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Selected Urban Storm Water Runoff Abstracts July 1971-June 1972

Office of Research and Monitoring
U.S. Environmental Protection Agency
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EPA-R2-72-127
December 1972

SELECTED URBAN STORM WATER RUNOFF ABSTRACTS

July 1971 - June 1972

By

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Contract No. 68-01-0161
Project No. 11020 HMM

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ABSTRACT

The July 1971 - June 1972 supplement to SELECTED URBAN STORM WATER RUNOFF ABSTRACTS is a compilation of abstracts summarizing articles from a variety of technical literature and conferences, both domestic and foreign, primarily related to the problems of urban runoff caused by storm water discharges, combined sewer overflows, and nonsewered urban runoff. All aspects related to this topic fall under the selective areas of: design criteria and construction materials for sewers or apparatus employed in the flow of combined sewage and/or storm runoff; regulation devices for overflow or infiltration from urban runoff of storm water, combined sewage, or highway-salt runoff which can cause water pollution; water quality, legislation, or treatment methods based on problems caused from storm water; and, current tunnel technology and equipment used in the construction of sewer tunnels. The 215 abstracts covering a range of ten sections are arranged numerically by abstract accession number within each category. Each item includes a bibliographic citation, an abstract, and a set of indexing descriptors and identifiers. A subject index appended in this issue provides the necessary access to individual concepts. An author index and a glossary for journal abbreviations are also included.

Previous publications include:

SELECTED URBAN STORM WATER RUNOFF ABSTRACTS: July 1970-June 1971. Science Information Services Department, The Franklin Institute Research Laboratories, EPA/WQO Contract No. 14-12-904, Program No. 11024 FJE, July 1971. 173 p.

SELECTED URBAN STORM WATER RUNOFF ABSTRACTS: Third Quarterly Issue. Science Information Services Department, The Franklin Institute Research Laboratories, EPA/WQO Contract No. 14-12-904, Program No. 11024 FJE, April 1971. 75 p.

SELECTED URBAN STORM WATER RUNOFF ABSTRACTS: Second Quarterly Issue. Science Information Services Department, The Franklin Institute Research Laboratories, EPA/WQO Contract No. 14-12-904, Program No. 11024 FJE, January 1971. 45 p.

SELECTED URBAN STORM WATER RUNOFF ABSTRACTS: First Quarterly Issue. Science Information Services Department, The Franklin Institute Research Laboratories, EPA/WQO Contract No. 14-12-904, Program No. 11024 FJE, October 1970. 37 p.

SELECTED URBAN STORM WATER RUNOFF ABSTRACTS: July 1968-June 1970. Science Information Services Department, The Franklin Institute Research Laboratories, EPA/WQO Contract No. 14-12-904, Program No. 11024 FJE, July 1970. 375 p.

SELECTED URBAN STORM WATER RUNOFF ABSTRACTS: A Compilation of Selected Abstracts on Storm Water Discharges and Combined Sewer Overflows. The Franklin Institute Research Laboratories, Science Information Services, FWPCA Contract No. 14-12-467, January 1969. 321 p.

STORM WATER RUNOFF FROM URBAN AREAS: Selected Abstracts of Related Topics. FWPCA, Cincinnati Water Research Laboratory, Basic and Applied Sciences Program, Engineering Activities, April 1966. 98 p.

This work was submitted in fulfillment of Contract 68-01-0161 (EPA Project No. 11020 HMM) between the Environmental Protection Agency, Office of Research and Monitoring and The Franklin Institute Research Laboratories.

FOREWORD

This edition of SELECTED URBAN STORM WATER RUNOFF ABSTRACTS is a compilation of abstracts summarizing articles from a variety of technical literature and conferences, both domestic and foreign, primarily related to the problems of urban runoff caused by storm water and sewer overflows.

For convenience, these 215 abstracts are classed in ten categories and arranged numerically by abstract within each category. Since most of the papers fit into more than one category, a cumulative subject index appended in this issue provides the necessary access to individual concepts and should be utilized for locating all abstracts in which this concept is significant. The numbers following an index term are the accession numbers for the abstracts in which this term is found (e.g. II-003 refers to the third abstract in section II).

Each item includes a bibliographic citation, an abstract, and a set of indexing descriptors (subject terms listed in the WATER RESOURCES THESAURUS second Edition, 1971) and identifiers (newly suggested index terms). The most important index terms are marked by an asterisk. In the citation, periodic publications have been abbreviated through the use of CODEN.

Sponsored by the American Society for Testing and Materials, CODEN is the most extensive and widely used system for the storage and retrieval of information and communications involving journal references. A CODEN is defined as a five character code designating the title of a specific serial publication. An example similar to a citation reference found in this issue is as follows:

JISPA, 27(8):29-37 (Aug. 1971).

which is the JOURNAL OF THE INSTITUTION OF PUBLIC HEALTH ENGINEERS, volume 27, issue number 8, inclusive page numbers of the article abstracted, and date of issue. A glossary for CODEN as well as an author index have been included for the reader's benefit.

Copies of the articles abstracted in most cases can be obtained from research libraries covering water pollution or public health engineering literature.

This work, submitted in fulfillment of Contract 68-01-0161, was performed by the Science Information Services Department of The Franklin Institute Research Laboratories. Mrs. Dorothy Sandoski, acting as project leader, was responsible for the searching of literature for pertinent documents, abstracting and indexing, and overseeing the production of camera-ready copy of the report.

TABLE OF CONTENTS

SECTION I.

Construction: Equipment and Materials; and Instrumentation

I-001
JET VACUUM SEWER CLEANING.

AMCIA, 136(7):83 (July 1971).

Descriptors: *Sewers, *Mechanical equipment, *Costs, Maintenance, Human resources.
Identifiers: *Jet-vacuum sewer cleaners, *South Bend, Indiana.

The acquisition of a jet-vacuum sewer cleaner has made it possible for the city of South Bend, Indiana to clean its 350 miles of sewers on approximately a 3 year cycle, while lowering costs from 59¢ to 5¢ per foot cleaned. Without the jet rodder, sewer cleaning crews were able to service only about 5% of South Bend's 210 miles of small diameter (24" or less) sewers per year; at this rate the city's smaller sewers would be covered once every 42 years and no time would be left for the 140 miles of larger sewers. The jet rodder has also been found useful for other tasks, such as opening a grit clogged sludge line. Detailed cost studies of South Bend's old and new sewer cleaning systems are offered.

I-002
GAS ENGINES PROVIDE ECONOMIES IN OMAHA SEWER LIFT STATION.

DGTPA, 37:76-77 (Sept. 1971).

Descriptors: *Costs, *Municipal wastes, Environmental sanitation, Natural gas, Pumps, Sewage treatment.
Identifiers: *Omaha, *Sewage lifting stations, Nebraska.

Natural gas engines driving five 15,000 gpm vertical pumps at Omaha, Nebraska's Monroe St. Lift Station provide reliable sewage lifting at an average saving in operating costs of $5000 per year compared with alternate sources of station power. Even larger savings are anticipated when engine heat can be recovered and used for process applications in the secondary sewage treatment plant now being built. The lifting plant has a reserve capacity of at least 25% over maximum anticipated load, facilitating scheduling of routine preventive maintenance without interrupting normal flow of sewage. Unattended operation is made possible by automatic controls which activate the pumps as required. Even in the event of a power failure, the pumps can continue to operate since their prime movers operate on natural gas. Installation and operating details are discussed. Manufacturers of principal equipment used in the installation are listed.

I-003
NEW WATER AND SEWER LINES FOR SAIPAN.

WOCOA, 24(8):35-36 (Aug. 1971).

Descriptors: *Sewerage, *Drainage systems, Waste water treatment, Construction, Concrete pipes, Infiltration.
Identifiers: *Saipan.

A $25,000,000 construction project for the consolidation of separate, outdated, and inadequate water and sewer systems on Saipan is currently under way. Saipan's water has a high chemical content. Therefore, two water softener plants were included in the new scheme to reduce as much as possible the harsh corrosive environment and Johns-Manville TRANSITE asbestos-cement pipe was specified in the installation. Johns-Manville class 2400 sewer pipe with Ring-Tite couplings was used in the sewage collection systems since a large percentage of the pipe was to be installed below the groundwater table and high infiltration rates were a threat. In a previous installation under similar conditions, this pipe was found to be infiltration tight with no visible signs of deterioration after five years of operation.

I-004
WATER TECHNOLOGY. (Wasserwirtschaft.) Text in German.

WSLBA, special issue, 51-60 (June 1971).

Descriptors: *Sewage treatment, *Waste water treatment, Water purification, Equipment.

A new wastewater concentrator to be used for reduction of dirt caused by drainage system overflows is described. The concentrator has a diameter of approximately 84 inches and a height of about 73 inches. It has 18 grid plates on a rotating cage. A combination of high pressure flow and centrifugal force pushes 90-95% of the 440,000 cu. feet daily water handling capacity through the 105 micron grid, retaining about 99% of the solid material.

I-005
SEWAGE PIPES PROTECTION.

West German Patent: DT 1933723. (to C. Zschokke). Applied July 3, 1969. Issued May 27, 1971.

Descriptors· *Hydraulic conduits, *Plastics, *Linings, *Epoxy resins, *Patents, Pipes, Sewerage, Storm drains.

Curved walls of sewage and storm water channels, subject to heavy chemical and/or mechanical stress, are protected by a lining of synthetic resin mortar in the form of flat plates which are plastically deformed to fit the wall and attached to it. The joints are closed. Preferably the plates are of a polyester or polyether based polyurethane, Na aluminosilicate quartz powder and corundum. The adhesive is epoxy resin; as is the joint sealant with the addition of sand.

I-006
IMPREGNATION OF CONCRETE PIPE.
Southwest Research Institute, San Antonio, Texas

EPA/WQO Contract No. 14-12-835, Program No. 11024 EQE, June 1971. 59 p, 14 fig, 4 tab, 22 ref, 2 append.

Descriptors: *Concrete pipes, *Corrosion, *Corrosion control, *Protective coatings, *Sewers, *Sulfur, Hydrogen sulfide, Resins. Identifiers: *Impregnation, *Hydrofluoric acid, *Acid resistance, *Bacterial action, *Sulfate resistance.

Methods to increase the corrosion resistance, increase the strength, and reduce the permeability of concrete used in sewer line applications by impregnating the concrete pipe with relatively low cost resins such as asphalt, coal tars, linseed oil, sulfur, urea-formaldehyde, and others were investigated. The materials, techniques of application, test results and economics are presented. A large number of candidate impregnation materials were obtained and screened both in the laboratory and in limited field tests. Dilute hydrofluoric acid, sulfur and modified sulfur were found to impart the best corrosion resistance by impregnation. Other materials including vinyl-vinylidene chloride, vinyl acetate-acrylic, nitrile rubber latex, nitrile phenolic rubber, an emulsified reclaimed rubber and a rubber base adhesive, although failing to impregnate the concrete, formed surface coatings having exceptional corrosion resistance.

I-007
HEAT SHRINKABLE TUBING AS SEWER PIPE JOINTS.
The Western Company of North America, Richardson, Texas

EPA/WQO Contract No. 14-12-854, Program No. 11024 FLY, June 1971. 79 p, 36 fig, 4 tab, 18 ref, 6 append.

Descriptors: *Pipes, *Sewers, Testing, Water pollution sources, Cost analysis, Construction costs, Plastics, Construction materials. Identifiers: *Sewer joints, Sewer repair.

Preliminary testing had indicated that commercial sewer pipe might be coupled in tight waterproof joints using the heat shrinkable plastic tubing (HST) developed and used extensively in the electronics and aerospace industries. Laboratory studies of such materials and joints were conducted to determine their characteristics and their operational and economic feasibility. A wide variety of HST materials and joints were tested in addition to conventional joints for clay, concrete and asbestos-cement pipes. The results of both small scale tests and full scale tests using commercial 8 inch sewer pipe indicated that a polyolefin with a polymeric base hot melt adhesive produced the most durable, watertight joints and were significantly superior in performance compared to existing pipe joining mechanisms. In addition, the cost analysis indicated that HST joints are economically feasible and compare favorably to conventional joints when considering both material and installation costs. The HST joint requires no significant departure from current installation practice and is equally adaptable to repair of installed commercial pipe and joints. Field development and in-use demonstration of the HST system is recommended.

I-008
CHEMICAL GROUT CONTROLS HAZARDOUS INFILTRATION.

Ronald A. Antonio
WOCOA, 24(8):33-34 (Aug. 1971).

Descriptors: *Infiltration, *Chemical grouting, Safety factors, Hazards.
Identifiers: *Petrochemicals.

Petrochemicals seeping into a large intercepting sewer caused explosions periodically. To end the problem, the space around the pipe is being sealed chemically. Chemical grout was selected because of its low viscosity and controllable gel time. Terranier C, manufactured by ITT Ragonier, is the product being used. It is highly resistant to deterioration by petrochemical substances and relatively low

in cost. Safety considerations call for spark proof materials and extremely good ventilation in the work area. A detailed description of the grouting operation is given.

I-009
1700-FOOT OUTFALL LAID IN ONE DAY.

Charles A. Bell
AMCIA, 86(9):66-67 (Sept. 1971).

Descriptors: *Comparative costs, *Plastic pipes, Construction, Metal pipes, Waste water treatment, Sewerage.
Identifiers: *Butt-fusion joints, *Pipe installation, *Greenwood State Park, South Carolina.

The first polyethylene pipe of a significant diameter and length to be used in a U.S. sewerage system was installed recently at Greenwood State Park, Greenwood, South Carolina. The high density Sclairpipe had an estimated installed cost 50% less than the alternate material, cast iron pipe. Because of its light weight, the polyethylene pipe could be installed completely by only 8 men, including supervision, without any hoisting equipment, in one day. The last 1500 ft of the 1710 ft pipeline lies unburied on the lake bottom. The flexible quality of polyethylene pipe allows it to follow the contour of the lake bottom without the use of ball and socket joints which would have been necessary if cast iron had been used. Installation involved only the joining together of pipe ends using the butt-fusion method which joins melted pipe ends and results in a leak-free joint, hand launching, and sinking. It is estimated that installation of cast iron pipe would have required 12 men working for a full week, together with a barge, a 3/4 ton crane, and a loader. Polyethylene pipe also offers the advantages of chemical resistance and freedom from maintenance. This sewer line is part of a new package wastewater treatment plant of the activated sludge type being constructed to service Greenwood State Park.

I-010
IN-PLACE LINING OF SMALL SEWERS.

R. M. Bremmer
JWPFA, 43(7):1444-1456 (July 1971). 32 fig, 3 tab.

Descriptors: *Maintenance, *Plastic pipes, *Sewers, *Linings.
Identifiers: Toronto, Canada.

A practical method of relining small-diameter sewers with high-density polyethylene pipe has been developed. The method can be used with little or no disruption of surface activities or traffic and can considerably lengthen the service life of existing systems that have deteriorated. Although the lining reduces the cross-sectional area of the conduit, an increased hydraulic capacity is possible, and this is especially attractive in areas undergoing intensive redevelopment. In Toronto, where the system is in use, the reinstated system will serve as a sanitary sewer when the existing combined sanitary-storm system is separated.

I-011
HEAD CONSTRUCTION AT SPILLWAYS. (Kopfbauwerke bei schussrinnen.) Text in German.

Hans Bretschneider
WSWTA, 61(5):140-147 (May 1971). 22 ref.

Descriptors: *Spillways, Design criteria, Dam construction, Comparative benefits.
Identifiers: Head construction.

Two types of head construction for spillways are described; the top spillway where the catchment and the conduit form a right angle and the side spillway having parallel catchment and conduit. Top spillways have the disadvantage of initiating Mach waves caused by an accumulation of dirt or bottom damage. Side spillways do not have such waves, at least not in the conduit. In the case of the side spillway the best design of the catchment at the head and the conduit to the straight channel was studied on a model of the Pineios dam in Greece. The Baxin profile for storm water relief was not suitable. Inflow over the weir opening on the top extends the screw-type motion of the fluid particles. Furthermore the rushing water in the conduit produces an initial speed which permits a smaller cross section.

I-012
A BASIS FOR THE STRUCTURAL DESIGN OF P.V.C. GRAVITY SEWERS.

R. C. Carter
JISPA, 70(3):132-142 (July 1971). 5 fig, 9 ref.

Descriptors: *Design criteria, *Plastic pipes, Mathematical studies, Sewers, Regression analysis.

PVC pipes have not been widely used for non-pressure applications such as gravity sewers. In considering load effects, PVC pipes behave as flexible pipes. Load transfer can be

achieved through surrounding the flexible pipe with a free-flowing, granular fill. The Marston/Spangler equations for determining load due to backfill for rigid and flexible pipes are presented and discussed. Regression curves for PVC pipes of various wall thicknesses subjected to internal or external pressure are analyzed. Curves of deformation developed from external pressure progress in linear manner to log time until some specific value of deformation is reached, are included. This value increases with wall thickness and as wall thickness decreases, the linear value of the deformation curve assumes a steeper angle. Evidence suggests it will be possible for long term, flexible pipe use to predict safe wall thicknesses and select allowable limits of deformation using Spanglers' formula, with considerable confidence. Pipes having a diameter/wall thickness ratio (D.R.) over about 35 are likely to be unsatisfactory in the long term, while a 4" Class 'C' pipe having a D.R. of 25 or an 8" Class 'C' pipe with a D.R. of 28 could conceivably have a safe deformation allowance as high as 5%.

I-013
STRUCTURAL DESIGN CRITERIA FOR INSTALLING UNDERGROUND PLASTIC SEWER AND DRAIN LINES.

Anton F. Fonda
PLENA, 25(20):46-48 (Sept. 30, 1971).

Descriptors: *Plastic pipes, Design criteria, Drainage systems, Chemical wastes, Installation.

The use of fiberglass reinforced plastic (FRP) pipe for chemical sewer and drain lines is discussed. For proper pipe performance, care must be taken in installation - shaping the trench walls, levelling the trench bottom, and proper bedding and backfilling are extremely important. The most suitable bedding for FRP pipe is a layer of fine granular material, although an earth foundation shaped to fit the lower part of the conduit is adequate if the trench and foundation shape are cut straight. Three primary loads must be considered in the use of FRP pipe: overburden loading, live loads from wheeled traffic, and hydrostatic loading. If traffic will be regularly moving over the trench, exterior protection is recommended. The preferred method is insertion of the FRP pipe in a corrugated steel pipe. The chemical properties of FRP pipe have been responsible for its success in handling highly corrosive waste effluent its performance as a sewer or drain line depends on the measures taken to offset the external physical forces acting on it.

I-014
FILTRATION METHOD BY HORIZONTAL FILTER LEAF TYPE PRESSURE FILTER AND ITS DEVICE. (Suihei royo gata kaatsushiki rokaki no rokahoho oyobi sono sochi.) Text in Japanese.

Shinsaburo Hayakawa
Japanese Patent: Sho 46-16872. Applied May 14, 1968. Issued Mav 10, 1971.

Descriptors: *Patents, *Filters, *Design, Water purification, Waste water treatment, Liquid wastes.
Identifiers: *Japan.

This newly designed horizontal leaf type pressure filter is equipped with two assembled units of ordinary filter leaves, an assembled unit of specially designed residual liquor filter leaves, and a pipeline system that can perform manifold functions by closing or opening its many control valves. It feeds in the raw liquor, circulates it for a single cycle or any desired number of cyles, and takes up the residual liquor in the lower part of the device to feed it back into the device from above or discharge it. All the filter leaves are mounted in the hollow rotary center shaft. They are so designed and connected to the center shaft that the filtered liquor flows into the hollow interior of the shaft through which it is led to the discharge pipes. The hollow interior of the shaft is divided into upper and lower sections. The liquor filtered by the residual filter leaves goes into the upper section and is discharged through a separate pipe extending out from the top of the shaft, while the liquors filtered by the ordinary filter leaves are discharged through a pipe connected to the bottom of the shaft. The design is such that the liquor filtering up to 2/3 or even 1/2 the device's capacity, as seen when the operation is approaching its final stage, can be effectively filtered to the last drop.

I-015
STRUCTURAL ANALYSIS AND DESIGN OF PIPE CULVERTS.

R. J. Krizek, R. A. Parmelee, J. N. Kay, and H. A. Elnaggar
National Cooperative Highway Research Program Report 116, 1971. 158 p, 109 fig, 38 tab, 124 ref, 14 append.

Descriptors: *Design criteria, *Culverts, Analytical techniques, Conduits, Mathematical studies, Pipes, Comparative benefits, Costs, Construction.

Procedures for the structural analysis and design of pipe culverts are surveyed and evaluated, and suggestions made for improvement. For large diameter pipes under high fills, substantial savings are possible through the use of flexible design procedures. A new approach to the soil culvert problem is suggested - it would treat the surrounding soil as a continuum and would have the advantages of inherently taking the soil-culvert interaction into account; input parameters would consist of more fundamental characterizations of the soil and culvert material behavior, and pipes of intermediate stiffness could be handled rather than considering only extreme cases (flexible or rigid) as in the Marston/Spangler approach. For analytical techniques to realize their full potential, proper inspection and control of construction procedures is essential. Virtually every culvert failure reported can be attributed to either improper construction procedure or imposition of a condition not considered in the design. A systematic interpretation of the safety factor of a culvert is presented which emphasizes the relationship between failure stresses and the stresses produced by a specified load distribution on the culvert. A simplified procedure is developed to predict the camber of pipes resting on compressible foundation soils; the problems associated with construction and inspection are discussed, and a formulation of the economic considerations of a culvert installation is presented along with an identification of the parameters required for a meaningful evaluation. Finally procedures for analysis and design of culverts in Canada, Europe, and Japan are given.

I-016
WHAT CAN BE LEARNED FROM TWO WAYS TO BUILD A SEWER.

Alex Mair
ENCRA, 84(7):64 (July 1971).

Descriptors: *Sewers, Construction materials, Comparative benefits.
Identifiers: *Construction techniques, Canada.

For a short time this spring two crews were working on a street in Edmonton, Alta., Canada, about a block apart, each installing a sewer line. Although the job being done in each case was the same, the techniques used by the crews differed. One crew worked by the conventional method of sinking shafts, tunneling, shoring and installing precast concrete pipes, while the other produced a very similar result using a traveling form and concrete pumping operation. Although no figures have been released as yet, the obvious simplicity of this latter method coupled with the anticipated savings should make this a popular sewer construction technique.

I-017
DESIGNING OF RAINWATER PUMPING PLANTS. (Usui ponpu-jō sekkei ni tsuite.) Text in Japanese.
Nagoya Municipal Government, Department of Waterworks

Koji Narumi
NGKHB, 8th:31-32 (May 1971).

Descriptors: *Pumping plants, *Estimating equations, Data collections, Design criteria, Analytical techniques.
Identifiers: *Vertical axis pumps, Japan.

The scale of a pumping plant is based on the number of pumps, the types of pumps and motors, supplemental equipment, and the electric system of the proposed plant. Utilizing the data accumulated between 1963 and 1970 by the Nagoya Municipal Sewage Department mainly on vertical axis rainwater pump models, analytical studies were made, and new, simplified equations for calculation of pumping station scales were obtained. Equations include those for calculation of the total surface area of the pumping station from the desired quantity of discharge water, and calculation of the length of the girder and span of the plant from the diameter of discharge pipes. These calculations are applicable to pumping stations utilizing diesel-engine vertical axis rainwater pumps with discharge pipes of diameters from 40 to 68 inches.

I-018
CONCRETE FLUME SOLVES DRAINAGE PROBLEMS.

Alfred R. Pagan
PUWOA, 102(8):77-78 (Aug. 1971).

Descriptors: *Flood control, *Construction costs, *Channel improvement, Financing, Drainage.
Identifiers: *Bergenfield, New Jersey.

Frequent flooding of the residential area bordering Hirschfield Brook in Bergenfield, N. J. pointed up the need for improvement in the drainage system. A 16 ft wide channel with concrete walls and bottom was designed to flow 6 ft deep with 1 ft of freeboard at a slope of 0.0025. Financing problems forced phased construction with the initial work being done along a reach approximately 600 ft long in the most flood-prone section of the 1600 ft area involved. Construction bids were taken in November 1969, and a low bid of $129,203 was accepted. Work was largely done

in the summer of 1970, and completed in August. An important aspect of the contractor's work was his decision to dam the stream upstream from the project and pump the flow through flexible hose to the downstream side of the excavation where another dam prevented the water from backing upstream. Estimates indicate that the water surface elevation has been lowered about 18 inches because of the improvement.

I-019
NEW TYPES OF PUMPS WITH RELIABLE CHARACTERISTICS. (Pumpen neuer und bewährter konstruktion.) Text in German.

Herbert Pötschke
WSLBA, special issue, 37-40 (June 1971).

Descriptors: *Pumps, Water conveyance, Municipal wastes, Sewage treatment, Equipment, Treatment facilities.

A range of new types of pumps which can be used in urban sewage treatment plants is presented. One of these is the hydrostatic pump provided with a relief valve jet for the adjustment of maximal lifting pressure. The discharge portion of these pumps can be adjusted for both cooling or heating. These pumps can be driven by electrical, diesel, gasoline, or air engines. A new type of these pumps is the TPK, triplex plunger pump. The steam-jet water pump is suggested to be used for liquids containing smaller solid particles. The high pressure rotary pump is being manufactured for conveying up to Q=140 m^3/H volumes of liquid. This type of pump can be either vertical or horizontal. Another plant provides a type of pump referred to as CPK (chemistry normal pumps) which can be utilized for water, chemically aggressive liquids, and also for greasy or very hot media. The same plant produces ETA and ETANORM-low pressure rotary pumps which can be used for water supply irrigation as well as in drainage operations, discharge of cooling waters, and in conveying of sea water or turbine oils.

I-020
MAIN DRAINAGE IN A CITY.

D. C. Smart
SLGTA, 137(4120):77 (May 28, 1971).

Descriptors: *Drainage systems, Construction, Design, Pipelines, Pumping plants, Outlets.
Identifiers: Great Britain.

In 1965 the Cardiff City Council approved a scheme estimated at $6 million (£1=$2.80 U.S.) for the reconstruction and improvement of the drainage system for the eastern district of the city. The plan involved construction of 5 miles of sewers in diameters ranging from 36"-96", a new major pumping station, and a 6000 foot. submarine outfall. The design of the system, procedures followed, and difficulties encountered in its construction are described.

I-021
SEWERAGE SYSTEM PIPELINES: OPTIMUM MODEL AND ITS APPLICATION. (Gesuikankyo keikaku no saitekika moderu to sono oyo.) Text in Japanese.

Jun Yamada
NGKHB, 8th:26-28 (May 1971). 5 ref.

Descriptors: *Pipelines, *Sewerage, Investigations, Optimum development plans, Feasibility studies, Costs, Application methods.
Identifiers: Japan.

The purpose of this study is for reexamination of the present sewerage system and reevaluation of the currently used pipeline planning method in Japan. The present procedure of designing a sewerage system includes the determination of the location of the proposed sewage treatment plant, plans for the main sewerage route, and plans for the network of pipelines. Most recent studies on optimization of sewerage systems consist of two phases: a large-scale design of the treatment plant and the main sewage route and then, based on this plan, more detailed sewage pipeline network plans; these two phases are treated separately. This study proposed to combine the two by careful calculations and examination of costs and feasibility of the system as a whole. First, the plan for the main route is proposed, and then an optimum pipeline network is planned and costs are calculated; the main route is reconsidered in light of the cost calculation, and the plan for the entire system is finalized. Characteristics of this program are: 1) relatively strict considerations for limiting conditions of the proposed area; 2) optimum choice for the entire route and pipeline combined; 3) a simplified calculation; and 4) improved accuracy through repeated calculations. The calculating time in relation to the number of pipes was 0.05 seconds per pipe. This will increase in relation to the number of pipes involved.

I-022
DRAINAGE PIPELINES - 2.

O. C. Young
BRSDB, 131:1-4 (July 1971). 3 fig.

Descriptors: *Plastic pipe, Drainage systems, Installation.
Identifiers: *Flexible pipes.

The uses of pipes made of pitch fibre, UPVC, and reinforced plastics are examined. Considerations such as the types of effluent for which a pipe is suitable and wall thickness, which governs pipe stiffness, specify the types of installation for which various flexible pipes should be considered. Among the joints most desirable for use with these pipes are snap joints and push-in joints. Limitations on laying depths (upper and lower limits) and installation, including the importance of good compaction of the sidefill to insure resistance to deformation are discussed. It is generally considered advisable to limit the vertical reduction in diameter of these pipes to about 5%; if they become excessively oval in cross section there is danger of blockage, leakage at joints, or overstressing of the pipe material. Wall thickness, nature of pipe material, temperature of discharges, magnitude of external load, and nature and condition of surrounding soil all influence the extent to which the pipes will deform. Finally, the proper method and equipment for clearing of blockages in flexible pipe are described.

I-023
LINER SAVES SEWER REPLACEMENT.

AMCIA, 84(11):33 (Nov. 1971).

Descriptors: *Sewers, *Construction materials, Construction, Pipe flow.
Identifiers: *Driscopipe, Houston, Texas.

The AAA Pipe Cleaning Company has eliminated infiltration and exfiltration in a 1280-foot newly constructed sewer section in Houston, Texas. Phillips Products 8-inch IPS Driscopipe, supplied in 32-foot lengths and butt-fused before insertion, was drawn through the leaking sewer. The smooth interior lends itself to extremely good flow characteristics.

I-024
SEWAGE DISPOSAL BRIEF REPORTS: THREE CONTRACTS MODERNISE WARWICK AND LEAMINGTON.

SMENB, 138(4141):45 (Oct. 22, 1971).

Descriptors: *Contracts, Sewage disposal, Construction costs, Sewers, Concrete pipes, Storage tanks, Screens, Sewage treatment, Pumping plants.
Identifiers: Great Britain.

Sewerage and sewage disposal in the boroughs of Royal Leamington Spa and Warwick, England are to be improved under the terms of the following three contracts: 1) a double-filtration system to treat a design DWF of 6 mgd serving 68,700 people; 2) a trunk sewer constructed in extra-strength concrete pipes of five systems ranging from 4 to 5.5 feet in diameter with rubber-ring flexible joints; and, 3) the construction and installation of storm water tanks, screens, and a storm water pumping station. The total cost for the above contracts is approximately $7.46 million ($2.60/£).

I-025
THE SEWER JOB WAS STYMIED UNTIL--.

WOCOA, 24(12):30 (Dec. 1971).

Descriptors: *Construction equipment, *Excavation, *Hydraulic machinery, Sewers.
Identifiers: Great Britain.

A thick seam of very hard sandstone held up the progress in excavating a trench for a sewer main in Liverpool, England. The 30-foot thick strata resisted every method Sir Lindsay Parkinson & Company Ltd. tried for nearly a month. An all-hydraulic excavating unit, Hy-Mac 880, dug the first 6-foot depth with its rock bucket. The bucket was then replaced by a ripper tooth attachment to shatter and rip out the sandstone. The sewer trenching totaled 600 feet with an average cover of approximately 4 feet. Deep sections, such as the 150-foot long stretch through the sandstone seam, necessitated widening the trench to 13.8 feet at its top.

I-026
MONTGOMERY'S SEWER SYSTEM BECOMES NATIONAL SHOWCASE.

WSIWA, 118(10):312-313 (Oct. 1971).

Descriptors: *Sewers, *Maintenance, Construction, Contracts, Project planning.
Identifiers: *Sewer systems, Montgomery, Alabama.

In 1960 a sewer maintenance program was initiated in Montgomery, Alabama. Two flexible rodding machines and two bucket machines were purchased to maintain 6- to 15-inch mains. Rigid control over sewer construction is maintained with contractor firms submitting

bids on labor costs and construction expertise only while all other aspects pertaining to the line are handled by the Water Works Board. The city, adding 20 miles of sewer main each year, now has 505 miles of sewer mains serving 140,000 people in a 100 square mile area.

I-027
FIBERGLASS REINFORCED PIPE SUPPORTS FAILING SEWER.

WSIWA, 118(10):318-319 (Oct. 1971).

Descriptors: *Construction materials, *Pipelines, *Repairing, Pipe flow, Sewers, Maintenance.
Identifiers: Kansas City, Kansas.

A flexible fiberglass-reinforced polyester resin pipe, Flextran, has been used to line a 209-foot stretch of sewer tunnel in the central district of Kansas City, Kansas. The Flextran pipe has high design flow, is thin-walled, and is resistant to acids and other corrosives. An abrasive hand grinder was used to cut both pipe lengths and sidewall cutouts, thus saving time.

I-028
5 INTO 1 = BETTER SEWER SYSTEM.

WWAEA, 10(8):48-49 (Oct. 1971).

Descriptors: *Construction, *Design criteria, *Concrete pipes, Project planning, Construction costs, Piping systems (mechanical).
Identifiers: *Sewer systems, *Sanitary sewers, *Storm sewers, Lincoln City, Oregon.

Stevens, Thompson & Runyon planned and designed the construction of a modern, unified sewer system for Lincoln City, Oregon. The program called for new sanitary and storm sewer lines, three added lift stations, plus repairs on existing lines -- altogether over 20 miles of new pipeline. The overall cost of improving the sewers was more than $2 million, financed by the city (about 50%), the state, and the Economic Development Administration. A dual system of storm and sanitary lines, which rests in a bed of 1¼-inch clean rock 5 feet wide and 24 inches deep, was designed laying both lines in the same trench. A Hopto 700 backhoe did the trenching, poured the rock base, and lowered pipe and manhole sections. Concrete pipe was used throughout the dual line, with storm line pipes running 21, 18, and 15 inches and feeders running 12 inches; most of the sanitary line was of 8-inch pipe. Much of the storm drain was pipe with a flat bottom side, to provide a better bearing surface than conventional round pipe.

