DISASTER MITIGATION

Raging waters: New guideline aims to protect society from devastating flood impacts

Top water engineers and researchers have collaborated to produce a comprehensive guideline for municipalities to demarcate safer and more consistent floodline development boundaries. Tony Carnie reports.

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Thousands of people have been carried to their deaths by sudden and unpredictable floods in many parts of South Africa over the centuries. One of the most recent reminders of this terrifying power of floodwaters and mudslides came in April 2022, when at least 460 people died and more than 8 000 homes were destroyed in Durban and other parts of KwaZulu-Natal and the Eastern Cape.

According to researchers at the University of the Witwatersrand, nearly 40 000 people became homeless, and up to 45 000 people were left temporarily unemployed following that flood. Roads and bridges were also torn away, along with tap water and sewage reticulation pipelines – leaving behind an infrastructure damage bill at around US$2 billion.

While little can be done to stop major rivers from overflowing during such extreme and unpredictable weather events, the death toll and the extent of damage can be reduced by controlling or restricting the development of homes and other human infrastructure in the most flood-prone areas in built-up areas. The most common method used to reduce such risks is by demarcating a 'floodline' (an imaginary line on the ground that denotes the probable edge of the water during a flood). One of the most widely-used examples is a 1:100-year floodline, which delineates the probability of a flood exceeding this level once in a 100 years (or a 1% probability in any year).

Yet, at a time when the country's urban population is expanding rapidly, there are still no consistent design standards for urban

flood estimation and risk assessment in South Africa – a situation that has been exacerbated by a decline in engineering expertise at municipality level. These were some of the factors that prompted the Institute of Municipal Engineering of Southern Africa (IMESA) and the Water Research Commission (WRC) to develop a new flood estimation guideline for municipalities.

The new 300-page technical tool, entitled ***A best practice guideline for design flood estimation in municipal areas in South Africa*** (**WRC report no. TT 921/23**), was produced by a group of six expert academic researchers and private practitioners and published by the WRC.

Chris Brooker, a Johannesburg-based civil engineering consultant who helped develop the guideline, notes that vulnerable communities living in shack settlements are often "left with nothing" in the aftermath of such events. Whereas more affluent families may be covered by insurance or could afford to relocate to a hotel or other accommodation while their homes are repaired – residents of informal settlements have to start from scratch after losing their only source of shelter, their clothes, their furniture – even their ID books.

"So, we need to be looking at protecting these vulnerable communities – from themselves, as well as from avaricious politicians or developers," he says, in reference to the illegal infilling of flood-prone land that is then sub-divided and sold for informal settlement. "Are development plans being interpreted in the best interests of society, or to provide a developer with a few extra property stands? I'm not sure that the potential social consequences are always addressed adequately at the municipal level," he says.

He notes that South Africa has always been exposed to flood events, with a corresponding need to provide guidance on locations where it is 'safe' to develop – or not. Yet it was not until the 1970s that regulation in this area was formalised, with the first references to floodline estimation published in an amendment to the Water Act in 1975.

The new National Water Act in 1998 further defined the rationale for floodlines, so that people could better understand the risks they were exposed to. Brooker notes that there are also several different methods for calculating flood risks – ranging from statistical analysis developed in the 1960s to more modern computer-based models.

And because different engineers employ different models or approaches, this can result in significant variations in flood risk estimation for the same rivers and IMESA recognised that this was a problem.

"So, the idea was to develop comprehensive guidelines that would allow for more reasonable and consistent flood line estimation."

Brooker notes that basing development decisions around the annual probability of flooding (e.g. a 1:100 year chance of

Shawn Herbst

The Umgeni River in Durban in full spate in April 2022. However, many flood estimation methods were developed in the late 1960s or early 1970s. As a result, there are still no universally applicable methods for design flood estimation in South Africa and practitioners should use their experience and professional judgement in selecting the most appropriate methods for a specific design situation.

flooding) is fraught with problems, so there should be more emphasis on the lifetime risks of flooding, rather than annual risks. Equally, it was unacceptable to allow people to establish shelters next to flood-prone rivers and streams because, if their homes were washed away, they were left with nothing.

"This is not a situation peculiar to Africa. Just look at countries like Bangladesh where up to 100 million people can be displaced by a sudden flood in low-lying areas. I believe there is certainly sufficient land available for housing in South Africa that would not expose vulnerable people to such hazards. If necessary, you can engineer some of the risks away or manage the catchments more effectively to reduce water flows and flow velocity," he notes, pointing to the stormwater guidelines that have been developed by municipalities in major cities to mitigate the risks of urban development.

While high-rise development was often promoted as a solution to reducing urban sprawl, cramming more people into high-rise developments could also lead to negative social costs such as an increase in crime levels. "From a flood management perspective high-rise development might be a solution, but planners should be conscious of the potentially negative social impacts."

Brooker suggests that a 1:100 floodline is a "good start" and a reasonable boundary line for the bulk of urban development, but more conservative guidelines (e.g. 1:500 year or even 1:1 000 year) were also needed for emergency response infrastructure such as hospitals and police stations as well as hazardous facilities such as petrol and diesel filling stations, with even stricter floodlines for nuclear power plants.

