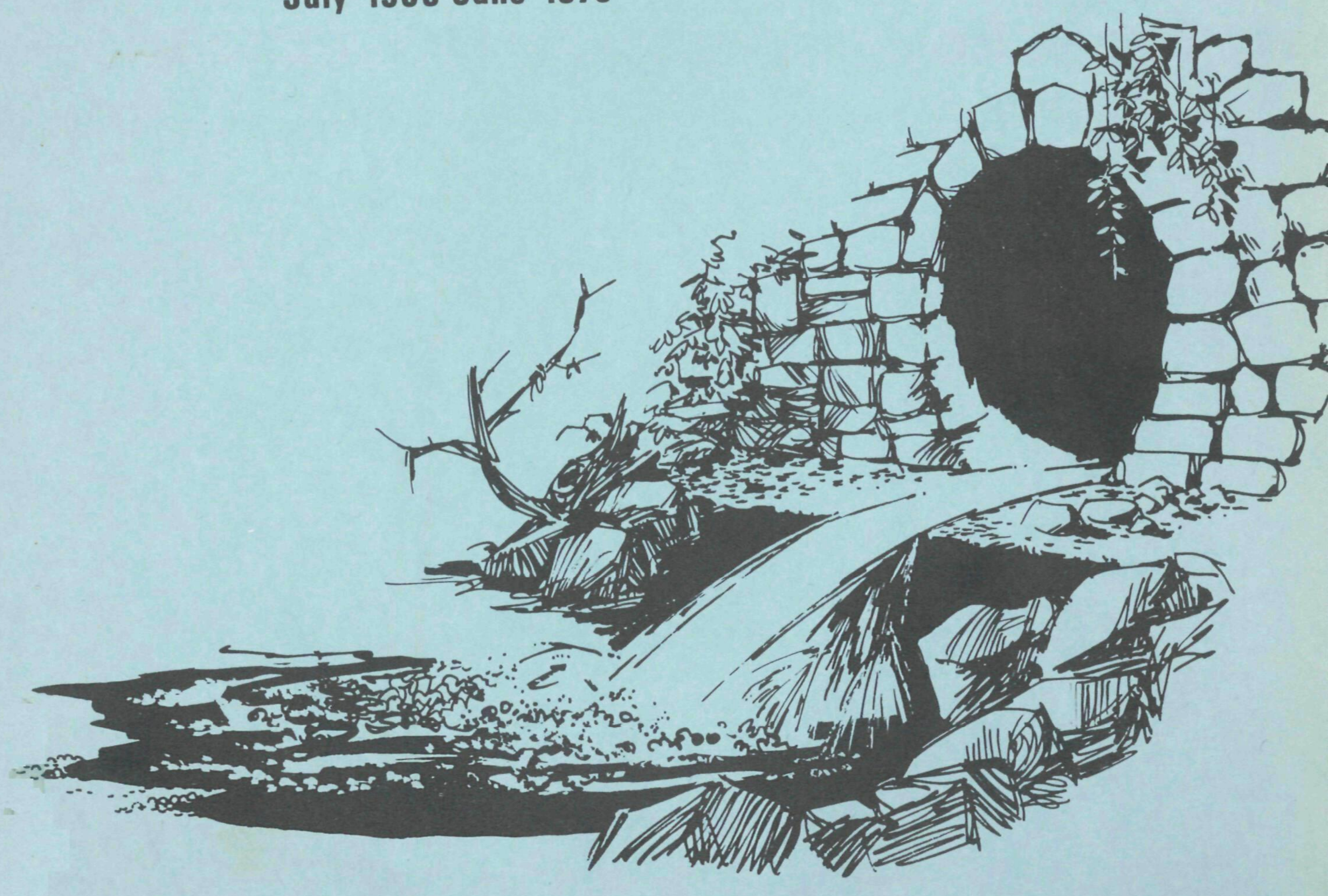
WATER POLLUTION CONTROL RESEARCH SERIES • 11024EJC 07/70

Selected Urban Storm Water Runoff Abstracts

July 1968-June 1970



ENVIRONMENTAL PROTECTION AGENCY • WATER QUALITY OFFICE

WATER POLLUTION CONTROL RESEARCH SERIES

The Water Pollution Control Research Reports describe the results and progress in the control and abatement of pollution of our Nation's waters. They provide a central source of information on the research, development and demonstration activities of the Water Quality Office of the Environmental Protection Agency, through in-house research and grants and contracts with the Federal, State, and local agencies, research institutions, and industrial organizations.

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11024 EJC 10/70	Selected Urban Storm Water Abstracts, First Quarterly Issue

Continued on inside back cover....

SELECTED URBAN STORM WATER RUNOFF ABSTRACTS

by

Science Information Services Department

The Franklin Institute Research Laboratories

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This report has been reviewed by the Water Quality Office and approved for publication. Approval does not signify that the contents necessarily reflect the views and policies of the Water Quality Office, nor does mention of trade names or commercial products constitute endorsement or recommendation for use.

ABSTRACT

A compilation of abstracts summarizing articles from a variety of technical publications constituting the problem of urban drainage was developed by the Franklin Institute Research Laboratories. The present work includes 599 abstracts of documents published for the most part from July 1968 through June 1970. The abstracts are classed in ten sub-topic categories and arranged alphabetically by author and numerically by abstract number within each category. Each item includes a bibliographic citation, an abstract, and a set of indexing descriptors and identifiers. A cumulative subject index at the end of the volume provides the necessary access to individual concepts. An author index and journal list are also included.

This work was submitted in fulfillment of Contract 14-12-904 between the Federal Water Quality Administration and the Franklin Institute Research Laboratories.

Key Words: Storm runoff, urbanization, drainage systems, overflow, rainfall-runoff relationships, sewers, sewage treatment, water pollution control.

FOREWORD

SELECTED URBAN STORM WATER RUNOFF ABSTRACTS is a compilation of abstracts summarizing articles from a variety of technical publications, covering the subjects of urban runoff, storm water drainage, storm sewers, and legislation -- together constituting "the problem of urban drainage". Articles on more general subjects, such as "sewerage" or "sanitary engineering", and topics not closely related to storm water have been excluded.

The present work includes 599 abstracts of documents published from July 1968 through June 1970. A few abstracts summarize material published before this period that were not included in the previous volume of SELECTED URBAN STORM WATER RUNOFF ABSTRACTS, published in June 1969. For convenience, the abstracts are classed in ten sub-topic categories and arranged alphabetically by author and numerically by abstract number within each category. Since most of the papers fit into more than one category, a cumulative subject index at the end of the volume 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 numbers for the abstracts in which this term is found. Each item includes a bibliographic citation, an abstract, and a set of indexing descriptors (subject terms listed in the WATER RESOURCES THESAURUS, November 1966 edition) and identifiers (newly suggested index terms). The most important index terms are marked by an asterik. An author index and journal list are 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.

Suggestions concerning the improvement of content and format, or expansion of subject coverage in future supplements to this compilation, which will be issued quarterly, will be gratefully received.

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Am City, Vol 85, No 4, p 18, Apr 1970,

Descriptors: *Waste treatment, *Storage, Instrumentation, Storm runoff.
Identifiers: *Lake Erie, Monitoring system, Stormwater storage.

The Detroit Metropolitan Water Service is putting existing technology into effect to help decelerate the aging of Lake Erie. Proposed programs include: solids reduction by addition of mechanisms to the regional wastewater plant, coliform removal through chlorination, phosphate reduction using pickle liquor from steel mills, waste oil and grease removal using oil skimmers, construction of phenol-removing systems, and installation of smokestack air cleaners to prevent air pollution. A monitoring system to reduce stormwater overflows is also being built to warn of approaching rainfall, thus allowing sewers to be pumped before the storm. This will permit sewers to store contaminated stormwater, the dirtiest water being sent to the treatment plant. Further long range plans are being made to meet future demands of the region.

002
STEEL PIPE SELECTED FOR STORM SEWER SYSTEM,

Am City, Vol 85, No 3, p 22, Mar 1970.

Descriptors: *Pipes, Construction costs.
Identifiers: Steel pipes, Storm sewers, Sewer system.

Steel piping instead of the more-commonly used reinforced concrete was employed to construct a storm sewer system in Lakewood, New York. Advantages of this material include its strength, lighter weight, and lower cost. Savings in material cost alone were about 15%, and lower labor costs were incurred because steel is simpler to handle than other materials. Dimensions of the storm sewer system are given.

003
UNDERWATER SEWAGE STORAGE AN AID TO POLLUTION ABATEMENT,

Am City, Vol 84, No 9, pp 30 and 34, Sep 1969.

Descriptors: *Construction materials, Storm runoff, Pollution abatement, Waste storage, Overflow.
Identifiers: *Rubber storage containers, Storm tank, Anacostia River.

Goodyear Tire & Rubber Co. and Underwater Storage, Inc. of Washington D.C. have announced a joint project to attack water pollution by collecting wastes in huge, collapsible, underwater, rubberized tanks. Two prototype systems are being tested in the Anacostia River in Washington; one to trap stormwater overflow, and the other near a marina to collect wastes from boats. These storage tanks could resolve a variety of problems such as threats of river fires caused by accidentally-ignited oily wastes, and pollution from stormwater which was previously eliminated only through costly sewer reconstruction.

004
UNDERWATER LINE SPANS 32 FEET BETWEEN SUPPORTS,

Am City, Vol 84, No 8, p 58, Aug 1969.

Descriptors: *Concrete pipes, *Installation, *Construction equipment.
Identifiers: *Underwater pipeline.

An underwater pipeline of prestressed concrete units was installed in St. John's River as an outfall sewer from a waste treatment plant to serve a new industrial area of Jacksonville, Florida. Double sections of cylinder pipe were laid on concrete piles topped with precast concrete caps to cradle the pipe. Scuba divers guided and joined pipe sections. Extensions and other installation techniques are given.

005
IT'S IN THE BAG,

Am City, Vol 84, No 4, p 88, Apr 1969.

Descriptors: *Storage tanks, Overflow, Storm runoff, Ohio.
Identifiers: *Rubber storage containers, Combined sewers, Storm tank.

The problem of stormwater overflows from combined sewers is being combatted in Sandusky, Ohio through the implementation of a plan which is much less costly than the common solution of sewer separation. The new system consists of rubberized storage reservoirs that trap the heavily-polluted "first flush" of stormwater. When the storm ends, pumps transfer the stored stormwater to the treatment plant for processing along with the normal wastewater. Costs, details, and a diagram of the system are included in the article.

006
SCREEN TREATMENT FOR SEWER OVERFLOWS,

Am City, Vol 84, No 3, p 24, Mar 1969.

Descriptors: *Screens, Storm runoff, Overflow, Oregon.
Identifiers: *Runoff treatment, Combined sewers.

An alternative to separation of combined sewers in Portland, Oregon is being tested under a FWPCA grant. The experimental pilot plant includes high-rate, fine-mesh screens which treat overflow that is pumped to the plant during periods of heavy rainfall. Previously, only one-third of the rainy season flow was treated while the remainder was discharged untreated into a receiving stream. A description of the structure and workings of the screen operation is given. Laboratory tests will determine the effectiveness and feasibility of the system.

007
TRENCHER AND BOX SHIELD MAKE SEWER JOB ALMOST ONE-RIG OPERATION,

Construct Methods Equip, Vol 51, No 4, pp 134-135, 138-140 and 143, Apr 1969. 8 fig.

Descriptors: *Excavation, *Construction equipment, *Cost analysis.
Identifiers: *Hydraulic trencher, *Storm sewers, *Guidance system, Oakland, Michigan, Laser beam.

A tractor-powered hydraulic trencher used a three-line bucket arrangement to perform digging for a 43,000-foot storm sewer in Oakland, Michigan. A box shield moved ahead 28 inches at a time and carried a hopper to distribute gravel for the pipe bed. Job difficulties held cost savings to about 10% below conventional backhoeing, but the trencher did protect against cave-ins in addition to providing safety in opening a trench parallel to gas and water lines. The trencher had three basic components: (1) a standard Cat D9 up front; (2) a ladder type bucket line and transverse unloading conveyer; and (3) a hydraulically powered telescoping box that slid along two sled type runners. Dimensions of each part are given along with details of the workings and operation of the trencher and its parts. Loading of spoils to trucks is described. Two guidance systems are mentioned; one which used a survey string line, and the other which employed an Acme laser gun.

008
TOOLS OF THE BUILDER,

Construct Methods Equip, Vol 51, No 2, pp 164-168, 170-172, 174-175, 177-178, 180, 183-184, 186, Feb 1969. 15 fig.

Descriptors: *Construction equipment, *Tunneling machines, *Tunneling, *Hydraulic equipment, Tunnel construction, Piping, Control systems, Concrete construction, Electronic equipment.
Identifiers: *Mole, Laser beam.

This article explores advances made since 1963 in equipment used by contractors in non-highway construction. Means for handling, lifting, and moving materials grew steadily in size and power. Conventional-type equipment—cranes, derricks, conveyors, and pumps, became taller, stronger, and more versatile. Earth and rock boring for tunnel construction became easier with the development of machines able to tackle any type of geological formation. Special rigs are described which place large-diameter piping inside long tunnels. Advances in mole tunneling are cited. Hydraulic pumps, driven by electric motors, provide rotation, twist, and up-and-down actions of the boom and bucket, and they also propel the machine. Construction crews use laser beams as constant reference lines. They are visible day and night for long distances and are weak enough to be harmless. Future tunneling may be accomplished by rapid melting of rock with lasers or electron beams. New innovations discussed include: hydraulic-boom cranes, hydraulic fork lifts to handle heavy wall and slab forms, lightweight plastic-foam materials, concrete pumps, electronic computers, and television.

009
WASHED-OUT PLATE CULVERT RESET IN 17-TON SECTIONS BY CRANE,

Construct Methods Equip, Vol 50, No 7, pp. 54-57, Jul 1968. 6 fig.

Descriptors: *Flood damage, *Culverts, *Cranes, *Repairing, *Construction, *Installation.

When a 500-foot length of culvert comprised of 600 plate sections was washed out by a flash flood, the contractor unbolted the conduit in 36-foot barrels instead of dismantling the pipe plate by plate and lifted the sections out by crane. The sections were stored on the bank to be reset after the bed dried and was restored. A simple wooden screed shaped the concrete sand bed for the 21-foot diameter culvert. Details of the construction and installation procedures are included.

010
WORK STARTS ON 11-MILE INTERCEPTOR TO SOLVE TORONTO'S SEWER PROBLEM,

Eng Contract Record, Vol 83, No 6, pp 68-69, Jun 1970. 2 diag.

Descriptors: *Construction, *Contracts, *Interception, *Design, *Sewers.
Identifiers: *Canada, *Interceptor sewer, Toronto.

In metropolitan Toronto an interceptor to relieve existing high- and low-level interceptor sewers, which are inadequate for the area they cover, is under construction. S. McNally and Sons Ltd. was among a number of bidders, and it was awarded all portions of the project. The project entails the construction of a 61,640 foot-long shaft varying in diameter from 60 to 120 inches spanning the city from east to west. The estimated time of construction is three years. Information on the operation and techniques used is included.

011
PLASTIC FITTINGS SPEED LAYING OF SEWER PIPE,

Eng Contract Record, Vol 81, No 10, p 73, Oct 1968.

Descriptors: *Pipes, *Construction equipment, *Construction materials, Installation.
Identifiers: *Transite pipe system.

The Roll-Tite system which combines a Transite asbestos-cement pipe with a new type of plastic fitting blow-molded from black polypropylene, is described. The installing operation for this system takes considerably less time than for other systems. Other advantages of this system as well as distributive information are mentioned.

012
PLASTIC MAY BE PIPELINER'S BOON,

Eng News-Record, Vol 184, No 10, pp 28-29, Mar 5, 1970.

Descriptors: *Plastic pipes, *Installation, Cost comparisons, Construction materials.
Identifiers: *Germany, *Fusion welding.

In Germany, plastic pipes with up to 40-inch diameters and pieced in 500 to 1,000 foot sections are common engineering equipment. These polyethylene pipes cost slightly more than other types of pipes; however, installation costs are drastically lower, especially when used in long runs. The butt-fusion welding practice is quite routine in Europe. This process of installation is described.

013
WINNER 3.6% UNDER ON CALIFORNIA STORM DRAIN,

Eng News-Record, Vol 184, No 3, p 46, Jan 15, 1970. 1 tab.

Descriptors: *Construction materials, *Costs, *Concrete pipes, *Concrete construction, *Bids, California.
Identifiers: *Bedding material, Solid shoring, Storm drainage system.

Costs and quantities of materials proposed for use in the construction of a storm drainage system in Torrance and Los Angeles, Calif. are tabled for the two lowest contract bidders. The hired contractor will use reinforced concrete box construction and reinforced concrete pipe. Excavated sandy silt material will be used for bedding. Solid shoring is necessary for most of the project.

014
STORMWATER OVERFLOW GETS BAGGED,

Eng News-Record, Vol 181, No 18, p 14, Oct 31, 1968.

Descriptors: *Construction equipment, *Construction costs, *Separation techniques, Overflow.
Identifiers: *Rubber storage containers.

The FWPCA is financing projects to install rubber stormwater storage bags at three locations: Washington's Anacostia River, Sandusky, Ohio at Lake Erie, and Cambridge, Md.'s Choptank River estuary. The bags will store stormwater overflow that normally flows untreated into rivers and lakes along with sanitary sewage, when flows exceed treatment plants' capacities during heavy rainfall. The Washington bags rest on the bottom of the Anacostia River offshore of the pumping plant. The plant will chop overflow solids before the water reaches the bags, and an aerator will suspend the solids. The solids come out with the stored water when it is pumped back into the sewers for treatment. These plans are considerably less costly than sewer separation which would cost an estimated $48 billion to accomplish throughout the United States.

015
STORMWATER SEWER DESIGN IN METRIC,

Inst Munic Engrs, Vol 97, No 5, supplement no 4, May 1970.

Descriptors: Measurement, Design.
Identifiers: Metric system, Conversion charts, Storm sewers.

First impressions of the use of metric units in stormwater sewer design are expressed. In using the metric system, awkward multipliers are removed. Conversion charts are listed.

016
DESIGN EXAMPLES IN METRIC,

J Inst Munic Engrs, Vol 97, No 2, supplement no 2A, Feb 1970.

Descriptors: Measurement, Design.
Identifiers: *Combined sewers, Metric system.

A metric example of the combined sewer and small pumping station is worked out using the rational formula and the Ministry of Health figures for intensities of rainfall.

017
STORAGE BLADDERS FOR SEWAGE,

Ind Water Eng, Vol 5, No 8, p 30, Aug 1968.

Descriptors: *Construction equipment, *Rubber, *Storage tanks, Storm runoff, Overflow.
Identifiers: *Rubber storage containers, *Anacostia River.

Two large 100,000 gallon tanks of nylon-impregnated rubber have been anchored in metal cradles on the bottom of the Anacostia River. During rainfall the tanks are used to hold overflow and later, when the water has receded, the tanks are emptied and their contents pumped easily to the sewage treatment plant. These tanks have also been used for holding fuel, water, oil, beer, and wine.

018
REMOTE-CONTROL 'MINI-DAMS' GUARD MINNEAPOLIS SEWERS,

Munic Eng, London, Vol 146, p 358, 1969.

Descriptors: *Construction materials, Overflow, Outlets, Water pollution control, Mississippi River.
Identifiers: *Minneapolis-St. Paul, Rubber storage containers, Storm sewage.

A description is given of the installation of inflatable bags of rubberized fabric at the outlet points of the storm-sewage overflows serving Minneapolis and St. Paul, Minn. The bags, which were installed to reduce pollution of the Mississippi River during storms, can be inflated by remote control to provide dams varying in height, thereby at any time diverting as much storm sewage into the interceptor sewers as the treatment works can accept.

019
ISLAND CITY SOLVES TOUGH SEWERAGE PROBLEM,

Public Works, Vol 101, No 2, p 95, Feb 1970.

Descriptors: *Sewers, *Steel pipes, *Design, Construction costs, Construction equipment, Infiltration.
Identifiers: *Galveston, Texas, *Truss pipe.

By using Armco Steel Corporation's double-walled Truss pipe, a groundwater infiltration problem was eliminated from Galveston's sewer system. The Truss pipe can also be easily tapped for house connections, and its low infiltration specifications make possible an economical design for factory-built treatment plants. Construction costs for such plants are included, as well as dimensions of the extra-strength piping.

020
CONSTRUCTION COST REQUIREMENTS FOR WATER AND WASTEWATER FACILITIES,

Public Works, Vol 98, No 12, pp 112-113, Dec 1967.

Descriptors: *Cost analysis, Waste water treatment.
Identifiers: *Wastewater facilities.

The Business Defense Services Administration surveyed 1200 major water utilities in order to predict the construction cost requirements for water and wastewater facilities. The forecasted average annual expenditure over the 14-year period (1967-1980) showed a 139% increase over annual amounts for the past 12 years. These expenses result from the need to remedy present defects, to account for depreciation and obsolescence, and to counter the demands of an increasing population. Data included indicating costs required for various types of water supply and wastewater utilities in addition to amounts to be spent to combat individual problems can serve to guide manufacturers in planning future construction.

021
INTERNATIONAL BUILDING EXHIBITION - OLYMPIA LONDON 13-25 NOVEMBER 1969,

Surveyor, Vol 84, No 4039, pp 54, 74, 77, Nov 7, 1969. 3 fig.

Descriptors: *Plastic pipes, *Rain gages, *Design criteria, *Construction materials, *Underground structures, Flow rates, Drainage systems, Equipment, Plastics.
Identifiers: *Great Britain.

This article reviews exhibitions of products, equipment, materials, and techniques at the International Building Exhibition at Olympia, London. A new square-line instead of round rainwater gutter system of plastic was displayed, in addition to a squareflow rainwater gage. Both have greater flow capacity than their traditional counterparts. A new drainage system exhibited has the following features: simplicity of layout and specification, push jointing of pipes, fittings, and plumbing connections, and fast laying speed. A domestic underground stormwater drain using plastic Polydrain PVC pipe was demonstrated; this material is now being employed extensively for underground drainage systems.

022
SEWERS UNDER ATTACK,

Surveyor, Vol 85, No 4048, p 38, Jan 9, 1970. 2 fig.

Descriptors: *Construction, *Construction materials, *Sewers, *Pipes, *Installation, Cements.
Identifiers: *Great Britain.

Doncaster sewers were improved once in 1956, but in 1966 a major reconstruction of the pipes was necessitated due to corrosion by sulfuric acid produced by bacterial action. Adjacent to the old sewer, the new sewer was constructed in the material most resistant and readily available, namely, bitumen-coated asbestos-cement. Procedures followed for construction and installation of the pipes is described.

023
PUBLIC WORKS EXHIBITION PREVIEW,

Surveyor, Vol 82, No 3988, pp 82, 130, 135, Nov 9, 1968. 5 fig.

Descriptors: *Construction materials, *Construction equipment, *Drainage systems, *Underground structures, Sewerage, Plastic pipes, Pipes.

Among the previewed exhibits of the Public Works and Municipal Services Exhibition were Metrex sewage and drainage and rigid PVC rainwater systems, a large range of PVC pressure pipe, examples of asbestos-cement pressure pipes, Polydrain PVC underground drainage systems, and plastic pipes. The PVC pressure pipes had a push type Z joint with a lip rubber seal. This joint, which is easy and quick to assemble, had been made practicable for pressure mains of large diameters up to 18 inches. The asbestos-cement pipe display showed not only new pipes but also old, well-preserved pipe that had lain in the soil for many years. One exhibit demonstrated the economy gained in cost, labor, weight, and maintenance when using plastic pipes and systems.

024
DRAINAGE AND TREATMENT,

Surveyor, Vol 82, No 3988, p 150, Nov 9, 1968. 1 fig.

Descriptors: *Piping, Pipes, *Linings, Drainage engineering, Drainage systems, Plastic pipes, Sewers.

This brief review of recent advances and contracts in drainage and treatment includes a description of a new continuous length land drainage piping made from rigid unplasticised PVC which can be laid by mole-ploughing with backfill fed into the trench via a hopper above the plough. Also described is a new inexpensive method for relining sewer pipes using a sectioned plastics pipe, and a contract for a new £1½ million, mile-long trunk sewer.

025
COMBINED SEWER SOLUTION SOUGHT IN SANDUSKY FIELD DEMONSTRATION,

Water Sewage Works, Vol 116, No 10, pp 386-387, Oct 1969.

Descriptors: *Overflow, *Construction materials, Storm runoff.
Identifiers: *Storm overflows, Rubber storage containers, Storm tank, Sandusky, Ohio.

The use of flexible rubber containers for off-shore underwater temporary storage of storm overflow from a combined sewer has been proposed for the Sandusky Bay area as the answer to its storm overflow problems. The containers are predicted to temporarily hold overflows equivalent to a one-year storm. When the plant can handle the excess, the contents of the containers are pumped back to the plant where the sewage is treated and piped into the bay.

026
SEWER IMPROVEMENTS CALL FOR TRUNK,

Water Sewage Works, Vol 116, No 10, pp 406-407, Oct 1969. 3 fig.

Descriptors: *Construction materials, *Pipelines, *Installation, Infiltration.
Identifiers: *Asbestos-cement piping, *Palo Alto, California.

Asbestos-cement piping was installed in Palo Alto when urban growth caused an increase in sewer problems and demands. Because a large portion of the pipe had to be laid below the water table level, city engineers considered endurance, infiltration factors, and a construction course in deciding upon materials for the sewers. Steps in the installation procedure were outlined. Prior to final acceptance of this trunk line, tests were performed, and no infiltration was found. Dimensions are listed for amounts used of each type of asbestos-cement piping in the three-mile project.

027
LASER BEAM AND POWDER-ACTUATED TOOL SPEED PIPE LAYING,

Water Sewage Works, Vol 115, No 12, pp 574-578, Dec 1968.

Descriptors: *Installation, *Construction equipment, *Application methods, Sewers.
Identifiers: *Laser beam, Laser kit.

A new laser beam-aligner system, which includes a powder-actuated fastening tool as basic hardware, is enabling contractors to complete sewage installations at least 35% faster and with virtually 100% accuracy. Basic kit and hardware can meet more than 95% of requirements for average storm and sanitary sewer contracting job. Laser kit is designed for application with precast manhole with concrete base, concrete base without precast manhole, or simple bottom-of-the-ditch installation without concrete base. It is accurate in uphill or downhill alignments.

028
ALUMINUM PIPELINE FOR SEA OUTFALL SEWER,

Water Waste Treat, Vol 12, No 11, p 361, Jan/Feb 1970.

Descriptors: *Aluminum, *Pipelines, *Installation, *Construction equipment, *Construction materials, Outfall.
Identifiers: *Great Britain, *Trestles.

A welded aluminum pipeline has been used to extend a sea outfall sewer at Anglesey. Aluminum was selected because of its weight, corrosive nonliability, strength, and resistance to seawater and domestic sewage. The pipeline was assembled progressively by bolting the flanged ends of the 100-foot pieces underwater. The aluminum trestles, to support the pipeline, and the method of installation are described.

029
SUSPENDED SEWAGE PIPELINE,

Water Waste Treat, Vol 12, No 8, p 256, Jul/Aug 1969.

Descriptors: *Construction equipment, *Installation, *Pipelines.
Identifiers: *Great Britain, *Suspended pipeline.

By the use of Hepworth-Polva pvc pipe with flexible couplings, a 12-inch diameter sewage pumping main has been suspended from a bridge (which crosses the River Tay) on fabricated metal brackets which allow for pipe movement arising from thermal expansion and contraction of the pipeline. The method of suspension allows for leveling, and the completed pipeline has an insulating wrapping. The installation also has advantages over traditional materials in that the pipeline is light in weight, immune to corrosion, and requires no maintenance.

030
STORM WATER STORAGE SCHEME,

Water Waste Treat, Vol 12, No 7, p 221, May/Jun 1969.

Descriptors: *Construction materials, *Storm runoff.
Identifiers: *Rubber storage containers, *Storm overflows, *Sandusky, Ohio, Storm sewage.

A pilot project to study the storage of storm sewage from combined sewers at Sandusky, Ohio, is described. Two 100,000 gallon collapsible fabric-reinforced rubber tanks have been installed on the bottom of Sandusky Bay; the tanks will fill by gravity and will temporarily store overflows equivalent to a 1-year storm on a small area. Subsequently the storm sewage will be pumped to the works for treatment and discharged to the bay between storms.

031
TRENCHLESS PIPELAYING DEMONSTRATED,

Water Waste Treat, Vol 12, No 2, p 71, Jul/Aug 1968.

Descriptors: *Tunneling machines.
Identifiers: *Great Britain, *Badger Major.

The Badger Major, a trenchless pipelaying machine, has been designed to revolutionize the laying and ducting of plastic pipes, pvc pipes, and cables in all types of soil and climatic conditions for water supply, sewage, land drainage, etc. The Badger Major works on a trenchless principle, passing through the ground a narrow blade with specially designed expanders at its base to create a smooth tunnel for the pipe. The control of the machine is fully automated by the use of an infra-red light beam and hydraulic systems engineering. The system gives a working range of 2000 feet; accuracies of ±½ inch vertically and ± 3 inches laterally are achieved.

032
GALVANIZED BETH-CU-LOY STEEL SHEETS - FOR CULVERT PIPE AND UNDERDRAINS,

Bethcon Galvanized Steel Sheets, Bethlehem Steel, Bethlehem, Pa., Booklet 1956, pp 13-14. 2 fig.

Descriptors: *Steel, *Fabrication, *Construction materials.
Identifiers: *Beth-Cu-Loy.

Beth-Cu-Loy is Bethlehem's trade name for steel which has a small amount (.2 to .3 percent) of copper added to it for resistance to corrosion. When given a 2-oz coating of zinc, and then corrugated, these steel sheets form ideal materials for fabrication of culvert and drainage structures. Bethlehem manufactures culvert sheets for fabricators who form them into culverts and underdrains. Dimensions available are given along with advantages of the materials used, such as their strength and their light weight.

033
CORRUGATED STEEL PIPE STORM SEWERS,

National Corrugated Steel Pipe Assoc, Schiller Park, Illinois, Booklet STM 168, 32 p.

Descriptors: *Construction materials, *Steel, *Culverts, *Design, *Steel pipes, *Construction equipment, Installation, Data collections, Design standards.
Identifiers: *Storm sewers.

Corrugated steel is the accustomed material used in urban areas for culverts and storm sewers which form a part of Interstate highway construction. This technical manual provides information needed for the design of storm sewers which differ from culverts in details of hydraulics and fittings. The use of corrugated steel pipe insures that the following essentials will be provided: (1) strength, (2) positive couplings, (3) long service life, (4) unchanging hydraulic properties, (5) versatile fittings, and (6) proved materials. Each of these factors is demonstrated in corrugated steel pipe storm sewers. Product details are discussed, including sizes and details of the pipe and pipe-arch; couplers and fittings; and bituminous protective coatings. Technical data explained include: hydraulics and the determination of size, Manning charts, structural design, the height of cover tables, and service life design. Also described are techniques for installation and specifications for materials, fabrication, workmanship and finish, and inspection.

034
TANKS,

Owens-Corning Fiberglas Corp, Toledo, Ohio, Publ No 1-PE-3578-F, June 1970. 8 p.

Descriptors: *Storage tanks, *Construction materials, *Construction equipment, *Design, *Plastics, Treatment facilities.
Identifiers: *Fiberglas reinforced plastics.

The combined Fiberglas reinforced plastics have been utilized for years in demanding applications because of their chemical and electrolytic corrosion resistance and structural stability. The process industry uses these plastics for chemical storage tanks, gathering lines, salt water injection, and disposal oil well tubing. A detailed description of the design and manufacturing of Fiberglas Reinforced Plastic (FRP) storage tanks is included. Applications for this type of non-corrosive tank are mentioned with special reference to the use of Fiberglas tanks in providing the most economical solution to severe corrosive problems in holding, treating, and settling tanks.

035
CONTROL OF POLLUTION BY UNDERWATER STORAGE; Feasibility of Providing Temporary Underwater Storage of Storm Overflow from a Combined Sewer System,

Underwater Storage, Inc., Water Pollution Control Research Series, DAST 29, 161 p, Dec 1969. 9 tab, 56 fig, 12 ref.

Descriptors: *Pumped storage, *Waste storage, *Waste water treatment, *Overflow, Water pollution control, Laboratory tests, Storage tanks, Costs, Storm runoff, Estimated costs.
Identifiers: *Storm overflows, *Combined sewers, *Rubber storage containers, *Washington, D.C.

A pilot plant was designed, constructed and operated to assess the feasibility of providing a facility for the collection, treatment, storage and final disposition of a portion of the storm overflow from a combined sewer system serving a thirty-acre drainage area in Washington, D.C. A Parshall flume was installed in the overflow line for measurement of flow rates and determination of total overflow volume. A portion of the overflow was diverted to the pilot plant through grit chambers and a comminutor. Flow was stored in two 100,000-gallon underwater bags fabricated of nylon reinforced synthetic rubber and fastened to the river bed by a system of patented anchors. During the period of storage, compressed air was delivered to the tanks for agitation of the solids. Following cessation of the storm, contents of the bags were pumped to the interceptor sewer for delivery to the District of Columbia Sewage Treatment Plant at Blue Plains. Flow into and out of each underwater storage tank was metered and recorded. Samples of the combined sewage overflow discharged to the bags and pumped discharge from the bags were collected and subjected to laboratory analyses. During the operation period from January through September, 1969, a total of 1,600,000-gallons of diverted overflow from 38-storms was stored in the tanks. In addition, 600,000-gallons of river water was pumped into the underwater storage tanks for testing during dry weather periods. The total amount stored was pumped to the interceptor sewer in 26-separate pump out periods. The cost of the pilot plant was $341,480.00, or $1.70 per gallon of storage. This included facilities for testing, samples and flow measurement. Estimates for larger installations, without these special requirements range from 28.2 cents to 14.6 cents per gallon for plants with storage from two to twenty million gallons. The project demonstrated that temporary storage of overflow from combined sewers in underwater rubber storage tanks is feasible and may, under suitable conditions, be effective in eliminating direct, untreated discharge of combined sewage into surface waters during storm periods.

036
IMPROVED SEALANTS FOR INFILTRATION CONTROL; The Development and Demonstration of Materials to Reduce or Eliminate Water Infiltration Into Sewage,
Western Company of North America

Prepared for FWPCA, Program No 11020 DIH, Contract No 14-12-146, June 1969. 95 p.

Descriptors: *Evaluation, *Sealants, *Materials testing, *Sewers, *Cost analysis, *Leakage, Specifications, Infiltration, Comparative costs, Equipment.
Identifiers: *Cost-effectiveness analysis, *Infiltration control, *Sewer linings.

The objective of this program was to develop new, more effective sealants for sewer line leaks. This purpose was achieved, and all equipments and materials investigated, tested, or compared are presented, along with test results, supporting data, conclusions, and recommendations. Candidate materials were surveyed and weaknesses of rejected materials were noted. Specific properties of acceptable materials were ascertained, and materials having these properties were identified and subjected to tests designed to demonstrate their effectiveness as sealants. It was concluded that infiltration adversely influences sewer system operating costs and effectiveness, and that leakage repair systems are limited in their effectiveness. No significant cost increase beyond that experienced with present sealers was indicated. Some present sealant application equipment can be modified for use with the new materials, but new equipment designs are described and recommended.

037
MAIN DRAINAGE,

T. A. Anderson
Surveyor, Vol 83, No 4010, pp 92-94, Apr 18, 1969. 6 fig.

Descriptors: *Sewers, *Construction, Tunneling, Geomorphology, Installation, Legal aspects.
Identifiers: *Construction problems, *Sewer construction, *Scotland.

The author describes several sewer jobs he undertook as a Resident Engineer in the Glasgow Office of Public Works. One job entailed the construction of a two-mile main duplicate sewer in Rutherglen. Problems arising due to encounters with varying types of ground are related and measures taken explained. As a result of high pressure, escapes of air (blow-outs) occurred on a nearby railway line. Tunneling was halted until a tunnel shield was installed which helped complete the job. Other construction problems relating to sewer jobs are discussed. Interference with Glasgow parking areas due to sewer construction was solved through the institution of a program of conversion of open spaces to off-street car parks. In conclusion, the author recommends the establishment of regional sewerage authorities similar in organization to Scotland's Water Board, plus the formation of drainage boundaries on a topographical rather than a parochial basis.

