Integrated modelling of complex sewer-river interactions in the Woluwe catchment (Brussels, Belgium)

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ABSTRACT

The northern area of Brussels is currently not yet served by a treatment plant, which causes dramatic pollution problems in the receiving watercourses. Investment programmes are at the moment being worked out, with an emphasis on restoring the natural drainage system that as a result of urbanisation was lost. This paper describes the approach and the objectives of the integrated modelling study of the Woluwe catchment.

The Catchment Description

The Woluwe catchment (about 10 000 ha, 200 000 inhabitants) is an area at the eastern edge of Brussels (Belgium). It forms part of a larger drainage area (about 1.2 M inhabitants) that covers almost the whole urban area of Brussels. This global area is currently not served by a treatment plant but investment plans are now finally being worked out to build the plant and have it operational by 2004.

The catchment is – like the rest of the Brussels'area - specific in its hydraulic and hydrological characteristics, as a result of rapid urbanisation in the last two centuries. When first watercourses in the area became polluted by untreated sewage discharges, and later on – as a result of the urbanisation - also gave rise to floodings, measurements had to be taken to resolve huge sanitary problems.

A solution was found in culverting larger parts of the watercourses, thereby degrading them to mere sewers: a process which, during the years, lead to the complete 'destruction' of the natural hydrological system of the catchment. It is to be mentioned though that – unlike the other catchments in the Brussels' area - the Woluwe catchment has at least preserved some parts of the open watercourses, thus leaving a starting point for rehabilitation.

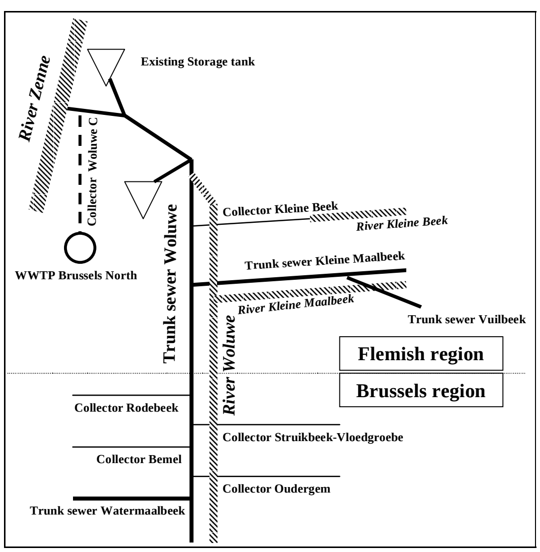

Figure 1 Schematic view of the backbone infrastructure in the Woluwe catchment

The backbone of the drainage system are the four cunette shaped trunk sewers (with sizes ranging from 2.5 to 4.5 m and with a total length of about 30 km). The largest one carries a dry weather flow of more than 1 m^3/s, and storm flows of around 35 – 40 m^3/s. Besides the wastewater of the householdes and large industrial estates, the sewer system also carries all storm waters from houses, streets, parking areas, some 25 km of motorways around Brussels, and even from the International Airport.

Due to multiple interconnections between sewer and river system, the flow from all the natural watercourses, including runoff from large agricultural areas at the boundary of the catchment, and even the groundwater, drained from the very trench of the main trunk sewers, are finally all collected in the main trunk sewer. The result is a complex, extremely combined sewer network that drains a mixture of wastewater, storm water, surface water and infiltration water.

Besides hydraulic problems, it can be understood that such a system also suffers enormous dilutions during wet weather. This could be a major problem for the operation (or should we say 'operationability'?) of the future treatment works.

The Study Objectives

The objectives of this study are multiple and can be summarised as follows:

- to analyse the hydraulic and hydrological behaviour of the system, through an inventory and a thorough analysis of the sewer system and the water courses in the whole of the catchment;
- to analyse the behaviour of the system from a pollutants point of view;
- to put forward a number of options and solutions for the rehabilitation of the drainage system (both the sewers and the natural watercourses), both from a hydraulic and water quality point of view;
- to define a strategic plan for the most necessary investments.

The main immediate objective of this study will be the engineering design of six collector sewers in the downstream part of the system, transporting the wastewater to the treatment plant Brussels-North. These are to separate important parts of the now combined flow and carry 8 DWF to the future STW. Their design need to fit in the global objectives of the study.

Future investments will concentrate on restoring natural watercourses and separating surface waters and motorway drainage from the sewer system. Negotiation will also be held to build separate system for the huge industrial estates.

The Modelling Study

The study set-up exists of three major parts: data collection, modelling existing situation, modelling planned situation and optimisation of designs. (see figure 2).

Data Collection

For the data collection of sewers and rivers various approaches were followed over the Woluwe catchment. For the upstream part in the Brussels region a broad brush model exists, and so no additional data collection is carried out. For the part of the catchment different levels of simplification were used in the data collection. In the core area, where new collectors are to be designed shortly, a more detailed level of data collection is carried out than in the outer area. The full database and model consists of over 3000 nodes.

A five months flow and quality monitoring campaign was carried out to identify the major bottlenecks and anomalies in the system, both during dry weather and wet weather.

To this end, 45 flow monitors were installed, as well as 10 rain gauges, 5 samplers and 3 water quality probes. Special attention was needed for the flow monitors in the trunk sewers. At these locations use was made of double sensors, so as to get a full picture for the flow in these unusual shapes. An investigation on the velocity patterns in cunette shaped sewers under various flow conditions, was carried out by the university of Sheffield, using 3D computational models .

