Green engineering brings urban flood relief

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Following severe flooding of residential homes, and damage to public and private property, environmentally sound infrastructure solutions are being implemented in Atlasville.

BACKGROUND

River engineering specialists Fourth Element Consulting have combined hydraulic engineering with green infrastructure to provide urgently needed flood relief in the Atlasville suburb of the Ekurhuleni Metropolitan Municipality.

Atlasville is a suburb of Boksburg just east of the OR Tambo International Airport in Johannesburg, Gauteng. Transformation of the area began in the early 1970s, when a natural wetland was drained to allow development of a middle-class suburb for personnel employed at the newly established Atlas Aircraft Company and affiliated industries. The flow of the natural watercourse was confined in a narrow canal and named the Atlaspruit, and the surrounding wetland area was backfilled with subsoils and building rubble on which residential houses were constructed. At the same time the area immediately adjacent to the canal was established as a recreational park. With ongoing residential and industrial development upstream of Atlasville, however, there was an increase in the generation of run-off from the catchment. This continuously increased the volume of water carried in the canalised Atlaspruit during storm events. From February 2006 the canal was no longer adequate to carry the run-off from major storms, and flooding caused severe damage to adjacent properties and households. Residents were forced to leave their homes while repairs were undertaken. Sewers and stormwater drains backfilled and overflowed, presenting health hazards. Insurance cover was refused in some instances and property values fell substantially.

Fourth Element Consulting was first approached by the Ekurhuleni Metropolitan Municipality to undertake specialist flood analysis following these 2006 floods. It was found that flooding was due to a combination of limitations in the local

stormwater network, and limited capacity in the Atlaspruit itself. Reed infestation in the canal also restricted flow, but even if these were cleared, the existing size of the canal was insufficient to carry the increased storm run-off.

PROJECT DESCRIPTION

The occurrence of even more severe flooding in January and February 2010 compelled the Municipality to appoint Fourth Element to conduct a feasibility study for improving canal conveyance. A detailed hydrological model of the upstream catchment was developed, and the results from this provided the input for a further hydraulic model which was calibrated to the January 2010 flood event. The calibration process included iterative tests of both the hydrological and hydraulic probabilities. Using radar data provided by the SA Weather Services, the calibration process entailed the refinement of the rainfall depth and distribution across the catchment, and getting an accurate measurement of hydraulic resistance of the reeds in the canal.

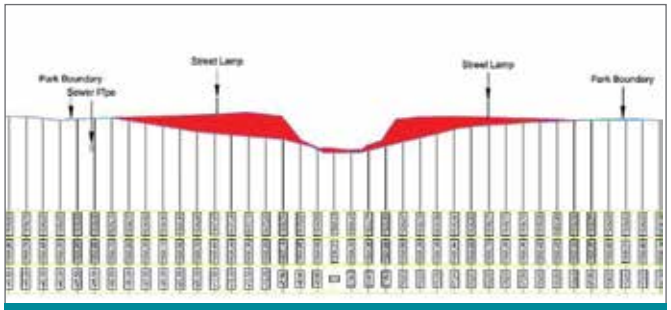

Figure 1: Sample cross section of the canal area – the red shading shows the extent of the bulk excavation to increase conveyance

Figure 2a: Pre-development 100-year floodline

Figure 2b: Post-development 100-year floodline

RIVER ENGINEERING AND LANDSCAPING

The key components of the improved conveyance scheme were to remove the reeds and sediment build-up in the main canal and to deepen the floodplain within the park area, while simultaneously preserving its recreational functions and improving natural habitats. The banks of the canal were profiled to increase conveyance and improve access to the water's edge. In-stream vegetation was carefully selected to meet water flow requirements, habitat potential and ease of maintenance. Bulk earthworks are shown by the red shading on the sample cross-section in Figure 1.

Throughout the feasibility, concept design, detailed design and construction phases Fourth Element worked closely with the project manager, Sintec Consultants, and the landscape architects, Outerspace Design, to achieve the desired objectives of the study. Construction of Phase 1 of the scheme began in May 2012 and was commissioned in June 2013.

The main hydraulic requirements were to reduce the resistance to flood flows and enlarge the geometry of the floodplain to accommodate these flows. Environmental considerations in-

The challenging landscaping phase of the rehabilitation project in progress

Planting included hydro-seeding on the embankments and planting by hand in the main canal

cluded providing reed beds and riffle sections for suitable habitat features to increase biodiversity, while stabilising the central stream and embankments with vegetation.

FLOOD RELIEF

The project is being undertaken in two stages: the first consisted of work along approximately 1.3 km of the stream where 100-year flood relief will be achieved. The flood relief achieved in Phase 1 is shown by the pre-and post-development 100-year flood lines in Figure 2. The flooded area that previously extended into the properties of Atlasville is now confined within the park area.