038
COMPUTERS IN HONG KONG PUBLIC WORKS,

A. T. Armstrong-Wright
Surveyor, Vol 84, No 4029, pp 34-39, Aug 22, 1969. 12 fig.

Descriptors: *Computers, *Computer programs, *Project planning, Highways, Water supply, Expenditures, Sewage disposal, Design, Hydrologic data.

This article describes applications of electronic computers to public works projects in Hong Kong. Their feasibility is obvious due to their speed and accuracy. Applications of computers are discussed for the following areas: project scheduling; highways (road alignment, flyover beam design, pile loading and setting-out road curves and flyovers); water supply (hydrologic data, dam stability analyses, flood balancing reservoirs, yield of water supply schemes, operation of reservoirs, and project appraisal); and expenditure control. In the area of sewage disposal, computers aid in developing suitable designs for multi-port diffusers on ends of submarine outfalls. Computers also process hydrologic data which engineers use in water management and operation of existing facilities. The author concludes that as time progresses, increased use will be made of computers, not only in sophisticated studies but also in day-to-day operations.

039
PROFESSIONALISM AND WATER POLLUTION CONTROL IN GREATER CHICAGO,

Vinton W. Bacon and Frank E. Dalton
J Water Pollution Control Fed, Vol 40, No 9, pp 1586-1600, Sep 1968.

Descriptors: *Overflow, *Construction materials, Storm runoff.
Identifiers: *Storm overflows, Rubber storage containers, Storm tank.

Rubberized fabric tanks are under construction along Lake Erie at Sandusky, Ohio to solve the pollution problem resulting from combined sewer overflows. The tanks will be submerged underwater to store sewage during storm periods. The sewage will be pumped back to treatment plants during normal flow periods. The tanks are designed to hold overflows of a one-year storm.

040
PLASTICS IN WATER AND SEWAGE CONTROL,

C. A. J. Benfield
Surveyor, Vol 85, No 4048, p 2, Jan 9, 1970.

Descriptors: *Construction materials, *Design criteria, *Plastics.
Identifiers: *Polyester resins.

In this letter to the editor, the author attempts to clarify the original article's reference to inadequacies of glass fiber reinforced polyester resin (RP) when submersed in water. He notes that considerable research has shown raw materials in the form of improved polyester resins, glass sizes, and fabricating processes to permit application of RP in environments of total immersion in water. Practical experience has demonstrated that by considering certain design criteria, RP laminates can be and are being used in the water and sewage control industry. The author also suggests that "case histories", written by users of plastics components, be published in the journal in order to promote dissemination of design and performance data within the water purification industry, as was recommended in the original article.

041
STRUCTURES PREVENT URBAN SEDIMENT DAMAGE,

Stephen M. Boysen
Public Works, Vol 100, No 8, pp 116-117, Aug 1969. 3 fig.

Descriptors: *Design, *Construction, *Settling basins, *Storm runoff, Performance, Operations research, Sediment control.

District of Columbia area engineers and the USCA Soil Conservation Service jointly worked to improve sediment basin design. These basins prevent damages originating from soils disturbed by intensive construction. Their purpose is to trap eroding soil and keep it on or near its original site while earth-movers do grading for new developments. These structures are temporary, but they protect stream-channels, impoundments, roads, etc. from damaging sediment. A typical sediment basin holds ponded runoff from which soil particles settle as water passes slowly into a vertical drain shortly after a heavy rain. Details regarding construction and performance are discussed. The fundamental design problem of striking a balance between detention time and economical basin size is also explored. Effectiveness of these basins is proven by the increasing number of counties employing the structures in the metropolitan Washington and Baltimore areas.

042
PLASTIC RELINING OF SMALL-DIAMETER PIPES,

Raymond M. Bremver
J Sanit Eng Div, Am Soc Civil Engrs, Vol 96, No SA2, pp 297-317, Apr 1970.

Descriptors: *Storm drains, *Sewerage, Pipes.
Identifiers: *Toronto, *Storm sewers, *Combined sewers, Plastic pipes, Capacity.

The combined sewer system of the city of Toronto measures approximately 933 miles. In 1965, a 25 year staged and planned program for installing new storm sewers at a net cost of $154 million was instituted as a result of the hydraulic inadequacies of the then existing system. A chart showing the inventory results concerning the sewer system is given. The surcharge amount on water bills is explained and the common defects in the existing sewers are discussed. A detailed report on the method of relining the existing sewers, which involves the insertion of high density plastic pipes into the sewers and the connecting of all private and catch basin drains into the plastic conduit, is given. The effect of relining on hydraulic capacity is explained.

043
INSTALLATION OF SOIL, WASTE AND DRAINAGE PIPING IN FILL OR UNSTABLE SOIL,

T. Cecil Brown
Water Sewage Works -- Reference Number, pp R-47 to R-50, Nov 28, 1969.

Descriptors: *Installation, *Sewers, *Drainage engineering, *Costs, Subsurface runoff, Infiltration.

Drainage lines, which can be sanitary, storm or combined sewers, should be well designed and constructed, properly supervised during construction, and closely inspected. Recommendations are made in this article to facilitate compliance with these objectives. Sewer installation is described in terms of considerations to be made regarding the filled area. Cost criteria are also discussed. Economy is not always limited to the selection of the least expensive materials because cheaper material may prove to be the most expensive to the taxpayer in the long run. Infiltration and joint failure are treated briefly with recommendations for tight joints and for the prevention of stormwater entrance into sanitary sewers.

044
PLASTICS IN WATER AND SEWAGE CONTROL,

G. M. Cave
Surveyor, Vol 84, No 4041, p 44, Nov 21, 1969. 1 fig.

Descriptors: *Plastics, *Flow control, *Control systems, *Construction materials, *Equipment.

Rigid plastics, able to provide structural as well as protective functions, are suggested for use in fluid control equipment such as valves, penstocks, sluice gates, etc. Improvements made in plastics over the years are noted, and requirements needed for introducing the materials to industry are listed. Also listed are advantages of a well-designed plastic penstock compared to a conventional unit in cast iron, with copper-alloy sealing and bearing surfaces. Benefits of these modern materials cannot be realized until they are employed to a greater extent by civil engineering contractors and by engineers in the water purification industry.

045
SCRAPER PRODUCTION SPEEDS PIPE TRENCHING AT LOWER COSTS,

William Donnely
Construct Methods Equip, Vol 51, No 8, pp 38-41, Aug 1969.

Descriptors: *Trenches, *Excavation, *Backfill, *Construction equip-

ment, Comparative costs, Comparative productivity, Linings.
Identifiers: *Scraper.

Extra-wide slots for pipes were opened by scrapers thus adding width that provides operating room for direct machine excavating and backfilling and eliminates any hand shoveling. With this method, the scrapers complete the trenching and backfilling 50% faster with an overall saving of some 20% in total labor costs. Before pipes are placed the trench receives a 2-inch layer of leveling sand followed by a plywood screed creating a contoured bed in the sand for the pipe. A detailed description of the equipment used in the trenching is included.

046
A GUIDE FOR CONTRACTORS ON THE CONSTRUCTION OF DRAINAGE SYSTEMS,

A Drechsel
Ber Abwassertech Ver (BABVAD), No 17, pp 123-131, 1964.

Descriptors: *Hydrogeology, *Drainage patterns (geologic), *Drainage engineering.
Identifiers: *Drain pipes, Storm sewers.

The author stresses the importance of preliminary hydrogeological investigations and studies on flow conditions of the area where a drainage system is to be installed. He then deals with the design, construction, materials, and equipment which should be used where drain pipes are required for ordinary drainage systems and/or storm-sewage systems.

047
ANGLESEY ALUMINUM SEA OUTFALL,

Bruce Dumbleton
Surveyor, Vol 85, No 4049, pp 22-25, Jan 16, 1970. 5 fig.

Descriptors: *Outlets, *Methodology, *Aluminum, *Construction materials, *Construction.
Identifiers: *Great Britain.

Decisions and procedures involved in constructing an aluminum sea outfall extension are reviewed. Methods employed for determining the following factors are discussed: length of the extension, material selection, the method of support, construction and launching procedures. Although extension of the outfall presented many constructional problems, its cost was less than for any alternate scheme involving sewage treatment. A significant feature of the construction process was that work took place from a ten-man inflatable craft with heavy materials towed into position using buoyancy tanks.

048
RUBBER TANKS AID SEWAGE FIGHT,

Jonathan Eberhart
Sci News, Vol 94, No 5, p 115, Aug 3, 1968.

Descriptors: *Construction materials, *Construction costs, Storm runoff, Overflow.
Identifiers: *Storm overflows, Rubber storage containers, Washington D.C.

In Washington D.C.'s Anacostia River, a new technique is being tried to eliminate pollution of the river caused by sewage overflows during severe rainstorms. This new method is less expensive than Chicago's underground sewer project which will cost almost $15 million for the pilot project and more than $2 billion for city-wide installation. In Washington, large rubber tanks will be anchored beneath the surface of the Anacostia. Stormwater and sewage overflow will be diverted to these tanks and stored there until the water has receded, and the tanks' contents can be pumped to the nearby sewage treatment plant.

049
GLASS FIBER-REINFORCED PLASTICS PIPES FOR WATER PIPELINES,

E. Faust
Kunststoffe-Plastics (KUPLAK), Vol 15, No 6, pp 191-193, 1968.

Descriptors: *Pipelines, *Plastics, Construction equipment, Sewers.
Identifiers: *Fiberglass pipe.

Glass fiber-reinforced plastics pipes for water pipelines and sewer pipe systems are described. The technical and economic advantages of applications of plastics in sewer pipes are detailed. Requirements that must be taken into account in selecting proper plastics for special purposes with regard to the use of a glass reinforced polyester pipe are mentioned. The properties and performances of the pipe made by filament winding and centrifugal casting techniques are listed, and the comparison of the production method by filament winding with that by centrifugal casting is examined.

050
STABILIZED BASE FOR RESIDENTIAL STREETS,

W. J. Gallup
Civil Eng, Vol 39, No 5, pp 40-42, May 1969.

Descriptors: *Design, *Construction materials, *Illinois, Cements, Construction equipment.

A public works project devised to improve streets and drainage in Stickney Township, Ill. is described. For street improvements, soil cement was used to stabilize bases when streets were covered with 2 in. of asphalt. Depending on the conditions in a particular area, a contractor would either set up a central-mix plant to process base material or would mix it in place. Excavation for the central-mix operation was done with a track-type end loader, a motor grader and dump trucks. Equipment as well as self-loading scrapers were used for in-place processing.

051
CATAD SYSTEM CONTROLS FOR REGULATION OF COMBINED SEWAGE FLOWS,

Charles V. Gibbs and Stuart M. Alexander
Water Wastes Eng, p 46-49, Aug 1969. 2 fig.

Descriptors: *Mathematical models, *Computer programs, *Sewers, *Storage capacity, *Storm runoff, Sewage disposal, Municipal wastes, Automatic control, Hydrologic properties.
Identifiers: Combined sewers.

The installation of a computer-augmented treatment and disposal (CATAD) system to utilize optimum storage within an existing municipal combined sewer system was described. The other objectives of CATAD were: (1) to make available the maximum capacity of the interceptor for combined storm and sanitary flows in unseparated areas by utilizing the storage capability of trunk and interceptor sewers in separated areas; and (2) to control necessary overflows at selected locations so as to minimize harmful effects on marine life and public beaches. Control commands were generated internally by a computer under program control. A mathematical model was developed in order to implement a fully automatic control. The model incorporated elements of meteorology and hydrology including seasonal precipitation patterns and area runoff characteristics. An analysis of the regulation of stormwater inflows by the use of trunk sewer storage established the operating rules required for effective utilization of the available storage.

052
THE LE ACOUSTIC FLOWMETER - AN APPLICATION TO DISCHARGE MEASUREMENT,

C. R. Hastings
J Water Works Assoc, Vol 84, No 2, pp 127-151, Jun 1970.

Descriptors: *Flowmeters, *Discharge measurement, *Hydraulics, *Instrumentation, Testing.

A variety of discharge measurement devices have been invented of which a flow measuring system using the LE Flowmeter is the most recent system to substantially advance the art. The concept employed is an application of numerical integration by Gaussian Quadrature. Test results under varying conditions of fully developed and distorted flow show that this measurement system has an rms accuracy better than 1.0 percent. Use of the LE Acoustic Flowmeter gives this flow measuring system features not possessed by other devices, such as linearity, bidirectionality, no head loss, and no need for calibration.

053
REHABILITATION OF A CONCRETE SEWER UNDER INFILTRATION PRESSURE,

Harold H. Haugh
Public Works, Vol 100, No 7, pp 89-90, Jul 1969.

Descriptors: *Concrete additives, Concrete technology, Sewers.
Identifiers: Coating method.

The successful conversion of a storm sewer into a sanitary sewer in Albert Lea, Minnesota is discussed. It was necessary to apply Cital-Aquacoat as a coating on the wet surface of the concrete sewer, which was under hydrostatic head conditions, in order to give the required protection.

054
A GENERAL REVIEW OF CONTINUOUS WATER QUALITY ANALYSIS INSTRUMENTATION,

Robert H. Jones
Beckman Instruments, Inc. Process Instruments Division, Fullerton, Calif. 15 p.

Descriptors: *Instrumentation, *Monitoring, *Water quality.
Identifiers: *Water quality monitor.

Beckman Instruments, Inc. offers a multi-parameter Water Quality Monitor for continuous measurement of: disolved oxygen, temperature, pH, chloride ion, turbidity, oxidation-reduction potential, sunlight radiation intensity and conductivity. The new instrument features sensors which improve reliability of continuous monitoring while reducing maintenance requirements. This instrument is compatible with conventional forms of transmission and data handling. Pollutants in water such as silt, slimes, soluble and suspended solids, and algae coat and contaminate sensing elements. This paper explains Beckman's approach to this problem of continuous water quality monitoring.

055
ACCURATE SMALL ORIFICE RAIN GAGE,

J. D. Kalma, J. Lomas, M. Thaller, and Y. Shashoua
Water Resources Res, Vol 5, No 1, pp 300-305, Feb 1969.

Descriptors: *Rain gages, *Instrumentation.
Identifiers: *Small-orifice rain gage.

An accurate, inexpensive, small-orifice rain gage with an orifice diameter of 29.2 mm was developed for use in rainfall networks and in agrometeorological and hydrological studies. It has a large capacity and can be installed and read easily. In comparison with standard rain gages, the small-orifice rain gage showed good agreement under various conditions of exposure and with different observation techniques.

056

DEVELOP AND FIELD TEST METHOD OF INSTALLING PRESSURE CONDUITS IN COMBINED SEWERS.

Henry J. Kazienko

Combined Sewer Separation Project, Johns-Manville R and D Center, Dec 30, 1968. 38 p, 15 fig, 9 tab. FWPCA Program No 11020 EKO.

Descriptors: *Design, *On-site-tests, Epoxy resins, Pressure conduits.
Identifiers: *Development, *Polyester conduit hanger, Allowable load, Combined sewers.

This report describes laboratory development and testing of polyester molded hangers cemented to a sewer pipe crown. Polyester hanger material formulations, epoxy cement, and hanger dimensions are specified, and methods of installation are given in detail. Test of the hanger to failure in the laboratory showed fracture in tension through the conduit ring, leaving the upper part bonded to the concrete sewer crown. The field installation of 100-ft. of 3-in. diameter PVC pipe filled with water was made in a 7-ft. sewer in Evanston, Ill., in cooperation with the Metropolitan Sanitary District of Greater Chicago. The installation was sound and unaffected when removed after 4½ months.

057

WATER POLLUTION CONTROL. 5 BILLION DOLLARS TAB,

C. Laverty
Rubber World, Vol 160, No 1, pp 48-49, Apr 1969.

Descriptors: *Rubber, *Biocontrol, Water pollution control, Construction materials.
Identifiers: *Rubber storage containers, Rubber gates, Acid-resistant hose.

A summary is given of various uses of rubber for combatting water pollution. Chunks or strips of rubber compounds containing relatively insoluble organo-metallic compounds or alkanolamine salts of salicylanilides as toxicants are dropped into contaminated water for biocidal action lasting one year or more. Other antipollution methods employ: giant (100,000 gal) rubberized Pillow tanks, used as temporary storage for sewage overflow triggered by heavy rains; nylon-reinforced polychloroprene Fabridam rubber gates for storm control; and acid-resistant hose, for carrying pickle liquor to storage tanks for treatment and ultimate disposal in underground sandstone reservoir.

058
PROBLEM OF FLOOD-CONTROL IN SMALL BASINS,

G. Lombardo
Giorn Genio Civile (GIGCAO), Vol 106, No 2-3, pp 110-115, Feb-Mar 1968.
Descriptors: *Computer programs, *Flood control, *Data storage and retrieval.
Identifiers: *Rainfall analysis.

The study of possible utilization of a computer for control of floods in small basins, with revised methods and procedures for gathering and elaborating hydrological data is examined. The procedure for rapid calculation of a rainfall graph and for obtaining flow regime from rainfall characteristics in absence of analytical relation of hydrology is explained.

059
LOW-PRESSURE AIR TESTS FOR SEWER LINES,

W. J. Malcolm
Am City, Vol 84, No 11, pp 74-75, Nov 1969. 2 diag.

Descriptors: *Testing, *Sewers, *Infiltration, Leakage.
Identifiers: *Sewer lines, *Air-testing.

New wastewater lines can be tested for leakage or exfiltration either by the common method of water pressure or by low-pressure air, a method becoming more popular. Such testing is imperative since if there is no exfiltration, neither will there be infiltration. A tight sewer line lowers the volume flowing into lines and treatment plants., thus, pumping and treatment costs are lowered, and less flooding occurs. The author presents eight frequently-asked questions concerning air testing, and he answers the questions briefly.

060
FIBERGLASS WINS PIPELINE,

William Marquardt
Water Sewage Works, Vol 116, No 6, pp 228-229, Jun 1969. 3 fig.

Descriptors: *Bids, *Piping systems (mechanical), Construction materials, Comparative costs.
Identifiers: *Fiberglass pipe, *San Francisco.

Corrosion resistant fiberglass was chosen over a cement-mortar lined steel pipe in competitive bidding for the replacement of a corroded waste return piping system in the San Francisco area. The fiberglass pipe weighed one-tenth of the weight of the cement-lined steel pipe, and the cost of the fiberglass pipe was $5 per foot less. Hydrogen sulfide caused leakage of the original pipe by penetrating the cement lining and steel wall at the welded seams. Three types of fiberglass reinforced plastic (FRP) were used in constructing various parts of the waste return piping system. Dimensions and descriptions of the three pipe types are given, and installation methods are also discussed. Alternate materials investigated and rejected were: cement-lined steel, cement-lined cast iron, asbestos cement, plastic protected metal (IPM), reinforced concrete, glass or glass-lined pipe, uncoated steel or cast iron, epoxy-coated steel, and vitrified clay pipe. Reasons for rejecting these materials were given.

061
SEWERS UNDER ATTACK,

G. L. Marsden-Jones and J. A. Foster
Surveyor, Vol 85, No 4053 and 4055, p 3, Feb 13 and 27, 1970.

Descriptors: *Construction materials, *Pipes, *Concrete pipes, Asbestos cement.
Identifiers: *Sanitary sewers.

G. L. Marsden-Jones: With reference to the article, "Sewers Under Attack" (9 January), he questions whether or not the use of bitumen-coated asbestos pipe implied that concrete could not be used for sanitary sewers. He also wonders if gravel used to surround pipes produces a drainage effect that harms farm land where groundwater is short in supply and, at sewage works, raises groundwater level causing floods. J. A. Foster: In reply to this first question, he notes that only the specific circumstances at Doncaster warranted use of bitumen asbestos-cement pipes and that for most sanitary sewers, concrete is a suitable material. He further explains reasons for Doncaster's use of the unusual material. In answer to the second point, he states that normal practice in waterlogged ground is to supply impervious clay cut-off walls at proper intervals to prevent groundwater movement along pipelines.

062
FLOOD CONTROL DESIGN UTILIZES LARGE ELLIPTICAL PIPE,

Alfred R. Pagen
Public Works, Vol 100, No 12, pp 87-88, Dec 1969.

Descriptors: *Pipes, Installation, Design, Overflow, New Jersey.
Identifiers: *Elliptical pipes.

The use of 72- by 113-inch elliptical reinforced concrete pipes in checking overflows in Woodbridge, New Jersey is discussed. A number of special fittings were designed which included access structures, connections, and horizontal storm drain deflection sections. Cylinder tests and installment difficulties are mentioned.

063
LONG-TIME DRAINAGE PROBLEM IS ELIMINATED,

Alfred R. Pagan
Public Works, Vol 100, No 6, pp 98-99, Jun 1969.

Descriptors: *Drainage engineering, Design storm, Hydraulics, New Jersey
Identifiers: *Pipelines.

The manner in which Demarest, New Jersey solved its drainage problem is discussed. The pipe line has a flow velocity during the design storm of less than 9 feet per second. Calculations indicate that the pipe provides an additional margin of capacity for even greater storms. Costs, contractors, and unforeseen complications are discussed.

064
INVESTIGATION AND REPAIR OF EXISTING SEWERS,

K. F. Perkins
Water Pollution Control, Vol 107, No 11, pp 32-33, Nov 1969.

Descriptors: *Maintenance, *Instrumentation.
Identifiers: *Sewer inspection.

Various modes of repair and investigation of sewer line flaws are explored including techniques of T.V. and photographic examination. Existed oombined sewer lines are commonly inspected at the time when separate storm sewer lines are about to be installed. This procedure prevents digging into newly resurfaced roads in order to examine sewer lines.

065
STEEL STORM SEWER SAVES MONEY FOR PHOENIX,

Sam A Phillips
Water Wastes Eng, Vol 6, No 4, pp 56-57, Apr 1969.

Descriptors: *Storm drains, *Installation costs, Construction materials, Steel.
Identifiers: *Storm sewers.

In order to fulfill the need for additional storm sewers at the lowest possible cost, the City of Phoenix asked for bids on types of materials which could be used in the construction of an efficient and durable storm drainage system. The city lately installed two such pipelines of asphalt-lined and corrugated, galvanized steel for a cost 20 to 25% below the city engineers' estimate given before other bids were requested. Completed in 1967, these new systems appear completely satisfactory, and their installation was accomplished with greater facility and speed than is usual when materials other than galvanized steel are used.

066
CALCAREOUS PIPE FOR SEWERS,

R. D. Pomeroy
J Water Pollution Control Fed, Vol 41, No 8, pp 1491-1493, Aug 1969.

Descriptors: *Aggregates, *Concrete pipes, *Sewers, *Testing, *Pipes, *Corrosion, Drainage water.
Identifiers: *Pipe materials.

Although the use of calcareous aggregate in the manufacture of concrete pipe for sewers has been advocated for those situations where there is a hazard of mild sulfide conditions, there is a lack of data comparing this material with others. Tests on five 8-inch diameter pipes handling septic wastewater were run for a period of seven years. Results show that the rate of corrosion was inversely proportional to the alkalinity of the pipe materials. The pipe with composition of type II cement plus limestone aggregate had a rate of corrosion approximately one-third as great as the average of the others made without limestone aggregate.

067
INSULATED CO-AXIAL PIPELINES,

J. S. W. Riach
Pipes Pipelines Intern, Vol 13, No 11, pp 27-28, 30, Nov 1968.

Descriptors: *Pipes, *Installation, *Piping systems (mechanical), Drainage.

The installation procedure of a conduit system of inner and outer pipes that is prefabricated off-site in 40 ft lengths together with all elbows, expansion loops, tees, and other special sections is described. It is then delivered to the site for assembly. The annular air space between service pipe insulation and the interior of conduit provides drainage passage for any water which may inadvertently enter the system.

068
HOW TO THINK ABOUT INSTRUMENTATION AND CONTROL,

Martin L. Roth
Calif Water Pollution Control Association, Los Angeles, Bulletin, Vol 6, No 2, pp 12-18, Oct 1969.

Descriptors: *Sewage treatment, *Instrumentation, *Control structures, *Control systems, *Treatment facilities.

Instrumentation and control are defined and applied to a sewage treatment process. Guidelines for operators are directed toward achieving highest efficiency from plant installations.

069
VALUE OF INSTRUMENTATION IN WASTEWATER TREATMENT,

J. J. Salvatorelli
J Water Pollution Control Fed, Vol 40, No 1, pp 101-111, Jan 1968.

Descriptors: *Instrumentation, *Waste water treatment, *Monitoring, *Sewage treatment, Design, Sewers, Operation and maintenance.
Identifiers: *Treatment methods.

Instrumentation can free the wastewater treatment plant operator to concentrate on matters requiring human attention. Mechanical, physical, and chemical processes can be used to monitor a number of systems and treatment programs. One diagram given illustrates a centrally-controlled municipal wastewater system including pump stations, overflow diversion chambers, and a treatment plant. The monitoring system is located on a central instrument panel found in the main administration and control building of the wastewater treatment plant. Costs usually are less than five percent of total project costs.

070
DENSE NETWORK FOR RAPID MEASUREMENT OF RAINFALL RATE,

R. A. Semplak and H. E. Keller
Bell System Tech J, Vol 48, No 6, pp 1745-1756, Jul-Aug 1969.

Descriptors: *Rain gages, *Design, *Data collections, *Rainfall disposition, *Instrumentation, *Measurement.

The design and operation of a dense rain gage system for obtaining statistical data on both the temporal and spatial distribution of heavy rainfall are discussed. This rain gage is a continuous, flow type with a response time of the order of one second. The system used for recording data on a magnetic tape is described, and typical computer-generated rain maps for large area storms and for localized showers are given.

071
MODIFIED TRENCHER SLICES THROUGH FLINT-HARD ROCK,

Lorraine Smith
Construct Methods Equip, Vol 52, No 6, pp 74-78, Jun 1970. 10 fig.

Descriptors: *Rock excavation, *Drilling equipment, *Drainage systems.
Identifiers: *Storm sewers, *Trencher.

A Texas contractor bought a strong stock model trencher and modified it to meet the need for a storm sewer to be cut through hard rock in downtown areas where blasting is forbidden. Major changes in the rig include the addition of three unique features: an adjustable three-part wheel, an hydraulic mast, and an adjustable crumbing shoe. Minor modifications include: converting the mechanical drive train from a 21- to a 42-tooth sprocket to increase torque on the cutting wheel, reinforcing the idler axle, and replacing an 8-foot Jetco arc-type conveyor with the Parsons original. The trencher not only cut through flinty rock, but it kept well ahead of rigs forming the cast-in-place drain.

072
SOME THOUGHTS ON SEWER PIPE BEDDING,

William J. Warwick
Water Pollution Control, Vol 107, No 8, pp 30-31, Aug 1969.

Descriptors: *Pipelines, Design criteria, Installation.
Identifiers: *Sewer pipe bedding.

Important aspects of sewer pipe bedding are explored in the areas of: satisfactory bedding needs, economics of installation, special cases, enforcement of design criteria, and performance. Technical information is lacking concerning the special case of common or separate trenches for side-by-side storm and sanitary sewers or sewer connections. Usually two such pipes are laid in a common trench, but the economics and functional usages may not always warrant this choice. More study is needed to determine the advantages or disadvantages of dual trenches.

073
LOW COST STORM DRAINAGE WITH PAVED CHANNELS,

Clifford Wendell and Robert Emmons
Public Works, Vol 101, No 4, pp 110-111, Apr 1970.

Descriptors: *Drainage systems, Design data, Concrete construction, Storm drains.
Identifiers: *Drainage channels.

Rockford, Illinois realized almost a 45% reduction in costs on its drainage system construction by installing concrete paved drainage channels instead of conventional storm sewer systems. Rainfall-runoff data was utilized in designing the channels for the 50-year frequency storm. This longer frequency design provides more adequate protection from flooding, and the channels still retain their self-cleaning capabilities. Dimensions and design diagrams of the paved drainage channels are given.

074
A CRITICAL REVIEW OF METHODS OF MEASURING DISCHARGE WITHIN A SEWER PIPE,

H. G. Wenzel, Jr.
ASCE Tech Mem No 4, Urban Water Resources Res Program, Sept 1968. 20 p, 2 fig, 2 append. USGS: 14-08-0001-11257.

Descriptors: *Stream gages, *Flow measurement, *Flowmeters, *Closed conduit flow, *Sewers, Venturi meters, Tracers, Radioactivity techniques, Dyes releases, Tracking techniques, Research and development.
Identifiers: Rating curves, Urban hydrology.

Existing methods of measuring discharge of sewers are discussed with respect to the requirements and physical limitations imposed by their use in an urban study area, and rating curves for a suggested critical flow device are presented with recommendations for future research. The gage must have an output in the form of an electrical signal for recording, be automatically turned on and off, and need no attendant. Laboratory velocity probes are unsuitable because of clogging problems. Desired accuracy is 5% in discharge measurement over a large flow range. The device must be capable of installation in any existing sewer at reasonable cost. Weirs, depth gages, and velocity meters, the methods presently available, all have serious disadvantages and are not recommended. Tracer dilution methods as well as Venturi flumes and other critical flow devices are suggested for development. A pipe section with a narrow throat acts as a Venturi flume for open flow and as a Venturi meter for full flow. Plans and theoretical rating curves for such a device are shown.

075
TV INSPECTION AND IN-PLACE GROUTING OF SEWERS,

R H. White
Water Wastes Eng, Vol 5, No 9, pp 72-74, Sep 1968.

Descriptors: *Inspection, *Cost-benefit analysis, *Equipment, Grouting, Sewers.
Identifiers: *Austin, Texas, *Television inspection, sanitary sewers.

Experiences of Austin, Texas, in using television camera inspection and inplace grouting in sewers are reported. The first experience with television inspection was so successful that lines in question were rehabilitated at a cost less than twenty thousand dollars, instead of two hundred and forty thousand dollars as was considered previously. Telespection equipment proved to be durable, and down-time was quite low. Television inspection has forced contractors and other utilities to respect sanitary sewers.

076
OPTIMIZING WASTE TREATMENT CONTROL SYSTEMS,

Ernest T. Williams, Jr.
Paper presented at the Third Annual National Pollution Control Conference and Exposition, April 1-3, 1970, San Francisco, California.

Descriptors: *Instrumentation, *Waste treatment, *Control systems, *Measurement.

As waste treatment and recovery processes become more complex and costly, there is increasing reliance upon instrumentation to assume control responsibility for the most economic and efficient operation. This paper describes the control systems normally used on four applications, and discusses what can be done to optimize performance. The use of dissolved oxygen and sludge density measurement in the activated sludge process is explored. The second application is pH neutralization. Feedforward control and the nonlinear controller have dramatically improved neutralization performance. Improvements are also suggested in the control schemes of chromate waste and cyanide waste treatment processes.

Section 2

OVERFLOWS AND REGULATION DEVICES

077
CLEANING OUR ENVIRONMENT-THE CHEMICAL BASIS FOR ACTION: SECTION 2 - THE WATER ENVIRONMENT: MUNICIPAL WASTE WATER TREATMENT,

Subcommittee on Environmental Improvement, Committee on Chemistry and Public Affairs American Chemical Society, pp 106-122, 1969. 2 fig, 4 tab.

Descriptors: *Waste water treatment, *Overflow, *Storm runoff, *Flocculation, *Treatment facilities, *Water reuse, Sewage treatment, Storage tanks, Underground storage.
Identifiers: *Combined sewers, *Stormwater quality.

This subsection discusses existing processes, recent advances, and current problems relating to municipal wastewater treatment. Urban stormwater problems from combined sewer overflows are explained, and possible solutions presented, such as storing overflow and then passing it to plants for skimming and sedimentation and/or polymeric flocculation treatment. Other means of handling overflows include storage in fully or partially flexible underwater tanks or in underground tunnels with subsequent treatment, chlorination, and filtration aided by ultrasonic energy. One current project is evaluating the use of 1-2-acre ponds to collect stormwater runoff and then treat it for reuse. The following recommendations in the area of municipal wastewater treatment were made: (1) more research by biochemists and biologists on sewage treatment, primarily to seek radical innovations based on fundamentals of microbiological processes; (2) research expansion on new methods of handling wastewater treatment sludges and on parameters involved in using synthetic polymers and polyelectrolytes to improve flocculation, sedimentation, and conditioning of such sludges; and (3) more systematic studies on urban stormwater quality to provide a sounder base for evaluating various means of treatment.

078
NEW IDEAS FOR CALCULATING STORM WATER OVERFLOW SETTINGS AND THE DESIGN OF STORM WATER TANKS,

Civil Eng Public Works Rev, Vol 65, No 766, p 487, May 1970.

Descriptors: *Storm runoff, *Overflow, *Design.
Identifiers: *Storm overflows, Storm tank.

The Technical Committee on Storm Overflows devised a new formula for setting storm overflows which enables them to be designed without first conducting infiltration surveys. The report of this committee also condemns the use of low-side weir storm overflows because they cause excessive pollution. Ideas for the use of storm tanks during periods when they are not required for their design purposes are proposed. The question of flow standard storm tank effluent discharged at the same time as high-quality standard effluent is presented but not answered in this report.

079
STORM OVERFLOWS AND THE DISPOSAL OF STORM SEWAGE,

Effluent Water Treat, Vol 10, No 3, pp 154-155, Mar 1970

Descriptors: *Storm runoff, *Sewage, Design, Screens, Overflow.
Identifiers: Storm tank, Storm Sewage, Great Britain.

Comments on the final report of the technical committee concerned with storm overflows and the disposal of storm sewage, are discussed. It is the first known official document containing recommendations on the settling of storm overflows and on the bases of storm tank design. The main conclusions and recommendations of this British report are listed.

080
NOTES ON WATER POLLUTION,

Inst Sewage Purif, J Proc, Part 2, pp 199-202, 1966. 1 graph, 3 ref.

Descriptors: *Sewers, Investigations, Sewage, Water pollution, Runoff, Storage tanks.
Identifiers: *Storm sewage, *Combined sewers, *Storm overflows, Great Britain.

Stuides were performed in three areas served by combined sewerage systems on the amount, composition, and pollution load of stormwater overflows. There was regularity in the volume of storm sewage at the three sites in relation to impermeable area, total rainfall, and dry-weather flow; however, no regularity was detected in composition. Generalizations were made regarding runoff, sewage dilution, single storm discharges, etc., and specifics for each locale were also described. Recommendations were made for the placement of storage tanks alongside of storm overflows and for experimentation in designing different types of overflows in order to reduce pollution load discharges.

081
MIDLAND DISTRICT CENTER,

Inst Public Health Engrs, Vol 67, Part 1, pp 51-57, Jan 1968.

Descriptors: *Overflow, *Sewage treatment.
Identifiers: *Storm tank, Great Britain.

The reconstructed and extended Kidderminster Sewage Works will contend with excess water runoff by passing the overflow through screens or by storing it in stormwater tanks. The tanks will contain underwater sludge scrapers. Flow will be diverted from the river until all the tanks are individually filled. The stored water will eventually be pumped out for treatment.

082
DESIGN OF A COMBINED SEWER FLUIDIC REGULATOR; The Development of Basic Configurations and Design Criteria for Applications of Fluidics in Sewer Regulators,
Bowles Eng Corp.

Water Pollution Control Research Series, Report DAST-13, FWQA Contract 14-12-486, Oct 1969. 137 p, 98 fig, 3 ref, 1 append.

Descriptors: *Flow control, Sewers, Diversion structures, Design, Design criteria, Costs, Fouling.
Identifiers: *Sewer regulator, *Combined sewers, *Fluidic regulator, Interceptor sewer.

A generic Fluidic Regulator configuration was developed which diverts 0 to 75% of the combined sewer flow away from the interceptor sewer, or combined sewer, in either an analog or digital operational mode. Application design criteria were evolved for a range of small to medium sized municipal sewers, in terms of a few basic parameters. Preliminary analysis has shown that the installation of a combined sewer fluidic regulator is similar in nature and overall complexity to a conventional leaping weir, or side flow diversion structure. It is estimated that the use of a fluidic regulator would not increase the cost of a large diversion structure, and would add about 20% to the cost of a small diversion structure. A simulated fouling test showed a very low susceptibility to fouling by solid or soft sheet-like debris in the water flow.

