PAPER 17

FLOODING IN LADYSMITH, PROBLEMS AND SOLUTIONS.

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ABSTRACT

Flooding has been recurring in Ladysmith for the past 170 years due to its peculiar location in the uThukela catchment, in the foothills of the Drakensberg mountains. During 1987 and 1988, Ladysmith was flooded on three separate occasions and extensive damage was caused to residences and businesses. The worst flooding in 30 years occurred in 1996 leading to R500 million in damages and the evacuation of 400 families. Efforts to tame the river and manage the flooding has been going on since the 1940s. Subsequently, several solutions were put forward, including the relocation of residents, improved flood warning systems, channel improvement using levees, and the construction of a flood attenuation dam. Some of these solutions were implemented. Due to climate changes, research showed that the rain intensity slightly increases from year to year. Also, the return periods are getting closer than expected. The existing drainage system needs to be examined and its performance to be evaluated during flood incidents.

The paper diagnoses the causes to the chronic flooding and presents the various approaches to solve the problem. The paper examines the local risks, suggests measures and adjustment to the current drainage system, suggests measures to maintain the river systems and successfuly implement the solution within a tight schedule.

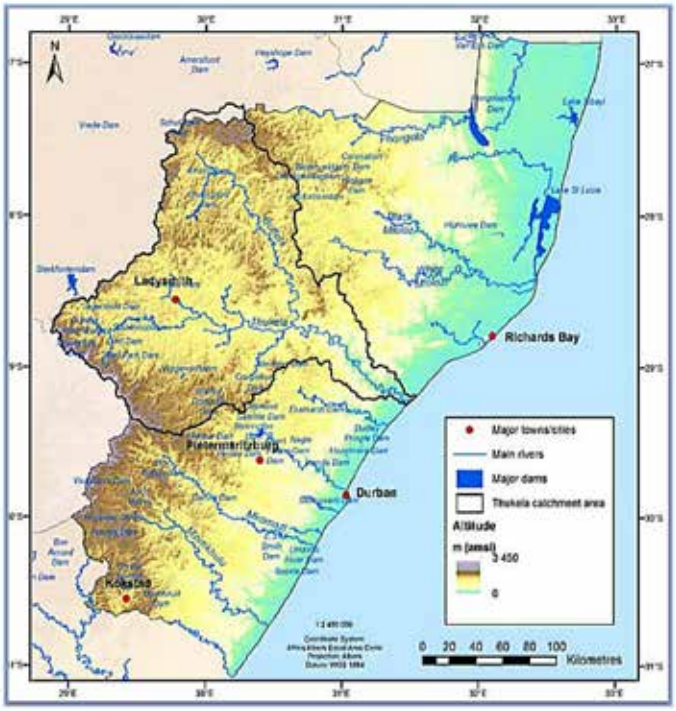

FIGURE 1: *Ladysmith within uThukela Catchment Area*

INTRODUCTION

Sequel to the continuous rain period exceeding 10 days over Ladysmith; it flooded. The town is subject to cycles of flood and subsequent calamities since its creation. In January of this year, it was devastated with the death of 28 people. The floods left more than 100 people homeless and were forced to evacuate to Care Centres. The town was flooded on 3 different occasions between January and April of 2022.

The town of Ladysmith was proclaimed on the 20th of June 1850 on the floodplain of the Klip River, and since then, flooding has always been part of the town's history. The first hundred years of the town's records show no less than 27 flood events. The worst flooding in 30 years occurred in 1996 leading to R500 million in damages and the evacuation of 400 families. Efforts to tame the river and mitigate the flooding has been going on since the 1940s.

In 1949, the Windsor Dam was completed, but the dam silted up very quickly and was not an effective means of flood control. As a result, a special committee was appointed to investigate the problem and come up with solutions. Various ideas were, consequently, put forward, including the relocation of residents, improved flood warning systems, channel improvement using levees, and the construction of a flood attenuation dam. The aforementioned solutions were implemented leading to the construction of the Qedusizi Dam in 1996 on the Sand and Klip River. The dam has a 32 m-high dam wall and was designed to manage the flood peaks and hold or delay floodwater from the upper region of the Klip River's catchment area. It was designed with 2 openings (without gates) that allows a discharge of 450 cu.m/sec. The dam limits any large-scale damage and provides an adequate evacuation warning period.

