Nelson Mandela Bay Municipality Stormwater Master Plan

Theescombe to 3rd Avenue, Walmer

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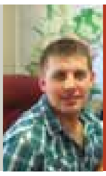

Droughts and floods are distinct features of the Eastern Cape climate. For some years climatologists have predicted that the Southern and Eastern Cape are likely to experience more frequent floods, while the Western Cape is expected to become dryer. The magnitude and frequency of flooding in parts of the Eastern Cape indeed bear testimony to these changing weather patterns.

STORMWATER MASTER PLAN NEEDED

In 2008 Nelson Mandela Bay Municipality appointed Jeffares & Green (J&G), a firm of engineering and environmental consultants, to compile a Stormwater Master Plan (SWMP) for the south-western region of Port Elizabeth, an area particularly hard hit by frequent flooding, often with devastating results.

In terms of planning hierarchy, a SWMP slots in between a Catchment and River Management Plan (CRMP) and a Local Stormwater Plan (LSWP).

In practice, an SWMP concerns the functioning of bulk infrastructure within a catchment, and examines the operation of both the above-ground flow routes as well as the underground conduits. It is a comprehensive plan that expresses the overall intent and breadth of the City's stormwater management plan and includes implementation tasks and, where possible, schedules. In many cases, however, it is difficult to determine implementation details years in advance, as so many variables are involved – and this certainly proved to be the case regarding the stormwater plans for Port Elizabeth.

The principal objectives of the commissioned SWMP were to analyse the response of the existing stormwater system with regard to runoff after both major and minor storm events, and to determine the capacity of the various elements. Once it had been established where the existing system was inadequate, strategies to mitigate these inadequacies and problems could be developed, analysed and costs roughly quantified.

The study area, which is located south-west of the CBD, extends from the Theescombe area in the west to 3rd Avenue, Walmer, in the east. It covers the residential areas of Lovemore Heights, Mount Pleasant, Providentia, Miramar, Charlo, Broadwood, Springfield, Greenshields Park, part of upper Walmer, Gqebera and the industrial area adjacent to the airport.

Stormwater manhole in Walmer, Port Elizabeth, during a major storm

AFFECTED AREA

The extent of the study area is demarcated by the watershed which separates it from the adjacent catchment areas. In residential areas, the de facto watershed is often defined by the roads and erf blocks, rather than by an actual ridge line.

Many of the stormwater management problems experienced by the Metro are related to flooding of properties. In most instances, the problems are caused by informal planning, rather than inadequate infrastructure, for example where preferential drainage paths are cut off by roads and erf blocks, with no allowance being made for overland escape routes. This was found to be a common occurrence in Mount Pleasant and Walmer, as well as in Walmer Heights where a large warehouse development had been constructed across a preferential drainage path.

Property developers also need to take heed of the important role they play in stormwater management. For example, a typical local authority requirement for new developments is that peak runoff must be reduced to pre-development levels before being released into the downstream infrastructure. The principle that developers must manage their own stormwater plans is generally accepted as reasonable. However, there are numerous situations where developers appear not to have adequately considered the upstream situation in their planning, or there is a perception that upstream runoff is the responsibility of the local authority.

MAINTENANCE AND MANAGEMENT

Another issue of concern is that of maintenance. No stormwater network can function optimally if the infrastructure is not maintained regularly, and this requires adequate funds to be allocated to the maintenance budget. Maintenance is of particular importance in areas where there are no overland escape routes to carry surplus runoff when the underground system fails, such as kerb inlets, pipe conduits and box culverts.

The general approach to urban stormwater management in South Africa is to accommodate minor events in the underground pipe network and to route the surplus runoff from major events overland – typically via the road network.

A number of key stormwater management issues were identified from the SWMP, while other specific issues were recorded during discussions with municipal officials. J&G's Port Elizabeth branch was assigned to design various stormwater systems to mitigate identified issues as instructed by the municipal officials.

The major stormwater systems identified were:

- Allister Miller Stormwater Canal
- Athlone Park Pond
- Airport Valley to Athlone Park Drainage System
- Walmer South to ACSA Stormwater (SW) Channel and related SW detention pond
- Stormwater Analysis of Walmer Country Golf Club Catchment
- Gqbera Pond
- Pipeline from Victoria Drive Pond to Star Bakery Pond
- Allister Miller Stormwater Canal Outlet to South End

As a result of urbanisation, the speed of the catchment response has increased, resulting in a higher peak discharge.