083
CRAZED RESIN FILTRATION OF COMBINED SEWER OVERFLOWS,
Hercules Inc, Cumberland, Maryland.

Prepared for FWPCA, Contract No. 14-12-39, Oct 1968. 78 p.

Descriptors: *Evaluation, *Filters, *Sewerage, *Sewers, *Suspended load, *Storm runoff, *Resins, *Overflow, Construction materials, Filtration, Volumetric analysis.
Identifiers: *Combined sewers.

This study was conducted to evaluate the feasibility of a self-adjusting and self-cleaning filter proposed for use on combined sewer systems to remove a large portion of suspended solids from sewage influent during storm flow conditions. The experimental filters were cylindrical structures about one foot in diameter by one foot in length and whose materials of construction were fibers laid down in predetermined patterns by a winding process and bonded in place by resins. The permeability of the structure is imparted by a mechanical crazing of the resin. Filtration runs showed a 62% reduction of suspended solids in the filtrate; however, sustained runs could not be realized. The self-cleaning capability was not demonstrated.

084
SYMPOSIUM ON STORM SEWAGE OVERFLOWS,

Inst Civil Engrs (London), 1967. 160 p.

Descriptors: Hydraulics, Statistics, Overflow.
Identifiers: Sewer separation, Storm sewage.

The twelve papers presented consist of experimental studies, which provide technical data on flow conditions, performance of sewerage systems, and design factors for various situations. Particular attention is paid to behavior of mixed flows and to both vertical and horizontal separation methods.

085
RAPID - FLOW FILTER FOR SEWER OVERFLOWS: The Evaluation of Course Coal as a Filter Medium to Remove Large Solids from Sewer Overflows,
Rand Development Corp.

Water Pollution Control Research Series, Report 11023 DP1--08/69, FWQA Contract WA-67-2, Aug 1969. 81 p, 10 fig, 12 tab, 4 ref, 1 append, photos.

Descriptors: *Sewage treatment, *Overflow, Filtration, Storm runoff, Sampling.
Identifiers: *Rapid-flow filter, *Coal filter medium, *Combined sewers.

In a pilot installation at the terminus of an existing urban overflow location, a rapid-flow filter using lump coal as the filter medium performed with a minimum of maintenance or difficulty. The preferred filter used lump coal with a size of approximately 3/4 inch by 1¼ inch, free of fines, and about 8 inches in depth. The overflow is directed onto the filter bed in such a manner that the filter bed is not displaced. Filter bed depth did not appear to be critical; the degree of solids removal does not materially increase at depths exceeding 8 inches. Because the concept is based on the use of a disposable filter medium, no backwashing or other processing is required. It appears that replacement approximately 6 times per year might be expected as an average. At no time during this investigation was an odor of sewage solids or garbage detected as long as unoiled coal was used and the filter was shaded from the sun.

086
DISSOLVED-AIR TREATMENT OF COMBINED SEWER OVERFLOWS; The Demonstration Project of a Prototype Treatment Plant Designed to Treat Wastes Found at a Combined Sewer Overflow,
Rhodes Technology Corp., Houston, Texas.

Federal Water Pollution Control Administration, Research Series, WP20-17, Jan 1970. 216 p.

Descriptors: *Infiltration, Storm runoff, Overflow, Flocculation, Investigations.
Identifiers: *Combined sewers, *Dissolved-air flotation, Suspended solids, Treatment methods.

A dissolved-air flotation system was evaluated for primary treatment of combined sewer overflows. The major pieces of component equipment were a gyratory screen, hydrocyclones, an air dissolving tank, and a flotation cell. The principal aspects investigated were: (1) performance of the system during rain events and dry periods; (2) evaluation of individual components; (3) capital costs and operating costs for utilizing a flotation system for various size combined sewage overflows; (4) the adaptability of the system for automation and use in remote location; and (5) the ability of the system to treat intermittent and highly variable flows from combined sewage systems. Some chemical aids to flocculation were also tested. It appears that dissolved-air flotation systems would be economical for handling combined sewer overflows up to 8 MGD. Automation of dissolved-air flotation systems appears possible with conventional control equipment. Chemical aids to flocculation seem to have promise that warrants further study. The system was unique in that all liquid flow passed direttly through the air dissolving tank with no recycle. Domestic sewage was studied in lieu of combined sewage during periods of no rain. Conclusions, recommendations, and benefit-cost relationships are presented in the report. A description of the demonstration plant and the drainage area served by the flotation system are appended.

087
DETROIT SEWER MONITORING AND REMOTE CONTROL; Research Project Aiming at the Reduction of Combined Sewer Overflow Pollution in Detroit using System Monitoring and Remote Control Techniques,
Detroit Metro Water Depart.

In: Combined Sewer Overflow Abatement Technology. Water Pollution Control Research Series, Report 11024--06/70, pp 219-290, Jun 1970. 33 fig, 2 tab.

Descriptors: *Overflow, *Control systems, *Monitoring, *Remote control, Storm runoff, Runoff forecasting, Sewers, Water pollution control.
Identifiers: *Combined sewers.

The Detroit Metro Water Department has installed the nucleus of a sewer monitoring and remote control system for controlling the pollution from the combined overflow from many small storms at a cost of slightly over $2 million. The system includes telemetering rain gages, sewer level sensors, overflow detectors, a centrally located computer and data-logger, and a centrally located operating console for controlling pumping stations and selected regulating gates. Installation has been virtually completed and now enables applying such pollution control techniques as storm flow anticipation, first flush interception, selective retention, and selective overflowing.

088
STORM WATER RETARDING BASINS SOLVE URBAN DRAINAGE PROBLEMS,

A. P. Aitken.
Australian Civil Eng, Vol 10, No 2, pp 35-37, Feb 1969.

Descriptors: *Watersheds (basin), Drainage systems, Design, Hydraulics, Hydrologic aspects.
Identifiers: *Australia, Stormwater basins.

Urban flooding problems solved by Melbourne and the Metropolitan Board of Works are discussed. Hydrologic and hydraulic problems posed in design of retarding basins are explained. 16 stormwater retarding basins varying in capacity from 13 to 2350 acre feet were constructed to reduce peak flow downstream of basin by temporarily storing portion of inflow from upstream catchment. Land acquisition, design considerations, and cost of basins are mentioned.

089
STRAINER/FILTER TREATMENT OF COMBINED SEWER OVERFLOW,

Stephen S. Blecharczyk and Edward L. Shunney.
Final Report prepared for FWPCA, Report WP-20-16, Contract No 14-12-17, Jul 1969. 53 p, 26 tab, 6 fig, 14 ref, 1 append.

Descriptors: *Evaluation, *Systems analysis, *Overflow, *Cost analysis, Suspended load.
Identifiers: *Strainer-filter system, *Treatment methods, *Combined sewers.

The principal of a "self-cleaning strainer, self-cleaning filter" concept for the treatment of combined sewer overflows was evaluated in this feasibility study. The strainer and filter systems were examined using a synthetic substrate (prepared on the basis of overflow sample analysis data obtained from analysis of a combined sewer overflow in Providence, Rhode Island), primary influent to two separate municipal treatment plants, fresh sewage solids, and combined sewer flow. It was demonstrated that the strainer model produced consistent suspended solids removal rates near 35% under highly varying load conditions, at a flux of 25 gallons/minute/sq. ft. The authors believe that a strainer-filter system of the type originally envisioned is not feasible from a cost and operational point of view if additional treatment is necessary beyond that attainable with a self-cleaning strainer.

090
FREQUENCY OF STORM-SEWAGE OVERFLOWS. THE FREQUENCY OF STORM-SEWAGE OVERFLOWS IN COMBINED SEWERAGE SYSTEMS IN CONNECTION WITH STORAGE AND PUMP CAPACITY, CONCLUSIONS FROM THE RAINFALL DATA OF THE KNMI FOR 1926-1962,

W. O. J. Böttger and A. G. v.d. Herik.
Water (WTRHA7), Vol 50, pp 154-161, 1966.

Descriptors: *Overflow, Data collections, Frequency analysis, Precipitation (atmospheric).
Identifiers: *Storm sewage, *Netherlands.

Tabulated and graphical data on the number of operations of storm-sewage overflows and the amounts of overflow at De Bilt, Netherlands, in the period 1926-1962 are presented. These data were compiled by a computer using the Ribbius-Kragt-Kuipers method (in which it is assumed that no overflow will occur until the sewers are filled to the crest of the lowest weir). The average overflow frequency, calculated monthly, reached a maximum in August and a minimum in March. Results for individual years and individual months were quite variable, and no useful relations could be found between the annual precipitation, the number of operations of the overflows, and the amounts of overflow.

091
SOME ASPECTS OF SEWAGE TREATMENT AT COVENTRY,

R. W. Brooks, H. V. Lee, and M. J. Price.
Water Pollution Control, Vol 68, No 2, pp 129-145, Mar 1969.

Descriptors: *Sewage treatment, *Sludge treatment, *Filtration, Storm runoff.
Identifiers: *Storm sewage, Storm overflows, Sewer hydraulics, Great Britain.

An historical progress report of Coventry involving the sewage treatment outline development, activated sludge treatment, and sand filtration is presented. In the 1960's, the elimination of direct storm overflows and the provision of regional storm sewage balancing stations was initiated. Excess flow would be diverted to tanks at the stations until available capacity could be made in the sewer downstream and pumps then would automatically return the contents of the tanks. In the reply to the discussion following the article the limits for discharges from the storm overflows are presented.

092
STORM OVERFLOWS AND STORM SEWAGE,

John T. Calvert.
Surveyor, Vol 85, p 22, Apr 1970.

Descriptors: *Sewage disposal, *Design standards, *Design criteria, *Separation techniques.
Identifiers: *Storm overflows, *Storm sewage, Great Britain.

Conclusions of the Final Report of the Technical Committee on Storm Overflows and the Disposal of Storm Sewage are summarized. The Ministry of Housing and Local Government accepted the report's recommendations regarding the general design and setting of storm overflows, and they are considering recommendations for further research and investigation. The major outcome of the report proposes a formula for the setting of storm overflows which replaces the former method of fixing the setting at 6 d.w.f. Features and advantages of the formula are given. Sewer separation was considered but eventually rejected by the committee because of the huge cost involved and the inevitable pollution from surface water drains of separate sewers. Other areas studied were the effects of storm sewage on rivers and the composition and strength of storm sewage.

093
DRAINAGE OF WIDE ROAD PAVEMENTS,

K. W. Dobinson.
Inst Engrs (Australia), Vol CE 10, No 1, pp 1-6,
Apr 1968.

Descriptors: Surface drainage, Design, Drainage engineering, Drainage systems.

The effectiveness of various types of pavement drainage structures is discussed. The surface drainage design method, used under certain conditions, is described. A graphic system for the design of pavement drainage is examined.

094
MORE THAN JUST A BUILDING,

L. C. Dubs.
Am City, Vol 85, No 6, pp 119-124, Jun 1970.

Descriptors: *Drainage systems, Construction, Overflow, Ohio.
Identifiers: *Dry wells.

A three-phase program designed to place all the city's service functions in one area is underway in Canton, Ohio. The first phase involves the construction of two buildings; one a motor vehicle service center, and the other a street and sewer department. The service center's unusual drainage system consists of a system of dry wells constructed throughout the area with one large dry well absorbing overflow from the smaller ones. This system was adopted because storm sewers were not available in the region. Only minor flooding occurred once when there was a heavy rainfall, so the effectiveness of this system was evidenced.

095
CHARACTERIZATION AND CONTROL OF COMBINED SEWER OVERFLOWS, SAN FRANCISCO,

D. W. Eckhoff, A. O. Friedland, and H. F. Ludwig.
Water Res, Vol 3, No 7, pp 531-543, 1969.

Descriptors: *Overflow, Outlets, *Analytical techniques, Runoff, Sewage treatment.
Identifiers: *San Francisco, *Storm sewage.

In order to find methods for controlling or treating storm-sewage overflows from combined systems in urban areas, overflows from the combined sewerage system of San Francisco were measured and sampled for analysis at two outfalls in the city. The dry-weather flows were also monitored. From the data obtained and other observations, the annual runoff for the whole of the city was compared with its total annual discharge of treated sewage effluent, and the effects of the dry-weather flow on the overflow and of the overflow on receiving waters were investigated. The latter effect produced a considerable increase in the numbers of coliform bacteria which remained higher than normal for about two weeks. The studies showed that treatment of overflows from combined systems could result in a substantial reduction of pollution at less expense than would be involved in separating the systems, and that dissolved - air flotation with chlorination appeared to be a promising method.

096
OVERFLOW STUDIES AT A SEWER SYSTEM OF A METROPOLITAN CITY,

Wilhelm v.d. Emde and Siegfried Hoffman.
Gas Wasserfach (GAWFAN), Vol 110, No 12, pp 321-325, Mar 1969. 4 ref.

Descriptors: *Sewers, *Measurement, *Storm runoff, *Overflow, *Parametric hydrology, *Rainfall, *Mathematical studies.
Identifiers: *Capacity, *Germany.

For determining the capacity of the sewer system including stormwater drainage in Hamburg, the flow speed, the water level, and the sludge deposition during dry weather were measured. The speed is found to be approximately 0.5m/sec, and sludge deposition is hardly avoidable at the low inclination of the canal system. The conditions during rainy weather were determined with automatic level recording units. From these level measurements the frequency of overflow in days/year, the overflow duration in hours/year, and the overflow quantity/year were calculated. From the recordings of rainfall and the level measurements at the overflow spills of the sewer system a diagram is drawn according to Kuipers' equation providing information on the storage capacity and discharge capacity of the overflow spills. These two parameters determine the critical rainfall for the overflow spill. Its magnitude decreases with increasing duration of rain and asymptotically approaches the discharge capacity. To avoid frequent overflow, calculations should be based on the critical rainfall as a function of the overflow time. Since this is not practical, it is recommended to use the normal rainfall for the calculation and multiply the quantities obtained by a constant factor.

097
A RE-EXAMINATION OF THE STORM TANK PROBLEM,

L. B. Escritt.
Water Waste Treat, Vol 12, No 9, pp 298-300, Sep/Oct 1969. 1 tab.

Descriptors: *Sewers, *Overflow, *Treatment facilities, *Design, Sewage treatment.
Identifiers: *Storm tank, *Capacity, *Stormwater treatment.

Where sewage works treat flow from catchments which are served by combined or partially-separate sewers, a moderately intense railfall-runoff rate will necessitate passage or storm-tank storage of excess flow. The Royal Commission on Sewage Disposal makes recommendations regarding the handling of such overflows. The author of this paper disputes their statement that storm tanks able to hold one-quarter of the daily dry-weather flow will suffice for storing spill-over from small storms. He notes that a capacity of two days dry-weather flow is often needed to prevent spill-over occurring. Functions of storm tanks and the mathematics of stormwater treatment are described. A suggested design for tanks consists of circular tanks with ratating sludge mechanisms. A formula for calculating the required capacity of a tank to prevent spill-over is included.

098
BUILDING DRAINAGE PUMP STATIONS WITHIN LIMITED BUDGET,

E. W. Fritschi
Public Works, Vol 1oo, No 2, pp 104-105, Feb 1969.

Descriptors: *Design, *Louisiana, *Pumping plants, Construction.

The design of a pump station, located 15 miles south of New Orleans is described. The primary stage of the pump station was designed for rainfall of 2.5 in. for one hour and then ½ in./hr for a total of 6 in. Emphasis was placed on the design of a sub-structure which had to serve as a cofferdam preventing leakage from the tail bay into the suction bay, and as a retaining wall resisting vertical, horizontal and lateral forces. Requirements were met by designing a series of bays that structurally act as a continuous arch bridge.

099
STEPS TO SUCCESS IN WATER POLLUTION CONTROL,

Charles V. Gibbs
Public Works, Vol 101, No 5, pp 62-67, May 1970.

Descriptors: *Overflow, *Pollution abatement, *Sludge digestion, Sewage treatment, Separation techniques.
Identifiers: *Interceptor sewer, *Seattle, Combined sewers.

Plans and actions of the Municipality of Metropolitan Seattle (Metro) in regard to combatting the city's water pollution problems are presented. Metro has devised various solutions to underground construction problems with pipelines and pumping stations. Other problems tackled by Metro include the removal of digested sludge from Puget Sound and the elimination of combined sewer overflows. Sewer separation is not presently feasible because of the expense, so the Metro interceptor system is being ordered to run the entire system. In the meantime, money originally reserved for storm water holding tanks is being contributed to the city's proposed sewer separation system. Metro is continuing its innovative engineering programs and is coordinating its activities with community agencies working in the same or related fields.

100
THE CROSSNESS SEWAGE TREATMENT WORKS, GREATER LONDON COUNCIL: FIVE YEARS OPERATION, 1963-68,

R. W. Horner.
Water Pollution Control, Vol 69, No 2, pp 180-194, 1970.

Descriptors: *Sewage treatment, *Flow control, Flow rates, On-site investigations.
Identifiers: *Maximum flow requirements, *Average flow requirements, Storm tank, Combined sewers, Great Britain, Stormflow detention.

A description of the structure and an assessment of the 5-year operating success of the Crossness Sewage treatment plant are discussed. All flow which once passed to the river must now be pumped through the plant, even wastewater gravitating in storm tanks oribinally used as reservoirs. Moderate storms occurring after two or three weeks of dry weather create flows which exceed the capacity of the screening gear when old combined sewerage systems are in use. In the "Discussion," H. H. Stanbridge asked how the plant operates under maximum flow in comparison to average flow. The authors replied that maximum flow was 216 mil gal and that flows exceeding this level passed to storm tanks. Most of this excess (3.2% of the total flow in 1968-9) was later returned for treatment, but 19% of this load was discharged to the river. Tables and graphs describing the 5-year operation of the plant include: the effect of rainfall on suspended solid load, syspended solid load per day, main pumping station statistics, and the performance of primary sedimentation tanks, activated-slude plants, primary and secondary digestion plants, and the power-house. Diagrams are drawn of the engine cooling water system, the high tension distribution system, and the grit washing plant.

101
ALL YOU SEE IS THE STREAM,

H. S. Hulme, Jr.
Am City, Vol 85, No 3, pp 77-78, Mar 1970.

Descriptors: *Drainage systems, *Stream improvement.
Identifiers: Swales, Storm sewers, Arlington County, Virginia.

A controlled stream was constructed above a reinforced-concrete storm sewer enclosing Pimmet Run in Arlington County, Va. to prevent erosion upstream while retaining the aesthetic value of the stream downstream. Swales created along the stream carry local drainage and overflow from storms into the main culvert. Methods of construction and problems encountered are explained. Dimensions and costs of the system are included.

102
LETTERS TO THE EDITOR--WATCH OUT FOR CROSS CONNECTIONS,

Gary D. Hutchinson
Am City, Vol 84, No 1, p 21, Jan 1969.

Descriptors: *Construction equipment.
Identifiers: *Storm sewers.

Additions are made to a previously-published article concerning hazards of well-to-storm-sewer connections. In one southeastern city, these connections were not protected from backflow, thus, the municipal water system was subject to dangerous innundation from storm sewers. City officials corrected the situation by installing above-ground, air-gap separations.

103
WHITHER WATER POLLUTION CONTROL?,

C. P. James
Water Pollution Control, Vol 67, No 5, pp 579-583, Sep 1968.

Descriptors: *Sewage disposal, *Water pollution, *Overflow, Flow rates.
Identifiers: *Hydraulic analysis, Storm sewage.

The author comments on sewage disposal, river pollution prevention services, and research in a general manner. He contends that storm overflow problems are more easily solved on large works than on smaller ones. James contests the equivalent of 3xd.w.f. for the sewage rate of flow in dry weather as the standard measurement.

104
WATER TREATMENT - A GUIDE TO THE TREATMENT OF WATER AND EFFLUENTS PURIFICATION: CHAPTER 13 - INTRODUCTORY: SEWER SYSTEMS--OVERFLOWS--CONSERVANCY,

G. V. James
The Technical Press Ltd, London, pp 247-252, 1966. 1 fig, 5 ref.

Descriptors: *Sewerage, *Flow characteristics, *Sewers, *Overflow, *Weirs, Sewage treatment.
Identifiers: *Storm overflows.

General facts concerning sewage and sewer systems are presented, including explanations of sewage "strength"; variations in flow; the influence of seasonal and weather changes; and the three types of sewerage systems --combined, partially separate, and entirely separate. The operation of local storm overflows to relieve tributary sewers before they are surcharged is described. The three types of overflows are: the ordinary weir type; the improved weir type with a horizontal iron plate and a vertical deflecting plate directing water to the overflow pipe; and the leaping weir type, the best of the three sewage treatment processes mentioned include: chemical precipitation; use of comminutors; and dilution, bleaching and trenching of cesspool contents.

105
CRITICAL OBSERVATIONS FOR HYDRAULIC MEASUREMENTS OF FIXED STORM-SEWAGE OVERFLOWS,

J. Jehne
Wasserwirtsch-Wassertech (WSWSAO), Vol 17, No 4, pp 122-127, Apr 1967.

Descriptors: *Specific capacity, Sewerage.
Identifiers: *Storm overflows, Combined sewers.

In connection with hydraulic measurements for storm sewage overflows, the author discusses the errors which are caused by using the concept "dilution". The specific concentration of one or more substances (referred to as the specific load) is recommended as the criterion for the permissible load of combined sewerage systems on the receiving water. Equations are developed for calculating the maximal critical values for the specific load and runoff.

106
THE SIMULATION OF INFILTRATION FOR STUDIES IN OVERLAND FLOW,

G. A. Jobling and A. K. Turner
Proceedings of International Hydrology Symposium, Sep 6-8, 1967, Colorado State University, Fort Collins, Vol 1, Paper 27, p 203-210, 1967. 8 p, 7 fig, 3 ref.

Descriptors: *Rainfall-runoff relationships, *Overland flow, *Model studies, *Hydraulic models, *Simulated rainfall, Simulation analysis,

Artificial precipitation, Rainfall simulators, Runoff forecasting, Routing.
Identifiers: Watershed models.

"Overland flow' over natural surfaces is unsteady and spatially varied, due to both rainfall and infiltration. Most experimental work to date has been done using impermeable surfaces, the effects of time-dependent infiltration being ignored. Research into flows over natural surfaces is time consuming and the results are difficult to interpret at this stage in our knowledge of such flows. A method of simulating infiltration is described which enables experimental work to be undertaken in a tilting flume. The system produces a time-dependent decay in simulated infiltration, and can be described by an equation of the form used by Kostiakov. Since the two parameters involved can be readily altered, the system provides a means of simulating a range of field surfaces. Some initial results using the method are described.

107
COMBINED UNDERFLOW STORAGE PLAN FOR POLLUTION AND FLOOD CONTROL IN THE CHICAGO METROPOLITAN AREA,

Clint J. Keifer, A. L. Tholin, and Marshall Suloway.
Chicago, City Bureau of Engineering, Department of Public Works, Sep 1969. 43 p, 13 fig, 6 tab.

Descriptors: *Underground storage, *Tunnels, *Control structures, *Sewers, *Flood control, *Water pollution control, Water conveyance, Waste Water, Shafts, River regulation, Drainage systems, Drainage engineering, Design, Underflow.
Identifiers: *Chicago.

Three alternative plans, proposed locally as solutions to flood control and pollution problems in the Chicago metropolitan area, are described and compared. The combined sewer systems, which carry the municipal and industrial wastes as well as storm water runoff, spill raw sewage into the Des Plaines, Chicago and Calumet Rivers, and the Sanitary and Ship Canal from 400 outlets, during overflows occuring when interceptor sewers and treatment plants are loaded beyond capacity. The flow from these rivers empty via the Des Plaines River into the Illinois River. Intense rainstorms frequently result in basement and underpass flooding. The $650 million plan suggested by the City proposes the construction of 95 miles of huge conveyance tunnels, 26 ft wide and 50 ft deep, excavated through solid rock beneath the Chicago, Calumet, and Des Plaines Rivers, and the Sanitary and Ship Canal. Flows from the combined sewers would be dropped through shafts into these tunnels to provide temporary storage for flood prevention and to collect sewer overflows for subsequent pumping to three major existing treatment plants. Improvements along the Des Plaines River and the Sanitary and Ship Canals planned by the Illinois Division of Waterways are also described. The project design would be based upon handling the runoff from a storm with a 100 year average recurrence interval.

108
NEW REGULATIONS AND CONSTRUCTIONS OF STORM-SEWAGE OVERFLOWS, FOR THE RELIEF OF RECEIVING WATERS,

R. Lautrich
Ber Abwassertech Ver (BAEVAD), Vol 19, pp 175-193, 1968.

Descriptors: *Regulated flow, Rainfall-runoff relationships.
Identifiers: *Storm overflows.

This paper deals with the relation between the critical rainfall and runoff and the resulting dilution. Investigating the effect of the fundamental lay-out of storm sewage overflows, the author concludes that if two storm sewage overflows are constructed at a given position in place of one, the polluting load discharged to the receiving water can be greatly reduced.

109
PAVING CURES DUST AND DRAINAGE ILLS,

Jack Lough
Am City, Vol 84, No 7, pp 97-98, Jul 1969.

Descriptors: Concrete construction, Drainage programs, Storm runoff.
Identifiers: Street drainage.

A far-reaching street-paving program was implemented in Albion, Nebraska after heavy rains caused driveway culverts to overflow, ditchwater to stagnate, and runoff to spill into streets and parkways because ditches were clogged. Concrete curbs, gutters, and pavements were installed to ameliorate this situation and also to provide dust control. The entire project cost $473,619.48 (about $5700 per block).

110
A BREAK FROM ACCEPTED PRACTICE . . . BRINGS STORM-WATER CONTROL WITHIN REACH OF OUR BOROUGH'S POCKETBOOK,

L. L. Lowry
Am City, Vol 83, No 6, pp 108-109, Jun 1968.

Descriptors: *Reservoir storage, Storm runoff.
Identifiers: *Stormwater control.

State College, Pa. constructed a reservoir to contain runoff until after a storm, instead of installing a more costly water-carrying conduit. An electrically controlled gate closes when rain causes the water level in the reservoir to rise, and it opens when the storm subsides, thus, allowing the rainwater to drain. As a part of State College's sewage project, a new storm trunk line was built contrary to common practice; that is, from the center of the job downstream, to reduce the threat of the pipe coming afloat in the event of a flash flood. This plan was also successful; flood water was forced inside the pipe rather than flowing around the outside and causing flotation. State College also formed a Storm Water Authority to undertake the financing of such storm water control projects.

111
WATER STORAGE METHODS -- FROM CUPPED HANDS TO COMPUTERS,

T. W. Lumsden
Water Pollution Control, Vol 107, No 6, pp 16-19, and 30, Jun 1969.

Descriptors: *Reservoir storage, Construction costs, Storm drains, Storm runoff.
Identifiers: *Stormwater systems.

Storage tanks and reservoirs should provide for flow equalizing, fire protection, and emergencies. An overall system analysis is usually necessary to determine the most economical combination of storage facility, trunk mains, and pumping facility. Criteria for locations of storage facilities and construction cost considerations are noted in this article. Stormwater systems exhaust sizable segments of expenditures utilized for water storage in general. Drains must provide for normal stormwater runoff and higher flows resulting from reservoir emptying and inadvertent overflows.

112
THE WRAY FLOOD DISASTER AND ITS EFFECTS ON THE PUBLIC HEALTH SERVICES,

D. H. Maud
Inst Public Health Engrs, Vol 67, Part 4, pp 244-249, Oct 1968.

Descriptors: *Storm runoff, *Outlets, *Bypasses, Sewage treatment, Repairing, Sewerage.

Intense thunderstorms and flooding damaged the water supply system and sewerage and sewage disposal systems of the town of Wray on the river

Roeburn. As a result of the storm, the outlet pipe, which allowed storm water overflow to pass to the river, was completely filled with silt as were other parts of the sewage disposal system. In addition to repairs on the sewer disposal and sewerage systems, town workers cleared the outfall pipe, thus, establishing a bypass to the river. They then connected the washout valve on the filter feedline near the dosing chamber to the humus tanks. By re-opening the inlet valve to the primary sedimentation tank and opening the dosing chamber's washout, primary tank effluent was routed to the humus tanks; and thus, a two-stage settlement treatment system was instituted in place of discharging raw sewage over the side weir storm overflow.

113
CITY OF OXFORD: EXTENSION TO SEWAGE-TREATMENT WORKS,

A. T. Morris, C. E. Copeland, and V. H. Lewin
Water Pollution Control, Vol 69, No 3, pp 249-256, 1970. 1 diag, 2 graphs, 5 ref.

Descriptors: *Sewage treatment, *Overflow, *Separation techniques.
Identifiers: *Storm sewage, Storm tank, Great Britain.

The City of Oxford extended its 1957 sewage treatment works in order to cope with overloads caused by housing, industry, and population expansion. The original plant made no provision for storm sewage; however, the new plant includes storm/sewage balancing tanks with a capacity of 1.5 mil gal ($6.82 \times 10^3 m^3$). The workings and dimensions of these tanks are detailed along with descriptions of other essential portions of the plant such as the activated-sludge plant, final separating tanks, and sludge treatment and disposal parts.

114
SOLVING A SEWER OVERFLOW PROBLEM,

Charles R. North
Public Works, Vol 97, No 4, p 92, Apr 1966. 1 diag.

Descriptors: *Sewers, *Design, *Planning, *Pumping plants, *Overflow, Investigations.
Identifiers: *Painesville, Ohio.

The 1910 sewer line in Painesville, Ohio is discussed. A pump station and force mains were added to an existing sanitary sewer system, and subsequently caused flooding. An investigation was undertaken to identify and correct the cause of the problem. The following conclusions were included: 1) in future designs, considering the capacity of older sewers as two-thirds full; 2) recommending of camera inspection with semi-annual cleaning; 3) running of pumps on an alternate basis; 4) telemetering; 5) checking of the upstream side of the pump station for excessive infiltration; and, 6) checking the operation of the regulator.

115
THE DISCHARGE OF STORM SEWAGE TO PUBLIC WATERS FROM AREAS OF GROUNDS WHICH ARE ENDANGERED BY OIL, IN CONNEXION WITH THE CLEAN WATER ACT FOR BERLIN,

K. -H. Salewski
Gesunh Ingr,(GEINA5), Vol 87, pp 265-266, 1966.

Descriptors: *Legislation, *Surface waters, *Design, *Separation techniques.
Identifiers: *Germany, Storm sewage, *Oil separators.

In connection with the legislation for the protection of Berlin surface waters, which prohibits the discharge of oil emulsions, the author discusses the use of oil separators for areas where large volumes of oil are handled and where spillage is washed off into the receiving water by rainfall. These oil separators can be installed in sections along areas likely to be affected before storm sewage enters the receiving waters. Standards for the design of such separators are discussed.

116
STORM WATER TREATMENT AT CLEVELAND,

George D. Simpson and Lamont W. Curtis
J Water Pollution Control Fed, Vol 41, No 2, Part 1, pp 151-168, Feb 1969. Paper from Am Water Works Assoc - 88th Annual Conference, Cleveland, Ohio, Jun 2-7, 1968.

Descriptors: *Watersheds (basins), *Multiple-purpose projects, *Pressure conduits, *Pumping plants, *Water pollution control, *Chlorination, *Pollution abatement, *Lake Erie, Biological treatment, Reduction (chemical), Recreation facilities.
Identifiers: *Gravity sewer, *Cleveland, Ohio.

A feasibility study was conducted for the FWPCA of a proposed offshore stabilization-retention basin, for the treatment of various polluting flows now being discharged to Lake Erie. The basin would receive treated effluent flow from the City's Easterly Wastewater Treatment Plant, as well as flow from six large combined sewer overflow outfalls, and flow from five polluted streams which drain the service area. The proposed basin would be approximately 900 acres in area, with a mean water depth of 33.5 ft. A shoreline collection system is included to convey flows to two central points for discharge into the basin. The collection system will consist of a combination of gravity and pressure conduits, with two pumping stations. Two basic types of purification processes will take place in the basin. Biological and chemical oxidation will result in reduction of BOD and COD; this process will require an aerobic environment. Sedimentation of fine suspended solids, particularly the activated sludge cell matter in the treatment plant effluent, will require quiescent settling. To meet these two conditions, a two stage basin is contemplated. The first stage will be maintained in aerobic condition by air-lift or mechanical pumping. In the quiescent sedimentation stage, it is expected that an upper layer of five to ten feet of water will be aerobic, with the remainder of the depth anaerobic. The basin will create a sheltered bay at the shoreline, which will be used for boating, fishing and swimming. A small boat marina is contemplated as part of the overall project. The basin will be provided with facilities for chlorination. Effluent will be discharged at about 8,000 ft. from shore in a water depth of approximately 42 ft. The basin has been found feasible from the standpoint of pollution abatement and reduction of bacterial contamination of the City's beaches resulting from polluted discharges.

117
ALTERNATIVES TO SEPARATION OF COMBINED SEWERS,

D. H. Waller
Paper presented at the 21st Annual Meeting of the American Water Works Association, Atlantic Branch, Canadian Section, Oct 8, 1968.

Descriptors: *Pollution abatement, *Application methods, *Separation techniques, Overflow.
Identifiers: Combined sewers.

The drawbacks of separation include high costs, public inconvenience during construction, and the continuing problem of polluted stormwater runoff. Alternative solutions to this pollution problem either reduce pollutants in the overflow or decrease amounts of combined sewage that is overflowed. Pollutants can be eliminated from overflows through storage and treatment methods such as disinfection, screening, sedimentation, filtration, and other overflow devices. Possible procedures for diminishing combined sewage overflows outlined include real-time control of discharge points, storage by use of larger pipes, or increased interceptor and treatment plant capacity. Each locality's circumstances will determine which method or combination of methods will provide the best means for solving its pollution problem.

118
METHOD OF AND MEANS FOR DEALING WITH STORM-WATER OVERFLOWS IN SEWERS AND LIKE DRAINAGE SYSTEMS,
F. Wood and Longwood Engineering Co, Ltd.

Brit Patent 1,023,311.

Descriptors: *Overflow, *Drainage systems, *Bays, *Treatment facilities, Sewerage, Screens, Outlets.
Identifiers: *Storm sewage, *Storm overflows.

The equipment examined for dealing with storm-sewage overflows in sewerage and other drainage systems comprises a bay fitted with a trough or channel which has walls of unequal height and a mouth covered with a filter screen, which can be cleaned by a rake or rakes rotating in the direction of flow of water through the bay. Under normal conditions of flow, water passes through the bay directly to the sewer, but under storm conditions, the increased flow causes a build-up of pressure in the bay so that water and floating trash flows over the lower wall of the trough and through the screen to the storm-sewage outlet. Trash is swept from the screen by the rake(s) over the higher wall into a trash pit and thence to the sewer.

Section 3

SEWER HYDRAULICS

119
A NEW TWIST (90 DEGREES IN FACT) TO SEGMENTED SEWER - PIPE DESIGN,

Eng Contract Record, Vol 83, No 6, pp 56-57, Jun 1970.

Descriptors: *Sewers, *Design, *Estimated costs, Installation.
Identifiers: *Canada, *Sewer hydraulics.

The City of Edmonton, Canada, is using a new segmented pipe on the sewer line in the downtown area. Chief design engineer F. Bereczky thought of tilting a horizontal sewer line to a 90 degree position, thus changing the flow characteristics. The design of the pipe has been worked out so that all dimensions are a function of the inside diameter, and the design can be adopted to any size of pipe. The installation procedure and the estimated cost of the new line are given.

120
PORTABLE RECORDING OF SEWER FLOW,

Water Wastes Eng, Vol 6, No 12, p 12, Dec 1969.

Descriptors: *Storm runoff, *Manholes, Sewerage, Hydrology.
Identifiers: *Sewer hydraulics, Sanitary sewers, Surface flow, Toronto.