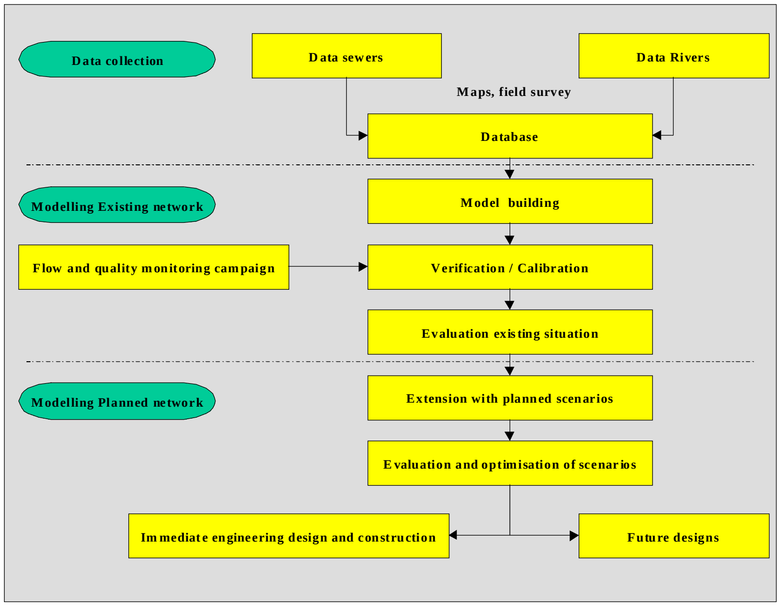

Figure 2 Schematic view of the study set-up

Modelling existing network

A first phase in the model verification was the analysis of the recorded dry weather flow data. Comparison of different dry weather periods, and also a comparison with a limited monitoring campaign, carried out two years earlier (but in very different antecedent hydrological conditions), clearly revealed important infiltration and inflow of surface water in almost all locations.

For the most downstream location in the main trunk sewer, it can be shown that the dry weather flow (about 1.2 m^3/s) consists for almost 50 % of infiltration and surface water. For the remaining wastewater flow, a very constant camel shaped diurnal profile can be derived. This can also be seen in the other locations, be it more scattered as a result of the smaller flows. In some areas, the contribution of offices to the daily wastewater profile is very pronounced, leading to a significantly different dry weather flow during week and weekend.

A remarkable issue on the wet weather verification was that -although the catchments contain a considerable number of storage tanks and open ponds (the largest ones being an open pond of 350 000 m^3 and an underground storage tank of 40 000 m^3)- no event in the monitored period seemed to be large enough to cause the structures to operate or to fill significantly. It must be admitted that no really heavy thunderstorms were recorded.

To have a better view on this, a general evaluation of the existing network was finally carried out using composite design storms with a return period of 2, 5 and 10 years and including RTC modelling for the bigger ancillary structures.

It can be noticed that different locations show a very pronounced ‘tail’ in the velocity hydrographs, which prooves the connection of surface water and delayed runoff from pervious surface.

Modelling Planned Network

The extension of the existing model to a planned situation, with a view to defining the necessary investments, is a rather complicated issue, as a result of the large amount of parties involved.

Only in the Flanders' region, modifications in the sewer network are depending on the investment schemes of Aquafin, the Brussels' Region (the treatment works), CEC (the company entrusted with the maintenance and operation of the existing trunk sewers) and 6 different municipalities. Rehabilitation schemes for the watercourses have to be approved by three different authorities and again the muncipalities. All water quality aspects finally are to be discussed with the Flemish Environmental Agency (VMM).

Besides the investment schemes for sewers and watercourses, the economic activity in this area is a very important factor. Industrial estates (mainly offices) and airport related services like hotels etc., are subject to continuous expansion and restructuring.

The major challenges for the immediate future are the engineering aspects of the six collector sewers, which are planned to be constructed during the next three years. The main one has a pipe diameter of 2.2 m, runs at more than 7 m deep in places, and has to be constructed in the middle of a busy industrial area (including major utility mains). It has to cross the entrance roads to the motorway and two major railway lines.

Interim Conclusions

The integrated modelling of the Woluwe catchment is to result in restoring the natural drainage system of an area, where currently all possible waste flows and natural drainage are completely interwoven. Considering the impact of all political, social, technical and financial constraints, a huge effort will be needed over several years to realise all the necessary decoupling of rivers and waste water infrastructure, which is to lead to a serious improvement of water quality and the water management as a whole.

The water quality modelling aspects will not only show the impact of the future investments on the river quality (including the intermittent pollution to be expected by CSO discharges), but will be a major tool to optimise the quality of the influent to the Brussels' treatment works.

Discussion

Question Ian Holroyd Engis

Why does Brussels not have a sewage treatment works?

Answer

The reason for not building a works many years ago must be seen in relation to the rest of Belgium. Before Aquafin was set up in 1990, only a marginal part of the country had treatment facilities. Apparently for some reason Belgium did never show a big interest in the problem.

More recently, when things started to change, Brussels did not follow mainly because of the difficult political and economical situation of Brussels as an independent region on the one hand but as a conglomerate of 19 autonomous municipalities on the other hand.

Discussion

Question **Adrian Saul** **Sheffield University**

You have a lot of nice cunette shaped sewers, will you keep this type of sewer or move to more traditional circular systems?

Answer

As the new systems do not suffer from such big variaties in flows to be carried, there is no need for cunettes at this moment. It must be admitted though that for this existing system, the same self cleansing capacities could probably never be reached with a circular pipe.

We will be using circular pipes for new construction, but will be keeping the existing cunettes , particularly for the river systems.

Question **Gerard Morris** **Environment Agency**

When you are disconnecting the major land drainage inflows, the airport is being taken out, where will it go?

Answer

Not the whole airport is connected to this system but this one is the only combined connection. There are no plans to separate it or to disconnect it, neither are there plans for building a specific works for the airport.