

# DIGITAL PLANNING OF WASTE WATER FLOWS IN THE CITY OF AMSTERDAM

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## ABSTRACT

The Department of Urban Water Management and Sewer Systems and the Tauw Consultants are developing a planning-tool based on a geographical information system. The aim is a system that is flexible and adaptive, and to realise this objective they are making use of recent developments in (standard) software and data management. The waste water planning system intends to operate on a user-friendly interface which will connect digital information from different sources such as: waste water production; city development locations for housing; public, commercial and factory areas; collection of polluted rainwater from main traffic roads and alternative routes of the wastewater transport system. The collection and flexible management of data is a very important part of the planning process.

## INTRODUCTION

Amsterdam is one of the first cities in the Netherlands where separated sewer systems were build and have been used since 1930. Thirty percent of the city's paved area is connected to traditional combined systems, compared to 70% connected to separate systems that discharge storm water directly into the surface water. There are more than 300 collection areas, each containing a sewer system and a pumping station.

The city of Amsterdam is a dynamic environment in a relatively small area. A big part of the city is situated below sea level. The optimisation of land use leads to many major developments such as the overbuilding of main traffic connections with office and housing apartments and commercial areas (Plan South-Axe), the intended relocation of treatment plants to Amsterdam West and the construction of new main subway connections (North-South line).

At present the waste water is transported to four main treatment plants through a network of collection systems with pumping stations and pressured pipes. Future city developments will have a big quantitative impact on the waste water system (collection-transport-treatment): the capacity of pumping stations and piping systems, etc.

In the next ten to twenty years the waste water production in the South-Axe area (figure 1) will increase more than 100%. The new main treatment plant is located in Amsterdam West. The existing

treatment plants in the east and south-eastern area of the city will be closed down. Therefore, the main direction of the waste water transport system will be changed from eastward to westward.

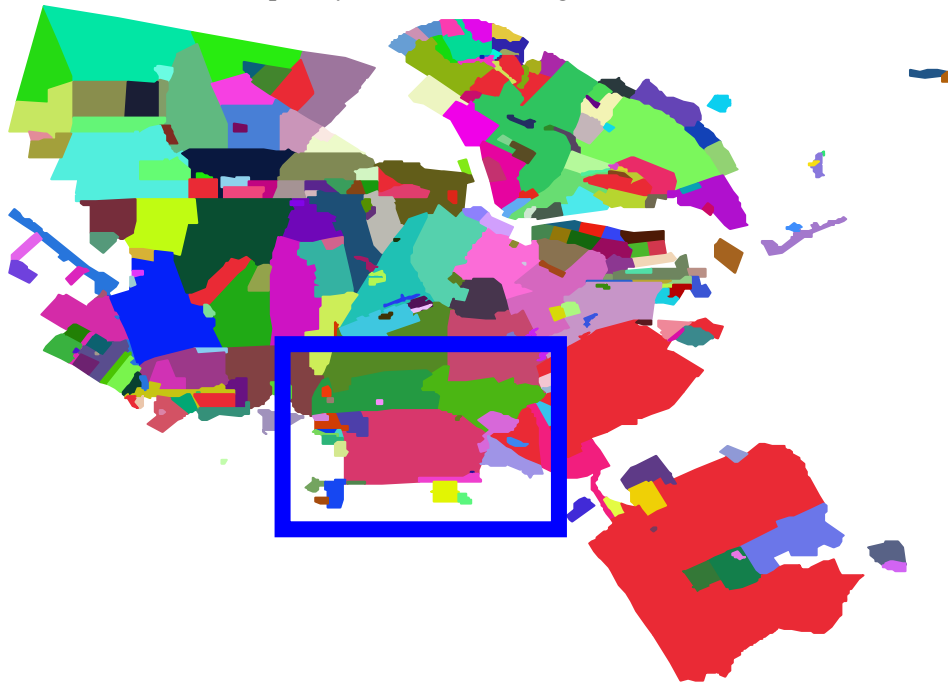


Figure 1 Waste water collection areas in the city of Amsterdam, research area (South Axe) indicated in (blue) frame.