Consequently the stormwater management system, specifically the detention storage components and the "dual drainage system" concepts, should form the main elements of the Nelson Mandela Bay drainage system.

This will ensure that the criterion of "zero increase in peak discharge above the pre-development scenario" can be achieved with the provision of a detention pond. This approach will attenuate the peak discharge, reduce the cost of the stormwater drainage infrastructure where applicable and eliminate damage to downstream residential properties.

The stormwater will be managed by means of a combination of concrete pipes and reinforced concrete channels. The runoff will be split into sub-catchments which will either drain to the existing water course or be directly channelled to the proposed detention ponds.

The proposed conduit for this runoff to the pond is by means of an open concrete-lined channel. Before the stormwater is discharged into the proposed detention pond, it is suggested that it should be directed through a debris screen to prevent any plastic, bottles and the like from being discharged into the natural system.

A model of the major system was constructed using the *EPA SWMM 5.0 Storm Water Management Model* software, incorporating the required elements such as the topography, land use, soil type and infiltration, etc. The modelling exercise went through several iterations to produce a sufficiently detailed model that could provide a reasonable understanding of the study area from a stormwater-master planning perspective.

Jeffares & Green used the latest software from the *Civil Designer* suite of programs for the detail design of the proposed stormwater drainage systems.

In addition the Rational Method was used to check the results obtained from the analysis when using the above-mentioned software. The criteria used for determining the stormwater runoff in accordance with the Rational Method were:

$Q = CIA$

Q = Stormwater runoff (m^3/s)

C = Runoff coefficient

I = Average rainfall intensity over catchment (mm/h) (610 mm/year)

A = Effective area of catchment (km^2)

The stormwater runoff was calculated for the following flood recurrence periods:

- Pipe system – 1:5 years
- Overland flows – 1:100 years
- Pond size determination – The difference between pre- and post-development flows for 1:100 year flood recurrence period

The runoff coefficient (C) varies between 0.4 and 0.65, depending on the characteristics of the terrain.

ALLISTER MILLER STORMWATER CANAL

In 2009 Allister Miller Drive was part of an upgrade project concurrent with the 2010 Soccer World Cup, and J&G was appointed to do a detail design of the required stormwater services.

However, critical time frames leading up to the World Cup made the relocation of the two existing water mains prohibitive and thus the opportunity to install underground stormwater conduits during the construction project was lost. A decision was made to install four 450 mm diameter stormwater pipes across Allister Miller Drive as a temporary measure, but during construction it was found that an existing service blocked the way of one of the pipes and therefore only three pipes could be installed.

A number of key stormwater management issues were identified at this time and J&G was instructed to proceed with the detail design of a concrete-lined canal through the open area adjacent to the Transnet narrow gauge railway line, which acted as a natural drainage route for stormwater runoff from the west.

The initial stormwater runoff figure used in the proposed stormwater canal design at Allister Miller Drive was 26 m^3/s for a 1:100 year return period event.

The proposed stormwater management system at Allister Miller Drive comprises a 340 m long concrete-lined open canal system adjacent to the existing Transnet narrow gauge railway line, to discharge through "splitter boxes" over rock fill into the existing open area.

The principle design elements for the proposed stormwater system can be summarised as follows:

- 150 mm thick mesh-reinforced concrete-lined canal with 110 mm diameter weep-holes, for sub-terrain drainage, for the 1:20 year return period event;
- grass-lined side slopes for the 1:100 year return period event;
- typical longitudinal slope that varies from 0.26% for the western sector to 0.4% for the eastern portion;
- typical channel side slopes of 1:3 for ease of entrance and exit, as well as for maintenance of vegetated slopes;
- excavated channel depths that vary from 0.7 m to 3.0 m deep; and
- distance from break point to break point (top of bank to top of opposite bank) that varies from 8.5 m to 18.5 m.

The area into which the Allister Miller Canal discharges must be investigated to establish the natural flow of the major storm.

J&G issued detailed tender drawings, as well as a schedule of quantities of the proposed open concrete-lined canal, to the client on 22 October 2012, and construction started in March 2013. The project is currently 60% complete, despite major challenges posed by excessive groundwater and existing services crossing the canal route.