Brooker and his fellow authors stress that municipal planners should not focus on flood depth alone. They should pay equal attention to how fast the water flows and how quickly the water rises during a flood event. "You have to be looking at the potential impacts of ankle-deep or calf-deep water flowing at several meters a second compared to waist-deep water that is standing still. You have to look at both water depth and water velocity."

"Municipalities can still be held responsible if they cannot prove that they followed reasonable practices before accepting a developer's plan."

While car parks or sports fields are often seen as acceptable 'low-risk' developments in flood prone areas, Brooker notes that many urban rivers are highly contaminated with chemicals and sewage-borne pathogens that can be deposited on grass surfaces during a flood – and remain there for months afterwards. "There is also another dimension to flood plains – and that is their right to exist for ecological reasons and also to mitigate the impact of floods," he says, noting that nature reserves and large natural areas are very valuable ecological assets.

Ethekwini Municipality

Vegetation, plastic and other debris piled up beneath several bridges during heavy rains across Durban last year, destroying infrastructure or forcing flood waters to tear through homes built on low-lying land.

From an ecological perspective, it was crucial for these natural areas to remain connected, a bit like beads on a string. "Though it can be hard to persuade developers to leave such areas off-limits to development, there is a very good case to be made for the maintenance of riparian corridors in urban areas."

Capacity and skills

The authors of the new guidelines caution that many municipalities do not even have qualified engineering technologists – so there is no capacity to assess the flood related work of established engineers. One of the aims of the guidelines is to provide sufficient knowledge to municipalities to assess whether they are complying with their responsibilities.

The new guideline further emphasises and describes the critical legal responsibilities of municipalities and municipal managers for flood management planning and awareness, and the required level of expertise for officials and appointed external practitioners. It is therefore recommended that design flood practitioners should be either a professionally registered engineer (Pr Eng), technologist (Pr Tech Eng), or natural scientist (Pr Sci Nat), all with the required experience in engineering hydrology.

The guideline notes that the calculation of floodlines is complex and can entail a considerable degree of uncertainty, and hence they should be undertaken only by suitably qualified and experienced practitioners. Although current legislation holds municipalities mostly responsible for ensuring that all development requirements are met, engineers also carry a professional responsibility. Nevertheless, it remains the responsibility of municipalities to apply proper professional judgement in appointing appropriately trained advisors to ensure a safe environment.

The National Building Regulations and Building Standards Act imposes further responsibilities on local authorities and the new guideline recommends that they should refuse any building plans unless they are satisfied that a new building is not a danger to life or property during flooding.

Bylaws in major cities such as Johannesburg, Durban and Cape Town stipulate that developers bear the responsibility to show the 1 in 100-year floodline on all building plans, but municipalities can still be held responsible if they cannot prove that they followed reasonable practices before accepting a developer's plan.

Regular floodline revisions

The authors note that it is not sufficient to rely on existing floodline determinations. They have to be updated constantly to account for changed land uses and development in rapidly expanding urban areas.

More attention is also needed to account for the impacts of global climate change, says Brooker. "We don't know exactly what climate change is doing with respect to flooding in urban areas, but we are already seeing indications of change in biological systems and some evidence of more energetic storms – so that is another uncertainty that we need to be aware of when updating the floodlines."

Groundup / Ashraf Hendricks

A flooded informal settlement outside Kraaifontein during a flood in 2021. Vulnerable communities living in shack settlements are often worst affected due to flood events.

Given these changes in climate, the team provides guidance regarding which storm rainfalls need to be used in the determination of future climate induced flood events. There has also been a dramatic increase in impermeable areas (paved or hard concrete surfaces) in several municipalities. This increase in impermeable surfaces means that flood water flows are now more powerful because they are no longer able to soak downwards into soft soil or grass surfaces.

A third factor was the changing nature of water courses over time, such as the construction of new bridges, erosion or build-up of sediments in river channels. "Even if a dam has been built upstream, I would caution against revising floodlines downwards," says Brooker. "Local authorities should be looking at the combination of land use changes within their catchments to establish whether existing floodlines are still relevant or appropriate."

As a rough guideline, he suggests any floodlines older than 10 years should be revisited, but a target of 5 years for an update is recommended in the guideline. Brooker believes it could be impractical and legally problematic to regulate the extent of impermeable surfaces for new or existing developments.

Rather than attempting to police and place limits on the percentage of property that can be paved, a more practical approach would be to require the installation and regular maintenance of flood attenuation structures around development complexes.

- The authors of the new guideline were Chris Brooker (CBA Specialist Engineers), Prof Kobus du Plessis (Stellenbosch University), Stuart Dunsmore (Fourth Element Consulting), Prof Chris James (University of the Witwatersrand), Prof Jaco Gerricke (Central University of Technology, Free State) and Prof Jeff Smithers (University of KwaZulu-Natal). To download the report, Visit: https://wrcwebsite.azurewebsites.net/wp-content/uploads/mdocs/TT%20921%20final%20web.pdf