Another development is the collection and treatment of (polluted) rainwater. Generally it is assumed that main traffic roads, connected to a separate system, are a major source of pollution of the surface water in the Amsterdam canals. Additional collection of polluted rainwater from main roads will lead to an additional increase of the load on both the waste water system and the waste water treatment plant.

To handle these large amounts of data accurately an information management procedure is set up using components such as a G(eographical) I(nformation) S(ystem) and an hydraulic model (Infoworks). This procedure enables the system to flexibly adapt to changing data, to function as a geographical check for missing and double data, and to make quick and flexible comparisons of different scenarios. The connection of geographical data to an hydraulic model makes it possible to analyze a broad range of scenarios simply by varying: the structure of the transport system, the collection of extra rainfall-runoff amounts, the boundaries of the collection areas, future developments. This paper will discuss the definition and presentation of the basic data, the testing of the planning system on measured data and it will give examples of scenarios in handling future waste water flows.

## AMSTERDAM COLLECTION AND TRANSPORT SYSTEM

The waste water is collected into 300 different combined and separated sewer systems. More than 99% of the waste water is pumped under pressure to a waste water treatment plant (wwtp). The collection systems and pumping stations transporting the waste water to the treatment plant are mainly switched serially (figure 2). Often the water is pumped from one collection system into the next system. Therefore a change in the capacity of an upstream pumping station may effect the functioning of several downstream components of the waste water system.

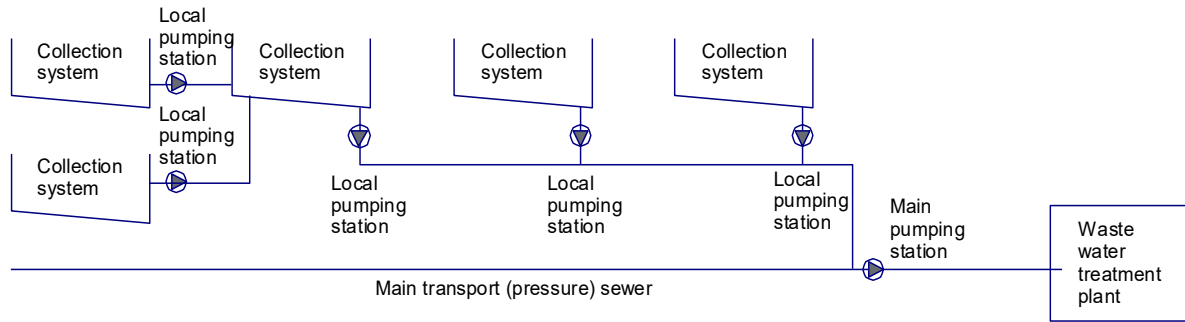


Figure 2 Scheme of collection systems, pumping stations and transport system.

In the traditional approach, the dimensioning of the system is based on analogue data. Without a geographical check however, it happens that information on the waste water load is counted double. Traditionally the hydraulic functioning of the collection systems is handled individually. In every collection system a safety factor is used to determine the capacity of the pumping station. The present waste water system, therefore, has a substantial overcapacity because of multiple use of safety factors. This integral approach to assess the necessary capacity of system components is needed to determine the available overcapacity in the existing system in order to handle the extra waste water loads (quantities) of nearby and future developments.

## GEOGRAPHICAL DATA

The collection of geographical data is an important first step in a digital planning system. The basic waste water production data is administrated in many different city departments. Four sources are used to generate the following digital data:

- information on housing and population;
- information on land use, marked in water and green areas, roads, roofs, etc (figure 3);
- information on drinking water distribution (figure 4);
- information on future developments (figure 5);
- information on traffic movement.