ATHLONE PARK POND

J&G was appointed to design a detention pond on the public open space known as Athlone Park to attenuate the major return storm event. This pond will be used as a detention facility for the accumulated storm runoff from the Walmer catchment area from 6th Avenue along Heugh Road and 3rd Avenue, as well as the runoff from the low-lying areas from the informal settlement between Airport Valley and the industrial area via a proposed open concrete-lined channel.

There are no formal stormwater detention facilities in this sub-catchment, although Athlone Park provides some informal detention storage when the incoming peak runoff exceeds the capacity of the outlet pipe. However, when this occurs, it tends to exacerbate the local ponding in Union Street. The area is extremely flat, and as a result there are numerous trapped low spots that experience localised ponding, even during low-order storm events.

Runoff accumulates via the roads and underground pipe network and eventually discharges into an unlined open channel on the public open space (Athlone Park) bordered by Union Street, the railway, 4th Avenue and 3rd Avenue.

The collected flow will be discharged eastwards beneath 3rd Avenue via two 425 mm pipes into the canal currently being constructed onAllister Miller Drive.

The following specifications show the typical characteristics of the proposed stormwater system:

Athlone Park Pond

- 4.5 ℓ/s inflow from the Walmer Catchment area
- 3.9 ℓ/s inflow from the Airport Valley concrete-lined channel
- 0.62 ℓ/s outflow discharging into Allister Miller Canal via two 450 mm diameter pipes
- 30 000 m^3 storage required.

Open concrete-lined channel from Airport Valley

- 125 mm thick mesh-reinforced concrete-lined channel with 110 mm diameter weep-holes, for sub-terrain drainage, for the 1:20 year storm
- grass-lined for the 1:100 year storm
- typical channel side slopes of 1:3 for ease of entrance and exit, as well as for maintenance of vegetated slopes.

AECON Consulting was assigned to conduct the procedure for a Basic


Allister Miller canal excavation in progress


Allister Miller canal concrete lining

Walmer South – excavation of detention pond

Walmer South detention pond after heavy rainfall

Environmental Study (BES) to be submitted to the Department of Environmental Affairs (DEA). Formal approval of the study report is still pending. An application for approval was done for the entire proposed stormwater system, for both Walmer Country Golf Course Catchment Ponds and Athlone Park Pond.

WALMER SOUTH TO ACSA STORMWATER CHANNEL

The suburb of Walmer South lies to the north-west of the airport and a portion of the suburb's stormwater runoff drains towards the ACSA property. Although most of the catchment has formal residential infrastructure and housing, there are various undulations and depressions in the topography which presently cause localised retention of stormwater within the catchment.

At a meeting between J&G and the Nelson Mandela Bay Municipality it was agreed that the stormwater drainage system from the high point in Walmer South towards the ACSA buildings should be designed to drain the major return period. It was agreed that the area west of the high point must drain via its own stormwater system to the western side.

The ACSA property is very flat and consequently the stormwater drainage system to deal with airport drainage, as well as the proposed system for runoff from Walmer South, has been designed to accommodate the 1:100 year return period event.

The stormwater runoff from the Walmer South catchment draining to the east from the localised high point for the 1:100 year return period event has been calculated to be in the order of 12.785 m^3/s.

In principle, the localised runoff from-Walmer South will drain into the ACSA system and then be conveyed through the airport to discharge into the Allister Miller Canal after crossing through an existing 3.6 m by 1.5 m concrete portal culvert under Allister Miller Drive.

The stormwater runoff from the residential areas from Walmer South must be diverted across to the proposed Walmer South channel to prevent flooding of the Airport Valley informal settlement and surrounding low-lying areas.

J&G issued detailed tender drawings, as well as a schedule of quantities for the proposed open concrete-lined channel, to the Municipality on 23 November 2012 and construction started in March 2013.

The project is currently 40% complete. Hard calcrete layers and the continuous ingress of groundwater are posing major challenges in completing the project on time.

STORMWATER ANALYSIS OF WALMER COUNTRY GOLF CLUB CATCHMENT

This sub-catchment drains the Walmer Heights residential area, the Walmer Country Club and the rural area extending from the country club to Arlington Racecourse. Although the golf course is largely undeveloped at present, there are plans to use portions of the land for high-density housing.

Runoff from Walmer Heights accumulates mainly via the road network and is discharged into small existing ponds located on the golf course. These ponds appear to be localised low ponds which have been deepened over the years but has no formal drainage system to allow them to serve as a detention facility. Consequently, this area is subject to severe localised flooding during significant rainfall events.