LOCATION, POPULATION AND THE ENVIRONMENT

Ladysmith is located on the banks of the Klip River at 26°48'11.83" E, latitude 8°33' 35.30"S, with its central business district and a large part of the residential areas located within the flood basin of the river. It is at the foothills of the Drakensberg mountains. The Thukela and Klip Rivers are the source of water for the Thukela-Vaal Transfer Scheme, which, inter alia, transfers water to the Vaal River System.

The latest population records show the population of Ladysmith to stand at about 250,000 capita. However, this population figure appears to be gross underestimation for 2022. The land in the Thukela catchment is mainly used for agriculture which includes beef and dairy pastures, sugar cane, vegetables, nuts, and citrus fruit. Other areas of the catchment are dedicated to game reserves and national parks, such as uKbahlamba Drakensberg Park World Heritage Site.

Soil erosion is a particularly serious problem in the upper catchment areas of the KwaZulu-Natal province and communal land mainly linked to poor grazing management and abandoned agricultural fields. In the Northwest of Ladysmith in particular, severe overgrazing and soil erosion problems are being experienced in the Driefontein Block and Marianismo areas.

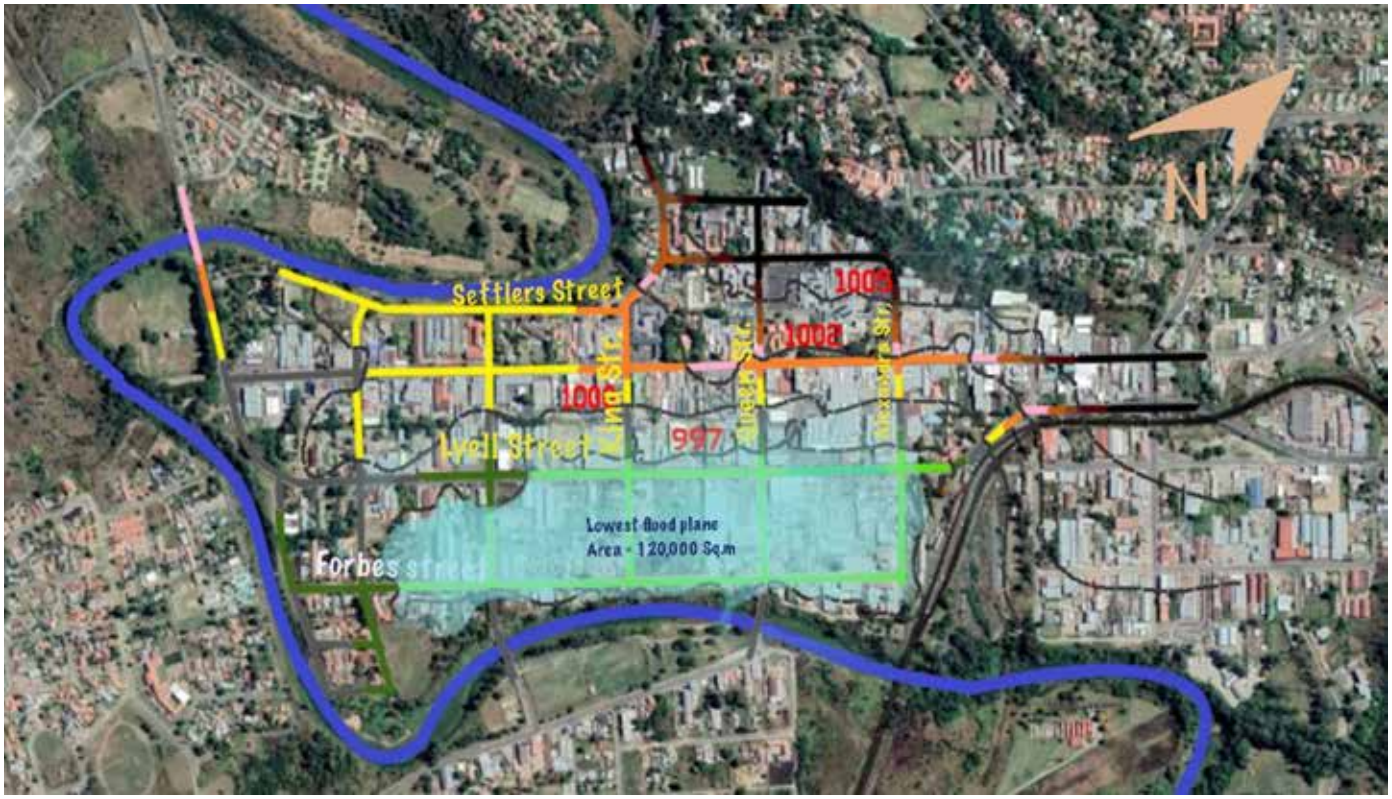

FIGURE 2: *Topography of Ladysmith CBD and its flood plain – Basemap from Google*

The Ladysmith area is extremely rich in cultural heritage sites of various traditions and periods. At least twenty-one cultural heritage sites are situated adjacent to the N11 that is crossing the town from south to the north. These include Later Iron Age sites, Anglo-Boer War period sites, homesteads, and