



**CHALMERS UNIVERSITY OF TECHNOLOGY**

**URBAN GEOHYDROLOGY RESEARCH GROUP**

**Geology**

**Geotechnical Engineering**

**Hydraulics**

**Water Supply and Sewerage**

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Hydrology Research**

**URBAN HYDROLOGY RESEARCH IN SWEDEN 1978**

**JAN HÄLLGREN**

**PER - ARNE MALMQUIST**



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## FOREWORD

This report is an off-print of a paper presented at the Nordic Hydrological Conference in Helsinki July 31 - August 3, 1978. The paper has been initiated by the Swedish Coordinating Committee in Urban Hydrology Research and describes briefly the tasks of the Committee and some of the more comprehensive research projects within urban hydrology in Sweden.

Jan Hällgren      Per-Arne Malmquist

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## URBAN HYDROLOGY RESEARCH IN SWEDEN

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## ABSTRACT

Swedish urban hydrological research is slowly changing directions. From being oriented mainly towards the design of storm water facilities, the urban hydrological research now turns towards the planning of urban water systems and towards the maintenance and operation of existing storm water systems.

The Coordinating Committee for Urban Hydrology Research has been working since the autumn of 1977. The tasks of the committee are, e.g., to initiate, plan and coordinate urban hydrological research in Sweden. The committee has developed a research model which is briefly described in the paper.

Of the great number of existing research projects only some of the more comprehensive ones are presented in the paper, namely "Infiltration of storm water", "Optimization of storm water systems", "Water balance studies", "Snow hydrological studies" and "Operations of combined sewer systems".

## INTRODUCTION

Swedish urban hydrological research is financed mainly by three agencies. The Swedish Council of Building Research (BFR), the National Swedish Environmental Protection Board, Research Committee (SNV-F), and the Swedish Natural Science Research Council (NFR).

During the seventies BFR has sponsored most of the geohydrological research, especially pertaining to urban areas, in Sweden.

Paper presented at the Nordic Hydrological Conference in Helsinki  
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BFR appointed in 1972 a Research Coordinating Group for Geohydrology. The research field comprised ground-water and surface water problems related to building technology. The work of this group was terminated in 1976/77 but there was a need for further coordination of the urban hydrological research. An organization plan of a new coordinating group, covering also interests other than those of BFR, was suggested in "Urban Hydrologi - översikt av forskningsbehovet" (Carlsson & Falk, 1976). That report also deals with the research needs and gives a first research model for urban hydrology in Sweden.

In October 1977 the Swedish Coordinating Committee for Urban Hydrology Research (SUH) was established. The tasks of SUH are, among other things, to initiate, plan and coordinate urban hydrological research in Sweden. Dissemination of research results is also an important task. SUH consists of members from the three mentioned research financing agencies and of members from the National Swedish Environmental Protection Board, the Swedish Geotechnical Institute, the Swedish Geological Survey, the Swedish Meteorological and Hydrological Institute and the Swedish Water and Sewage Works' Association (VAV).