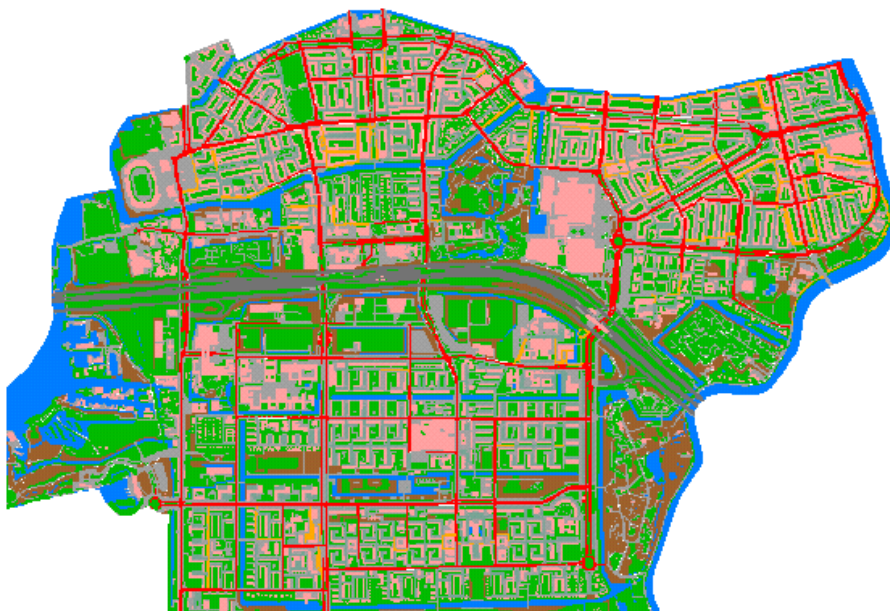


Figure 3 Land use classification in the South axe area.

The plan area is situated around the South Axe highway, part of the Amsterdam ring road (beltway). In this area the Olympic stadium (1936) is situated in the north-west.

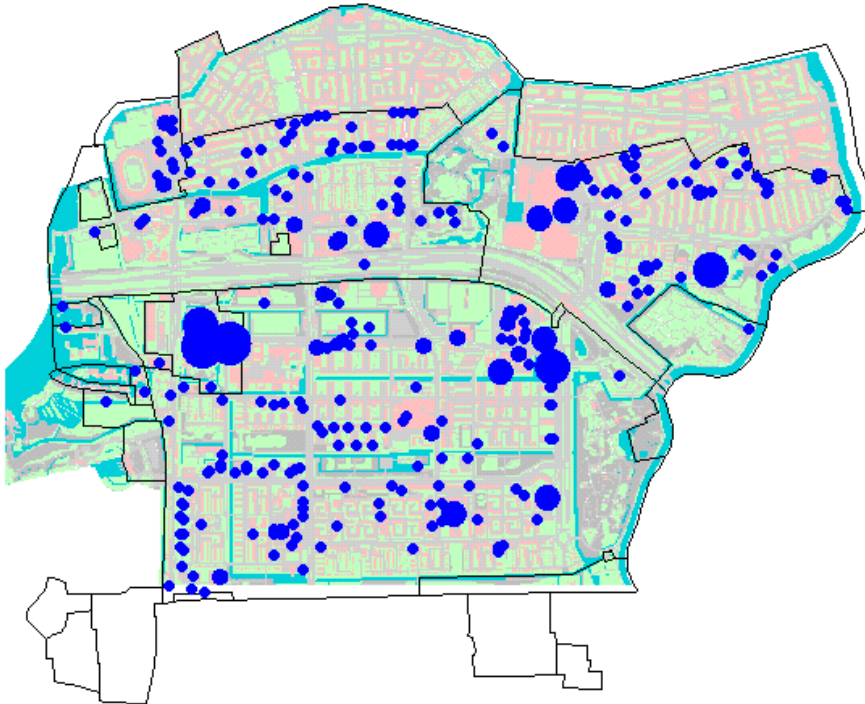


Figure 4 Water distribution , users > 300 m<sup>3</sup>/year.