Phase 2 is currently in the detailed design stage and, when implemented, 100-year flood relief will be achieved over the entire 2.2 km length of the Atlaspruit through Atlasville.

LANDSCAPING

The challenge was balancing flood relief with recreation and habitat requirements, which needed careful hydraulic design. This placed specific demands on the landscaping and planting of the site. Planting comprised a combination of hydro-seeding on the embankments and park area, transplanting of smaller trees in the floodplain, and planting by hand in the main canal. However, because the wetland area had been backfilled with building rubble and sediment dredged from the canal, the topsoil was of a very poor quality. In addition, the landscaping and planting had to take place during the wet season of 2013. As a result, the

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vegetation did not establish optimally. These shortcomings will be addressed in Phase 2 when good quality topsoil will be imported to the site and construction and landscaping will be completed during the dry period to allow an optimal period for growth in spring.

EROSION CONTROL

Fourth Element analysed shear stress and velocity of flow in the main canal in order to specify erosion control measures. In-stream vegetation was carefully selected to balance habitat potential and hydraulic conveyance, and once established, the vegetation will stabilise the canal. However, to ensure stability during the establishment phase, erosion protection measures were identified at locations of high-shear stress.

The MacMat™ product supplied by Maccaferri Africa was specified, and it proved its worth during the month of high rainfall and river flows in December 2012. The roughness and relatively high permeability of MacMat™ allows for natural deposition of sediment in flowing water and offers a good retention to a pre-seeded/hydro-seeded environment. In fact, sediment deposits were clearly visible in the stream within three months after construction. MacMat™is a three-dimensional permanent erosion control geosynthetic turf geomat consisting of entangled polypropylene monofilaments, UV-stabilised non-degradable synthetic fibres providing a dimensionally stable matrix for soil erosion protection from wind, rain, run-off or flooding.

A total of 13 100 m² of MacMat™ was installed. This is one of the largest installations of this nature in South Africa. The layout arrangement and pegging were designed to suit the canal dimensions, flow depth and velocities. Initially the geomat shields the bed material, preventing the soil from washing out before the vegetation has established itself. Then, as the vegetation matures, the roots anchor the mat to the soil, providing a higher shear resistance, capable of handling steeper embankment slopes and higher flow velocities. A biodiverse application for the vegetation gives the best results and this benefited from the planned mix of sedges, water grasses and wetland vegetation selected for the project. This type of application usually incorporates a nursing (pioneer) species, which establishes easily, is fast-growing and gives immediate protection. The pioneer species are often dependent on a lot of nutrients, so their initial growth rate starts slowing and they start to die off as the high nutrient content in the soil is depleted. At this stage, the main vegetation, which is more sustainable and does not need as many nutrients, but grows slowly, starts taking off.

The installation of the geomat required sloping of the canal to the required levels according to design, mostly done by machinery. Hand labour was then used to level the canal bed to a smooth surface ready for the laying of the geomat. Maccaferri Africa provided training to the contractor on the correct installation of the MacMat™. It took the construction team, which consisted of about 10 labourers and a supervisor, a bit more than a week to complete the laying of the geomat, with pegging and anchoring.

FLAGSHIP GREEN INFRASTRUCTURE PROJECT

The project started out with a flood relief focus, and it was only during the feasibility and design phases that attention was drawn to other services that would benefit from the same scheme; in this case recreation and biodiversity. An intensive public involvement scheme helped drive the project towards providing each of these services, and as a

Hand labour was used to prepare the canal bed for the laying of MacMat™ to control erosion

MacMat™ directly after installation

result the Atlasville flood relief scheme has become one of the flagship green infrastructure projects of the Ekurhuleni Metropolitan Municipality. It has allowed for the integration of engineering specialists with the landscaping architect and environmental team to produce an innovative engineering solution. In terms of flood relief the scheme has performed very well and was suitably tested during construction in December 2012, and again in the very wet period of February 2014. Property values have increased and home owners are once again able to reinstate home insurance policies which had been cancelled.

Green infrastructure projects are still fairly new to South African municipalities, although eThekwini and the City of Cape Town are making good progress. One of the challenges in implementing green infrastructure projects is that they should have multiple stakeholder departments, in line with the range of services they provide. This points to shared funding, maintenance and management responsibilities that are not always made easy by existing municipal structures. One of the primary concerns with the Atlaspruit project is that the reeds need to be controlled. If managed on a regular basis (at least annually) this will be a low cost, but if left uncontrolled it will reduce both the flood benefits and the habitat potential of the scheme. Reed control is not a Roads and Stormwater function, even though it is one of their projects, and this will be a good test of inter-departmental cooperation to see how sustainable this green infrastructure project will be. □

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