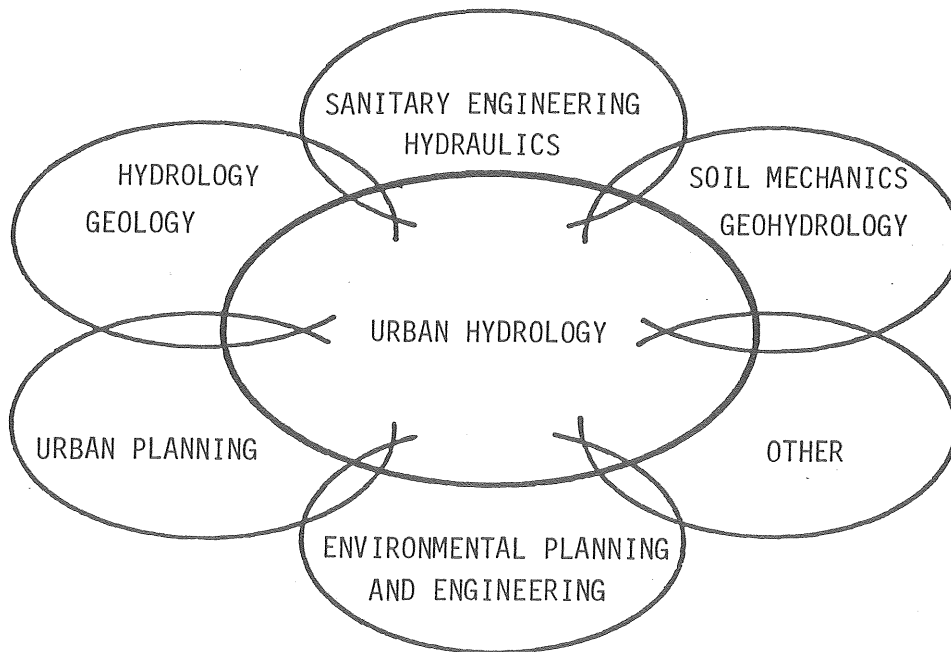


Fig.1. Urban hydrology

Urban hydrology is a science with vaguely defined borderlines. Fig. 1 shows some of its components. To the group "other" can be brought e.g. socioeconomics, ecology, civil engineering and operating technology. The particular aspects of urban hydrology dealt with by SUH concern mainly storm water and ground water. The hydrology-related geotechnical problems in urban areas are handled by the Coordinating Committee for Groundwater - Geotechnical Research. An inter-Nordic group for the coordination of research on the operation of sewage systems is now being considered.

The future direction of urban hydrology, in particular storm water handling, is dealt with by a Storm Water Group, consisting of members from SNV, BFR, VAV, the Swedish Association of Municipalities and the Swedish Board of Urban Planning. The Storm Water Group assists the authorities, mainly the National Environmental Protection Board, in their work on legislation and guidelines for storm-water handling. The interrelations between the different agencies and groups can be seen in Fig. 2.

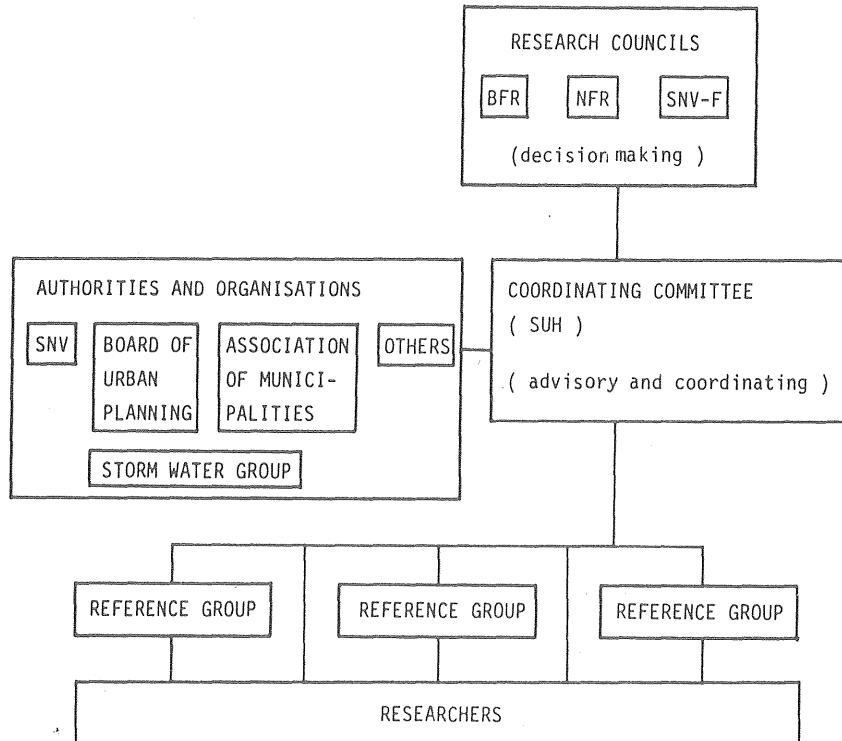


Fig.2. Research administration

## RESEARCH MODEL

A research model has been developed by SUH (1977). The model is based on the three basic steps of urbanization: planning, design and construction, and operation, Fig. 3. Each step has its given conditions and will create certain effects. The model is thus divided into nine subgroups - the conditions of planning, the actual planning, the effects of planning etc.

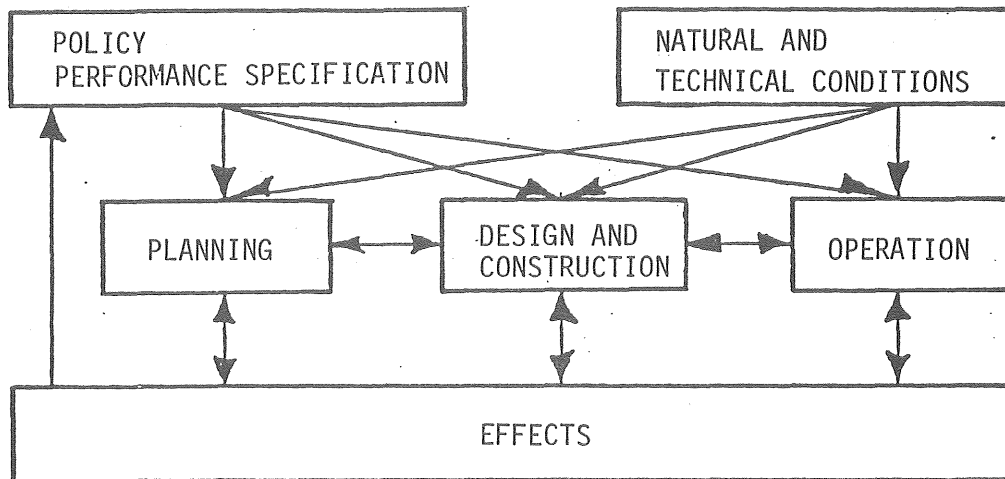


Fig.3. Research model

One of the aims of the research model is to create a basis for giving priority to research projects, and the following principles are followed: The research should basically be of an applied nature. The goals of the work should be guided by assessed benefits for the society, and the anticipated results should be considered in relation to the efforts.