farmsteads older than sixty years of age, public buildings over sixty years of age, one memorial, and two contemporary places of worship. All the historical homesteads and public buildings are in Lyell Street within the Ladysmith Central Business District (CBD).

TOPOGRAPHY OF LADYSMITH'S CBD

Ladysmith's CBD is like a cradle surrounded by the meanders of the Klip River from the left and the right at a higher level than most of it. The CBD is surrounded by elevated ground, with the lowest ground cutting across from Princess Street to Alexander Street at a level of 997 amsl. (The area marked in blue in Figure 2 is the lowest area within the CBD).

RAIN INTENSITY AND RIVER HYDROLOGY

The analysis of the precipitation during flood events at which such period shows the following:

- The Maximum Daily Precipitation (MDP) occurring at every 25-year period stands at 95mm.
- The Maximum Hourly Precipitation (MHP) is about 40mm with a return period of less than 4 years.

Windsor dam was constructed to retain the centennial flood water, or flood water that exceeds a flow of 700cu.m per sec. It was reported that, historically the Klip River had a full bank discharge of approximately 700m cu.m/s, such carrying capacity deteriorated over the years due to siltation and lack of maintenance of the meanders of the Klip River. The Qedusizi Dam during a flood incident is restricted to about 450 cu.m/s to retain more floods than Windsor Dam. The latter was decommissioned in 1998. Additional peak flow of 50 cu.m/s shown entering the Klip river from the Southwest through

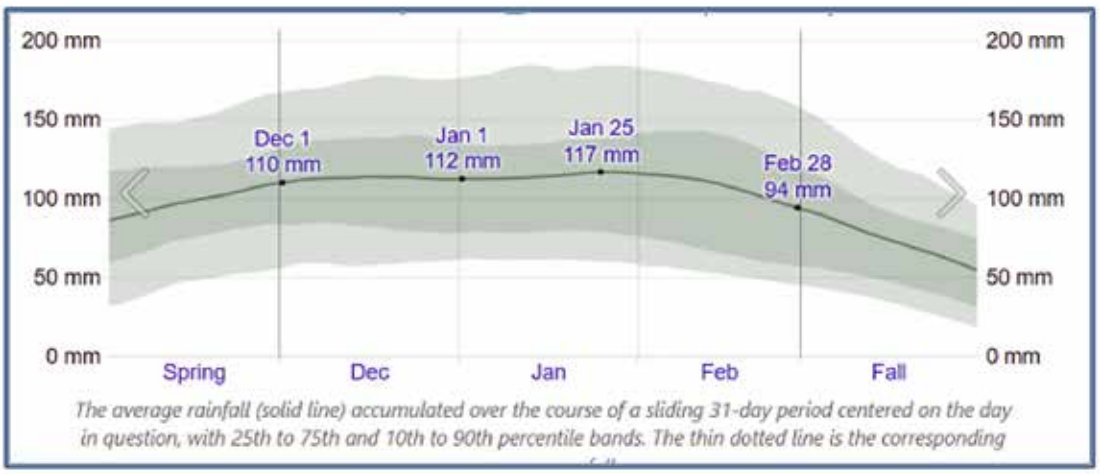

FIGURE 3: *Max-Min values of recorded monthly rain intensity in Ladysmith – source: weather-atlas.com*