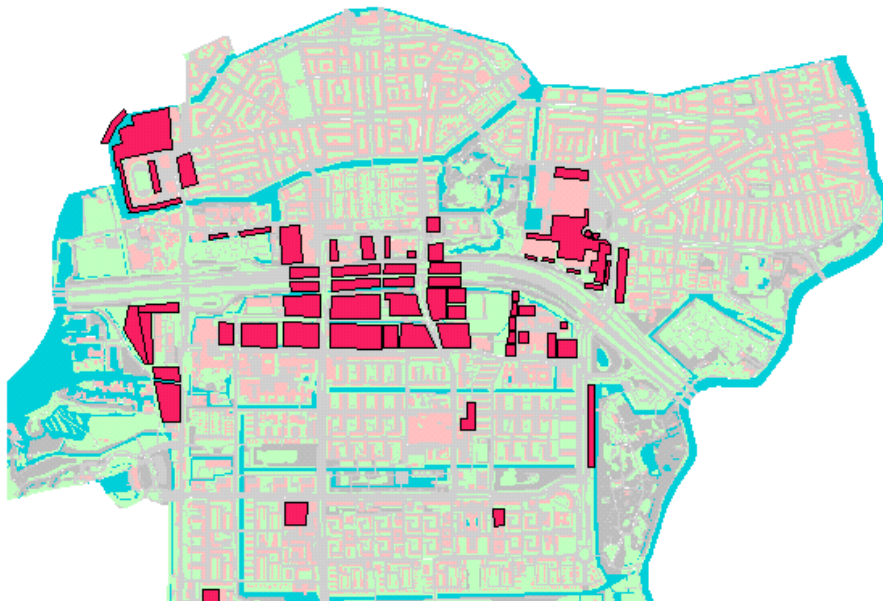


Figure 5 Future land use developments until 2030.

Amsterdam is one of the few cities in the Netherlands where water distribution to older housing areas is not metered. Consequently information on water distribution to small-scale users is not available. Information on housing and population is used to predict the waste water production of users that produce less than 300 m<sup>3</sup>/year. The water distribution map (figure 4) shows locations with a water use of more than 300 m<sup>3</sup>/year. These are mainly small business and commercial areas, hospital and exhibition areas. The annual amount is transformed into a daily average, taking into account the type of water use (5 week days, 8 hours per day; 7 week days, 24 hours per day; etc).



Future developments in the area are concentrated up and around the highway. The area planning is to cover the transport area with high-rise buildings to provide space for multifunctional centres with business and commercial areas, housing, hotels, theatres. A substantial amount of housing is planned in the Olympic stadium area

The area-shapes shown in the map are marked with an estimate of the future population in the housing areas and the future number of waste water equivalents related to a classification in area use. Also given is the year of realisation.

The future development map is based on fast changing data from many different sources. A visual check-up proved to be necessary to prevent double counting of data.