I-029
PLASTIC PIPES FOR WATER AND WASTEWATER. (Plastroer i VA-tekniken.) Text in Swedish.

Anders Cronström
TTIDA, 101(18):43-44 (Nov. 1971).

Descriptors: *Plastic pipes, *Reviews, Construction materials.

This article reviews the application of plastic pipes used in water supply and wastewater treatment. The life of plastic pipes is limited by shrinkage to approximately fifty years. Pipe quality is highly affected both by the material used and the manufacturing process. Glass-fiber reinforced polyester pipes are hardly suitable for wastewater because of low resistance to axial forces. Underground plastic pipes should be covered by friction material in a width of twice the pipe diameter. The fatigue fracture in plastic pipes is dependent on the magnitude of the mechanical stress and that of the elongations caused by the stress.

I-030
DIGITAL CONTROL AT GRAND RAPIDS, MICHIGAN.

James E. Curtis and M. R. Van Eyck
Abstract, Water Pollution Control Federation, Washington, D.C., 1971. (Presented at the 44th Annual Conference of the Water Pollution Control Federation, San Francisco, California, October 3-8, 1971.)

Descriptors: *Digital computers, *Control systems.
Identifiers: *Direct Digital Control system, Grand Rapids, Michigan.

During the study of the required plant expansion program at Grand Rapids, Michigan, a comprehensive monitoring and process control system, having a flexible configuration to meet future changes in technology without major revisions, was determined essential. Direct Digital Control (DDC) was selected as the central control system for the expanded plant. The functions of the DDC system include: 1) controlling flow to the plant and through the various treatment units; 2) monitoring of the chemical and physical parameters of the sewage as it flows through the plant; 3) controlling chemical dosages in the phosphate removal process; 4) monitoring the flow conditions in the combined sewer system; 5) monitoring rainfall conditions in the combined sewer area; and, 6) compiling and calculating data for daily, monthly, and yearly reports. This system can be modified by addition of process signals and reprogramming to accomodate any changes in treatment philosophy or technique within the physical limitations of the plant piping and structures.

I-031
NEW SEWER PROGRAM FOR A NEW CITY.

E. E. Halmos
WSIWA, 118(9):307-309 (Sept. 1971).

Descriptors: *Sewerage, Sewers, Pumping plants, Operation and maintenance, Costs.
Identifiers: Chesapeake, Virginia.

Chesapeake, Virginia, the result of a merger of South Norfolk and Norfolk County, faces the problems presented by flat, wet land as it connects and extends the sewage systems which it recently acquired. Variation in elevation is less than 2 feet and groundwater in most places is within a foot or two of the surface. Gravity sewer lines must start as near to the street surface as possible and can be carried only to depths of about 12 feet, with a maximum length of 3,000 linear feet and then flow must be lifted so that another gravity run can be constructed. By 1975, a total of 53 pumping stations with 125 miles of collector lines will be operating in addition to the 35 pumping stations in use with the existing 150 miles of sanitary sewer collection lines. Of the 13 new stations installed in the past year, 10 are above-ground installations requiring only a single well and easily accessible for maintenance. The city has constructed attractive structures to house the equipment and has installed a by-pass pipe stub outside each station which will allow the station to be bypassed in the event of need for repairs. Each station contains two pumps of various sizes up to 994 gpm, which can be operated individually or in tandem. Costs are lower and maintenance easier with this type of pumping station.

I-032
EFFECTIVE USE OF TV INSPECTION AND SEALING CAN SAVE MONEY.

Tom Lenahan and Joe Herndon
Abstract, Water Pollution Control Federation, Washington, D.C., 1971. (Presented at the 44th Annual Conference of the Water Pollution Control Federation, San Francisco, California, October 3-8, 1971.)

Descriptors: Repairing, Costs, Sewers.
Identifiers: *Sewer inspection, *Closed-circuit television.

This paper discusses a method utilizing closed-circuit television which permits sewer lines to be viewed from the surface and leaking joints to be repacked remotely without the necessity of costly excavation. This method involves running a special television camera through the line for inspection and location of trouble areas. A companion system is used for isolating points of water infiltration and repacking faulty joints with a special quick-setting chemical grout. Examples are cited from various states to show how these two techniques are helping to accomplish reduced costs of operation and improved maintenance programs.

I-033
RENEW OLD SEWERS AND THEN MAINTAIN THEM.

William A. Olson
AMCIA, 85(10):105-106 (Oct. 1971).

Descriptors: *Sewers, *Repairing, *Maintenance, Concrete construction.
Identifiers: Peoria, Illinois.

A sewer-rehabilitation program, investigated and determined feasible by Warren & Van Praag, Inc., Consulting Engineers and Architects of Decatur, Illinois, will extend the useful life of the existing sewers in Peoria by forty to fifty years at reasonable costs. The sewer rehabilitation was done by Pressure Concrete Construction Company, Florence, Alabama. The following procedure was used for rehabilitation: sewer flow is diverted in a section of the sewer; the surface and joints are cleaned; and, crowns or missing portions of the sewer are patched with a high-grade, air-entrained concrete. This last step is accomplished by anchoring mesh to the inner walls and guniting a sand-cement mortar under high pressure onto the inner wall surface thus building the inner face of the existing structure to the desired thickness.

I-034
RESEWERING IN GATESHEAD.

B. H. Pritchard
JMUEA, 98(1):305-311 (Nov. 1971). 8 fig, 1 tab, 3 ref.

Descriptors: *Drainage systems, Sewers, Construction, Pipelines, Computers, Analytical techniques, Excavation, Flow characteristics, Tunneling, Design.
Identifiers: Sewer inspection, Great Britain.

The preliminary investigations and design have been completed for a drainage system aimed at achieving a completely separate system utilizing as many of the sewers from the existing combined system as is practical. Other aims of the design include relief of the Western Outfall and High Street Sewers, and provisions of adequate sewerage system to proposed redevelopment areas. Inspection of existing

sewers was carried out using a television camera along smaller sewers and computer analysis was undertaken to assist in design considerations. The design of the West Street Outfall, the first phase of the major drainage scheme proposed, is complete and the contract is underway. Open trench construction is planned. Most of the techniques involved in descending the 200-foot slope with reduction in velocity of flow were not economical. The provision of steel bars as obstructions in the pipeline to accelerate the rate of head loss down the slope was a simple, economic solution. Excavation up the steep bank was carried out by drag line, after terracing the slope. One section of the sewer was tunneled through firm boulder clay, and smooth-lined, boltless tunnel segments were successfully used to construct the 60-inch pipeline.

I-035
PRESENT STATUS OF LOW PRESSURE AIR TESTING FOR SANITARY SEWERS.

Roy E. Ramseier
Abstract, Water Pollution Control Federation, Washington, D.C., 1971. (Presented at the 44th Annual Conference of the Water Pollution Control Federation, San Francisco, California, October 3-8, 1971.)

Descriptors: *Pipes, *Testing, Leakage, Construction materials.
Identifiers: *Low pressure air testing, Sanitary sewers.

Where newly installed sewers are tested for possible leakage, the most widely accepted methods of testing have been measurement or observation of water infiltration, water exfiltration, or leakage of air under low pressure. Water infiltration is dependable only if the sewer pipe is completely below ground water. For many years, the accepted test of a pipe not submerged in ground water has been made by measuring the amount of exfiltration with the pipe completely filled with water under moderate pressure. Recent development of the low pressure air test has provided consistently accurate results at a lower cost and in less time. Suggested specifications that can be used for any type of pipe are so designed that the engineer may select a leakage allowance which will result in the quality of work desired, yet is neither unduly harsh nor too lenient. Existing pipe materials vary between manufacturers, and regionally. New pipe materials may indicate the desirability of new specification points for allowed leakage.

I-036
UPDATING SUBSTANDARD WATER AND SEWER SYSTEMS.

B. F. Rivers and Edwin A. Apel
PUWOA, 102(12):73 (Dec, 1971).

Descriptors: *Construction costs, *Sewerage, Construction, Project planning, Piping systems (mechanical), Water management (applied), Grants.
Identifiers: Mineral Wells, Texas.

Due to a high population growth rate the city of Mineral Wells, Texas in 1966 adopted rigid specifications requiring pipe with compression joints for trunk lines, laterals, and service lines. However, by 1969 the inadequacy of both the pre- and post- 1946 sewerage collection lines warranted immediate action to bring them up to standards and provide capacity for future growth. A HUD grant offer of $805,000 has been made in response to a $1.6 million request for improvements in the sewage collection system, water distribution system, and the storm sewer system. Presently the projects under review include bolstering the water feeder main system together with construction of a new, high service water pumping system.

I-037
FUNCTIONAL REQUIREMENTS OF A SEWER.

Ragnar Tillander
Preprint, 1970. 4p, 3 fig. (Presented at the International Water Conservancy Exhibition, Jönköping, Sweden, September 2-9, 1970.)

Descriptors: *Sewers, *Repairing, *Sealants, Methodology, Equipment.
Identifiers: Sweden.

A method that permits existing sewers to be sealed from the manholes while in service uses a "pressure head" apparatus. The pressure head consists of two laterally fixed rubber rings that can be inflated. To one end of the tool a compressed air hose for inflating the rings is connected, while the sealant is fed into the opposite end. It is essential that the sealant be pressed through the leaks and penetrate into the backfill around the pipe. After the joint has been sealed and the soil grouted, the pressure head is moved to the next joint and the procedure repeated. The sealant required must be decided for each job. At the present, the best type of sealant for sewers laid in rock trenches or in frictional soils is a properly compounded cement grout. Conduits best suited for sealing using this method are: sewer lines where traffic congestion either precludes ex-

cavations or makes them difficult and costly, and combined sewer lines to be retained as surface water conduits when a separate system is built.

I-038
STRUCTURAL STRENGTHS OF BURIED PIPE MATERIALS.

Reynold K. Watkins
Abstract, Water Pollution Control Federation, Washington, D.C., 1971. (Presented at the 44th Annual Conference of the Water Pollution Control Federation, San Francisco, California, October 3-8, 1971.)

Descriptors: *Pipes, Piping systems (mechanical), Construction materials, Design criteria.

For buried pipes the structural performance limit is a deformation of the pipe-soil system beyond which the system cannot perform its designed function. One such performance limit is crushing or buckling of the pipe wall, or excessive deflection of the ring with reduction of pipe flow or formation of objectionable cracks or plastic hinges. In order to simplify design of the ring, the strength of material can be defined as the yield point of the pipe material provided that the calculated ring compression stress in the pipe wall is adjusted by factors based on soil density and, for very flexible rings, on ring stiffness.

I-039
A COMPUTER PROGRAM FOR SEWER DESIGN AND COST ESTIMATION.
Regional Planning Council, Baltimore, Maryland

P. L. Zepp and A. Leary
HUD No. p-71, Apr. 1969. 83 p, 9 fig, 5 tab, 8 ref, 5 append.

Descriptors: *Computer programs, *Programming languages, *Estimated costs, *Design criteria, Piping systems (mechanical), Comparative costs.
Identifiers: *Sanitary sewers.

The need for a faster and more economical method of cost analysis and design of a sanitary sewer system is satisfied by using a computer program. The Design Model Program is written in the General Electric Time-Sharing Fortran Language for use on the G. E. Model 235 computer, using paper type and teletype input and output. Digital input to the program consists of the area tributary to each pipe for each land use type, pipe length, and ground elevation at each manhole. The model is composed of three separate programs linked together and run sequentially. The first calculates sewage flows and makes assignments to various pipes. The second calculates pipe sizes, invert elevations at manholes, pipe grades, and optimum pipe costs. A subroutine calculates total costs, including the pumping station. By comparing several pairs of system costs, the most economical system (e.g., gravity pipe versus pumping station design) can be selected. The third program prints the results. The output consists of peak sewage flows, pipe sizes, elevations of pipe inverts at manholes, pipe slopes, costs of pipes per foot between manholes, total costs of pipes between manholes, and total system costs.

I-040
HOW POLYETHYLENE PIPE WAS USED TO REHABILITATE COLLECTOR SEWER.

ENCRA, 85(2):52 (Feb. 1972).

Descriptors: *Repairing, *Pipelines, *Sewers, Tunneling, Construction Costs.
Identifiers: *Polyethylene Pipe, Canada.

A collapsed, 36-inch-diameter sanitary collector sewer in the City of Dorval, Quebec, has recently been repaired by relining with 32-inch Sclairpipe polyethylene pipe from Du Pont of Canada. For this rehabilitation, a winch was located at the nearest manhole and a steel cable was fed back through the old sewer to a 50-foot-long access shaft. A vibrating pulling head was then attached to a 38-foot length of polyethylene pipe, lowered into the shaft, and pulled into the old sewer. When all but about four feet of the pipe had been pulled into the sewer, a butt-fusion joining machine was lowered into the shaft and a second length of Sclairpipe was fused to the first. The process was repeated thus relining a total of 1900 feet of the old sewer. This procedure required the excavation of three access shafts and two lateral connections, both of which were located near existing manholes. A cost saving of approximately 50% over what would have been required for reconstruction has been estimated.

I-041
FIBERGLASS PIPE RENEWS FAILING BRICK SEWER.

ROSTA, 115(2):75 (Feb. 1972).

Descriptors: *Repairing, *Pipelines, *Sewers, Tunneling.
Identifiers: *Fiberglass Pipe, Kansas City, Kansas.

A clogged sewer under a switch line of the Kansas City-Southern Railroad tracks in Kansas

City, Kansas, recently was opened by a tunneling technique using fiberglass pipe. Bricks from the old sewer arch had loosened from the arch and fallen into the sewer, which was close to the surface underneath the tracks. A single entrance shaft about 16 feet wide opening down to a flow line depth of about 12 feet was located near one corner of the street intersection midway along the 209-foot sewer tunnel. This method allowed the four-man crew to work in both directions. The thin-walled polyester resin Johns-Manville pipe called Flextran was cut as it was being installed. Linings, wrapping coating, and cathodic protection were not needed.

I-042
SEWER LINE FILLS 30 YEAR NEED.

WWAEA, 9(3):55-56 (March 1972). 2 fig.

Descriptors: *Sewers, *Construction, Construction Costs, Construction Equipment, Construction Materials, Pipelines.
Identifiers: *Alta Ski Resort, Utah.

For over thirty years, obstacles such as weather, legal, geographic, and economic, have deterred construction of much needed sewer line service for ski lodges and private homes in the Alta ski resort area in Utah. Finally, Alta decided to build their own sewer line, which would stretch 2¼ miles to connect with the Snowbird line at a nearby resort. The job was estimated at $380,000 and Pacific States 10-inch-diameter mechanical joint ductile iron pipe was selected. The line features 133 manholes, one at every change of direction, over its 32,412-foot length. Construction, begun in November 1970, was halted by snow and subsequent skiers. In that time, however, 600 feet of pipe were laid. A demolition point on a pile hammer was used against the 15-foot granite boulders since conventional blasting techniques were too expensive. When the snow melted in April 1971, construction resumed.

I-043
SIX MONTHS EXPERIENCE WITH A PRESSURE SEWER SYSTEM DEMONSTRATION.
New York State Department of Environmental Conservation, Albany, New York.

Italo G. Carcich, Leo J. Hetling, and R. Paul Farrell
Technical Paper No. 4, April 1971. 46 p, 24 fig, 17 ref.

Descriptors: *Sewerage, *Pressure Conduits, *Sewers, *Sewage Disposal, *Pump Testing, Waste Water Disposal, Sanitary Engineering, Prototype Tests, Data Collections, Monitoring.
Identifiers: *Pressure Sewer System, *Albany, New York, Pumpgrinder.

A general description is presented of a combination sewage grinder-pump unit presently under test in Albany, New York. The unit was developed by the General Electric Company Re-entry and Environmental Systems Division in cooperation with the American Society of Civil Engineers. The grinder-pump unit has application in situations where gravity-flow sewer systems are not feasible. This would be the case for a building having plumbing fixture drains located below the elevation of the lowest possible gravity sewer connection. The grinding component consists of a rotating wheel carrying two hammers inside a fixed stationary cutting ring. The unit is designed to grind sewage and foreign objects that may accidentally enter the unit with sewage flow. The pump is designed to pump between 11 and 15 gpm over a range of heads from zero to 35 psig. Installations were made in basements of 12 townhouses in Albany for the purpose of demonstrating the operation of the unit. Six operating parameters are monitored at 15-minute intervals by a remote system using telephone wires. All data are recorded on paper tape and fed into a computer for analysis of the data.

I-044
PRESSURE SEWER DEMONSTRATION PROJECT.

Italo G. Carcich, R. Paul Farrell, and Leo J. Hetling
JWPFA, 44(2):165-175 (Feb. 1972). 12 fig, 2 tab, 17 ref.

Descriptors: *Sewerage, *Pressure Conduits, *Sewers, *Sewage Disposal, *Pump Testing, Waste Water Disposal, Sanitary Engineering, Prototype Tests, Planning, Design Criteria.
Identifiers: *Pressure Sewer System, *Albany, New York, Pumpgrinder.

The New York State Department of Environmental Conservation is evaluating the concept of pressure sewers to serve areas where gravity flow is uneconomic or impossible. The project involves 12 townhouses in a low- to middle-income development near Albany, New York. Each townhouse is equipped with a storage-pump-grinder unit that discharges into a pressure main. Automatic monitoring is provided for each unit. This paper describes planning and initial design of the project and comments on the first 6 months of operation.

I-045
HARD POLYETHYLENE PIPES FOR PRESSURE AND SEWAGE SYSTEMS. (Rohre aus Hartpolyathylen für Druck-und Abwasserleitungen.) Text in German.

Wilhelm Müller and Kurt Graf
ENTEA, 24(1):15-22 (Jan. 1972). 20 fig, 1 tab, 3 graph, 12 ref.

Descriptors: *Pipelines, Construction Materials, Sewers.
Identifiers: *Polyethylene Pipe.

Hard polyethylene(PE) pipes are quite adaptable for use as sewage draining receptacles in apartment houses. They are resistant to hot water, freezing, and chemical agents and have smooth walls thus minimizing incrustation. Their hydrophobic properties are advantageous in their utilization as drainage pipes. Pipes are welded or screwed together, forming a completely tight unit. PE pipes can also be used in sewer construction because of their weldability, with an important influence on cleanliness of groundwater and soil. The PE pipes used in sewer construction have diameters up to approximately 4 feet. In case of aggressive vapors, corrosion-proof shaft linings of hard PE coil tubes, with welded shaft bottoms and connecting pieces, are used.

SECTION II.

Overflows, Infiltration, and Regulation Devices

II-001
SEPARATOR REMOVES OILS FROM STORMWATER.

PUWOA, 102(7):92 (July 1971). 1 fig.

Descriptors: *Water pollution control, *Oil wastes, *Separation techniques, Storm runoff, Illinois.
Identifiers: *Oil separation.

To meet the Chicago Sanitary Sewer District code on amounts of contaminants discharged into the Chicago River, the Shell bulk terminal at Argo, Illinois installed an oil separator utilizing the Heil corrugated plate intercepts. Located downstream from the normal box separators, the unit functions during storm water conditions. The separator's design and operation are described and diagramed.

II-002
NEW CONVERSION PLANT, SEWER SEPARATION SYSTEM BOAST "FIRSTS".

WWAEA, 8(7):10 (July 1971).

Descriptors: *Computers, *Sewers, *Automatic control, Costs, Drainage systems, Flood control, Water pollution control.
Identifiers: *Minneapolis-St. Paul.

In Minneapolis-St. Paul, a unique computer directed sewer system is now in use. The new system was created from the existing 90 year-old facility for approximately $1.7 million, a fraction of the $200 million estimate for sewer separation to provide comparable performance. Heavy spring rains, floods, and resulting water pollution in the Mississippi River made the new system necessary. Its purpose was to convert the Twin Cities' combined sewers into controllable reservoirs.

II-003
EVALUATION OF STORM STANDBY TANKS: COLUMBUS, OHIO.
Dodson, Kinney and Lindblom, Columbus, Ohio

EPA/WQO Program No. 11020 FAL, Mar. 1971. 99 p, 51 fig, 4 tab, 1 append.

Descriptors: *Waste water treatment, *Sewers, Sedimentation.
Identifiers: *Storm tanks, *Columbis, Ohio, Intercepting sewer, Solids removal, Dissolved oxygen improvement, Biochemical oxygen demand removal.

The operation of three storm standby tanks contiguous to an intercepting sewer which serves both combined sewers and sanitary sewers was investigated to determine the effectiveness of the tanks in improving the quality of the wastewater prior to its discharge into the river. Based on influent and effluent sampling data collected during the study period, storm standby tank facilities reduce significantly concentration of solids and B.O.D. in the wastewater in storm runoff periods. The extent of reduction is dependent to a major degree on the detention time of flow passing through the tanks. Improvement of dissolved oxygen resulting from passage of wastewater through the tanks is very substantial, especially during periods when the dissolved oxygen content of the influent is low. Since improvement in water quality of effluent from the tanks would normally occur when volume of flow in the receiving river is above average and when its quality can be expected to be reasonably good, it is concluded that the tanks would contribute to pollution abatement only to a minor degree. However, some benefits would result from the reduced load applied to the stream, even at a time when the river could handle such load.

II-004
STORM WATER PROBLEMS AND CONTROL IN SANITARY SEWERS: OAKLAND AND BERKELEY, CALIFORNIA.
Metcalf & Eddy, Inc., Palo Alto, California.

EPA/WQO Contract No. 14-12-407, Program No. 11024 EQG, Mar. 1971. 270 p, 48 fig, 31 tab, 25 ref.

Descriptors: *Infiltration, *Sewerage, *Overflows, *Flow measurement, *Computer models, Sampling, Sewage treatment, Storm runoff, Rainfall-runoff relationships, Estimated costs.
Identifiers: *Sanitary sewers, Oakland, California, Berkeley, California.

An engineering investigation was conducted on storm water infiltration into sanitary sewers and associated problems in the East Bay Municipal Utility District, Special District No. 1, with assistance from the cities of Oakland and Berkeley, California. Rainfall and sewer flow data were obtained in selected study subareas that characterized the land use patterns predominant in the study area. Results obtained were extrapolated over larger drainage areas. A computerized flow routing program for the sewer system was used in this analysis. Ratios of infiltration to rainfall in the study

subareas range from 0.01 to 0.14. Ratios of peak wet weather flow to average dry weather flow range from 2.1 to 9.1. About 11.1 percent of the rainfall enters the sanitary sewer system; 30.6 percent of the infiltration is contributed by the 4 percent of the study area that has combined sewers. Problems associated with infiltration and resulting overflows and bypasses are: 1) pollution of San Francisco Bay, 2) operational difficulties at the treatment plant, and 3) danger to public health, property damage, and nuisance. Estimated costs for the most feasible combinations of solutions to these problems, consisting of treatment plant improvements, separation of remaining combined sewers, partial treatment of overflows, and sewer improvements, range from approximately $42 million to $94 million. Specific recommendations for subsequent developmental programs are presented; complete implementation of the recommended plan will take about 7 years.

II-005
DISPATCHING SYSTEM FOR CONTROL OF COMBINED SEWER LOSSES.
Metropolitan Sewer Board, St. Paul, Minnesota

EPA/WQO Demonstration Grant 11020 FAQ, Mar. 1971. 206 p, 81 fig, 30 tab, 36 ref.

Descriptors: *Storm runoff, *Sewers, *Overflow, *Pollution abatement, *Mathematical models, Sewerage, Sanitary engineering, Model studies, Water pollution control, Mississippi River.
Identifiers: *Combined sewers, *Minneapolis-St. Paul, Urban hydrology.

Impressive reductions in combined sewer overflow pollution of the Mississippi River in Minneapolis and Saint Paul have been effected by a regulator control system. Working entirely within the limits of the existing interceptor sewer system, and with relatively minor modifications to selected major combined sewer regulators, incidence of overflow was reduced by 66% and duration of overflow by 88% during most of a rainfall season. Computer simulation techniques using actual rainfall data indicate that the amount of overflow volume reduction achieved is the equivalent of a $200 million separation project. The efficiency of collection was improved by about 20% at controlled regulators. The reduction in volume of combined overflow to the river is estimated to be between 35% and 70% during the runoff season. The unmodified combined sewer system captured about 65% of the urban runoff. Where modified, the system captured about 77% of the urban runoff. A mathematical model has been prepared that will, with rain gage data as input, perform rainfall-runoff analysis, diversion of combined sewer runoff hydrographs through the interceptor system. This model will assist in operation of the system to retain combined sewer flows and utilize the maximum flow capacity of the existing interceptor sewer system. The 1.75 million dollar project includes a computer-based data acquisition and control system that permits remote control of modified combined sewage regulators. Data from rain gages, regulator control devices, trunk sewers and interceptors, and river quality monitors provide real-time operating information. Time varient quality data from key locations in the sewer system were obtained by automated analysis of numerous hourly samples.

II-006
MONEY DOWN THE DRAIN.

Carl F. Buettner
AMCIA, 86(8):60-62 (Aug. 1971). 1 fig, 2 tab.

Descriptors: *Cost comparisons, *Infiltration, Drainage, Data collections, Real benefits, Flow measurement, Instrumentation, Rain water, Surface runoff, Groundwater.
Identifiers: *Polcon Wastewater Flow Tubes.

Groundwater infiltration into a city's wastewater collection system can be a major source of public dollar waste. It is not uncommon for a city to pay from $100 to $2000 per day in additional wastewater treatment expense for the unnecessary treatment of ground or surface water leaking into the sewer system. One sewer authority's method for locating points of infiltration is described. By using Polcon Wastewater Flow Tubes and related portable instruments, the sources of infiltration were isolated without the need for digging, breaking pavement, or building expensive structures. The Polcon tube is an accurate, inexpensive, primary element for metering flows in a partially-filled conduit. Using this equipment it was possible to establish a daily relationship between the potable water entering the system and the wastewater leaving each drainage area, and to establish a dry versus wet weather flow ratio, then to isolate the areas of infiltration. In this particular case, the authority estimated an annual saving of approximately $24,000. After the expenses incurred in locating and sealing infiltration points, a small saving was realized even in the first year.

II-007
THE WASTEWATER LOAD OF THE MAIN CANAL THROUGH RAIN OUTLETS WITH AND WITHOUT INTERMEDIATE STORM WATER RETENTION TANKS. (Die schmutzwasserbelastung des vorfluters (sbv) durch regenüberlaüfe (rü) mit und ohne zwischenschaltung von regenüberlaufbecken (rüb).) Text in German.

R. Lautrich
WUBOA, 23(8):234-235 (Aug. 1971). 2 graph, 7 ref.

Descriptors: *Computer programs, *Drainage water, *Outlets, Data collections, Rainfall-runoff relationship.

An electronic computer program has been developed for which the wastewater load of the main canal passing through rain outlets can be determined with sufficient accuracy. The calculation uses the following data: flow time, runoff delay, height of annual precipitation, rain frequency, rain duration curve, supply of water other than rainwater, distribution of the daily wastewater accumulation over an optional number of hours, and industrial wastewater amounts. The mixing ration which continuously changes can be applied to rain overflows connected in tandem.

II-008
RELIEVING COMBINED SEWER POLLUTION.

WSIWA, 118(10):334 (Oct. 1971).

Descriptors: *Control systems, *Computers, *Gate control, Pollution abatement.
Identifiers: *Sewer overflows, Minneapolis-St. Paul Sanitary District, Combined sewers.

A computer directed sewer system has solved the pollution problem from combined sewer overflow in the Minneapolis-St. Paul Sanitary District. 18 of the system's regulator gates, controlling about 80% of the total sewage flow, have been modified to operate under semi-computerized control. 15 air-inflatable rubber dams, underground control vaults, five river water quality monitoring subsystems, and a data acquisition and control system were installed. The data acquisition and control system handles 135 simultaneous water quality and water level measurements from 40 different locations. The computer-generated analysis of this data is used in making gate adjustments.

II-009
DEMONSTRATION OF ROTARY SCREENING FOR COMBINED SEWER OVERFLOWS.
Bureau of Sanitary Engineering, Portland, Oregon

EPA/R&M Contract No. 14-12-128 Modification No. 7, Program No. 11023 FDD, 55 p, 9 fig, 8 tab.

Descriptors: *Storm runoff, *Water pollution control, *Overflow, Efficiencies.
Identifiers: *High-rate screening, Combined sewers, Solids removal, COD removal.

The objective of this demonstration was to determine screen durability, solids removal, COD removal, and hydraulic efficiency of rotary fine screening of storm-caused combined sewer overflows. 2300 gpm were evenly distributed to a 60-inch diameter rotating (55 rpm) screen cage holding 18 square feet of 165 mesh stainless steel screens (105 micron opening, 47.1% open area). During a screening cycle a concentrate sensor stopped the sewage pumps, ending the screening phase and initiating a 30-second cleaning phase during which the screens were automatically washed. At the end of the cleaning phase the pumps restarted automatically and a new cycle began. Performance on storm-caused combined sewage flow averaged 54.8% removal of settleable solids, 26.6% removal of suspended solids, and 15.5% removal of COD. Duration of the screening phases averaged 14.6 minutes with average hydraulic efficiencies dropping from 0.880 to 0.668. The ultimate screen life varied from a minimum of 190.5 hours to a maximum of 516 hours with an average of 346. Screens required an average of 3.5 repairs during this life.

II-010
OPERATING RESULTS OF A REMOTE CONTROL SYSTEM FOR COMBINED SEWER OVERFLOWS.

James J. Anderson and Robert L. Callery
Abstract, Water Pollution Control Federation, Washington, D.C., 1971. (Presented at the 44th Annual Conference of the Water Pollution Control Federation, San Francisco, California, October 3-8, 1971.)

Descriptors: *Control systems, *Remote control, *Computers, Installation, Costs, Operations, Mathematical models, Rainfall-runoff relationships.
Identifiers: *Sewer overflows, *Overflow regulators, Combined sewers, Minneapolis-St. Paul Sanitary District.

The results of operation of a computer-based combined sewer control system in Minneapolis and St. Paul, Minnesota, are presented. Combined sewer regulators which control overflow from major trunk sewers were modified for remote control and monitoring. The modified regulators were operated to reduce overflow based on rainfall, interceptor sewer, and trunk sewer level measurements collected in real time. Costs of installation and operation of the system, now in its third year of use, are presented along with a description of major problems encountered in installation and operation. The annual overflow volume was reduced by more than 50% and the annual duration of overflow (total overflow hours) reduced by about 90%. The rainfall-runoff mathematical model of the combined sewer system shows the elimination of overflow for 30-minute rainfalls up to .37 inches per hour, 75% reduction at .75 inches per hour, and 50% reduction at 1.25 inches per hour, based on certain conditions. The control system was designed and operated to take advantage of rainfall characteristics. Much of the annual rainfall occurs at low intensities; the system strategy also considers areal variability of rainfall during a given event.

II-011
SEWER FLOODING CONTROL SYSTEM.

Lloyd G. Cherne
United States Patent: 3,605,799. Applied Apr. 24, 1970. Issued Sept. 20, 1971.

Descriptors: *Flood control, *Sewers, *Sewerage, Flood damage, Patents, Equipment.

An improved sewer flooding control system utilized to prevent the flooding of a building basement because of a backup in the building sewer or the surging of sewage in the sewer has been patented. The system is mounted below the floor level of a basement and is actuated by the presence of sewer flooding conditions in the sewer. Means for preventing flooding or damage as a result of surging sewage both in the basement as well as within the system and novel guide means for guiding a float and preventing damage from surging are also provided. When flooding conditions exist, a float member rises with the level of the sewage, and in turn, causes a valve to close in the sewer pipe, thereby preventing any flow of sewage through the pipe. When flooding conditions subside, the float is correspondingly lowered with the level of sewage and the valve is opened.

II-012
SEWAGE "RESERVOIR" SOLVES OVERFLOW PROBLEM.

Fred M. Conger
AMCIA, 84(11):103 (Nov. 1971).

Descriptors: *Storm runoff, *Retention, Sewage treatment, California.
Identifiers: *Sewer overflows, Overflow abatement.

A trapezoidal holding basin of about 100,000 gallons capacity is being used temporarily for four hours per day to eliminate the overflowing of the main transmission line for the La Jolla-Pacific Beach area. Adjacent to a sewage-pumping station at an elevation about 25 feet lower than the sewer, the basin measures 40 by 50 feet and is 10 feet deep. A ten-mil polyethylene film covers the bottom and sides. A 50-gallon drum punched with 3-inch holes on the end of the influent line was installed to diffuse the flow thus eliminating the problem of holes in the bottom caused from the speed of the entering sewage.

II-013
DETENTION AND CHLORINATION STATION SOLVES COMBINED SEWER OVERFLOW PROBLEM ECONOMICALLY.

K. Peter Devenie
PUWOA, 102(11):48-50 (Nov. 1971). 3 fig.

Descriptors: *Automatic control, *Overflow, Treatment facilities, Storage tanks, Sewage treatment, Chlorination, Construction costs.
Identifiers: Combined sewers, Overflow abatement, Cambridge, Massachusetts.