In the region including Toronto, sewer flows were measured in order to assess problems arising from storm flows and infiltration into sanitary sewers. It was found that poor manhole hydraulics in one or two manholes can reduce capacities of large sewer systems. Continued observation and control of methods by which surface water enters sanitary sewers was recommended.

121
POLYMERS FOR SEWER FLOW CONTROL; The Development and Demonstration of the Use of Polymers that Reduce or Eliminate Sewer Overflows by Flow Energy Reduction,
The Western Company of North America

Prepared for FWPCA, Program No 11020 DIG, Contract No 14-12-34, Aug 1969.
179 p.

Descriptors: *Infiltration, *Overflow, *Sewers, Toxicity.
Identifiers: *Overflow control, *Polymers, *Sewer lines, Economic analysis.

Six water-soluble polymers were investigated to determine their effects upon aquatic flora and fauna, flow characteristics of wastewater, and the operation of a wastewater treatment plant. It was found that the polymers and gels, in the magnitudes tested, were not toxic to bacteria, algae, or fish, and did not act as a nutrient for algae growth. Based upon calculations obtained from flow test data, a maximum flow increase of 2.4 times the flow prior to injection could be obtained if a constant head was maintained. Laboratory flow test data indicated that if flow rates were held almost constant prior to and during polymer injection, a reduction in the static head occurred as a result of friction reduction within the fluid. The most effective polymers in providing energy reduction were Polyox Coagulant-701, WSR-301, and AP-30; however, AP-30 required higher polymer concentration to obtain equivalent flow characteristics. In field tests on a 24-inch diameter line, it was found that polymer concentrations of between 35 and 100 mg/l, decreased frictional flow resistance sufficiently to eliminate surcharges of more than six feet. Based upon an economic analysis, the average annual cost of new construction was approximately five times the cost of using polymers during peak storm-flow periods.

122
DESIGN OF SUB-SURFACE DRAINAGE SYSTEM FOR INNER RING ROAD OF CITY OF ANTWERP,

E. W. Brand
Roads Road Construct, Vol 46, No 546 and 547, pp 162-168, Jun 1968, and pp 201-207, Jul 1968.

Descriptors: Pump testing, Evaluation, Seepage, Electrical studies, Pipe flow.
Identifiers: *Belgium.

The procedure adopted for the design of a permanent dewatering system for the depressed inner ring road in the City of Antwerp, Belgium is presented. Details are given related to the execution and analysis of extensive field pumping tests; the calculation of seepage quantities; and the study of hydraulics of horizontal intake pipes adopted to effect ground water lowering. A number of electrical model tests that map flow nets for a number of values of parameters determining critical pipe elevations are examined.

123
SOLUTION OF AN UNUSUAL SUBSURFACE DRAINAGE PROBLEM,

E. W. Brand
J Irrigation Drainage Div, Am Soc Civil Engrs, Vol 94, No IR2, pp 199-221, Jun 1968.

Descriptors: *Subsurface drains, *Surface-groundwater relationships,

Design, Storm runoff.
Identifiers: *Surface runoff, Groundwater, Belgium.

The stages followed in designing a subsurface drainage system for the inner-ring road being built in Antwerp, Belgium are described. The system will collect and carry away surface runoff, will permanently lower the groundwater table, and will collect and carry away seepage water resulting from this lowering. Conventional methods were adopted for stormwater drainage design. The seepage water and stormwater collected in a catch basin will run by gravity in pipes to one of four low points in the road's vertical profile. From two of these points the water will flow to pumping stations and from the other two, into rivers. The most complicating factor in the subsurface drainage design was the possible effect of the precipitation of ferric oxide from groundwater. This factor necessitated complete submergence of the intake system. Factors influencing the final selection of the subsurface drainage system are explored in detail.

124
RATIONAL "RATIONAL" METHOD OF STORM DRAINAGE DESIGN,

Discussions by Lamont W. Curtis and Dah-Cheny Woo.

J Irrigation Drainage Div, Am Soc Civil Engrs, Vol 95, No IR4, pp 634-637, Dec 1969.

Descriptors: *Design storm, Time series analysis, Rational formula.
Identifiers: *Sewer hydraulics.

The value of using the rate-duration-frequency curve as the design storm pattern is discussed in reference to intensify-time rainfall charts compiled in Cleveland, Ohio. Incomplete computation in the Rational Method is due to the omission of time needed for flow traveling through the sewers.

125
VELOCITY MEASUREMENTS IN SEWERS VITAL TO DESIGN AND MAINTENANCE,

Lamont W. Curtis
Water Sewage Works, Vol 116, No 4, pp 144-147, Apr 1969. 2 diag, 2 tab, 2 graphs, 1 ref.

Descriptors: *Flow measurement, *Sewers, *Analysis, *Methodology, *Velocity, Mannings equation.
Identifiers: *Sewer hydraulics.

Discharges can be converted to wastewater volumes per capita in a sanitary sewer, or can be related to rainfall in a storm sewer. The velocity, depth, and slopes measured can be used to compute Manning's coeeficient of the roughness-friction factor. The salt-concentration method of measuring velocity was best suited for developing a discharge-depth relationship for a number of sewers, as well as giving an indication of the condition of the sewer. The equation applicable for the salt-concentration method is Q = AV, where: Q is the discharge; A is the area, computed from the measurement of the flow depth; and, V is the velocity measurement. The equipment needed, procedure, analyses of data, and continuous gaging methods are discussed in detail. It is concluded that there is no ratio, which when applied to surface velocity measurements, will give accurate average velocities in a pipe. Results of the studies indicate, however, that a ratio of .75 will give a good approximation for flow depths between .2 and .4 of the pipe diameter.

126
DETERMINATION OF FLOOD FLOWS AND DISCHARGE COEEFICIENTS IN MUNICIPAL SEWERAGE SYSTEMS,

T. Dimchev
Vodosnab Sanit Tekh, Vol 3, pp 115-132, 1966.
pp 115-132, 1966.

Descriptors: *Discharge coefficients, Sewers.
Identifiers: *Bulgaria.

Studies have continued on the discharge properties of sewerage systems in Bulgaria, and results are given for catchment areas in Sofia, Varna, and Burgas. From these data a new formula was developed for calculating the overall discharge coefficient for a particular area. The effect of the free volume in the sewerage system on the quality of the discharge was also considered.

127
DEVELOPMENTS IN SEWER MONITORING EQUIPMENT AND TECHNIQUES,

R. Galliers and M. V. King
J. Inst Munic Engrs, Vol 97, pp 27-31, Jan 1970.

Descriptors: *Instrumentation, *Storm runoff, Sewers.
Identifiers: Sewer hydrualics, Birmingham, Alabama.

This paper describes equipment and techniques developed over the last five years by the City of Birmingham Public Works Department concerning flow in sewers. These methods can be applied to the control of trade effluent discharge, the design of sewers and river channels, and to the solution of drainage problems brought on by sewer flows such as storm overflows on rivers. Automatic equipment only was used to study storm flows since waiting for storm is not feasible. Automatic depth recording of rivers will soon be undertaken to obtain unit hydrographs for intense storms. This is the best method of designing natural catchments. Included are labeled diagrams of equipment used such as the streamline pressure head and recorder for depths of flow and various sampling machines used for qualitative tests on samples taken at known times.

128
PRACTICAL METHODS FOR DETERMINING SEWAGE FLOW FOR ALL COMMUNITIES,

R. M. Girling
Water Sewage Works, Vol 116, No 7, pp 250-258, 1969.

Descriptors: *Flow, *Instrumentation, *Measurement, *Sewers.
Identifiers: *Sewer hydrualics.

This article comprises a discussion on the principles, uses, and practice of the determination of flow in sewers. Flow measurements taken by the float or tracer methods, or by using weirs or flumes are described. Calculations of pumping rates are listed along with associated experimental apparatus.

129
REAL TIME ROUTING OF HYDROGRAPHS IN STORM SEWERS,

Garth S. Harris
J Hydraulics Div , Am Soc Civil Engrs, Vol 96, No HY6, pp 1247-1260, Jun 1970.

Descriptors: *Flood routing, Storm runoff, Hydrographs.
Identifiers: *Average-lag method, Interceptor sewer.

A rapid computation of routed flood hydrographs in circular sewers was required for use in the evaluation of the effect of storm flooding in the Minneapolis-St. Pual Interceptor sewers. The method of characteristics is used to provide an accurate assessment of the routed hydrograph, but this method requires use of a large computer and a comparatively large amount of computer time. The progressive average-lag method, fully described in the article, is used to carry out the evaluation in real time (i.e., when rainfall is occurring and before the flood wave travels far down the channel). The routing constants of this method are determined by comparing the results of this method with those from the method of characteristics until good agreement is obtained. It has not been possible to determine the routing constants in the progressive average-lag method analytically.

130

HYDRUALIC DESIGN OF LARGE SURGE TANKS FOR PUMPING PLANTS,

Ravinder K. Jain, Roy T. Nakahara, and John W. White
Tech Memo No 38, Dept Water Resour, Calif, Nov 1968.

Descriptors: *Surge tanks, *Hydraulic design, Water hammer, Pressure, Transients, Discharge lines, Energy losses, Graphical analysis, Surges, Hydraulic structures, Pumping plants, Orifices, Analysis.
Identifiers: *Pressure waves, *Water column separation.

The hydraulic design of large surge tanks is described, placing emphasis on designs used for the Tehachapi surge tank. Graphical and analytical methods for determining the size of large surge tanks for pumping plants are given. Energy loss coefficients for different orifice configurations tested are included. Surge tanks are used to control transient pressures and to prevent water column separation. Flow in discharge lines communications with the surge tank through orifices connecting discharge lines with the tank is related. Normal operation produces changes in flow rates in discharge lines, resulting in positive or negative transient pressure waves reflected at the surge tank as minor fluctuations in water surface elevation protecting discharge lines and downstream tunnels from these surges. During emergency conditions all pumps could be shut down at once by a power failure. This condition causes the pumps to halt, changing rotational direction as soon as water begins to flow back. The reverse flow continues until the downstream valves are closed. To prevent low pressures in discharge lines or water column separation under this condition, water is supplied from the surge tank.

131

THE SEWER HAD TO BE CLEANED BEFORE SNOWFALL,

Charles Knecht
Am City, Vol 84, No 10, pp 120 and 123, Oct 1969.

Descriptors: *Maintenance, *Sewers, Hydraulics.
Identifiers: *Sewer cleaning, Sewer hydraulics.

In Houghton, Michigan, a cold-climate town, water pollution and sewage problems are serious due to the sand and grit from street traction abrasives, which enter sewer interceptors during rain and spring thaw conditions. Not only do the interceptors become clogged and sewers inoperable, but public health is threatened by unclean water developing from overflow bypassing treatment. The town hired a company this year to utilize traditional cleaning techniques to unclog the sewer system. The line was only two years old and designed to self-clean, but preventive maintenance programs are necessary for all sewers in cold-climate towns like Houghton.

132
STUDIES ON THE CHEMICAL CONTROL OF TREE ROOTS IN SEWER LINES,

O. A. Leonard and Neal Townley
Paper presented at the Calif WPCA 42nd Annual Conference, Sacramento, Calif, April 29 to May 1, 1970.

Descriptors: *Sewers, *Laboratory tests, *Root systems.
Identifiers: *Tree roots, Sewer hydraulics.

This study was a cooperative effort by the authors and Dr. Ahrens of the Connecticut Agricultural Experiment Station. The problem was studied at Davis and the Utilities Division of Sacramento by growing wood plants in pots filled with a potting mix which were placed on open cans. Roots which grew into cans were treated for periods of time by solutions of different chemicals. The most promising treatments were examined in a single test in July, 1969 in the sewer lines of Sacramento County. All treatments were effective in killing the roots in the lines but some were more effective than others in killing roots in and outside of joints. Studies are being continued to evaluate factors influencing kill, cost, and safety to trees.

133
PRACTICAL HYDRAULICS FOR PUBLIC WORKS ENGINEER,

F. E. McJunkin and P. A. Vesilind
Public Works, Vol 99, No 9, 10 and 11, pp 88-97, Sep 1968, pp 114-120, Oct 1969, pp 77-81, Nov 1968.

Descriptors: *Hydraulic engineering, Multiple-purpose projects. Flow, Flow measurement, Pumping.
Identifiers: *Sewer hydraulics.

This article is a review of methods of application of hydraulic engineering principles and procedures to meet the needs of engineers involved in hydraulic work of design and analysis of public works projects. The conveyance of water by means of flow in closed conduits, flow in open conduits, and fundamentals of flow measurement are explored. The hydraulics of pumps are investigated.

134
DEPTH OF FLOW AS DESIGN CRITERION FOR CHANNELS WITH ARTIFICIAL LINERS,

J. C. McWhorter, T. G. Carpenter, and R. N. Clark
Nat Acad Sciences—Nat Research Council—Highway Research Rec, No 261, pp 18-24, 1969.

Descriptors: *Design criteria, *Drainage water, *Erosion control, *Channels, *Linings, Testing.

A study of water disposal systems which drain runoff is presented. Six artificial liners were investigated to develop design criteria for erodible channels. Liners installed on flat-bottom earth channels (2 ft wide, 60 ft long) and on slopes were subjected to increasing flows to channel failure. Test sections of sand to heavy clay were inserted in the channel floor, and the effectiveness of the liners was observed. Measurements consist of flow rates, channel and water surface profiles, and test section erosion.

135
INCREASING WASTE-WATER FLOW VELOCITY BY USING CHEMICAL ADDITIVES,

J. L. Overfield, H. R. Crawford, J. K. Baxter, L. J. Harrington, and I. W. Santry
J Wat Pollution Control Fed, Vol 41, No 9, pp 1570-1585, 1969.

Descriptors: *Model studies, *Flow rates, *Sewers, *Analysis, Overflow, Costs.
Identifiers: *Polymers, *Additives, Sewer hydraulics.

Pilot-scale experiments are reported on the effect of adding polymers to sewers in order to increase the rate of flow of the sewage and thus reduce surcharging and/or overflow from sewers. The tests showed that sewage flow could be increased by a factor of two or more by adding 45-200 ml of polymer per litre. The concentration required depended on the additive used, the concentration of sewage, the flow increase desired, and the temperature. Experiments showed that the additives used did not have an adverse effect on sewage bacteria or fish and did not encourage algal growths in receiving streams. They tended to improve the rates of sedimentation and sludge dewatering in the sewage works. Economic analyses showed that, for a given example, the cost of eliminating overflow from a constriction by use of additives was less than half the cost of installing an additional sewer. However, there are certain limits to the use of additives as a long-term solution to such problems.

136
INCREASING SEWAGE FLOW VELOCITY BY USING CHEMICAL ADDITIVES,

J. L. Overfield, J. K. Baxter, Dr. H. R. Crawford, and I. W. Santry
Paper presented at Water Pollution Control Fed—41st Annual Conference, Sep 22-27, 1968.

Descriptors: *Sewers, *Flow rates, *Cost analysis, *Flow characteristics,

*Additives.
Identifiers: *Sewer hydraulics, *Chemical additives.

It is possible today to increase the flow of sewage in an existing sewer without increasing the fluid head. This increase can be made by the addition of selective chemicals. The flow in an overflowing sewer may be increased to the extent that sewage does not back up in the sewer manhole and overflow into streams and house basements. By using these chemicals, it is possible for a community to relieve sewer lines of their periodic peak loads without resorting to expensive relief sewers. Data measured during an extensive test program show that flow can be increased approximately 2.5 times original flow. Measurements were made on a test facility utilizing six-inch sewer pipe (plus auxiliary equipment required to operate the test facility). Biochemical tests were conducted on sewage, sewage bacteria, fish, and algae to determine adverse effects of chemical additives to sewerage or receiving streams. No significant adverse effects were found. A cost/effectiveness analysis showed that, for a sample case, it cost less than one half as much to use chemicals to relieve an overflowing sewer than to put in a relief line. Development of improved flow characteristics was based upon work performed by The Western Company, in improving its oil field servicing activities.

137
HYDRAULIC DESIGN OF SELF-CLEANING SEWAGE TUNNELS,

Discussion by A. S. Paintal
Am Soc Civil Engrs, Vol 95, No SA6, pp 1182-1184, Dec 1969.

Descriptors: *Hydraulic design, Sewers, Bed loads.
Identifiers: *Sewer hydraulics, *Capacity, *Sewage tunnels.

The author contends that: 1) the main concern in the design of sewage tunnels is the transportation of incoming grit and sewage material; 2) the transporting capacity of water is important because of its bearing upon the possible clogging of sewers; 3) the minimum traction assumed in the design of sewer tunnels must be adequate to keep it thoroughly flushed; and, 4) the application of existing bed load formulas to fixed bed channels is not desirable.

138
TURBULENT FRICTION IN ECCENTRIC ANNULAR CONDUITS,

James M. Robertson
ASCE Combined Sewer Separation Project, Univ of Illinois, T and AM Report No 310, Mar 1968. 13 fig, 3 tab, 48 ref. FWPCA Program No. 11020 EKO.

Descriptors: *Flow around objects, *Head loss, *Pressure conduits, Data collections, Flow rates.
Identifiers: *Annular pipes, *Hangers, Eccentricity, Sewer-in-sewers.

Following a general review of the analytical and experimental information on the friction loss encountered by fluids flowing in annular pipes, with particular regard to the influence of eccentricity of the inner member, experiments are described on an evaluation of the friction of water in a steel annular pipe of diameter ratios 5.8 and 3.2 in the Reynolds number range of ten to the fifth power to ten to the sixth power. It is found that on a discharge basis, for the same head loss in a given length, with the diameter ratio of 5.8 the flow capacity of the pipe line is decreased 12.7% in the concentric situation but only 4.5% with full eccentricity. The latter decrease is not greatly different from the 3% reduction in area due to the inserted smaller pipe. An analysis is included showing that for the simple insert at full eccentricity the near-full-flow capacity of a sewer is little affected. The effects of hangers such as might be employed to support inserts in sewers is found to have an appreciable effect on the flow capacity of a full-flowing sewer.

139
INFILTRATION IN SEWERS,

W. J. Robertson and A. W. Bird
Australian Civil Eng, Vol 10, No 4, pp 44-47, Apr 1969.

Descriptors: *Investigations, *Infiltration, Sewers.
Identifiers: *Australia.

Extensive investigations carried out by the Melbourne and the Metropolitan Board of Works, where the problem of entry of extraneous water into the sewerage system was studied, is discussed. Factors affecting wet weather infiltration are enumerated.

140
EXPERIMENTAL ESTIMATION OF DETENTION IN STORM SEWER SYSTEM,

T. Sueishi and A. Katsuya
Trans Japan Soc Civ Engrs, Vol 151, pp 47-57, Mar 1968.

Descriptors: *Storm runoff, *Investigations, *Flow characteristics, Rational formula, Floods.
Identifiers: *Storm sewers, *Capacity, Sewer hydraulics.

Results of an experimental study on storm runoff in an urban area showed that the phenomena called as flow detention, retardation, storage and flooding were hydraulically identical phenomena. These experiments were made for sewer slopes of 1/200 and 1/1000. The control structures had negative effects on the capacity of dynamic storage except when flooding in the lower area was concerned or when the drainage pump capacity was designed to be depressed. Flooding does not always occur by increasing the return period, because the maximum rate of runoff becomes a steady state when calculated by the rational method.

141
PEAK FLOWS OF SEWAGE FROM INDIVIDUAL HOUSES,

Donald H. Waller
ASCE Combined Sewer Separation Project, Technical Memorandum No 9, Jan 1, 1968. 117 p, 45 fig, 23 tab, 15 ref. FWPCA Program No 11020 EKO.

Descriptors: *Peak discharge, *Water demand (household), Data collections, Plumbing.
Identifiers: *Sewage flow (household), Louisville, Kentucky, Sampling stations, Capacity.

Sewage flows and water demands measured at two household observation stations, as well as water and wastewater flows from individual fixtures and appliances are used to estimate upper limits of pump and storage capacities for a storage-grinder-pump unit for individual homes and to examine the relationship between peak rates of sewage flow and corresponding water demand rates. For individual fixtures, combination of rate, duration,and frequency of discharge that will produce maximum hydraulic loading conditions are selected. Single-fixture hydrographs are combined to produce synthetic hydrographs of peak period sewage discharge, from which combinations of storage and pump capacities are derived. Peak sewage flows and simultaneous water demands for a fourteen day period at one house are presented and analysed.

Section 4

SEWER SYSTEMS

a. Combined
b. Sanitary
c. Storm

142
SEPARATE AND COMBINED SEWERS,

Water Wastes Eng, Vol 5, No 12, p22, Dec. 1968.

Descriptors: *Sewerage, Structural design, Systems analysis, Separation techniques.
Identifiers: *Combined sewers, Sewer hydraulics.

This round table discussion describes the general picture of the storm and sanitary sewerage systems, including the ranges and sizes of each of the types of sewers, of the cities the participants represent. Each participant also relates his city's problems in regard to the effect of combined sewers on treatment plants and under conditions of storm flow. Three of the cities have implemented separate sewers, while three others have not undergone separation because of its high cost. Our city has proposed a less costly plan of eliminating ground water seepage into sewers, and the last city (the only one located in Canada) has not yet estimated the cost of separation.

143
SEPARATE AND COMBINED SEWERS

Water Wastes Eng, Vol 5, No 7, p 26, Jul 1968.

Descriptors: *Sewers, *Methodology, *Separation techniques, Surveys, Comparative costs.
Identifiers: *Combined sewers, Sewer-in-sewers.

Replies by six spokesmen from various regions of the United States are given in relation to the following areas of questioning: 1) mile of sewers in the areas investigated; 2) ranges of sizes of each of the sewer types; 3) population serviced by the system; 4) effect of combined sewers on treatment plant operations; 5) surcharging; and, 6) plans on sewer separation and costs.

144
REPORT ON PRESSURE SEWERAGE SYSTEM, SUMMER STREET SEPARATION STUDY AREA, BOSTON, MASSACHUSETTS,
Am Soc Civil Engrs, New York; and Camp, Dresser and McKee, Boston, Mass.
Combined Sewer Separation Project, Report, Sept 1968, FWPCA Program No 11020 EKO.

Descriptors: *Cost analysis, *Design, Pressure conduits.
Identifiers: *Building plumbing separation, *Sewer separation, Boston, Massachusetts, Gravity sewer, Sewage flow variations.

The report studies the design, estimated costs, and evaluates the feasibility of the hypothetical application of the ASCE Project Scheme of pressure sewers for separation in representative combined sewer areas from layouts by the Project staff. The Boston study researched the 53-acre gently sloping, heterogeneous commercial Summer Street Separation Study Area. The report describes the separation of building plumbing in detail in a typical three-quarter century old five story and basement commercial building 65-ft. by 145-ft. in plan, and estimates the cost of plumbing separation. Four alternative pressure sewer collection systems are indicated with plans and hydraulic profiles. Some systems included in-line main pumping stations. The least expensive complete pressure system, which did not include a main pumping station, is estimated to cost $4,700,000. Both costs include costs of building plumbing separation, $4,000,000 for the pressure system including communitors, wet walls and non-clog pumps, and 2,000,000 for the gravity systems.

145
COMBINED SEWER SEPARATION PROJECT, REPORT ON MILWAUKEE STUDY AREA,
Am Soc Civil Engrs, New York; Greeley and Hansen, Chicago, Ill.

ASCE Combined Sewer Separation Project Report, Dec 1968, FWPCA Program No 11010 EKO.

Descriptors: *Annual costs, *Cost analysis, Design, Pressure conduits.
Identifiers: Building plumbing separation, *Sewer separation, Gravity sewer, Milwaukee, Wisconsin, Sewage flow variations, Storage-grinder pump.

The report covers the design, estimate costs and evaluate the feasibility of the hypothetical application of the ASCE Project scheme of pressure sewers for separation in representative combined sewer areas from layouts by the Project staff. The Milwaukee study researched the 157-acre mainly dense residential, moderately sloping Prospect Avenue Study Area. The report describes methods of building plumbing separation and indicates two alternative arrangements of pressure sewers with plans and a profile. Estimates of construction cost of each are compared with that of a conventional gravity system of separation designed by the consultant. Plumbing separation, is estimated to cost $912,000 for the gravity alternative and $971,000 for the pressure alternatives, not including storage-grinder-pump units.

146
COMBINED SEWER SEPARATION USING PRESSURE SEWERS,
Am Soc Civil Eng

Prepared for FWPCA, Program No 11020 EKO, Contract No 14-12-29, Oct 1969. 198 p.

Descriptors: *Separation techniques, *Sewers, *Pressure conduits, *Design, *Systems analysis, Storm runoff, Snowmelt.
Identifiers: *Combined sewers, *Interceptor sewer, *Sewer-in-sewers, *Sewer hydraulics.

The feasibility, selection of systems components, and the development of a new method for separating community wastewaters and runoff from rainfall and snowmelt in areas served by combined and intercepting sewers are reported on the basis of information drawn from 25 projects' reports and technical memoranda whose abstracts are appended in this final compilation. The general concept involves pumping ground wastewater from buildings through pressure tubing connected to street pressure conduits discharging in turn into interceptors. The tubing and conduits would be contained within existing combined sewers, thus allowing runoff from rainfall and snowmelt to be removed from the community unencumbered by wastewaters. Pressure conduits suspended inside combined sewers can be entered by workmen, but generally this system will cost more than new gravity systems.

147
SEPARATION OF COMBINED WASTEWATER AND STORM DRAINAGE SYSTEMS, SAN FRANCISCO STUDY AREA,
Brown and Caldwell,

ASCE Combined Sewer Separation Project Report, FWPCA Program No 11020 EKO.

Descriptors: *Cost analysis, *Design, Pressure conduits.
Identifiers: *Building plumbing separation, *Sewer separation, Gravity sewer, Plumbing code, San Francisco, Calif., Storage-grinder pump.

The report studies the design, estimated costs, and evaluates the feasibility of the hypothetical application of the ASCE Project Scheme of pressure sewers for separation in representative combined sewer areas from layouts by the Project staff. The San Francisco study researched the 323 acre predominantly residential, steeply sloping, Launa Street Sewer Service District. The report describes methods of building plumbing separation and indicates two alternative arrangements of pressure sewers, with plans and profiles. Estimates of construction cost of each are compared with that of a conventional gravity system of separation designed earlier by the City. Plumbing separation, is estimated to cost about $5,400,000 for the gravity method and about $4,400,000 for the pressure method not including storage-grinder-pump units.

148
FINAL REPORT TO THE AMERICAN SOCIETY OF CIVIL ENGINEERS ON TASK 7 AND TASK 9 OF THE COMBINED SEWER SEPARATION PROJECT,

Robert N. Bowen and John G. Havens
National Sanitation Foundation, ASCE Combined Sewer Separation Project, Dec 1967. 55 p, 18 fig, 4 tab, 14 ref. FWPCA Program No 11020 EKO.

Descriptors: *Construction materials, *Materials testing, *On-site tests, *Pressure conduits, *Specifications, Installation.
Identifiers: *Fittings, *Plowing method, *Sewer-in-sewers.

Assistance was provided in connection with special field trial installations of flexible tubing inserted in building sewers. Materials were proposed for pushing or pulling through a building sewer and a methodology and necessary attachments and tools were recommended. Polyethylene and polybuthylene tubing are recommended for use inside building sewers, and copper tubing for use in open trenches. A saddle type of connection is recommended for connecting pressure tubing to street pressure conduits. Cast iron, PVC, asbestos cement, or ductile iron are recommended for pressure conduits. Experience with the plowing of a pressure pipe is reviewed. Reference is made to the standard practice for trench installations, street crossings, and thrust blocking. Two methods of cleaning hose pressure tubing are proposed. Six possible layouts of pressure conduits are discussed in terms of operation and maintenance. All six arrangements provide for routine rerouting of flow by exploiting a dual conduit configuration.

149
WATER-POLLUTION ABATEMENT,

F.C. DiLuzio
Am City, Vol 82, No 12, p 21 and 29, Dec 1967.

Descriptors: *Sewers, Pollution abatement.
Identifiers: Holding tanks, Treatment processes, Combined sewers.

The FWPCA is searching for more effective and less expensive means than physical sewer separation to solve combined-sewer problems. A combination of holding tanks and treatment processes is one method being tested; other alternatives are being examined.

150
COMBINED SYSTEM--SEPARATE SYSTEM,

W.V.D. Emde
Oesterr Wasserwirtsch (OSWAAI), Vol 19, No 7/8, pp 125-130, 1967.

Descriptors: *Investigations, *Sewers, *Sewerage, *Hydrograph analysis, Design.

Identifiers: *Combined sewers, *Separate system.

In a paper presented at a seminar on canalization held at Raach, Austria, in 1967, the author gave details of investigations into the efficiency of sewerage systems, and outlined the advantages and disadvantages of separate systems as compared with combined systems. Describing the design and construction of each system he emphasized that neither could be regarded as the more efficient, and stressed the need for graphical and hydrographical surveys when sewerage systems are planned and that the final decision must depend on the purposes which the sewerage system is to serve. For small communities, housing estates, and small hotels the combined system can be of advantage, provided the discharge of rainfall and runoff is controlled and the quality of the receiving waters is not affected. Where future plans require extensions of sewerage systems, the separate system is more suitable, as long as operational control and plant maintenance are carried out regularly.

151
STUDY OF APPROXIMATE LENGTHS AND SIZES OF COMBINED SEWERS IN MAJOR METROPOLITAN CENTERS,

Dasel E. Hallmark and John G. Hendrickson
ASCE Combined Sewer Separation Project, Technical Memorandum No 4, May 1, 1967. 9 p, 2 tab, FWPCA Program No 11020 EKO.

Descriptors: *Sewers.
Identifiers: *Combined sewers, *Sewer sizes, *Combined sewer lengths, Walk-through sewers.

A tabulation is given for give major cities of mileage and percentage of combined sewers with heights: greater than 48 inches; equal to or less than 48 inches; and equal to or less than 24 inches. An average of 72 percent of the sewers are smaller than 24 inches. Heights of 54 inches and larger, classified as walk-through sewers, account for an average of about 15 percent of the total combined sewer mileage.

152
STORM-WATER TANKS IN COMBINED SEWERAGE SYSTEMS,

D. Londong
Ber Abwassertech Ver (BABVAD), Vol 19, pp 195-210, 1968.

Descriptors: *Design, *Application methods, *Flow control.
Identifiers: *Storm tank, Combined sewers.

The author discusses the important role of stormwater tanks used to prevent and retard the discharge of sudden and heavy rainfalls from combined sewerage system to reveiving waters, and he gives details of design calculations for these tanks and their application.

153
STORM-WATER TANKS IN COMBINED SEWERAGE SYSTEMS,

D. Londong
Staedtehyg (STDHAT), Vol 17, No 9, pp 199-206, 1966.

Descriptors: *Flow control, *Analysis, *Pollution abatement, *Rainfall disposition, Flow rates.
Identifiers: *Storm tank, Germany

Rainwater, discharged from combined or separate systems, can have severe polluting effects on receiving waters especially in industrial areas. Discussing the methods used for reducing such pollution, the author refers to German specifications for three standard types of stormwater retarding. tanks, designed to prevent the direct discharge of the first flush of rainfall and to restrict the flow from being carried forward to receiving waters or sewage works. Various methods of calculations for stormwater retarding tanks in sewerage systems are reviewed and compared as to their accuracy. Illustrated details are given of a revised method in which different rates of flow at varying durations of rainfall can be calculated using different parameters.

154
MALLING RDC REGIONAL DRAINAGE SCHEME,

D. Lowe
Surveyor, Vol 82, No 3971, pp 29-33, Jul 12, 1968. 5 fig, 1 tab.

Descriptors: *Sewage treatment, *Sewers, *Treatment facilities, *Sewage disposal, *Design, *Construction.
Identifiers: *Combined sewers, *Great Britain, Trunk sewer.

Owing to restrictions on the choice of available sites, unusual design and construction techniques were required to build a sewage treatment works which forms part of the £ 3 million Snodland-Ightham regional drainage scheme in a rural district of Kent. The Snodland area was mostly sewered on a partially combined system to a totally inadequate sewage disposal works, and the Ditton area's disposal works was heavily overloaded. The basis of the new sewerage system is a trunk sewer laid from a new sewage disposal works. Into this main trunk system flow from area villages will be brought by either pumping or gravity. Solutions to each town's problems will be implemented through the use of intercepting sewers, pumping stations, pumping mains, etc. Aspects concerning site selection for the new sewage works are discussed, and then the design of the works is detailed. Construction problems and solutions to these problems are explained in regard to both the regional sewerage scheme and the sewage disposal works.

155
WASTEWATER SYSTEM FOR THE METROPOLITAN CORPORATION OF GREATER WINNIPEG,

A. Penman
J. Water Pollution Control Fed, Vol 39, No 3, pp 373-383, Mar 1967.

Descriptors: *River regulation, *Sewerage, Future planning (projected), Recreation, Urbanization.
Identifiers: *Separate system, *Investigations.

The Metropolitan Corporation recognized its duties in restoring the rivers to the requirements of the urban area so that the citizens could use these rivers for recreational purposes. This necessitated the expansion of the existing facilities and the addition of new facilities. Sewer rentals and industrial wastes were two major areas investigated. A separate sewer system was looked into by both city and consulting engineers. It was decided that the $200 million plus cost of intercepting the old combined system was not feasible; however, future development of areas along the Red and Assiniboine Rivers will be based on separate sewer systems.

156
STORM AND COMBINED SEWER DEMONSTRATION PROJECTS, JANUARY 1970,

William A. Rosenkranz
Federal Water Pollution Control Administration Research Series Report DAST-36, Jan 1970. 121 p, 3 fig, 1 tab, 24 ref.

Descriptors: *Urbanization, *Storm drains, Sewage treatment, Overflow, Sewage disposal, Cities, Research and development, Grants, Federal Government, Water pollution control.
Identifiers: *Combined sewers.

Studies sponsored by FWPCA of combined storm and sanitary sewers, and treatment of combined wastes are listed. Abstracts of completed reports are presented, and active projects are described in information sheets. Subjects needing more research are also listed and described. Equipment, data methods, and criteria for urban drainage projects are outlined.

157
ASSESSMENT OF COMBINED SEWER PROBLEMS,

Richard H. Sullivan
In: Combined Sewer Overflow Abatement Technology. Water Pollution Control Research Series, Report 11024--06/70, pp 107-121, Jun 1970. 8 fig.

Descriptors: *Storm runoff, *Overflow, *Storm drains, *Surveys.
Identifiers: *Combined sewers.

This article is a final report on an inventory of combined sewer facilities in the United States. 641 jurisdictions, or 46% of the communities with 94% of the population and 84% of the area served by combined sewers, were interviewed directly. The results of the survey indicated that 36,236,000 people, living on 3,029,000 acres were served by combined sewers. This total indicates that approximately 29% of the nations total sewered population is served by combined sewers. The types of problems incurred, regulator devices, and infiltration control are discussed.

158
PROBLEMS OF COMBINED SEWER FACILITIES AND OVERFLOWS,

R. H. Sullivan
J Water Pollution Control Fed, Vol 41, No 1, pp 113-121, Jan 1969.

Descriptors: *Surveys, *Effects.
Identifiers: *Combined sewers.

The author summarizes and discusses some of the principal points found during a survey, carried out by the Federal Water Pollution Control Administration, on the problems caused by combined sewers.

159
OPERATION OF SEWERAGE WORKS FOR BUDAPEST,

M. Szilagyi
Paper presented at a conference on the Construction of Complex Supply Installations at Budapest, 1968, Theme No 4.4.

Descriptors: *Sewerage, *Sewers, *Surveys.
Identifiers: *Hungary.

The built-up area of Budapest covers 23,700 ha, of which 9400 ha are connected to the sewerage system. In 1966 the length of the sewer network has about 2000 km. There were 32 sewage works and pumping stations, and the quantity of sewage and rainwater discharge amounted to over 300 million m^3. The annual volume of sludge removed from the sewer amounted to 60,000 m^3.

160
PRESSURE TUBING FIELD INVESTIGATION,

L. Scott Tucker
ASCE Combined Sewer Separation Project, Technical Memorandum No 5, Aug 15, 1967. 29 p, 19 fig, 2 tab, 1 ref. FWPCA Program No 11020 EKO.

