed SuDS projects and the spaces in which they are located, should be undertaken by a multidisciplinary team. The assessment feedback could be useful in informing local authorities' forward planning exercises which are undertaken at regular intervals through the IDP review process to inform spatial planning at municipal level.

# 5 URBAN DESIGNER

## 5.1 Introduction to the role

The spatial discipline of urban design can play a critical role in ensuring that investment in SuDS interventions is maximised to its fullest. Land is a scarce resource and regardless of its priority function, has to work hard in terms of what it can offer to citizens of increasingly dense cities. Fiscal constraints also point to the need to spend effectively by ensuring that multiple challenges can be met through spending on infrastructure. Urban Designers are able to suggest how buildings should be shaped to interface with the green open spaces, such that they add value to the open space and are able to benefit from the opportunities associated with being close to green open space. Urban Designers can also help to address the challenges of vandalism and other forms of anti-social behaviour by employing good environmental design best practise in shaping development on the edges of the spaces.

Urban Design plays an important role in guiding how to retrofit SuDS into city environments where many of the SuDS interventions will be located within the public realm comprising streets, squares and courtyards. This discipline can also look for opportunities to incorporate SuDS type interventions into the greening of building facades and streets to address Heat Island effects.

## 5.2 Best Management Practices learned

**Design**

- Open spaces can be made more safe if adjacent buildings and properties open up towards the open spaces (i.e. windows, access doors, balconies and terraces are designed to overlook the space) and by the space being used actively and positively through the day (and evening in some circumstances such as the CBD). The latter requires that the space is attractive and addresses daily needs of locals. To ensure the communities retain interest in the open spaces, and value the site, the site must provide local landowners and building occupants (residents and workers) a reason to value the space. Here is a list of potential uses that might make an open space have more value in this sense:
    - In the case of suburban residential contexts, one should consider providing recreational opportunities including play and gym equipment, walking paths, kick about spaces and educational opportunities (art, information boards etc.).
    - In industrial areas providing relaxation spaces, walking paths, kick about spaces and lunch spaces would be desirable.
    - In lower income township environments one should consider providing above mentioned recreational opportunities as well as economic opportunities. For example, urban agriculture and itinerant trading might be desirable as economic opportunities, while recreational opportunities may include cooling effect to provide relief during hot season.
    - In mixed-use CBD type environments one should consider providing landscaped areas with dense tree planting for shading along north facing interfaces, as well as planting

and seating within street spaces and other open spaces for visual relief and workers' relaxation purposes, and/or planted facades to offer visual relief and cooling of internal building areas and/or planted rooftops with opportunities for relaxation and small scale agriculture.

- Intensity of use of the open space is dependent on good context sensitive design solutions that respond to local climatic conditions, local economic development patterns and local social and cultural practises.
- Water safety (hazard) considerations must guide design of SuDS interventions especially where they are expected to contain permanent water bodies / watercourses.
- SuDS interventions in built up areas can contribute to heat stress management if sufficient shade can be provided and evaporation can happen at scale.
- Where SuDS are being retrofitted, design of the space in which SuDS interventions are being implemented must be informed by careful assessment of the local context and existing user needs. The analysis must include consideration of the following, amongst other things:
    - The nature of the built interfaces with the open space / site;
    - Current pedestrian desire lines and how these will be impacted and / or improved; and
    - Current land use activities in and around the site, their distribution, temporal nature and intensity and how these will be impacted and / or improved.

**Management and Maintenance**

- Management and maintenance of open spaces containing SuDS by adjacent / local land owners is a good solution for South African urban environments given the increasing fiscal constraints of local authorities. However, agreements must be put in place that ensure public access to the space is not limited to those managing the space. Large green field developments might be the exception in this regard where the green open spaces play a local source control role. Where green open spaces play a regional role, access to the general public should be protected at all costs, as these spaces can play a valuable amenity role in increasingly dense urban environments.
- While it is not always reasonable or realistic to expect surrounding landowners to manage and maintain the open spaces in which SuDS interventions are located, it is beneficial for locals to have an interest in the condition of the open space and contribute to "passive management and regulation" of activities that occur on site. To support the community in providing this passive management and regulation it is recommended that local authorities support and encourage property owners to open their building facades and properties up towards the open space. This allows property owners and occupants to keep an eye on site activities and conditions through the day and night. Direct lines of communication must also be set up between local communities and businesses through which concerns can be directed to the most appropriate municipal department, for action.
- The complexities and cost of Management and Maintenance of the open spaces associated with the SuDS interventions can potentially be reduced through urban design. Designs for the space adjacent to the SuDS intervention should therefore be partly informed by the capacity of the local landowners, communities and local authorities to manage and maintain the space.

# 6 STORMWATER DESIGN ENGINEER / HYDROLOGIST

## 6.1 Introduction to the role

The stormwater designer will essentially determine the hydrological, hydraulic and water quality performance of the treatment train. The stormwater designer ideally should already be part of the development processes when the land use plan is determined, so that sufficient space, at logical locations, can be reserved for SuDS and the stormwater designer co-designs with the other experts the development. Performance targets would be ideally set out in a Catchment Management Plan, of which the first pilots are currently being developed in Gauteng (see **Box 1** and further reading in Implementation Manual). Performance requirements will be determined by:

- the supply catchment (size, land cover, pollution yields, etc.),
- the site opportunities and constraints (space, soils, gradients, vegetation, etc.),
- downstream requirements and constraints (flood risk, streamflow yield, water quality, etc.)
- discharge limits (e.g. through bylaws, etc.)

Importantly the performance requirements will also be determined by factors determined by other specialists in the team, and the local community, such as:

- ecological requirements,
- space and amenity requirements,
- hazard and security requirements,
- use-value and other economic objectives.

The Neighbourhood Planning and Design Guideline (Department of Human Settlements, 2019) supports SuDS stormwater management where applicable and gives design considerations for the stormwater design engineer. Instead of focusing on these specific design considerations, this chapter in the Best Management Practices is guiding the process of the design.

