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Open LID stormwater system tested during severe flood event

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ABSTRACT: An open stormwater system for Low Impact Development (LID) was constructed in Augustenborg (Malmö, Sweden) 15 years ago, to ease the problem with basement flooding, and increase the ecological and aesthetical values of the area. The more or less regular floods were stopped. In 2014, during a severe flood in Malmö, the LID were proven to work efficiently during extreme events.

In Augustenborg, a 31 hectares residential area, stormwater is controlled in LID system containing detention in ponds and areas for temporarily flooding, infiltration on green roofs, lawns and parking, as well as slow transport in swales, ditches and canals. The old combined sewers are still used for wastewater. The LID stormwater system was constructed by the end of the 1990s by VA Syd (utility company) and MKB (housing company) as a part of the project called Eco-City Augustenborg. For a detailed description of LID in Augustenborg, see Villarreal et al. (2004). Two pictures from the area are shown in figure 1. About 3,000 people live in the area in 3–6 storeys apartment blocks built in 1948–1952. The area continues to be developed and this year a 14-storeys building named Greenhouse is finished.

Figure 1. Canal and pond in Augustenborg. Photographer: Johanna Sörensen.

Roesner et al. (2001) claimed that attenuation by 90% of annual runoff is needed to protect receiving waters. Augustenborg does not directly connect to receiving waters, but to a combined sewer. Therefore, flood risk reduction and reduction of combined sewer overflow (CSO) has been in focus. CSO and flood risk reduction are achieved by reduction of peaks and total flow by LID structures. Villarreal et al. (2004) modelled this effect for Augustenborg and could show that the ponds play a major role to reduce flood risk. By hydrograph simulations, they could show that the system is able to detend all runoff from a 10-year event. Shukri (2010) compared the open stormwater system in Augustenborg with the former (combined sewer) system by modelling, and found a 50% decrease in runoff for a heavy rainfall in June 2007. During the flood event in 2014, the system was tested with a real, heavy rainfall, which had a noteworthy longer return period than events earlier tested in models.

On August 31, 2014, an intense rainfall hit Malmö. Almost the entire city was affected and about 3,000 properties were reported flooded. Streets, houses, underground garages and even the hospital got flooded. Several families could not move back to their home for more than one year. The rainfall over Malmö had a total volume of 60–120 mm (Figure 2), and corresponds to rainfall with return period of 50 to ~200 years. In Augustenborg, 116 mm was measured, and most of the rainfall (100 mm) fell within 3.5 hours. This was the biggest rainfall event since the measurements started in the late 1800s. Data from nine stations were analysed. Maximum rainfall volumes were calculated for durations in the range of 15 minutes to 12 days with a moving window of the corresponding duration (Figure 2).

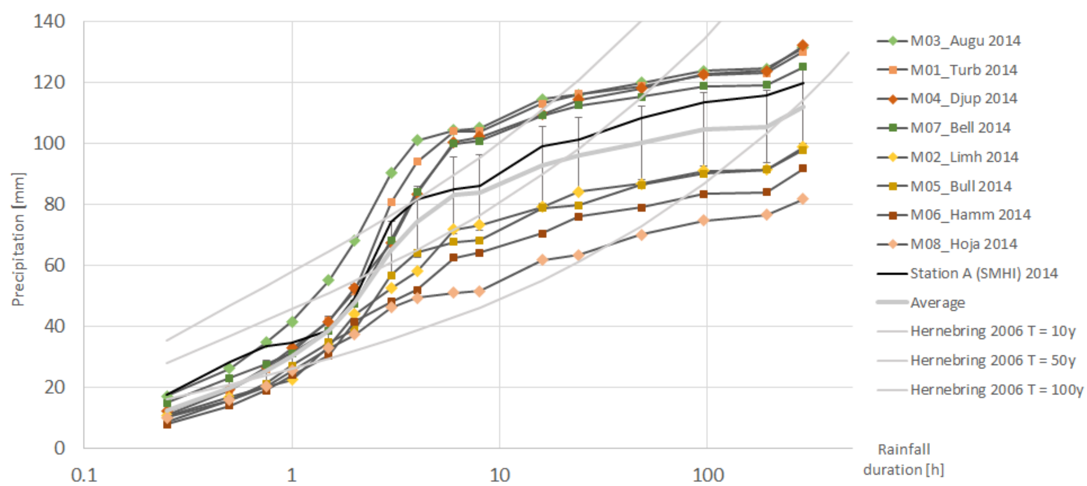

Figure 2. Maximum precipitation volumes for durations between 15 minutes and 12 days rainfall. Precipitation is measured at Augustenborg, Turbinen, Djupadal, Bellevue, Limhamn, Bulltofta, Hammars park, Höja and SMHI station A. For comparison the intensity-duration-frequency (IDF) curves from Hernebring (2006) are given.

Flood claim data were collected from both an insurance company (Länsförsäkringar Skåne), as well as the water utility company of Malmö (VA Syd). Flood magnitude is defined as number of flooded properties per hectare. The flood magnitude for the 31st of August 2014 is shown in figure 3 and table 1. Five areas with similar age and building coverage (% building area compared to total area) around Augustenborg were selected for comparison. All five areas have combined sewer system, corresponding to what Augustenborg had before LID was implemented.