A completely automatic combined sewer overflow detention and chlorination station in Cambridge, Massachusetts, reduces the cost of the downstream relief sewers, headworks, tunnels, and treatment facilities and should eliminate the overflow of raw sewage from combined sewers. Overflows enter the station from three new relief sewers through the three channels which contain mechanically cleaned screens. If all gates are shut the flow will back up to the overflow weirs on the relief sewers. Screenings are dumped into a sluiceway and flushed back to the sewer system by stripping pumps in the pumping station wet well. The total design flow of 233 mgd can be pumped with any one of the four engines or pumps inoperative. A residual chlorine analyzer provides final trim of chlorination rates from two 4,000-gallon tanks containing approximately 15% sodium hypochlorite solution to provide a residual of 1 mg/liter. For 80% of the overflows the total contact time will be in excess of 1/2 hour. The six detention

tanks also remove solids through settling and floating. Mesh screens with 0.2-inch openings at the effluent end trap floating material and it is returned with the sludge to the sewer system, in conjunction with dewatering of the tanks after use. The detention tanks, which are a major portion of the station, have been covered with earth and planted with grass. The total construction cost of the station was $4.7 million.

II-014
MICROSTRAINING OR COMBINED SEWER OVERFLOWS.

E. W. J. Diaper and G. E. Glover
JWPFA, 43(10):2101-2113 (Oct. 1971). 2 fig, 6 tab, 7 ref.

Descriptors: *Storm runoff, Waste water treatment, Chlorination, Costs.
Identifiers: *Microstraining, *Sewer overflows, Ozonization, Philadelphia, Pennsylvania.

Treatment of an actual storm water overflow in a residential area of Philadelphia, Pennsylvania, by microstraining has produced solids removals averaging 91% of high throughput conditions with a 23-μ screen and 80% at lower throughputs. Volatile suspended solids removals averaged 70%. The process can be followed by chlorination or ozonation for bacterial reduction. Biochemical oxygen demand removals vary and are sometimes negative. Pretreatment of microstrainer influent by a heavy solids trap and bar screen is recommended for full-scale installations. Costs of bar screening, and microstraining would be about $10,200/acre ($26,300/ha), with chlorination, $11,200/acre ($27,600/ha), and with ozonation, $19,800/acre ($49,000/ha).

II-015
SNOWMELT TEMPERATURE INFLUENCE ON INFILTRATION AND SOIL WATER RETENTION.

Glen O. Klock
JSWCA, 27(1):12-14 (Jan./Feb. 1972). 1 fig, 2 graph, 6 ref.

Descriptors: *Snowmelt, *Temperature, *Infiltration, *Soil Water, Retention, Watershed Management, Overland Flow.

Temperature effect of snowmelt on infiltration and soil water retention is shown by theory and experimentation. The infiltration of water near snowmelt temperature, 0½C, into a column of soil was measured at one-half the rate at 25°C. Increasing the temperature of a drained soil column near 0°C to a higher temperature, resulted in additional soil water drainage and a significant decrease in the amount of water held by the soil. Watershed management implications including the recognition of possible overland flow hazards, effects of thinning, and wildfire are discussed.

II-016
SILO IN THE SEWER STORES STORM WATER OVERFLOW.

ENREA, 188(21):18 (May 25, 1972). 1 fig.

Descriptors: *Underground Storage, *Storm Water, *Treatment Facilities, *Overflow, Sewerage, Pollution Abatement, Waste Water Treatment.
Identifiers: Lancaster, Pennsylvania.

As a $1.7 million demonstration project aimed at preventing pollution of the Conestoga River by overflows from the sewer system, Meridian Engineering, Inc. of Philadelphia, Pennsylvania has designed an overflow treatment facility to be added to the existing sewers that includes an underground silo to store excess flow. During overflow periods, excess wastewater will enter a swirl chamber where the sewage will flow in a fast circular motion, forcing the solids to the center of the vortex where they will settle out of the liquid. The pretreated sewage then flows into the silo, an underground chamber 100 feet deep and 50 feet in diameter with a 1.2-million-gallon capacity. After the storm ends, the silo's contents are pumped back into the interceptor for treatment in the existing treatment plant.

SECTION III.

Sewer Hydraulics

III-001
HERBICIDE CLEARS SEWER ROOTS.

AMCIA, 86(9):16-17 (Sept. 1971).

Descriptors: *Herbicides, *California, Sewerage.
Identifiers: *Root control, *Sewer stoppages.

The use of chemical foam has proved highly effective in relieving the root growth problem in the sewer system of Sacramento County, California. In 19,500 ft of line, main-line stoppages from root growth were reduced from 9 in 1969 to one in 1970. Killing the roots by means of an herbicide is more effective than cutting with conventional root-cutting equipment since cutting stimulates new growth. The herbicide used was a product known as Metham (SMDC), having the trade name Vaporooter. Vaporooter (plus) consists of Stauffer Chemical's Vapam with the foaming agent, Triton X-100 and dichlobenil, a deterrent to regrowth.

III-002
POLYMERS CAN RELIEVE SURCHARGED SEWERS.

John I. Cahalan, Logan V. Miller, and D. Russel Tatman
AMCIA, 86(9):87-92 (Sept. 1971). 3 fig.

Descriptors: *Sewerage, *Costs, *Overflow, *Delaware, Test procedures, Sanitary engineering, Waste water disposal.
Identifiers: *Polymers, *Sewer capacity.

A series of tests conducted at the Cool Run Interceptor, New Castle County, Delaware indicate that the use of polymers increases sewer capacity by reducing frictional resistance to flow. Effective friction-reduction polymers, or flocculants, are characterized as high molecular-weight synthetic organic polymers which can be cationic, anionic, or nonionic. Investigators believe the best polymer for a specific sewer system is one with an extremely high molecular weight, no extensive cross-linking and one which is not a good flocculant for the sewage solids being carried. The polymer used in these tests was a conventional anionic, polyacrylamide based, high molecular weight polymer (Tychem No. 8030) manufactured by Standard Brands Chemical Industries. Purifloc A22, Nalcolyte #673, or Hercofloc No. 836.2 are chemically comparable. These products are not toxic to bacteria, algae, or fish and do not act as nutrients for algae growth. They will not disrupt the biological treatment of sewage and may aid sludge drying rates. Tychem No. 8030 currently sells for $1.10/lb in truckload quantities. The addition of 50 lbs. per day, over a 3 day period, will increase the capacity of a sewer by approximately 25%; 600 lbs. per day over 3 days would increase sewer capacity by approximately 50%. To alleviate sewer overflows polymer injection should begin before surcharging starts.

III-003
SEWERAGE TRANSMISSION SYSTEM.

Ernst Kuntze, Wilhelm Zander, and Bernd Zander
United States Patent: 3,590,836. (to Firma Dr.-Ing. W. Zander). Applied Sept. 25, 1968. Issued July 6, 1971.

Descriptors: *Pipes, *Patents, Sewerage.
Identifiers: *Sewage flow.

In this system, a series of controlled discharge collection stations are linked to a central sewerage transmission pipe. Conduits are pressurized in part with air to create turbulence thus minimizing settlement within the relatively small-diameter pipe.

III-004
THE USE OF FRICTION REDUCING ADDITIVES TO INCREASE THE CAPACITY OF STORM WATER SEWERS.

R. H. J. Sellin and B. J. S. Barnard
JMUEA, 98:207-209 (Aug. 1971).

Descriptors: Storm drains, Storm runoff, Sewers, Sewage treatment, Water pollution, Sanitary engineering.
Identifiers: *Polymers, *Sewer capacity.

The use of minute quantities of certain polymers as additives to increase the capacity of storm water sewers does not add appreciably to the polluting potential of the storm water runoff. Friction reduction by this means is only possible when the flow in the sewer is turbulent in character. The effect of pipe size on the process is complex and not yet completely understood. It is foreseen that these drag reducing additives may prove of greatest value for the field of drainage in supplying a temporary or emergency means of increasing the capacity of a sewer. Tests using the polymer Polyox WSR-301 are described. Experiments indicate the increase in sewer capacity is not sensitive to gradient and amounts to approximately 80% for a 10 ppm dose of Polyox.

III-005
HYDRAULICS OF LONG VERTICAL CONDUITS AND ASSOCIATED CAVITATION.
St. Anthony Falls Hydraulic Laboratory, University of Minnesota, Minneapolis, Minnesota

EPA/R&M Contract No. 14-12-861, Program No. 11034 FLU, June 1971. 49 p, 22 fig, 8 ref.

Descriptors: *Investigations, *Storm drains, *Flow characteristics, *Cavitation, *Sewers.
Identifiers: *Dropshafts.

Experimental studies have been undertaken to examine the flow in long vertical conduits with particular reference to the design of storm water dropshafts. A distinguishing characteristic of such flow is the cavitation regime which may exist in the head-discharge relationship. The cavitation regime will develop when the conduit is sufficiently long and the head sufficiently large. It can also be generated at a lower head if a control valve is installed in the supply line so that the net head can be negative. The cavitation region consists of a rather finely divided mixture of water and water vapor at a constant cavitation pressure of about -32.0 feet of water throughout the region and for all discharges. The concentration of vapor, while relatively constant throughout the cavitation region, decreases with increasing discharge. The location of the shock front is also a function of the discharge. If a small amount of air is introduced into the system, the cavitation region is eliminated, the pressure gradient is more uniform, and the flow consists of a white mixture of air and water. The study also showed that the cavitation region is only one phase of the total head-discharge regime and that its existence depends upon the design of the structure.

III-006
CHARACTERISTICS OF SEPARATED AND COMBINED SEWER FLOWS.

J. A. DeFilippi and C. S. Smith
JWPFA, 43(10):2033-2058 (Oct. 1971). 20 fig, 4 tab, 3 ref.

Descriptors: Measurement, *Water analysis, *Water quality, Rainfall intensity, Storm runoff, District of Columbia, Flow rates, Sewers.
Identifiers: Combined sewers, Sanitary sewers.
Water quality in separated and combined sewers in the District of Columbia was measured during rainfalls. Total flows were measured with a lithium chloride tracer solution, and samples were taken at 5-minute intervals and analyzed. Results show that pollutant concentrations in combined sewers are not influenced by rainfall intensity in short storms and increase with discharge rate during the initial flushing period. Pollutant concentrations were high and remained so throughout short storms but dropped after the initial flushing period in long, intense storms. Organic and nutrient concentrations in separated storm sewer runoff were one-third those in combined sewers. The total waste loads were proportional to the length of dry weather between storms. Bacteriological counts varied with flow rates and peaked in the initial flushing period.

III-007
EXAMINING A PVC-DRAIN WITH AND WITHOUT COIR SOLID FILTER MEDIUM IN A DRAIN TEST BOX. (Prufüng eines PVC-Dräns mit und ohne Kokosvollfilter in Dränkasten.) Text in German.

H. Bruns
WUBOA, 12:350-353 (Dec. 1971). 3 tab, 1 graph, 6 ref.

Descriptors: *Drains, *Hydraulic Transportation, *Filtration, Runoff, Testing.
Identifiers: *Polyvinyl Chloride Pipe, *Coir Filter, Germany.

Drain filters fulfill two requirements: protection against silt-up of major soil particles; and improvement in the hydraulic radius of drain pipes, which keeps drain plants operational for longer periods and improves hydraulic capacity. Drain capacity is influenced more by hydraulic conditions in the immediate vicinity of the drain pipe, than by the transport of water. The object tested was a corrugated PVC pipe, developed by Oltmanns, Jeddeloh/Ammerland, surrounded by a .03 feet strong coir filter. A foot-long section of the filter weighs .31 pounds. 105 holes, 2.5 x 10^{-3} by 1.3 x 10^{-1} feet, occur in rows of two at approximately 1-foot intervals on the pipe in the trough. Total entrance area is .52 square inches/foot. Tests with and without a coir filter in a drain test box showed the following results. 1) The use of a filter enables soil water to get into the drain more easily. In the case of equal water supply, compared with an unfiltered pipe, the filtered pipe's runoff is 2.5-4.2 times higher and runoff time is shorter, at a 45-100% lower stagnation pressure directly at the drain; 2) Runoff increases with increasing stagnation height. This applies to filtered and unfiltered pipes, however, runoff of filtered pipes is 6 times higher; and 3) When the tests began, the same slight amount of sand was washed out with the drain water, by filtered and unfiltered pipes. When the tests ended, the unfil-

tered pipes showed .43 pounds of sand per foot, while no sand was found in the filtered pipes.

III-008
ROUTING STORM WATER THROUGH A DRAINAGE SYSTEM.

Subin Pinkayan
JYCEA, 98(HY1):123-135 (Jan. 1972). 7 fig, 6 ref, 2 append.

Descriptors: *Storm Drains, *Storm Water, *Flood Routing, Hydraulics, Numerical Analysis, Unsteady Flow.

The unsteady free-surface flow in a storm drain with lateral flows is described by two partial differential equations. One is the continuity equation and the other is the momentum equation. These equations with one lateral inflow were solved by the method of characteristics. For this problem, the storm drain consisted of a single continuous line of circular channel with constant slope; the main inflow to the drain was at the upstream end; the lateral inflow came through a circular conduit at the junction box being normal to the direction of the main drain; and, the outflow was a free fall at the downstream. The following conclusions are drawn: 1) the method of characteristics is applicable in solving the equations of unsteady free-surface flow in a storm drain with lateral inflow and power-losses function at the junction box; 2) the storm drain with more lateral inflows can be solved using a modified computer program from the one herein used; and, 3) the approximation of solving the unsteady flow equations at the junction box should be reconsidered in order to give better results.

III-009
METHOD OF RATING FLOW IN A STORM SEWER.
Geological Survey, Mineola, New York.

G. E. Seaburn
Geological Survey Research 1971, Chapter D, Professional Paper 750-D, p D219-D223 (1971). 5 fig, 3 ref.

Descriptors: *Discharge (Water), *Storm Drains, *Flow Measurement, Discharge Measurement, Current Meters, Critical Flow, Flowmeters, Urban Hydrology.
Identifiers: Long Island, New York.

Accurate flow measurements in storm sewer systems are required for many hydrologic studies and are generally difficult to obtain. One approach is to use a theoretical rating curve between stage and discharge developed by using the critical-flow relationship and the Bernoulli equation. To verify this curve, a rating curve for the local storm sewer system was developed from flow measurements of water supplied by nearby fire hydrants. Three methods were used to measure flow: volumetric, current-meter, and critical-flow measurements. The field-determined rating curve and the theoretical rating curve are nearly identical for the range of the field tests. Instantaneous discharges exceeding the field rating curve were evaluated by using the extension of the theoretical curve.

III-010
INFILTRATION MEASURE IN SANITARY SEWERS BY DYE-DILUTION METHOD.

Stanley A. Smith and Larry G. Kepple
WSWOA, 119(1):58-61 (Jan. 1972). 1 fig, 1 tab, 4 ref.

Descriptors: *Dyes, *Sewers, *Infiltration, Measurement, Groundwater, Sewage.
Identifiers: *Sewer Hydraulics.

Dye-dilution technique can be used to measure sewage flows and evaluate groundwater infiltration problems in municipal collection systems. The advantages to this technique are: limited equipment requirements; measurement of flows at a number of points along a sewer in a short time, making possible the comparison of portions of a collection system under similar conditions; collection of samples at street level; and, measurement of flows in sewers running full or surcharged. There are also disadvantages and limitations. Sampling must be done in early morning hours when flow fluctuations are at a minimum; surges within the system make interpretation of flow data difficult; and, possible interference from chlorine should be further evaluated in a community with a chlorinated water supply before using this flow measuring technique.

III-011
SIPHONS: SOME SCALE-EFFECTS IN MODELS.

Richard B. Whittington and Kamil H. M. Ali
JYCEA, 98(HY1):45-70 (Jan. 1972). 21 fig, 6 tab, 18 ref, 2 append.

Descriptors: *Siphons, *Hydraulics, Laboratory Tests, Hydraulic Models, Discharge Coefficient.
Identifiers: *Storm Overflows, Great Britain.

A simple design of storm overflow siphon for

the city of Liverpool, England, has been tested in the laboratory at scales from 1/3 to 1/80. A systematic study was made of the effect of the siphon's absolute size upon the discharge-coefficient, and the priming and depriming phenomena, and on the pressures at the vertex. In addition, the overall discharge-coefficient was analyzed in terms of the components arising from the various bends in that particular siphon. It is shown that the discharge-coefficient, C, and deprime-head/diameter are to be continuously variable with diameters. Siphons with square cross sections yield similar results. The effects upon C of the inlet and outlet bends, are roughly additive and from the use of a convergent inlet leg, a very large rise in C results. The writers suggest that C will at first increase with increasing Reynolds Number, then fall, and start to rise again with further increase ir the Reynolds Number. Measurement made upon short, straight pipes confirms that the value of C at low Reynolds Numbers is higher for the circular than for square pipes.

III-012
FLOW CHARACTERISTICS OF SEWAGE SLUDGE IN PIPES. (Gesui odei no kanro yuso tokusei.) Text in Japanese.

Nobuyuki Yoshida, Etsuo Ogino, and Akira Yokogawa
GSKSA, 9(92):2-14 (Jan. 1972). 2 diag, 3 tab, 15 graph, 6 ref.

Descriptors: *Flow Characteristics, *Pipe Flow, Laboratory Tests, Sewage Sludge, Slurries, Hydraulic Transportation.
Identifiers: Japan.

Sewage sludge and simulated sludge, of kaolin slurry, were used in a pipe-flow experiment. The slurry was sent to the head tank, which had a capacity of approximately 35.7 cubic feet, by a slurry pump; overflow slurry was returned to a circulation tank. The lower end of the head tank was connected to a magnetic flowmeter and flowpipe, which was approximately 328 feet long. Carbide steel pipes, with diameters of .173 and .345 feet, were used. Slurry flow into the pipe was adjusted by a pinch valve, and the condition of flow was observed through a transparent window. Results indicate that homogeneous sludge, of a non-sandy content, can be treated by employing formulas for plastic fluidity, assuming Newton's Law. If the shearing stress submission index and plastic viscosity are known, flow speed limitations can be calculated; pressure loss can also be obtained. When sludge concentration is low, sand will precipitate even in turbulence. When sand content is low, pressure loss can be calculated in the same way as plastic fluidity.

SECTION IV.

Sewer Systems

a. Combined

THERE ARE NO ABSTRACTS FOR THE SUB-SECTION OF THIS ISSUE DUE TO A LACK OF INFORMATION PERTINENT TO THIS CATEGORY.

b. Sanitary

IVb-001
CONTROL OF INFILTRATION IN SEWER SYSTEMS - DESIGN AND MAINTENANCE.

R. Harrington
Proceedings, 8th Annual Environmental and Water Resources Engineering Conference, June 5-6, 1969. Technical Report (20), 7 p.

Descriptors: *Infiltration, *Sewers, Sewage disposal, Waste water treatment, Groundwater movement, Tennessee.
Identifiers: *Nashville, Tennessee.

The City of Nashville and the County of Davidson merged in 1963 and brought about an evolution in the design, construction, and maintenance of sanitary sewers. New specifications were required to upgrade the outdated standards of yesteryear. Modern technology has allowed a great reduction in the infiltration allowed under these new specifications at a reduction in initial cost. A change in pipe material, stone bedding, precast manholes, precast service connections, and improved stoppers have reduced the amount of infiltration into the sewerage of this community.

c. Storm

IVc-001
FEDERAL GRANT PERMITS COMPLETION OF STORM SEWER SYSTEM.

Harold M. Klein
PUWOA, 102(10):78 (Oct. 1971).

Descriptors: *Drainage systems, *Construction costs, Grants, Concrete pipes, Construction, Storm runoff.
Identifiers: *Storm sewers, Metuchen, New Jersey.

The Borough of Metuchen, New Jersey has received a $354,400 HUD grant for the construction of a storm sewer. The balance for costs to the municipality is $505,100. The project which will handle the discharge from ten separate, smaller systems is designed to eliminate almost 4,000 feet of open ditches. Total length of the project is 4,285 feet and will include reinforced concrete pipe varying in size from 15 inches in diameter to 91 by 58-inch elliptical pipe. The system is designed to accommodate a flow of 110 cfs at its higher end and a maximum flow at its outfall of 460 cfs.

IVc-002
CONSTRUCTION OF SEPARATE SEWAGE PIPES AND THE COMPLETE SEPARATION OF STORM WATER AND SANITARY WASTE.
Text in Japanese.

Koji Hirota
GSKSA, 9(93):17-25 (Feb. 1972). 11 fig, 4 photos.

Descriptors: *Storm Water, *Drainage Systems, *Separated Sewers, *Combined Sewers, *Storm Drains, Sewerage, Pipes, Ditches, Open Channels, Closed Conduits, Engineering Personnel.
Identifiers: Japan.

The article includes discussions on the necessity of sewer separation for storm water and sanitary waste, the present condition of sewer pipe systems, sewage problems, and the policy toward the complete separation of sewage systems. Through experience it has been found that incorrectly joined pipelines are a direct result of the shortage of technically qualified engineers. Pipelines may be tested for proper joining by floating a pingpong ball down the conduit or by an echo check. In the case of the later method, if the sound is not heard at a manhole further down the channel, the pipes are more than likely incorrectly joined. Various types of sewer systems are illustrated. The complete-separation method entails the installation of at least two pipe systems per road, one for storm water and another for sewage. This system is complex and costly. A partial separation system involves installation of sanitary waste pipes under public highways and the use of existing drains or open gutters on both sides of a road for storm water. "Blind ditches," or drain pipes, can be constructed with minimal time and expense to accomodate for overflows. U-shaped or L-shaped drainage conduits are the two available methods. A suitable ground surface and a slant are required for flow properties in either method.

SECTION V.

Storm Water -- Quality, Quantity, and Pollution

a. Caused from combined overflows

Va-001
URBAN STORM RUNOFF AND COMBINED SEWER OVERFLOW POLLUTION.
Envirogenics Company, Division of Aerojet-General Corporation, El Monte, California

EPA/R&M Contract No. 14-12-197, Program No. 11024 FKM, Dec. 1971. 193 p, 64 fig, 33 tab, 13 ref, 2 append.

Descriptors: *Methodology, *Water pollution, *Water pollution control, *Storm runoff, Waste water treatment, Treatment facilities, Systems analysis, Cost analysis, Waste assimilative capacity.
Identifiers: *Sewer overflows, *Combined sewers, *Sewer separation, Sanitary sewers, Sacramento, California.

A general method was developed to assess, primarily from readily available precipitation and wastewater quality data, the extent of water pollution occurring from storm water runoff and combined sewer overflows in an urban area, and is applied to Sacramento, California. Systems for the control and treatment of these wastewaters are developed and evaluated. The least costly system to adequately protect the receiving waters from storm water runoff and combined sewer overflows would retain the combined sewers for the conveyance of combined sewage during wet-weather flow conditions. Facilities would also be required for the treatment of existing separated storm water flows. Total annual cost for this system was estimated to be $6.99 million. A slightly more costly system ($7.09 million) incorporating complete sewer separation of sanitary sewage and storm water runoff is recommended to the City of Sacramento. The similarity in annual costs for the separated sewer and the combined sewer systems results from the requirement for major enlargement of the existing combined sewer system to adequately convey anticipated combined sewage flows. In areas where existing combined sewer capacities would not be grossly inadequate, the separation of combined storm water runoff and sanitary sewage flows to achieve receiving water quality objectives would appear unwarranted, due to the high cost of constructing new conveyance facilities and the probable requirement to treat separated storm water runoff, since its quality is not substantially different from that of sanitary sewage.

Va-002
SUGGESTED CORRELATION BETWEEN STORM SEWAGE CHARACTERISTICS AND STORM OVERFLOW PERFORMANCE.

R. D. Goffey and M. Lansdell (discussion)
G. Hedley and M. V. King (rebuttal)
PCIEA, 50:181-183 (Oct. 1971).

Original Paper: SUGGESTED CORRELATION BETWEEN STORM SEWAGE CHARACTERISTICS AND STORM OVERFLOW PERFORMANCE.
G. Hedley and M. V. King
PCIEA, 48:399-411 (Mar. 1971).
Original abstract in the July 1970-June 1971 issue of 11024 FJC, as number 066.

Descriptors: *Overflow, *Storm runoff, *Sewers, Detention reservoirs, Biochemical oxygen demand, Water quality.

Goffey agrees with the term 'rate of load' for measurement of BOD and suspended solids as revealing far better indication of discharge effects on a receiving watercourse. Application of the solution on existing sewerage systems seems somewhat limited, so Goffey maintains, to situations where the sewer gradients are favorable. A review of current sewerage practice with reference to the improvements of gullies and more centralized and efficient oil and grit separating facilities is suggested by Lansdell. In rebuttal, the authors recommend a full investigation into the nature of separate storm water discharges, and into the traditional gully system.

Va-003
THE POLLUTION OF EFFLUENTS IN MIXED WATER SEWAGE SYSTEMS BY RAIN. (Die Verschmutzung des Abflusses in Mischwasserkanalisationen bei Regen.) Text in German.

Karlheinz Krauth
GWWAA, 113(3):130-131 (March 1972).

Descriptors: *Storm Drains, *Storm Water, *Storm Runoff, *Rainfall Intensity, *Pollution Abatement, Sewage Treatment, Rainfall, Water Pollution Sources, Sewerage, Combined Sewers, Overflow, Biochemical Oxygen Demand.
Identifiers: Sewer Loads.

Investigations on the pollution of effluents in mixed water sewage systems by storm water are described and appropriate measures to minimize such pollution are suggested. Mixed water samplings during rainfall periods contained pollutants composed of sewage water, rain water, and sludge deposits in the sewage system. Some 10% of the solid pollutants and 27% of BOD, total phosphorus, and total

nitrogen were due to the sewage water, while the respective contributions by storm water and sludge deposits to the remainder of the solid load were 44% and 56%. Some 22% of the organic pollutants originated in the storm water. The washout of sludge deposits was found to be dependent on rainfall intensity, and flow rates above 20 inches/second caused practically complete washout. Both the BOD values and the solid contents decreased as the rainfall subsided. On a yearly average, the respective BOD and solid pollutant loads of the effluents due to storm water were equal to and ten times higher than those caused from a biological sewage treatment plant. The pollution level of effluents can be made independent of rainfall by an appropriate combination of storm water runoff and storm water basins. The excess water should be retained in a storm water basin during rain periods, and the contents of the basin transferred for biological treatment following storms. Using this method, the BOD discharge due to storm water would decrease by 60%.

b. Caused from storm runoff

Vb-001
CLEANING THE STREETS.

TEREA, 73(6):68 (Apr. 1971). 1 fig.

Descriptors: *Storm runoff, *Water pollution, Floods, Fishkill.

When a sudden spring thunderstorm flooded Jordan Creek in Springfield, Missouri in 1968, the creek's water quality went precipitously down not from untreated waste in overburdened sanitary sewers but from the poor quality of runoff through the separate storm sewer system. Street refuse, oil, animal droppings, disintegrated asphalt, stagnant water from catch basins, and chemicals from many sources are all swept into storm sewers whose water is not treated before discharge.

Vb-002
STORM AND COMBINED SEWER POLLUTION SOURCES AND ABATEMENT: ATLANTA, GEORGIA.
Black, Crow and Eidsness, Inc., Atlanta, Georgia

EPA/WQO Contract No. 14-12-458, Program No. 11024 ELB, Jan. 1971. 181 p, 48 fig, 10 ref, 2 append.

Descriptors: *Overflow, *Storms, *Storm runoff, *Water pollution sources, *Waste water treatment, *Rainfall-runoff relationships, Water quality, Cost-benefit analysis, Simulation analysis.
Identifiers: *Combined sewers, *Overflow quantity, *Overflow quality, *Atlanta, Georgia.

Six urban drainage basins within the City of Atlanta, Georgia, served by combined and separate sewers, are studied to determine the major pollution sources during storm events. Rainfall frequency analysis and simulation techniques are utilized to obtain design criteria for alternative pollution abatement schemes. High frequency storms are shown to cause the worst impact and most of the pollution from combined sewer areas. Annual BOD from these areas is 2,078,000 pounds, or 460 lbs/acre, of which 57 percent is due to storms of two-week or higher frequency. Bypassing of wastewater treatment plant flows during storms adds 690,000 pounds BOD/year. Runoff from storm-sewered areas, at 253 lbs/acre, adds 5,577,000 pounds/year. Overflows and bypassed flows have severe impact upon the South River, due to their high deoxygenation rates and coliform concentrations. Annual BOD reduction from combined sewer areas of 57 percent may be achieved for a total annual cost of $165,000, by modifying the three regulators and treating 80 percent of the overflows, in conjunction with storage sufficient to contain a two-week storm. Alternate, less favorable solutions include storage and treatment at existing treatment plants, and storage with release to receiving streams after chlorination. Separation of combined sewers would achieve 60 percent BOD removal for $3,030,000/year.

Vb-003
URBAN STORMWATER QUALITY AND ITS IMPACT ON THE RECEIVING SYSTEM.

Edward H. Bryan
PWRPA, 20:(Apr. 1, 1971). 19 p, 4 tab, 10 ref.

Descriptors: *Storm runoff, *Water quality, Drainage systems, Pollution abatement, Environmental sanitation, Analytical techniques.
Identifiers: *Durham, North Carolina, Tulsa, Oklahoma.

A study undertaken to characterize storm water from a typical urban drainage basin in Durham, N. C. indicated that BOD discharged to the receiving stream by urban storm water was about equal to the effluent from the secondary sewage treatment plant, which, in this case, was 50% above the BOD normally attributable to domestic sewage. The major long-term pollution impact

was a large fixed solids residue and long-term COD. Efforts to improve excessive erosion of construction sites should improve the problem of solids which projected to an annual loss of volume displacement capability of 100 cu ft of impoundment capacity per tributary acre. Contribution of pollutants by urban storm water is intermittent, made in slugs during and immediately following storms. Large amounts of lead in surface wash were attributed to leaded gasoline in internal combustion engines. Correlation coefficient between rainfall and runoff was 0.89. The drainage basin, an area of 1.67 square miles, represented a good cross-section of land use in the state; typical of North Carolina, the storm water drainage system was largely made up of exposed open channels. Findings are compared with similar studies made in Tulsa, Oklahoma.

Vb-004
EFFECTS OF URBANIZATION ON STORM WATER RUNOFF QUALITY: A LIMITED EXPERIMENT, NAISMITH DITCH, LAWRENCE, KANSAS.

Ernest E. Angino, Larry M. Magnuson, and Gary F. Stewart
WRERA, 8(1):135-140 (Feb. 1972). 4 fig, 1 tab, 9 ref.

Descriptors: *Water Pollution Sources, *Water Analysis, *Storm Water, *Urban Runoff, *Water Quality, Urbanization, Snowmelt.
Identifiers: Lawrence, Kansas.

The extensive use of storm water runoff as an auxiliary source of water will probably be justified economically in the near future, providing the water is of proper quality. Water samples were collected for dry weather periods, rainstorms, and snowmelts and evaluated for pH, residue (total, volatile, filterable), chemical oxygen demand (COD), biochemical oxygen demand (BOD), NO_3, Cl and total alkalinity. Most changes in water quality are not so great as to be apparent by inspecting the data. Statistical analysis is necessary for testing the more subtle chemical relationships. Suspended solids concentration during snowmelt and rainstorms do not differ; NO_3 is relatively high; COD averages 34 ppm. Occasional pollutants include: Cr^{+6}, 27 ppm; Br, 5 ppm; and Cl, 2150 ppm. Pb concentrations in suspended solids as high as 0.55% were found. The general extent to which urban storm runoff contributes to pollution of the streams is yet to be completely determined.

Vb-005
QUALITY OF STORM WATER DRAINAGE FROM URBAN LAND.
Rex Chainbelt, Inc., Milwaukee, Wisconsin

E. H. Bryan
Preprint, 1971. 11 p, 1 fig, 7 tab, 12 ref. (Presented at the American Water Resources Conference, 7th, Washington, D. C., October 28, 1971.)

Descriptors: *Water Pollution Sources, *Urbanization, *Storm Water, *Urban Runoff, *Pollutant Identification, Water Analysis, Organic Matter, Pesticides.
Identifiers: Durham, North Carolina.

Urban storm water (from a 1,067-acre drainage basin in Durham, N. C. with a population density of 9 persons per acre) produced an annual BOD load approximately equal to the contribution of its secondary wastewater treatment plant effluent. Total organic matter (COD) exceeded the amount in raw sanitary sewage from a residential area of the same size. Mean basin yields (lb/acre/day) were: BOD 0.23, COD 2.85, Total Solids 43.6, Volatile Total Solids 4.8, Total Phosphate 0.01, and Chloride 0.20 (as NaCl). The yield of lead presumed to originate from internal combustion engines operating on and near the basin was 0.006 lb/acre/day. The concentration of total pesticides (Dieldrin; p,p'DDE; o,p-DDT; p,p'DDD; and p,p'DDT) weighted for flow significance was estimated to be 1.2 parts per billion. The major longterm pollutional impact on a projected downstream reservoir was considered to be the fixed solids residue and long-term oxygen demand.

Vb-006
STORM WATER SHOULD BE CLEANED. (Dagvattnet maste renas.) Text in Swedish.

Eduard Kruse
TTIDA, 101(20):25-28 (Dec. 1971). 4 fig.

Descriptors: *Storm Water, *Separation Techniques, Drainage Systems, Tunnels, Storage, Sewage Treatment, Basins.
Identifiers: Sweden.

Urban storm water combined with oil, soot, plant parts, animal excrement, and mineral particles is causing overflows in combined sewer systems and subsequent pollution problems. Tunnels providing separation can be used in draining rainwater. Such tunnels should be constructed to provide for precipitation fluctuations. Storage basins with outlets to final drainage areas or sewage treatment plants can also be used. Systems

including storage basins have a higher efficiency. Direct separation at discharge, flow compensation in separating basins - with or without connection to sewage treatment facilities, are all possible solutions.