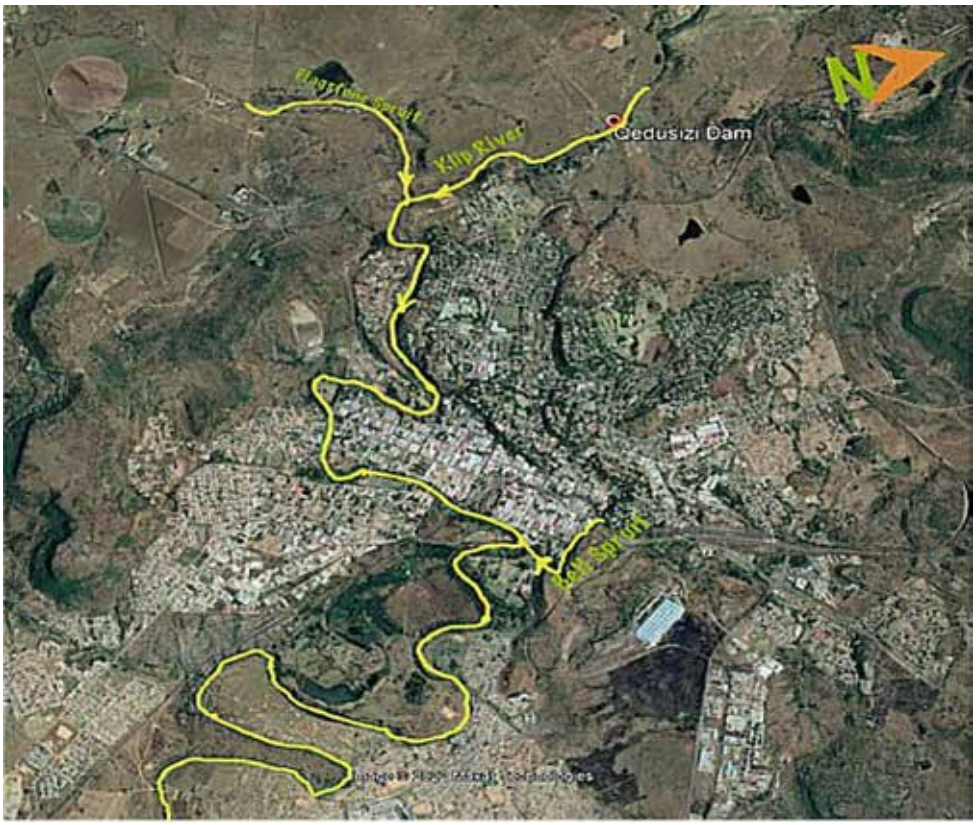

FIGURE 4: *River System Upstream of Ladysmith CBD*

Flagstoneproot during flood events. (Source: Alfred Duma municipality). Based on the historical data of flow, the probability of a flow of about 1000cu.cm/sec, occurring upstream the Qedusizi Dam is about 70% every 5 years, while the probability of a flood about 1500 cu.m/sec can happen every 100 years.

THE CARRYING CAPACITY OF THE RIVER

Studying the cross-sectional capacity of the Klip River's meander; results show that the section's average carrying capacity has deteriorated to less than 50% of the maximum discharge from the Qedusizi dam and represents about 23% of the original carry capacity in some areas (section 3 of Figure 4).

Sections 1 to 3 are critical, and will overflow the banks, even during a 5-year flood cycle. These sections are on a higher land of the CBD, and flood water breaches the levees and overflows the banks towards the lowest point in the CBD.

Based on the cross sections of the river in Table 1, the quantity of water overflowing the river's banks from sections 1 to 3 is to be about 734,000cu.m/hr (about 203 cu.m/sec), flowing towards the lowest point of the CBD, the flood will cover up to Lyell Street; putting Forbes Street under 3 m of water on average.

GEOLOGICAL FORMATIONS AND SOIL TYPES

The geology underneath the Ladysmith area is part of Vryheid Formation of the ECCA group, its geology consists of shales, mudstones and fine-grained sandstones These were intruded by dolerite sills and dykes of Jurassic age.