The Swedish research on urban hydrology has during the seventies been directed mainly towards design and construction, that is investigations on the fundamentals of urban hydrology and the development of design tools and storm-water facilities. The other two main steps - planning and operation - must therefore be given higher priority in the future. The following three research fields are specifically emphasized by SUH:

- Urban hydrological problems within existing settlements.
- Planning and operation of the technical systems of urban areas.
- Water balance studies in urban areas, comprising water quantity and quality.



## CURRENT RESEARCH PROJECTS

The total cost of the research projects handled by SUH is for the budget year 1978/79 4.1 M Skr, whereof BFR contributes with 3.3 M Skr, SNV-F with 0,5 M Skr, and NFR 0,3 M Skr. The sum is not final since research grants will be given on several occasions during the year. In addition, the universities of technology, city authorities, and private companies spend a great deal of money on urban hydrological research and development.

The actual research is carried out mainly at the universities of technology but also at the larger consulting firms and at some of the larger municipal water and sewage works.

Of the great number of existing research projects only some of the more comprehensive ones will be presented here, namely:

- Infiltration of storm water.
- Optimization of storm water systems.
- Water-balance studies.
- Snow hydrological studies.
- Operations of combined sewer systems.

A state-of-the-art report covers some of the storm-water research results achieved during the seventies (Bucht, 1977).

### Infiltration of storm water

The conventional handling of storm water in urban areas - discharge through pipe systems - causes society many problems, e.g.

- Subsidences and damage to the vegetation by decreased ground water recharge.
- Costly pipe systems with low efficiency.
- Damage to the receiving waters by polluted storm water.

One way of minimizing these difficulties is to infiltrate the storm water into the ground. Research on storm-water infiltration started at the beginning of the seventies at the same time as the construction of the first storm water percolation basins. (Paus, 1974).

The Urban Geohydrological Research Group at Chalmers University of Technology (CTH) initiated in the spring of 1976 the project "Local infiltration of storm water". The project will be terminated in 1979. The aim of the project is to investigate the theoretical and practical requirements for the location and design of percolation basins. The project is divided into three subprojects: Soil water in urban areas, Local infiltration of storm water - hydrological conditions, and Local infiltration of storm water - geohydrological conditions (Cederwall & Holmstrand, 1976).

Within the project different aspects of local infiltration are being studied. The performance of percolation basins has been studied in, among other places, Halmstad (sandy soil) and in Bratt- hammar, Göteborg (clay). Furthermore an inquiry has been carried out concerning the design of percolation basins in Sweden (Eriksson & Lindvall, 1978).

The consequences to the environment of storm-water infiltration are going to be studied during the next two years by the Urban Geohydrology Research Group. The effects on the ground-water quality will be examined at three different sites: a residential area, an industrial area, and a highway. This project is part of a group of projects managed by SNV-F. Some of the other projects in the group deal with the infiltration of waste water and of leachrates: the physiochemical and microbiological aspects of the infiltration processes, and the calculation of ground-water movements in the saturated and the unsaturated zone.

Storm-water infiltration is also being studied by the Royal Institute of Technology, Stockholm, together with the consulting firm AIB and the Stockholm Water and Sewage Works at the residential area Dalen in Stockholm. This project concerns mainly the operation and maintenance problems of percolation basins.

The infiltration of storm water on grass surfaces is a technique that has gathered a great deal of interest lately. There are, however, many problems involved, e.g. what are the capacity and performance of the surface, and the impact on the vegetation, and how does frost in the ground affect infiltration. Two research projects are being started within this field, one by the construction firm BPA and the consulting firm Orrje and one by the Urban Geohydrology Research Group.

### Optimization of storm-water systems

This project is a joint effort by the Urban Geohydrology Research Group and the consulting firm VBB, Stockholm. The project aims at the development of methods for the optimization of storm-water sewer systems and for the choice of design flooding frequency. The methods will consider the costs of construction, operation, and maintenance, the costs of flooding, social aspects, and legal limitations. The project will start in 1978 and end in 1982. The work will be divided into six stages:

1. Investigations of the actual flooding frequencies of today and the costs of floodings occurred.
2. Analysis of the design flooding frequencies in relation to the total costs of the sewer system.
3. Analysis of the effects of uncertainties in the design methods on the actual flooding frequency.
4. Investigations into the question of responsibility at sewer system optimization.
5. Studies of flooding frequencies accepted by the public.
6. Development of optimization methods for sewer systems and of methods for the control of flooding frequencies.