Vb-007
FEATURES OF RAINFALL-GENERATED RUNOFF POLLUTION. (Charakterystyka zanieczyszczen sciekow pochodzacych z wod opadowych.) Text in Polish.

Rafal Milaszewski and Elzbieta Osuch-Pajdzinska
GWTSA, 46(4):112-116 (1972). 3 fig, 5 tab, 17 ref.

Descriptors: *Rain Water, *Rainfall-Runoff Relationships, *Sewerage, *Water Pollution Sources, *Runoff, Urbanization, Industries.

Problems related to runoff pollution are reviewed. Industrial development and urbanization during the past years have led to a considerable degree of air pollution affecting the purity of the rain water. Precipitation-generated runoff may carry aerosols from industrial smoke, dusts or other pollutants, radioactive fallout, synthetic fertilizers and pesticides, domestic pollutants, or other impurities. Nitrogen, phosphorus, and organochloric compounds ranging from 0.5 to 2.8 mg/liter, 0 to 0.9 mg/liter, and 0.08 to 0.41 mg/liter concentrations, respectively, in rain water were found while 0.7 to 2.9 mg/liter of ammonia were analyzed from roof runoff. Included in this article are graphs describing the diurnal variation of ammonia concentrations in domestic sewage systems and discussions on the sewage systems as affected by the runoff. The intensity of road traffic and ground conditions constitute additional factors in the contamination of the runoff.

c. Caused from highway-salt runoff

Vc-001
HIGHWAY CHLORIDES - MENACE OR MANNA?

Ronald H. Hughmanick
PUWOA, 102(8):64-66 (Aug. 1971). 1 tab.

Descriptors: *Drainage, *Chlorides, *Deicers, *Environmental effects, Water quality.
Identifiers: *Salt runoff.

The role of chlorides, used as highway deicers, in environmental pollution is defined in a report prepared by the Highway Research Board (National Cooperative Highway Research Program Report 91, Effects of Deicing Salts on Water Quality and Biota). An important consideration in determining the pollutant factor is not simply the amount of chloride present, but rather the ratio of salt to water. Although salt can be tasted in water at 250 ppm, water containing as many as 2000 ppm has been used for human consumption without adverse effects. In using chlorides, if recommended application rates are followed and salt spreaders are properly calibrated, problem areas are seldom encountered on the highways, but they do occur in runoff areas adjacent to bridge decks, steep grades, intersections, and in storage yards. The use of a scupper ditch to lead the brine solution to the nearest drainage channel, and consolidation of stockpiles are recommended. In storage areas, proper facilities and drainage are especially important.

Vc-002
RUNOFF OF DEICING SALT: EFFECT ON IRONDEQUOIT BAY, ROCHESTER, NEW YORK.

R. C. Bubeck, W. H. Diment, B. L. Deck, A. L. Baldwin, and S. D. Lipton
State University College of Forestry, Syracuse, New York, Proceedings of the Street Salting Urban Water Quality Workshop, May 6, 1971.
9 p, 4 fig, 13 ref.

Descriptors: Water quality, Environmental effects, Salts, Chlorides.
Identifiers: *Salt runoff, Salt deicing, Rochester, New York, Irondequoit Bay.

Salt used for deicing the streets near Rochester, New York has increased the chloride concentration in Irondequoit Bay at least five fold during the past two decades. During the winter of 1969-1970, the quantity and salinity of the dense runoff that accumulated on the bottom of the bay was sufficient to prevent complete vertical mixing of the bay during the spring. Comparison with 1939 conditions indicates that the period of summer stratification has been prolonged a month by the density gradient imposed by the salt runoff.

Vc-003
THE EFFECT OF HIGHWAY SALT ON WATER QUALITY IN SELECTED MAIN RIVERS.

F. E. Hutchinson
State University College of Forestry, Syracuse, New York, Proceedings of the Street Salting Urban Water Quality Workshop, May 6, 1971.
4 p, 3 tab.

Descriptors: *Sampling, *Maine, Water quality, Highways, Salts, Sodium, Chlorides, Snowmelt.
Identifiers: *Salt runoff.

Water samples extracted from seven rivers in Maine over a two-year period were analyzed for content of sodium and chloride ions. Four of the rivers selected were from the southwestern section of the state because of the relatively high road density and consequent salt usage in that area. Three rivers were from the eastern part of the state where there are few roads. Sodium and chloride concentrations were highest in the rivers in the southwestern part of the state. Furthermore, the results indicate that the influence of highway salts on sodium and chloride levels in the rivers was compensated for in the spring, when snowmelt is at a maximum, by the increased volume of flow in the rivers.

Vc-004
EFFECTS OF ROAD SALT ON A VERMONT STREAM.

Samuel H. Kunkle
State University College of Forestry, Syracuse, New York, Proceedings of the Street Salting Urban Water Quality Workshop, May 6, 1971. 14 p, 6 fig, 5 tab, 15 ref.

Descriptors: *Water quality, *Vermont, Chlorides, Highways, Investigations.
Identifiers: *Salt runoff.

Water quality, sediment, and runoff studies were carried out in the Sleepers River basin of Vermont during 1968 to 1970. Streams not influenced by the highway averaged 2 to 5 mg/liter chloride, while concentrations in the stream affected by the highway were about an order of magnitude higher. During spring melt, salt concentrations were low in all streams because of the high dilution, while concentrations peaked during summer baseflow. However, at the highway-influenced sites salt delivery rates (tons per day) were high. Conversely, control catchments demonstrated very little seasonal fluctuation in either concentrations or delivery rates. Electrical conductivity was observed to be a good predictor of road salt in the natural stream studied.

Vc-005
ROAD SALT AS A POLLUTING ELEMENT.

Robert W. Sharp
State University College of Forestry, Syracuse, New York, Proceedings of the Street Salting Urban Water Quality Workshop, May 6, 1971. 4 p, 5 ref.

Descriptors: *Water pollution sources, *Water pollution effects, Environmental effects, Chlorides.
Identifiers: *Salt runoff, Road salt.

The question of possible damage to the aquatic and terrestrial environments due to road salt and its additives is discussed. The following approaches for prevention of critical chloride build-up in the environments in heavily urbanized areas or along major highway systems were presented: 1) greater use of sand in place of salt in less critical icing areas; 2) careful metering of salt where used; 3) greater use of mechanical snow removal technique, instead of melting snow through the use of salt; and, 4) improved storm water disposal systems.

Vc-006
DEICING SALTS AND THE ENVIRONMENT.

PUWOA, 102(12):54 (Dec. 1971).

Descriptors: *Chlorides, Highway effects, Deicers, Legislation, Water pollution sources.
Identifiers: *Salt runoff.

An interview with William E. Dickinson, President of the Salt Institute, produced some information on the use of chlorides in highway snow and ice control programs in the face of growing criticism from environmentalists. Legislation limiting the use of chlorides in snow removal has been passed in Minnesota and proposed in Massachusetts, Oklahoma, and Vermont. The Ontario Water Resources Board has found in extensive studies in Lake Ontario, a moderate rise in chloride over the last 40 years, mostly from sewage treatment plants and industry in general. There have been some problems with wells and ponds adjacent to roadways. Excessive use and no provisions for storage may be responsible. The effect on trees has been studied and heartier species are recommended for highway planting. The salt industry is trying to educate the public with the facts about salt as a deicing agent.

Vc-007
RELEASE OF MERCURY FROM CONTAMINATED FRESHWATER SEDIMENTS BY THE RUNOFF OF ROAD DEICING SALT.

G. Feick, R. A. Horn, and D. Yeaple
SCIEA, 175(4026):1142-1143 (March 10, 1972). 1 tab, 4 ref.

Descriptors: *Mercury, *Deicers, *Salts, *Runoff, Sediment Discharge, Fluvial Sediments, Calcium Chloride, Sodium Chloride, Heavy Metals, Water Pollution Sources.
Identifiers: *Mercury Contamination.

A recent report of the contamination of freshwater by the runoff of $CaCl_2$ and NaCl used

for deicing roads, raised the possibility that road salt could release mercury from bottom sediments. This was proven to be true with the addition of NaCl or $CaCl_2$ increasing the relative amount of mercury in the water in equilibrium with the sediments by 2-5 or more orders of magnitude. The effect tends to increase as the mercury burden of the sediments increases. The *p*H changes, consequent upon salt addition, probably also contribute to the release of mercury. In addition to being a serious contaminant itself, road salt in natural waters can acerbate mercury contamination and undoubtedly contamination by other heavy toxic metals.

Vc-008
WE ARE USING SALT--SMARTER.

F. A. Mammel
AMCIA, 87(1):54-56 (Jan. 1972). 2 fig.

Descriptors: *Deicers, *Salts, *Snow Removal, *Surveys, *Vegetation Effects, *Highway Effects, *Water Pollution Effects, Environmental Effects, Water Pollution Sources.
Identifiers: *Ann Arbor, Michigan.

Ann Arbor, Michigan has done an extensive study to search for more economic, efficient, and environmentally acceptable methods of controlling snow and ice. There is special interest in new spreaders and plows, more accurate cab-monitoring devices that will control the application of salt, and new training programs for equipment operators. An intensive effort to win public support for more safe driving techniques on snow and ice has been made. The Park Department is altering their policies covering planting of trees and vegetation, in areas adjacent to streets and intersections subject to deicing salts; they will only plant species known to be resistant to chloride exposure. The effects of salt were explored in the following areas: safety on public streets, automobile corrosion, vegetation effects, surface water effects, pavement effects, cost comparisons with other deicing agents, studded tires, educational requirements for developing a policy using something other than salt, legal obligations, and policies of other local governments. In contacting officials in other cities, 100% decided to continue using salt. All recognized that excess salt can be detrimental, but felt the amount used for deicing streets was not a contributing contaminating factor. It was emphasized that when compared with cost in human lives from accidents, fire, and slow movement of safety vehicles, salt disadvantages were minimal. Consequently, Ann Arbor is still using salt, but on a reduced level of application.

Vc-009
GROUNDWATER CONTAMINATION BY ROAD SALT: STEADY-STATE CONCENTRATIONS IN EAST CENTRAL MASSACHUSETTS.

Edwin E. Huling and Thomas C. Hollocher
SCIEA, 176(4032):288-290 (April 1972). 2 tab, 13 ref.

Descriptors: *Groundwater, *Sodium Chloride, *Massachusetts, *Water Pollution Sources, *Investigations, Highway Effects.
Identifiers: Road Salt, Salt Runoff, Chloride Concentrations.

The steady-state concentrations of salt expected in groundwater in the suburban area around Boston, Massachusetts, providing present rates of salt application (about 20 metric tons of total salt [NaCl + $CaCl_2$] per lane mile per year) are continued, are estimated. The dissolution of 3.7 mg of NaCl per cm^2 of ground area in 23 cm of water yielded an average steady-state NaCl concentration of about 160 mg/liter, or 100 mg of chloride per liter. Local deviations from this regional average could be easily two to four times this figure, especially in the vicinity of major highways or areas of high population.

Vc-010
EFFECTS OF ROAD SALT ON A VERMONT STREAM.

Samuel H. Kunkle
JAWWA, 64(5):290-295 (May 1972). 6 fig, 6 tab, 16 ref.

Descriptors: *Highway Effects, *Sodium Chloride, *Investigations, *Streams, *Vermont, Water Pollution Sources, Runoff, Summer.
Identifiers: Road Salt.

The fate of highway salt applied in the Sleepers River basin of northern Vermont has been evaluated with the salt content of the streams considered in terms of concentrations, seasonal trends, and the total annual budget of salt delivery. Results indicate that the relatively high runoff per unit area inherent to most eastern United States watersheds may result in dilution of the stream's salt content within only a short stretch of stream travel. Thus, road salt pollution in the East possibly may tend to be restricted to stretches of streams actually near highways. Much of the study area's road salt was flushed away during the spring melt being discharged into roadside soils and reappearing later in the summer baseflow. As shown in the study, the stream's highest salt concentrations occur during the summer.

SECTION VI.

Surveys, Reports, and Evaluations

VI-001
STORM OVERFLOWS AND THE DISPOSAL OF STORM SEWAGE.

WPOCA, 70(3):275-284 (1971).

Descriptors: *Storm drains, *Overflow, Storm runoff, Costs, Waste treatment, Estimating equations, Drainage systems, Water pollution, Sewerage, Weirs, Sewers.
Identifiers: Great Britain.

The conclusions and recommendations reached by the Technical Committee on Storm Overflows and the Disposal of Storm Sewage in their 15 year study are reported and discussed. Since approximately 76% of the population of England and Wales lives in areas serviced by combined or partially-separated sewerage systems, it would be financially unrealistic to consider elimination of storm overflows by enlarging or separating these systems. A new formula for the setting of storm overflows was suggested substituting the sum of the dry weather flow (DWF) and the amount of surface water to be retained in the sewer before overflow commences for the traditional 6 DWF. High side weir and stilling pond construction is preferable to the inefficient low side weir design; the best type of overflow provides an element of storage before coming into operation, preventing discharge of the first flush of highly polluting storm sewage. More efficient performance can be expected from storm overflows when the upstream sewer is laid at a sub-critical gradient. Wherever practicable, some form of hydraulic control should be incorporated as part of all storm overflow installations. The use of purpose-made, mechanical raked screens should be considered for the removal of gross solids. For new works, a capacity of 15 gal/ha was recommended for combined or partially separated areas draining into treatment works. Multiple discharges of storm sewage should be eliminated where there were several overflows located close together on a sewerage system.

VI-002
TAKEN FOR GRANTED.

WPOCA, 70(3):285-305 (1971).

Descriptors: Water quality, Water pollution control, Sewerage, Sanitary engineering, Water reuse, Sewage treatment, Environmental sanitation, Costs, Legal aspects, Effluents, Industrial wastes.
Identifiers: Great Britain.

The main recommendations of the Working Party on Sewage Disposal appointed by Britain's Minister of Housing and Local Government are set forth. Among the courses of action suggested are larger public investment in sewerage and sewage treatment plants, improvement of rural sanitation, increased control of discharges including industrial effluents and proper treatment of sewage before discharge. In areas around shellfisheries, it was recommended that bacterial loadings and positions of outfalls be considered before granting consents for discharges. The increasing need to deal with sewage disposal as a water resource problem was emphasized. Implementation of the Working Party's recommendations will result in increased costs, but no estimate of the amount involved was given. In the discussion following presentation of the report, the necessity for attempting to predict the nature of pollution problems of the future and counteract them, and the need for stricter control on the storage and use by industry of dangerous chemicals which were potential water pollutants were emphasized.

VI-003
PROGRESS REPORT ON MUNICIPAL POLLUTION ADVANCES.

WWAEA, 8(7):6 (June 1971). 1 fig.

Descriptors: *Waste water treatment, *Treatment facilities, *Municipal wastes, Grants, Costs.

Cities across the United States are expanding their waste treatment facilities in an attempt to keep up with population growth. Several such expansions are described, along with their projected costs. In conjunction with expansion projects, in some cases grants have been awarded for the gathering of information. For example, in Montgomery County, Pa. the EPA is funding a pilot operation to gather information for a standard of wastewater treatment not previously required in the state, while in Milwaukee the same agency is helping to finance a project for measuring with ultrasonic pulses the volume of wastewater entering treatment plants. Municipalities discussed range from such giants as Chicago and Philadelphia to small towns in New England and South Dakota.

VI-004
WATER-SEWER AND DRAINAGE PLAN FOR FORT SMITH URBANIZING AREA-PHASE II.
Arkhoma Regional Planning Commission, Fort Smith, Arkansas

HUD Project No. Ark P-105, June 1970. Volume II, 232 p, 7 fig, 6 tab.

Descriptors: *Sewers, *Sewage treatment, *Drainage, *Planning, Water quality control, Waste water treatment, Arkansas, Oklahoma.

A unified sanitary sewer system is recommended to serve the urbanizing area of Forth Smith which includes communities in both Arkansas and Oklahoma. Of the ten communities in this area, only Fort Smith, Van Buren and Alma have public sewer systems and public sewage treatment facilities. Large distances between growth centers and a diversity of drainage areas impede the development of a unified area-wide sewerage system and central disposal facilities. Sewage lift stations will be required to conduct flows to the Arkansas River to avoid constructing lengthy sewer lines. The river separates the urbanizing area into two parts. This dictates that two systems of interceptor sewers should be built paralleling the stream. It is recommended that two activated sludge sewage treatment plants be built downstream from the urbanizing area, one on each side of the river. Areawide requirements to facilitate connecting even the smallest residential developments to interceptor sewers when feasible are recommended. Interim sewage treatment facilities involving stabilization ponds or package plants are suggested until connections can be made to future interceptor sewers. Design criteria, capacity requirements, construction and operating costs, user charges, legislative needs, financing, cost sharing, existing system deficiencies, recommended improvements, and storm drainage needs are discussed.

VI-005
ENVIRONMENTAL IMPACT OF HIGHWAY DEICING.
Edison Water Quality Laboratory, Edison, New Jersey

EPA/WQO Program No. 11040 GKK, June 1971. 120 p, 43 fig, 9 tab, 147 ref.

Descriptors: *Highways, *Highway effects, *Reviews, Ice, Snow removal, Environmental effects, Water pollution sources.
Identifiers: *Urban runoff, *Highway deicing, Salt runoff.

This State-of-the-Art report critically reviews the available information on methods, equipment, and materials used for snow and ice removal; chlorides found in rainfall and municipal sewage during the winter; salt runoff from streets and highways; deicing compounds found in surface streams, public water supplies, groundwater, farm ponds, and lakes; special additives incorporated into deicing agents; vehicular corrosion and deterioration of highway structures and pavements; and effects on roadside soils, vegetation, and trees. It is concluded that highway deicing can cause injury and damage across a wide environmental spectrum. Recommendations describe future research, development, and demonstration efforts necessary to assess and reduce the adverse impact of highway deicing.

VI-006
STORM WATER MANAGEMENT MODEL: VOLUME I FINAL REPORT.
Metcalf & Eddy, Inc., Palo Alto, California
University of Florida, Gainesville, Florida
Water Resources Engineers, Inc., Walnut Creek, California

EPA/WQO Contract Nos. 14-12-501,-502,-503, Program Nos. 11024 EBI,-DOC,-EBJ, July 1971. 352 p, 55 fig, 20 tab, 90 ref, 2 append.

Descriptors: *Water quality control, *Mathematical models, *Storm runoff, Simulation analysis, Rainfall-runoff relationships, Sewerage, Waste water treatment, Cost-benefit analysis.
Identifiers: *Combined sewer overflows, Urban hydrology.

A comprehensive mathematical model, capable of representing urban storm water runoff, has been developed to assist administrators and engineers in the planning, evaluation, and management of overflow abatement alternatives. Hydrographs and pollutographs (time varying quality concentrations or mass values) were generated for real storm events and systems from points of origin in real time sequence to points of disposal (including travel in receiving waters) with user options for intermediate storage and/or treatment facilities. Both combined and separate sewerage systems may be evaluated. Internal cost routines and receiving water quality output assisted in direct cost-benefit analysis of alternate programs of water quality enhancement. Demonstration and verification runs on selected catchments, varying in size from 180 to 5,400 acres, in four U.S. cities (approximately 20 storm events, total) were used to test and debug the model. The amount of pollutants released varied significantly with the real time occurrence, runoff intensity duration, pre-storm history, land use, and maintenance. Storage-treatment combinations offered best cost effectiveness ratios. A user's manual, complete program listing, and verification and testing document were also prepared.

VI-007
STORM WATER MANAGEMENT MODEL: VOLUME II - VERIFICATION AND TESTING.
Metcalf & Eddy, Inc., Palo Alto, California
University of Florida, Gainesville, Florida
Water Resources Engineers, Inc., Walnut Creek, California

EPA/WQO Contract Nos. 14-12-501,-502,-503, Program Nos. 11024 EBI,-DOC,-EBJ, Aug. 1971. 139 p, 48 fig, 27 tab, 10 ref, 1 append.

Descriptors: *Water quality control, *Mathematical models, *Application methods, *Storm runoff, *Testing, Simulation analysis, Rainfall-runoff relationships, Sewerage.
Identifiers: *Combined sewer overflows.

A comprehensive mathematical model, capable of representing urban storm water runoff, has been developed to assist administrators and engineers in the planning, evaluation, and management of overflow abatement alternatives. Hydrographs and pollutographs (time varying quality concentrations or mass values) were generated for real storm events and systems from points of origin in real time sequence to points of disposal (including travel in receiving waters) with user options for intermediate storage and/or treatment facilities. Both combined and separate sewerage systems may be evaluated. Internal cost routines and receiving water quality output assisted in direct cost-benefit analysis of alternate programs of water quality enhancement. This volume describes the methods and results of model application in four urban catchment areas. (See abstract number VI-006.)

VI-008
STORM WATER MANAGEMENT MODEL: VOLUME III - USER'S MANUAL.
Metcalf & Eddy, Inc., Palo Alto, California
University of Florida, Gainesville, Florida
Water Resources Engineers, Inc., Walnut Creek, California

EPA/WQO Contract Nos. 14-12-501,-502,-503, Program Nos. 11024 EBI,-DOC,-EBJ, Sept. 1971. 347 p, 85 fig, 59 tab, 16 ref, 1 append.

Descriptors: *Water quality control, *Mathematical models, *Storm runoff, Simulation analysis, Rainfall-runoff relationships, Sewerage, Waste water treatment.
Identifiers: *Combined sewer overflows, *Manual.

A comprehensive mathematical model, capable of representing urban storm water runoff, has been developed to assist administrators and engineers in the planning, evaluation, and management of overflow abatement alternatives. Hydrographs and pollutographs (time varying quality concentrations or mass values) were generated for real storm events and systems from points of origin in real time sequence to points of disposal (including travel in receiving waters) with user options for intermediate storage and/or treatment facilities. Both combined and separate sewerage systems may be evaluated. Internal cost routines and receiving water quality output assisted in direct cost-benefit analysis of alternate programs of water quality enhancement. This volume contains program descriptions, flow charts, instructions on data preparation and program usage, and test examples. (See abstract number VI-006.)

VI-009
STORM WATER MANAGEMENT MODEL: VOLUME IV - PROGRAM LISTING.
Metcalf & Eddy, Inc., Palo Alto, California
University of Florida, Gainesville, Florida
Water Resources Engineers, Inc., Walnut Creek, California

EPA/WQO Contract Nos. 14-12-501,-502,-503, Program Nos. 11024 EBI,-DOC,-EBJ, Oct. 1971. 249 p.

Descriptors: *Water quality control, *Mathematical models, *Storm runoff, Simulation analysis, Rainfall-runoff relationship, Sewerage, Waste water treatment.
Identifiers: *Combined sewer overflows, *Program listing.

A comprehensive mathematical model, capable of representing urban storm water runoff, has been developed to assist administrators and engineers in the planning, evaluation, and management of overflow abatement alternatives. Hydrographs and pollutographs (time varying quality concentrations or mass values) were generated for real storm events and systems from points of origin in real time sequence to points of disposal (including travel in receiving waters) with user options for intermediate storage and/or treatment facilities. Both combined and separate sewerage systems may be evaluated. Internal cost routines and receiving water quality output assisted in direct cost-benefit analysis of alternate programs of water quality enhancement. This volume lists the main program, all subroutines, and JCL as used in the demonstration runs. (See abstract number VI-006.)

VI-010
WATER AND SEWER PLAN AND PROGRAM.
Metropolitan Washington Council of Governments, D. C.

HUD Project No. DC-12, Sept. 1970. 126 p, 14 fig, 9 tab, 88 ref.

Descriptors: *Water supply, *Water quality control, *Waste water treatment, *Planning, Urbanization, Cities, Sewers, Overflow.
Identifiers: *Metropolitan Washington, *Potomac River.

This report identifies the existing problems and concerns; documents the progress made recently; and discusses the existing national, state and regional goals, objectives, and policies regarding water and sewer facilities. A regional water and sewer plan and a short range program for the 1970-76 period are outlined. Future water and sewer policies for the region are also recommended. Critical overflows in certain sewer systems and the need for providing, expanding, and implementing wastewater treatment plants are some of the other concerns identified in this report.

VI-011
URBAN RUNOFF CHARACTERISTICS.
University of Cincinnati, Cincinnati, Ohio

EPA/WQO Research Grant 11024 DQU, Interim Report, Oct. 1970. 340 p, 161 fig, 67 tab, 37 ref.

Descriptors: *Storm runoff, *Overflow, *Watersheds (basins), *Hydrographs, Model studies, Sequential generation.
Identifiers: *Pollutographs, Model testing, Cincinnati, Ohio.

This is an interim report on investigations for the development of a comprehensive storm water management model. Detailed information on the watershed characteristics and data on runoff quantity and quality have been compiled from a one year study of a combined sewer watershed of approximately 2380 acres in Cincinnati, Ohio. Collection of these data is planned to continue over a several year period. The information collected will be used to test and develop practical storm water management models.

VI-012
PRELIMINARY DESIGN REPORT, URBAN STORM DRAINAGE MODEL CITIES--DENVER.
Wright-McLaughlin Engineers

Consultants' Report for Waste Water Control Division, Department of Public Works, City and County of Denver, Jan. 1971. 3 fig, 2 tab, 26 dwg, append.

Descriptors: *Storm drains, Design criteria, Storm runoff.
Identifiers: *Model cities, *Denver, Colorado.

The investigation of the urban storm drainage problems, the development of the goals and objectives for the area, and the planning of suitable solutions as presented in this report have been related to the overall urban system of Model Cities and the adjacent City and County of Denver. The summary and conclusions relative to the urban storm drainage system of Model Cities study areas A, C, D, and G are as follows: (1) poor urban storm drainage systems have significantly contributed to the depressed nature of the neighborhoods; (2) health, security and welfare of residents can be materially improved by bettering the drainage system; (3) potential for improving the study areas appears to be great; (4) the 1985 land use map, prepared by the City in 1966, is a reasonable projection of future land uses and urban drainage planning; (5) the future degree of imperviousness and runoff coefficients were chosen on the basis of the 1985 map; and (6) the selection of the design storm frequency for design of the major drainage system ranged from 25 to 100 years.

VI-013
SOUTH HAMPSHIRE: SOME PROBLEMS OF MAIN DRAINAGE IN A RAPIDLY EXPANDING AREA.

H. G. Barrett and S. L. Wright
WPOCA, 70(4):371-382 (1971).

Descriptors: *Water pollution control, *Drainage systems, *Urbanization, Outlets, Sewerage, Sewage treatment, Effluents, Computer programs, Density.
Identifiers: Great Britain.

Rapidly growing population has forced an evaluation of foul drainage facilities serving South Hampshire, and recognition of the need for expansion. Among the conclusions reached are the fact that discharge of sewage into streams in the area would result in unacceptable levels of pollution; possibilities for the construction of new sewers serving part of the area and continued use of existing systems in the remainder are recommended. A computer program was written to assist in the development of local sewerage systems. Costs of recommended schemes are compared. Tidal water tests to determine the effectiveness of proposed new outfalls are described. The study points up the need for a wide range approach to pollution control on a national level and for new, large scale, high cost drainage systems. In the discussion following presentation of the report the point was made that little consideration had been given to storm drainage and the question raised as to what effect storm discharges would have on small streams in the area as a consequence of further urbanization.

VI-014
HYDRODYNAMICS AND DISCHARGE MEASUREMENTS OF STORM SEWERS.
New Jersey Water Resources Research Institute, New Brunswick, New Jersey

E. L. Bourodimos and A. Oguntase
OWRR Project A-028-NJ, Mar. 1971. 13 p, 4 fig.

Descriptors: *Storm drains, *Hydrodynamics, Storm runoff, Flow, Reviews.
Identifiers: *Urban hydrology, Storm sewers.

This completion report was a first step in a study of flow in storm sewers. A critical review of a major portion of numerous theoretical and experimental research papers on gradually varied unsteady flows has been completed. The engineering relevance of these studies to storm sewer flow dynamics is evaluated and practical applications for storm runoff in urban areas are given.

VI-015
CAMPUS PLANNING - WATER, STORM & SANITARY.

Al Calenda
BUSDB, 68(7):40-42 (July 1971).

Descriptors: *Long range planning, *Colleges, *Sewerage, Sanitary engineering, Drainage systems, Design criteria.
Identifiers: Municipal services, Pipe materials.

In this day of new college construction in rural and suburban areas away from major urban centers, a key to long-range planning is the inter-relationship of buildings, site, and surrounding municipality. Factors such as the availability of adequate municipal services to accommodate the new college population, or, lacking these, the selection of a site which at least offers water and is receptive to sewage disposal, assume vital importance. Recommendations are made as to the most efficient methods of planning and designing effective utility systems including storm drainage, taking into consideration the full exploitation of natural features afforded by the site. Although construction specifications are not normally a part of long-range master planning, the selection of pipe materials is discussed as this can be critical to effective design. Actual scheduling of utility construction in a pattern compatible with the building program is recommended only after plans for the overall network have been completed.

VI-016
STORM SEWER GRANT AIDS SEWER IMPROVEMENTS.

C. Edwin Dalgleish
PUWOA, 102(9):86-87 (Sept. 1971).

Descriptors: *Drainage systems, *Financing, *Grants, *City planning, Flood protection, Storm drains, Storm runoff, Urban renewal.
Identifiers: *Richmond, California, Phased construction.

In September 1970, Richmond, California received a $932,400 grant for storm drain construction from HUD. This made possible the correction of a problem which had long plagued Richmond - localized flooding due to the lack of a storm drainage system. In 1967-68 a portion of the storm sewer project servicing the central business district was partially financed through HUD's Water and Sewerage Facilities Grant Program. Lack of available funding forced postponement of the remaining construction. Selection of Richmond for a Model Cities Neighborhood Grant made completion of the storm drainage project essential. The total estimated cost of the completed project, to be handled in phases with final completion planned for 1974, is $3,300,000 with an anticipated maximum HUD commitment of $1,500,000.

VI-017
MANAGEMENT AND CONTROL OF COMBINED SEWER OVERFLOWS.
Edison Water Quality Laboratory Edison, New Jersey

Richard Field and Edmund J. Struzeski
Preprint, 1971. 30 p, 10 fig, 35 ref. (Presented at the 36th Annual Sewage Works Operator's Conference, Springfield, Illinois, Apr. 21, 1971.)
ALSO APPEARED AS:
Preprint, Environmental Protection Agency, 1971. 29 p. (Presented at the Design Seminar: Sanitary Engineering Operations and Processes, Conventional and Expanded Views, Technology Transfer Program, Kansas City, Missouri, Sept. 8-9, 1971.)
Preprint, 1972. 29 p. (Presented at the Annual Conference of the New York Water Pollution Control Association, 44th, New York, N. Y., Jan. 26-28, 1972.)
Preprint, 1972. 29 p. (Presented at the Annual Conference of the New Jersey Water Pollution Control Association, 57th, Atlantic City, N. J., May 10-12, 1972.)

Descriptors: *Pollution abatement, *Technology, *Methodology, *Research and development, *Storm runoff, *Reviews.
Identifiers: *Combined sewer overflows.

Combined sewers are a source of water pollution problems, but even flows of storm water alone can seriously affect water quality. Sewer separation is very costly and solves only about 50 percent of the problem. Current approaches involve control of combined overflows, treatment and combinations of the two. Control can involve maximizing of treatment with existing facilities, improvement of regulator maintenance, control of infiltration and extraneous inflows, surface sanitation, and addition of flow-increasing polymers, as well as flow regulation and storage, use of porous pavement, and vacuum and pressure-type sewer systems. A number of treatment methods are being evaluated among the most promising of which are microstraining at high rates, ultra-high-rate filtration on various media, screening and dissolved-air flotation, and the rotating biological contractor. Disinfection processes also can be adapted to storm flows.

VI-018
DESIGN OF SEWER SYSTEMS.

J. M. Fisher, G. M. Karadi, and W. W. McVinnie
WARBA, 7(2):294-302 (Apr. 1971). 4 fig, 7 ref.

Descriptors: *Optimization, *Linear programming, *Sewers, *Costs, Pipes.
Identifiers: Iteration process, Algorithms.

The objective of this paper was to review and evaluate the merits of certain methods aimed at finding optimal solutions in sewer design. First, basic principles of sewer design were outlined. Then a linear integer programming algorithm, based on principles similar to the ones proposed by Deininger and Holland, was developed in which cost was expressed as a function of the pipe diameter and slopes. In order to show the application of the programming algorithm and to find out what difficulties are encountered in an actual problem, it was applied to an existing design of an interceptor sewer to be built in the Chicago metropolitan area and composed to a traditional approach. A computer program based on the SIMPLX method was developed to find the optimum pipe diameter, invert depths and slopes based on the objective cost function and subject to certain given constraints. An iteration process was used for the solution. The results of the optimization were summarized and a 10% difference was found between the results of the new algorithm and results of the traditional approach shown.

VI-019
TOO MUCH "TAKEN FOR GRANTED".

G. Hedley and J. C. Lewin
WPOCA, 70(3):338-347 (1971). 3 tab.

Descriptors: Water quality, Water pollution control, Sewerage, Sewage treatment, Costs, Effluents, Industrial wastes, Water conservation.
Identifiers: Great Britain.