The stormwater specialist also has an important contribution to make in the in the urban planning processes where water sensitive spatial planning, catchment management planning and the likes of 'regional scale' SuDS are being developed (see Section 4.2 and **Box 1**). Hydrological perspectives and evaluation (and allocation) of water resources are central part of these plans. Thus, the stormwater expert should be part of the multidisciplinary teams during these processes.

## 6.2 Best Management Practices learned

### *6.2.1 Outline for developing a treatment train*

SuDS technology is based on the hydrological functioning of natural systems. In most cases the performance of a SuDS treatment train seeks to reflect more natural hydrological responses; typically slower and longer storm responses, less flash flooding and better quality stormwater (than an equivalent urban catchment). The treatment train is rarely only one or two SuDS facilities, and there use usually a number of possible combinations to consider, and these combinations will be of interest

to other project team members, the developer and stakeholders. As such, the design of a SuDS treatment train is usually a creative design process with a number of important stakeholders.

The nature based design of SuDS and treatment train means there is no rigorous step-by-step process for design. Useful guidelines are provided by Armitage, et al, 2013, and Woods-Ballard, et al, 2015, but in practice there may need to be more flexibility in how systems are combined. What is important is that the performance of each component in combination with the others, and of the system as a whole, is understood over a range of rainfall and storm conditions. The information that can be useful for this process, in particular in Gauteng, has been described in the Literature Review, section 2.7 "Design process of SuDS in South Africa and differences with conventional design of stormwater systems".

The assessment of case study sites in this research study, and from experience in the development of the City of Johannesburg Stormwater Design Manual (CoJ, 2019), the basic steps in the design of a treatment train are seen to include the items in **Table 4**. The steps will be common to each stage of the development programme (Figure 2), though they will be undertaken to different levels of detail.

*Table 4: Summary of basic steps in determining a SuDS Treatment Train*

| Nr | Step | Description |
|---|---|---|
| 1 | Analyse catchment area | In addition to the fundamental hydrological analysis of the catchment, it is important to understand the land use, water use and waste water services, land cover, soil types and soil characteristics, and the functioning of existing drains (grey or natural) in the project area. |
| 2 | Investigate environmental conditions | These will be wide ranging and may include downstream flood risk or water use requirements, ecological conditions and environmental water requirements, dolomitic conditions, societal behaviour patterns within the catchment (e.g. disposal of domestic waste in sewer systems, rainwater harvesting), water quality discharge limits. Information from catchment management plans will be important sources of information. |
| 3 | Assess SuDS site conditions | Existing ecological systems (e.g. wetlands), soils, vadose zone and local aquifer conditions, existing landuse, pollution risks (e.g. illegal dumping), erosion and channel stability. |
| 4 | Undertake hydrological analysis | Undertake a hydrological of the catchment by continuous simulation and in compliance with local municipal stormwater requirements. A minimum rainfall record length of 5 years is recommended. Determine pre-[4] and post- |

[4] Some municipalities require that the "pre-development" scenario refers to the state of the catchment before any human related development (i.e. in its original natural state). This is used to determine the discharge limits for the site.

| Nr | Step | Description |
|---|---|---|
| | | development annual catchment yield[5]. Determine design storm responses for the same pre- and post-development scenarios (in line with local municipal design storm requirements). |
| 5 | Assess retention requirements | Determine the retention requirements of the treatment train. Typically this is determined by ensuring post-development catchment yield is no greater than pre-development yield. |
| 6 | Determine scope for retention functions | Typically the primary retention functions are a combination of storage, evaporation, infiltration and re-use. These will vary from site to site depending on site characteristics (e.g. soil and aquifer conditions), on available open surface areas (e.g. extensive roof space for green roofs), and on interest within the community for harvesting and re-use (e.g. for food gardens). |
| 7 | Assess Water Quality requirements | Identify treatment requirements of the SuDS treatment train. These may include 'typical' urban stormwater pollutants (phosphorus, nitrogen, gross pollutants), or may include site specific pollutants (e.g. E.coli, hydrocarbons, etc.). |
| 8 | Set out & test treatment train options | Identify one or more combinations of SuDS technologies that can be used within the space available on site. Trial these by applying the same rainfall time series to the model (see below). Refine options/combinations to improve hydraulic, hydrological and water quality performance.<br>Consider maintenance requirements |
| 9 | Integrate with other potential services | Review the options with the project team, and with stakeholders, to explore enhancements for ecological, amenity and any economic services. |
| 10 | Concept Design | Develop Step 9 into a Concept Design for the preferred solution. |
| 11 | Refine preferred option | After comprehensive stakeholder consultation, EIA and WULA, refine preferred solution accordingly and take forward to detailed design. Review and refine maintenance requirements. |

[5] Only present-day catchment yield will be required for retro-fit projects as there is not normally any post-development scenario.

| Nr | Step | Description |
|---|---|---|
| 12 | Detailed design | Undertake necessary additional site investigations (e.g. geotechnical investigations, infiltration and soakaway tests), develop the design detail, confirm hydraulic and treatment performance, prepare Bill of Quantities. Develop OEMP (Operational Environmental Management Plan). This should include monitoring the performance of all aspects of the SuDS treatment train (i.e. flow quantity, quality, ecological function and amenity functions). |