Descriptors: *On-site tests, Conduits, Cost analysis, Trenches, Pressure conduits.
Identifiers: *Sewer-in-sewers, Copper tubing, Plastic tubing, Washington, D.C.

Three methods of installing pressure tubing from houses or small buildings, and of connecting the tubing with street pressure conduits, are described and discussed. One would be the installation and connection of pressure tubing and conduit in trenches by traditional water distribution methods. Field trials were conducted to indicate the feasibility of inserting tubing in building sewers. Tubing was pushed through an 86-foot long 4- 5-inch diameter building lateral, which included three 45 degree bends, from a specially dug pit at the upstream end into a 4-foot diameter combined sewer. The forward end of the tubing was guided by a special leader device. Three fourths-, 1-, and 1 1/2-inch polyethylene tubing could be pushed. Polybutylene and copper tubes could not be pushed because they buckled or crimped. A Kellums grip and swivel on the end of a rope were used to pull tubing from the combined sewer to the upstream pit. Three fourths-, 1-, and 1 ¼-inch polyethylene and 3/4- and 1-inch polybutylene could be pulled. Three fourths-inch copper tubing could not be pulled because of its stiffness. The third method, tested in the field, combined the insertion of tubing with a street main in the trench. Cost estimates were made for the latter two methods.

161
COMBINED SEWERS MAY BE AN ADVANTAGE,

Frank I. Vilen
Am City, Vol 85, No 1, pp 68-70, Jan 1970.

Descriptors: *Sewers, *Design, Storm runoff, Biological treatment, Separation techniques.
Identifiers: *Kenosha, Wisconsin, *Combined sewers, Sludge treatment plants.

An alternative to separation, which utilizes combined sewers in conjunction with activated sludge treatment plants, is being put into operation in Kenosha, Wisconsin through a FWPCA grant. The plant employs the biological-adsorption process and can treat up to 20 mgd of combined sewage. Details of how the system works are included as well as a flow sheet diagram of the plant. The plant will save the city at least $6 million over sewer separation and during dry weather portions of the system can supplement normal plant operations. The plant will treat flow from only 70-80% of the storms, but because of the "first flush" action of storm runoff, the greatest bulk of BOD and suspended solids will be captured. Parameters to be measured and evaluated to determine the efficiency of the system are listed.

162
COMBINED SEWERS IN CANADA,

D. H. Waller
Eng J, Vol 52, No 6, pp 22-30, Jun 1969.
Paper presented at the Annual General Meeting of the Engineering Institute of Canada, May 29-31, 1968.

Descriptors: *Sewers, *Surveys, Overflow, Separation techniques.
Identifiers: *Combined sewers, *Canada.

The author presents a survey of combined sewers in Canada similar to the one he undertook in 1967 on the same subject in the United States. Even when combined sewers are large enough to carry peak storm flows in addition to domestic sewage, they do not provide the higher velocities in dry weather that are needed to prevent solid deposition. Thus, up to 1/3 the annual production of solids and BOD may be overflowed during storms and held back from treatment. Problems such as these necessitated this study which provides information in four main areas: 1) the extent and distribution of Canada's combined sewers; 2) the prevailing attitudes and policies in regard to combined sewers; 3) factors influencing these attitudes and policies; and 4) descriptions of methods proposed and adopted to diminish overflows from combined sewers. A majority of the population surveyed considered combined sewer overflows to be a nuisance. Separation is too expensive to warrant institution in most communities. Some combined systems have not yet developed to the point where they include overflow, and in some areas the pollution from this source is not considered to be a problem. More information is needed regarding less-costly alternatives to separation. Separation should be implemented without delay for flood relief, when combined sewers are replaced and in new construction, or in plumbing for new buildings. These programs are not overly expensive, and they leave open the option of instituting alternatives which future technology may uncover.

163
AVONMOUTH INDUSTRIAL ESTATE--UNUSUAL DRAINAGE SCHEME,

K. J. West
J Inst Munic Engrs, Vol 95, No 12, pp 363-367, Dec 1968.

Descriptors: *Drainage systems, *City planning, Urbanization, Sewerage, Separation techniques.
Identifiers: *Great Britain, *Combined sewers.

Systems of drainage considered for the City of Bristol, England include: a separate system with stormwater draining to rhines; a separate system with stormwater draining through pipes to existing outfall culverts; and, combined systems. The combined sewerage system was adopted for a major part of the estate.

4b. Sanitary

164
STOKE SEWER RENEWED AFTER CRUDE SEWAGE OVERFLOW,
Surveyor, Vol 85, No 4049, pp 38-39, Jan 16, 1970. 1 fig.
Descriptors: *Sewerage, *Sewers, *Treatment facilities, *Control structures, Control systems, Contracts, Construction.
Identifiers: *Great Britain.

A sewerage reconstruction program in the Burslem area of Stoke-on-Trent involves a four-stage renewal of the sewer system and reconstruction of the water pollution control works. Old sewers were in poor structural and hydraulic condition, and several sections of the main outfall sewer upstream of the treatment works collapsed causing crude sewage to overflow and form a large lake of sewage. Two contracts provided a sanitary sewer from the works plus a surface water culvert connecting with a feeder to the River Trent. A third contract provided a separate storm and sanitary system connecting the old sewer network with the sewer and culvert constructed previously. Other structures built under the contract are described.

165
OUTLINE DESCRIPTION OF ASCE PROJECT ON 'SEPARATION OF SANITARY SEWAGE FROM COMBINED SYSTEMS OF SEWERAGE',
Am Soc Civil Engrs, New York.

ASCE Combined Sewer Separation Project, Technical Memorandum No 1, Feb 21, 1966, FWPCA Program No 11020 EKO.

Descriptors: *Pressure conduits, Separation techniques.
Identifiers: *Combined sewers, *Sanitary sewage, Comminuted sewage.

Descriptions of the project separation scheme, project goal and project background are given. The general concept of the ASCE Project scheme is to pump comminuted sanitary sewage from individual buildings and building complexes through relatively small pressure tubing laid in existing building connections and thence into new pressure conduits suspended in existing street sewers. Potential advantages of the scheme are discussed. The project wishes to develop feasible designs and operations and to test them in actual systems. The immediate objective is to examine and evaluate both the feasibility and probable cost. The background of the project is reviewed. An appendix summarizes the need for separation of combined sewerage systems and the national scope of the problem.

166
MASSIVE SEWER INFILTRATION,

Thomas E. Llewellyn
Am City, Vol 83, No 10, pp 90-91, Oct 1968.

Descriptors: *Maintenance, *Repairing, Infiltration.

The North Tahoe Public Utility District instituted a massive sewer repair program after it discovered that sewage flows were highly excessive. Snow Creek and Lake Tahoe were becoming polluted, 200 manholes were leaking and permitting entrance of surface and ground water, and many lateral sewers were causing infiltration. Smoke bombs employed to pinpoint offenders disclosed storm inlets connected to sanitary sewers. Methods used to correct violations and sewer defects are described.

167
DOMESTIC SEWAGE FLOW CRITERIA FOR EVALUATION OF PROJECT SCHEME TO ACTUAL COMBINED SEWER DRAINAGE AREAS,

Murray B. McPherson
Combined Sewer Separation Project, Technical Memorandum No 8, Nov 17, 1967. 19 p, 2 fig, 3 tab, 9 ref. FWPCA Program No 11020 EKO.

Descriptors: *Design criteria, *Water demand (household), Data collections.
Identifiers: *Domestic water use, *Peak demands, Demand variations, Sewage flow.

Residential sewage flow criteria are developed for use in design of pressurized sanitary sewers for hypothetical applications of the ASCE Project scheme. In a typical combined sewer area, data on domestic water demands is the most that can be expected to be available. On the basis of a study of winter water demand data it is concluded that projection of such observed demands for a service area to the end of the design period is the preferred basis of design. Data for California and the northeastern United States are presented separately. For each region, design curves represent the variation, as a function of the number of dwelling units served, of flow for the minimum 24 hours, for the peak hour of the minimum day, and for the maximum peak hour of any day, expressed as ratios to the annual average rate.

168
MINIMUM TRANSPORT VELOCITY FOR PRESSURIZED SANITARY SEWERS,

Murray B. McPherson, L. Scott Tucker, and M. Floyd Hobbs
Combined Sewer Separation Project, Technical Memorandum No 7, Nov 16, 1967. 23 p, 4 fig, 2 tab, 8 ref. FWPCA Program No 11020 EKO.

Descriptors: *Deposition (sewage sediments), *Pressure conduits, *Scour, Data collections, Design criteria, Regression analysis, On-site tests.
Identifiers: *Sand concentration, *Sewage analysis, *Transport velocity, Comminution, Grinding, Sanitary sewage.

Raw sewage, with and without particle-size reduction by comminution, was pumped through 2-in. to 8-in. clear plastic pipe. Extensive observation indicated rather conclusively that the material last to be scoured and first to be deposited was predominantly sand. For all tests, the sewage was salted with ground egg shells but these were always moved at lower mean flow velocities than the sand, which was in low concentrations, viz., 8 to 78 ppm. No discernable difference was noted in the minimum transport velocities for comminuted and uncomminuted sewage, and the difference between minimum scouring velocities and maximum depositing velocities was small. Test results were blended with those from sand transport experiments elsewhere for general representation. Exploratory open channel tests were made with the 8-in. pipe for a firmer correlation with sand tests. Results are presented in terms of dimensionless parameters. Limited tests were made on 8-in. spiral corrugated pipe.

4c. Storm

169
RACE TO PLUG BURST MAIN BEFORE RAINS CAME,
Eng Contract Record, Vol 82, No 12, pp 44-45, Dec 1969.

Descriptors: *Damages, *Remedies, *Repairing, Estimated costs.
Identifiers: *Storm sewers.

The article describes how a municipal storm sewer section, solidly plugged with a mixture of mud and water, ruptured and was repaired. Three steps were taken to correct the damage: 1) temporary lines were laid along the surface and the mains were pumped through these surface lines; 2) drop manholes were constructed at two sides of the threatened area; and, 3) three pumps were used to by-pass the plugged section of the line. The emergency measures for the public are related, and the theoretical causes for the break are included. The cost of repair for this unexplained occurrence is given.

170
DROP INLET REPAIRS STORM DAMAGE TO SEWER SYSTEM,

Eng Contract Record, Vol 82, No 2, p 26, Feb 1969.

Descriptors: *Damages, *Repairing, *Intakes, *Construction materials, *Sewers, *Construction equipment.
Identifiers: *Storm sewers, *Medary, Wisconsin.

In Medary, Wisconsin, a storm sewer, washed out by heavy rainfall, was repaired in twelve days. The Wisconsin Culvert Co. recommended that the now exposed area, which had previously held a 750 foot-long piece of a 72 inch diameter storm sewer pipe, be contained by fabricating a 96 inch diameter drop inlet constructed of 8-gage corrugated galvinized steel, closely riveted and caulked. The drop inlet would connect to the existing 72 inch line by means of a watertight 84 inch diameter, 8-gage galvinized steel pipe, close riveted and caulked, outlet connected at the base of the drop inlet would run 400 feet along the gouged ditch line. The method was approved and immediate fabrication of sections of the drop inlet began followed by trucking of these sections to the site and their installation.

171
WISCONSIN SANITARY SEWER WON BY 2.3%,

Eng News-Record, Vol 182, No 14, p 43, Apr 3, 1969. 1 tab.

Descriptors: *Costs, *Bids, Construction materials, Drainage systems.
Identifiers: *Storm sewers, West Allis, Wisconsin.

Unit prices and quantities of materials proposed for a 3-branch storm sewer contract in West Allis, Wisconsin are tabulated and discussed for the two lowest bidders for each branch. Branch A includes three reinforced concrete storm tunnels and a corrugated metal culvert arch. Branch B and C will relieve severe flooding conditions in this area of Wisconsin.

172
CHICAGO SEWER DRAIN PROJECT,

Eng News-Record, Vol 182, No 10, p 41, Mar 6, 1969. 1 tab.

Descriptors: *Contracts, Drainage systems, Flood control, Concrete construction, Cost comparisons.
Identifiers: *Chicago, *Sewer relieving.

Detailed statistics are given concerning bids for a contract to construct sewer drains extending the sewer system in a section of Chicago. Consolidated Construction Co., Inc. won this contract, and it will undertake the project to provide flood relief from a storm of five frequency or less. Inadequate smaller sewers will be replaced, and a number of trunk sewers and siphons will be relieved. The project will be constructed in open cut, and reinforced concrete will be the principal material used. Prices from the two lowest bidders are tabulated for each of the items to be included in the project.

173
MICHIGAN SEWER AND ROAD JOB,

Eng News-Record, Vol 182, No 9, p 43, Feb 27, 1969. 1 tab.

Descriptors: *Bids, Construction materials, Concrete pipes, Backfill.
Identifiers: *Port Huron, Michigan, *Storm sewers.

Unit prices and quantities of materials proposed for a Port Huron, Michigan paving, storm sewer, and water main contract are tabulated and described for the two lowest bidders. Reinforced concrete will be used for storm sewer piping. The contractor will excavate and backfill over existing sewers because of the formerly poor backfill.

174
STORM SEWER CHANNEL IN NEBRASKA,

Eng News-Record, Vol 181, No 2, p 69, Jul 11, 1968. 1 tab.

Descriptors: *Construction costs, *Bids, Concrete pipes.
Identifiers: *Omaha, Nebraska, *Storm sewers.

Bids for constructing a channel section of a storm sewer in Omaha are compared, and prices for quantities of materials are tabulated for the two lowest bidders. A long riprapped, flat-bottom ditch will be filled with reinforced concrete piping. The proposed length of the channel was shortened due to difficulties in obtaining easements. The project will improve alignment and flow capacity to prevent property damage by erosion.

175
ADDITIONAL INFORMATION-FAILURE OF STORM SEWER SYSTEM,

Water Sewage Works, Vol 117, No 6, p 191, Jun 1970.

Descriptors: *Sewers, *Decision making, Overflow.
Identifiers: *Storm sewers, *Medary, Wisconsin.

A description of the storm sewer system situation in Medary, Wisconsin prior to the overflow in June 1968 is given. The article states that the failure of the sewer line in Medary was not due to the design of the storm sewer system, the installation of the pipe, or the type of pipe used. Two reasons are given as to the cause of the overflow: modifications to the storm sewer without informing the consultant engineer; and, lack of knowledge or consideration of hydraulic principles.

176
RX FOR . . .,

Water Sewage Works, Vol 116, No 12, pp 464-465, Dec 1969.

Descriptors: *Construction materials, *Sewers, Storm runoff, Steel.
Identifiers: *Storm sewers, *Medary, Wisconsin.

Failure of a concrete storm sewer system in Medary, Wisconsin during a heavy rainfall resulted in property damage and threatened disaster for two major arterial highways. With weather forecasts predicting more storms, officials ordered the construction and installation of a large corrugated, galvanized steel storm sewer. Dimensions and details are given of the system which was installed and operating in 12 days--an unlikely feat to perform using other conduit materials.

177
SUBURB MEETS URBANIZATION HEAD-ON,

Water Wastes Eng, Vol 4, No 11, pp 47-49, Nov 1967.

Descriptors: *Sewerage, *Design, Costs, Michigan.
Identifiers: *Storm sewers, Expenditures.

The city of East Lansing, Meridian Township Board, and Michigan State University jointly agreed to provide a municipal sewer system for the fast-growing college and recreational area in Ingham County, Michigan. The original septic tanks were connected to storm sewer systems which led to a newly constructed sewage treatment plant. Financial problems and an itemized list of expenses are discussed.

178
SEWERAGE,
British Standards Inst, The Council for Codes of Practice

British Standard Code of Practice CP2005, 1968.

Descriptors: *Design, *Construction, *Sewers, Legislation.
Identifiers: Storm overflows, Tidal outlets, Trade effluents, Great Britain.

The Civil Engineering Code of Practice (No. 5, 1950), entitled DRAINAGE has been completely revised to incorporate new methods for the design and construction of sewers and auxiliary works. Recommendations are made regarding materials and components, basic data requirements, general design and construction of sewers, discharge of trade effluents, manholes, storm overflows, siphons, pumping stations and mains, and tidal outfalls. The relevant legislation is indicated, and methods for calculating rates of runoff are appended.

179
MODEL STUDIES OF STORM SEWER DROP SHAFTS,

Sigurd H. Anderson
St. Anthony Falls Hydraulic Laboratory, Minneapolis, Technical Paper No 35, Series B, pp 1-61, Dec 1961.

Descriptors: *Hydraulic structures, *Laboratories, *Model studies.
Identifiers: *Drop shafts, *Storm sewers.

The Department of Public Works of the City of St. Paul, Minnesota, presently engaged in a program of enlarging their storm sewer system, is developing a drop-shaft design which will reduce the possibility of impact damage to the structure and also insure stable flow conditions in the underground interceptors. It was found that past designs required frequent inspection and maintenance at the base of the shaft to prevent failure of the structure. An experimental study led to the development of an impact-cup type of drop structure which could be effectively used to convey storm runoff waters from the surface to subterranean collecting systems with a minimum of air entrainment and a reduction in possible damage at the base of the drop. Pictures and measured sketches of the designs are included.

180
STORM DRAINAGE PRACTICES OF THIRTY-TWO CITIES,

Colby V. Ardis, Kenneth J. Dueker, and Arno T. Lenz.
J Hydraul Div, Am Soc Civil Engr, Vol 95, No HY1, pp 383-408, Jan 1969. 26 p, 13 fig, 12 tab, 12 ref, append.

Descriptors: *Drainage, *Storm drains, *Drainage water, *Waste water disposal, *Waste water treatment, Wisconsin, Urbanization, Runoff, Storm runoff, Cost analysis, Drainage systems, Water pollution control, Design, Rational formula.
Identifiers: Urban hydrology, Municipal engineering, Storm sewers.

Wisconsin cities with populations of 7,500 to over 60,000 are developing comprehensive plans with all storm sewer designs done by registered professional engineers. Storms with 5 to 10 yr frequency are used in design. Two-foot inlest depressed one in., 12-in. minimum pipe size, and pipe velocities of 2 to 15 fps are common. Urban drainage designers who provided current practice, policy, procedure and cost information for a typical 15-acre, 6-block area indicated wide diversity in results when using the Rational Method to compute flows. Only 6 of 23 cities which contributed sample designs used variable intensities correctly in the Rational Method. Errors in the use of the runoff coefficient C were common. Total project costs varied from $8,000 to $65,000 for this sample area. The need for narrower guide lines for design is suggested.

181
PLANNING STANDARDS FOR STORM DRAINAGE,

Myron D. Calkins
Urban Planning Devel Div, Am Soc Civil Engrs, Vol 96, No UP1, pp 53-58, Mar 1970.

Descriptors: *Storm runoff, *Storm drains, Design, Standards.
Identifiers: *Storm sewers, Design criteria.

The construction of facilities for the control and containment of storm water runoff is advocated. Some historical background concerning the organization of interested engineers is given. Two publications were issued in 1966 containing: 1) the standard design criteria for storm sewers and appurtenances; and, 2) storm sewer construction specifications. The former document proved to be more valuable and is outlined.

182
UNDERWATER INSPECTION--SEEING IS REVEALING,

Tom Davey
Water Pollution Control, Vol 107, No 11, pp 16-17 and 31, Nov 1969.

Descriptors: *Outlets, *Storm runoff, Sewage effluents.
Identifiers: *Storm sewers, Toronto.

On one underwater diving job, two consulting engineers inspected storm water outfalls near the lakeshore in Toronto. They were lowered into manholes, and inside they found accumulations of silt and domestic and industrial sewage debris even though these were storm sewers. As a result of these obstructions, storm flow had become more restricted over the years.

183
URBAN RENEWAL IN WHITE PLAINS, NEW YORK,

J. Michael Divney
Civil Eng, Vol 39, No 9, pp 69-72, Sep 1969.

Descriptors: *Urban renewal, Storm drains.
Identifiers: *White Plains, New York.

In an urban renewal program in White Plains, N. Y., a scatter housing plan was developed. A scheme employing pairs of one-way streets and at-grade intersections was used. The Davis Brook storm drain (84 in. diameter, 3000 ft. long) will divert the route of the David Brook culvert from the center of the project to the Bronx River, along the southern boundary of the project. The pipes were jacked under the commuter rail line, and gravel was pumped into the voids, thus stopping the track settlement.

184
POLLUTION ABATEMENT THROUGH SEWER SYSTEM CONTROL,

W. T. Eiffert and P. J. Fleming
J Water Pollution Control Fed, Vol 41, No 2, pp 285-291, Feb 1969.

Descriptors: *Waste water treatment, *Pollution abatement, Sewers, Sewerage.
Identifiers: *Storm sewer pollution, *Dayton, Ohio

Concurrent with a major wastewater treatment plant expansion program in Dayton, Ohio, for effluent release into the Great Miami River, a four point program has been initiated to eliminate pollution from storm sewers. Although Dayton has a separate sewer system, untreated industrial plant wastes and municipal by-passes must be eliminated to insure the 90 to 95 percent pollution reduction required by water quality standards.

185
SOME ASPECTS OF DEEP SEWER MAINTENANCE,

L. Goodhew
Water Pollution Control, Vol 68, No 2, pp 217-221, Mar 1969.

Descriptors: *Sewers, Weirs.
Identifiers: *Storm sewage, *Deep sewers.

The design and construction of deep sewers which are described are drawn from the Rochester, Chatham and Gillingham Joint Sewerage Board. It is advised to restrict the admission of storm sewage and to install storm overflow weirs only on the branch sewers. The maintenance of deep sewers as well as safety precautions, and cleaning and inspection methods are explained. For the first flush of storm sewage into the trunk sewer, a long and narrow chamber, with an overflow weir at the upstream end and an outlet into the trunk sewer from its downstream end, is constructed at a point where a branch sewer enters a trunk sewer.

186
ORGANIZING AND PLANNING FOR SEWER MAINTENANCE,

Glen J. Hopkins and Don Hurlbert
J Water Pollution Control Fed, Vol 39, No 2, pp 230-239, Feb 1967.

Descriptors: *Maintenance, *Repairing, Sewerage, Gate control.
Identifiers: Storm sewer valves, Sewer separation, Kansas City, Missouri.

The sewer maintenance program devised by the Maintenance Division of the Department of Pollution Control, Kansas City, Mo., is geared toward public service in the quick repair of damaged sewers, whatever the cause. This program also deals with sewer and catch basin cleaning, sewer malfunctions and connections, and preventive maintenance. The sewer system includes a number of gate and sluice gate valves on storm sewers that must be closed in times of flooding. In the case of overloaded sewers, if stormwater lines are found to be connected to sanitary sewers, the Maintenance Division requests that the two lines be disconnected.

187
STORM DRAINAGE PRACTICES OF THIRTY-TWO CITIES,

Discussions by Richard A. Rogers, and Kenneth R. Wright and Elmer L. Claycomb
J Hydraulics Div, Am Soc Civil Engrs, Vol 95, No 6, pp 2195-2196, Nov 1969.

Descriptors: *Design criteria, *Storm drains, Rational formula.
Identifiers: *Urban Storm Drainage Criteria Manual.

Wright and Claycomb state that the Denver Regional Council of Governments (DRCOG) commissioned the preparation of an Urban Storm Drainage Criteria Manual in 1967. The related findings indicate that the Rational formula is often misused. They also mention that extensive research has been conducted on the subject of practical storm sewer design by the University of Missouri.

188
RATIONAL "RATIONAL" METHOD OF STORM DRAINAGE DESIGN,

R. A. Rogers
J Irrigation Drainage Div, Am Soc Civil Engrs, Vol 94, No IR4, pp 465-480, 1968.

Descriptors: *Storm drains, *Drainage systems, *Design, *Rational formula, *Non-uniform flow, *Computer programs, Runoff Pipes.

Identifiers: *Submerged systems.

The method of a storm drainage system design is presented which utilizes the Rational Formula with a modification to allow for nonuniform runoff. The system is designed for critical periods when flow in a system or parts of a system is maximum as determined from a hydrograph of the runoff. This method is particularly suited for the design of submerged systems, and therefore, it was computerized. The results of a sample problem show larger pipe sizes than would be found when using the conventional method which adds times of flow in lines to concentration time at some arbitrary starting point.

189
DUNFERMLINE PAST, PRESENT AND FUTURE,

William G. Stephenson
J Inst Munic Engrs, Vol 96, pp 53-60, Feb 1969.

Descriptors: *City planning, Drainage programs.
Identifiers: *Dunfermline, Scotland, *Storm sewers, Combined sewers.

The highways, drainage works, water supply, and lighting of Dunfermline are discussed. The overloading of combined sewers since the last war has necessitated extension of storm relief sewers. Two projects will begin to ameliorate the situation. Menawhile, all new drainage projects have been laid on the separation system.

190

MULTI-MEANS EFFORT FOR URBAN FLOOD CONTROL,

Kenneth R. Wright

Paper presented at International Conference on Floods: Their Protection and Defense of the Soil, held by the academia Nazionale Dei Lincei, Rome, Italy, Nov 1969.

Descriptors: *Flood control, *Planning, *Drainage systems, *Drainage engineering, Storm drains, Storm runoff, Drainage programs, Hydraulic structures, Water policy.

Urban drainage is usually very localized, although it is believed that damages due to urban drainage problems are equal to report flood losses.

An effective way to deal with this problem is by a multiple means effort based on a basic urban drainage policy. Such a policy should be formulated in lieu of various inputs, principles of urban drainage, hydrology and hydraulics of small urban basins, and accurate knowledge of urban drainage law. Urban drainage policy must also recognize that urban drainage is directly related to the total urban system. The planning process is based on the concept of two urban drainage systems. The initial drainage system, typically storm sewers, is designed to handle storm runoff expected to occur once every 2-10 years. The major drainage system is the area which must accomodate the 100-year runoff and includes both natural and artificial elements. Other specific aspects of urban drainage planning discussed are functions of storm sewers and streets, hydraulic structures, inlets and culverts, storage and floodproofing.

Section 5

STORMWATER - QUALITY, QUANTITY, AND POLLUTION

a. Caused from combined overflows
b. Caused from storm runoff

5a. Caused from combined overflows

191
OHIO STORMS BURST TWO RESERVOIRS,

Eng News-Record, Vol 183, No 3, p 13, Jul 17, 1969.

Descriptors: *Ohio, *Damages, Storm runoff, Storm drains.
Identifiers: *Storm overflows, Storm sewage.

Severe storms in northern Ohio caused serious damage to 23 counties in the state. In four sections of Bellevue, the heavy rains raised the water table so high that sewage-filled water rose out from the limestone channels of the underground storm drainage system. Residents spent days pumping water off to ditches draining Lake Erie. The flooding also destroyed much of Bellevue's $4.5-million sewage interceptor and treatment plant in addition to damaging reservoirs, bridges, etc. in other Ohio areas.

192
WATER FOR PEACE, VOLUME 3, WATER SUPPLY TECHNOLOGY,

Int Conf on Water for Peace, May 23-31, 1967.

Descriptors: *Water management (applied), *Pipelines, Water quality, Water conservation.
Identifiers: *Water quantity forecasting.

The third volume includes 97 papers dealing with water supply problems associated with the management of groundwater resources. Water pipeline design, materials, and construction are explained. Water quantity forecasting and water conservation techniques are examined. Water quality considerations such as water pollution, and methods of water quality maintenance are discussed.

193
WATER FOR PEACE, VOLUME 4, WATER SUPPLY TECHNOLOGY,

Int Conf on Water for Peace, May 23-31, 1967.

Descriptors: *Water pollution control, *Standards, Filtration, Water quality, Data storage and retrieval, Water resources development.
Identifiers: *Treatment processes.

The fourth volume includes 103 papers dealing with water pollution control and research work carried out to improve water analysis, filtration, and treatment techniques. Water quality standards, and methods and instrumentation for hydrologic data collection and retrieval are discussed so they may be used for water development and water programs.

194
WATER FOR PEACE, VOLUME 8, PLANNING AND DEVELOPING WATER PROGRAMS,

Int Conf on Water for Peace, May 23-31, 1967.

Descriptors: *Waste water treatment, *Pollution abatement, *Quality control, *Water utilization, *Cost analysis.

The eighth volume includes 78 papers dealing with the development of water programs, in various countries, associated with water and wastewater treatment, water pollution abatement, and water quality control. Water utilization for multiple agricultural and industrial purposes, and for electric power requirements are explored. Financing considerations, involved in the planning, organization, management, and design of public water supplies are studied.

195
WATER POLLUTION ASPECTS OF URBAN RUNOFF; The Causes and Remedies of Water Pollution From Surface Drainage of Urban Areas,
Am Public Works Assoc

Prepared for FWPCA, Contract No WA 66-23, Jan 1969. 272 p.

Descriptors: *Water pollution, *Water pollution sources, *Storm runoff, *Water pollution effects, Solid wastes, Data collections, Watersheds (basins), Runoff, Pesticides.
Identifiers: *Environmental pollution, *Storm sewers, *Combined sewers, *Urban drainage.

The environmental pollution factors and their potential pollutional effects resulting from the water-wastes interfacial contracts during precipitation and runoff have been analyzed based upon collected field data and theoretical calculations. The surface urban environment factors studied included, street refuse and litter, catch basins, environmentally used chemicals, contributions from air pollution and its control, and sewer solids deposition. It was found that street refuse could present a significant pollution load. It is estimated that a pollution load - measured in terms of BOD - of a) 1% of the total raw sewage or 5% of the total secondary treatment effluent in terms of average daily load, and

b) 160% of the raw sewage and 800% of the secondary effluent load, expressed in terms of the shock pollution load on the receiving body of water results from the dust/dirt fraction of street litter. Summary-form findings and recommendations, raw data collected, survey questionnaires, and a comprehensive set of ordinances govering a wide sampling of possible sources of urban storm water pollution are compiled in this report.

196
WATER QUALITY CRITERIA: REPORT OF THE NATIONAL TECHNICAL ADVISORY COMMITTEE TO THE SECRETARY OF THE INTERIOR,

U.S. Federal Water Pollution Control Admistration, 245p.

Descriptors: *Water quality control, *Standards.
Identifiers: *Water quality criteria.

To assist State and Federal agencies in establishing water quality standards, as required by the Water Quality Act of 1965, the first National Technical Advisory Committee on Water Quality Criteria has collected into this volume a basic foundation of water quality criteria with individual sections on: recreation and aesthetic aspects; public water supplies; fish, other aquatic life, and wildlife; agricultural uses; and, industrial water supplies. Tabulated numerical data, appended references for each section, and a subject index are included.

197
NEW ENGLAND INTERSTATE WATER POLLUTION CONTROL COMMISSION: NINETEENTH AND TWENTIETH ANNUAL REPORTS ON INTERSTATE WATER POLUTION CONTROL, 1966 AND 1967,

Descriptors: *Standards, *Water quality, *Classification, *Sewage treatment, *Waste water treatment, *Planning, *Operations, Legislation.

These reports outline the activities and accomplishments of the Commission, and the signatory states, in the improvement of water quality. Tables are included showing the 1967 revision of the scheme used for classification of water according to the intended uses and the corresponding physico-chemical and bacteriological standards. Each state has been classifying the interstate streams, and subsequent to approval of the classification by the Commission, each state will undertake establishing a program for treatment of sewage and waste waters to meet the appropriate standards. Progress in the planning and construction of treatment plants is summarized for the individual states, and some individual states, and some individual plants are described and illustrated. Research has included studies on the legal aspects of water right and on the identification and solution of major operational problems at sewage works. Attention has also been given to the training of operators for waste water treatment plants particularly in view of the requirements of the 600 new plants which have been proposed for the near future. Federal and state legislation is also summarized.

198
OHIO RIVER VALLEY WATER SANITATION COMMISSION: SEVENTEENTH, EIGHTEENTH, NINETEENTH, AND TWENTIETH YEARBOOKS,

28 pp, 165; 44 pp, 1966; 40 pp, 1967; 44 pp, 1968.

Descriptors: *Water quality, *Control structures, *Ohio River, *Water management (applied), Monitoring, Geological surveys, Hydroelectric plants.
Identifiers: *Water quality criteria, Hydrological surveys.

Progress in cooperative work on the management of water quality in the Ohio River valley is reviewed. The 18th yearbook contains the criteria which have been recommended for water quality. Since the Water Quality Act of 1965 required the establishment of water quality standards for the individual states, a major problem is the reconciliation of standards, especially where different standards are applied to the same stretch of river bordering two states. Other projects include: expansion of the system for monitoring water quality, appraising river conditions, and forecasting impending changes some days in advance; development of automated forecasting procedures for management of water quality using a mathematical model; geological and hydrological surveys to determine the potentialities and limitations of deep wells for the disposal of difficult or toxic waste waters; assessment of changes in aquatic life; and, investigations on the enrichment of oxygen in rivers by various methods of operation at hydroelectric power facilities. Each yearbook includes data on the individual water quality characteristics in the Ohio River and its tributaries, and on the present status of municipal and industrial pollution control facilities. The 20th yearbook also contains an article by R. H. Leach, reviewing the accomplishments of the Commision during the 20 years since its establishment.

199
SEWER MAINTENANCE IN A COLD CLIMATE,

F. E. Ayers
J Water Pollution Control Fed, Vol 41, No 3, pp 418-423, Mar 1969.

Descriptors: *Runoff, *Hydrology, *Water pollution sources, Storms, Infiltration.
Identifiers: *Sewer maintenance, *Canada, Combined sewers.

Sewer maintenance problems in Ottawa include threatened explosions due to improper sewer ventilation during snow and sleet storms, the entrance of granular street materials into catch basins and then the sewer systems, and the handling of excess runoff during spring thaws. The problem caused by the entrance of sand and peastone traction materials into the sewer system is greatest in the city's combined sewer district where pipes are older and laid on flatter grades than those of the newer separate system. Means of combating Ottawa'a sewer maintenance problems are discussed. Two programs adopted are the crash maintenance program during spring to remove grit in flat sewers, thus allowing sewers maximum capacity for spring runoff; and the development of detained sewer maintenance records which are made available to crews handling sewer problems.

200
PROPOSED PROCEDURE FOR DETERMINING QUANTITY AND QUALITY OF STORM FLOW,

M. B. Fielding
Water Resources Commn, Div Res Pap No 2002, 1966.

Descriptors: Measurement, Flow, Planning.
Identifiers: *Storm sewage, Suspended solids.

The author outlines a suitable procedure for meassuring the flow of storm sewage and for collecting samples for the determination of BOD and suspended solids. A graphical form is proposed for reporting the results.

201
URBAN EFFECTS ON QUALITY OF STREAMFLOW,

E. Gus Fruh
In: Effects of Watershed Changes on Streamflow, Water Resources Symposium No 2, Oct 1968, p 255-282, University of Texas Press, Austin and London, 1969. 28 p, 22 fig, 5 tab, 15 ref. NSF Grant GU-1963, and Texas Water Quality Bd Contract No 68-69-281.

Descriptors: *Reservoirs, *Urbanization, *Water quality, *Stratification, *Texas, Water pollution sources, Water pollution effects, Dissolved oxygen, Aquatic bacteria, Algae, Colorado River.
Identifiers: Austin, Texas.

The effects of impoundments and urbanization on the water quality of the Colorado River ot Texas were studied in the reservoirs near Austin, Texas. Lake Travis, upstream from Austin, is large and deep and has no significant input of pollution. Lake Austin, the next reservoir downstream, is much smaller and shallower, and receives some recreational and urban runoff pollution. Town Lake, in Austin, is small and narrow and receives some urban runoff pollution. Oxygen concentration/water depth data for the 3 reservoirs are tabulated. In Lake Travis, even in the winter, the temperature varied with depth. During the summer, the oxygen first became depleted at the thermocline region. Throughout the fall, various depths of Lake Travis became reaerated, but oxygen-depleted waters were still passing through the penstocks in November. In winter, oxygen was present at all depths. In Lake Austin, the summer oxygen concentration in the epilimnion varied around saturation. Dissolved oxygen decreased steadily in the hypolimnion during the summer and was consistently lower above the sediments. After autumn turnover, oxygen remained uniform from top to bottom. High numbers of total and coliform bacteria were found in Lake Austin during the spring following periods of intensive rainfall. The urban stream, Barton Creek, had significantly higher concentrations of solutes, nutrients, and bacteria than Town Lake above the stream's entrance, particularly during the spring rainfall period. All of Austin's urban streams enter Town Lake and Lake Austin, with the streams from the more highly developed areas entering Town Lake.