This article is a rebuttal of the report discussed in "Taken for Granted". It is suggested that the rate of increase in water consumption assumed by the Working Party (3% per annum) is overgenerous. Also, the report's failure to make effective reference to water conservation is noted instances of industrial and domestic water conservation are cited. Issue is taken with the figures presented in the report, and with the recommendation that properly digested, chemically conditioned sludge can be used as fertilizer with no danger. Sludge which is excessively contaminated with toxic materials from industrial wastes should never be used on agricultural land. The primary criticism offered, however, is that the far-reaching recommendations for reorganization made by the Working Party are premature since the full effect of existing pollution control work has not been taken into account. In an editorial comment following the article, it is suggested that regional authorities assume overall responsibility for all aspects of trade effluent control, rather than having this administered by individual local authorities. (See abstract number VI-002.)

VI-020
SANITATION FOR SMALL NORTHERN COMMUNITIES: SOME PROBLEMS AND GOALS.

G. W. Heinke
CJPEA, 60(3):220-226 (1971). 15 ref.

Descriptors: *Municipal water, *Water supply, Municipal wastes, Water pollution, Environmental effects, Chlorination.
Identifiers: *Northern Canada, *Utilador.

The provision of safe water supplies in sufficient quantity and adequate sewage and refuse disposal systems in small communities in the far north presents many problems. Among the difficulties encountered are permafrost, climate, lack of planning, inaccessibility, and housing, resulting in greatly increased costs over provision of water and sanitary services in southern communities. Pipelines may be buried in permafrost only in well drained, non-frost susceptible soils extending to a depth of 15 feet. Continuous heating and circulation of the water has been employed to prevent water mains from freezing. New regulations in the Northwest Territory (NWT) permit water mains and sewers to be placed in the same trench; heat from the sewers helps prevent freezing of the mains, resulting in lower construction costs. When placed on or above ground, mains must be protected from extreme temperature

variations, weather, and vandalism by an insulated box structure called utilador. Overall cost for the most expensive, best utilador in Canada was $230/ft; lower cost models are in use ranging from $25-$75/ft. In 23 communities of the NWT, there is no organized community-wide water delivery or sewage pickup; and few communities have sewage treatment facilities. In addition to a discussion of the various methods for provision of water and sanitary services presently in use in northern Canada, the article discusses considerations to bear in mind for those planning future settlements in the north.

VI-021
DESIGN ENGINEERS MUST ANALYZE MORE CRITICALLY TO BEAT MOUNTING COSTS.

John W. Saucier
WWAEA, 8(9):48-49 (Sept. 1971).

Descriptors: *Design criteria, *Tennessee, *Waste water treatment, Pollution abatement, Costs, Sewage treatment, Construction, Sewerage.

Because of increasingly heavy costs in designing, constructing, and operating modern wastewater facilities, the design engineer should make a critical analysis of his project, including actual flow measurements and predictions of future flows. Characteristics of industrial wastes must be carefully studied and the possibility of pretreatment considered. Tennessee is one of the states currently providing minimum guidelines for the design of municipal wastewater treatment systems. Sewers must be designed for the estimated ultimate tributary population and maximum hourly quantity of wastewater; industrial wastewater and groundwater infiltration must be considered. The design should accommodate an average daily per capita flow of 100 gpd. Specifications for sewer lines including acceptable materials, slopes and pipe sizes, manholes, and inverted siphons are detailed, as are provisions for protection of the potable water supply from sewage contamination.

VI-022
WASTEWATER AND STORM FLOW HANDLING (LITERATURE REVIEW).

D. J. Weiner
JWPFA, 43(6):1154-1160 (June 1971). 44 ref.

Descriptors: *Drainage systems, *Sewerage, *Construction materials, Waste water disposal, Water pollution treatment, Overflow, Storm runoff, Herbicides, Design, Water resources, Pipelines, Operation and maintenance.
Identifiers: Combined sewers, Ocean outlets.

The growth concept of the metropolitan area has expanded to such an extent that the disposal of all liquid wastes including storm water has become a sensitive matter in the control of the environment. In addition, the comparative low cost of transportation by pipeline has led to the use of sewers for the transporting of solid wastes from residences and industries. Attention is being directed to new materials for pipeline construction, operation and maintenance, and to different methods of installation. Sewer lining materials such as polyurethane foam and glass reinforced plastic pipe are discussed, as are the use of various pipe materials such as plastic, concrete, fiber glass, asbestos cement, and galvanized steel, in specific situations. Sewer maintenance programs in several locations are described along with a method for sewer design and cost estimation written in time-sharing Fortran. Studies are presented on the toxic effects of a number of herbicides on tree roots and their effectiveness in alleviating root growth problems in sewer lines. Among the other topics covered by papers presented are wastewater treatment, control of combined sewer overflows, and the resulting pollution problems and design of ocean outfalls.

VI-023
ON SEWAGE TREATMENT. (Gesui shori ni tsuite.) Text in Japanese.

Takeshi Yoshida
NEONA, 38(5):46-50 (May 1971).

Descriptors: *Sewerage, *Sewage treatment, Pollution abatement, Water quality, Surveys, Sewage disposal.
Identifiers: Japan, Sewer construction.

In Japan, only 14% of the population is served by a sewer system. Because of geographical and topographical conditions, large investments in flood control projects were necessary. Water pollution control efforts in Osaka are described. In 1965, 6 billion tons of tap water and 20 billion tons of industrial water were used. This is expected to rise sharply in the future. Joint treatment of factory effluent and home wastewater has been promoted. Japan is beginning a 5-year program of sewer construction this year which is expected to increase the population serviced by sewers to 38%.

VI-024
COMPUTER ASSISTED SEWER DESIGN.

WPCOA, 109(11):36-39 (Nov. 1971).

Descriptors: *Computers, Computer models, Design criteria, Data collections, Automatic control, Input-output analysis.
Identifiers: *Sewer design.

The use of a computer in the design of storm and sanitary sewers has many advantages. Computation time can be reduced from several weeks to several minutes. There is greater accuracy and virtually no limit to the number of alternate designs. A program designed for Proctor and Redfern illustrates the usefulness of the computer. Basic data are prepared by engineering technicians or design draftsmen and modified without major revisions. General Input Data consists of information which remains fixed for a given job. Special Input Data describe the physical layout of the district, population, and other variable factors. Effects of any changes in the final design are computed automatically by the computer.

VI-025
WATER, SEWER AND DRAINAGE PLAN, COMPREHENSIVE PLANNING STUDY, BLYTHEVILLE-GOSNELL, ARKANSAS. Ellers, Reaves, Fanning and Oakley, Engineers; and Manes and Associates, Inc.

HUD Project No. ARK P-116, Apr. 1971. 18 p, 3 fig, 1 tab.

Descriptors: *Planning, *Arkansas, *Sewerage, *Drainage systems, Storm drains, Treatment facilities, Urbanization.

A plan is presented for future water, sewer, and drainage needs for the Blytheville-Gosnell Urban Area. The plan is based on projected growths for 10 year and 25 year programs. The Sanitary Sewerage System Study provides an estimate of future sewage volume and characteristics and is based on projected growth. The study includes a description of future lift stations and treatment facilities, required force main sizes, their general location, and cost estimates. Drainage constitutes an unusually significant problem in the area due to the flat terrain and consequently high cost of structures. The report makes no attempt to divide the plan into short or long range projects, rather each drainage item needed is assigned a cost figure and a total combined figure is then given. The report includes evaluations of existing sewer and water drainage facilities and identifies deficiencies in these systems. The problems of providing sewerage in the area are compounded by the terrain which is essentially without slope. In addition to the normal flow of domestic, commercial, and industrial wastes, the sewers carry large amounts of infiltration flows. Storm sewers are being constructed in Blytheville during urban renewal project work.

VI-026
EARTHQUAKE DAMAGE TO THE LOS ANGELES SEWERAGE SYSTEM.

Jack M. Betz and Philip V. King
Abstract, Water Pollution Control Federation, Washington, D.C., 1971. (Presented at the 44th Annual Conference of the Water Pollution Control Federation, San Francisco, California, October 3-8, 1971.)

Descriptors: *Damages, *Repairing, *Sewerage, Future planning (projected), Evaluation, Earthquakes.
Identifiers: Sanitary sewers, Los Angeles, California.

On February 9, 1971 a major earthquake hit the northerly portions of the City of Los Angeles and adjacent regions. The total damage is estimated at $500 million. Rodding the sewers indicated severe damage and that a program of televising all suspected sewers was needed. Within the severely damaged area, 45,000 linear feet of sanitary sewer must be replaced entirely, repairs must be made at 4,000 individual locations, and 400 manholes must be repaired. An analysis of the damage indicates the following points for future design considerations: 1) polyvinyl chloride or polyurethane compression joints are superior to mortar joints in resisting earthquake damage; 2) concrete encased sewers suffered far more damage than unencased pipes; 3) damage appeared to be directly proportional to the diameter (at least within the 6-inch to 21-inch sizes); and 4) depth of cover was not significant.

VI-027
FUNCTIONAL SEWER REQUIREMENTS.

Anders Cronström
Preprint, 1970. 11 p. (Presented at the International Water Conservancy Exhibition, Jönköping, Sweden, September 2-9, 1970.)

Descriptors: *Sewers, Design criteria, Construction, Construction materials.
Identifiers: *Sewer requirements.

In this general knowledge article, technical and hygienic requirements for sewers are discussed. The author maintains that a sewer

possess the following features so as to fulfill these requirements: 1) adequate strength to withstand external static and dynamic pressures; 2) watertightness at prevailing pressures; 3) resistance to mechanical and chemical attacks; 4) smoothness of inside walls; 5) ease for laying and jointing; 6) uniform quality and small dimensional tolerances; and, 7) durability and little maintenance requirements. Of these features impermeability by keeping out infiltrating groundwater and preventing the seepage of liquid wastes is the most important property. It is concluded that a sewer line should be made as tight as permitted by circumstances and that surface water lines also should be sealed unless particularly favorable geotechnical conditions allow relaxed sealing requirements.

VI-028
ADVANCES IN STORM AND COMBINED SEWER POLLUTION ABATEMENT TECHNOLOGY.

Allen Cywin and William A. Rosenkranz
Abstract, Water Pollution Control Federation, Washington, D.C., 1971. (Presented at the 44th Annual Conference of the Water Pollution Control Federation, San Francisco, California, October 3-8, 1971.)

Descriptors: Water pollution control, Water pollution sources, Pollution abatement, Evalution, Treatment facilities.
Identifiers: *Storm water discharge.

Research, development, and demonstration efforts sponsored by the Environmental Protection Agency since 1966 have resulted in advances in technology which can be applied as alternatives to sewer separation for abating pollution from combined sewers. The overall problem is caused by basic deficiencies in collection, transport, and treatment systems, which must be corrected to provide truly efficient sewerage facilities. All the sewerage facilities must be evaluated in order to plan modifications which will provide the capability to adequately control and treat wastewaters during and immediately following storm events. Control facilities such as in and off-system storage, flow regulation and routing, remote flow-sensing and control, coupled with treatment, are applicable solutions. Physical, chemical, biological, and physical-chemical treatment methods are under investigation, with a screening, dissolved-air flotation process, and a high-rate multi-media filtration process offering the best current potential for producing good quality effluents. Requirements for control of pollution from combined sewer overflows are rapidly becoming more stringent. Control of pollution caused by urban storm water discharges is on the horizon.

VI-029
ECONOMICS OF WASTEWATER COLLECTION NETWORKS.

Jarir S. Dajani and Robert S. Gemmell
WRC Research Report No. 43, July 1971. 65 p, 6 fig, 3 tab, 36 ref.

Descriptors: *Sewers, *Waste water treatment, *Costs, Design, Economics, Urbanization.

The provision of wastewater collection services is used to demonstrate how technological relationships and principles of microeconomics can be used to generate normative cost functions for urban service networks. The study explores both the demand for the service, as measured by parameters of urban development, and the supply of the service, as determined by the basic technology of providing it. A wastewater collection network is first broken down into its basic component: the sewerline or link satisfying a linear demand. A sewerline cost equation is empirically obtained from actual bid information. The concept of optimization is then explored with respect to overall collection networks. Present design methodology and recent developments in both network layout and design are explored. The problem of the optimal choice of a mix of diameters and slopes for a given network, and a specific set of economic and technological inputs, is fitted to a separable convex programming framework, for which a global optimal solution can be obtained using existing commercial computer programs. The nature of an areally distributed demand is dependent on the type of urban development generating it. Population, area and density are basic parameters for the measurement of urban settlements. Following a review of relevant research methodologies and concepts, a 160-acre experimental module is presented as a basis for the development of normative network cost models. Different population densities and subdivision patterns can be superimposed on this module in a controlled environment.

VI-030
WASTEWATER SYSTEMS FOR ASIAN CITIES.

R. Dennis C. Lloyd and Robert H. Thomas
Preprint, 1971. 18 p. (Presented at the Technical Conference on New Technology in the Solution of Practical Problems in Air and Water Pollution Control, Tokyo, Japan, December 9, 1971.)

Descriptors: *Sewage treatment, *Treatment facilities, Sewerage, Project planning, Estimated costs, Sewers.
Identifiers: Taiwan, Thailand.

Experience in sewerage planning in Bangkok and Taipei indicates that successful implementation of large scale wastewater programs in Asia requires the adoption of reasonable goals and engineering solutions which are compatible with the economic, social, and technological conditions. Concerning their wastewater problems, Taipei and Bangkok have important similarities. The population is about 2½ million, and the cities are generally flat, are located on estuarial portions of major river systems, and have the extremes of extensive flooding and very low flows. In Taipei, separate sanitary sewer and storm water drainage systems were recommended, with disposal of collected wastewater into the Straits of Taiwan from shore through a suitable diffuser after removal of floatables. It was recommended that industrial wastewater, only after required pretreatment, be collected with domestic wastewater. Cost comparisons show the advantage of a single, regional system over separate local systems. The length of the sewer system proposed for construction during the first 17 years is 143 miles of trunk and 806 miles of local street sewers. Because of the flat grades, the system includes 6 major and 2 temporary pumping stations and 4 local lift stations. Two unusual features in the proposed system are: a structure for interception of dry-weather flow from the grossly polluted Hsinsheng Canal, and a night-soil collection station. The recommended program for construction of the proposed system, which will cost about $400 million at 1970 prices, is spread over a period of 37 years. In Bangkok, separate systems were proposed since klongs could continue to be used as main drainage channels but not as combined sewers. Due to lack of suitable conditions for disposal of large volumes of waste by dilution, treatment to a high degree by a biological process will be necessary. The proposed system in Bangkok includes flood control, is estimated to cost $544 million at 1969 prices, and scheduled for completion by the year 2000.

VI-031
AN IMPROVED METHOD FOR THE APPLICATION OF HARMON'S EQUATION IN THE DESIGN OF SEWER SYSTEMS. (Nuevo metodo mas racional para aplicar la fórmula de Harmon en el diseño de las redes de alcantarillado.) Text in Spanish.

Avram Radev
INCVA, 22(4):339-344 (July/Aug. 1971). 2 tab, 1 graph.

Descriptors: *Design criteria, *Sewers, *Mathematical studies.
Identifiers: *Harmon's equation, *Sewer systems

The traditional application of Harmon's formula in the design of a sewer system involves many calculations and graphs. The graph of an improved method shows the number of inhabitants on the abscissa and the amount of flowing water (in liters/second/inhabitant) on the ordinate. In this method, the number of inhabitants using the sewer constitutes the only required paramenter, obtained from the multiplication of the size of the drained area by its population density (inhabitants/ha), for its design. Knowing the number of inhabitants of the area for a period of thirty to fifty years and the standards of water consumption (liters/inhabitant/day) corresponding to this number of inhabitants, Harmon's curve can be drawn. This curve can then be utilized in the design of a sewer system for the specified area.

VI-032
SEWER MAINTENANCE COSTS.

I. W. Santry, Jr.
Abstract, Water Pollution Control Federation, Washington, D.C., 1971. (Presented at the 44th Annual Conference of the Water Pollution Control Federation, San Francisco, California, October 3-8, 1971.)

Descriptors: *Costs, *Repairing, *Maintenance, *Sewers, Data collections, Infiltration.

Experiences and costs in repairing sewer mains and building service lines along with cleaning and television inspection of the sewers are herein reported. In addition, data is presented relative to the costs and impact of infiltration on the maintenance of sewers. Factors of the sizes of sewers, lengths of various sizes, and stoppages occurring in the sewers are cited. Cleaning costs using bucket machines, rodding machines, and hydraulic turbine machines are presented in terms of total cost per foot. In general, the average cost of repair varied from $115 to $778 per repair with the labor being approximately 65.7% of the cost, the equipment charges 8.4%, the material costs 18.5%, and the administrative charges at 7.4%.

VI-033
ANALYSIS OF DESIGN FACTORS FOR SEWAGE PIPELINES. (Gesuido kankyo keikaku ni okeru sekkei inshi no renkan bunseki.) Text in Japanese.

Tomitaro Sueishi, Atsushi Yamada, and Toru Hashimoto

Preprint, Japan Society of Civil Engineers, Tokyo, 1971. 2 p. (Presented at the 26th Annual Science Lecture Meeting, October 1971.)

Descriptors: *Optimum development plans, *Sewers, Design criteria, Model studies, Comparative costs.
Identifiers: *Sewer systems, Japan.

An optimization model has been developed for sewer system design so as to evaluate design methods and design factors. Evaluation of an existing system is accomplished by comparing its costs with costs calculated from the model. It was found that the cost of an existing system exceeded the model value for upstream systems, yet close results were realized in sewer system plans calculated for geographically similar regions.

VI-034
SELECTED INFORMATION ABOUT REPORTED RESEARCH ON THE SUBJECT OF POLLUTION DUE TO STORM WATER AND OVERFLOWS FROM COMBINED SEWAGE.
Nova Scotia Technical College, Halifax. Atlantic Industrial Research Institute.

D. H. Waller
Central Mortgage and Housing Corporation Project on Pollution due to Storm Water and Overflows from Combined Sewers, Technical Report No. 1, Oct. 25, 1968. 21 p, 5 tab, 90 ref.

Descriptors: *Storm runoff, *Water pollution effects, *Water pollution sources, Water analysis, Investigations, New York, Domestic wastes.
Identifiers: *Sewer overflows, *Storm sewers, *Combined sewers.

A two-year study has been undertaken to study the pollutional effects of both storm runoff and the overflow from combined domestic waste and storm sewers. Both storm sewer and combined sewer waters were analyzed for solids, BOD, nitrogen and phosphorus, and bacteria in an effort to determine the effects of these waters on a receiving water. Coliform densities were obtained from sampling stations in New York City beach areas which varied 14 to 1 to 0.5 to 1 wet population versus dry population based on the geometric mean. In 17 out of 24 cases, the bacterial count during wet weather was 2 or more times the dry weather count. These and other studies indicated that storm runoff which had not been contaminated by domestic sewage was still causing much pollutional damage. References are given for the treatment that has been considered to date, namely screening, disinfection and/or sedimentation. The role of solids in the collection system is also discussed along with the percentages occurring in various flows.

VI-035
THE FLOODING AND COMBINED SEWER OVERFLOW PROBLEM IN URBAN METRO AREAS.

Vinton W. Bacon
College of Applied Science and Engineering, University of Wisconsin-Milwaukee and University Extension, University of Wisconsin, Proceedings from Deep Tunnels in Hard Rocks: A Solution to Combined Sewer Overflow and Flooding Problems, Civic Center Campus, Milwaukee, Wisconsin, November 9-10, 1970. 4 p.

Descriptors: *Flooding, *Combined Sewers, *Separated Sewers, *Municipal Water, *Waste Water Treatment, *Overflow, *Underground Storage, *Interceptor Sewers, Water Pollution Sources, Tunnels, Pollution Abatement, United States.

In the United States there are 1329 jurisdictions, served in whole or in part by combined sewers, having a total population of 54 million. Of this projected population, it is estimated that 36 million are actually served by combined sewers. Although the gallonage of sewer overflow is only about 5% of the total, it is estimated that about 30% of the total pollution material is overflowed to the waterway. The combined sewer overflow problem can be solved in one of the following three ways, or a combination of the three. 1) Sewers can be separated. 2) Treatment can be provided at the point of overflow simply by interception before discharge. 3) Conveyance tunnels (sewers) and storage caverns can be built in the underground rock, thus storing the polluted combined sewer overflow during the storm, pumping back to the surface after the storm, and finally treating in existing or new plants.

VI-036
THE ROLE OF STORAGE IN ECONOMICS OF SEWAGE TREATMENT PLANT DESIGN.

William J. Bauer
College of Applied Science and Engineering, University of Wisconsin-Milwaukee and University Extension, University of Wisconsin, Proceedings from Deep Tunnels in Hard Rock: A Solution to Combined Sewer Overflow and Flooding Problems, Civic Center Campus, Milwaukee, Wisconsin, November 9-10, 1970. 16 p, 6 fig.

Descriptors: *Storage, *Underground Storage, *Treatment Facilities, *Economics, Design Criteria, Sewage Treatment, Overflow, Flow Rates, Combined Sewers.
Identifiers: Deep Tunnel Plan.

The significance of demand for treatment plant capacity is becoming greater with time because the cost of treatment is going up. The way of making an expensive plant work harder is with storage, and the economic choice involves the relative costs of water storage and treatment capacity. As the storage of a system is increased, the frequency of spill is reduced thus reducing the total quantity of the spill and subsequent water pollution. The cost of storage varies widely depending upon the facilities that are provided. In the Deep Tunnel Plan studies of Greater Chicago, the bulk storage amounted to approximately $1.50 per cubic foot of storage. On the other hand, the cost of concrete boxes with lids at ground level, scraper mechanisms for handling solids, plus some aeration facilities would cost about $5.00 a cubic foot. Some non-economic advantages to providing storage are: performance improvement, provided the rate of flow through the plant is capable of being controlled; higher sustained flow and fewer high peaks; in the event of mechanical breakdown in the plant, an option to dumping of the water; and, a solution to the problem of combined sewer overflows.

VI-037
RAPID EXCAVATION IN HARD ROCK: A STATE-OF-THE-ART REPORT.

William E. Bruce and Roger J. Morrell
College of Applied Science and Engineering, University of Wisconsin-Milwaukee and University Extension, University of Wisconsin, Proceedings from Deep Tunnels in Hard Rock: A Solution to Combined Sewer Overflow and Flooding Problems, Civic Center Campus, Milwaukee, Wisconsin, November 9-10, 1970. 33 p, 11 fig, 2 tab, 10 ref.

Descriptors: *Drilling, *Rock Properties, Tunnel Design, On-Site Investigations, Borehole Geophysics, Rock Excavation, United States, Reviews.

The evolution of present day tunnel boring techniques are herein described. Emphasis is directed toward selected cases from the past decade whose data have been generated, for the most part, by Bureau of Mines personnel during on-site studies of the particular job. The significant problems and accomplishments for various actual operations are presented. Wherever possible, physical characteristics of the rock encountered to aid the audience in evaluating rock hardness are given. Trends for the future are forecast relying on objectives as developed by the Organization for Economic Cooperation and Development as well as on experience of Bureau of Mines personnel.

VI-038
GEOLOGIC EXPLORATION FOR CHICAGOLAND AND OTHER DEEP ROCK TUNNELS TO BE CONSTRUCTED BY MECHANICAL MOLES.

George Heim, R. W. Mossman, and Homer W. Lawrence
College of Applied Science and Engineering, University of Wisconsin-Milwaukee and University Extension, University of Wisconsin, Proceedings from Deep Tunnels in Hard Rock: A Solution to Combined Sewer Overflow and Flooding Problems, Civic Center Campus, Milwaukee, Wisconsin, November 9-10, 1970. 29 p, 17 fig, 2 tab, 4 ref.

Descriptors: *Tunnel Construction, *Rock Excavation, *Tunnel Design, *Water Conveyance, *Subsurface Investigations, Groundwater.
Identifiers: *Mechanical Moles, *Deep Tunnel Plan, Outward Seepage, Chicago, Illinois.

The Deep Tunnel concept consists of interception of the sanitary and storm water overflow at the overflow points, and conveyance of the overflow water in tunnels to a mined room and pillar type storage area from which the overflow water can be pumped at a reduced rate to permit treatment of all wastewater. Herein described is the subsurface geological exploration program performed in 1967 and 1968 for the Chicagoland Deep Tunnel Project. Results indicate that to obtain the most favorable geologic condition for deep tunnels to be constructed by mechanical moles, the tunnels should be located in structurally sound and uniform rock strata with a minimum of potential groundwater problems. If the tunnels are designed to be unlined and to carry sanitary water, it is necessary to carefully evaluate the groundwater conditions to assure this valuable resource from becoming contaminated by outward seepage from the tunnels.

VI-039
THE IMPACT OF THE DEEP TUNNEL PLAN ON WATER RESOURCES IN THE CHICAGO AREA.

Victor Koelzer
College of Applied Science and Engineering, University of Wisconsin-Milwaukee and University Extension, University of Wisconsin, Proceedings from Deep Tunnels in Hard Rock: A Solution to Combined Sewer Overflow and Flooding Problems, Civic Center Campus, Milwaukee, Wisconsin, November 9-10, 1970. 27 p, 5 fig, 1 tab.

Descriptors: *Water Conservation, *Water Resources, *Storm Water, *Tunnels, *Surface Waters, *Groundwater, Overflow.
Identifiers: *Deep Tunnel Plan, Chicago, Illinois.

The Harza-Bauer proposal of a Deep Tunnel Project for the Metropolitan Sanitary District of Greater Chicago is designed to provide temporary storage for storm water and its accompanying pollution load. The impact of this Deep Tunnel Project on two aspects of water resources for Northeast Illinois - surface water and groundwater - are herein described. It shows that the benefits to conservation of water can be as significant as those originally expected for flood and pollution control. For surface water, it is estimated that the Deep Tunnel Project would ultimately make available an additional 515 cfs for use in Northeast Illinois because of better regulation and complete treatment of storm water overflows. For groundwater, detailed are elaborate measures planned to protect the aquifers, presently sources of about 202 cfs of the metropolitan area supply, from pollution by the Project, thus reversing the trend of groundwater mining in the metropolitan area.

VI-040
MAXIMIZING STORAGE IN COMBINED SEWER SYSTEMS.
Municipality of Metropolitan Seattle, Seattle, Washington

Curtis P. Leiser
EPA/WQO Contract No. 13-Wash-1, Project No. 11022 ELK, Dec. 1971. 227 p, 64 fig, 25 tab, 54 ref, 12 append.

Descriptors: *Combined Sewers, *Waste Water Treatment, *Separation Techniques, *Conveyance Structures, *Storage, Separation, Storm Water, Overflow, Sampling, Monitoring, Data Collections, Analytical Techniques, Interception, Computers, Control Systems.
Identifiers: *Seattle, Washington.

A major portion of the Seattle Metro area's comprehensive sewage collection and treatment plan launched in 1958, included improvements to an existing combined sewer system within Seattle's city limits. Initial plans included: (1) interception and treatment of raw sewage flowing to saltwater points, (2) regulation of combined flows to utilize all available trunk storage and (3) construction of temporary storage tanks at freshwater overflow points. In 1968, a $70 million sewer separation project was approved and will enlarge system storage by reducing storm inflow. All construction has been completed in an effort to demonstrate the feasibility of applying computer-control concepts to theoretically make maximum use of all available storage within a collection system. Automatic and manual sampling programs are monitoring overflows and adjacent waters. Accumulated and analyzed data shows dramatic improvements in receiving water quality resulting from interception and treatment phases of construction. Analysis of separation monitoring data, projects a 50-70% reduction in pollutant loading to fresh water from combined sewer overflows. Overflow volume, frequency and quality factors are established to serve as a basis for measuring the performance of the control system as it leaves the instrumented local control phase and begins the totally computer-managed phase.

VI-041
METROPOLITAN SANITARY DISTRICT OF GREATER CHICAGO EXPERIENCES AND FUTURE PLANS FOR HARD ROCK TUNNELS.

Forest Neil
College of Applied Science and Engineering, University of Wisconsin-Milwaukee and University Extension, University of Wisconsin, Proceedings from Deep Tunnels in Hard Rock: A Solution to Combined Sewer Overflow and Flooding Problems, Civic Center Campus, Milwaukee, Wisconsin, November 9-10, 1970. 22 p, 10 fig.

Descriptors: *Water Quality Control, *Overflow, *Underground Storage, *Storage, Storm Water, Waste Water Treatment, Tunnels, Separated Sewers, Combined Sewers, Economics, Geology, Flood Control, Water Quality Standards, Channels.
Identifiers: *Chicago, Illinois.

In the City of Chicago and older suburbs, there are over 300 square miles served by combined sewers which, for the most part, discharge their storm overflow to the local streams. The estimated cost of separation of sewers is over $4 billion and it is doubtful if separation would sufficiently improve the quality of the waterways to meet standards. Rapid urbanization of the area is increasing runoff and peak flows in the waterways. No major improvements to increase the outlet capacity have been made to the Sanitary and Ship Canal or the Des Plaines River since their original construction. Additional capacity in the canal and river system must be provided by deepening and widening, or storm water must be detained and gradually released after the peak of the storm. Retention of storm flows in surface reservoirs has been a standard flood control practice for many years primarily in the separated sewer areas. In the combined sewer area, the flat topography, development of the area, and cost of land, limit the number of reservoir sites. Investigation of the potential of subsurface storage thus became desirable. The merging of two proposed plants, by the Metropolitan Sanitary District and the City of Chicago, will result in the most feasible method of underground rock tunnels combined with storage underground and on the surface.

VI-042
OXYGEN ADSORPTION IN STREAMS.

John D. Parkhurst and Richard D. Pomeroy
JSEDA, 98(SA1):101-124 (Feb. 1972). 3 fig, 5 tab, 28 ref, 2 append.

Descriptors: *Mathematical Studies, Adsorption, Reaeration, Sewers, Data Collections.
Identifiers: Sewage Streams.

Information on the rate of absorption of oxygen in sewers in needed for calculations of biological oxidation in sewers and for an understanding of sulfide buildup in sewers. Published equations for stream aeration are at variance with one another, and in any case do not provide a basis for needed predictions of reaeration rates in sewers. Measurements of oxygen uptake were made in twelve functioning sewers. By viewing all of the data and prior mathematical treatments synoptically, a general predictive equation was devised. Reaeration rates for sewage streams can now be predicted with an expected standard error of ±10%. The general equation coefficient for predicting reaeration in streams of pure water is not yet known with similar accuracy, but could be determined by precision experiments. The rates in sewage streams are apparently about a third as great as in pure water.

VI-043
UNDERWATER STORAGE OF COMBINED SEWER OVERFLOWS.
Karl R. Rohrer Associates, Inc. Akron, Ohio

Karl R. Rohrer and William J. Bandy, Jr.
EPA/WQO Contract No. 14-12-143, Program No. 11022 ECV, Sept. 1971. 170 p, 42 fig, 16 tab, 33 ref, 3 append.

Descriptors: *Combined Sewers, *Pilot Plants, Water Pollution Control, Lake Erie, Operating Costs, Model Studies, Comparative Costs, Sewage Treatment, Construction.
Identifiers: *Storm Overflows, *Temporary Storage, *Underwater Storage, *Flexible Tanks, Sandusky, Ohio.

The purpose of this study was to demonstrate off-shore underwater temporary storage of storm overflow from a combined sewer in flexible tanks. Site selection, model testing, system design, construction, and one year's operation were conducted under the study. A pilot demonstration facility was constructed in Sandusky, Ohio where combined sewer overflow from a 14.86-acre residential drainage area was directed to two-100,000 gallon collapsible tanks anchored underwater in Lake Erie. The stored overflows were pumped back to the sewer system after a storm event for subsequent treatment. During the year's operation, a total of 988,000 gallons of storm overflow was contained and returned for treatment. As constructed, the facility cost was about $1.88 per gallon of storage capacity while future projections indicate costs of less than $0.40 per gallon possible. Evaluation of the underwater storage system in controlling combined sewer pollution, comparison of cost with other storage methods and other combined sewer pollution control methods, operational difficulties and recommendations of an improved system are included in the study report.

VI-044
MASTER SEWERAGE SYSTEM PLAN FOR MANILA.

John O. Schmidt
JSEDA, 98(SA1):125-152 (Feb. 1972). 8 fig, 13 tab.

Descriptors: *Sewerage, *Project Planning, Sanitary Engineering, Economics, Engineers Estimates, Design Criteria, Sewers, Waste Water Treatment, Feasibility Studies.
Identifiers: Philippines.

In 1969 Black & Veatch International completed a 2-year comprehensive sewerage study of Metropolitan Manila. The existing sewerage facilities were found to be inadequate, and generally poorly maintained and operated. Rehabilitation of the Manila Portion of the systems was badly needed. An extensive oceanographic study led to the conclusion that satisfactory disposal of untreated wastes was possible through a suitable outfall and diffuser system. Design criteria for sewers and wastewater treatment which were developed included earthquake considerations. The recommended first phase construction program was estimated to cost $22 million at a 1969 cost level. Financing was believed feasible by a combination of connection charges, sewer service charges, and government contributions.

VI-045
INVESTIGATION OF POROUS PAVEMENTS FOR URBAN RUNOFF CONTROL.
The Franklin Institute Research Laboratories, Philadelphia, Pennsylvania

Wilford C. Grover, Arnold J. Hoiberg, Thomas I. Haigh, Francis J. Sweeney, and Edmund Thelan
EPA/ORM Contract No. 14-12-924, Program No. 11034 DUY, March 1972. 142 p, 19 fig, 21 tab, 37 ref.

Descriptors: *Urban Runoff, *Laboratory Tests, *Economic Justification, *Feasibility Studies,

*Road Design, *Asphaltic Concrete, Overflow, Combined Sewers, Water Conservation, Traffic Safety, Water Pollution Control.
Identifiers: *Porous Pavement.