On top of the sandstone/shales subsoil, lies a layer of loamy clay. The clay-rich soils have the largest pore space; hence, has the highest water retention capacity.

The typical co-efficiency of seepage for such soil stands at 0.8cm/hr, as an average value for this type of soil. The estimated seepage to the soil from the meander and the surface of the CBD is 1700 and 1800cu.m/hr, respectively.

Investigations in the vicinity of Ladysmith, where soil is of the same soil structure, experienced a groundwater level fluctuation and rainfall variation of approximately 3.2m and 15% respectively. In general, the response of groundwater levels to changes in rainfall across the province has a lag time from 2 to 4 months.

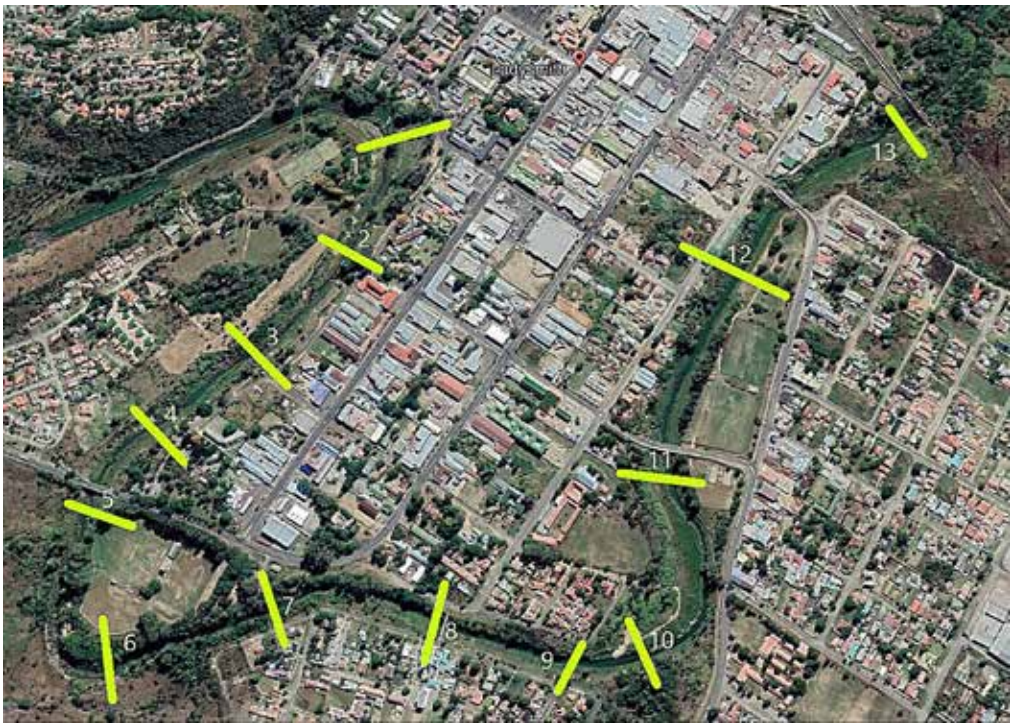

FIGURE 5: *Key plan for section assessed along Klip River to be read with Table 1 – Basemap from Google*

TABLE 1: *Section properties long the meander as per Figure 4*

	Area	Perimeter	Safe carrying capacity through Clay.
1	487.3 sq.m	121.0 m	487.3 cu.m/s
2	270.0 sq.m	84.7 m	270.0 cu.m/s
3	160.0 sq.m	92.0 m	160.0 cu.m/s
4	228.0 sq.m	75.0 m	228.0 cu.m/s
5	319.0 sq.m	84.0 m	319.0 cu.m/s
6	308.4 sq.m	88.4 m	308.4 cu.m/s
7	413.5 sq.m	95.0 m	413.5 cu.m/s
8	287.0 sq.m	77.5 m	287.0 cu.m/s
9	355.2 sq.m	92.0 m	355.2 cu.m/s
10	484.0 sq.m	132.0 m	484.0 cu.m/s
11	531.0 sq.m	145.0 m	531.0 cu.m/s
12	382.0 sq.m	100.0 m	382.0 cu.m/s
13	401.5 sq.m	120.0 m	401.5 cu.m/s

THE DRAINAGE SYSTEM IN LADYSMITH CBD

The existing drainage pipes convey the storm water from the CBD into the Klip River through the 24 existing valve chambers (Figure 6).