202
URBAN PLANNING ASPECTS OF WATER POLLUTION,

Sigurd Grava
Columbia University Press, New York, 1969. 232 p.

Descriptors: *City planning, *Water quality control, *Urban renewal, *Urbanization, Water pollution control.

This study, strictly limited to water-borne wastes and water quality control, represents a synthesis of experience and thought on water pollution as it applies to urban planning and is intended as a guide and source of information for urban planners and community decision makers. Although non-technical in nature, the work includes data, financial and administrative considerations, and reference material.

203
COMBINED SEWER CONSIDERATIONS BY PHILADELPHIA,

Carmen F. Guarino, Joseph V. Radziul, and William L. Greene
J Sanit Eng Div, Am Soc Civil Engrs, Vol 96, No SA1, pp 1-14, Feb 1970.

Descriptors: *Pollution abatement, *Water quality, Sewage Treatment, Instrumentation, Application methods.
Identifiers: *Philadelphia, Sewer overflows.

The City of Philadelphia's experience and study of the combined sewer overflow pollution problem are described. Water quality legislation and pollution abatement philosophies are considered. The needs for problem definitions are delineated along with pertinent constraints of existing methodology and measuring instrumentation. Costs and economic analysis of some abatement schemes are evaluated. Complete separation of stormwater and sanitary wastes, storage in conduit or detention basins, a total systems concept and microstraining, chlorination, and ozonation of discharges are some of the principles reported for the control and treatment of combined sewer overflows. The authors basically recommend partial separation in certain areas of the City and alternate methods or the continuance of combined sewerage for the remaining areas. However, further knowledge is needed regarding all types of sewerage systems and treatment.

204
EVALUATION OF WATER-QUALITY MONITORING IN THE ORANGE COUNTY WATER DISTRICT, CALIFORNIA,

Joe A. Moreland and John A. Singer
Geological Survey Open-file report, 1969. 27 p, 5 fig, 3 tab, 12 ref.

Descriptors: *Water quality, *Monitoring, *Groundwater, *California, Data collections, Saline water, Water pollution sources, Irrigation water, Municipal water.
Identifiers: Orange County, California.

Water samples for chemical analysis are collected periodically from 272 wells in the Orange County, California Water District by 16 agencies. Many other wells are sampled at infrequent intervals by these and other agencies. The efficiency and completeness of the entire network are evaluated, and changes in standards for the network are suggested. Complete chemical analysis of a water sample is not always necessary. Selective analyses suggested for obtaining specific types of data include: (1) Chloride determination and electrical conductivity measurements on samples from aquifers susceptible to intrusion of sea water; (2) sulfate, bicarbonate, and nitrate determinations on samples from aquifers underlying the forebay area; and (3) sodium, sulfate, chloride, and boron determinations and electrical conductivity measurements on samples from aquifers used as a source of irrigation water.

205
THE MAGNETIC SPHERULES IN SEDIMENTS OF LAKE MENDOTA, WISCONSIN,

Jerome O. Nriagu and Carl J. Bowser
Water Res, Vol 3, No 11, pp 833-842, Nov 1969. 5 tab, 4 graphs, 12 ref.

Descriptors: *Industrial wastes, *Domestic wastes, *Water pollution sources, *Wisconsin, *Influent streams, *Sediment distribution.
Identifiers: *Lake Mendota, Urban runoff.

Magnetic microspherical particles which occur in the bottom muds of Lake Mendota have been analysed chemically and mineralogically. The data suggest that these spherules are flue products derived from industrial and domestic activities and are being supplied to the lake either through the action of washing the atmosphere or as the detrital load of the influent streams and urban runoff.. These particles are apparently unaffected by diagenetic changes and since the chronological pattern of the lake sedimentation is well documented, the distribution of these microspherical particles has been used to evaluate the role of man in the trophic evolution of the lake.

206
WATER QUALITY: COST BENEFITS OF IRREDUCIBLES,

Ralph Stone, William Garber, and Helen Friedland
J Sanit Eng Div, Am Soc Civil Engrs, Vol 96, No SA3, pp 691-697, June Jun 1970. 4 tab, 2 ref.

Descriptors: *Reasonable use, *Beneficial use, *Surveys, Water

The ASCE Committee on Sewerage and Sewage Treatment distributed a questionnaire to members of the Sanitary Engineering Division in order to determine the attitudes and opinions of members in regard to existing and future research and development, the social and economic value of alternate beneficial uses of the Nation's water, and to demonstrate an algorithmic technique for quantifying probabilistic or nondeterministic data. Results of the questionnaire are listed and interpreted. Responding engineers generally indicated that sewer and storm drain design would benefit least from existing or future research and development work. The authors conclude that it is possible and desirable to quantify qualitative factors relating to engineering decisions. Also, as algorithmic methods are used increasingly, future technical refinements may be expected.

207
WATER AND WASTE WATER, AND WATER POLLUTION CONTROL IN AUSTRALIA,

D. K. B. Thistlethwayte
Water Pollution Control, Vol 68, No 3, pp 256-274, 1969.

Descriptors: *Water sources, *Water utilization, *Sewerage, *Sewage treatment, *Water pollution, *Water pollution control, *Surface runoff, Biocontrol, Legal aspects.
Identifiers: *Australia.

The author outlines the sources and use of water in Australia, the development of sewerage facilities and of water and sewage treatment, and the problems of pollution and pollution control. Although sewage from most large communities receives full biological treatment, there is growing pollution of surface waters by urban runoff and from agricultural sources; and little attention has so far benn given to reclamation and reuse of water. The control of pollution is the responsibility of various agencies, and differs from state to state.

5b. Caused from storm runoff

208
QUALITY OF SURFACE WATERS OF UNITED STATES, 1960--3,4,
U.S. Geological Survey

Water Supply Paper 1742, 1968. 309 p.

Descriptors: *Ohio River, *St. Lawrence River, *Watersheds (basins), *Water quality, Chemical analysis, Temperature, Rainfall.

Records of chemical analysis, suspended sediment, and temperature for surface waters serve as a basis for determining the suitability of waters which were examined for all uses in the Ohio River and the St. Lawrence River basins. The discharge of stream and chemical quality are related to variations in rainfall and other forms of precipitation. The records are arranged by drainage basins in downstream order.

209
WATER QUALITY MONITORING FIELD STUDIES,

Bruce R. Barrett
Paper presented at the Calif Water Pollution Control Assoc 42nd Annual Conference, Sacramento, Calif, April 29 to May 1, 1970.

Descriptors: *Monitoring, *On-site investigations, *Instrumentation, Water pollution, Water quality.

Continuous water quality monitors have been used by the Technical Services Program of the Robert S. Kerr Water Research Center, Ada, Oklahoma, in a variety of field water pollution studies and for various purposes. Two commercially available types of monitors have been used. Monitors were used in the James River Project along with recording flow gages to determine the relationship between stream quality and storm runoff. In a before-and-after type study to determine differences in quality due to navigation impoundments, monitors were used to establish the existing quality of the waterway. In a research study of a refinery waste treatment plant, a monitor was used to study the various unit processes for purposes of treatment control and overall refinery waste monitoring. The sample taking capability of the monitors was indispensable in an enforcement case involving a mine waste.

210
FECAL COLIFORM CONCENTRATIONS IN STORMWATERS,

Robert A. Buckingham and Roger P. Betson
Paper present at the Am Geophys Union, Fifty-first Annual Meeting, 1970.

Descriptors: *Storm runoff, *Coliforms, *Overland flow, *Water quality, *Water pollution sources, *Testing.
Identifiers: *Fecal coliforms, *Tennessee Valley.

Recent limited stormwater bacteriological water-quality sampling in the Tennessee Valley indicates that high fecal coliform loads are common in stormwater runoff. In clean residential areas sustained high fecal coliform loads were observed uring stormwater runoff. The source of these loads was associated with overland flow, and it appears that staggered contributing times account for the sustained high loads. High fecal coliform counts were also measured in stormwaters originating from agricultural areas and forested watersheds. The consistency with which fecal coliform counts in excess of accepted standards are commonly found further substantiates the need for a reappraisal of this test as an indicator of pathogenic organisms. These data also point to the importance of recognizing the streamflow regime in the analysis of water-quality sampling data since observations taken during storm periods usually in high bacteriological loads.

211
STORM WATER POLLUTION FROM URBAN LAND ACTIVITY,

Jerry G. Cleveland, Ralph H. Ramsey, and Paul R. Walters
In: Combined Sewer Overflow Abatement Technology. Water Pollution Control Research Series, Report 11024--06/70, pp 1-55, Jun 1970.

Descriptors: *Storm runoff, *Water pollution, *Water pollution sources, *Investigations, *Urbanization, *Pollutants, *Sampling, Cities.
Identifiers: *Tulsa, Oklahoma.

An investigation of the pollution concentrations and loads from storm water runoff in an urban area was conducted in Tulsa, Oklahoma during the period from October 1968 to September 1969. The scope of the project included a field assessment of the storm water pollution by obtaining samples of the water resulting from rainfall and surface runoff from test sites in the metropolitan area; development of an analytical procedure for correlation of storm water pollution with defined variables of land uses, environmental conditions, drainage characteristics, and rainfall; and development of an abatement plan for pollution in urban areas. Runoff samples were analyzed in terms of quality standards for BOD, COD, TOC, organic kjeldahl nitrogen, soluble orthophosphate, chloride, pH, solids, total coliform, fecal coliform, and fecal streptococcus pollutants. Results of this investigation are detailed herein.

212
SEASONAL VARIATIONS IN SURVIVAL OF INDICATOR BACTERIA IN SOIL AND THEIR CONTRIBUTION TO STORMWATER POLLUTION,

D. J. Van Donsel, E. E. Geldreich, and N. A. Clarke
Appl Microbiol, Vol 15, No 6, pp 1362-1370, 1967.

Descriptors: *Streptococcus, E. coli,* Bioindicators.
Identifiers: Seasonal survival study.

A three-year study was made on the survival of selected strains of *Escherichia coli* and *Streptococcus faecalis* in shaded and exposed outdoor soil plots. The soils were dosed periodically, and subsequent reductions in survival are shown graphically as seasons variate. Periods for 90-per cent reduction of *Esch. coli* ranged from 3.3 days in summer to 13.4 days in autumn and for *S. faecalis* from 2.7 days in summer to 20.1 in winter. During the fall, the survival periods for the organisms were the same, but in spring and winter *Streptococcus* survived longer. Both organisms could be isolated from runoff during period of heavy rainfall in spring; however, isolation during summer and autumn months was sporadic. On account of these results and other factors, it was considered that *Esch. coli* was the better indicator of pollution.

213
CONCEPTS OF FECAL STREPTOCOCCI IN STREAM POLLUTION,

E. E. Geldreich and B. A. Kenner
J Water Pollution Control Fed, Vol 41, No 8 pp R336-R352, Aug 1969.

Descriptors: Storm runoff.
Identifiers: Fecal coliforms, Fecal streptococci, Stream pollution.

Results of an intensive study on the occurrence and strain distribution for 12, 536 fecal streptococcus strains found in warm-blooded animal feces and numerous water sources from a wide geographical area reveal several new factors that must be understood for a proper interpretation of the sanitary significance of this bacterial group in water pollution studies. These studies were conducted in streams, agricultural waters, recreational and public water sources, and on domestic wastewater and stormwater and food processing wastes. The ubiquity of *Streptococcus faecalis* var. *liquifaciens* in the water environment and the occasional occurrence of an atypical *S. faecalis* associated with vegetation shows the need for including the fecal coliform examination in recreational water quality measurements. Applications of the fecal streptococcus indicator system in stream pollution are the development of fecal coliform to fecal streptococcus ratios that will further define possible sources of the fecal discharge into the stream; and the detection of the *S bovis* and *S. equinus* subgroup which was not found in human feces and may be considered a specific indicator of non-human animal pollution.

214
THE BACTERIOLOGICAL ASPECTS OF STORM-WATER POLLUTION,

E. E. Geldreich, L. C. Best, B. A. Kenner, and D. J. Van Donsel
J Water Pollution Control Fed, Vol 40, No 11, pp 1861-1872, Nov 1968.

Descriptors: *Water pollution sources, *Pollutant identification, Remedies.
Identifiers: *Fecal coliforms.

The bacteriological composition of stormwater from a variety of areas was compared and seasonal differences noted. Higher numbers of organisms appear to persist during winter than during summer. The fecal coliform segment of the total coliform population for all stormwater samples averaged 8.6 percent; however, 21.1 percent fecal coliforms were observed in stormwater taken in autumn from a suburban business district. Evidence indicates that fecal contamination in separate stormwater systems originates from cat and dog deposits on soil and from rodent deposits in urban areas. Thus, regulations to prohibit pets on public beaches and improved garbage control plans to discourage rodent proliferation are recommended. Also, diversion of storm drains and land drainage away from beaches and reservoirs would aid in reducing bacterial contamination.

215
RESEARCH REGARDING SEDIMENT AND URBANIZATION,

Harold P. Guy
J Hydraulics Div, Am Soc Civil Engrs, Vol 93, No HY6, pp 247-254, Nov 1967.

Descriptors: *Sedimentation, Urbanization, Streamflow, Water resources, Storm runoff.
Identifiers: Sediment pollution, Storm drainage.

Sediment derived from construction in areas of urban growth has profound impact on downstream channels and water resources. Such sediment pollution is usually much more dynamic and intense than sediment derived from rural areas. Research needs concerning urban drived sediment are similar to those already underway in rural areas; however, new emphasis must be given to exposed subsoils, to problems in existing stream channels, to pollution of existing and future water resources, and to more effective planning and phasing of construction. Storm drainage, that flows through existing and new channels that are later complicated by urban changes, is a foremost topic of urban hydrology; and it is discussed in this article. Some of the needed soils and stream channel research can be accomplished in laboratories, but much needs to be done on small areas at the construction sites. Although many urban research methods can be adapted from related rural programs, consideration must be given to the fact that the extent and location of the exposed subsoils in the drainage basin will change rapidly and that extremely high and variable sediment loads will be imposed upon the stream channels. Better planning and legal backing will make research findings more useful.

216
ON SIGNIFICANCE OF *PSEUDOMONAS AERUGINOSA* IN SURFACE WATERS,

A. W. Hoadley
J. New Eng Water Works Assoc, Vol 82, No 2, pp 99-111, Jun 1968.

Decriptors: *Pseudomonas, *Drainage, Indicators.
Identifiers: **Pseudomonas aeruginosa.*

Although sewage discharges represent major potential sources of *P. aeruginosa* in the environment, storm drainage from municipal areas contributes continuous inoculum to surface waters. Farm drainage also can contain small numbers of bacteria under certain conditions. Relatively heavy populations of *P. aeruginosa* in streams below sewage outfalls decrease rapidly as they progress downstream. The usefulness of this organism as an indicator of the possible presence of enteric pathogens is therefore limited.

217

THE OCCURRENCE AND BEHAVIOUR OF *PSEUDOMONAS AERUGINOSA* IN SURFACE WATERS,

A. W. Hoadley
Thesis, University of Wisconsin, 1967, 224 pp; Diss Abstr, Vol 28B, pp 459-460, 1967.

Descriptors: *Pseudomonas, *Indicators, *Storm runoff, *Water pollution sources, *Surface waters, Drainage, Sewage.
Identifiers: **Pseudomonas aeruginosa.*

Studies on the ecology of *Pseudomonas aeruginosa* in surface and tap waters and on its usefulness as an indicator of pollution showed that *Pseudomonas* probably does not occur in waters unaffected by the activities of man and domestic animals. Although farm drainage and storm runoff from urban areas contribute small numbers of *Pseudomonas*, sewage discharges probably represent the major source of these organisms entering streams, particularly discharges of crude sewage which may contain up to 7×10^5 organisms per 100 ml. Although secondary sewage treatment reduces the number of *Pseudonomas* in domestic sewage by about 99 per cent, growth of the organism has been observed during treatment of slaughterhouse wastewaters. Populations of less than 100 per 100 ml occurred in surface waters near areas of human activity but not directly receiving sewage discharges; however, populations of about 100 per 100 ml were detected in public bathing waters in the Madison lakes, Wis., and very much greater populations were observed in waters recently contaminated with sewage. Although some sterile natural waters supported growth of *Pseudonomas* in the laboratory, populations of viable *Pseudonomas* were reduced rapidly in natural surface waters, with reductions of more than 90 percent in three hours. It is concluded that *Pseudonomas aeruginosa* is a sensitive indicator of pollution of surface waters by sewage and by runoff from urban areas and farmyards.

218
QUALITY OF SURFACE WATERS OF UNITED STATES, 1960-7,8,
U S Geological Survey
S. K. Love
Water Supply Paper 1744, 1968.

Descriptors: *Mississippi River Basin, *Water temperature,, *Suspended load, *Water quality.
Identifiers: *Gulf of Mexico Basin, *Chemical analysis, *Stream quality.

Records of chemical analysis, suspended sediment, and temperature for surface waters given in this volume serve as a basis for determing suitability of waters examined for all uses in the lower Mississippi River Basin and the Western Gulf of the Mexico Basin. Discharge of stream and chemical quality are related to variations in rainfall and other forms of precipitation.

219
DESCRIPTION OF THE DRAINAGE OF STREET FLUSHING WATERS,

N. A. Pravoshinskiy
Soviet Hydrol: Selec Pap, Issue No 2, p 168-170, 1968. 2 tab, 8 ref.

Descriptors: *Water pollution sources, *Roads, *Urbanization, *Drainage systems, Storm drains, Municipal wastes, Organic wastes, Sediments.
Identifiers: *USSR.

The quality and quantity of runoff from street washing operations in Minsk were measured to study the contribution of street washing to water pollution. Data from earlier studies in Moscow and Leningrad are included for comparison. The BOD of street cleaning runoff is 6-223 mg/liter, petroleum products are up to 110 mg/litter, and coliforms are nearly as abundant as in wastewater. These waters, unless they are treated, can be a major source of pollution.

220
CALCULATION OF WATER POLLUTION BY SURFACE RUNOFF,

N. A. Pravoshinskiy and P. D. Gatillo
Water Res, Vol 2, No 1, pp 24-26, Jan 1968.

Descriptors: *Surface runoff, *Water quality, Data collections, Evaluation.
Identifiers: *Surface runoff pollution, *USSR.

The extent of surface runoff pollution was calculated in the Minsk and Soligorsk districts using the five-day BOD as the main index. Other data were accumulated to determine the variations in the quality of the water when compared with the type of storm, the length of the previous dry weather period, the season, the surface of the region, and the amount of transport and pedestrian traffic. With these results, evaluations can be made of the influences of the pollutants and of the effects of measures such as catch basins, settling basins, storm sewers, and increased sewer capacity, on the maintenance of sanitary pond conditions.

221
ASSESSING THE QUALITY OF URBAN DRAINAGE,

Walter Viessman, Jr.
Public Works, Vol 100, No 10, pp 89-92, Oct 1969.

Descriptors: *Urbanization, *Runoff, *Water quality, Storm runoff, Pollutant identification.
Identifiers: *Sediment.

Recommendations are made for further study in the area of identifying sources and constituents of urban runoff through the development and testing of urban water quality models and through the national collection of urban water quality data. Possible sources of pollutants and constituents of stormwater runoff are described with emphasis on a primary pollutant, sediment. Approaches to the development of water quality models are discussed.

Section 6

SURVEYS, POLICIES, AND REPORTS

222
ENVIRONMENTAL QUESTIONS THAT NOBODY LIKES TO HEAR,

Am City, Vol 85, No 3, p 8, Mar 1970.

Descriptors: *Water pollution, *Costs, Storm runoff, Overflow.
Identifiers: Storm sewers, Sewer separation.

This short review summarizes environmental problems in the United States such as water pollution, refuse collection and disposal, mineral depletion, and air pollution. Under water pollution, it is noted that $48 billion is required to separate sewers in the U.S. in order to correct effects of stormwater overflow. Grim predictions concerning the environment are made, and immediate action to improve conditions is advocated.

223
MOLE TUNNELING RESEARCH ADVOCATED,

Civil Eng, Vol 37, No 8, pp 48-49, Aug 1967. 1 diag.

Descriptors: *Tunneling, *Tunnels, *Comparative costs.
Identifiers: *Viewpoint, *Mole.

Dr. Walter Hibbard, Jr., Bureau of the Mines Director, recently emphasized the need for more research and development on mechanized tunneling. There is a growing demand for tunnels for the following purposes: subways, utilities, transmission lines, mining, and urban freeways. Needs in each of these areas are discussed as are advances already made with the mole borer. Savings in the billion-dollar range are possible with advanced tunneling procedures. In addition to perfecting moles, guidance control, placement of lining, and methods for the transportation of muck out of the tunnel must be developed.

224
THE TIDAL THAMES 1967,

Effluent Water Treat J, Vol 8, No 9, pp 463-465, Sep 1968.

Descriptors: *Pollution abatement, *Design, Sewerage, Estuaries, Storm runoff.
Identifiers: Thames River, Storm sewage, Great Britain.

The article concerns aspects of pollution control along the tidal river. The greatest effect of the discharge from the Greater London Council sewage works on the tidal Thames originated from the outfall works at Beckton. A scheme for reduction in storm sewage discharges from the sewerage system leading to the Beckton works was being examined. New trunk sewers, a pumping plant, and storm sewage tanks would be most likely involved in the scheme. The cost of the Beckton improvements was estimated at 21 million pounds, and of the improvements of the sewerage and storm sewage disposal systems at 22 million pounds.

225
SAIGON'S SEWER NEEDS STUDIED,

Eng News-Record, Vol 183, No 5, p 16, Jul 31, 1969.

Descriptors: *Investigations, *Water pollution sources, *Drainage systems, Storm runoff, Sewerage, Water pollution control, Sewers.
Identifiers: *Saigon River.

The Agency for International Development (AID) is conducting a 15-month, $800,000 study to discover the most efficient and economic sewer system for the disposal of Saigon's sewage and stormwater runoff. The present system is almost entirely non-functioning and as a result, the waterways of the city, including the Saigon River, are highly polluted with human waste and refuse. One plan to be explored is a drainage canal system for stormwater that would double as a transportation system. The results of the study will be used to support requests for financial assistance for reconstructing Saigon's sewers.

226
WHAT TO DO WITH SEWAGE WHEN IT RAINS HARD,

Eng News-Record, Vol 178, No 16, pp 30-31, Apr 20, 1967.

Descriptors: *Tunnel construction, *Tunnels, Storm runoff, Water treatment, Control systems.
Identifiers: *Chicago.

Chicago is building a $14.4-million deep tunnel system to carry spillages from combined storm and sanitary sewers during rainfall. The FWPCA has indicated four main areas related to stormwater runoff problems which require further study and demonstration: drainage area control; collection system control; external discharge control, including treatment of both combined sewer overflow and stormwater run-off;

and a miscellaneous area, consisting of the economic feasibility of substituting separate sewers for combined sewers and local for central treatment facilities, better hydrologic analyses, new management procedures, construction materials and methods, and the development of performance criteria for standards of water quality.

227
WATER MONEY NEEDS REQUIRE MORE THAN PROMISES,

Environ Sci Technol, Vol 4, No 4, pp 278, Apr 1970.

Descriptors: *Pollution abatement, *Water treatment.
Identifiers: Waste treatment costs, Sewered population statistics.

S. 3472, the program for water pollution cleanup, calls for $10 billion for construction of municipal waste treatment plants. Among spokesmen at the 4th Annual Legislative Seminar concerned with the continuing cleanup is James R. Ellis who states that cities are in a catch-up situation. According to Ellis, 35% of the sewered population in the United States received 5% of the federal dollar during the period 1965 - 1969. Some of Ellis' suggestions are cited. John L. Salisbury, a Maine spokesman, contends that the need for secondary treatment is being challenged.

228
WATER POLLUTION -- COAST TO COAST,

Environ Sci Technol, Vol 3, No 9, pp 804 - 805, Sep 1969.

Descriptors: *Municipal wastes, *Pollution abatement, Sewage disposal, Thermal pollution.
Identifiers: *Combined sewers, *Water pollution.

A report on the FWPCA's regional review notes includes: the municipal problem and the pollution abatement activities; industrial sources of water pollution abounding in the Northeast, Great Lakes, and Ohio regions; agricultural activities; the Northeast problem of combined sewer discharge with 90% of the United States population served by combined sewers located in this area; thermal pollution problems; and salinity. Statistics are given.

229
URBAN RUNOFF ADDS TO WATER POLLUTION,

Environ Sci Technol, Vol 3, No 6, p 527, Jun 1969.

Descriptors: *Runoff, *Data collections, *Cost analysis, *Surveys, *Separation techniques, Rainfall, Overflow, Biochemical oxygen demand.
Identifiers: *Urban runoff, *Chicago, Combined sewers.

An APWA survey indicated that: 1) urban runoff constitutes approximately 1% of the raw sewage load which amounts to 5% of the BOD discharged from the area's secondary waste treatment facilities; 2) water pollution from this urban source occurs creating a shock pollution load on receiving waters; 3) the most determinable measure of pollution potential of street litter is the BOD load of the soluble dust and dirt fraction; 4) an estimated expenditure of $48 billion would be needed to separate sanitary and storm waters; and, 5) $15 billion would be needed for alternate control methods for abatement of combined sewer overflows.

230
REVIEW OF LITERATURE OF 1968 ON WASTEWATER AND WATER POLLUTION CONTROL,

J Water Pollution Control Fed, Vol 41, No 6, pp 873-1251, Jun 1969.

Descriptors: *Water pollution control, *Chemical analysis, *Sewage treatment, *Storm runoff, Publications, Estuaries.

This review covers 1968 literature on analytical methods (analysis of anions, cations, and gases; and instrumentation), biological filters, activated sludge, detergents, anaerobic processes, sludge treatment, disinfection, water reclamation and reuse, storm flow, facility evaluation, kinetic models, physical and chemical wastewater treatment, effects of pollution on aquatic life, eutrophication, thermal pollution, microbiology, oxygen sag, groundwater, marine and estuarine pollution, economics of treatment, standards, and industrial wastes (paper, fermentation, meat, dairy, canning, coal, tannery, steel, petroleum, plating, chemical, and radioactive). Included under topics on "Disinfection," are the results of Elliassen's studies evaluating the efficiency of chlorination of stormwater overflows from combined sewers in Boston. He found that chlorination of overflows appreciably reduced numbers of coliform organisms in the Charles River basin, and it substantially impeded regrowth of such organisms. In the "Wastewater and Stormflow Treatment" section, advances, present techniques, and problems relating to sewer construction and operation are discussed. Recent literature on the stormwater disposal problem is also explored including solutions to the problem other than separation. Various treatment procedures described include the use of stabilization-retention basins, chlorination, and sedimentation.

231
A REVIEW OF THE LITERATURE OF 1967 ON WASTE WATER AND WATER POLLUTION CONTROL,

J Water Pollution Control Fed, Vol 40, No 6, pp 897-1219, 1968.

Descriptors: *Water pollution control, *Sewage treatment, *Analytical techniques, *Waste treatment, *Sludge, *Water pollution effects, Estuaries, Standards, Legislation.
Identifiers: *Storm sewage.

A review, with bibliographies, is given of literature published during 1967, dealing with sewage and trade waste treatment, and the control of pollution. Subjects dealt with include methods of analysis; biological, physical, and chemical methods of sewage treatment; detergents; anaerobic processes; treatment, disposal, and utilization of sludge; disinfection of effluents; reclamation and re-use of water; sewerage and treatment of storm sewage; effects of various pollutants on aquatic life; microbiology of polluted waters; oxygen sag and self-purification; effects of pollution on surface and ground waters; bottom deposits; marine and estuarine pollution and its effects; pollution control legislation; surveys of polluted waters; stream standards; and treatment of waste waters from various industries, including radioactive waste waters.

232
PROBLEMS OF COMBINED SEWER FACILITIES AND OVERFLOWS, 1967,

U.S. Federal Water Pollution Control Administration, Publ No WP-20-11, 1967.
Public Works, Vol 99, No 12, pp 130, 132-133, and 138, 1968.

Descriptors: *Sewers, *Statistics, *Surveys, Overflow, Water pollution sources.
Identifiers: *Combined sewers.

The report of a national survey by the APWA, of communities and other jurisdictional entities served wholly or partly by combined sewers, is summarized. The population served by separate sewers is approximately half of that served by combined sewers, and the latter systems are concentrated mainly in the north-east, the region of the Great Lakes, and the Ohio River basin. Statistical information is given of the numbers and types of overflows in the U. S. and regulation devices used in combined sewer overflows, which represent 75% of all overflow sources. The survey confirms that combined sewer overflows contribute a significant part of the water pollution problem in the U. S.

233
OHIO TOWN GETS SEWERAGE SYSTEM AFTER 20 YEARS,

Water Sewage Works, Vol 116, No 6, pp 218-221, Jun 1969. 4 fig.

Descriptors: *Sewerage, *Treatment facilities, Installation, Construction, Joints (connections).
Identifiers: *Middleport, Ohio.

This article describes the twenty-year struggle that evolved in Middleport, Ohio over the construction of a sewerage system and treatment plant. Without such a system, Middleport's sewage was dumped raw into the river. A combination of a lack of funds, the granting of numerous six-month sewage dumping permits, and village councils' opposition tactics prevented installation of the system until September 1968. Factory-made compression joint pipe was used to minimize infiltration when the river level is above the pipe's level. This vitrified-clay pipe contains patented O-ring joints.

234
ENVIRONMENTAL RESEARCH IN S E ASIA,

Water Waste Treatment, Vol 12, No 12, pp 392-396, Mar/Apr 1970.

Descriptors: *Storm runoff, *Sewage treatment, *Water pollution, *Foreign research.
Identifiers: *Thailand.

The Thailand government's decision to plan for drainage and sewerage in Bangkok has led to increased research at the Asian Institute of Technology in Bangkok. Studies relating to stormwater collection, river pollution, and sewage treatment have been made in cooperation with interested authorities; and the results are applicable not only to Bangkok's project but also to other tropical regions. Topics of pertinent research projects include: (1) the anaerobic treatment of tapioca starch waste; (2) characteristics of treatment of Bangkok septic-tank sludge; (3) a Bangkok runoff hydrograph; (4) the ecology of polluted canals in Bangkok; (5) a study of photosynthetic oxygen production in the Chao Phya River; (6) pollution of the Chao Phya River, Bangkok; and (7) oxygen balance in the Chao Phya River estuary. Research is also proceeding on industrial waste treatment in Southeast Asia including studies on design criteria for waste stabilization ponds and sludge drying beds, and the progress of biological assimilation of wastes in a tropical climate. Water treatment is another area currently being investigated.

235
MEMORANDUM OF EVIDENCE TO THE MINISTRY OF HOUSING AND LOCAL GOVERNMENT WORKING PARTY ON SEWAGE DISPOSAL,
Committee from the Institute of Water Pollution Control.

Water Pollution Control, Vol 68, No 6, pp 603-609, 1969.

Descriptors: *Water pollution control, *Sewage disposal, *Deterioration, *Sewage treatment, *Treatment facilities, Planning, Storm runoff.
Identifiers: *Separate system, Storm sewage, Great Britain

The Institute of Water Pollution Control gives evidence on and makes suggestions relating to sewage disposal for a Memorandum to the "Jeger" Working Party. Topics discussed are divided into five categories: (1) public health, (2) amenity, (3) economic effects, (4) sewage treatment and disposal processes, and (5) administration and standards. Under the section on amenity, the Institute notes that with regard to the amenities of rivers, the major cause of deterioration is the generally inadequate provision for sewage disposal integral with residential and industrial expansion. Even where adequate sewage treatment facilities exist, storm-sewage discharges often impair river amenities. Separate sewer construction is recommended. Methods of sewage treatment are discussed such as: sewage sludge utilization after heated digestion, plus quaternary processes for de-nitrification, de-salination, and phosphate removal. Other topics covered are: trade effluent control, planning authorities, coastal pollution, settling tank design, and suggestions for investigational research.

236
HANDBOOK OF STEEL DRAINAGE AND HIGHWAY CONSTRUCTION PRODUCTS,

Am Iron Steel Inst, New York, N.Y., 1967. 382 pp.

Descriptors: *Drainage, *Construction, *Design data, *Design, *Steel, *Steel structures, *Installation, *Application methods, Construction materials, Construction equipment.

The main purpose of this handbook is to aid engineers in overcoming problems involved in highway, railway, municipal, agricultural, and industrial drainage and construction. The text aims to present engineering practices based on sixty years of practical experience compatible with existing technology. Design data and designer aids are cited extensively, while theory is kept at a minimum. The design and application of flexible steel underground conduits, plus good installation practices, are described in the first two parts of the book. The third part concerns other steel products for related construction. The first part on general design considerations includes chapters on: product details, strength design, service life, hydraulics, cost factors, couplings and fittings, and installation instructions. Part II on applications covers the following subjects: culverts, sewers, subdrainage, airport drainage, erosion prevention, dam and levee drainage, tunnels, shafts, caissons, underpasses, and service tunnels. The book also contains a glossary of terms, a list of symbols, conversion tables, general tables, and gage/height-of-cover tables.

237
HANDBOOK OF STEEL DRAINAGE AND HIGHWAY CONSTRUCTION: CHAPTER 1 - PRODUCT DETAILS,

Am Iron Steel Inst, New York, N.Y., pp 10-37, 1967. 14 fig, 22 tab, 14 ref.

Descriptors: *Underground structures, *Conduits, *Steel, *Analysis, Steel structures, Design, Surface drainage, Subsurface drainage, Bypasses
Identifiers: Storm sewers.

This chapter studies product details involved in design of flexible steel underground conduits. Design factors are listed, and the book elects to begin with an analysis of the required strength factor of the conduit wall. The background of corrugated steel conduits is given as well as specifications in common use; a description of corrugations, sectional properties, pipe seams, and shapes of conduits; data on structural plates that are field assembled, and on bolts and nuts, and arch channels. The following three principal types of underground conduits are introduced: (1) conduits for surface drainage, such as culverts, storm sewers, and stream enclosures; (2) conduits for subdrainage for controlling underground water; and (3) conduits for traffic underpasses, and service passes.

238
HANDBOOK OF STEEL DRAINAGE AND HIGHWAY CONSTRUCTION: CHAPTER 2 - STRENGTH DESIGN,

Am Iron Steel Inst, New York, N.Y., pp 38-63, 1967. 18 fig, 5 tab, 20 ref.

Descriptors: *Design, *Underground structures, *Design criteria, *Strength of materials, Design data, Operation and maintenance.

Design methods discussed in this chapter are based on more than sixty years satisfactory field experience with buried flexible structures. The new design approach explained considers overall needs of the drainage structure--environment, service demands, and strength requirements under dead and live loads. Computer analysis is practical and is an anticipated future development when sufficient research evaluates the influence of different soils and compactions on the structure. The following topics are treated in the chapter in the same sequence in which decisions are made in designing buried structures: (1) computation of loads; (2) culvert structural design; (3) earth backfill design; (4) foundation preparation; (5) minimum cover; (6) end treatment; and (7) maintenance.

239
HANDBOOK OF STEEL DRAINAGE AND HIGHWAY CONSTRUCTION PRODUCTS: CHAPTER 3 - SERVICE LIFE,

Am Iron Steel Inst, New York, N.Y., pp 64-81, 1967. 20 fig, 2 tab, 10 ref.

Descriptors: *Drainage systems, *Steel structures, *Economic feasibility, Inspection.
Identifiers: Soil conditions, Water conditions.

This chapter confirms that corrugated steel drainage structures can be economically designed for either normal conditions or for highly corrosive industrial and sanitary sewers and for mining, salt water and other difficult service conditions. The first section deals with inspection methods and results, including parts on: destructive forces; methods of determining durability; laboratory tests; highway culvert inspections; sewer inspections, air force base drainage inspection; air port drainage; and levee culverts and sewers. Section II concerns the influence of various types of soil and water conditions, and Section III discusses design for service life, including topics such as: the amount of durability needed; service conditions; base metals; galvanized coatings and their service life; non-metallic coatings and linings; pavements in pipe; California service life determination; and miscellaneous products and conditions (subdrainage, steel end sections, steel retaining walls, liner plates, sheeting, and guardrail).