### Water balance studies

Water balance studies of various extent have been done or are being done in Sweden. The most comprehensive work is being performed in Lund by the University of Lund (LTH), Department of Water Resources Engineering together with the City of Lund.

The project aims at the development of a water budget for the City of Lund by means of direct gauging of the water quantity and quality. The gaugings are being carried out in such a way that the recorded water and pollutant flows can be related to their governing factors, that is the cause/effect relations can be established. Thus it will be possible to obtain general results. Alternative ways of handling the urban water will be discussed. The project is expected to give the basis for an integrated management of urban water systems.

The water budget will include water flows, suspended solids, organics, phosphorus, nitrogen, and heavy metals. The gauging system comprises 15 precipitation gauges, 4 gauging stations for soil water, 19 gauging stations for ground water, 8 stations for flow metering at overflows, 7 stations for storm-water flow metering. The sewage treatment plant is controlled at 4 points, and the receiving water is controlled at 3 locations. The recorded results are going to be analysed by the storm-water management model SWMM (Andersson, 1977).

### Snow hydrological studies

During a normal winter the whole of Sweden is covered by snow, which causes high costs to the society. The hydrology of snow is little known, and the calculation of the spring thaw is done by rather approximate methods. In the northern part of Sweden snow melt may be dimensioning for the storm-water sewer system.

The snow hydrological research in Sweden is carried out at the University of Luleå. The studies aim at describing the snow hydrological processes and at the development of simple calculation methods. The studied processes are for the calculation of snow melt, 1) evaporation from snow, 2) direct heat exchange between air and snow, 3) heat conduction between snow and ground and 4) the albedo of snow. For the calculation of water runoff from melting snow the following are being studied: 5) runoff in the snow and 6) infiltration of melt water on the frozen ground under the snow cover. Field observations are being done in three areas, each divided into three subareas. The measurements include solar radiation, snow melt at one point, heat content of the snow and of the ground, ground water level, evaporation, runoff, and meteorological observations.

The correct way of calculating snow melt is to use an energy budget. However, since the heat transfer processes are very difficult to estimate, the melting rate is usually described by a degree-day method. The degree-day coefficient depends on solar radiation, cloudiness, wind speed, air humidity, and effects of forest cover (Westerström 1977).

One of the interesting findings concerns infiltration into the ground under the snow cover. It has been found that no runoff from snow melt occurs until the groundwater and soil-water storages have been filled up. This study is quantitatively described in a report from LuH (1978).

The studies have so far only comprised rural areas, but the intentions are to include urban areas as well.

#### Operation of combined sewer systems

The planning and putting into effect of measures of the limitation of overflow problems in existing combined sewer systems require suitable calculation methods for the quantifying of overflows. At KTH, Department of Hydraulics, a research project with the aim of developing such methods is being carried out. Verifications of existing storm-water models will be performed within the project. The investigation area is a 700 ha city area in Stockholm with a complex sewer system.

The project involves surveys of the area, gauging of precipitation, water flows, and water levels and sampling of overflow water and receiving water. Studies of continuous measurements of suspended solids in the waste water are carried out as well as studies of different flow measurement methods.

A limited number of existing simulation models are going to be applied to the collected data. The hydraulics and operation of the overflow structures are studied both in the laboratory and in the field. The project runs from 1977 to 1980.

Closely connected to this project, a project concerning detention storages in sewage systems is being carried out at KTH, Division of Water Resources Technology. The scope of this project is to study different types of detention storages (local infiltration, on-site detention, in-line detention and off-line detention) and to work out general guidelines for the use of detention storages.

The project is divided into four parts: 1) Survey of existing installations, 2) Operation studies, 3) Studies of controlled transition of storm-water to waste water treatment plants, and 4) Summaries, conclusions and guidelines. (Stahre, 1977). Up to now five reports have been published, describing the research project, detention in pipe packages, detention in open ponds, flow measurements and storm-water infiltration.

### Abbreviations

BFR	The Swedish Council of Building Research
NFR	The Swedish Natural Sciences Research Council
SNV	The National Swedish Environmental Protection Board
SNV-F	The National Swedish Environmental Protection Board - Research Committtee
VAV	The Swedish Water and Sewage Works Association
CTH	Chalmers University of Technology
KTH	The Royal Institute of Technology
LTH	Lund Institute of Technology
LuH	University of Luleå
SUH	The Coordinating Committee for Urban Hydrology Re- search.

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