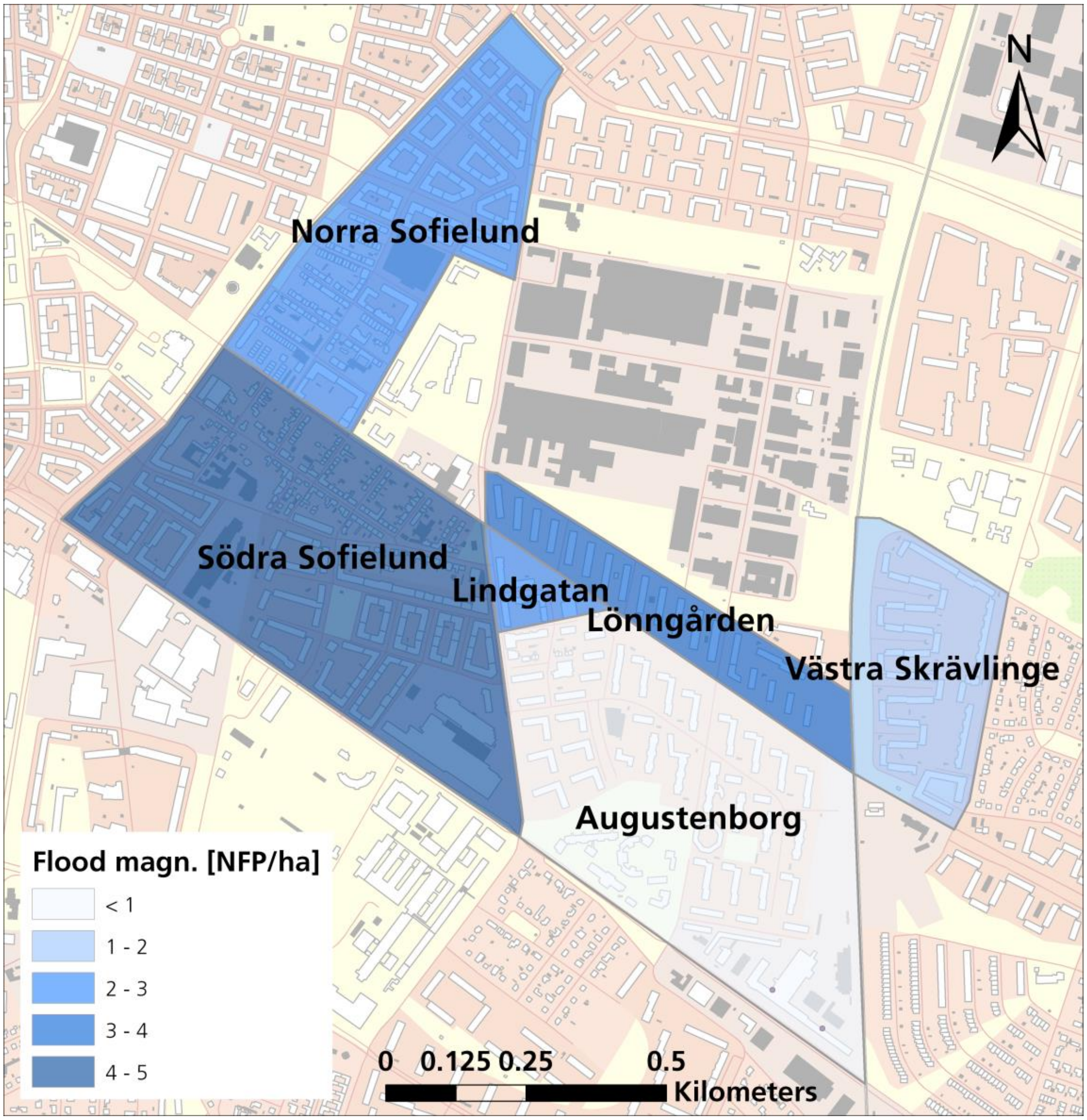

Figure 3. Flood magnitude for Augustenborg and five similar areas. Great flood magnitude is shown in dark blue and lower flood magnitude in light blue.

Table 1. Area, building cover, number of flooded properties (NFP), and flood magnitude (NFP/ha) for 31 August 2014 in Augustenborg and five similar areas.

Name	Area [hectares]	Building coverage [%]	Number of flooded properties (NFP) [average LF&VA Syd]	Flood magnitude [NFP/ha]
Augustenborg	**31**	**20%**	**7.0**	**0.2**
Lindgatan	2	18%	4.5	2.2
Lönngården	8	20%	28.5	3.6
Norra Sofielund	18	33%	37.0	2.0
Södra Sofielund	33	30%	144.0	4.4
Västra Skrävlinge	11	19%	20.0	1.8

Compared to five similar areas in the same part of Malmö, not constructed according to LID, 10 times less properties were flooded in Augustenborg approximately (see table 1 and figure 3) during the event. All areas evaluated have combined sewerage systems and are mainly residential areas. Building coverage in the areas is 18–20 %, except for Norra and Södra Sofielund, where the coverage is 30–33 %, see Table 1. A comparison between the five surrounding areas and Augustenborg is therefore reasonable.

Earlier research has only made model simulation of flood reduction, but no test during actual flooding has been found in the scientific literature. With model simulation, Qin et al. (2013) found that a LID in Guang-Ming New District in Shenzhen, China could reduce flood risk. They also discussed different kinds of solutions and their impact on flooding. Liu et al. (2014) claimed that runoff with 1–2 years return period can be eliminated, while runoff with 5–10 years return period can be reduced by 93–97% in an urban community in Beijing.

Even though a few properties were flooded in Augustenborg, it can be concluded that the LID stormwater system performed successfully during the extreme storm event on the 31st of August 2014. This is the most severe flooding in Malmö in modern history.

KEY WORDS: extreme precipitation; pluvial flooding; open stormwater system

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