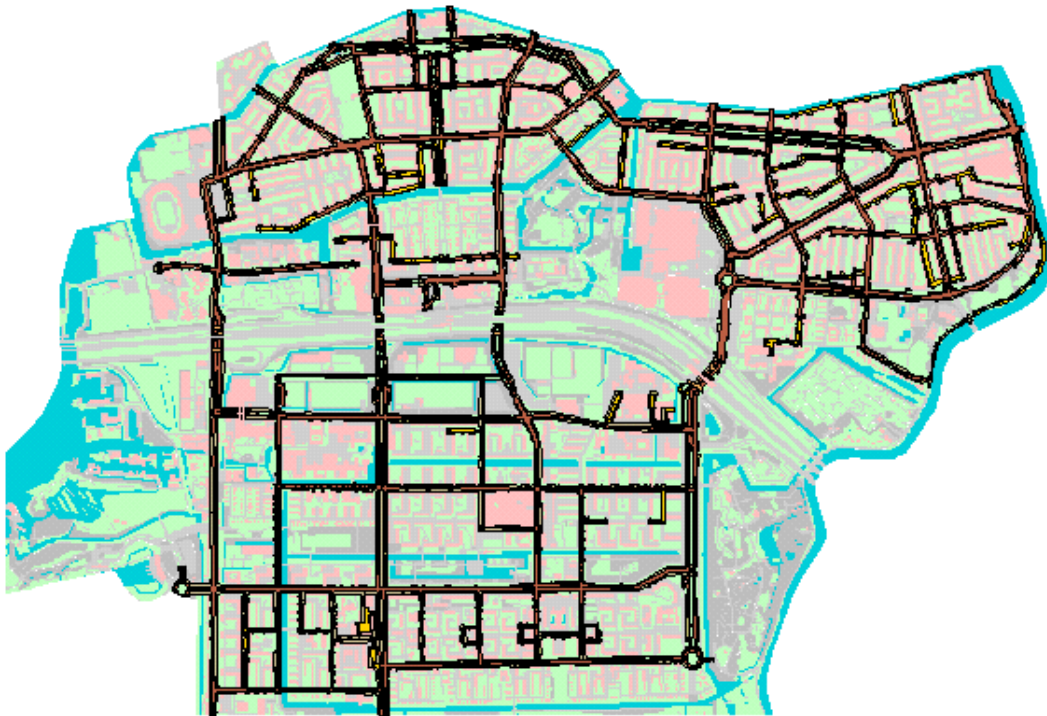


Figure 6 Road areas with potentially polluted rainwater.

Another future source of waste water is the collection of waste water from polluted roads. In the Netherlands it is a basic assumption that rainwater from roads with a traffic intensity of more than 1000 vehicles per day has to be collected and treated. These surfaces are shown in figure 6.

The previous description of the waste water production components is not 100% complete. There are more sources of waste water on the system such as discharges from companies using surface or groundwater, discharges of pure groundwater draining lower areas, controlled discharges of polluted groundwater, discharges of large number of houseboats (not registered in the housing database), discharges from waste water systems of other municipalities. The main part of these discharges are manually registered in a special GIS layer. An extra 10% safety factor is used to account for unknown sources. The plan area is covered with the collection areas of the urban waste water system (figure 7).

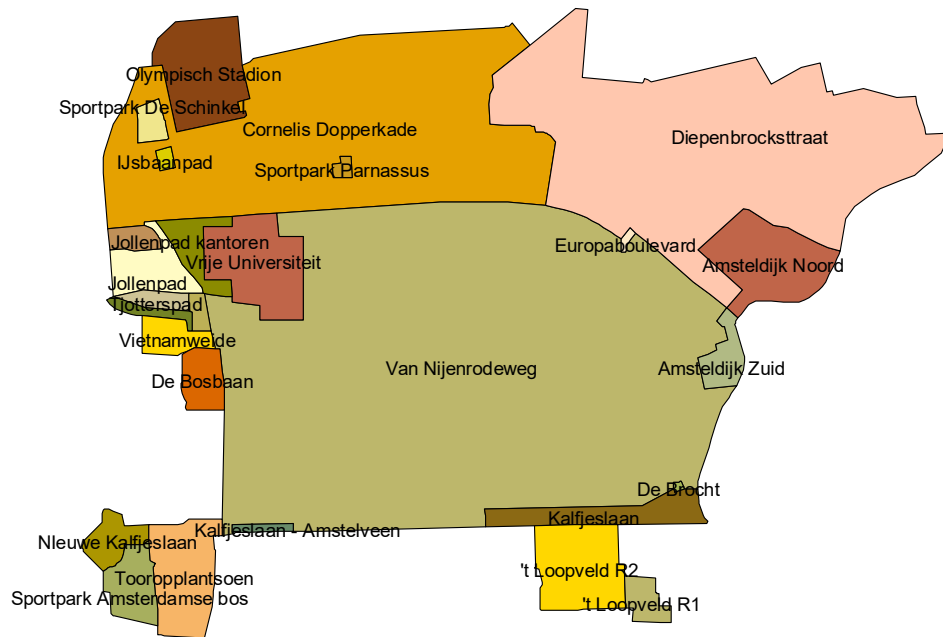


Figure 7 Collection areas Amsterdam South Axe.

The collection areas are connected to the waste water transport system (figure 8). In Infoworks an hydraulic model of the transport system is built consisting of one storage node per collection system. This storage node is connected to the transport system with a pumping station (red triangles).