*Table 5: Stages in the land development process (Figure 2), and suggestions for application of Decision Support Tools*

| **Stage in** Figure 2 | **Main steps in** Table 4**.** | **Decision Support Tools** |
|---|---|---|
| **Development programme** | Steps 1 to 9 at a high level scan. | High level Trade-Off Analysis<br>High level Land- Value analysis |
| **Concept design** | Steps 1 to 10 in moderate detail, perhaps giving detailed attention to steps 1 to 7 to avoid duplication in the detailed design stage. | Life-Cycle Analysis to refine scale of the scheme(s) |
| **EIA & WULA** | Steps 9, 10 and possibly 11. Use Concept Design options as the preferred scheme with alternatives. Refine where necessary during consultation. | (Update) Life-Cycle Analysis<br>Trade-Off analysis (in detail)<br>Use-value/Land-value analysis |
| **Detailed design** | Steps 11 & 12. | Life-Cycle Analysis (in detail) |
| **OEMP (Operational Environmental Management Plan)** | Step 12. This integrates the monitoring and maintenance requirements of the SWMP with the wider environmental management requirements of the site. This reflects the integration of SuDS with open space, ecological and amenity features of the site, acknowledging they need to be maintained together. | |

### 6.2.2 Use of hydrological models

To determine the runoff yield of the catchment and the performance of the SuDS treatment train, it is recommended that a suitable hydrological model is used to carry out a continuous simulation analysis of the system using a rainfall time series of at least 5 years. **Deliverable 2: Literature review on SuDS definitions, science, policy and legal context in South Africa** provides an overview of current software for the hydrological modelling of urban stormwater systems, with specific capability for modelling SuDS, both in terms of stormwater quantity and quality. It is understood that at the time of writing there are no particular software packages specified by Gauteng municipalities. However, it is important best practice that use of hydrological models requires expert oversight.

Experience in Australia has shown the availability of a suitable hydrological model provided an important boost to the update of SuDS. In the late 1990's, in recognition of the growing concerns of water security, the Australian government commissioned some of the countries thought leaders behind what is now known as WSUD (Water Sensitive Urban Design), and developed software that covered the hydrological analysis described above, with particular attention to stormwater quality analysis which is not dealt with particularly well in other stormwater software. This led to the production of the MUSIC software in 2001 which was tailored to meet the requirements of planners, designers and municipal officials. Today the software is widely adopted across Australia, and it has reportedly significantly improved the planning, concept design and municipal approval processes (ref: https://ewater.org.au/products/music/music-overview/).

Best Management Practice therefore includes modelling that looks at more than just the minimum hydrological analysis requirements, but it should also consider municipal requirements and the benefits of standardising planning and approval processes. *[Note that in this example, the MUSIC software is not suitable for detailed design, but is sufficient for concept design and that the municipalities in Australia accept concept designs for review and approval of site Stormwater Management Plans. This is an important reference for the adaption of the permitting processes (SWMP, EIA and WULA) required in South Africa.]*

### 6.2.3 Retrofitting SuDS

Retrofitting SuDS will be an important part of its implementation in Gauteng given the location of the province on a continental watershed, the already advanced level of development and the severe condition of many of the province's rivers. Retrofit requires a slightly different approach because:

- The treatment train is required to address existing problems caused by upstream conditions, and
- Space utilisation is opportunistic, using available space, rather than being part of an integrated development plan.

As a result, SuDS treatment trains are equivalent to regional attenuation dams, and should be planned as such. They are likely to be located in municipal open space and could have higher than optimum hydraulic loading, resulting in lower treatment performance (as experienced in the Johannesburg CBD case study). Both Life-Cycle and Trade-Off analyses will be useful decision support tools in these situations, and an important benefit will be relatively short-term relief (for example, of bad water

quality, flash flooding) in the receiving systems when it may otherwise take decades to see any improvement through incremental site redevelopment.

### *6.2.4 Inputs in Operational Environmental Management Plan (OEMP)*

The OEMP integrates the monitoring and maintenance requirements for the SWMP and the environmental management requirements of the site as a whole. SuDS facilities provide more than just stormwater functions and they need to be managed as an integrated part of the site while still maintaining the performance integrity of the overall SWMP. It also helps ensure that vegetated SuDS facilities are not mistaken for other landscaped spaces and not repurposed in the future by mistake.

The OEMP for the site will be compiled by the others in the developer's team, though this may often fall to the EAP. The section of the OEMP relating to the stormwater and SuDS facilities should be prepared by the multi-disciplinary team involved in the design. They will submit the SWMP portion of the OEMP for integration in the site OEMP. Many of the specialists involved are likely to be active in both. Examples of typical features of the SWMP portion of the OEMP will include:

- A monitoring programme that is tailored to the expected performance objectives of the SuDS treatment trains and SWMP as a whole. This may include any, or all, of the following; stormwater quantity and quality monitoring, ecological and amenity observations, sediment and water levels in SuDS facilities, observations of surface ponding and flood damage. It will also include more infrequent tests or inspections that may be done when the frequent observations provide warning signs. Examples include soil media infiltration tests in bioretention filters, or on permeable pavers.
- The monitoring specification shall include whether measurements during storm events are required, and an indication of the timing of the measurements (e.g. during the storm event, or within a certain time after the storm event). Also the preferred number of storm events monitored per season should be specified.
- Higher frequency inspections and sediment removal of sediment traps are to be specified. In many cases this will include disturbance, and even destruction, of habitat that has established in the sediment traps. This must be an accepted part of the maintenance of SuDS treatment trains as this will typically allow more stable habitat conditions in downstream sections of the treatment train.
- Aspects such as sediment removal and habitat protection of other SuDS facilities should also be indicated to clarify priorities that will guide maintenance crews. For example the establishment of reeds (*typha sp.*) may compromise hydraulic capacity and should be removed, rather than protected to preserve habitat.
- In SuDS constructed wetland systems where vegetation is part of the treatment performance, the OEMP should specify how best to maintain the systems, including removal of moribund vegetation and regular harvesting of plants to rejuvenate the system.
- The OEMP should also assist EAPs and GDARD to identify maintenance activities that should be exempt from any future WUL or environmental authorisation obligations for maintenance work.
- The OEMP shall also set out the process of handling and removal of any suspected contaminated soils, filter media and vegetation.