The current and proposed residential developments in the area have fast-tracked the need to identify stormwater management solutions, and various interconnecting detention ponds have been proposed to minimise the potential flood risk from high-return storm events.

The seven proposed detention ponds have been strategically positioned to attenuate and direct the major storm runoff from William Moffet Drive and Buffelsfontein Drive away from the problem area found at Victoria Drive. The major storm flow from Victoria Drive will be directed to the Star Bakery pond via an underground system.

The design criteria used for the analysis of the 1:100 years flood for the existing ponds to determine if the capacity of these ponds could successfully attenuate the anticipated runoff was in accordance with the SANRAL Road Drainage Manual and the CSIR Building and Construction Technology design manual, *Guidelines for Human Settlement Planning and Design.*


Major storm flow from Victoria Drive will be directed to the Star Bakery pond in the background

The proposed ponds were designed to be constructed in three phases:

- Phase 1: Proposed Ponds 1, 7 and 3
- Phase 2: Proposed Ponds 2, 4 and 5
- Phase 3: Proposed Pond 6 linked with Star Bakery pond

The specifications detailed in Table 1 show the typical characteristics of the proposed stormwater system.

Construction of Phase 1 is planned to commence during the 2013/2014 financial year.

CONCLUSION

The following may be concluded from the analysis:

- The stormwater management issues affecting the study area can be split into three broad categories – localised ponding, high flows in roadways, and inadequate infrastructure.
- There are numerous mitigation measures that can be put in place to address the identified issues.
- Some of the proposed interventions – such as the construction of new detention facilities – will address multiple issues and have the greatest impact in minimising the potential flood risk from high-order storm events.
- Although there are areas where infrastructure upgrades are required, many of the localised flooding problems are caused by trapped low spots resulting from informal planning, rather than inadequate infrastructure.
- The proposed mitigation measures should be implemented to limit the flood risk throughout the study area, with the prioritised list of interventions taking precedence.
- A comprehensive and adequately funded maintenance programme must be put in place to ensure that the existing infrastructure functions at an acceptable level.
- Where new developments necessitate

upgrades to the existing stormwater system, the cost of such improvements should be co-funded by the developer.

- As a condition for approval, property developers should be required to provide evidence that they have taken adequate cognisance of the impact of their proposed development on the stormwater network. This would typically be a local stormwater plan or a feasibility report. □

KEY PLAYERS

NELSON MANDELA BAY MUNICIPALITY
Yussuf Gaffore (Acting Executive Director: Infrastructure & Engineering)
Lwazi Kelembe (Project Manager)
Abongile Toto (Project Manager)
Isaac van Rooyen (Project Manager)
JEFFARES & GREEN (Pty) Ltd
Johan Booyens (Project Engineer)
Fanie du Toit (Project Leader)
Deon Joubert (Hydrologist)
Mthuthuzeli Gqokoma (Technologist)

Table 1 Specifications showing the typical characteristics of the proposed stormwater system

Pond 1 ▪ Footprint area: 59 020 m² ▪ Inflow: 4.16 m³/s ▪ Outflow: 0.311 m³/s ▪ Capacity: 68 500 m³	**Pond 2** ▪ Footprint area: 14 720 m² ▪ Inflow: 0.46 m³/s ▪ Outflow: 0.311 m³/s ▪ Capacity: 17 400 m³
Pond 3 ▪ Footprint area: 70 474 m² ▪ Inflow: 16.8 m³/s ▪ Outflow: 0.32 m³/s ▪ Capacity: 89 000 m³	**Pond 4** ▪ Footprint area: 9 422 m² ▪ Inflow: 2.63 m³/s ▪ Outflow: 0.46 m³/s ▪ Capacity: 7 000 m³/s
Pond 5 ▪ Footprint area: 17 698 m² ▪ Inflow: 7.6 m³/s ▪ Outflow: 0.23 m³/s ▪ Capacity:17 200 m³	**Pond 6** ▪ Footprint area: 6 346 m² ▪ Inflow: 1.8 m³/s ▪ Outflow: 0.311 m³/s ▪ Capacity: 500 m³
Pond 7 ▪ Footprint area: 3 915 m² ▪ Inflow: 1.8 m³/s ▪ Outflow: 1.1 m³/s ▪ Capacity: 2 080 m³	