Laboratory and economic studies were undertaken to determine the feasibility of utilizing porous pavements to alleviate combined sewer overflow pollution and reduce the design parameters of storm sewer systems by allowing storm runoff to percolate back into the ground. Laboratory studies of candidate materials revealed a porous asphaltic concrete containing 5.5% asphalt by weight and aggregate graded to allow a water flow of 76" per hour to be the optimal porous road material. Materials testing for stability, durability, and freeze-thaw susceptibility proved this material suitable for use in road construction. Asphalt Institute specifications were used to design roads with porous asphaltic concrete surfaces and gravel bases for varying traffic densities. Major design parameters considered were the load-bearing capacity and permeability of the subgrade, expected maximum precipitation and depth of frost penetration. Roads designed with porous asphaltic concrete were found to be generally more economical than conventional roads with storm sewers. The economics of porous pavement were further enhanced by the added value of benefits from combined sewer overflow pollution relief, augmentation of municipal water supplies, improved traffic safety, preservation of vegetation, relief of flash flooding, and the aesthetic and directional benefits of a colored porous surface.

VI-046
SEWER BEDDING AND INFILTRATION - GULF COAST AREA.
Tulane University, New Orleans, Lousiana

John K. Mayer, Frank W. Macdonald, and Stephen E. Steimle
EPA/WQO Contract No. 80-04-68, Program No. 11022 DEI, May 1972. 183 p, 48 fig, 33 tab, 21 ref, 15 append.

Descriptors: *Infiltration, *Sewers, *Manholes, *Groundwater, Construction, On-Site Investigations, Water Pollution Sources, Gulf Coastal Plain.
Identifiers: *Sewer Bedding, Sewer Failure.

Groundwater infiltration studies were performed on several Gulf Coast area sewer systems in 1962 - 1963 and again in 1970 with the results being compared. Infiltration measurements in the systems ranged from zero to 111,560 gallons per inch of diameter per mile per day. The infiltration was slightly increased in some lines and was greatly decreased in others. The decrease is attributed to soil and grease clogging the breaks, as was observed in subsequent television inspection. Infiltration has been found to vary with time. The high infiltration rates were attributed to poor construction methods used by contractors on the main sewer system and by plumbers on house connections. A survey of 1600 manholes showed 3.5% to have infiltration at the time of the inspection and others likely to develop infiltration during periods of heavy rainfalls. Most of these could be easily repaired to prevent infiltration. Poor construction procedures are considered to be the most significant contributor to infiltration and sewer failure. This situation can be remedied through adequate inspection and testing. Bedding and select cover should provide even distribution of load and support for the pipe. A second function of this material should be to impede the flow of water surrounding the sewer when the pipe is laid below the water table. The material should completely surround the pipe. A coarse granular material such as clam or oyster shells, gravel, or crushed stone, provides excellent support and load spreading but does not impede flow. Mixtures of these with sand and other materials can provide flow impedance.

VI-047
STORM WATER PURIFYING - ADVANCED GUESSWORK AT A COST OF FOUR THOUSAND MILLION DOLLARS. (Dagvattenrening - kvalificerad gissningslek om tjugo miljarder.) Text in Swedish.

Gunnar Soderlund
KETIA, (4):50-59 (1972). 6 ref.

Descriptors: *Storm Water, *Sewage Treatment, *Project Planning, *Water Pollution Control, *Technology, *Economics, *Optimum Development Plans, Sewers, Separated Sewers, Combined Sewers, Data Collections, Water Pollution Sources, Pollutant Identification, Urbanization, Reviews, Suspended Load.
Identifiers: Sweden.

Technical and economic aspects of water discharge planning in Sweden, with special consideration to storm water treatment, are detailed. Investments in Sweden for sewage and storm water treatment are usually not preceded by appropriate investigation. The respective advantages and disadvantages of combined and separate systems for sewage and storm water treatment are reviewed. Latest studies indicate that the efficiency of sewage treatment plants is not deteriorated by medium amounts of storm water. Investigations in the Stockholm and Goteborg area revealed that the storm water had lower BOD

and COD values and contained more suspended matter and bacteria than sewage waters from the same areas, and that the amount of pollutants in the storm water was increased by both high population and traffic density. The storm water investigated contained oil, heavy metals, organochlorine substances, and even 3,4-benzopyrene. While key data required for economic optimum in planning are still missing, the intermediate storage of sewage water prior to treatment can be regarded as the least expensive method. As settling alone is not sufficient, flocculation is required for suspended matters. Other methods such as sifting, flotation, and chlorination are briefly reviewed.

VI-048
SOLVING THE COMBINED SEWER OVERFLOW PROBLEM OF A MAJOR CITY.

Roy F. Weston, James E. Germain, and Michael E. Fiore
PUWOA, 103(5):106-108 (May 1972). 2 fig, 1 tab, 2 ref.

Descriptors: *Overflow, *Conveyance Structures, *Underground Storage, *Tunnels, *Evaluation, *Cost Analysis, *District of Columbia, Combined Sewers, Sewerage, Water Pollution Control.

A study was undertaken by Roy F. Weston, Inc. to: 1) define the magnitude of combined sewer overflows within the District of Columbia; 2) investigate the feasibility of high-rate filtration for treatment of combined sewer overflows with the District; and, 3) develop alternative solutions to the District's problem. The four combined sewer overflow control methods investigated included sewer separation, storage in reservoirs, storage and treatment at each overflow point, and storage in tunnels and mined-storage facilities. The alternative systems, based on a 15-year occurrence and 24-hour duration design storm, were evaluated and detailed cost analyses performed. The graphs reveal that the cost for tunnels and mined storage is approximately $320 million, representing a $40 million savings over the next best approach. As a result, a network of conveyance tunnels and mined storage was suggested as the appropriate system.

SECTION VII.

Legislation and Standards

VII-001
YEOMAN V KANSAS CITY (MUNICIPALITY'S LIABILITY FOR INSTALLATION OF CULVERT AND ALTERING FLOW OF STREAM).

18 SW 2d 107-111 (Kansas City Ct App 1929).

Descriptors: *Missouri, *Cities, Floods, Overflow, Culverts, Storm runoff, Surface drainage, Judicial decisions, Legal aspects.

Plaintiff riparian landowner sued defendant municipality for damages resulting from overflow of the creek in front of plaintiff's property. Plaintiff asserted that defendant had negligently installed a culvert and altered the flow of the creek. Before the culvert was installed the creek had never overflowed onto plaintiff's land. Defendant answered that the damage was the result of extraordinary rainfall. At trial, verdict was given for defendant. Plaintiff moved for a new trial, alleging that the verdict was against the weight of the evidence. Although the Kansas City Court of Appeals determined that the evidence failed to show that the culvert ipso facto caused the overflow, it found that the evidence demonstrated that defendant's raising of a street downstream had caused the overflow. In granting plaintiff's motion for a new trial, the court stated that it was no defense for defendant to answer that its actions were a governmental function, performed in good faith.

VII-002
NAGY V CITY OF AKRON (MUNICIPAL SURFACE WATER DRAINAGE).

27 Ohio App 250, 161 NE 226-228 (1927).

Descriptors: *Ohio, *Surface drainage, *Storm runoff, Storm drains, Damages, Judicial decisions, Legal aspects, Drainage systems.

Plaintiff landowner sued defendant city for damages to his crops caused by overflow from a county drainage lateral which passed through plaintiff's land. Plaintiff's complaint alleged that the overflow resulted from defendant's storm water sewer emptying into the lateral at a point 1000 feet outside defendant's corporate limits. The lateral was a watercourse under Ohio law. Defendant denied liability because only the flow and not the drainage area of the lateral had been increased by defendant's storm sewer drainage. The trial court sustained defendant's demurrer and the Court of Appeals of Ohio reversed. The court treated defendant municipality as an individual landowner in applying the civil law rule for surface water drainage. While acknowledging the rule that a landowner may, without liability, drain surface water into a natural watercourse upon his land and thus increase the volume and flow of the watercourse, the court pointed out that the watercourse in the instant case did not at any point come within defendant's corporate limits. The court therefore held plaintiff's complaint to state a cause of action.

VII-003
KELLY V CITY OF CAPE GIRARDEAU (LIABILITY OF CITY FOR FAILURE TO PROVIDE ADEQUATE STORM SEWERS).

72 SW 2d 880-884 (Ct App Mo 1934).

Descriptors: *Missouri, *Storm drains, *Damages, Sewers, Overflow, Surface runoff, Legal aspects, Judicial decisions, Flood damage.

Plaintiff landowner sought compensatory and punitive damages for flooding of his land resulting from defendant city's inadequate storm sewers. Defendant, over a period of several years, had failed to comply with an injunction requiring it to replace the inadequate sewers. Plaintiff contended he was entitled to compensation for each incident of flooding not previously the subject of judgment. Defendant contended plaintiff's recovery of damages in a prior suit barred all claims arising prior to that action. The court held that when flooding results from an abatable nuisance, the wrong is re-created on each occasion of flooding. The injured property owner has the right to bring an action on each incident of flooding, notwithstanding prior judgment on other such incidents. Noting that the defendant's failure to comply with the prior injunction entitled the plaintiff to punitive as well as compensatory damages, the court affirmed the lower court's award of damages.

VII-004
ROSSI V CITY OF SCHENECTADY (CONDITIONS PRECEDENT TO SUIT AGAINST MUNICIPALITY FOR FAULTY SEWERS).

133 Misc 792, 233 NYS 512-515 (Sup Ct 1929).

Descriptors: *Storm drains, *Flood damage, *Adjudication procedure, Sewers, Storm runoff, Legal aspects, Floods.
Identifiers: *Schenectady, New York.

Plaintiff resident sought damages from defendant municipality after sewer back up and overflow flooded plaintiff's premises. Plaintiff timely filed a statutorily required notice of claim stating his residence and that the faulty sewer was 'in said vicinity'. Plaintiff contended the defendant had negligently constructed the sewer. Defendant moved for dismissal, alleging plaintiff's notice had failed to explicitly describe the faulty sewer's location and, therefore, did not meet the statutory condition precedent to suit. The Supreme Court, Schenectady County, held that a description enabling municipal authorities to determine, with reasonable diligence, the location of a defective sewer, suffices to meet statutory requirements of notice prior to suit. Plaintiff's description of residence coupled with a statement alleging negligence in the backing up of sewers 'in said vicinity' provided defendant with adequate notice of the plaintiff's claim. Defendant's motion to dismiss was denied absent any claim of misrepresentation.

VII-005
STACK V CITY OF NEW YORK (MUNICIPAL AND PRIVATE LIABILITY FOR SEWAGE OVERFLOW).

134 Misc 105, 234 NYS 486-489 (NY City Ct 1929).

Descriptors: *Flood damage, *Storm drains, *Sewers, Storm runoff, Overflow, Judicial decisions, Legal aspects, Sewerage.
Identifiers: *New York City, New York.

Plaintiff tenant sought damages from defendant landlord and from defendant city for losses incurred when a sewer overflow flooded her premises. The street abutting plaintiff's residence contained both a sanitary sewer and a rainwater drainpipe. During an extraordinary rainfall, water flowed over the gutter and into plaintiff's residence. Plaintiff contended defendant landlord knowingly maintained the premises below street level and that defendant city had negligently failed to provide an adequate drainage system. The City Court of New York held that: (1) absent fraud or express warranties, no cause of action against a landlord arises from flood damage to premises below the street grade; and (2) a city in constructing sewers is not bound to provide for extraordinary rainfalls and is not liable when, after such rainfalls, sewers back up and flood private premises. The court noted that plaintiff had failed to establish that sewage came onto the premises or that the drainpipe had been improperly constructed or maintained. Ruling that plaintiff had failed to state a cause of action against the landlord or establish the city's negligence, the court granted verdict for defendants.

VII-006
HILL V CITY OF WINTERSET (DAMAGES FOR CITY'S MAINTENANCE OF NUISANCE).

214 NW 592-593 (Iowa 1927).

Descriptors: *Iowa, *Water pollution, Sewers, Drainage, Discharge (water), Judicial decisions, Legal aspects.

Plaintiff landowner brought suit against defendant city to recover damages for maintenance of a nuisance. Defendant had constructed a storm sewer along a public street adjacent to plaintiff's property, and this sewer discharged into an open ditch near plaintiff's premises. Defendant also connected drains from septic tanks and cesspools to the storm sewer, thereby causing the discharge to become offensive and obnoxious. Plaintiff's complaint was based on the offensive nature of this nuisance. Plaintiff received a verdict and defendant appealed. The Supreme Court of Iowa affirmed. The statute under which the action was brought was sufficiently broad to allow introduction of evidence concerning the health hazards of the nuisance, even though plaintiff's claim was based on the obnoxious odors caused by the nuisance. Portions of the evidence regarding sanitary aspects in the utilization of septic tanks were immaterial but were not prejudicial to defendant's case.

VII-007
MOARTTY V TOWN OF HAMPTON (MUNICIPAL LIABILITY FOR STORM DRAIN OVERFLOW).

272 A2d 606-608 (NH 1970).

Descriptors: *Storm drains, *Overflow, Storm runoff, New Hampshire, Legal aspects, Judicial decisions, Flooding, Drainage systems.

Plaintiff landowner brought action for property damage resulting from flooding when defendant town's drainage system overflowed. Heavy precipitation preceded the flooding. Plaintiff claimed defendant was negligent in maintaining the system. Defendant asserted that the precipitation was an act of God which overtaxed the system. Defendant contested a jury verdict in favor of plaintiff and the trial court's denial of his motions for non-suit and directed verdict. The Supreme Court of New Hampshire held that a property owner is not entitled to recover for flood damage resulting from drainage system overflow unless the town's negligence in performing maintenance, or the existence of obstructions within the system, is first established. The court ruled that defendant's negligence could not be inferred from the mere fact of injury to plaintiff's property. Finding no evidence of either an

obstruction within the system or negligence, the court held defendant's motions should have been granted.

VII-008
O'HEARN V TOWN OF ADAMS (DAMAGES FOR OVERFLOW OF SEWAGE).

288 Mass 185, 192 NE 524-527 (1934).

Descriptors: *Massachusetts, Overflow, Damages, Legal aspects, Judicial decisions.

Plaintiff landowners brought a tort action against defendant town for damages to land and property resulting from the overflow of a river and discharge of sewage from an alleged common sewer. Plaintiffs alleged that the damage complained of resulted from acts of the superintendent of sewers commencing sixteen years before filing of action. The superintendent had diverted stream water into a channel near plaintiffs' land and extended the sewer line to this channel. The Supreme Judicial Court of Massachusetts gave judgment for defendant. Private actions will lie against a municipality where it is negligent in maintaining a common sewer, control of which is authorized by statute. However plaintiff must show that the town was obligated to do the work resulting in injury or that it was an exercise of corporate power. Here the proximate cause of injury was not the building and maintenance of the sewer but diversion of the stream. Further, plaintiff must show acceptance by the town of the statute relating to laying out of sewers. In the instant case defendant had not accepted the statute. Liability could not be predicated on eminent domain as there was no taking of plaintiffs' land.

VII-009
PROPOSED FEDERAL FUNDING FOR CONSTRUCTION OF COMMUNITY WATER AND SEWAGE FACILITIES.

HR Report 91-1263, 91st Congress 2nd Session, 11 U.S. Code Congress and Administration News, (1970). 5 p, 1 tab.

Descriptors: *Sewage treatment, *Sewage disposal, Water pollution, Cities, Sewers, Legislation, Administration, Water quality, Pollution abatement.

Recommending passage of a House bill (H.R. 17795 which ultimately became Public Law 91-431) to provide funds for water and sewer facilities, this report by the Committee on Banking and Currency sets out the important aspects of the legislation. Included in the report are: (1) the objectives of the bill, (2) its background, (3) why the bill is needed, (4) the availability of funds for projects in small towns, (5) additional views of the committee, and (6) dissenting views. The bill amends Title VII of the Housing and Urban Development Act of 1965 and would: (1) help finance construction of urgently needed public facilities to provide for the public health and check water pollution, (2) reenact the balance of the authorization for basic water and sewer facilities under the 1965 Act, (3) make an additional one billion dollars available for grants, and (4) extend the time in which a community could qualify for a basic water and sewer facilities grant. The bill is necessary because local communities do not have the resources to provide needed water and sewer facilities. Funds would be available for projects in small communities. Dissenting views on the bill emphasized the lack of available funds to finance the proposed projects.

VII-010
ENVIRONMENTAL LAW: AN ANALYSIS OF SOME RECENT COURT DECISIONS IN THE FIELD OF SEWAGE TREATMENT.

Gordon M. Betz
WSIWA, 118(6):169-172 (June 1971).

Descriptors: *Sewage treatment, *Water pollution, *Legal aspects, Environmental pollution, Waste disposal, Judicial decisions.

Five recent court decisions in the field of sewage treatment and water pollution are examined. The first case involved a suit for nuisance conditions. The Plaintiff brought action against a metropolitan sewer company which had constructed, in accordance with state Department of Health requirements and proper building permits, sewage lagoons on property adjacent to his. He contended the lagoons rendered part of his property unfit for housing construction at some future time. The court decided for the defendant. Since there were no noticeable odors impairing the use of the adjoining property, and inasmuch as there were no dwellings at present within the distance specified by law from the sewage treatment facilities, the court held that the loss of aesthetic value suffered by the plaintiff constituted a loss without injury. Case No. 2 was an action brought by a county board of commissioners (P) for an easement over the defendant's land for a sewer line. Defendant (D) filed a cross petition, charging that P was maintaining a public nuisance by operating a sewage treatment plant in which sewage was inadequately treated and the effluent was contaminating a lake adjacent to his property. Inasmuch as he was the operator of a marina, this pollution threatened his livelihood. The court's decision

was governed by the constitutional prohibition against taking of private property for the public good without due compensation. The taking of property need not mean actual seizure, any actual or material interference with private property rights constitute a "taking". Additionally, the court found that D, although a private citizen, not a public official, was capable in this instance of bringing action on a public nuisance charge since there was evidence of injury to himself over and above that suffered by the public in general. The third case cited was a complaint brought by P, a non-profit improvement association whose members were owners of property on a lake, against D, a municipality and industrial firm charged with dumping sewage and wastes into the lake. This state had a water resources commission act detailing the procedure for elimination of water pollution, and there was undisputed evidence that improperly treated wastes were being discharged into the lake by the defendants. While the case was in the courts, the water resources commission entered into agreements with D for the installation of proper treatment facilities. The agreements made between the commission and the D's required a public hearing. Inasmuch as this had not been held, P could challenge the sufficiency of the agreements before the commission. The court refused a decision on the suit, stating that P had not exhausted the avenues of relief open through the water resources commission. Generally, where a matter is before an administrative body, the injured party must pursue all relief provided by statute through that body before bringing a matter into court. In the fourth case, an injuction was sought by land owners enjoining a college from disposing of its sewage into a small stream on which both they and the college owned property. The college had obtained easements permitting discharge of the sewage on or from the lands of two nearby riparian owners. Despite this, the injunction was granted. The court's decision stated that although there is no evidence of the extent to which the stream would be polluted, the constant addition of liquid wastes would necessarily change the nature of the water quality and alter the stream's natural flow. Additionally, the use, which may constitute injury without damages, may become prescription, i.e., the right to another's land acquired by carrying on a particular activity over a prescribed period of time, unless some action is taken to prevent this. In the final decision described, an injunction was denied a municipality which brought suit to prevent an adjacent sanitary district from construction of a sewage disposal plant, contending that the wastes would be deposited in the channel of a creek carried by a stream through the municipality. The court found that since the sewage would be properly treated, the effluent would represent no hazard to the municipality.

VII-011
LIABILITIES OF MUNICIPALITIES FOR DAMAGES CAUSED BY WASTE WATER FROM A COMMUNAL SEWER SYSTEM. (Haftung der gemeinden für schäden durch die abwässer einer kommunalen kanalisation.) Text in German.

E. Hussla
WSWTA, 61(5):163-164 (May 1971).

Descriptors: Waste water treatment, Water purification, Fishkill, Sewers, Legal aspects, Judicial decisions.
Identifiers: Germany.

In a village in the Allgau, West Germany with a population of 7000 wastewater is purified in a mechanical purification plant. Some of the wastewater, however, entered into a nearby river without treatment. It was primarily wastewater from a dairy plant and a brewery. Subsequently a massive fish kill of primarily trouts occurred in October 1960. There fish were kept in several ponds fed by the local river. After unsuccessful investigations new trouts were placed in the ponds for breeding. They, too, were killed in June of 1971. The owner of the fish ponds suffered a loss of about $71,430 (3.5 DM/$1). He sued the municipality for disposing untreated wastewater into the river. In a verdict filed by the federal court in January 1971, the municipality was defeated and partial payment for damages granted to the owner of the fish ponds on grounds that the municipality was liable for said damages even if the municipality prohibited users of the sewer system to dispose of untreated wastewater.

VII-012
CITY OF BIRMINGHAM V NORWOOD (CITY'S LIABILITY FOR OBSTRUCTED SEWER).

126 So 616-619 (Ct App Ala 1930).

Descriptors: *Overflow, *Flood damage, *Legal aspects, Storm runoff, Legislation.
Identifiers: *Storm sewers, Birmingham, Alabama.

Plaintiff homeowner sought to recover damages from defendant city for flood damage. The storm sewer outside plaintiff's house became obstructed and caused surface water to overflow into the cellar of plaintiff's home. Plaintiff lived in a section of defendant city which had previously been another municipality, but was absorbed by defendant. The sewer had been constructed by the other city. After holding that defendant was obligated to reasonably maintain the sewer not-withstanding its construction by another city, the Alabama Court of Appeals held that an allegation of notice to defendant of the sewer defect was

necessary where the damage resulted from an obstructed sewer. One of the counts in the complaint was held to allege the requisite notice, but the other failed for insufficient allegation of notice.

VII-013
SEWER CONSTRUCTION.

Michigan Comp Laws Ann secs 323.401 thru 323.412 (Supp 1971).

Descriptors: *Grants, *Sewers, *Construction costs, Legislation, Water law, Financing, Water pollution control, Michigan.

This Act was designed to provide financial assistance to local agencies for the construction of collecting sewers to prevent the discharge of untreated and inadequately treated sewage or other liquid wastes into the waters of the state and to abate and prevent pollution of the waters in and adjoining the state. The state sewer construction fund was established to be used for state grants to local agencies for their construction of collecting sewers. The grants are limited to a certain percentage of the construction costs and are subject to other limitations. Priority of eligible projects is established by a point system, with points being awarded for such water pollution control needs as: 1) public health, 2) public water supply, 3) irrigation, 4) recreational use, 5) aesthetic value, 6) water supply for animals, and 7) usefulness of fish or game for human consumption. The projects for which the grants are disbursed must be certified by the water resources commission from the eligibility list established by the commission and as approved by the legislature.

VII-014
RULES AND REGULATIONS ESTABLISHING MINIMUM STANDARDS RELATING TO LOCATION, DESIGN, CONSTRUCTION, AND MAINTENANCE OF INDIVIDUAL SEWAGE DISPOSAL SYSTEMS.
Rhode Island State Department of Health, Providence, Rhode Island

1968. 21 p.

Descriptors: *Sewage disposal, *Regulation, *Water pollution control, Rhode Island, Legislation, Construction, Specifications, Design, Maintenance.

Before constructing or improving an individual sewage disposal system, an individual must obtain written consent from the director of health of the plans and specifications for such work. Each application for approval of a sewage disposal system must contain basic data and other specifications, and the use of such a system must conform with the terms of its approval. A new system shall not be covered with earth until the director has inspected it and certified that it is in conformance with the approved terms. At any stage of construction, the director may inspect the installation and require modifications if unanticipated conditions so require. Without an order from the director, any discharge of sewage into any waterbody is prohibited. If a public sanitary sewer is reasonably accessible, an individual system shall not be approved. Other provisions of the regulations control: 1) sewer system maintenance; 2) sewage flow levels; 3) the building of sewers; 4) septic and dosing tanks; 5) distribution boxes; 6) sewage seepage systems; 7) specifications for disposal trenches and beds; 8) seepage pits; 9) cesspools, privies, and chemical toilets; 10) subsoil exploration; 11) percolation test procedures; and 12) ground water table elevation determinations.

VII-015
RATZLAFF VERSUS FRANZ FOODS OF ARKANSAS (VIOLATION OF CONTRACT NOT TO OVERSATURATE CITY SEWER SYSTEM).

468 S. W. 2d 239-242 (Ark. 1971).

Descriptors: *Arkansas, *Cities, *Contracts, *Sewage Treatment, *Sewers, *Farm Wastes, *Water Pollution Sources, Legal Aspects, Treatment Facilities, Judicial Decisions.

Plaintiff dairy farmers sought damages from defendant, who operated a chicken processing and fertilizer plant, for its discharge of noxious wastes into a municipal sewer system, which in turn discharged the sewage into a creek upstream from plaintiffs' lands. Plaintiffs alleged that defendant had failed to perform its contract with the city to remove and eliminate certain wastes from its sewage so as to prevent over-saturation of the city's sewer system and harm to downstream landowners. The trial court sustained defendant's demurrer and dismissed the complaint. Upon appeal the Supreme Court of Arkansas reversed, holding: (1) as a general rule, one who creates a nuisance such as stream pollution is liable to lower riparian owners for direct, probable consequences thereof; (2) a user of a city sewer is clothed with immunity from liability once he lawfully deposits sewage with the city; (3) a party who normally owes no obligation to the public may nevertheless contract to assume an obligation of due care; and (4) from plaintiffs' allegations it does not logically follow that defendant in violation of his contract can wrest control of the city sewage facilities from the city while at the same time claiming immunity from liability.

SECTION VIII.

Treatment Methods and Water Reuse

VIII-001
NEW SEWERAGE SCHEMES OPENED FOR HEXHAM RDC AND WINSLOW RDC.

SLGTA, 138(4125):34-35 (July 2, 1971).

Descriptors: Sewerage, Sewage treatment, Construction costs, Operations.
Identifiers: Great Britain.

Two new sewerage and sewage disposal schemes have recently had their formal opening ceremonies, the $2,400,000 ($2.40/ь) first phase of the Mid-Tyne sewerage scheme for Hexham RDC, and the Newton Longville, Whaddon and Nash main drainage scheme for Winslow RDC. In the case of Hexham, the construction was divided into three contracts: construction of sewers, pumping mains and pumping stations; supply and erection of pumping machinery; and, construction of the treatment works. The most expensive aspect of this new scheme was the construction of sewers and pumping mains. The layout and operation of both systems are described.

VIII-002
ULTRASONIC FILTRATION OF COMBINED SEWER OVERFLOWS.
American Process Equipment Corporation, Hawthorne, California

EPA/WQO Contract No. 14-12-195, Program No. 11023 DZF, June 1970. 49 p, 13 fig, 1 append.

Identifiers: *Combined sewer overflows, *Ultrasonic filtration, *Vortex separator, Atlanta, Georgia.

A 250,000 gpd ultrasonically cleaned microfiltration system was unsuccessful in treating combined sewer overflows at an Atlanta, Georgia test site. High concentrations of rust clogged the porous polyethylene filter elements. It is anticipated that with stainless steel filter elements, influent BOD and suspended solids concentrations of 100 mg/l or less could be reduced by 50%. A novel flotation vortex separator is described, which could serve as a pretreatment device for the filter.

VIII-003
COMBINED SEWER OVERFLOW ABATEMENT ALTERNATIVES, WASHINGTON, D.C.
Roy F. Weston, Inc., West Chester, Pennsylvania

EPA/WQO Contract No. 14-12-403, Program No. 11024 EXF, Aug. 1970. 123 p, 33 fig, 23 tab, 50 ref, 7 append.

Descriptors: *Storm runoff, *Overflow, *Flow measurement, *Underground storage, *Filtration, Design storm, Rainfall-runoff relationships, Treatment facilities, Tunnel design, Sewers, Capital costs, Comparative costs, Hydrology, Tracers, District of Columbia.
Identifiers: *Combined sewers, Potomac River.

Objectives of the project were: 1) define the characteristics of combined sewer overflow; 2) investigate the feasibility of high-rate filtration for treatment of combined sewer overflow; and 3) develop and evaluate alternative methods of solution. Investigative activities included: the review of pertinent reports and technical literature; field monitoring of combined sewer overflows and separated storm water discharges at three sites; laboratory studies of ultra-high-rate filtration of combined sewer overflow; hydrological analysis; and evaluation of feasible alternatives. Reservoir storage, treatment at overflow points, conveyance tunnels and mined storage, and sewer separation were the approaches considered sufficiently promising for detailed evaluation. Tunnels and mined storage with treatment at the Blue Plains plant and at Kingman Lake after subsidence of the storm is recommended. Estimated capital costs (based on the 15-year storm) are $318,000,000 with annual operation and maintenance costs of $3,500,000. This approach also was preferable to the others on the basis of systematic evaluation of reliability, flexibility, public convenience, and other non-quantifiable factors.

VIII-004
A CRAZY IDEA ON URBAN WATER MANAGEMENT.

Sie Ling Chiang
WARBA, 7(1):171-174 (Feb. 1971). 2 fig.

Descriptors: *Water resources, *Water management (applied), *Cities, *Storm runoff, Flood control.
Identifiers: Urban hydrology, *Rooftop storage.

Two different schemes using roofs as urban flood control devices are discussed. One scheme utilizes the roof as a detention reservoir for flood control; the other employs a recharge pit to convert runoff into a groundwater resource. The proposed schemes are hydrologically, hydraulically, and structurally sound and also economically feasible.

VIII-005
ATOMIC ABSORPTION SPECTROPHOTOMETRY FOR STUDIES OF WASTE WATER AND SEWERS.
(Die atomabsorptions-spektrophotometrie in der abwasser-und vorfluteruntersuchung.) Text in German.

Hans Guenter Goebgen
CITEA, 43(15):862-866 (Aug. 1971). 7 ref.

Descriptors: *Spectrophotometry, *Analytical techniques, Waste water, Water purification, Sewers, Measurement.

Metal ions in wastewater are hazardous for sewer canals and the biological stages of purification plants because they impair the biochemical processes of natural self cleaning and artificial wastewater purification. Atomic absorption spectrophotometry has proved to be a suitable method for determination of trace metals in wastewater. In this method glowing metal vapor absorbs the light which it, itself, emits. The absorption spectrum developed through resonance is absolutely specific for each element. For the determination of each element a hollow cathode lamp is needed which emits the respective resonance wave length. The most suitable spectral line for analysis can be selected by a monochromator and, after passage of the flame, it can be converted into a measurable electric signal. If the water or wastewater contains no undissolved substance, the sample is measured after acidification. Analysis of wastewater in the main sewer canal should be performed on the untreated or filtered sample, without preliminary concentration. The advantages of the method are a low detection limit, and no intereference by other components.

VIII-006
MIDWEST FLOOD FORCES SEWER CLEANUP.

Philip J. Hollinger
WWAEA, 8(9):62 (Sept. 1971).

Descriptors: *Flood control, Sewers, Overflow.
Identifiers: *Sewer maintenance, *Brookfield, Illinois.

Extremely heavy rainfall accompanied by severe flooding pointed up the need for sewer cleanup and maintenance activity in the village of Brookfield, Illinois. The steps taken to alleviate this problem and to prevent recurrence, such as the adoption of the village's first comprehensive sewer cleaning and catch basin repair program, as well as the method of financing through a special sewer charge supplemented with special state income tax funds, are described. Results of the sewer rehabilitation activity undertaken in this community appear highly salutary.

VIII-007
SURVEYING, SEALING, SAVE SEWERS.

Harold Kosova,
WWAEA, 8(8):35-37 (Aug. 1971).

Descriptors: *Sewerage, *Sewers, *Chemical grouting, *Leakage, *Inspection, Waste water disposal, Costs, Groundwater, Environmental sanitation.
Identifiers: *Closed-circuit television, *Sewer sealing, *New York City, New York.

For the first time in its complex sewer maintenance history, New York City tested closed-circuit television to search out defective pipe joints that were allowing large volumes of sewage to leak out of lines, and used internal chemical grouting to seal these exfiltration points. Three projects have been completed using this method, one each in the boroughs of Manhattan, Queens, and the Bronx. The conventional "dig and hope" excavation method for locating problem points had in one case been tried unsuccessfully, and in the remaining two was rendered impractical by extreme traffic in the effected areas. In spite of this, leakage into subway tunnels and a city park, coupled with the normal hazards of exfiltration, made location and correction of the problem imperative. The methods used are described in detail. Total cost for the entire project was under $20,000; total time for completion of the three jobs - 14 days.

VIII-008
WASTEWATER CONCENTRATOR AIDS TREATMENT DURING PEAK FLOWS.

WPCOA, 109(11):40 and 42 (Nov. 1971).

Descriptors: Economics, Separation techniques.
Identifiers: *Wastewater concentrator, Combined sewers.

A wastewater concentrator, presently being tested by the SWECO Corporation, appears to be an economical aid in the problem of peak flows, especially storm flows in a combined sewer system. Operating basically on a centrifuge principle, the device concentrates solids in effluents into a volume one-tenth the hydraulic flow passing through it. The influent enters through the central pipe and passes out over the fan-like "flighted dome". Travel over these vanes sends the water across rotating 105 micron screens at an impingment velocity of about 15 feet/second. In company tests, 99% of floatables and settleable solids, 34% suspended solids, and 27% COD were removed by this process. Installation can be at virtually any convenient point, and maintenance is simplified.

VIII-009
SEWAGE CHLORINATOR.

Fred W. Beutnagel
United States Patent: 3,620,416. Applied Apr. 2, 1970. Issued Nov. 16, 1971.