240
HANDBOOK OF STEEL DRAINAGE AND HIGHWAY CONSTRUCTION PRODUCTS: CHAPTER 4 - HYDRAULICS,

Am Iron Steel Inst, New York, N.Y., pp 82-141, 1967. 47 fig, 18 tab, 22 ref.

Descriptors: *Hydraulic design, *Drainage structures, *Culverts, *Design data, *Runoff forecasting, Open channels, Sewers, Design flow.

Identifiers: *Sewer hydraulics.

This chapter explores the hydraulics of various drainage structures such as open channels, culverts, storm drains, and sanitary sewers, with the emphasis placed on culverts. Section I includes methods of hydrologic design and factors in drainage design. Section II involves the estimation of runoff from small areas and discusses the rational method, watershed characteristics, time of concentration, drainage area, and the Talbot and Burkli-Ziegler formulas. The hydraulics of open drainage channels such as ditches, gutters, and median swales is treated in the next section. Section IV discusses the hydraulics of sewers, including: design flow of sanitary sewers and of stormwater; hydraulic considerations for sewers; transitions, bends, and junctions; pipe friction formulas; values of $\underline{n}$ -- the roughness coefficient in the Manning equation; determining storm sewer sizes; and the hydraulics of subdrains.

241
HANDBOOK OF STEEL DRAINAGE AND HIGHWAY CONSTRUCTION PRODUCTS: CHAPTER 5 - COST FACTORS,

Am Iron Steel Inst, New York, N.Y., pp 142-150, 1967. 5 fig, 4 tab, 4 ref.

Descriptors: *Maintenance costs, *Cost analysis, *Cost trends, *Cost comparisons, Costs, Economic prediction.

Cost per year of service depends on durability, maintenance, ease of replacement, and factors influenced by local conditions. Recent trends show an increase in pre-engineered and prefabricated structures with consequent reduction of on-the-job labor. This has the following three-way effect: (1) promotes factory-controlled quality under more ideal working conditions; (2) by reducing design and inspection time, it permits the engineer to concentrate on the whole job rather than its details; and (3) although product cost may be higher, installed cost is usually less. Subsections of this chapter discuss: (1) price vs. cost; (2) cost items included; (3) material cost; (4) hauling and handling; (5) excavation and backfill; (6) installation; (7) replacing the traffic surface; (8) detours, slow orders; (9) supervision, overhead, contingencies insurance; (10) engineering costs; (11) unstable foundation conditions; and (12) the cost end of treatment.

242
HANDBOOK OF STEEL DRAINAGE AND HIGHWAY CONSTRUCTION PRODUCTS: CHAPTER 6 - COUPLINGS AND FITTINGS,

Am Iron Steel Inst, New York, N.Y., pp 151-159, 1967. 16 fig.

Descriptors: *Steel pipes, Joints (connections), Installation, Design data.
Identifiers: *Couplings.

Shop-fabricated corrugated steel pipe and pipe-arches are delivered in lengths convenient for shipping and handling. For longer installed lengths, standard connecting bands or special field joints are used. Joint selection criteria covered in this chapter include strength, joint tightness, simplicity, and economy of installation. Also treated are design features of couplings, standard and special fittings, fabrication details, and field installation of fittings.

243
HANDBOOK OF STEEL DRAINAGE AND HIGHWAY CONSTRUCTION PRODUCTS: CHAPTER 7 - INSTALLATION INSTRUCTIONS,

Am Iron Steel Inst, New York, N.Y., pp 160-183, 1967. 22 fig, 3 ref.

Descriptors: *Steel structures, *Installation.
Identifiers: *Corrugated steel, *Installation methods, Installation procedure.

Because of their strength, light weight, and resistance to fracture, corrugated steel structures can be installed rapidly, easily, and with the least expensive machinery. The first part of this chapter outlines the importance of good installation and the advantages of using corrugated steel in installation procedures. Other subsections discuss: preparation of the base, assembly of pipe culverts and sewers, vertical elongation of corrugated steel pipe, and backfilling. Entire sections are devoted to jacking, boring, lining, and bridge filling.

244
HANDBOOK OF STEEL DRAINAGE AND HIGHWAY CONSTRUCTION PRODUCTS: CHAPTER 9 - SEWERS,

Am Iron Steel Inst, New York, N.Y., pp 202-211, 1967. 9 fig, 4 ref.

Descriptors: *Sewers, *Design standards, *Treatment facilities, Sewerage, Steel, Equipment, Control systems, Control structures.
Identifiers: *Sewer design, Steel structures, Storm sewers, Combined sewers, Sanitary sewers.

This chapter defines terminology associated with sewers and sewerage and explains basics involved in the following areas: sewer system design, corrugated steel sewers, storm sewer inlets, standard and special fittings, manholes, sewer joints and outfalls, sewage treatment plants and lagoons, septic tanks, water control gates, and sewer maintenance and repair. Definitions include: sewer, sewage, storm sewer, sanitary sewer, combined sewer, industrial wastes, half-soling, threading, and tunneling.

245
HANDBOOK OF STEEL DRAINAGE AND HIGHWAY CONSTRUCTION PRODUCTS: CHAPTER 11 - AIRPORT DRAINAGE

Am Iron Steel Inst, New York, N.Y., pp 240-247, 1967. 4 fig, 2 tab, 4 ref.

Descriptors: *Surface runoff, *Drainage systems, *Controlled drainage, *Design standards, *Standards, *Drainage practices, *Rainfall-runoff relationships.
Identifiers: *Airport drainage.

The purpose of airport drainage is to remove water which may hinder any activity necessary for the safe and efficient operation of the airport. Artificial facilities are needed to collect surface runoff, dispose of excess groundwater, lower the water table, and protect slopes. Characteristics of airport drainage are summarized, and a list is presented of information needed prior to designing the drainage system. Requirements of airport drainage differ from those of culverts, storm drains, and subdrainage of highways, railways, industrial areas, agricultural, urban, and suburban areas; and these differences are reviewed, especially in regard to rainfall-runoff computations. Four types of drainage appearing on airports are mentioned, and Federal Aviation Agency recommended standards are listed. Remaining sections of the chapter concern the size of conduits, the selection structures, and storm drains.

246
COMBINED SEWER OVERFLOW ABATEMENT TECHNOLOGY,

A Compilation of Papers Presented at the Federal Water Quality Administration Symposium on Storm and Combined Sewer Overflows, Chicago, Illinois, June 22-23, 1970. 336 p.

Descriptors: *Storm runoff, *Overflow, *Conferences, Sewage treatment, Treatment facilities, Water pollution control.
Identifiers: *Combined sewers, *Demonstration projects.

This compilation of papers has been prepared based on a discussion of several demonstration projects. Material from these projects to be highlighted include: 1) alternatives to storm and combined sewer pollution in a small urban area, 2) screening and air flotation for solids removal, 3) underflow deep tunnel system concept, 4) urban erosion and sediment control, 5) sewer monitoring and remote control, 6) combined sewer overflow regulators, 7) use of fine mesh screens, and 8) land use and urban runoff pollution. Each of the papers is abstracted separately.

247
DRAINAGE MASTER PLAN FOR THE CITY OF FORT WORTH, PUBLIC WORKS DEPARTMENT, STORM DRAINAGE CRITERIA AND DESIGN MANUAL,

Knowlton-Ratliff-English, Consulting Engineers, 1967. 74 p.

Descriptors: *Drainage engineering, *Design criteria, *Drainage programs, *Drainage practices, *Storm runoff, *Surface drainage, *Storm drains, *Flood control, Rainfall-runoff relationships, Hydrology, Hydraulic structures, Hydraulics, Intakes, Open channels, Storage, Culverts.
Identifiers: *Fort Worth, Texas, Nomographs, Gutter flows.

The purpose of this drainage manual is to establish standard criteria, principles, procedures, and practices for the design of storm drainage facilities within the City of Fort Worth, Texas. The manual constitutes the first phase of the development of a master plan for storm drainage to guide the design and construction of storm sewers and channels in the City and its anticipated growth area. The following eight sections give a logical development to the solution of storm drainage problems.

248
SECTION I, INTRODUCTION; SECTION II, DETERMINATION OF DESIGN DISCHARGE; SECTION IX, APPENDIX.

In: Drainage Master Plan for the City of Fort Worth Public Works Department, Storm Drainage Criteria and Design Manual, Knowlton-Ratliff-English Consulting Engineers, 1967. 19 p.

Descriptors: *Watersheds, *Time of concentration, *Runoff coefficient, Bibliographies.
Identifiers: *Glossary, Drainage, Computation forms.

Section I is an introduction explaining the purpose and arrangement of the manual. Division of the urban area into defined watersheds, drainage areas, and drainage sub-areas and a system of coding these elements of the drainage system are also presented. Section II sets forth six conditions which should govern the design of a storm drainage system. This section also treats methods for determining the amounts and rates of runoff using the Rational Method and the Unit Hydrograph Method. The Rational Method is specified for watershed areas up to 1,000 acres. Above this area, computations using both methods are specified and the greater discharge is to be used for design of the elements of the system. The use of planimetrictopographic maps of the area is recommended for determining the size and shape of watersheds. Runoff coefficients and graphs of rainfall intensity vs. duration and frequency are included as being representative of the Fort Worth area. A nomograph for computing 'time of concentration' is presented. Section IX constitutes an appendix which includes a glossary of terms, bibliography, and forms for use in making engineering computations.

249
SECTION III, FLOW IN GUTTERS; SECTION IV, STORM DRAIN INLETS,

In: Drainage Master Plan for the City of Fort Worth Public Works Department, Storm Drainage Criteria and Design Manual, Knowlton-Ratliff-English, Consulting Engineers, 1967. 56 p.

Descriptors: *Hydraulic structures.
Identifiers: *Inlets, Drainage design computations, Computation aids.

Section III presents information, a nomograph, and curves to facilitate making computations required in designing the various hydraulic properties of street gutters and roadway ditches. The nomograph and curves greatly simplify the solutions for depth of flow of drainage runoff in gutters and the lateral spread of the water into traffic lanes. The nomograph and figures, which are graphical solutions of Manning's Equation for uniform flow, are developed for streets of different widths and roughness coefficients, and for streets with straight cross slopes and others with various size parabolic crowns. Section IV presents sketches, criteria and examples to illustrate design procedures, standards and techniques for determining hydraulic capacities and required dimensions of storm drain inlets. Three major classifications of inlets are treated; namely, (1) inlets in sumps, (2) inlets on grade without gutter depression, and (3) inlets on grade with gutter depression.

250
SECTION V, FLOW IN STORM DRAINS AND THEIR APPURTENANCES; SECTION VI, DESIGN OF CLOSED STORM DRAINAGE SYSTEM; SECTION VII, DESIGN OF OPEN CHANNELS,

In: Drainage Master Plan for the City of Fort Worth Public Works Department, Storm Drainage Criteria and Design Manual, Knowlton-Ratliff-English, Consulting Engineers, 1967. 29 p.

Descriptors: *Hydraulic design, *Pipe flow, *Closed conduit flow, Channel flow, Concrete pipes, Metal pipes, Drainage systems, Mannings equation, Joints, Head loss, Hydraulic gradient, Roughness coefficient.

Section V presents criteria, procedures, formulas, and roughness coefficients for use in designing the hydraulic elements of storm drains and appurtenances to storm drainage systems. A minimum mean flow velocity of 2.5 ft. per sec. is specified, as are minimum grades for various sizes of concrete pipe and corrugated metal pipe. Charts for facilitating hydraulic computations based upon the Continuity Equation and Manning Formula are included. Tables of design coefficients are included for calculating head losses at inlets, manholes, junctions, bends, obstructions and size changes. The hydraulic grade line is required to be 2 ft. or more below ground or streets. Section VI presents the overall drainage system design procedure, step-by-step, applying the criteria, techniques, formulas, coefficients, and charts presented in the preceding sections of the manual. Section VII presented procedures for designing the hydraulic elements of lined and unlined open channels, rectangular and trapezoidal in cross-section, and natural ditches. The Manning Formula is the basis of design.

251
SECTION VIII, DESIGN OF CULVERTS,

In: Drainage Master Plan for the City of Fort Worth Public Works Department, Storm Drainage Criteria and Design Manual, Knowlton-Ratliff-English, Consulting Engineers, 1967. 34 p.

Descriptors: *Drains, *Outlets, *Hydraulic design, Pipes, Roads, Concrete pipes, Metal pipes, Head loss, Roughness coefficient, Culverts.
Identifiers: *Highway drainage, Pipe culverts, Culvert sizing, Nomographs.

Section VIII defines the functions of drainage culverts, presents design criteria, establishes the method of flow determination, and sets forth design formulas, coefficients, and procedures for sizing various types of culverts. It is specified that the quantity of flow shall be determined by the Rational Method or the Unit Hydrograph Method. All designs are to be based on a 50-year storm frequency. Formulas are specified for hydraulic computations under various culvert flow depths and various degrees of submergence at the entrance and inlet. Nomographs are included for use in simplifying computations associated with the hydraulic design of culverts.

252
REPORT OF COMMISSION TO INQUIRE INTO ALLEGED NUISANCES IN AUCKLAND METROPOLITAN DRAINAGE DISTRICT,

New Zealand House of Representatives, 1965. 32 p.

Descriptors: *Sewage treatment, Evaluation, Remedies.
Identifiers: *New Zealand.

This report, on the investigation of nuisances caused by midges and offensive odors at the Mangere sewage works of the Manukau Sewerage Scheme, Auckland, deals with the causes of these nuisances, possible methods of elimination, and the necessity for legislation. Since much of the nuisance is attributable to the sewage reaching the works in a stale condition, it is recommended that the Orakei combined sewerage system be cleaned at least once a year, regular sampling be carried out during periods of low flow, provision be made for the injection of compressed air at each pumping plant to minimize septic conditions in the pressure mains, and the inverted siphons be flushed at least once a week during the dry season. Certain modifications are also recommended at the sewage works, including the covering of preliminary aeration and primary sedimentation tanks, the use of percolating filters to regulate the load on the oxidation ponds, and the reduction of recirculation of effluent to increase the period of sedimentation and the amount of sludge digested. In view of the increasing population, the design load of the works for a population of 800,000 will possibly be reached by 1986; and since the existing oxidation ponds cannot be extended economically, investigations are necessary to determine the best process for the extensions. It is proposed to consider the activated-sludge process.

253
URBAN WATER RESOURCES RESEARCH; SYSTEMATIC STUDY AND DEVELOPMENT OF LONG - RANGE PLANS, FIRST YEAR REPORT, SEPTEMBER, 1968,
ASCE - Urban Hydrology Research Council

Office of Water Resources Research Contract No 14-01-0001-1585, various paging, 1968.

Descriptions: *Rainfall-runoff relationships, *Urbanization, *Systems analysis, *Drainage engineering, Data collections, Storm runoff, Urban sociology, Community development.
Identifiers: *Urban hydrology.

The first year emphasis was on subjects requiring earliest consideration, such as urban storm drainage. An assessment is given of the potentials, liabilities, and available knowledge of the rainfall-runoff-water quality process; and model requirements for process simulation are detailed. Immediate research needs with regard to damage evaluation are given; and the utilization of storage to ameliorate flooding is outlined. The principal non-hydrologic aspects of urban water are listed, and include administration of works, economics of planning and operation, financing of systems, recreational facilities, planning and operation, and sociological problems. The report contains 11 appendices, each with technical papers dealing with the appendix subject.

254
COMBINED SEWER OVERFLOW SEMINAR PAPERS; Compilation of Technical Papers and Discussions Presented at a Seminar at Hudson-Delaware Basin FWQA Office, Edison, New Jersey,

Water Pollution Control Research Series, Report DAST-37, 1970. 199 p.

Descriptors: *Overflow, *Conferences, Storm runoff, Sewage treatment, Water pollution control.
Identifiers: *Combined sewers.

This report is a compilation of twelve papers dealing with various aspects of combined sewer overflows, such as: storage and treatment of combined sewage as an alternate to separation, polymers for sewer flow control, treatment methods, microstraining with ozonation and chlorination of combined sewer overflows, a simulation technique for assessing storm and combined sewer systems, and the Boston deep tunnel plan. Each of the papers is abstracted separately.

255
MASTER PLANNING FOR STORM RUNOFF FOR NEW NORTH/SOUTH RUNWAY AND ENVIRONS --STAPLETON INTERNATIONAL AIRPORT,
Wright-McLaughlin Engineers, Denver, Colorado

Report given to the City and County of Denver, Depart of Public Works, Nov 1969. 39 p. 13 fig, 5 tab.

Descriptors: *Storm runoff, *Ponding, *Airports, *Detention reservoirs, *Drainage, *Drainage engineering, *Drainage programs, *Runoff, Pondage, Flood control.

Identifiers: *Denver, *Stapleton International Airport, Storm sewers.

This engineering report is unique because it incorporates new and unconventional concepts in planning drainage facilities for removal of storm-water runoff. The master plan for providing storm-water drainage at Stapleton Airport emphasizes detention and slow discharge of runoff at outlet points. Conventional designs usually embody high discharge rates at outlets which promotes downstream flooding. The drainage of Stapleton Airport has been complicated by the construction of a new highway and a new runway, both of which combined to block overland drainage and discharge to Sand Creek. In addition, new land development nearby and the probability of constructing another runway further complicates the drainage problem. The engineers propose the development of unconcentrated overland flow planes as well as swales and grass-lined open channels on flat grades to convey runoff slowly to existing and proposed detention ponds and outlets. Rooftop ponding is recommended for new buildings proposed on and near the airport. Undersized storm sewers are recommended to force overland flow during intense storms--thereby reducing discharge rates and downstream flooding.

256
URBAN STORM DRAINAGE CRITERIA MANUAL,
Wright-McLaughlin Engineers, Denver, Colo

Work performed for the Denver Regional Council of Federal Governments. Vols I and II, Mar 1969.

Descriptors: *Drainage engineering, *Design criteria, *Drainage programs, *Drainage practices, *Storm runoff, *Surface drainage, *Storm drains, *Flood control, Rainfall-runoff relationships, Hydrology, Hydraulic structures, Water law, Administration, Watershed management, Hydraulics, Intakes, Open channels, Storage, Culverts, Drainage systems. Identifiers: *Denver, *Storm drainage policy, Street drainage, Curb and gutter design.

The manual was written to suggest techniques, methodology, and guidelines to facilitate the implementation of a new and more thorough approach to storm drainage problems in Metropolitan Denver. The authors recomment adoption of the manual by government agencies in Metropolitan Denver, and that the Denver Regional Council of Governments provide coordinate drainage activities. The following eight chapters are a review of the most comprehensive treatment of urban storm drainage design criteria available.

257
DRAINAGE POLICY, (CHAPTER 1)
Wright-McLaughlin Engineers, Denver, Colo

In: Urban Storm Drinage Criteria Manual, Vol 1, Mar 1969. 54 p.

Descriptors: *Design criteria, *Water policy, *Drainage programs, *Drainage practices, *Drainage engineering, *Storm runoff, *Watershed management, *Flood control, Design standards, Flood plains, Design storm, Storage, Watersheds (basins), Surface runoff, Drainage, Surface drainage, Drainage systems, Drainage water, Hydrology, Ponding, Rational formula.
Identifiers: *Denver, *Storm drainage policy.

This chapter recommends the adoption of this manual by government agencies. Storm drainage is presented as a 'space-allocation' problem demanding planning and integration on a regional basis. A set of policy statements, based upon underlying principles, technical criteria, and data is recommended to provide direction for planning, providing, and operating drainage facilities. These statements call for the initiation of flood plain management programs and a program for collecting and analyzing stormwater runoff and flood data. Stormwater drainage master plans, based upon the criteria in this manual and consistent with the comprehensive plan, are encouraged for adoption by each urbanized drainage basin. Coordination by the Denver Regional Council of Governments is suggested. The report includes recommendations for participation by governmental units in the National Flood Insurance Act of 1968. Design criteria discussed relate to storm frequency, initial and major drainage system considerations, natural drainage-ways, water quality control, and runoff computation. Emphasis is placed upon coordinating drainage planning with transportation and open space planning.

258
SUMMARY OF COLORADO DRAINAGE, (CHAPTER 2), AND PLANNING (CHAPTER 3), Wright-McLaughlin Engineers, Denver, Colo

In: Urban Storm Drainage Criteria Manual, Vol 1, Wright-McLaughlin Engineers, Mar 1969. 43 p.

Descriptors: *Water law, *Legal aspects, *Legislation, *Natural flow doctrine, *Administration, *Watershed management, *Flood routing, *Water resources planning, *Riparian rights, Water rights, Judicial decisions, Obstructions to flow, Drainage programs, Flood control.
Identifiers: *Denver.

Chapter 2 presents the responsibilities and legal liabilities of municipalities relating to planning, constructing, operating, maintaining, and repairing drainage improvements. The importance of obtaining all pertinent facts and developing a plan before initiating a proposed improvement is stressed. Municipalities proceeding in this manner can be relatively assured of no legal complications and should be able to use any of several different means to finance proposed improvements. Specific legal actions are cited and briefed. Chapter 3 cites drainage systems as being subsystems of the total urban system, affecting orderly growth and development. Planning should include consideration of multiple-uses and additional benefits which can result from well planned drainage systems. Emphasis is placed upon adopting plans which incorporate undisturbed natural swales and waterways. Other aspects discussed include drainage management measures, master planning, flood plain planning, initial and major systems, transportation facilities relationships, open space, and planning and sizing storm sewer systems.

259
RAINFALL FOR THE DENVER REGION, (CHAPTER 4), AND RUNOFF (CHAPTER 5), Wright-McLaughlin Engineers, Denver, Colo

In: Urban Storm Drainage Criteria Manual, Vol 1, Wright-McLaughlin Engineers, Mar 1969. 77 p.

Descriptors: *Rainfall, *Runoff, *Rainfall disposition, *Rainfall intensity, *Hydrology, *Rainfall-runoff relationships, *Storm runoff, *Design criteria, *Drainage engineering, Design storm, Duration curves, Hydrograph analysis, Unit hydrograph, Rational formula, Flood forecasting, Frequency analysis.
Identifiers: *Denver.

The chapter on 'Rainfall' suggests a rainfall analysis technique similar to that employed by the U.S. Weather Bureau. The chapter includes several key rainfall-frequency maps making it possible to determine any combination of return-period from one to 100 years and durations from 5 minutes to 24 hours. Chapter 5 describes in detail the following three methods of calculating runoff applicable to Metropolitan Denver: (1) Rational Method, for sewers draining areas less than 200 acres; (2) Colorado Unit Hydrograph Procedure, for sewers draining basins in excess of 200 acres; and (3) Statistical Analysis, for streams upon which future urbanization will have little effect on runoff inflow. Two statistical methods are illustrated: (1) Log-Pearson Type III, and (2) Index Flood. Flood Plain Information Reports, prepared by the Corps of Engineers for delimiting flood hazard areas and stream surface profiles, are cited. Users are urged to allow for anticipated urbanization.

260
STORM SEWERS (CHAPTER 6); STREETS AND INTERSECTIONS (CHAPTER 7); AND STORMWATER INLETS (CHAPTER 8).
Wright-McLaughlin Engineers, Denver, Colo

In: Urban Storm Drainage Criteria Manual, Vol 1, Wright-McLaughlin Engineers, Mar 1969. 252 p.

Descriptors: *Storm drains, *Drainage systems, *Design criteria, *Hydraulic design, *Intakes, Design standards, Surface drainage.
Identifiers: *Street drainage, *Street design criteria, *Stormwater inlets, Curb and gutter design, Storm sewers.

The chapter on 'Storm Sewers' presents criteria intended for use by engineers in designing systems of storm sewers for collecting and conveying stormwater runoff to points of discharge in the major drainage system, including conduits, channels, inlets, bends, junctions, manholes, outlets, pressure systems, and the related hydrologic aspects of rainfall and runoff. Chapter 7 presents criteria and suggested procedures and standards for street design. Drainage design of streets is approached from the standpoint of providing systems to drain streets and, secondarily, using streets as integral parts of local drainage systems. Chapter 8 discusses the various types of inlet devices used for providing openings to drain stormwater from streets into sewers. Design criteria and inlet capacity graphs are treated in detail. Several examples of typical designs of storm sewers, streets, and stormwater inlets are presented.

261
PILOT PLANNING STUDY FOR AREA WIDE STORM DRAINAGE PLANNING,
Wright-McLaughlin Engineers, Denver, Colo

Pilot Planning Study for Area Wide Storm Drainage Planning, Vol II, April 1969. 76 p.

Descriptors: *Planning, *Water management (applied), *Flood control, *Drainage, Drainage systems, Flood plain zoning, Methodology, Estimated costs, Legal aspects, Multiple-purpose projects, Regional analysis, Hydrograph analysis, Unit hydrograph, Detention reservoirs, Channels, Conduits.
Identifiers: *Boulder, Colorado, *North Boulder, Colorado, *Environmental design.

This pilot planning study includes: (1) the development of a methodology for the preparation of an area wide storm drainage plan, (2) a study of alternate solutions to the North Boulder, Colorado major drainage problems, (3) preparation of storm drainage master plans for five North Boulder waterways, and (4) development of a financing strategy and a practical test of the recently completed Urban Storm Drainage Criteria Manual. North Boulder was chosen as a pilot study because it represented most of the urban drainage problems found in the Denver region and because it had no flood plain management program, policy, or regulation ordinances. Field and office studies to develop all practical alternates and to study these alternates using a qualified environmental design team approach defined the problem. Economics, comprehensive plans and programs of the city and county, open space needs, greenbelt requirements, and legal aspects of urban storm drainage were all taken into consideration when evaluating alternates. A detailed discussion of the Colorado Urban Hydrograph Procedure, which was used in determining flood magnitudes was given. The report is contained in two volumes: Volume one contains the text of the report and Volume two contains thirty detailed drawings of the proposed Wonderland Creek Drainage.

262
LANCASHIRE RIVER AUTHORITY. FIRST AND SECOND ANNUAL REPORTS FOR THE PERIOD 15TH OCTOBER 1964 TO 31ST MARCH 1966 AND THE YEAR ENDED 31ST MARCH 1967,

Descriptors: *Water quality, *Water pollution sources, *Water pollution control, *Standards, *Storm runoff, *Design, Effluents, Estuaries, Evaluation.
Identifiers: Storm sewage.

The Lancashire River Authority has taken over the functions of the former Lancashire River Board in regard to land drainage, fisheries, and pollution prevention; and it also exercises new functions relating to the conservation and management of water resources. The annual reports contain sections on all these aspects of the work, and tabulated analytical data are appended for various rivers. In the first report, a summary is given of the features influencing the quality of water in rivers and streams in the area. A map has been prepared indicating the general level of water quality in the various streams. The sources of pollution and remedial action are outlined. Standards for sewage effluents are based on those of the Royal Commission except in a few cases where more stringent or extended standards are necessary owing to local conditions. Wherever possible, permission is given for discharge of storm-sewage flows in excess of 3 times the normal flow receiving complete treatment, with no limitation on BOD and a relaxed standard of 100 mg per litre for suspended solids. Under certain circumstances storm flows exceeding about 300 gal per head per day may also be discharged after removal of coarse solids. The Authority encourages discharge of trade effluents to the sewers, but where this is impossible the standards applied are similar to those for sewage effluents. Discharge of effluents to underground strata is discouraged owing to the possibility of contamination of ground water; however, this is not considered to include the disposal of small volumes of sewage effluent via subsurface soakaway systems and this method of disposal is advocated wherever practicable. Preliminary work has been undertaken on the water demands and resources of the area, and a hydrometric scheme has been prepared. As an alternative to the Morecambe bay barrage, it has been suggested that small barrages be constructed at Arnside on the Kent estuary and Greenodd on the Leven estuary. Consideration is being given to the establishment of minimal acceptable flows for the inland waters and suitable data are being collected. A technical note is appended to the second report, describing the operation of dissolved-oxygen recorder on the River Calder at Whalley. Information was obtained showing the effects of climatic and storm conditions on the dissolved-oxygen concentration in the river. Although the dissolved-oxygen concentration is usually above 75 per cent saturation, it decreases while the initial wave of storm runoff is passing downstream. In the absence of an increased runoff from the Ribble catchment to compensate, conditions harmful to migratory fish might occur in the Ribble below the Calder confluence.

263
WATER RESEARCH: MAJOR RESEARCH PROBLEMS IN HYDROLOGY AND ENGINEERING,

William Ackermann
The Johns Hopkins Press, Baltimore, Maryland, pp 495-501, 1966. 11 ref.

Descriptors: *Information retrieval, *Planning, *Water resources, Engineering geology, Dams.
Identifiers: *Water resources information, Urban hydrology.

Sources of information on water resources problems in general are discussed, such as government publications and publications of activities of professional organizations like the American Geophysical Union. Research problems on hydrology and engineering cited as needing special attention are: river forecasting for water resource management, urban hydrology, the engineering and geology of dams, evaporation and transpiration, and prime water resources. (See abstract number 292).

264
LAKE COUNTY ADOPTS CLEAN LAKE POLICY,

R. E. Anderson
Water Sewage Works, Vol 115, No 11, pp 412-415, Nov 1968.

Descriptors: *Sewage effluents, *Sewage treatment, *Water pollution control, Hydraulics.

Identifiers: *Lake County, Illinois, *Storm sewage, Capacity.

Effluents from sewage works of the North Shore Sanitary District, Lake County, Illinois, will be discharged into the Des Plaines river instead of into Lake Michigan, thus reducing pollution of the lake. Those works giving primary treatment only will be abandoned, and their services absorbed in expansion programs of other works. The capacity for storm sewage flows is to be increased, so that storm sewage will not enter the lake but will be pumped to works for treatment after the storm.

265
A STORM DRAINAGE AND OPEN SPACE MASTER PLAN FOR HAMILTON COUNTY, OHIO,
Hamilton County, Ohio Regional Planning Commission
Ralph G. Berk
Urban Planning Project, Ohio, P-53, Dec 1966. 77 p. 13 fig, 2 plates.

Descriptors: *Drainage systems, Storm runoff, Sewers, Urbanization, Surface runoff.
Identifiers: *Hamilton County, Ohio.

A planning study of Hamilton County, Ohio which provides a complete inventory and location of all streams, culverts, and bridges having drainage areas greater than 300 acres is presented. The complete physical characteristics of the drainage structures and the intervening reaches of their streams are given. A method is developed for determining flood flows. Flow quantities to be considered for design purposes are established, as well as indications for improvement of inadequate flows. The study provides accurate information about present and future flood hazards, their location and extent; the erosion and siltation problems; and open space needs. Provided are suggestions for subdivision regulations for the enabling and enforcing of protective measures. Guidelines for legislation necessary for carrying out any plans selected by decision makers are supplied. Suggestions for the financing and administering of public improvement programs are also made.

266
A LONG-TERM PLAN FOR SEWERAGE DEVELOPMENT IN THE JOHANNESBURG REGION,

V. Bolitho
Water Pollution Control, Vol 69, No 1, pp 79-91, 1970.

Descriptors: *Waste water treatment, Water resources, Overflow, Hydrology.
Identifiers: *Sewer hydraulics, Outfall sewers, Storm sewage, Combined sewers, Johannesburg, South Africa.

The present-day Johannesburg waste water scheme is described along with long-term planning needs for expansion of water resources systems. Population forecasts are used in considering water usage and its effect on sewer flows. Present problems of outfall sewer designs are discussed including the imperfect separation of storm and sewage flows and the obsolence of outfall sewers due to overload from combined sewage and storm overflows. The capacity of existing treatment works is also considered as well as developments in treatment technology and recommendations for the enlargement of sewers to meet future demands. Financial implications of the development plans are included.

267
THE COST OF SEWAGE TREATMENT,

R. M. Bradley and Peter C. G. Isaac
Water Pollution Control, Vol 68, No 4, pp 368-402, Jul 1969.

Descriptors: *Costs, *Sewage treatment, Cost analysis.
Identifiers: *Sewer hydraulics, Great Britain.

A detailed report on capital and operational costs with data for 79 works situated in areas of England, Scotland, and Wales, all of which were commissioned after 1952, is presented. Graphs of costs in relation to specific problems are shown as well as cost analysis charts. Some works had a record of the total flow entering the works in various time periods, but few were able to differentiate between the flows receiving full treatment and those diverted to storm treatment. Because of the lack of reliable flow data, operating cost data is presented on a population basis.

268
FINANCING CONSTRUCTION OF A MAJOR DRAINAGE IMPROVEMENT,

Peter M. Callihan
Public Works, Vol 100, No 6, pp 105-106, Jun 1969.

Descriptors: *Storm runoff, *Construction costs, Drainage systems, California.
Identifiers: Drainage improvements

Rohnert Park, Sonoma County, and the Sonoma County Flood Control District have developed a new method of financing major drainage channels. One channel, which served as a major drainage facility to accomodate storm flows from the anticipated high density development area, could not be improved because of costs. A policy requiring land developers to improve all major drainage ways was adopted and the problem was solved. A large drainage area plan is discussed along with problems of financing its improvements.

269
ON WATER POLLUTION CONTROL POLICY,

Thomas R. Camp
Eng News-Record, Vol 181, No 7, pp 22-23, Feb 12, 1970.

Descriptors: *Pollution abatement, *Regulation, Storm drains, Sewer separation.
Identifiers: *Construction grants, *Combined sewers, *Viewpoint.

The author criticizes the FWPCA's new policy of refusing construction grants for projects that provide less than 85% removal of five-day BOD, because this requirement does not cover the oxygen demand of ammonia (derived from human urine) or of combined sewer overflows. This policy would eliminate aid to most communities since many areas have combined sewer overflows. Big cities are cited as having the worst water pollution problems because they utilize storm drains as combined sewers, and street congestion hinders sewer separation. Chicago's alternate solution of underground deep rock storage tunnels for sewage is described and praised. The following recommendations are made towards achieving pollution abatement: (1) authorization for grants-in-aid to solve combined sewer problems; (2) mandatory heavy chlorination of sanitary sewage; (3) water pollution control authorities to manage watersheds; and (4) FWPCA's promotion of further legislation required to carry out the above aims.

270
PLAN AND PROGRAM FOR THE BRANDYWINE,

Robert J. Coughlin, John C. Keene, Benjamin H. Stevens, and Ann Louise Strong
Pennsylvania Univ, Inst for Environmental Studies, Oct 1968.

Descriptors: *Urbanization, *Drainage systems, *Land use, *Water resources development, Storm runoff, Real property, Legislation.
Identifiers: *Conservation easements, Brandywine, Pennsylvania, Chester County, Pennsylvania.

The Plan is a proposal for the wise use of the water and land resources of the Upper East Branch of Brandywine Creek, Chester Co., Pa. The Plan was developed for the Chester Co. Water Resources Authority by the Institute for Environmental Studies, University of Penna; Regional Science Research Inst.; United States Geological Survey; and their consultants. The aim of the Plan is to prevent deterioration of the water resources and thus to retain the amenities of related land when urbanization occurs in the Brandywine watershed. The Plan recommends 3 types of action; public purchase of conservation easements or other less than fee interests on flood plains, stream and swale buffers, steep slopes, and forests; development and adoption of detailed water supply and sewage disposal plans in advance of urbanization; and enactment of strong local regulations for erosion and storm runoff control.

271
WATER RESEARCH: SOME OBSERVATIONS ON RAINFALL AND RUNOFF,

Norman H. Crawford
The Johns Hopkins Press, Baltimore, Maryland, pp 343-353, 1966. 10 fig, 5 ref.

Descriptors: *Runoff, *Runoff forecasting, *Rainfall-runoff relationships, Synthetic hydrology, Volumetric analysis.
Identifiers: *Volume-time distribution.

This paper's purpose is to explain the complex processes involved in finding the volume and time distribution of runoff; two factors basic to the study of the rainfall-runoff relationship. Illustrations of the role of various basic hydrologic processes are made using digital synthesis models (Standford Watershed Model IV). A schematic description of a watershed, presented in the first section, provides background for concepts and terms which follow. The second section discusses volume of runoff, and the third illustrates timing and runoff distribution. The conclusion comments on education in the response of watersheds to rainfall and on the application of synthesis methods of investigation to water resources studies in general. (See abstract number 292).