# 7 ECOLOGICAL ADVISOR

## 7.1 Introduction to the role

The role of an ecological advisor is to ensure that ecological aspects are adequately integrated into site development planning and design. The approach needs to be underpinned by an understanding of the mitigation hierarchy, which should be approached in a stepwise process and effectively entails:

- **Avoid:** Ensuring the important and sensitive ecological attributes are avoided through careful site planning;
- **Minimise:** Where impacts are unavoidable, efforts need to be made to minimise these as far as practical;
- **Mitigate:** Where risks are identified, these need to be mitigated through interventions that seek to reduce impacts to the natural environment;
- **Rehabilitate:** Rehabilitation should seek to maintain and where possible enhance ecological attributes of the site;
- **Offset:** In situations where significant impacts remain, offsets may be required to counter-balance the negative impacts associated with the planned development.

Where the site is located away from sensitive features, recommendations for integrating SuDS and basic habitat enhancement recommendations, could be fulfilled by an Environmental Assessment Practitioner. However, specialist support is required for sites containing sensitive features including all natural watercourses and areas of intact natural habitat. An ecologist should play a particularly important role in planning and designing large-scale local and regional SuDS interventions, to ensure that designs are fit-for-purpose and will contribute meaningfully to broader catchment objectives (e.g. as set by a Catchment Management Plan by the Municipality and/or by a Catchment Management Strategy by the Catchment Management Agency(See **Box 1**).

## 7.2 Best Management Practices learned

A suite of learnings has been synthesised from the Literature Review, case studies and interactions with developers as part of the WULA and EIA processes. These have been grouped into policy, planning and design guidelines for ease of reference.

**SuDS Planning Policy**

- Improving the status of urban watersheds requires more than pro-active planning of new developments. It requires strategic intervention to enhance ecological infrastructure through the implementation of local and regional SuDS schemes. Such interventions are typically beyond the scope of site-scale developments and will require bold leadership and active intervention by government.
- SuDS and associated ecological services are best supported at project level through regulation and policies. Fragmented policies and bylaws across the province will hinder the integration of ecological function and stormwater management. GDARD leadership and oversight of the integration of policies and bylaws is important.

- Initiatives to proactively promote SuDS including water sensitive spatial planning as proposed by Fourie, et al (2019 a,b) and catchment management planning envisaged by the City of Johannesburg (CoJ, 2019) can create important vehicles for ecological considerations to be integrated into spatial plans and objectives for Johannesburg urban catchments and can be replicated by other municipalities in Gauteng.
- The planning cycle needs to close the loop (i.e. beyond implementation and into the maintenance/monitoring phase).
- In addition to regulatory requirements, there is a need to raise awareness of the financial (and other) benefits that SuDS offer.

**Planning for SuDS implementation**

- SuDS should ideally be integrated into the initial **planning phase** of the development since many features require space and typically form and important part of the open space network.
- Whilst ecologists are required to approach planning from an environmental perspective, a **pragmatic mind-set** needs to be adopted, particularly in an urban context where space is valuable, and the maintaining ecological values may be one of many competing objectives.
- In a heavily developed urban context in particular, maximizing **ecological functions** that support societal needs and broader water resource management objectives rather than aiming to improve habitat condition should be considered. This can also serve to buffer the impacts on downstream areas that have a greater overall ecological value.
- Ensure that any discussions are informed by a sound understanding of the **regional context** since this can serve to emphasise the importance of ecological networks and broader catchment management objectives. Key resources here, include the Gauteng Conservation Plan (Gauteng Provincial Government, 2011 and Pfab, 2017), and relevant catchment studies particularly Resource Quality Objectives which serve to highlight issues that require attention in the catchment.
- Whilst desktop information is useful, it is critical that planning is informed by site visits to understand **site conditions**, in particular the location of sensitive habitats or biota that may need to be accommodated in planning, as well as existing impacts and problems within the habitats that could be addressed through the SuDS design at a site level. This can be further supported through communication with local and municipal stakeholders who know the area.
- It is important that the **vision / purpose** for SuDS are set out at the early stages of design. This should ideally be established through collaborative discussions with planners, urban designers, architects, engineers and wetland ecologists to ensure win-win solutions emerge. Such a discussion can be informed by tools such as Wet-EcoServices that can be used to broaden perspectives and can be used to inform trade-off analyses. It is however important that this is used to nurture 'team work' rather than to polarise views. This requires all parties to approach planning with an open mind rather than maintaining a silo mentality.
- Given that engineers are generally central to SuDS design, it is important that a 'green' engineer who is open to SuDS develops the stormwater management plan. Without this, an emphasis on traditional 'grey' infrastructure solutions is likely to prevail. A shift in traditional design paradigms will be required across the board in order for SuDS to make meaningful progress regionally.

**Ecological guidelines for SuDS design**

- It is important to differentiate between **site-level** SuDS planning which seeks to minimise the impacts of the development on downstream water resources and **local or regional** interventions that should seek to address catchment impacts and seek to maintain or enhance ecological networks.
    - Site level SuDS design should typically focus initially on addressing risks posed by development on downstream water resources (flow regimes & water quality), with ecological aspects being viewed as secondary considerations.
    - For local and regional interventions, biodiversity considerations typically play a much more important role. There are however situations where interventions should focus strongly on addressing risks (e.g. poor water quality, erosion control) rather than enhancing biodiversity aspects.
- Where development is planned alongside a wetland or watercourse, buffer zones could be utilised as an integral part of the SuDS network. Such buffer zones should be fit-for purpose and therefore be designed to cater for local site characteristics rather than applying a standard buffer rule. The following factors should be taken into account to determine the buffer zone width (Macfarlane & Bredin, 2017):
    - Abutting land-use scale and intensity (decreased width for low intensity/low risk uses);
    - Mitigation measures (including SuDS) that seek to reduce the risk of pollution runoff;
    - Importance and sensitivity of ecological assets and associated biodiversity to minimise impacts and anthropogenic disturbance;
    - Terrain and other factors that affect the ability of ecological buffers to polish stormwater runoff;
    - Presence of terrestrial habitat attributes of high biodiversity or functional value;
- The importance of maintaining or improving connectivity for locally important biota;
    - Flooding and flood risk areas;
    - Aesthetic and recreational uses; and
    - Practical management considerations.
- It is important that discharge into any buffer zone is not concentrated at a single point as this can cause erosion and will reduce the efficiency of the buffer zone. Numerous outlets, which spread flows across the buffer should therefore be accommodated as far as possible.
- Where possible, enhance SuDS facilities to improve social and ecological values.
    - Use local indigenous species that provide food and habitat for indigenous faunal populations.
    - Enhance habitat heterogeneity by introducing a range of plant species with varied structural characteristics.
    - Introduce islands in wet ponds, water features and constructed wetlands to increase visual appeal and provide refugia for wildlife where they won't be disturbed.
    - Manipulate the slope of wet ponds and constructed wetlands where possible to allow for expanses of open water closest to public view.
    - Select appropriate wetland planting types in contexts where it is important to provide recreational uses and unobstructed views.