The stormwater drains, pipes and existing structures are used to collect and carry stormwater away and release it into the river. The exiting stormwater system feeds the Klip River through the Duckbill Check valves.

In a post flood inspection, 11 out of 24 Check Valves were either damaged, or completely pulled out. Theoretically, such valves are non-return valves, but in practice, they come under passive pressure (water head from the receiving body) during flood and turbulence occurs at the outlet, which leads to damage of the valve.

WHAT HAPPENS DURING A FLOOD EVENT?

The water gradually rises behind Qedusizi dam and the discharge from the dam increases, raising the level of Klip River water. At peak discharge, the water level can reach up to 9m height in the river, and the following scenarios occur:

1. Water backflows through the drainage system:

The riverbed of Klip River meanders through the CBD and varies between

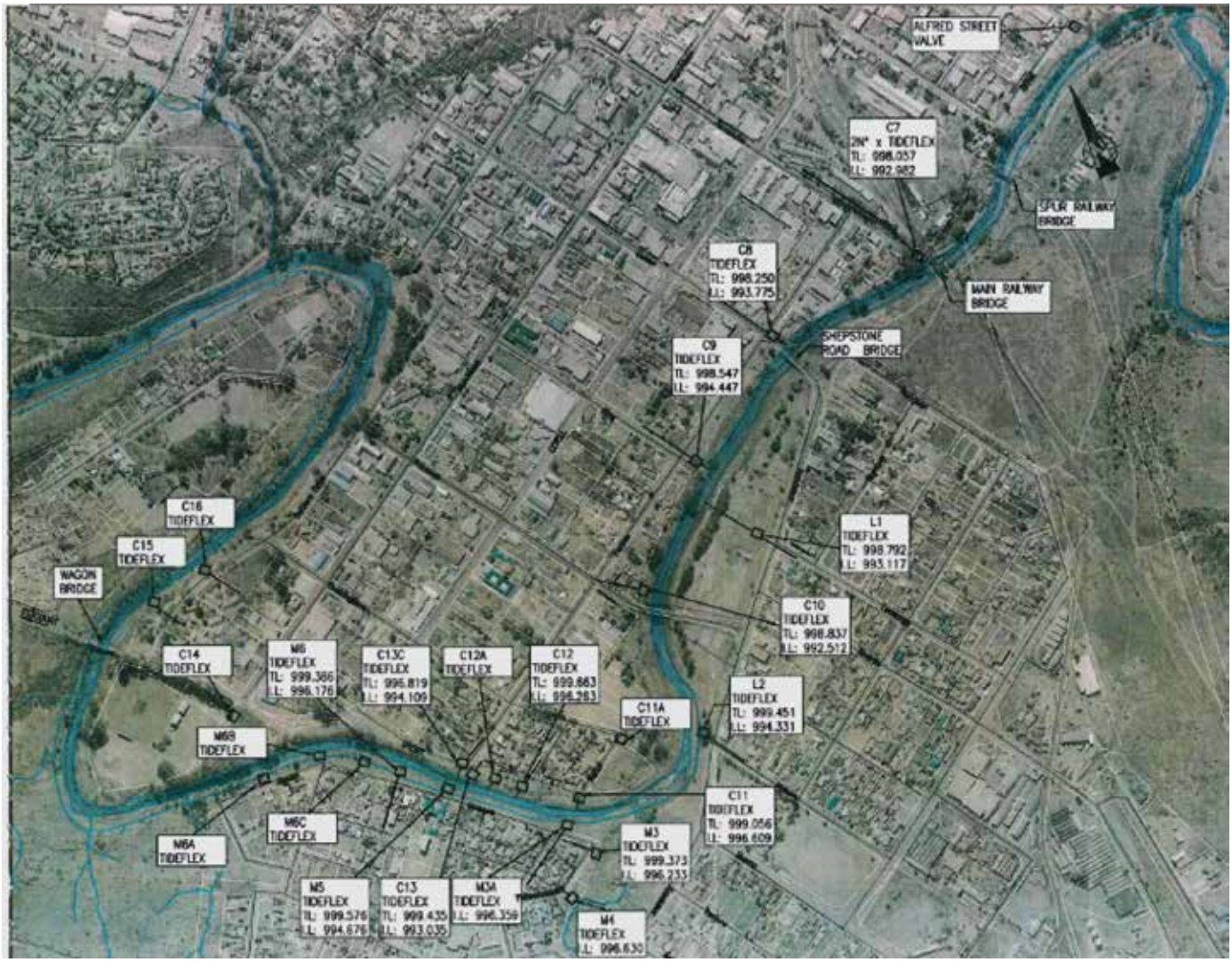

FIGURE 6: *Drainage System through CBD – Courtesy Alfred Duma Municipality*

996 and 992amsl, while the drainage pipes outfalls are located directly above the riverbed with diameters of 900mm to 1200mm. During a rain event the Duckbill valves will be opened to discharge water from the CBD drainage gravity line (Active Pressure), while from the river side (or the receiving body) the water will also be rising until it exceeds the top of the pipe or the upper tip of the already opened valve. when the water head in the river exceeds the level of Forbes Street (i.e., Passive Water Pressure from the river side exceeds the Active Pressure), water will flow back into the drainage system, and back to CBD. the backflow can reach 72,000cu.m/hr which can put the area marked in blue in Figure 2 (i.e., the lowest area in the CBD) under approximately 2m of water within 3.5 hours of reaching high water level in the river due to pressure difference.

2. Water overflowing the Banks:

When water flow from Qedusizi dam reaches the maximum discharge of 450cu.m/s, it flows towards the CBD joined by a discharge of 50 cu.m/s from the Flagstonesproot to reach the meander upstream of the Ladysmith CBD, the water will breach the banks of the meander and pour about 350cu.m/s towards the CBD, as a result of the reduction of the carrying capacity of the meander/river cross-section.

3. The runoff of the CBD:

It contributes about 60,000cu.m/hr during the storm, but the controlling factor is the level in the water of the river, which happens to be backflowing to the CBD.

4. Slow drainage through soil:

Due to the nature of the soil, as discussed above, the Loamy clay retains the water and takes considerable time to drain, which increases the surface runoff through the city.

FLOOD'S SOLUTIONS IN LADYSMITH CBD

From the above, it is necessary to attribute the flooding of the city to the following:

1. Topography and location of Ladysmith CBD.
2. Siltation and lack of maintenance to the Klip River meander.
3. The non-functional valves at the outfalls of the drainage system.

Several solutions have already been implemented, such as the warning system, raising the levees, and the construction of Qedusizi dam. However, flooding shall always be an attribute of Ladysmith due its location.

Four solutions were investigated such as:

1. Relocation of Ladysmith's CBD.
2. Full dredging of the riverbed and reformation of the channel.
3. Partial dredging and lining of the channel.
4. Construction of an Aqueduct for water transfer from upstream to downstream.

While the first and the last solution proved to be politically, environmentally, and financially costly, the second solution proved to be practical and attainable with the support of the national government. The preferred solution is mainly:

- Dredging of about 1.0 million cu. m of silt and deposits from the river, to enlarge and deepen the cross-sections.
- Installing a pump station on Queen Street. The station hosts 3 pumps of about 1 cu.m/sec discharge and head not less than 10m.
- Building a discharge and calming lagoon with gabions and lined with geotextiles to discharge water downstream of the CBD.
- Replace Duckbell Valves with automated Sluice Gates or with Flap valves.
- Installing 1 x 900mm collector pipeline across, from Alexander to Princess Street, with concrete chambers. The pipe will be a higher level than current drains.
- Installing 2 x 600mm steel pipeline to evacuate water from pipe station to the discharge lagoon.

CONCLUSION

The location of Ladysmith CBD leaves it vulnerable to flooding, especially that all studies show that there is an increase in the rain intensity and the imminent possibility of flooding due to climate change. Selection of the right equipment for the drainage system, can guard against flooding, however the need for yearly maintenance of the river channel is paramount. Looking into Qedusizi dam maintenance is necessary, to avoid silt built-up behind the dam wall like the Windsor dam.

There is a need to emphasize the annual maintenance culture in local government to avoid deterioration of the asset. Alternatively, we shall be faced by building a dam for every existing dam instead of dredging and de-silting.

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