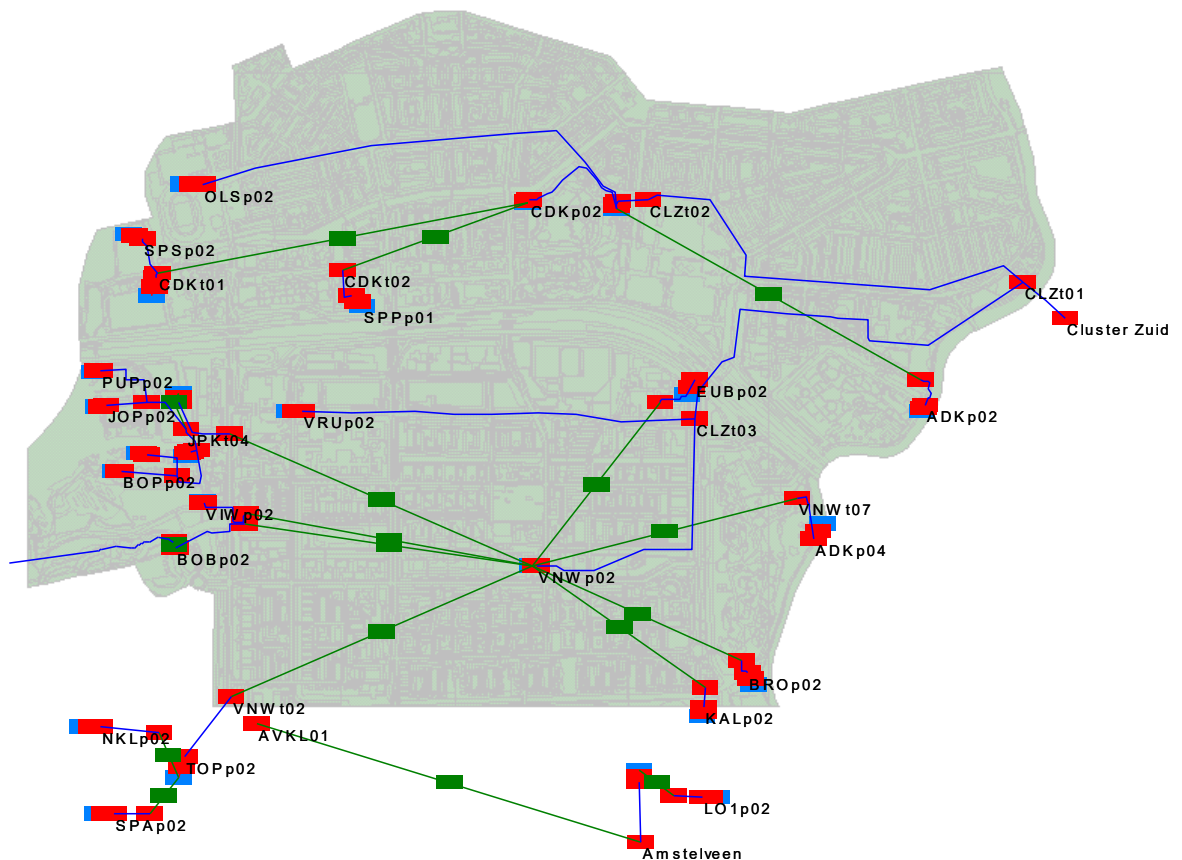


Figure 8 Transport system Amsterdam South Axe.

## INFORMATION MANAGEMENT SYSTEM

The information management system consists of a procedure which includes the following steps:

- 1 The waste water amounts of the different sources are assigned to the corresponding collection areas (GIS);
- 2 The waste water load on the collection areas is coupled to the hydraulic model of the waste water transport system (GIS-Infoworks);
- 3 A static simulation of the transport system gives an insight in the summarized flows in the different sections of the system, the necessary capacity of the piping system and pumping stations (Infoworks).

In Amsterdam the functioning of the (main) pumping stations is measured continuously. This makes it possible to compare the (dry weather) discharges of pumping stations in the theoretical model with the practical situation. The daily cycle of the Diepenbrockstraat pumping station is shown in figure 9.