Descriptors: *Equipment, Sewage treatment, Patents.
Identifiers: *Sewage chlorinator.

A device is provided in order to gradually add small quantities of an antiseptic solution, sodium hypochlorite, to the overflow conduit from a septic tank - said conduit leading to an adsorption field. The device operates to add the chlorinating fluid only when there is a quantity of flowing sewage in the conduit.

VIII-010
SCREENING/FLOTATION TREATMENT OF COMBINED SEWER OVERFLOW.

Donald G. Mason
Abstract, Water Pollution Control Federation, Washington, D.C., 1971. (Presented at the 44th Annual Conference of the Water Pollution Control Federation, San Francisco, California, October 3-8, 1971.)

Descriptors: *Overflow, *Treatment facilities, Estimated costs.
Identifiers: Combined sewers, Screening, Dissolved-air flotation.

The objective of the study, initiated as a result of the increasing emphasis being placed on water quality, was to develop an effective treatment system at the lowest possible capital cost. A combination of screening and dissolved-air flotation provided good removals in the laboratory. A 5 mgd demonstration system was designed, installed, and evaluated (during the period from June 1, 1969 through November 10, 1970). Suspended solids and volatile suspended solids removal in the range of 65-80% were consistently obtained at influent concentrations of 150 to 600 mg/liter. BOD and COD removals were slightly lower at 55 to 65% for influent concentrations of 50 to 500 mg/liter. Addition of chemical flocculants (ferric chloride and a cationic polyelectrolyte) was necessary to obtain these removals. Without the use of chemical flocculants, removal of BOD, COD, suspended solids, and volatile suspended solids were all in the range of 40-50%. Disinfection was accomplished with hypochlorite salts, and the screening/flotation system provided sufficient detention time (~15 minutes) for adequate disinfection. Cost estimates indicate a capital cost of $21,056 per mgd capacity for a 90 mgd screening/flotation system. Operating costs were estimated at 3.09¢/1000 gallons of treated overflow, including chemical flocculant addition.

VIII-011
IWATSUKA SEWAGE TREATMENT PLANT IN NAGOYA.

DGRHA, 10:65-67 (1971). 2 fig.

Descriptors: *Sewage Treatment, *Waste Water Treatment, *Aeration, *Separation Techniques, Sludge Digestion, Filtration, Incineration.
Identifiers: Japan.

Wastewater of an area of 5681 acres west of Nagoya can be fully treated. It is expected to collect and dispose sanitary and storm sewage in the service area, as well as, to control water pollution of the Shonai River. The plant was designed to be compact and so is effective only for an area of 8.4 acres. The function of the preaeration tank is to keep sewage clean and remove oil. Aeration tanks are designed for the step-aeration process, while the final sedimentation tank is the two-story type. Primary sewage effluent is accumulated at 4 points along the aeration tank, so that satisfactory purification can be obtained within 3½ hours. Runoff sewage is sedimented to separate sludge and water. The waste sludge is then pumped to the Yamazaki Sludge Treatment Plant, about 9.3 miles away. Later on, this sludge is processed by sludge digestion, vacuum filtration, and incineration.

VIII-012
NEW AMERICAN METHODS TO REDUCE WATER POLLUTION BY INTRODUCING MIXED WATERS.
(Neue amerikanische Verfahren zur Verminderung der Gewässerverschmutzung infolge Mischwassereinleitungen.) Text in German.

Paul G. Brunner
GWWAA, 112(12):592-596 (1971). 3 fig, 5 tab, 5 ref.

Descriptors: *Overflow, *Water Pollution Sources, *Waste Water Treatment, *Treatment Facilities, United States, Pollution Abatement, Methodology.

Although purification plants are used, rivers are highly polluted from resultant runoff following long rainfalls. One solution to decrease untreated overflowing mixed waters is to choose a high critical mixed water drainage system coupled with subsequent purification plant treatment. Special basins for temporary storage and different purification methods

are also available. Deep-tunnel projects have been developed for cities such as Boston, Massachusetts and Chicago, Illinois. In such projects excess mixed water reaches the tunnel through pits, is temporarily stored, and finally pumped to the purification plant. Storage basins of rubber-covered material strengthened by nylon have been built underwater in Washington D.C. For purification, a sifting plant followed by flotation tested in Portland, Oregon, showed 99% and 34% decomposition of sediments and suspended and suspended solids, respectively. Wastewater was pumped to the screening plant and distributed on a rotating screen, circulating revolutions per minute and with a mesh width of 105 microns. 90 to 95% of the water was discharged through the screen into the main sewer or river; the remainder was returned, with the separated solid material, to the purification plant. In Fort Smith, Arkansas, a flotation method with a rotation screen and four cyclones was tested. In Milwaukee, Wisconsin, a similar plant with a screen, compressed-air container, and flotation elements was examined. The addition of flocculants proved to be of little advantage since the highly variable dirt load and the widely fluctuating water quantities did not permit dosage.

VIII-013
HYPOCHLORITE GENERATOR FOR TREATMENT OF COMBINED SEWER OVERFLOWS.
Ionics, Inc., Watertown, Massachusetts

Frank B. Leitz, Steven A. Michalek, and John L. Greatorex
EPA/WQO Contract No. 14-12-490, Program No. 11023 DAA, Grant No. 11023 DME, March 1972. 89 p, 31 fig, 11 tab, 6 ref.

Descriptors: *Water Quality Control, *Electrochemistry, *Waste Water Treatment, *Combined Sewers, *Overflow, Brine, Sodium Chloride, Computer Programs.
Identifiers: *Electrolytic Hypochlorite Generator, *Sodium Hypochlorite, Electrolytic Cell, Somerville, Massachusetts.

An advanced electrolytic generator has been developed for on-site production of sodium hypochlorite for disinfection of overflows from combined sewer systems. In this system an electrochemical cell electrolyzes sodium chloride brine to chlorine gas and sodium hydroxide solution, which are reacted immediately outside the cell to produce a 5 to 10% sodium hypochlorite solution. Significant advances in safety and economy have been realized by use of a hydraulically impermeable cation exchange membrane. The most critical components have operated for over 3000 hours with no deterioration of performance. The generator requires 1.6 KWH of electricity and 2.1 pounds of salt per pound of sodium hypochlorite. The operating cost for systems larger than 500 pounds of hypochlorite per day is projected to be 3 to 4 cents per pound of hypochlorite. This cost is significantly below that of truck-delivered hypochlorite solution. Such economy of operation should make the generator useful for a wide variety of water treatment applications. The first field unit is scheduled for installation at at Metropolitan District Commission facility, in Somerville, Massachusetts.

VIII-014
SCREENING/FLOTATION TREATMENT OF COMBINED SEWER OVERFLOWS.
Rex Chainbelt Inc., Ecology Division, Milwaukee, Wisconsin

Donald G. Mason and Mahendra K. Gupta
EPA/WQO Contract No. 14-12-40, Program No. 11020 FDC, January 1972. 172 p, 25 fig, 42 tab, 109 ref, 4 append.

Descriptors: *Combined Sewers, *Overflow, Sewage Treatment, Sewerage, Suspended Solids, Estimated Costs.
Identifiers: *Screening/Flotation System, Milwaukee, Wisconsin.

From a laboratory study evaluating the processes of chemical oxidation, screening, dissolved-air flotation, and disinfection, a treatment system for combined sewer overflows was developed. A 5 MGD demonstration system was designed, installed, and evaluated. The system was utilized to treat 55 combined sewer overflows. The drainage area served by the system was a 500 acre completely developed residential area of Milwaukee, Wisconsin. Suspended solids and volatile suspended solids removal in the range of 65-80% were consistently obtained at influent concentrations of 150 to 600 mg/l. BOD and COD removals were slightly lower at 55 to 65% for influent concentrations of 50 to 500 mg/l. Addition of chemical flocculents (ferric chloride and a cationic polyelectrolyte) was necessary to obtain these removals. Without the use of chemical flocculents, removal of BOD, COD, suspended solids, and volatile suspended solids were all in the range of 40-50%. The screening flotation system provided sufficient detention time for adequate disinfection with hypochlorite salts. Cost estimates indicate a capital cost of $21,056 per MGD capacity of $3,828 per acre for a 90 MGD screening/flotation system. Operating costs were estimated at 3.09¢/1000 gallons of treated overflow, including chemical flocculent addition.

VIII-015
A FLUSHING SYSTEM FOR COMBINED SEWER CLEANSING.
FMC Corporation, Central Engineering Laboratories, Santa Clara, California

Darrell W. Monroe and John P. Pelmulder
EPA/WQO Contract No. 14-12-466, Program No. 11020 DNO, March 1972. 233 p, 30 fig, 25 tab, 7 ref, 6 append.

Descriptors: *Combined Sewers, *Storm Water, *Overflow, *Lateral Conveyance Structures, *Suspended Solids, Water Pollution Sources, Evaluation, Testing, Installation Costs.
Identifiers: *Periodic Flushing, *Solids Removal, Average Cleansing Efficiency.

Because solids deposits in lateral sewers are considered to contribute a significant quantity of pollutional material to storm water overflows from combined sewers, the use of a periodic flushing operation was evaluated as a means of maintaining lower levels of these deposited materials during low-flow, dry weather periods. Full scale tests were conducted on two variable-slope test sewers (12- and 18-inch diameters). During the tests, solids were first allowed to build up in both test sewers by passing domestic sewage through the sewers for durations of 12 to 40 hours and then were removed by hydraulic flushing. The results from the tests showed that flush waves generated using flush volumes ranging from 300 to 900 gallons at average release rates ranging from 200 to 3000 gpm were found to remove from 20 to 90% of the solids deposited in the 800-foot long test sewers. The cost of installing a periodic flushing system in a typical system of lateral sewers was estimated to be $620 to $1,275 per acre.

VIII-016
HIGH RATE FILTRATION OF COMBINED SEWER OVERFLOWS.
Hydrotechnic Corporation, New York, New York

Ross Nebolsine, Patrick J. Harvey, and Chi-Yuan Fan
EPA/ORM Contract No. 14-12-858, Program No. 11023 EYI, April 1972. 339 p, 199 fig, 41 tab, 27 ref, 5 append.

Descriptors: *Pilot Plants, *Storm Water, *Combined Sewers, *Treatment Facilities, Filtration, Capital Costs, Overflow, Suspended Solids, Biochemical Oxygen Demand, Estimated Costs.
Identifiers: *Cleveland, Ohio, Drum Screen.

Pilot plant studies were conducted at Cleveland's Southerly Waterwater Treatment Plant in 1970 and 1971, to develop and demonstrate the capabilities of the deep bed, dual media, high rate filtration process for storm caused combined sewer overflows. The treatment system is comprised of a drum screen with a 40 mesh screening element (420 microns opening) followed by a deep bed, dual media, high rate filter of five feet of No. 3 anthracite (effective size 4 mm) over three feet of No. 612 Sand (effective size 2 mm). The results show suspended solids removals of 93%, with polyelectrolyte addition, at a filtration rate of 24 gpm/sq ft at an average influent suspended solids of 411 mg/l. Reductions in biochemical oxygen demand averaged 65%. Capital costs (ENR=1470) for a high rate filtration plant are about $23,000 per mgd. Total annual treatment costs, including capital and operating charges, range from approximately $90,000 per year for a 25 MGD plant to approximately $390,000 for a 200 MGD treatment facility. Principal advantages of the proposed system are: high treatment efficiencies, automated operation, and limited space requirements as compared with alternate flotation or sedimentation systems.

SECTION IX.

Hydrology

IX-001
EFFECTS OF URBAN DEVELOPMENT ON FLOODS IN NORTHERN VIRGINIA.

Daniel G. Anderson
Geological Survey Water-Supply 2001-C, 1970. 22 p, 5 fig, 5 tab, 10 ref.

Descriptors: *Rainfall-runoff relationships, *Urbanization, *Flood damage, Virginia, District of Columbia, Geomorphology, Drainage systems, Planning, Flood forecasting.
Identifiers: *Urban hydrology.

Graphical and mathematical relations are presented to estimate the flood-peak magnitudes having recurrence intervals ranging up to 100 years for drainage basins with various degrees of urban or suburban development. Five independent variables are required for use of the relations. They are the size, length, and slope of the basin, and the percentage of impervious surface and type of drainage system. Based upon analysis of flood information for 81 sites, the relations presented are applicable only to the Washington, D.C., area, but the method of analysis is general and may be used for any area where the major floods result from rainfall. Improvements of the drainage system may reduce the lag time to one-eighth that of the natural channels. This lag-time reduction, combined with an increased storm runoff resulting from impervious surfaces, increases the flood peaks by a factor that ranges from two to nearly eight. The flood-peak increase depends upon the drainage-basin characteristics and the flood recurrence interval.

IX-002
METHOD FOR DIMENSIONING RAIN OVERFLOW CATCHING BASINS. (Verfahren zur bemessung von regenüberlaufbecken.) Text in German.

Paul G. Brunner
GWWAA, 112(7):354-359 (July 1971). 8 fig, 5 ref.

Descriptors: Overflow, Spillways, Watersheds (basins), Rainfall-runoff relationships, Analytical techniques.
Identifiers: *Dimensioning method, Germany, Overflow frequency.

A dimensioning method for rain overflow catch basins, which is mainly concerned with the protection of the main sewage canal, has been developed. It is assumed that a rain overflow catch basin should provide protection similar to that given by rain spillways whose dimensions are based on the critical rainfall. However, unlike rain spillways, the overflow quantity at rain overflow catchment basins is no direct measure for the dirt load which it carries. Rainfall diagrams were obtained for 10 summer seasons for Ingolstadt, Munich, and Mittenwald. Based on these diagrams the frequency for various critical rainfalls has been determined. The rainfall frequency has been set equal to the overflow frequency of relief facilities, although the two are not always identical. From the rainfall diagrams, lines with the same overflow frequency were plotted. The dimensioning diagrams permit optional combination of basin content and rain runoff from a rain overflow catch basin without increasing the overflow frequency above that of a conventional rain spillway. One diagram takes into account both the flow of the dirt load and overflow frequency.

IX-003
STUDIES OF THE STATISTICS OF RUNOFF/PRECIPITATION RATIOS. (Untersuchungen zur statistik von A/N-verhältnissen.) Text in German.

H. Buechner
WSWSA, 21(5):171-173 (1971). 7 ref.

Descriptors: *Mathematical studies, *Runoff coefficient, Storm runoff, Surface runoff, Measurement, Analytical techniques.

The runoff precipitation ratio, or runoff coefficient, is used for characterization of the runoff process. If a statistical runoff/-precipitation ratio is known for an area, flooding can be predicted. Since no statistical runoff/precipitation ratios have yet been set up, the data of four water level measuring stations in the river system of the Zschopau were used for a statistical analysis of the runoff/precipitation ratio. The analyses were based on the frequency sums for precipitation (average precipitation in the area) and surface flow of the storm water without base runoff. All available data were used. Data were not available for the entire period examined, however. As the studies revealed, this lack can be compensated by estimation of the annual storm water flow. The extreme value distribution type III was selected as the distribution function. By this method the flood recurrence interval belonging to a certain runoff/precipitation ratio can be determined.

IX-004
THE PLANNING AND DESIGN WORK OF DETENTION RESERVOIRS IN COMBINED SEWERAGE SYSTEMS OF TOWNS. (Die bemessung und gestaltung von rückhaltebecken in mischwasserkanälen der ortsentwässerung.) Text in German.

G. Guenzel
WUBOA, 23(8):230-234 (Aug. 1971). 9 fig, 1 tab, 4 ref.

Descriptors: *Runoff forecasting, *Overflow, *Reservoir design, Reservoir storage, Water levels, Hydrologic data, Sewerage, Hydrologic aspects.

In the year 1962 the Preliminary Guidelines for the dimensioning and designing of rain overflow reservoirs were established. This calculation method utilizes the runoff conditions at dry weather, the runoff conditions during precipitation, the water level in the main sewage canal, and the storage capacity of the canal system. Due to the enormous dilution of wastewater necessary as a requirement for these guidelines, the water level in the mixed water canals increases. Thus, retention basins in the mixed water canals provide the possibility of reducing the quantities to a more economical size. The dimensions of these retention basins are calculated on the basis of mean summer water level, mean peak discharge coefficient for the mixed water influx area, critical rainfall, and critical mixed water runoff. The storage quantity is determined by the residence time in the retention basin. A numerical example for the dimensioning of the rain overflow basins is given.

IX-005
MATHEMATICAL MODELS FOR FLOOD PREDICTION. (Mathematische modelle für die hochwasservorhersage.) Text in German.

H. Liebscher
UWTCA, 71(11):387 (1971).

Descriptors: *Flood forecasting, Mathematical models, Storm runoff.
Identifiers: Germany, Precipitation levels.

In order to forecast floods accurately mathematical models must be developed for each river system. For flood prediction the water levels expected at certain times must be determined. Primarily the peak of the flood wave and its arrival time must be predicted. In larger rivers the course of the flood wave can be predicted one or two days in advance by means of the water levels determined in the upper course of the river. In smaller river systems, however, flood prediction is based on close surveillance of the precipitation since time lapse between the precipitation onset and the flood wave formation is too short. A forecast well ahead of the flood event will only be feasible when meteorologists are able to forecast precipitation quantities. Since this is not possible yet, a mathematical model must be used. Such a model attempts to express the formation of a flood wave with the aid of physical laws or mathematical/statistical relationships. Various institutions in the Federal Republic of Germany are presently engaged in the development of such mathematical models.

IX-006
EXAMINATION OF DILUTION FACTORS OF RUNOFF WATER. (Utenji horyu osui no kishaku bairitsu no ichikosatsu.) Text in Japanese.
Tokyo Designing Co., Ltd.

Heiichiro Makino
NGKHB, 7th:29-31 (Apr. 1970). 13 ref.

Descriptors: *Water pollution, Drainage systems, Runoff, Rainfall-runoff relationships, Sewers, Rainfall intensity.
Identifiers: *Dilution factors, *Japan.

The determination of dilution factors of polluted water is an important key to the problems of runoff drainage and water pollution. At the present time, a dilution factor is obtained by calculating the ratio of the quantity of polluted water to the total maximum polluted water during the fine weather plus the quantity of first flushing. However, in determining dilution factors, the following must be taken into consideration: 1) fluctuation of rainfall intensity, rainfall duration, and the relationship between rainfall frequency and the hourly maximum polluted water dilution factor; 2) the correlation between the quantity of discharge pollutant load at the time of rain and the discharge basin's water demand plan, and the location of discharge outlets; 3) the cost of installation of discharge and collection pipes, pumps, and treatment plant's rainwater catchment; and, 4) examination and evaluation of cost based on the proposed alteration of the sewerage system. The rapid urbanization and increase of water pollution in public water, basic in recent years, have enhanced the need for some measure for maintaining water quality and securing water supply. In planning sewerage systems in Japanese cities, one method is the use of separate sewers for upstream areas where hills provide natural drainage, and limitation of the use of combined sewers to the downstream area where no other method can be utilized. Rain runoff should be discharged at points where the pollutant will have no effect on the public water supply. By increasing the dilution factor ratio, discharge frequency and load should be lightened. Graphs and tables show the relationships between the

intensity and duration of rainfalls, and the rain intensity and dilution factors of the total 1963 rainfall in Tokyo.

IX-007
THE HYDRAULIC DIMENSIONING OF RAIN SPILLWAYS WITH RETARDATION PATH. (Die hydraulische bemessung von regenüberläufen mit drosselstrecke.) Text in German.

W. Munz
SCBAB, 89(22):540-544 (June 1971). 9 ref.

Descriptors: *Spillways, Mathematical studies, Design flow, Hydraulic design.

Rain spillways are nowadays built with a more elevated spillway crest through which more water is stored in the outflow canal leading to the purification plant. The subsequent canal path assumes the role of a throttle. For proper dimensioning of the retarding path only the water flow from the moment the stored water begins to spill over the weir must be taken into account. The minimum allowable speed is used as base. The flow speed in the throttle path and in the spillway must not be smaller than that of the inflow provided it is below 194 cu. ft./sec. In order that the spillway does not spill over when the canal is flushed the incoming water quantity should not be below 0.9 to 1.3 cu. ft. per second.

IX-008
THE RUNOFF TIME FACTOR PROCEDURE FOR THE DIMENSIONING OF SEWER SYSTEMS. (Das zeitabflussfaktorverfahren zur bemessung von kanalnetzen.) Text in German.

Rolf Pecher
GWWAA, 112(6):312-319 (June 1971). 10 fig, 2 tab, 18 ref.

Descriptors: Estimating equations, Rainfall-runoff relationships, Analytical techniques, Runoff coefficient, Sewerage, Sewers.
Identifiers: *Dimensioning method, *Runoff-duration factor.

A procedure for the calculation of sewer systems which, for the first time, takes into account the time factor in the variability of the peak rainfall-runoff coefficient is presented. Seepage, evaporation, and ground slope as the main factors contributing to the general pattern of rainfall are analyzed. Thus seepage is a time-dependent factor and can be expressed as an exponential function with a negative exponent. The effect of evaporation on runoff is minor because of its small proportion as compared to the amount of storm water precipitation; it should, however, not be neglected. Slopes of 30-45¼ are considered to elicit the fastest runoff rates because of their optimal length-inclination relationship. Apparently the runoff time factor, E, varies much less than the time coefficient for the same rainfall duration.

IX-009
EXAMINATION OF RAIN WATER LOSS MECHANISM IN AN URBAN AREA. (Toshi do no usui sonshitsu kiko no kento.) Text in Japanese.

Toshihiko Ueda (discussion)
24ZAA, 7th:165 (Jan. 30-31, 1971). 2 ref.

Original Paper: EXAMINATION OF RAIN WATER LOSS MECHANISM IN AN URBAN AREA. Shigeaki Matsubara and Masai Yokoo
24ZAA, 7th:157 (Jan. 30-31, 1971).Original abstract in the July 1970-July 1971 issue of 11024FJC, as number 200.

Descriptors: *Infiltration, *Discharge (water), *Rainfall-runoff relationships, Data collections, Investigations, Water loss, Mathematical studies, Forecasting.
Identifiers: *Urban hydrology, Quantitative analysis, Japan, Discussion.

Ueda contends that: 1) infiltration loss capacity should decrease with the time and that the quoted figure of 1.14 inches seems extremely high; and, 2) an extensive discussion is given in the article concerning the outflow coefficient rational formula Q=(1/360)CiA (hereafter cited as (a)). In an actual situation, the outflow coefficient is obtained by an equation f=(total outflow/total rainfall) (hereafter cited as (b)). The author believes that to discuss C in the rational formula (a) in relation to f in (b) is meaningless since the values are arrived at by different methods, and in sewage engineering, it is f in (b) that is required. Ueda requests the authors' clarification on this matter. He also states that with a consistent loss during rainfall, it is probable that C in (a) and f in (b) might approximately coincide; yet a question might arise on the possibility of accumulation in puddles.

IX-010
GRAPHIC ANALYSIS OF ROADWAY RUNOFF.

J. B. Wolfson
CIVEB, 41(6):64-65 (June 1971). 2 fig.

Descriptors: *Analytical techniques, *Runoff forecasting, Surface runoff, Drainage, Mathematical studies, Measurement.
Identifiers: *Graphing procedures.

A method of charting roadway runoff is described. In the design of storm drain systems the engineer normally uses the rational formula to determine roadway storm water runoff. A separate calculation is needed for each contributing area. Curves can be developed which will give a graphic analysis for determing the rate of storm water runoff that will occur for a particular frequency storm. Surface area of the roadway and times of concentration are related to longitudinal gutter velocity (determined by considering slope and roughness of pavement). Runoff is then plotted against pavement length for a constant width of pavement for a particular longitudinal gutter velocity. This produces a curve of equal velocity relating storm water runoff to length of pavement. It is also possible to incorporate lag times and roof-to-gutter times into the graph by constructing lines of equal time on the chart.

IX-011
RUNOFF EVALUATION AND STREAMFLOW SIMULATION BY COMPUTER.

James A. Anderson
Army Corps of Engineers, North Pacific Division Report, May 1971. 138 p, 13 fig, 19 tab, 13 charts, 17 ref.

Descriptors: *Computer programs, *Rainfall-runoff relationships, *Simulation analysis, *Mathematical models, Model studies, Snowmelt, Runoff forecasting.

A computer program was developed to model basin runoff resulting from rainfall and snowmelt. In the watershed model portion of the program, soil moisture-runoff relationships, in the form of continuously varying soil moisture indexes together with variable evapotranspiration indexes, account for the overall water balance of drainage basins. These indexes provide continuity of functions by which the varying losses due to soil moisture increases and evapotranspiration can be computed for a wide variety of soil and runoff conditions, and may be applied to either rainfall or snowmelt runoff. Index values of soil moisture and evapotranspiration are established for a watershed by reconstitution studies or estimates based on climate, topography, geology, vegetation, and location of the watershed. Two illustrative examples of reconstitution studies are presented. One shows runoff and the soil moisture relation on a watershed in the Mekong River Basin, and the other shows runoff resulting from rainfall and snowmelt on a small basin in the Cascade Range of western Oregon.

IX-012
DEVELOPMENT OF A SIMULATION MODEL FOR STORM-WATER MANAGEMENT.

J. A. Lager, R. P. Shubinski, and L. W. Russell.
JWPFA, 43(12):2424-2435 (Dec. 1971). 9 fig, 1 tab, 4 ref.

Descriptors: *Simulation analysis, *Model studies, *Storm runoff, Water quality, Flow characteristics, Computers, Sewerage, Hydrographs, Cost-benefit analysis.
Identifiers: Urban hydrology, Combined sewers, Sanitary sewers, Pollutographs.

A comprehensive simulation model (Fortran IV, 10,000 + statements) capable of representing urban storm water runoff phenomena in quality and quantity has been developed. Hydrographs and pollutographs (time varying quality concentration or mass values) were generated for real storm events and systems from points of origin in real time sequence to points of disposal with user options for intermediate storage and/or treatment facilities. Incorporated dry-weather flow routines permitted the evaluation of both combined and separate sewerage systems. Internal cost routines and receiving water quality assisted in the direc cost benefit analysis of alternate programs of water quality enhancement.

IX-013
STUDY ON RAINWATER RUNOFF CHARACTERISTICS IN URBAN DISTRICTS. (Shigaichi usui ryushutsu tokusei ni kansuru kenkyu.) Text in Japanese.
Tohoku Institute of Technology and Kisarazu Technical College

Junichiro Matsumoto, Masao Onuma, and Yoshinori Honda
Preprint, Japan Society of Civil Engineers, Tokyo, 1971. 2 p, 2 ref. (Presented at the 26th Annual Science Lecture Meeting, October 1971.)

Descriptors: *Storm runoff, *Drainage systems, *Drainage water, Rainfall-runoff relationships, Water analysis, Rainfall intensity, Sewage treatment, Discharge measurements, Sewage effluents, Water pollution sources.
Identifiers: Japan.

During heavy rainfalls, sewage in drain pipes is diluted by inflowing storm water and subsequently discharged into a river. Water pollution caused from such final effluents is rapidly becoming a problem. The quality and quantity of the drainage water at a pumping plant in the City of Sendai has been determined by the examination of the

storm runoff as well as the change in water quality. Storm runoff was plotted against rainfall, intensity less than 0.05 inches/hour. Results indicate that storm runoff related in a linear fashion to rainfall and was unaffected by rainfall intensity. The quality of diluted drainage sewage was analyzed and compared with the water quality calculated from discharged sewage sampled on a clear day. The quantity of effluent doubled and the BOD was approximately half.

IX-014
THE INFLUENCE OF INCLINATION, EVAPORATION AND STORAGE ON THE RAIN RUNOFF IN SEWER SYSTEMS: A CONTRIBUTION FOR THE EVALUATION OF RAIN EVENTS. (Einfluss von geländeneigung, verdunstung und speicherung auf den regenwasserabfluss in kanalnetzen: ein beitrag zur auswertung von regenereignissen.) Text in German.

Rolf Pecher
GWWAA, 112(11):562-568 (1971). 9 fig, 3 tab, 12 ref.

Descriptors: Rainfall-runoff relationships, Rainfall disposition, Overflow, Depth-area-duration analysis.
Identifiers: Germany.

Correlation between rainwater accumulation and wastewater drainage through application of the median rainfall has been investigated. Data from three rain measurement stations in Bavaria were used covering the months from May to October for a ten-year period of time. The influence of a drainage area on the quantity of rain runoff showed that an increased amount of runoff occurs in direct relation with the slope of the inclined surface. Furthermore, the construction of rain can be maintained at a constant level. If a constant overflow quantity is maintained, the overflow frequency is reduced considerably.

IX-015
AN EMPIRICAL RELATIONSHIP BETWEEN RAINFALL AND RUNOFF.

R. J. Pittams
JLHYA, 9(2):357-372 (1970). 1 fig, 7 tab.

Descriptors: *Rainfall-runoff relationships, *Data collections, Parametric hydrology, Mathematical models.

A relationship was derived for the prediction of runoff from rainfall, using the basic hypothesis that a rainfall increment, when suitably modified by factors representing catchment response and antecedent rainfall effect, can be used as an index for discharge so that the sum of all the index increments gives the total storm runoff. The various parameters are explained and examples given to demonstrate the feasibility of the technique and the flexibility of its application. The ultimate success of the relationship depends on the ability to identify accurately the parameters for individual catchments from historical runoff and rainfall records. Subsequent calculation by a large computer can provide the generality and complexity often lacking in 'lumped' catchment models.

IX-016
OVERLAND FLOW ON AN INFILTRATING SURFACE.

R. E. Smith and D. A. Woolhiser
WRERA, 7(4)899-913 (Aug. 1971). 13 fig. 18 ref.

Descriptors: *Infiltration, *Mathematical models, *Rainfall-runoff relationships, Numerical analysis, Parametric hydrology, Runoff forecasting, Demonstration watersheds.
Identifiers: Hastings, Nebraska.

The partial differential equation for vertical, one-phase, unsaturated moisture flow in soils is employed as a mathematical model for infiltration rate. Solution of this equation for the rainfall-ponding upper boundary condition is proposed as a sensitive means to describe infiltration rate as a dependent upper boundary condition. A nonlinear Crank-Nicholson implicit finite difference scheme is used to develop a solution to this equation that predicts infiltration under realistic upper boundary and soil matrix conditions. The kinematic wave approximation to the equations of unsteady overland flow on cascaded planes is solved by a second order explicit difference scheme. The difference equations of infiltration and overland flow are then combined into a model for a simple watershed that employs computational logic so that boundary conditions match at the soil surface. The mathematical model is tested by comparison with data from a 40-foot laboratory soil flume fitted with a rainfall simulator and with data from the USDA Agricultural Research Service experimental watershed at Hastings, Nebraska. Good agreement is obtained between measured and predicted hydrographs, although there are some differences in recession lengths. The results indicate that a theoretically based model can be used to describe simple watershed response when appropriate physical parameters can be obtained.

IX-017
RAINFALL-RUNOFF INVESTIGATIONS IN THE DENVER METROPOLITAN AREA, COLORADO.
Geological Survey, Denver, Colorado

D. D. Gonzalez and G. L. Ducret, Jr.
Geological Survey Open-File Report No. 71003, Sept. 1971. 27 p, 3 fig, 2 tab, 16 ref.

Descriptors: *Rainfall-Runoff Relationships, *Urbanization, *Storm Runoff, Model Studies, Routing, Unit Hydrographs, Floods, Frequency Analysis, Data Collections, Depth-Area-Duration Analysis, Urban Hydrology.
Identifiers: Denver, Colorado.

Definition of the magnitude and frequency of floods on small urbanized watersheds in the Denver metropolitan area requires the collection and analysis of rainfall-runoff data needed to synthesize long-term runoff records from precipitation records. Hydrologic models and synthetic unit hydrographs are the primary analytical methods used in the study. Analytical applications of the rational method are also investigated. Dual-digital recorders provide the detailed records of rainfall and runoff required in a form convenient for computer translation and tabulation.

IX-018
INFILTRATION AND FLOW OF RAINFALL ON MOUNTAIN-SIDE. (Sanpuku ni okeru no shinko to ryuka ni tsuite.) Text in Japanese.

Yoshimi Okamoto
Preprint, Japan Society of Civil Engineers, Tokyo, Japan, 1972. 6 p, 2 tab.
(Presented at the Meeting on Hydrology, 16th, Tokyo, Japan, Feb. 18-19, 1972.)

Descriptors: *Measurement, *Rainfall-Runoff Relationships, Data Collections, Hydrologic Aspects, Flood Data.
Identifiers: Japan.

Total rainfall, flood runoff, runoff quantity on the hillside, results of a sprinkling experiment on the hillside, flow speed in the midstream, soil porosity, and temperature and humidity in the mountain forests upstream of the Tone River, were measured from June 1970 to February 1972, during which time 70 floods occurred. The measuring locations were 2460-2952 feet high, with a 40-60 degree inclination. Maximum rainfall was 4.94 inches; maximum runoff was 49.1 gallons per second. The following observations were made: increase in runoff started with the start of rainfall; decrease in runoff began simultaneously with the end of rainfall; rain intensity changed constantly with flow quantity also changing constantly; maximum runoff always appeared at the end of the rainfall, when intensity was constant; maximum runoff continued for sometime after the termination of the rain, when intensity was extremely weak; runoff increased as rainfall continued at a given intensity; and, flood wave recession differed for runoff from light showers and cloudbursts.

IX-019
VARIATION OF URBAN RUNOFF WITH DURATION AND INTENSITY OF STORMS.