    - Link SuDS through a connected open space system to enhance connectivity with local and regional corridors.
    - Provide safe spaces for social engagement with ecological infrastructure (consider accessibility, lighting and need for pedestrian bridges).
    - Integrate walking and cycling routes and other low-impact infrastructure such as water parks to promote connection with nature and cooler environment for recreational activities.
- Ensure that long-term management considerations including ecological processes such as fire and defoliation are integrated into open space planning to ensure that vegetation characteristics can be maintained over the long-term.

Note that it is also important for planners, designers and officials to be aware of the potential for increased mosquito populations as a result of the establishment of wetland and retention systems that are an inherent part of SuDS. Mosquitoes are a particular nuisance factor, and although Gauteng is generally a malaria free area, this may change with a warming climate. There are aspects that can mitigate the effects of this; for example reducing standing water retention times, improving maintenance to avoid unplanned ponding, varying water levels, and others (Armitage, et al, 2013), and potentially even careful vegetation selection. Hence SuDS designs can seek to minimise the effect, but monitoring will still be important.

# 8 COMMUNITY LIAISON / STAKEHOLDER ENGAGEMENT FACILITATOR

## 8.1 Introduction to the role

There are two particularly important outcomes from this study that relate to placing SuDS in a public or a community space:

- Consultation with all stakeholders should be initiated as early as possible (e.g. at early concept considerations) and run through the duration of the project, and
- Acceptance of the SuDS scheme by the local community is a critical success factor for its sustainability. Adoption of the SuDS scheme by the community and developing sense of "ownership" is ideal.

Most professional project teams are familiar in dealing with stakeholders such as municipal and provincial departments and including a consultation specialist on the project team for this level of liaison is not necessary unless the group of stakeholders large. The same may apply to SuDS projects on private land where the management of the SuDS system is written into the conditions of establishment and agreed with the developer. This too may be managed by the professional team, or through the environmental authorisation or water use license application processes. Irrespective of whether the project triggers the environmental authorisation, or Water Use License Application, community consultation will be important and it is recommended to start this in the Concept Design Stage (See **Figure 1**).

Instead, on SuDS projects in public open space areas, consultation with local communities is often a special relationship that requires continuity for the duration of the project. Ideally, the local community should be considered a member of the project team and involved in the scheme development and decision making process. This section focusses on the relationship with these local communities, particularly in working towards the second outcome above.

SuDS projects impose changes to the open space and needs to be maintained, and long-term partnerships are as important as the consultation process during project development. The initial community liaison is important to create a sense of 'ownership', to get the community to take responsibility for keeping it working (or at least not preventing it from working) and for monitoring of the performance.

Key questions for community liaison are summarized in **Box 2**. The iterative nature of the consultation process is essential. Regardless of what stage of the project consultation is taking place, the key questions can be repeated as needed. As budgets and timelines are not limitless, it is important to prioritize and make clear choices and be transparent about those choices.

***Box 2: Key questions for stakeholder participation, in particular for simpler projects (Source: IFC, 2007)***

- **Purpose** – What are the strategic reasons for consulting with a community at this particular phase of the project? These may span a wide range of objectives, from meeting regulatory requirements and negotiating compensation, to obtaining access to community land for survey work, building trust relationships, or managing expectations in general.
- **Requirements** – Are there requirements for consultation that need to be met at this stage of the process? These may be legal or regulatory requirements, internal corporate policy requirements or conditions of the lenders or shareholders.
- **Stakeholders** – Who are the key stakeholder groups that need to be consulted during this phase of the project? What are the likely issues that they will wish to discuss? What are their interests and why? Who is interested in the project?
- **Scoping of priority issues** – Are there any high risk groups or issues requiring special attention at this stage? Are there vulnerable groups in the project area or topics that are particularly sensitive or controversial? Advance planning may be required to tailor the consultation specifically to these needs.
- **Techniques** – Which techniques and methods will be most effective in communicating with the different stakeholder groups? Traditional or customary means of consultation and decision-making may be relevant here. Consider using participatory methodologies where appropriate and engaging skilled practitioners to facilitate the process, and the timelines and financial means involved.
- **Responsibilities** – Who is responsible for what activities? This can be responsibilities with the municipality, with the developer and/or with an external advisor. Are timetables, responsibilities and lines of reporting for consultation activities clear?
- **Documentation** – How will the results of the process be captured, recorded, tracked, and disseminated?
- **Indigenous Knowledge** – What historic issues exist, geographical location related to the project?

## 8.2 Best Management Practices learned

**Choosing the right engagement team and starting with the community leaders**

Effective consultation of this nature requires a dedicated person depending on the size and nature of the project and the communities. It is recommended that when stakeholder consultations are done with the community that the preferred language to be used is that of the community. A key factor is continuity; building trust is important and changing team personnel during the consultation process should be avoided.