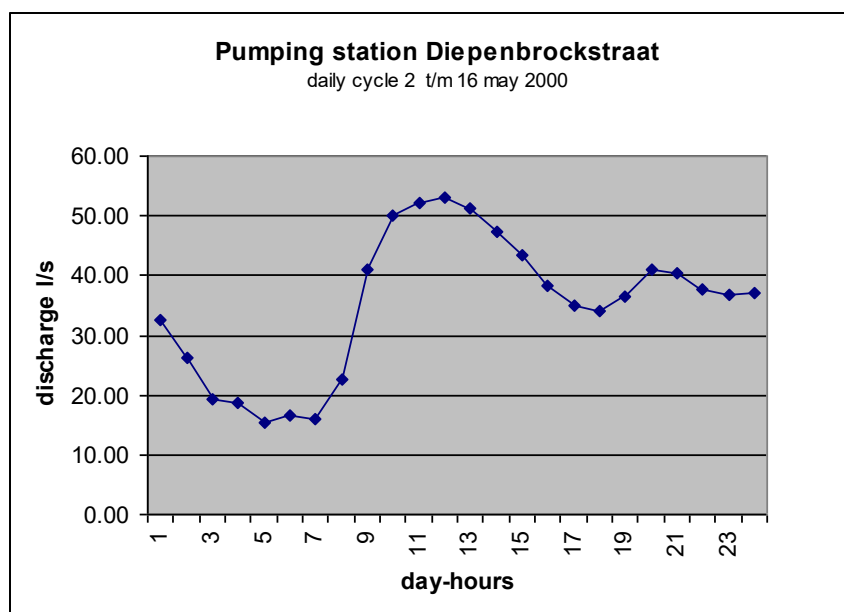


Figure 9 Daily pattern of waste water pumping station.

The average maximum discharge is measured close to 55 l/s. According to the traditional *safety on safety* design method the predicted discharge is 170 l/s, where the integral digital approach gives a predicted maximum discharge of 70 l/s.

The integral approach gives a more realistic prediction of discharge capacities in the system. This also affects the predicted discharge of waste water to the treatment plant. After a verification of the hydraulic model and the waste water input the procedure is carried out for a number of planning scenarios.

## PLANNING SCENARIOS

The major part of future developments in waste water production are shown in figure 5. The question is how to deal with a significant increase in waste water production. It is very likely that major parts of the present transport system have to be expanded.

Furthermore there are developments like the realisation of a new subway line, where the collection area Diepenbrockstraat is divided in two sections and a new pumping station is realised. The removal of the main treatment plant to Amsterdam West also means that changes are planned in the structure of the transport system. Four different planning scenarios of the collection areas are presented in figure 10.