D. M. Wells, T. A. Austin, and B. C. Cook
Texas Tech University Water Resources Center Project Completion Report, WRC-71-5, Aug. 1971. 30 fig, 24 tab, 37 ref, 2 append.

Descriptors: *Rainfall-Runoff Relationships, *Storm Runoff, *Cities, *Routing, *Mathematical Models, Systems Analysis, Urbanization, Urban Runoff, Texas, Simulation Analysis, Model Studies.
Identifiers: Road Research Laboratory Method.

A simulation model describes the quantitative and qualitative regimes of storm water runoff from urban watersheds. The urban runoff system consists of three basic subsystems: precipitation, runoff, and quality. Each of the three subsystems is mathematically modeled using probability and statistical techniques. Major flooding in the High Plains of Texas is associated with short-duration high-intensity convective storms. The model assumes these short-duration precipitation events are random and governed by a stationary probability distribution function. A bivariate log-normal distribution function fits the observed rainfall depths and durations for Lubbock, Texas. The runoff process is modeled by using the British Road Research Laboratory method, which assumes that all runoff is derived from interconnected impervious areas. Rainfall inputs are simulated by the Monte Carlo method. The outflow hydrograph is generated by single-step reservoir routing. The total pollutant load is predicted by a multiple regression involving the storm characteristics and the antecedent conditions. A one-step lag regression model is used to predict the pollutant concentrations.

IX-020
A STOCHASTIC MODEL OF RUNOFF-PRODUCING RAINFALL FOR SUMMER TYPE STORMS.

Lucien Duckstein, Martin M. Fogel, and Chester C. Kisiel
WRERA, 8(2):410-421 (April 1972). 5 fig, 1 tab, 20 ref.

Descriptors: *Runoff Forecasting, *Rainfall-Runoff Relationships, *Synthetic Hydrology, *Summer, *Storms, *Distribution Patterns, *Depth-Area-Duration Analysis, Watersheds (Basins), Model Studies, Parametric Hydrology, Precipitation Intensity.

Modification of watersheds occurs either through natural processes, such as erosion, or human influences, such as urbanization. In either case the rainfall input must be properly modeled before the runoff output can be predicted as the modifications take place. The paper considers runoff-producing summer precipitation of short duration and high spatial variability as an intermittent stochastic phenomenon. The probability distribution of seasonal total point or areal rainfall is obtained by convoluting a Poisson number of events with a geometric or negative binomial probability of rainfall amount. Close agreement with the experimental data is found. Next the probability of various combinations of rainfall amounts, given the seasonal total and the number of events, is computed. With these results, the theoretical seasonal water yield distribution can be obtained by using a simple rainfall-runoff relationship. The possibility of using regional input parameters to study the distribution of the output of poorly gaged small watersheds is discussed. In particular, extreme total flows can be computed.

IX-021
THE LOADING OF SEWERAGE DITCHES THROUGH FLOOD WAVES COMING FROM DRAINAGE NETWORKS: DETERMINATION OF THE CREST FLATTENING BY MEANS OF THE KALININ-MILJUKOV METHOD. (Belastung von Vorflutern durch Hochwasserwellen aus Entwässerungsnetzen: Bestimmung der Scheitelabflachung nach dem Kalinin-Miljukov-Verfahren.) Text in German.

G. Euler and K. Lerch
WUBOA, (5):128-131 (1972). 4 fig, 2 tab, 8 ref.

Descriptors: *Open Channels, *Computer Programs, *Drainage Systems, *Flood Waves, Drainage Effects, Retention, Sewerage, Water Level Fluctuations, Stage-Discharge Relations, Crest-Stage Gages.
Identifiers: Kalinin-Miljukov Method.

The retention effect of open ditches on the tide waves from drainage networks was studied for different gutter shapes by means of a computer program. Computation of the crest flattening for five wave shapes was performed according to the Kalinin-Miljukov procedure. Results indicate that short, steep waves underwent reduction faster than long, flat waves. The basic load of a ditch above the local drainage discharge point decreases the rate of the flattening process along with the partial filling of the ditch. The flow rate, which is determined by the gutter shape, slope, and roughness, constitutes the main factor determining the course of the crest flattening process.

IX-022
RUNOFF ANALYSIS OF THE UPSTREAM BASIN OF CHIKUGO RIVER: [CHARACTERISTIC CURVE METHOD.] (Chikugogawa joryuiki ni okeru ryushutsu kaiseki: [tokusei kyokusenho].) Text in Japanese.

Kozo Fujishita, Kinji Shinohara, and Takeo Kitajima
Preprint, 1971. 2 p, 1 ref. (Presented at the Meeting of the Japan Society of Civil Engineers, Western Japan Branch, Fukuoka, Japan, February 20, 1972.)

Descriptors: *Runoff Forecasting, *Duration Curves, *Mathematical Studies, *Mannings Equation, *Flow Profiles, Storm Runoff, Computer Programs, Hydrographs, Hydrologic Data, Rainfall.
Identifiers: Japan.

Using the characteristic curve method, the roles of the slope porosity and quantities from tributaries in the storm runoff pattern were examined. The characteristic curve was obtained mathematically, using a continuous formula based on Mannings Equation. The basin was divided into oblong segments and the characteristic value of each segment was obtained. The hydrologic properties and variables were programmed into a computer and a hydrograph obtained. The result and the actual measurements did not agree. It was concluded that the method of extracting effective rainfall quantity was at fault.

IX-023
RATIONAL RUNOFF CALCULATION METHOD USING A HYETOGRAPH. (Haietogurafu o mochiiru gorishiki ryushutsuryo santeiho.) Text in Japanese.

Masayoshi Ishiguro and Gyokuden Cho
Preprint, 1971. 2 p, 5 ref. (Presented at the Meeting of the Japan Society of Civil Engineers, Western Japan Branch, Fukuoka, Japan, February 20, 1972.)

Descriptors: *Hyetographs, *Runoff Forecasting, *Mathematical Studies, Rainfall Intensity, Rainfall-Runoff Relationships, Depth-Area-Duration Analysis.
Identifiers: Japan.

In this study, hyetographic analysis was used for calculating runoff. A new method for obtaining peak runoff by varying the runoff index utilizes the rainfall intensity, duration, and the ratio of the non-percolation surface area to the total basin. A conjectured rainfall distribution rate, the rainfall intensity ratio, and a continuous curve for the distribution rate were used for the calculation of the hyetograph.

IX-024
RUNOFF VOLUMES FROM SMALL URBAN WATERSHEDS.

Clayton R. Miller
WRERA, 8(2):429-434 (April 1972). 5 fig, 4 tab, 6 ref.

Descriptors: *Rainfall-Runoff Relationships, *Runoff Forecasting, *Mathematical Studies, *Small Watersheds, *Hydrologic Data, Storms, Urban Hydrology.

An empirical equation estimates the runoff volume from rainfall on small urban watersheds. If the rainfall is less than 1.5 inches, the runoff is predicted by the relationship between the percent impervious area in the watershed and the percent excess rainfall. An adjustment is made for the initial abstraction combined with the initial surface depression storage. For rainfall amounts greater than 1.5 inches, an additional increment of runoff is added for the pervious areas by using the hydrologic soil class, the vegetative cover, and the controlling parameters. Detailed 1- or 5-minute rainfall and runoff records from four small urban watersheds for 77 storms were used to develop the procedure. The method was tested on 17 additional storms on these watersheds. The maximum prediction error was 37% for over 80% of the test events. The median error was 17% of the actual runoff.

IX-025
STUDIES ON THEORIES OF STORM RUNOFF. (Kozuiryu no riron ni kansuru kenkyu.) Text in Japanese.

Tsugio Murase
Preprint, 1971. 4 p, 6 ref. (Presented at the Meeting of the Japan Society of Civil Engineers, Western Japan Branch, Fukuoka, Japan, February 20, 1972.)

Descriptors: *Storm Runoff, *Flood Routing, *Flow Control, Automatic Control, Control Systems, Model Studies, Rainfall-Runoff Relationships, Natural Flow, Mathematical Studies.
Identifiers: Japan.

This discussion includes the following topics: structural analysis of storm runoff as an automatic control system devised by nature; a new flood tracing method and its relationship with the Muskingum Method; a new interpretation for the principles of the Muskingum Method and reevaluation of its significance so as to clarify the nature of storm runoff; a new model for rainfall-runoff relationships and how it differs from the Prasad model; and, a special approach and clarification of the mechanism of formation of meandering rivers.

IX-026
WATER QUALITY FLUCTUATION OF SEWAGE WATER IN RAIN. (Utenji gesui no suishitsu hendo ni tsuite.) Text in Japanese.

Nobutoshi Nishi, Masayoshi Ishiguro, and Toshifumi Torigoe
Preprint, 1971. 2 p, 6 ref. (Presented at the Meeting of the Japan Society of Civil Engineers, Western Japan Branch, Fukuoka, Japan, February 20, 1972.)

Descriptors: *Water Quality, *Rainfall-Runoff Relationships, *Fluctuations, Rainfall Intensity, Flow Measurement, Storm Water, Sewage, Flow Augmentation, Water Analysis.
Identifiers: Japan.

As a basic study for examining the fluctuation of water quality, sewage water during rainfall was examined. A self-recording rain quantity simultaneous recorder was used which measured pH, DO, BOD, COD, nitrogen, turbidity, suspended material, and the residue after total evaporation. Results indicate that as the dry period preceding a storm increased, the quality of the sewer water decreased. The water quality grew worst near the peak flow, and its index was large in comparison with rainfall intensity. The quality of water also continuously

deteriorated as less intense rainfall was experienced over an extended period of time. Other findings showed the following: with an increase of flow, DO decreased; pH fluctuated minimally and was slightly acidic; and, residue after total evaporation showed the same fluctuation pattern as that of turbidity. BOD fluctuated and a peak was reached near the peak flow.

IX-027
RUNOFF ANALYSIS OF CHIKUGO RIVER BASIN. (Chikugogawa no ryuichi ryushutsu kaiseki ni tsuite.) Text in Japanese.

Kazuo Takeishi and Toichiro Tsubaki
Preprint, 1971. 2 p. (Presented at the Meeting of the Japan Society of Civil Engineers, Western Japan Branch, Fukuoka, Japan, February 20, 1972.)

Descriptors: *Depth-Area Curves, *Mathematical Models, *Model Studies, *Flow Profiles, *Runoff Forecasting, Analytical Techniques, Rainfall-Funoff Relationships, Flow Rates, Flow Characteristics.
Identifiers: Japan.

In this study, the characteristic curve method has been adopted for runoff calculations for the Chikugo River basin and smaller tributaries near the source. In the past, the role of the geographical slope had been emphasized in characteristic curve analyses while the role of the delayed effect in the river channel, neglected. In the case of the Chikugo River, the length of the slope is approximately 1.24×10^{-1} miles with segmented tributaries near the source. The river has a porous surface, and the flow over the slope is medially directed. Thus, the effect of delayed flow in the tributaries becomes an important factor. The basin's runoff is herein mathematically derived allowing for such considerations.

IX-028
STUDIES ON ACTUAL MEASUREMENT OF STORM RUNOFF IN SEWAGE [REPORT 5]. (Gesuido usui ryushutsuryo no jissokuteki kenkyu [Daigoho].) Text in Japanese.

Yutaka Tanaka, Masayoshi Ishiguro, and Kazutaka Kudoku
Preprint, 1971. 2 p, 6 ref. (Presented at the Meeting of the Japan Society of Civil Engineers, Western Japan Branch, Fukuoka, Japan, February 20, 1972.)

Descriptors: *Storm Runoff, *Runoff Forecasting, Rainfall-Runoff Relationships, Analytical Techniques, Surface Runoff, Measurement, Depth-Area Curves.
Identifiers: *Runoff Index, Japan.

In a study on runoff patterns based on data compiled at the Miyazaki University School of Engineering, the increase in the runoff index was examined. Analysis was obtained by dividing the total basin area into three categories: impervious surface, semi-pervious surface, and pervious surface. It was discovered that within the total basin area of 3.5 hectares, the impervious and semi-pervious areas increased approximately 19% over those of the previous year, with the runoff index changing by approximately 13 to 3%. In urban areas, the impervious surface ratio is great and further examination necessary. Runoff analyses were obtained by dividing the basin, forming a time-space map, designing a hyetograph, and calculating a hydrograph.

SECTION X.

Tunnels: Technology and Equipment

X-001
STORM WATER TO COOL?

WWAEA, 8(9):12 (Sept. 1971).

Descriptors: *Coolants, *Water reuse, Underground structures, Lake Michigan, Water conservation, Storm runoff, Cooling water, Nuclear powerplants.
Identifiers: *Storm water tunnels, Thermal pollution control.

The possibility of using storm water tunnels for cooling water in nuclear power plants was explored during a recent conference at the Metropolitan Sanitary District of Greater Chicago. Since water at 300 ft depths are extremely cold, returning the effluent to these tunnels would enable plants to use an enclosed recycling system and would eliminate the need for costly, unsightly cooling towers. Additionally, Lake Michigan would be protected from water diversion and thermal pollution.

X-002
BUREAU OF RECLAMATION EXPERIENCE IN USE OF BORING MACHINES IN TUNNEL EXCAVATION.

B. P. Bellport
Preprint, 1970. 61 p, 15 fig, 1 tab, 8 ref. (Presented at the Fall Meeting of the Society of Mining Engineers, St. Louis, Missouri, Oct. 1970.)

Descriptors: *Tunneling machines, *Tunnels, *Drilling, *Tunnel construction, Rock excavation, Geology.

The experiences of the Bureau of Reclamation in the use of tunnel boring machines to excavate 6 major tunnels on water resources development projects are summarized. Case studies for each of the 6 tunnels, with data on tunnel dimensions, geological characteristics of the excavated rock, the tunneling machines used, machine operation, muck handling, method of tunnel support, ventilation system, and related information are presented. Despite the diversity of dimensions and the variety of rock encountered during excavation, the 6 tunnels have one major characteristic in common: excavation was significantly expedited by the use of boring machines. Boring machines make possible smoother walls and uniform diameter, and more importantly in the tunnel lining, considerably less concrete is required to maintain the specified uniform thickness than is required for the rough, irregular walls of a conventionally driven tunnel. One example cited was estimated to require 3-1/2 times more concrete for lining a conventionally excavated tunnel than was used for lining the bored tunnel.

X-003
LASER ALIGNMENT TECHNIQUES IN TUNNELING.

A. Cooney
JSUEA, 96(SU2):229-243 (Sept. 1970). 10 fig, 2 tab, 1 ref, 2 append.

Descriptors: *Tunneling machines, *Alignment, *Surveying instruments, *Control systems, Tunneling.
Identifiers: *Lasers, Target systems.

With the introduction of the mechanical mining machine or 'mole', the role of the engineer has become one of providing a constant course of direction for the machine rather than establishing and projecting the tunneled path traversed by it. The primary tool in accomplishing this task is an alinement control system capable of providing guidance and detecting and distinguishing the components of motion generated by the mining machine. Consisting of a laser beam instrument, auxiliary control points along the tunnel, and a target system affixed to the machine, such a system provides a graphical guide to the machine operator. The mechanics of setting up such a system are outlined and various types of target systems are categorized. Techniques for adapting such a system to various alinement problems are proposed.

X-004
MELBOURNE & METROPOLITAN BOARD OF WORKS SOUTH-EASTERN SEWERAGE SYSTEM.

SMENB, 138 (4134):47-48 (Sept. 3, 1971).

Descriptors: *Tunnel construction, *Tunneling machines, *Drilling, Sewerage, Sewers, Project planning.
Identifiers: Australia.

By intercepting the wastewater flow in various main sewers and providing a main sewerage system for new, rapidly developing areas, the existing sewerage system will be sufficiently relieved to accommodate the projected population increase for the metropolitan area of Melbourne, Australia. This new system comprises intercepting sewers and pumping stations; a 20-mile long main trunk sewer; a purification plant; and, a 35-mile outfall tunnel for the discharge of reconditioned water. The first of three tunnel sections constituting the 20-mile trunk sewer passes through hard

silurian bedrock and the pipeline then continues through saturated tertiary sediments, ending as a cut-and-cover conduit. A flat-faced cutter head and flexible shielding system proved successful on the boring machine used for the first tunnel section. A hydraulically powered Mitsubishi soft-ground boring machine was used in compressed air for the saturated silts and sands, and an oscillating-type Caldweld machine was used to excavate the more weathered part of the final section.

X-005
DORCHESTER TUNNEL OF THE METROPOLITAN BOSTON WATER SYSTEM.

Francis T. Bergin and Tadeus J. Medowski
JNEWA, 85(4):309-324 (Dec. 1971). 3 fig.

Descriptors: *Tunnels, *Tunnel construction, *Tunneling machines, *Tunnel linings.
Identifiers: Boston, Massachusetts.

The Dorchester Tunnel, 6-1/3 miles long with a carrying capacity of 300 mgd, is being built for the sum of $19,100,385. Initial work, at at cost of $636,430, included construction and lining of Shaft 7C to a depth of 248 feet and finished diameter of 14 feet. An average of 13 inches of concrete was required in this lining with 4-inch by 12-inch horizontal key ways placed on 5-foot centers. 680 feet of tunnel with a diameter of 13 feet also was excavated. Shaft excavation and lining progressed at an average rate of 1.8 feet per working day. The contract work now being completed calls for excavation and lining of about 4.2 miles of tunnel from Shaft 7B to Shaft 7C and about 2.2 miles of tunnel from Shaft 7C to Shaft 7D, both tunnels having a finished diameter of 10 feet. Shaft 7C will be lined to a finished diameter of 6 feet with connections to two 36-inch water mains. Shaft 7D, 225 feet deep with a 6-foot diameter, will be connected to a 48-inch steel main.

X-006
NEW SEWER OUTFALL TUNNEL BRIGHTON AND HOVE IN SUSSEX.

J. D. C. Osorio
TUTUB, 3(6):412-413 (Nov. 1971).

Descriptors: *Tunnels, Tunnel construction, Sewers, Tunnel linings.
Identifiers: Great Britain.

The Brighton Intercepting and Outfall Sewer Boards, responsible for the collection and disposal of sewage from the Boroughs of Brighton and Hove, awarded to a tunneling contractor a contract for the extension of a sewer outfall. The ground through which the shaft is to be sunk is being treated by the injection of sand and cement grout from the surface. The shaft is to be 130 feet deep with a primary lining of bolted concrete segments, 12 feet internal diameter, and a secondary lining of in situ concrete. The tunnel will be 7 feet in diameter lined with "Kinnear Moodie Rapid" boltless segments with no secondary lining.

X-007
THE MERSEY OUTFALLS INTERCEPTOR SEWER AT WARRINGTON, LANCS.

G. Pakes
TUTUB, 3(6):415-417 (Nov. 1971). 9 fig.

Descriptors: *Outlets, *Tunnel construction, Tunneling, Construction costs.
Identifiers: *Intercepting sewer, Great Britain.

The Mersey Outfalls Interceptor Sewer in Warrington, Lancashire passes under the urban areas of Warrington and is intended to collect all public outfalls into the tidal section of the River Mersey and convey domestic and trade effluents to a new treatment plant. A tunnel construction was chosen because of poor ground conditions near the surface. A caisson shaft sinking method known as monolithing, proved very successful in the mixed ground conditions encountered. It consisted of building a section of segmental shaft in a shallow guide pit, loading the shaft with weights, and grabbing inside, thus forcing the shaft downwards. In water-bearing ground, the grabbing was done under water, equalizing the hydrostatic pressure and preventing ground loss. The shaft was grouted, from the bottom upwards, the grouting displacing the slurry. A 40-foot shaft could be completed in about 2 weeks. At a point about 8 feet from the river's edge where an existing sewer had to be connected to the tunnel, a 24-inch diameter borehole was drilled to a short branch tunnel. One of the encountered problems, groundwater having a pH of 11-13 and a sulfate content as high as 22,000 ppm near one of the chemical industries, was solved by lining the section with untreated steel. The internal concrete in situ lining was placed inside the waterproof membrane formed by the steel lining. The cost of the main contract, including shafts and manholes, main tunnel, subsidiary tunnels and box culvert, and river wall is about $1.9 million ($2.60/£) for 27 months' effort.

X-008
SEWER BUILT WITH RAY-GUN.

WWAEA, 9(3):58 (March 1972). 1 fig.

Descriptors: Tunneling, *Tunneling Machines, *Storm Drains, Construction Equipment, Construction, Construction Materials.
Identifiers: *Lasers, White Plains, New York, Swiss Darda Rock Splitter.

Laser beams and a special, experimental, Swiss rock-splitting machine were recently at work beneath the streets of White Plains, N. Y. These methods were used for a tunneling operation which is necessary to accomodate an 84-inch-diameter storm sewer that will divert the upper part of Davis Brook westerly and make the lower part go through the storm sewer on a shorter route to the Bronx River by flowing west instead of north. A laser-aiming type procedure was used to control digging of the tunnel for the 320-foot long section located ten to thirty feet below the surface. As earth and rock were removed, ring-like sections of liner plate were assembled and attached to the last section placed. No more than eight rings were placed without grouting to minimize cave-in danger. The laser technique involves checking alignment and grade of tunneling as the beam is shot directly down the center of the tunnel. Hand mining techniques in areas of solid rock were necessary, since the proximity of a high pressure gas main made blasting impossible. The Swiss Darda rock splitter was used to relieve this situation. Presently, the tunnel is being cleaned and rails laid at the bottom. The concrete pipe must still be pulled into the tunnel, the joints grouted, and a headwall built at the river.

X-009
EUORPEAN DEVELOPMENT AND EXPERIENCE WITH MECHANICAL MOLES IN HARD ROCK TUNNELING.

Pieter Barendsen
College of Applied Science and Engineering, University of Wisconsin-Milwaukee and University Extension, University of Wisconsin, Proceedings from Deep Tunnels in Hard Rock: A Solution to Combined Sewer Overflow and Flooding Problems, Civic Center Campus, Milwaukee, Wisconsin, November 9-10, 1970. 18 p, 12 fig.

Descriptors: *Tunneling Machines, Drilling, Equipment, Economics, Rock Excavation, Tunnel Design.
Identifiers: *Undercutting Principle, Moles, Europe.

The rock boring machines available for tunneling in Europe today are divided into two groups according to the method of operation. The first group consists of machines that work the full face of the tunnel at any moment, while being advanced continuously along the tunnel axis. All of these mole machines bore tunnels with a circular cross section because the cutter- or boring-head is rotated around an axis that coincides with that of the tunnel itself. Diameters for which standard machine designs are available range from approximately 9 to 14 feet. The latter group consists of machines with one or more cutter heads of dimensions substantially smaller than the tunnel cross section which work the face by a combined rotating and sweeping movement and are advanced stepwise in the longitudinal direction of the tunnel. Such machines can cut a tunnel of non-circular cross section and are, therefore, of special interest in mining operations where a flat footwall is required for haulage purposes. The majority of these machines are equipped with "pick-type" tools and have not been designed to work rock any harder than the relatively soft formations encountered in coal mining.

X-010
GROUND FREEZING FOR TUNNELLING IN WATER BEARING SOIL AT DORTMUND, GERMANY.

Bernd Braun
TUTUB, 4(1):29-32 (Jan. 1972). 13 fig, 1 tab.

Descriptors: *Tunneling, Tunnel Construction, Construction Materials, Construction Equipment, Concrete Pipes, Sealants.
Identifiers: *Ground Freezing, Germany.

In developing a sewer system in Dortmund, Germany, a tunnel had to be driven under the Dortmund-Mengede railway station. The object was a circular sewer of concrete pipes of 6.58-foot internal diameter and pressed rubber sealings. Soil conditions were known from two exploration drillings. For the construction of this tunnel, ground freezing was applied for the first time under a railway line. Freezing is economically competitive and, under difficult conditions, technically superior to other construction methods. Mechanical tunnel driving with a cutter loader proved to be an efficient method and has been applied on subsequent projects. Ground freezing has a wide range of application. It is equally successful and applicable in the construction of shafts and in the stabilization of large excavations. Heterogeneous soil and increasing depth have no adverse effects, and the entire process is labor saving.

X-011
EXPERIENCE IN EDMONTON, CANADA WITH EMPHASIS ON PNEUMATIC CONVEYANCE OF MUCK.

C. G. Chrysanthou
College of Applied Science and Engineering, University of Wisconsin-Milwaukee and University Extension, University of Wisconsin, Proceedings from Deep Tunnels in Hard Rock: A Solution to Combined Sewer Overflow and Flooding Problems, Civic Center Campus, Milwaukee, Wisconsin, November 9-10, 1970. 8 p.

Descriptors: *Tunneling, *Tunneling Machines.
Identifiers: *Pneumatic System, Canada.

As part of the sewer construction program, the City of Edmonton, Canada will build a major central sewage treatment plant with an extensive collection system of interceptor tunnels. All tunneling excavation is done with tunneling machines or moles commonly known in the industry. Due to operational problems early in the project, 57% of the time was spent in waiting for the empty trains and installing the primary liner. To ameliorate this situation a pneumatic system, designed to handle the maximum discharge from the mole at the maximum conveyance distance, was chosen so that the mole could work at full capacity at all times. The system consists of a large volume, low pressure, air blower installed in a closed-in trailer positioned at the surface of the shaft head. The air is piped to the stower, connected to the mole by means of a draw bar, and the hopper is located directly under the discharge conveyor from the mole. Two telescopes have been provided behind the stower, one for the air pipe and the other for the materials handling pipe to permit the blower to travel forward with the mole. When the excavation has advanced 10 feet, the telescopes are fully extended and the stower is shut down. The telescopes are then retracted, a 10-foot length of pipe is coupled into each line, and the excavation proceeds.

X-012
EUROPEAN DEVELOPMENT AND EXPERIENCE WITH MECHANICAL MOLES IN HARD ROCK TUNNELING.

Ernst Weber
College of Applied Science and Engineering, University of Wisconsin-Milwaukee and University Extension, University of Wisconsin, Proceedings from Deep Tunnels in Hard Rock: A Solution to Combined Sewer Overflow and Flooding Problems, Civic Center Campus, Milwaukee, Wisconsin, November 9-10, 1970. 17 p, 9 fig.

Descriptors: *Tunnel Construction, *Tunneling, *Tunneling Machines, Rock Excavation, Economics, Manpower, Tunnel Linings, Control Systems, Costs.
Identifiers: Geologic Disturbance, Lasers, Europe.

During the past ten years, mechanical tunneling techniques have become so sophisticated and improved that the economic employment of modern machinery is beginning to challenge that of conventional methods. In the future, developments are anticipated to further shift the economic aspects still more in favor of fully-mechanized driving. Problems which impede the performance of machinery and the miners is the placing of linings and supports at the correct time and driving through zones of geologic disturbance. Due to climatic problems the following measures are required: the design of a ventilation system, the treatment of heat generated by a tunneling machine, and the provision of a dust shield at the front of the machine. Control of line and level of the tunneling machine by means of a guide beam generated by a laser has proven successful. Control engineers are at present working on fully-automating the operation of a tunneling machine. A so-called template control system has proven very good for permitting a cross section of any form to be driven accurately. This equipment permits driving operations to be carried out manually or automatically from the control stand. The author maintains that proper organization by the site manager can cut down on down-time caused from faults within a transport system involved in transporting material inside and behind a tunneling machine.

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CUMULATIVE GLOSSARY FOR CODEN

(alphabetized by CODEN abbreviations)

CODEN Abbreviation	Full Title
1. AMCIA	1. American City (New York)
2. BRSDB	2. Building Research Station Digest (London)
3. BUSDB	3. Building Systems Design (New York)
4. CCISA	4. Canadian Controls and Instrumentation (Toronto)
5. CITEA	5. Chemie-ingenieur-technik, Zeitschrift Fuer Technische Chemie, Verfahrenstechnik Und Apparatewesen (Weinheim, Germany)
6. CIVEB	6. Civil Engineering. American Society of Civil Engineers (New York)
7. CJPEA	7. Canadian Journal of Public Health (Toronto)
8. DGRHA	8. Doboku Gakkai Rombun-hokokushu (Japan Society of Civil Engineers, Proceedings) (Tokyo)
9. DGTPA	9. Diesel and Gas Turbine Progress (New York/Milwaukee)
10. EHJIA	10. Ehara Jiro (Ebara Times) (Tokyo)
11. ENCRA	11. Engineering and Contract Record (Toronto)
12. ENREA	12. Engineering News-Record (New York)
13. ENTEA	13. Energie Und Technik, Fachzeitschrift Fuer Angewandte Energie Und Allgemeine Technik (Duesseldorf)
14. GSKSA	14. Gesuido Kyokai Shi (Journal of the Japan Sewage Works Association) (Tokyo)
15. GWTSA	15. Gaz, Woda I Technika Sanitarna (Warsaw)
16. GWWAA	16. Gas-Und Wasserfach, Wasser-abwasser (Munich)
17. INCVA	17. Ingenieria Civil (Havana)
18. JAWWA	18. Journal of the American Water Works Association (New York)
19. JISPA	19. Journal of the Institution of Public Health Engineers (London)
20. JLHYA	20. Journal of Hydrology (Hastings, New Zealand)
21. JMUEA	21. Institution of Municipal Engineers, Journal (London)

22.	JNEWA	22. New England Water Works Association, Journal (Boston)
23.	JSEDA	23. Journal of the Sanitary Engineering Division, Proceedings of the American Society of Civil Engineers (New York)
24.	JSUEA	24. American Society of Civil Engineers, Proceedings, Journal of the Surveying and Mapping Division (New York)
25.	JSWCA	25. Journal of Soil and Water Conservation (Baltimore)
26.	JWPFA	26. Journal of the Water Pollution Control Federation (Washington)
27.	JYCEA	27. Journal of the Hydraulics Division, Proceedings of the American Society of Civil Engineers (New York)
28.	KETIA	28. Kemisk Tidskrift (Stockholm)
29.	NEONA	29. Nenryo Oyobi Nensho (Fuel and Combustion) (Osaka)
30.	NGKHB	30. Nihon Gesuido Kyokai, Gesuido Kenkyu Happyokai Koen-shu (Japan Sewage Works Association, Proceedings of the Meeting on Sewage Works) (Tokyo)
31.	PCIEA	31. Institution of Civil Engineers, Proceedings (London)
32.	PLENA	32. Plant Engineering (Chicago)
33.	PUWOA	33. Public Works (Ridgewood, N. J./New York)
34.	PWRPA	34. Proceedings of the Southern Water Resources and Pollution Control Conference (Chapel Hill, N. C.)
35.	ROSTA	35. Roads and Streets (Chicago)
36.	SCBAB	36. Schweizerische Bauzeitung. Wochenschrift Fuer Architektur, Ingenierwesen, Maschinentechnik (Zurich)
37.	SCIEA	37. Science. American Association for the Advancement of Science (Washington)
38.	SLGTA	38. Surveyor - Local Government Technology (London)
39.	SMENB	39. Surveyor and Municipal Engineer (London)
40.	TEREA	40. Technology Review (Cambridge, Mass.)
41.	TTIDA	41. Teknisk Tidskrift (Stockholm)
42.	TUTUB	42. Tunnels and Tunnelling (London)
43.	UWTCA	43. Umschau In Wissenschaft Und Technik (Frankfurt Am Main)
44.	WARBA	44. Water Resources Bulletin (Urbana, Ill.)

45.	WOCOA	45. World Construction (Chicago/New York/ Easton , Pa.)
46.	WPCOA	46. Water and Pollution Control (Toronto)
47.	WPOCA	47. Water Pollution Control (London)
48.	WRERA	48. Water Resources Research (Washington)
49.	WSIWA	49. Water & Sewage Works Including Industrial Wastes (Chicago)
50.	WSLBA	50. Wasser, Luft Und Betrieb (Wiesbaden , Germany)
51.	WSWOA	51. Water and Sewage Works (Chicago/New York)
52.	WSWSA	52. Wasserwirtschaft-wassertechnik (Berlin)
53.	WSWTA	53. Wasserwirtschaft (Stuttgart)
54.	WUBOA	54. Wasser Und Boden (Hamburg-blankenese , Germany)
55.	WWAEA	55. Water and Wastes Engineering (New York)
56.	24ZAA	56. Doboku Gakki, Eisei Kogaku Iinkai , Eisei Kogaku Kenkyu Toronkai Koen Ronbun-shu (Proceedings of the Conference on Sanitary Engineering Research, 7th, Japan, January 30-31, 1971)

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25 Identifiers (Starred First)

27 Abstract

The July 1971 - June 1972 supplement to SELECTED URBAN STORM WATER RUNOFF ABSTRACTS is a compilation of abstracts summarizing articles from a variety of technical literature and conferences, both domestic and foreign, primarily related to the problems of urban runoff caused by storm water discharges, combined sewer overflows, and nonsewered urban runoff. All aspects related to this topic fall under the selective areas of: design criteria and construction materials for sewers or apparatus employed in the flow of combined sewage and/or storm runoff; regulation devices for overflow or infiltration from urban runoff of storm water, combined sewage, or highway-salt runoff which can cause water pollution; water quality, legislation, or treatment methods based on problems caused from storm water; and, current tunnel technology and equipment used in the construction of sewer tunnels. The 215 abstracts covering a range of ten sections are arranged numerically by abstract accession number within each category. Each item includes a bibliographic citation, an abstract, and a set of indexing descriptors and identifiers. A subject index appended in this issue provides the necessary access to individual concepts. An author index and a glossary for journal abbreviations are also included. This work was submitted in fulfillment of Contract 68-01-0161 (EPA Project No. 11020 HMM) between the Environmental Protection Agency, Office of Research and Monitoring and The Franklin Institute Research Laboratories.

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