It is important to note that the community leaders are able to advise the engagement team at an early stage if the community could be accepting for SuDS implementation. For example, a community could

inform the team that the community has other priorities (e.g. electricity supply), and therefore will not even have interest in being engaged in SuDS implementation if their main need is not addressed.

If the project is driven by a stormwater department or a developer, the stakeholder engagement can involve the community but also for example the parks department of the municipality, who might have also already more established connections with the community on their open spaces.

**Stakeholder identification and analysis**

This requires an understanding of the location and environment of the project, and the nature of the project itself. Ideally stakeholders are identified that connect to the project initiative, but at the same time stakeholders who are likely to resist the project need to be identified and consulted as early as possible in the consultation process. Techniques are available for identifying stakeholders (e.g. IFC, 2007), but the scale of most SuDS projects is such that word-of-mouth, and social media from early engagement is still a very successful approach.

An important aspect to be determined in early consultation is to try to establish the community's actual or perceived 'use-value' of the project area (see Chaper 5). This is likely to have important bearing on the planning and design of the SuDS treatment train, and support for wider benefits that may be of interest to the community.

**Connecting to the bigger goal**

Particularly for SuDS, it is important to educate the stakeholders about the overall objective of SuDS, not just the stormwater management aspect of it (water quantity and quality) but also the biodiversity / ecological value and the amenity value of additional green space. This requirement for education will apply to all community groups, irrespective of economic status. This may be more important for the community than the stormwater management aspect and may require some education (for UK context examples, see Woods-Ballard et al., 2015, chapter 34). The environmental conscience of adults can be raised through (their) children, and therefore schools and youth associations could be involved in raising awareness.

It is also important to identify issues within the community that may be addressed by the implementation of SuDS such as floods, lack of rangeland or recreation facilities (particularly for youth) or polluted streams in the area. This will make it easier for the community to adopt SuDS as they will recognise its benefits to the community as a whole and may also encourage them to take ownership in monitoring and protecting the structures.

**Involving communities in maintenance**

The case studies of this project have shown that the successful SuDS (or similar) schemes are those adopted by the local communities. This is recommended as Best management Practice, partly because if left entirely to municipal responsibilities the SuDS projects would be vulnerable to the same budget limitations that the rest of the stormwater network is subjected to. Hence adoption by the communities, or a partnership between communities and the municipality, is recommended. As shown below (***Box 3***) there are means of achieving this, particularly if use-value can be demonstrated.

However, these approaches still require some effort and often a 'champion' in the community to ensure momentum is maintained.

Stakeholders in this research project stressed the points that (1) if communities (including property owners) get maintenance responsibilities, they have to be formalised, (workshop report CBD) (2) government should maintain its part of the deal of monitoring and policing of environmental compliance (workshop-report Kagiso), (3) involvement of land owners can be triggered by the environmental authorization process (workshop-report Bonaero Park – Atlasville, see further below a role for GDARD).

Starting up voluntary or paid services for maintenance carried by community members, is not an easy task. If not forced by a Record of Decision or other legal way, it is probably wise to piggy-back on existing initiatives in the communities, such as clean up campaigns or existing partnerships of owners, see ***Box 3*** for inspiration. Again, the local sensitivities have to be explored.

***Box 3: Inspiration for community engagement in maintenance and monitoring***

- The Johannesburg Inner City Partnership is a well-functioning corporate where different property owners and the community at large take responsibility, in close co-ordination with the municipality, with formal engagements.
- In Bonaero Park-Atlasville, a Section 21 company was formed to jointly maintain a wetland (pan) for its ecological functioning.
- Future City Fourways (Johannesburg) was adding to the government services on maintenance "grounded on South Africa's City Improvement District (CID) Gauteng Provincial Ordinance No 12 of 1997, which provides successful applicants with the legislated powers to provide supplementary and complementary services" (http://futurecityfourways.co.za). However, this initiative seems to have died down after a few active years.
- In the Hennops catchment, citizen led initiatives to clean up the river and avoid pollution have started, initiated by downstream community members but also involving the upstream communities. (www.hennopsblue.co.za)
- In areas like Diepsloot (Johannesburg), Hammanskraal (Tshwane) and Jericho (Madibeng), the Department of Water and Sanitation is engaging community forums on water and sanitation, which could be engaged in decision making on maintenance.
- Piggy-backing for SuDS maintenance on other maintenance / cleaning up initiatives could also be useful. For example in Diepsloot extension 1, there is 10 years of engaging community members in the maintenance of sanitation points (Zack et al., 2019),
- Inspiration on how open space engagements are set up in the United States could be gained from the Trust for Public Land (https://www.tpl.org/how-we-work).

**Engaging pay-back schemes or community members in litter collection**

For SuDS, litter can be a big challenge, both because it blocks the functioning of some SuDS facilities (but also grey water drainage systems) and because it is a visual problem decreasing the amenity value. Apart from community clean-up campaigns or more formal organisations for area maintenance (See ***Box 3***), the engagement of the recycle pay-back schemes in cleaning of littering of stormwater

drains is relevant in the Gauteng context. Pay-back schemes for waste collectors are now based on weight of certain materials, therefore making an extra effort for litter on the street, seems less effective than collecting from bins (as explained in the Kagiso case study of this project). Other reward systems would need to be designed for those already active in the Reduce-Reuse-Recycle chain of litter collection. In other parts of the world there are reward systems for collection of litter by community members (free consumption in a restaurant after submission of a bag of litter collected) or people monitor themselves with their cell phones in their walks to collect litter (app.helemaalgroen.nl). In the affluent communities of South Africa, where the monitor and reward systems of Discovery Health are popular, this might be an option as well. In many areas outside of South Africa, also digital support tools such as the app 'NextDoor' are popular for engaging communities in maintenance in their neighbourhoods. This all will need further investigation.

