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Publication date
2022

Document Version
Final published version

Published in
Anthropogenic Rivers: Book of Abstracts NCR DAYS 2022 13-14 April | TU Delft

Anthropogenic Rivers

Book of Abstracts

NCR DAYS 2022

13-14 April | TU Delft

Astrid Blom, Laura M. Stancanelli, Jelle A. Dercksen, Clàudia Ylla Arbós, M. Kifayath Chowdhury, Shelby M. Ahrendt, Carolina Piccoli, Ralph M.J. Schielen, Kees Sloff & Jill H. Slinger (eds.)

NCR Publication: 49-2022

Netherlands Centre for River studies

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Keywords — River, Flood, Valkenburg

Introduction

Due to heavy rainfall and steep slopes, on the 15th July 2021 the Geul River discharge rose extremely quickly producing a dangerous flash flood. As a result, the river inundated the city of Valkenburg (Figure 1) causing vast damages. Strategies to avoid future flooding in the area demand understanding and quantification of the effects of different measures. The design of interventions in the river requires knowledge on the role of several factors affecting flood dynamics. For instance, it is important to assess the role of floodplain vegetation to establish whether it is needed to manage it and how. For this, an appropriate numerical model, which includes the river's main channel and floodplains, becomes necessary.

To this purpose, a 2D model was created with Delft3D 4 suite covering the river from the border between The Netherlands and Belgium to Meerssen, close to the confluence with the Meuse.

Figure 1 Affected and flooded areas in Valkenburg (Task Force Fact Finding hoogwater 2021 (2021)).

The Geul River

The Geul River is a right-bank tributary of the Meuse River starting in eastern Belgium at an elevation of 400 m a.s.l. (Figure 2). The confluence with the Meuse is located near Itteren, the Netherlands, at an elevation of 50 m a.s.l. The river is 56 km long in total and has a longitudinal slope of 0.02 m/m in its upper reach and of 0.0015 m/m in its downstream reach. The basin has a total surface of 380 km^2 with a precipitation of 750-800 mm/year in the area close to the confluence and of 1,000 mm/year, in its upper part (de Moor, 2007).

Figure 2 Geul River near the border between The Netherlands and Belgium.

The average river discharge is equal to 3.6 m^3/s and reached a maximum peak of 65 m^3/s.(Dautrebande, et al., 2000). However, the typical annual peaks vary between 20 to 30 m^3/s.
Flow rates higher than 13 m^3/s can generate local floods (de Moor, et al., 2007).

Available data

Discharge and water level measurements were provided by the Limburg Water Board at 26 stations along the Geul River and its tributaries, namely the Gulp, Eyserbeek and Selzerbeek. The most upstream available gauging station on the Geul is located in Cottessen, close to the Dutch-Belgian border, while the most downstream is at Meerssen.

The hydrographs from Cottessen and Meerssen stations had missing values around the peak of the July 2021 flood. The Water Board estimated that the peak discharge at Meerssen was around 85-90 m^3/s on July 15 at 10:00 (record value).

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Therefore, Rijkswaterstaat Zuid-Nederland re-constructed the hydrograph at Meerssen. (Figure 3) whereas we constructed a stage-discharge rating curve for the Cottessen station based on the available data during the flood. The latter curve was used to obtain the missing discharge values of the July 2021 event.

On another note, cross section measurements of the Geul River and its tributaries were provided by the Limburg Water Board. Finally, the elevation of the Geul's floodplains was obtained through the AHN4 digital terrain model (https://www.ahn.nl).

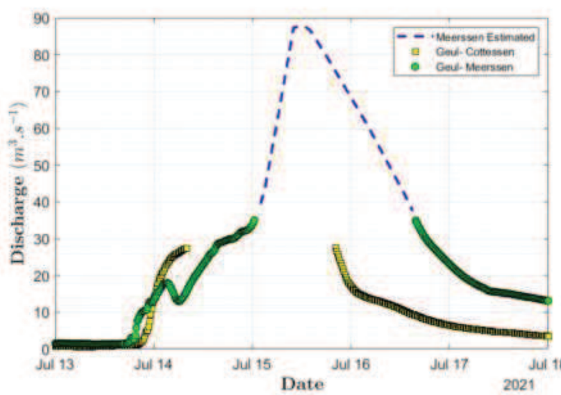

Figure 3 Hydrographs at Cottessen and Meerssen stations denoted in yellow squares and green circles, respectively. The dashed blue line represents the estimated hydrograph at Meerssen.

Delft3D 4 suite model

The model covers the Geul main channel and its floodplains along 34 km and includes all bifurcations and the final stretch of the tributaries. The model includes all buildings, water bodies and structures (weirs) that are present within the domain (Figure 4).

The main channel bed level is about 2.5 m lower than the floodplain level in the upper part of the river and 3.5 m lower in Valkenburg.

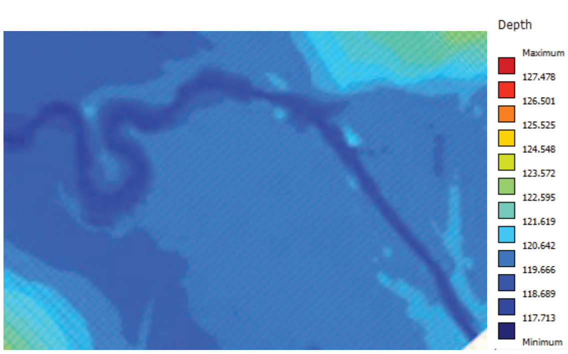

Figure 4 Model grid and elevation near the upstream boundary.

The boundary conditions are: hydrograph at the upstream end of the Geul, Gulp, Eyserbeek and Selzerbeek rivers, and water levels at the downstream end of the Geul (at the Meerssen station)

The roughness coefficients of the river and the floodplains are used for the calibration. Vegetation roughness is derived using the method developed by Baptist (2005).

Preliminary results

The water depth along the Geul River on the 28th of July 2012 is represented in Figure 5. It varies around 1 m and reaches 3.5 m in some pools. These preliminary results were obtained first by calibrating the model with a low discharge of 1.2 m^3/s at the Geul upstream boundary.

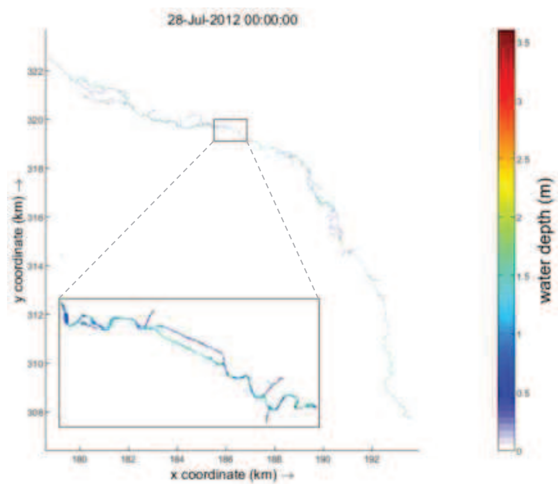

Figure 5 Water depth in the Geul River on July 28,2012, obtained through a Delft3D 4 suite model. The area around the Geul in Valkenburg is denoted by a black rectangle and magnified in the bottom left corner.

Future perspective

The calibrated model will be used to reconstruct the event of July 2021, evaluate the flooded areas, and analyse the role of floodplain vegetation on flooding in the area under several scenarios.

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