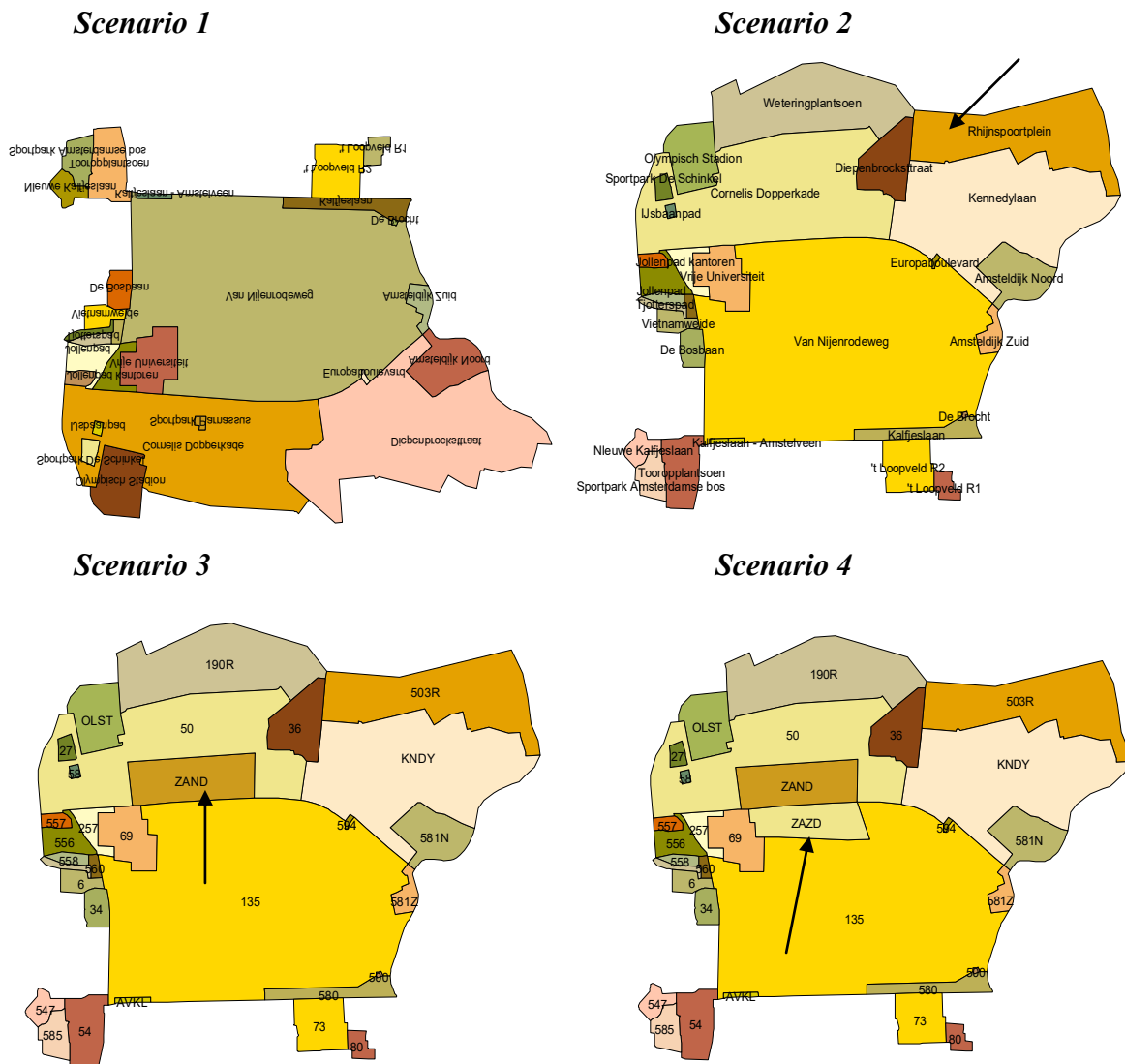


Figure 10 Planning scenarios Amsterdam South Axe

In scenario 1 the reference situation 1998 is presented. An additional input of rainwater from two additional collection areas in the north-eastern part of the system is taken into account in scenario 2. Also in this part of the system the collection area Diepenbrockstraat has been split up. The scenarios 3 and 4 deal with the developments around the South Axe Highway. In scenario 3 a new separate collection system is projected to realise a direct input to the main transport system.



The capacity of the present collection system is insufficient if there is a 100% increase of waste water production. According to the current future planning building activities will start along the northern border of the South Axe Highway. In scenario 4 an extra collection system is created along the southern border of the highway.

## DISCUSSION

The integral (digital) approach is aimed at making a quick analysis of the consequences of the different planning scenarios. It is an adequate method for anticipating building prognoses figures that change every month and for continuously developing ideas for possible solutions. By comparing the investments and exploitation costs, the most cost-effective way for collecting and transporting the waste water to the treatment plant can be obtained.

A new main transport route is projected through the South Axe area. There are many possible ways of adapting the structure of the transport system to future needs. This more accurate approach has shown that better use can be made of existing overcapacities in the system. Moreover a time dependent conversion to the future situation has to be tuned in to the flexibility of the existing system. The order of realisation of future developments can have a serious impact on a cost-effective development of the waste water system. This planning procedure offers a flexible method to try out a great number of variants in search of a well-founded and cost effective solution.

## CONCLUSIONS

- This procedure offers flexible adaptations for changing data, a geographical check on missing and double data, and a quick and flexible comparison of different scenarios.
- The connection of geographical data and an hydraulic model makes the analysis of a broad range of scenarios possible by varying among others: the structure of the transport system, the collection of extra rainfall-runoff amounts, the boundaries of the collection areas, future developments etc.
- An integral digital approach for obtaining waste water data based on a geographical information system offers a more accurate description of the waste water loads on the waste water transport system and treatment plant. The comparison of the observed and theoretical discharge capacities in pumping stations has shown that the integral approach is more reliable.

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