**Monitoring of performance with involvement of communities**

Monitoring of technical performances of SuDS by the community is a form of 'citizen science', which is getting more popular around the world, due to more monitoring being required, power of social media and more tools becoming available. For South Africa, an overview of the methods available for such monitoring is explained in Graham and Taylor (2018) and on the website www.capacityforcatchments.org (under construction). In particular with the Mini-SASS, a tool developed in South Africa for the monitoring of rivers by citizens including scholars, is a tool (www.miniSASS.org) already applied in many locations. More and more internet tools, and mobile Apps to do the monitoring (i.e. www.mobilewatermanagement.com) are becoming available. Monitoring can work in areas where most people can be able to afford and access internet to be able to use the above-mentioned tools, however it will be a challenge in township areas where the community will not afford or have access. The other problem maybe vandalism or theft of the infrastructure even though awareness raising campaigns have been carried out with the community.

**A role for GDARD in stimulating community engagement and monitoring**

To stimulate monitoring and maintenance by communities, GDARD can influence the Record of Decision (RoD).

For maintenance, property owners can be obliged to be involved in maintenance and set high enough ambitions. In Bonaero Park-Atlasville, the Record of Decision of GDARD influenced that the joined land owners set up a Section 21 Company for maintenance and monitoring of the pan (workshop report Bonaero Park-Atlasville, part of report 'Analysis of Study Areas with recommendations).

For monitoring, the Record of Decision can include the formation of a monitoring committee made up of members of the community (see further section below on maintenance and monitoring) and the benefits of these are as follows:

- The community can witness how their contribution has influenced the decision making process through the consultations;
- Records make it easier for the community to track and evaluate the progress;
- Community will also be able to identify any issues which were not addressed as per their recommendations during the consultations.

**Other ways of stakeholder engagement for the benefit of SuDS**

Most of the above was written from the perspective of a new development or retrofitting project, which takes community and stakeholder engagement seriously and therefore appoints a facilitator. However, there are other ways that may need to be mentioned in this section:

9. **Home Owners Associations or Business Park managers** – By implementers of SuDS (See report 'Data collection on SuDS installations in Gauteng'), concern was raised that some SuDS in Gauteng do not function anymore because uninformed Home Owners Associations or Business Property Managers take over after development and do not understand the originally designed maintenance requirement of SuDS or find them too expensive (See e.g. study report Data collection on SuDS installations in Gauteng). This creates opportunities for awareness raising and education by the municipality or province. Different priorities within Home Owners Associations can lead to conflicts. While the Community Schemes Ombud Services (CSOS) probably does not have a precedent in the matter of SuDS installation or maintenance, it could be engaged to play a role, as owners in community schemes are obliged to pay monthly levies since 2016.
10. **Information exchange with other similar areas** – For the community to understand and accept implementation of SuDS in their area, one could be to have communities engage with one another that have similar settings and issues such as township to township and see what has been done and exchange their experiences and what they learned which can make it more relatable. An example would be for Kagiso Township to learn from Diepsloot where SuDS have been implemented with success.

# 9 INTERCONNECTIVITY BETWEEN SPECIALISTS

## 9.1 Introduction

The different disciplines need to work together as a team, and this chapter briefly emphasizes the important interconnections. As mentioned in the introduction, the landscape architect is also a key discipline, but unfortunately, as per ToR, this discipline was not included in the project team of this research project and needs to be addressed in future research.

## 9.2 Urban Planner

- Urban Planners should input into Catchment Scale Planning and Catchment Management Plans alongside engineers, environmental specialists etc. Urban planners can add value to catchment management planning by identifying the development trajectories (geographic location and form of growth – expected densities, land uses, land use patterns, potential land invasions etc.) of urban areas and related challenges, with a view to identifying, in the context of Climate Change and other urban and societal challenges, the open space systems that are needed to support a positively transformed urban future.
- Opportunities for SuDS must be considered early on in any development process especially for larger greenfield developments. The urban planner can play a key role here by integrating the concerns from various disciplines (developers, engineers, urban designers, environmental specialists etc.), the client, community (through the public participation specialists) and the local authority.

## 9.3 Urban Designer

- Opportunities for SuDS must be considered early on in the development process especially for larger greenfield developments. This is to ensure there is sufficient space to accommodate complex space extensive natural systems that might be necessary as part of the SuDS system.
- Urban designers should help to identify the priorities for the space under consideration particularly where there may be conflict with the objectives of other disciplines.
- The urban designer can add value to the initial design processes by analysing the local area and identifying the existing spatial conditions, its challenges and the opportunities including but not limited to the following: the public open space system, the nature of its edges, view lines and zones suffering from a lack of surveillance, typical building typologies, cadastral patterns, drainage lines and patterns and character of the local area. This analysis should then feed into an integrated design process with the engineers (and environmental specialists).

## 9.4 Stormwater Specialist

- Most stormwater impacts are either social or environmental, and collaboration with the rest of the team to fully understand the issues for which SuDS designs are required should be standard practice. Furthermore, the failure of stormwater systems has significant and very costly impacts on infrastructure, which is critical for sustainable development.
- This also applies as to the design process itself. Team collaboration is required when setting and agreeing priorities for design, monitoring and management, particularly where there may be conflict with the objectives with other disciplines.
- Integration with the rest of the project team is a continuous iterative process for the life of the planning and design of the project.

## 9.5 Ecologist

The importance of promoting a collaborative approach to SuDS planning has already been emphasised. This can be achieved by establishing clear objectives prior to undertaking detailed planning which seek to integrate and balance the views of various parties.

It is important to recognise that historic approaches to open space management have often sought to protect key environmental attributes by excluding communities and so limiting any negative impacts that can result from human use. There is growing recognition however that long-term protection of open space networks is also contingent on these areas delivering positive benefits to local communities, and vice versa with local communities contributing positively to natural ecosystems. This is particularly important in the urban context, where green space is often limited.

Where this is not done, open spaces tend to become the back-end of development, become high security risk areas and are seen as a burden to society. For this to change, appropriate use needs to be integrated into open space management. This means actively encouraging reasonable levels of use, creating aesthetically pleasing landscapes and bringing the eyes and ears of the public into these areas so as to provide passive surveillance and reduce security risks. A design approach should therefore be adopted which seeks to integrate human use and environmental conservation by creating open spaces that are multifunctional and satisfy a range of objectives.

## 9.6 Community Liaison / Stakeholder Engagement Specialist

The inputs of the public / stakeholders have to be responded to by other disciplines (urban planner, ecologist, stormwater design engineer) and these disciplines may also have particular questions to the communities or stakeholders or may directly have to inform the communities / stakeholders. The role of the community liaison facilitator / stakeholder engagement facilitator is then to ensure that the stakeholders get a to-the-point answers, that are honest and do not leave a feeling of ‘covering up’.

Also, the facilitator has a role in making sure that expert presentations, responses or questions to the stakeholders are understandable from a lay-man’s perspective, understanding the background of the stakeholders involved. The facilitator additionally makes sure that the questions of the stakeholders get to the right expert and/or are escalated to the right level and get answered. The feedback to the

community is important, and the facilitator should oversee this process. It is also important that the facilitator flags if other experts would contradict each other in their communication with the public.

The main lesson of the IFC handbook (IFC, 2007) is to 'be transparent' and therefore make meaningful information as much as possible accessible. Another important lesson is to 'incorporate feedback' in the further process. The community / stakeholders facilitator will need to have a sufficient mandate of the project owners to guard that this can happen, on behalf of the project.

# 10 CONCLUDING REMARKS

These Best Management Practice guidelines draw heavily on the studies undertaken in this research project. They should not be in conflict with good practice within each of the specialist fields, and it is expected that a practitioner or a professional team should still seek to uphold their own professional good practice requirements when working on SuDS related projects.

The Best Management Practice guidelines are intended to be used as a reference by the developer, practitioner, stakeholder and authorities. In particular, the latter can use these guidelines to review and challenge the content and outcomes of SuDS development proposals.

A critical success factor will be the updating and integration of policies and regulations across the province ensuring, for example, common approaches to:

11. Water sensitive spatial land use planning
12. Catchment management planning
13. Urban water resource management
14. Refinement of ecological objectives for Gauteng rivers and streams, and
15. Stormwater management.

Enforcement of policies and bylaws will be another critical factor in ensuring the sustainability of SuDS projects. This will include the likes of encroachment of settlements and illegal dumping, both of which are regular features of urban rivers and streams.

Finally, community acceptance – or even adoption - of SuDS is critical for the sustainability of SuDS projects. The theme of community adoption needs to be developed further, drawing on experience demonstrated in all the case study areas, and testing the wider definition of “use-value” such that all communities may be able to see the benefit of SuDS in their environments.

# REFERENCES


Armitage, N., Vice, M., Fisher-Jeffes, L., Winter, K., Spiegel, A. & Dunstan, J. (2013). Alternative Technology for Stormwater Management: The South African Guidelines for Sustainable Drainage Systems. (WRC Report No. TT 558/13). Gezina: Water Research Commission

Bobbins, K (2015). Mapping Green Infrastructure Networks in the Gauteng City Region, South Africa. In: The Sustainable Infrastructure Handbook, South Africa, Volume 2. Publishers Alive2Green. https://issuu.com/alive2green/docs/ifra_web_v2 [Accessed 29 September 2019]

City of Tshwane (CoT) (2013). Green Building Development Bylaw. Local Authority Notice 328, Provincial gazette, 27 March, 2013 http://www.tshwane.gov.za/sites/business/Bylaws/Promulgated%20ByLaws%20Documents/PROMULGATED%20PROV%20GAZ%20No%2079%20LAN%20328%20of%2027%20March%202013.pdf [Accessed 29 September 2019]

City of Johannesburg (CoJ). (2019). *Stormwater Design Manual: Revision CV9 AF CJB 2019/05/31*. By Newtown Landscape Architects, CBA Specialist Engineers, Fourth Element Consulting and University of Witwatersrand. Available from the Johannesburg Roads Agency.

Department of Human Settlements (2019) Red Book – the neighbourhood planning and design guide, creating sustainable human settlements

Fourie, W., Rohr, H.E., Cilliers, J. and Mostert, W, (2019a). Final Draft Framework towards Water Sensitive Spatial Plans. Water Research Commission Project No. K5/2587

Fourie, W., Rohr, H.E., Cilliers, J. and Mostert, W, (2019b). Final Draft Guideline on Compiling Water Sensitive Spatial Planning and Land Use Management. Water Research Commission Project No. K5/2587

IFC (2007) Stakeholder Engagement: A Good Practice Handbook for Companies Doing Business in Emerging Markets

Graham, M. and J. Taylor (2018) Development of Citizen Science Water Resource Monitoring Tools and Communities of Practice for South Africa, Africa and the World, WRC Report No. TT 763/18

Macfarlane, D., and Bredin, I. (2017). Buffer Zone Guidelines for Rivers, Wetlands and Estuaries Part 1: Technical Manual. Water Research Commission. WRC Report No. TT 715-1-17. May 2017

Zack, Tanya, Kirsten Harrison, Mark Lewis and Sean Kearney (2019) Water Loss & Sewerage Leaks, Environmental & Health Crisis. Translating grass roots successes into working solutions – and financial savings – for the City of Johannesburg. Publication by Sticky Situations and WASSUP

Woods Ballard, B., Wilson, S., Udale-Clarke, H., Illman, S., Scott, T., Ashley, R. and Kellagher, R. (2015). The SuDS Manual. CIRIA Report C753. London. [full document downloadable at https://www.ciria.org/Resources/Free_publications/SuDS_manual_C753.aspx ]