272
KNOWLEDGE OF SEDIMENTATION IN URBAN ENVIRONMENTS,

David R. Dawdy
J Hydraulics Div, Am Soc Civil Engrs, Vol 93, No HY6, pp 235-245, Nov 1967.

Descriptors: *Sediment yield, Drainage effects, Geomorphology, Urbanization.
Identifiers: Sedimentation data.

The two types of sedimentation data are associated with: 1) gross drainage basin sediment yield; and, 2) time variability of sediment yield. For a given basin, the greater the forested area the smaller the sediment yield, and the effects of urbanization may influence the base condition of a given area. Geomorphic changes may be induced by the increased variability of flow caused by urbanization and highway construction.

273
FEDERAL GRANTS FOR MUNICIPAL WASTE TREATMENT--THE NEED FOR POLICY CHANGE,

James R. Ellis
J Water Pollution Control Fed, Vol 42, No 5, Part 1, pp 679-684, May 1970. 1 tab, 2 ref.

Descriptors: *Separation techniques, *Grants, *Pollution abatement, Overflow.
Identifiers: *Abatement facilities, *Combined sewers, *Policy change.

The article cites the federal government's neglect of big city's water pollution abatement needs. Recommended are federal grants for construction of combined sewer overflow abatement facilities, since this pollution problem is not solved by installation of wastewater treatment plants. Either sewer separation or stormflow storage is needed before treatment, and such projects are not now eligible for federal grants. Other suggestions include: (1) authorization of incentive grants for new big-city projects until recipients receive the level of federal support they deserved since 1956; (2) making federal grant committments reliable and adequate as to dollars; (3) strengthening the market for local bonds by renouncing abortive efforts to tax municipal bonds; (4) implementation of regulatory standards encouraging towns to correct their worst problems and to achieve the most pollution abatement for each federal and local tax dollar; and (5) encouraging local use of sewer service by offering a federal grant incentive, but prohibit an industry from destroying any stream for a fee.

274
ON THE CONCEPT OF MUNICIPAL SEWERAGE SYSTEMS,

H. Fathmann
IWL Forum 66/1, pp 1-23, 1966.

Descriptors: *Sewage treatment, *Costs, *Drainage systems, *Equipment, Design.

The author deals with various problems which are encountered in the design and operation of sewage works for local communities. Particular reference is given to the cost of drainage systems and mechanical treatment plants, the control of storm sewage overflows, the operation of screens, detritus, sedimentation and humus tanks, and the advantages of percolating filters and activated-sludge plants.

275
STATUS AND PROPOSED CONTROL OF POLLUTION IN BOSTON HARBOR AND ITS TRIBUTARIES,

John J. Flaherty
J Boston Soc Civil Eng, Vol 55, No 4, pp 221-230, Oct 1968.

Descriptors: *Pollution abatement, Sewerage, Discharge, Overflow, Storm runoff.
Identifiers: *Boston, Separate system, Deep tunnel plan, Combined sewers.

Stormwater overflows from combined sewerage systems and from industrial wastes is the principal cause of river pollution in the Boston area. About 100 outlets into the Harbor and its tributaries are affected by Boston storm overflows and combined sewer discharges from neighboring communities. Four principal alternative methods of pollution abatement for the area are: 1) complete separation of all sanitary sewerage and storm drainage systems, 2) construction of chlorination detention tanks, 3) construction of surface holding tanks, and 4) implementation of the deep tunnel plan. Engineers recommend the construction of sanitary sewers and storm conduits wherever existing principal design flows or runoff from 15-year frequency design rainstorms. The governmental agencies responsible for pollution control, as well as various studies and approaches to alleviation and abatement methods are listed. Results indicated that the most positive method of collecting and disposing overflows of mixed sewage and stormwater is the deep tunnel plan.

276
WATER RESEARCH: MAJOR RESEARCH PROBLEMS IN WATER QUALITY,

Ernest F. Gloyna
Johns Hopkins Press, Baltimore, Maryland, pp 479-493, 1966. 3 tab, 19 ref.

Descriptors: *Water pollution, *Water quality, *Pollutants, Water quality control, Research and development.
Identifiers: *Urban drainage.

This section describes the nature of pollution, some dimensions on quality, the current status of water renovation, and research needs. Considerable background information is provided. Types of pollution discussed are: disease-causing pollution, and conservative and nonconservative pollution. Factors which influence water quality are examined, namely: usage, natural pollution, agricultural and urban drainage, waste-solids disposal practices, recreation, and certain political implementations. The following are areas related to water quality which need the most research: improvement of treatment processes, translation of theory to design, optimization of water quality management, development of stream use criteria, groundwater quality management, and improvement of marine disposal systems. (See abstract number 292).

277
ARCTIC HEATED PIPE WATER AND WASTE WATER SYSTEMS,

J. W. Grainge
Water Res, Vol 3, No 1, pp 47-71, Jan 1969.

Descriptors: *Sanitary engineering, *Sewerage, Pipes.
Identifiers: *Canada.

Sanitation problems of communities in Northern Canada are discussed, and some environmental conditions are evaluated. Improvements in sanitation in small Canadian communities by providing piped water and sewage services have been proposed. Two original, relatively inexpensive, all-weather systems suitable where pipes may not be buried on account of soil conditions are described. Ideas and suggestions for planning water and sewerage systems are given.

278
DRAINAGE OF ROADS AND PAVED SURFACES,

M. J. Hamlin and F. D. Hobbs
Inst Public Health Engrs, Vol 69, Part 2, pp 122-141, Apr 1970.

Descriptors: *Rainfall intensity, *Storm drains, Hydraulic design, Roads.
Identifiers: *Stormwater inlets.

Factors to be considered in designing stormwater inlets for roads are discussed utilizing hydraulic requirements rather than a purely empirical viewpoint. Rainfall intensity is one determining factor since, theoretically, rainfall intensity is a function of the area to be drained. The intensity of rainfall and the period for which it lasts varies across the country, and therefore, this factor must be carefully evaluated before designing stormwater inlets.

279
WATER SUPPLY AND WASTE DISPOSAL,

W. A. Hardenbergh and Edward B. Rodie
International Textbook Company, Scranton, Pa., 1960. 513 p.

Descriptors: *Water supply, *Waste disposal, *Sanitary engineering, *Design, *Operations, *Industrial wastes, *Water treatment.

This volume presents the theory and practices relating to the interrelationship between the basic problems of water supply and waste disposal. The authors provide an integrated treatment of the fundamentals common to both of these areas of sanitary engineering. Detailed are the design and operation of systems for water supply and waste disposal. Problems in water supply caused by over-population and expansion plus unusual disposal dilemmas created by increased amounts of industrial waste products are described, and some solutions are proposed. The first nine chapters concern basic principles of water supply and waste disposal including: water use and sewerage volume, piping for water and sewage systems, and the collection and storage of water. The last fourteen chapters relate to either problems or solutions such as: water treatment by screening and sedimentation; control of corrosiveness, taste, and odor; sludge treatment and disposal; filtration and disinfection of water; removal of dissolved minerals from water; the activated sludge process; and primary and secondary sewage treatment.

280
WATER SUPPLY AND WASTE DISPOSAL - CHAPTER 1 - THE WATER-SEWAGE CYCLE,

W. A. Hardenbergh and Edward B. Rodie
International Textbook Company, Scranton, Pa., pp 1-7, 1960. 4 fig, 6 ref.

Descriptors: *Water supply, *Sewage disposal, *Storm drains, *Sewage treatment, *Water treatment, Separation techniques.
Identifiers: *Storm sewers.

This chapter enumerates the functions of water supply and sewage disposal systems and discusses terminology, financing, and other elements of each system. A section on storm drainage recommends the provision of separate sewage and stormwater systems when sewage treatment is required. General information on water and sewage treatment is also included in this chapter. (See abstract number 279).

281
WATER SUPPLY AND WASTE DISPOSAL - CHAPTER 2 - QUANTITY OF WATER FROM RAINFALL,

W. A. Hardenbergh and Edward B. Rodie
International Textbook Company, Scranton, Pa., pp 8-39, 1960. 13 fig, 6 tab, 11 ref.

Descriptors: *Rainfall, *Snowfall, *Runoff, *Streamflow, *Measurement, *Water yield, *Surface waters, *Water quality, *Rainfall disposition, *Storm drains, *Design, *Rational formula, *Runoff forecasting, Groundwater, Percolation, Evaporation, Absorption.

The first three sections of this chapter involve rainfall and snowfall, rain measurement, and rain making. Next, runoff is described with a method for measuring streamflow. Other sections discuss the estimation of watershed yield, empirical formulas for runoff of water supply, an investigation of the source for yield, and the quality of surface water. Rainfall-runoff proportions, along with rainfall rate and duration, are cited as important criteria for designing storm drainage facilities. Techniques for computing these three elements are given including the Rational Method and the Burkli Zeiger empirical formula for determining runoff. Other topics treated in the chapter include: percolation and absorption, evaporation, and groundwater. (See abstract number 279).

282
WATER SUPPLY AND WASTE DISPOSAL - CHAPTER 4 - HYDRAULICS OF WATER AND SEWAGE CONDUITS,

W. A. Hardenbergh and Edward B. Rodie
International Textbook Company, Scranton, Pa., pp 59-72, 1960. 5 tab, 3 fig, 2 ref.

Descriptors: *Pipe flow, *Pipes, *Sewers, Mannings equation.
Identifiers: *Sewer hydraulics.

General formulas describing the flow of water in pipes are used to compute pipe sizes. Such formulas and other aspects of flow in water pipes are presented in this chapter. Flow in sewers is described specifically with reference to the Manning Formula and other formulas. Additional topics discussed are: limiting velocities in sewers, and the design of full and partly filled sewers excluding circular sewers. (See abstract number 279).

283
WATER SUPPLY AND WASTE DISPOSAL - CHAPTER 5 - PIPING FOR WATER AND SEWER SYSTEMS,

W. A. Hardenbergh and Edward B. Rodie
International Textbook Company, Scranton, Pa., pp 73-98, 1960. 22 fig, 3 tab, 10 ref.

Descriptors: *Water supply, *Construction, *Construction materials, *Sewers, Design, Piping systems (mechanical).
Identifiers: Pipe construction.

Requirements for the construction of water supply and sewer pipes are listed, and descriptions of the most commonly-used materials are included. Cast-iron, asbestos-cement, concrete, and steel are discussed in terms of their use in water supply pipe construction. Vitrified-clay, concrete, and asbestos-cement are described for sewer pipes. Other topics in this chapter are: service pipes, electrolysis, water hammer, the thickness of metal pipe, appurtenances for water systems (valves, meters, hydrants) and for sewers (manholes, drop manholes, inlets, catch basins, flush tanks, diverting weirs, inverted siphons, and outlets), junctions of large sewers, loads on pipes in trenches, and the testing of sewer pipe strength. (See abstract number 279).

284
WATER SUPPLY AND WASTE DISPOSAL - CHAPTER 8 - COLLECTION AND TRANSPORTATION OF SEWAGE,

W. A. Hardenbergh and Edward B. Rodie
International Textbook Company, Scranton, Pa., pp 161-190, 1960. 3 tab, 8 fig, 4 ref.

Descriptors: *Sewerage, *Sewers, *Storm drains, *Design standards, *Specifications, Runoff, Time of concentration, Construction, Measurement.
Identifiers: *Storm sewers, *Capacity, Combined sewers, Curved sewers.

Subjects discussed in this chapter include: the layout of a sewerage system, the position of the sewer in the street, the procedure for establishing layout, and the design of sanitary sewers. Also described is the design of a storm drainage system including information of the inlet time or time of concentration, runoff, sizes and gradients of storm sewers, and inlet capacity. Combined sewers, noted to be rarely-built, follow the same design as that for storm sewers although their shape may be modified. Sewer construction, infiltration measurement, records, and curved sewers are additional topics explored. (See abstract number 279).

285
TARGET DATES FOR SECONDARY TREATMENT AND STORMWATER SEPARATION ON LOWER MISSOURI AND MISSISSIPPI RIVERS,

Glen J. Hopkins
Paper presented at the annual meeting of the Missouri Water Pollution Control Association, Jefferson City, Missouri, February 23, 1970.

Descriptors: *Water pollution sources, *Pollution abatement, Missouri River, *Mississippi River, *Surface runoff, Water pollution, Sewage treatment, Separation techniques, Overflow.
Identifiers: *Agricultural land runoff, Combined sewers.

The author discusses sources and effects of pollution in the lower Missouri and Mississippi Rivers, and explains his reasons for opposing secondary treatment and storm sewer separation for this area. He states that sufficient pollution abatement has already taken place in these rivers and that communities need not waste tax dollars supporting federal grants for further pollution prevention facilities. According to Mr. Hopkins, the Missouri River can assimilate wastes properly with the treatment that is presently offered. He also asserts that sewered wastes, municipal and industrial, and combined sewer overflows cause far less pollution to the rivers than does surface runoff from agricultural lands upstream. Cost of sewer separation for this area is estimated to exceed $250 million.

286
BUILDING PLANS AS A BASIS FOR THE DESIGN OF WATER AND SEWAGE WORKS,

E. Hornig
Gas Wasserfach (GAWFAN), Vol 107, pp 32-36, 1966.

Descriptors: *Planning, *Hydraulic engineering.
Identifiers: *Germany.

The federal German building plan of 1960 can also be applied to hydraulic engineering. The number of future inhabitants per 103 sq. m. for town and country planning is calculated by statistical analyses and also represents an overall basis for the future requirements of water supplies and sewage treatment facilities. This plan takes into consideration the average rainfall and the pollution potential of the population.

287
MASTER WASTEWATER COLLECTION AND TREATMENT PLAN FOR BOGOTÁ, COLUMBIA,

D. R. Horsefield
J Water Pollution Control Fed, Vol 48, No 8, pp 1443-1458, Aug 1968.

Descriptors: *Sewage disposal, *Design, Construction costs, Sewerage.
Identifiers: *Bogotá, Columbia, *Interceptor sewer, Stormwater disposal, Combined sewers.

Bogota has a population of 1,700,000 and an average wastewater flow of 88.2 mgd, both of which are expected to increase substantially by 1985. A Master plan for the disposal of domestic and industrial wastes, and stormwater through a multi-stage program consisting of canal and intercepting sewer construction is presently in the first stage and total costs are estimated at $85,000,000. Separation of existing combined sewer areas is not recommended because of cost and public inconvenience. Graphs concerned with water consumption trends, wastewater, sanitary sewage discharges, rainfall-runoff, and costs are included; and canal designs are pictured. Problems encountered, methods used, and design criteria are discussed.

288
THE INFLUENCE OF SALTS APPLIED TO HIGHWAYS ON THE LEVELS OF SODIUM AND CHLORIDE IONS PRESENT IN WATER AND SOIL SAMPLES,

Frederick E. Hutchinson
Maine University Water Resources Center Project Completion Report, Jun 1969. 18 p, 2 fig, 9 tab, 6 ref.

Descriptors: *Saline soils, *Maine, *Chlorides, *Saline water, Pollutant identification, Water pollution sources, Highways, Soil-water-plant relationships, Infiltration, Leaching.
Identifiers: Highway icing.

This research project was conducted to determine the effect of salt applications to de-ice highways on the sodium and chloride levels in 1) streams and rivers, 2) private water supplies contiguous to highways, and 3) soils bordering highways. Analysis of seven rivers in Maine from six samplings over a two-year period indicate that sodium and chloride concentrations are not affected by highway salting, since the level of both ions remained consistent throughout the period. Although the concentrations of both ions tended to increase from the headwaters to the mouth of the rivers the average concentrations for 27 sites were 3.4 and 1.5 ppm for sodium and chloride respectively. Semi-annual analyses of 100 randomly selected wells along Maine highways indicate that levels of sodium and chloride are much higher than normal, averaging 69 and 162 ppm respectively. 25% of the wells were unfit for potable supplies because they contained in excess of 250 ppm of chloride. Sodium and chloride levels in soils contiguous to highways bear a direct relationship to the length of time over which highways have been salted. In areas where salt has been applied for 20 years the sodium levels have risen over a distance of 60 feet from the edge of the highway, and to a depth of 18 inches. Sodium saturation of the soil approaches 15% at some sites, and chloride levels in the soil-water system ranged from 10 to 2525 ppm, thereby producing the equivalent of an "alkali" condition.

289
WATER AND METROPOLITAN MAN,

Stifel W. Jens and D. Earl Jones, Jr.
Rep of 2nd Eng Found Conf on Urban Water Resources Res, Aug 12-16, 1968, 1969.

Descriptors: *Water resources development, *Planning, *Urbanization, Systems analysis, Mathematical models, Social aspects, Legal aspects, Economics, Management, Water management (applied).
Identifiers: Water resources research, Sociology.

The second conference on urban water resources research stressed the interdisciplinary and systems analysis approaches to solving urban water and pollution problems. Recommendations were made for action and for further research in communication, planning, social impacts, regulation, data collection, precipitation, storage, urban design, and systems analysis.

290
DIVISION OF COST RESPONSIBILITY FOR WASTEWATER SYSTEMS,

James A. Johnson
J Water Pollution Control Fed, Vol 42, No 3, Part 1, pp 341-353, Mar 1970.

Descriptors: *Cost-benefit analysis, *Waste water treatment, Construction costs.
Identifiers: Combined sewers, Storm sewers.

The paper describes the level and trends of wastewater facility costs and the methods currently used to meet them; groups of beneficiaries of sewerage service; formulas for dividing costs among the groups; and it examines the differences in the formulas. Specifically, ideas are presented as to how combined sewers should be termed so as to determine who should pay the cost. In the case of separate storm sewers, the problem involves the amount of responsibility placed on the property owner.

291
PREDICTION MODELS FOR INVESTMENT IN URBAN DRAINAGE SYSTEMS,

John W. Knapp and Walter J. Rawls
Water Resources Research Center Bull No 24, Virginia Polytechnic Instit, p 1-55, April 1969.

Descriptors: *Mathematical models, *Investment, *Drainage systems, *Decision making, *Cost-benefit analysis, Design criteria, Planning, Economic feasibility, Geographical regions, Engineers estimates.

Linear models were developed and used to study the significant factors controlling costs of conventional urban drainage systems. The objective of the study was to find decision making tools which engineers and planners could employ for estimating the cost of alternative sizes of drainage facilities and the degree of protection to be afforded; and for judging the potential for development. Techniques of factor, component, and non-linear analysis were performed with data collected from 100 municipal agencies around the country. The study revealed that design practices as well as geographic areas were important. Physical features, although most important, were usually the fixed, uncontrollable variables. Design factors, on the other hand, were important in both degree and kind. The analysis explained the differences in the design methods and led to the development of equations to predict the cost for various levels of design.

292
WATER RESEARCH,

Allen V. Kneese and Stephen C. Smith, editors
Papers presented at Seminars in Water Resources Research, sponsored by Resources for the Future and the Western Resources Conference, at Colorado State University, July 1965. The John Hopkins Press, Baltimore, Md., 1966. 526 p.

Descriptors: *Water resources, *Water resources development, *Planning, *Water Resources Research Act, Water management (applied), Evaluation.

These conference papers reflect years of research activity on problems of planning and managing water resources. The following developments over the past decade are highlighted in the papers: (1) clarification and far-reaching applications of economic concepts to water development and use; (2) emphasis on cross-disciplinary research; (3) use of high-speed electronic computers in water management research; (4) emphasis on problems of recreation, water quality, and management of water-associated land used; (5) more research on political, administrative, and institutional factors; (6) the new role of federal agencies in water management research; and (7) the impact of the Water Resources Research Act of 1964. The papers are divided into areas including: (1) issues in theoretical economic analysis; (2) case studies of water management; (3) research on evaluation problems; (4) studies of water reallocation; (5) political and administrative studies; (6) research on hydrology and engineering; and (7) major research programs and needs.

293
HYDROLOGICAL ASPECTS OF WATER MANAGEMENT,

Gy Kovacs
2nd Int Postgrad Course on Hydrol Method for Develop Water Resources Manage, Jan-July 1968, Manual No 2, 1968.

Descriptors: *Water management (applied), *Water resources development, *Hydrologic aspects, Government, Planning, Urbanization, Water conservation, Flood control, Channel improvement, Irrigation, Water supply, Sewage, Waste disposal, Hydroelectric power, Economics.
Identifiers: Textbook, Technical manuals.

Water management is defined and the hydrological aspects of water management are discussed in the introductory section of a text written for an international post-graduate course in water resources management. The topics introduced are flood control, river training, water control on the catchment, irrigation, water supply and sewage problems, water power, and economics. The objectives of water management and the needs for data of the various branches of water management are outlined and summarized. Various national water management organizations and policies are briefly described.

294
A SIMULATION TECHNIQUE FOR ASSESSING STORM AND COMBINED SEWER SYSTEMS,

John A. Lager
In: Combined Sewer Overflow Seminar Papers, Edison, N.J., Nov 4-5, 1969. Water Pollution Control Research Series, Report DAST-37, pp 151-170, Mar 1970. 5 fig, 4 tab, 11 ref.

Descriptors: *Simulation analysis, *Assessments, *Computer programs, *Storm runoff, Water pollution control.

This paper describes work in progress to develop an assessment technique for comparing alternate solutions through a comprehensive computerized program capable of "representing urban stormwater runoff phenomena, both quantity and quality, from the onset of precipitation on the basin, through collection, conveyance (both combined and separate systems), storage, and treatment systems to points downstream from outfalls which are significantly affected by storm discharges". The program is intended for use by municipalities, government agencies, and consultants as a tool for evaluating the pollution potential of existing systems, present and future, and for comparing alternate courses of remedial action.

295
A PLAN FOR ENDING LAKE ERIE POLLUTION,

James C. Lamb
Public Works, Vol 100, No 6, pp 79-82, Jun 1969.

Descriptors: *Pollution abatement, Storm runoff, Sewage treatment, Separation techniques.
Identifiers: *Lake Erie, *Water quality programs, Combined sewers.

Sources and effects of pollutants in Lake Erie are described along with plans and recommendations for the elimination of pollution from the lake. Urban runoff and combined sewer overflows are major sources of pollution contributing BOD, bacteria, and nutrients--especially phosphorus. Detroit, Cleveland, and Toledo are the largest offenders in the area of storm water runoff. Suggested state water quality programs are outlined in addition to areas requiring research and development such as: tertiary treatment, nutrient removal, sediment evaluation, pesticide pollution, radioactive and thermal pollution, industrial sludge disposal, oxygen deficient zones, and eutrophication. Expensive separate sewerage systems are recommended only where feasible, such as in redevelopment projects. However, where combined sewers exist, overflows should be disinfected before being discharged to a body of water, and future plans for storage and treatment should be made.

296
POLLUTION OF THE CHAO PHRAYA RIVER,

R. E. Leffel
J Sanit Eng Div, Am Soc Civil Engrs, Vol 94, No SA2, pp 295-306, Apr 1968.

Descriptors: *Foreign research, Estuaries, Waste water treatment.
Identifiers: *Chao Phraya River, Thailand.

Programmed sampling and tests of the Chao Phraya River Estuary show that its pollution-receiving capacity is limited. No sewage collection system presently exists in Bankgok, but separate wastewater and stormwater systems are being planned because a combined system would undoubtedly cause further pollution of the estuary during severe rainfall. More studies must be made before the degree of oxidation of organic carbon, nitrogen, and amoniacal nitrogen can be accurately determined. Further studies are also being conducted to decide upon the necessary type of initial wastewater treatment. Such treatment must include sufficient oxidation of organic carbonaceous substances and oxidizable nitrogenous substances. This study also demonstrates the need for modifications in standard BOD measurements in addition to modifications of the parameters and equations defining DO concentrations for tropical estuaries.

297
WATER-RESOURCES ENGINEERING,

Ray K. Linsley and Joseph B. Franzini
McGraw-Hill Book Company, New York, 1964. 654 p.

Descriptors: *Water resources, *Water resources development, *Planning, *Hydrology, *Water pollution control, *Digital computers, *Water management (applied), *Engineering education, Water utilization.
Identifiers: *Textbook.

This book is basically aimed towards introducing water resources engineering to the undergraduate civil engineering student. The first five chapters present hydrology, the subject basic to water management. Chapter six involves legal aspects of water use which often constrain planning efforts. Chapters seven through twelve discuss physical works--dams, canals, pipelines, etc.--which are utilized in almost all types of water resources projects. Chapters fourteen through twenty cover principal water uses, and the last chapter summarizes the planning procedure for single and multi-purpose projects. Pollution control is stressed in regard to waste treatment, and the role of the digital computer in hydraulic engineering is thoroughly discussed.

298
WATER-RESOURCES ENGINEERING - CHAPTER 3 - QUANTITATIVE HYDROLOGY,

Ray K. Linsley and Joseph B. Franzini
McGraw-Hill Book Company, New York, pp 38-71, 1964. 18 graphs, 4 tab, 2 diag, 6 ref.

Descriptors: *Hydrologic aspects, *Runoff, *Infiltration, *Rainfall-runoff relationships, *Snowmelt, Rational formula, Estimating equations, Hydrographs.

This chapter presents examples of commonly used hydrologic procedures, some empirical, some rational. Terms relating to basin recharge and runoff are defined. Other topics discussed include: hydrograph analysis, infiltration and infiltration indices, rainfall-runoff correlations, moisture-accounting procedures, long-period runoff relations; plus topics relating to runoff from snow and techniques such as the rational method for estimating instantaneous peak-flow rates and computing complete hydrographs.

299
WATER-RESOURCES ENGINEERING - CHAPTER 10 - OPEN CHANNELS,

Ray K. Linsley and Joseph B. Franzini
McGraw-Hill Book Company, New York, pp 251-279, 1964. 18 diag, 9 tab, 1 graph, 8 ref.

Descriptors: *Open channels, *Hydraulic properties, *Flow measurement, Canals, Tunnels, Flumes.

The open channel and the pressure conduit are the two types of conduits that convey water. The open channel may take the form of a canal, flume, tunnel, or partly filled pipe, all of which are referred to in this chapter. Open channels are characterized by a free water surface, in contrast to pressure conduits which flow full. This chapter details salient features of the hydraulics of open-channel flow including: uniform and nonuniform flow, normal and critical depth, location of the hydraulic jump, free outfall, hydraulic efficiency of channels, channel transitions, and flow around bends and steep slopes. Measurement of flow in open channels is also explained for weirs and venturi flumes. Canals, canal appurtenances, and tunnels are described in the section on types of open channels.

300
WATER-RESOURCES ENGINEERING - CHAPTER 11 - PRESSURE CONDUITS,

Ray K. Linsley and Joseph B. Franzini
McGraw-Hill Book Company, New York, pp 280-322, 1964. 31 diag, 5 tab, 11 ref.

Descriptors: *Pressure conduits, *Hydraulic properties, *Flow measurement, Construction materials, Construction equipment.
Identifiers: *Pollution potential.

A pressure conduit flows full and is often less costly than an open channel because it generally follows a shorter route. If water is scarce, pressure conduits may be used to avoid water loss by seepage and evaporation that might occur in open channels. Pressure conduits are preferable for public water supplies because of the reduced opportunity for pollution. This chapter is limited to turbulent flow in pipes, since this is what the hydraulics engineer deals with exclusively. Topics covered under the section on the hydraulics of pressure conduits include: head loss due to pipe friction, minor losses in pipelines, flow with negative pressure, flow in branching and parallel pipes, and pipe networks. Other sections discuss: measurement of flow in pressure conduits; forces acting on pipes; materials such as steel, cast-iron, and concrete for pressure conduits; appurtenances for pressure conduits such as gates, valves, and surge tanks; and inverted siphons.

301
WATER-RESOURCES ENGINEERING - CHAPTER 18 - DRAINAGE,

Ray K. Linsley and Joseph B. Franzini
McGraw-Hill Book Company, New York, pp 490-533, 1964. 18 diag, 2 tab, 2 graphs, 8 ref.

Descriptors: *Drainage, *Storm drains, *Surface drainage, *Design, Surveys.
Identifiers: *Stormwater disposal, *Highway drainage.

The problems of drainage may be subdivided into municipal drainage, the disposal of excess stormwater from cities; land drainage, the disposal of stormwater from rural areas, and the removal of excess water from the soil; and highway drainage, the disposal of stormwater from highway rights of way. Principles governing most drainage projects are basically the same, but the differing physical problems encountered require different solutions. In describing procedures for designing storm drainage works, topics covered include: estimates of flow, gutters, inlets, grated and curb-opening inlets, manholes, and outlet works. The section on land drainage discusses: drainage ditches, underdrains, groundwater flow to drains, layout of a tile-drain system, drainage by vertical wells, and legal aspects of drainage. Topics included under highway drainage are: longitudinal and cross drainage, culverts, culvert inlets and outlets, debris barriers, culvert hydraulics, bridge waterways, and dips.

302
WATER-RESOURCES ENGINEERING - CHAPTER 19 - SEWAGE DISPOSAL AND WATER QUALITY CONTROL,

Ray K. Linsley and Joseph B. Franzini
McGraw-Hill Book Company, New York, pp 534-575, 1964. 13 diag, 4 tab, 1 graph, 17 ref.

Descriptors: *Sewage treatment, *Sewage disposal, *Sewage, *Industrial wastes, *Storm runoff, *Sewers, Infiltration, Flow rates, Construction.
Identifiers: Sewage quantity, Sewer hydraulics, Combined sewers.

In urban areas liquid wastes (sewage) which must be disposed of include domestic or sanitary sewage, industrial wastes, and storm runoff. Basic terms related to sewage disposal are defined in this chapter. The section on the quantity of sewage discusses infiltration and variations of flow. The laying of sanitary, separate, and combined sewers is described along with discussions of information on sewer construction and maintenance. Topics relating to sewage treatment are also detailed such as: screening of sewage, comminutors, grease removal, sewage sedimentation, filtration, oxidation ponds, the activated-sludge process, sludge digestion, and disposal, Imhoff and septic tanks, chlorination, and industrial waste treatment.

303
THE 1969 FLOODS,

John A. McCollum
Calif Water Pollution Control Assoc 42nd Annual Conference, Apr 29-May 1, 1970, Sacramento, Calif.

Descriptors: *Damages, *Sewers, *Storm drains, *Repairing.
Identifiers: *Los Angeles, California.

This paper describes the damage to the sewer and storm drain systems in the City of Los Angeles during and subsequent to the winter rains of January and February, 1969. Emergency repair work, performed by forces of the Bureau of Sanitation of the Department of Public Works under adverse conditions, resulted in the protection of public and private property from costly damages. Steps taken to insure the health and sanitary condition of the citizenry included restoration of sewer lines, repair to channels and debris basins, and alleviation of slide potential. Damage was also experienced on a county-wide basis and a summary of events shows the interrelationships involved in emergency repair work performed.

304
ST. LOUIS FLOOD PROTECTION: INTERIOR DRAINAGE,

Herman M. McKinney
J Hydraulics Div, Am Soc Civil Engrs, Vol 93, No HY4, pp 129-147, Jul 1967

Descriptors: *Drainage programs, Comparative costs, Storm runoff.
Identifiers: *St. Louis, Missouri, Sewer hydraulics.

The interior drainage considerations in the project authorization and basis for determinations of storm runoff, hydraulic gradients, sewer capacities, gate closing stages, stormwater ponding capacities, seepage, base flow, required pumping capacities, and sewer sizes are presented. In addition, the basis for schemes of plans considered, and comparative cost analysis and selection of plans are evaluated.

305
DESIGN OF ROUGHNESS ELEMENTS FOR ENERGY DISSIPATION IN HIGHWAY DRAINAGE CHUTES,

H. M. Morris
Nat Acad Sciences--Nat Research Council--Highway Research Rec, No 261, pp 25-37, 1969.

Descriptors: *Energy dissipation, *Channels, *Design criteria, Investigations, Analysis.
Identifiers: *Tumbling flow.

Laboratory and field studies were conducted at Virginia Polytechnic Institute to develop design criteria for a method of energy dissipation by providing roughness elements in a channel designed to produce the phenomenon of tumbling flow in a channel. Based on test results, it is recommended that either two-dimensional square elements or cubical elements be used. Design equations are presented, along with recommendations for spacing and placement of elements.

306
CONSERVATION PROGRAMS IN THE URBAN FRINGE,

John W. Neuberger
J Soil Water Conserv, Vol 24, No 6, pp 216-618, Nov/Dec 1969. 6 ref.

Descriptors: *Conservation, *Storm drains, *Drainage, Erosion control, Runoff, Sediment control, Nebraska.

Solutions to land erosion and drainage problems caused by suburban sprawl in a Nebraska conservation district are outlined. Increased paving, roofing, and compacted soils result in erosion and flooding; therefore, the construction of major and minor storm drainage and water runoff systems is recommended. An Omaha program to reduce sedimentation from developing areas is detailed in addition to guidelines for good land resource conservation. Examples of developers' initiatives towards furthering the urban conservation program are cited.

307
STREAM POLLUTION AND ABATEMENT FROM COMBINED SEWERS AT BUCYRUS, OHIO,

Richard F. Noland and Dale A. DeCarlo
In: Combined Sewer Overflow Abatement Technology. Water Pollution Control Research Series, Report 11024--06/70, pp 291-230, Jun 1970. 16 fig, 3 tab.

Descriptors: *Water pollution effects, *Overflow, *Water pollution control, *Investigations, Storm runoff.
Identifiers: *Bucyrus, Ohio, *Sandusky River, *Combined sewers, Treatment method.

This paper contains results taken from a detailed engineering investigation and comprehensive technical study to evaluate the pollutional effects from combined sewer overflows on the Sandusky River at Bucyrus, Ohio which evaluated the benefits, economics, and feasibility of alternate plans for pollution abatement from the combined sewer overflows. A year long detailed sampling and laboratory analysis program was conducted on the combined sewer overflows in which the overflows were measured and sampled at 3 locations comprising 64% of the city's sewered area and the river flow was measured and sampled above and below Bucyrus. The results of the study showed that the combined sewers will overflow about 73 times each year discharging an estimated annual volume of 350 million gallons containing 350,000 pounds of BOD and 1,400,000 pounds of suspended solids. A method of controlling the pollution from combined sewer overflows is presented along with the degree of protection, advantages, disadvantages, and estimate of cost.

308
UNDERFLOW SEWERS FOR CHICAGO,

Milton Pikarsky and C. J. Keifer
Civil Eng, Vol 37, No 5, pp 62-65, May 1967. 2 diag, 2 tab.

Descriptors: *Design, *Sewers, *Overflow, *Planning, *Tunnels, Costs, Construction equipment, Computer models, Underflow.
Identifiers: *Deep tunnel plan, *Chicago, Combined sewers.

Chicago is planning an underflow sewer system consisting of a large tunnel under rivers and canals into which all combined sewers will discharge. This system, costing $400 million dollars, will eliminate the need for a $4 billion dollar conventional separate sewer because spillages from combined sewers will be directed to the underground tunnel rather than polluting surface streams. The performance of the Lawrence Ave. underflow sewers was analyzed through a computer simulation of the system. Untreated overflow into local streams was reduced from 3%/year of the sewage from combined sewers to .8% from Lawrence Ave.'s underflow sewers.

309
WATER RESOURCES AS AN ELEMENT OF URBAN PLANNING,

M. L. Rockwell
J Urban Planning Devel Div, Am Soc Civil Engrs, Vol 94, No UP1, pp 1-9, Aug 1968.

Descriptors: *Water utilization, *Storm runoff, Reservoir storage, Urbanization.
Identifiers: *Water resource problems.

This paper examines the complex technical, legal, and administrative problems involved in northeastern Illinois' water situation and the high degree of use and reuse taking place in this area. Even stormwater runoff along with its pollutants is retained in reservoirs to be used later beneficially. Existing problems related to stormwater runoff in this area include the restriction of water infiltration and, thus, the production of increased runoff caused by the construction of impermeable surfaces (roof tops, streets, and parking lots), and the maintenance of unsightly stormwater basins in areas where water recreational facilities are needed.

310
OPENING REMARKS,

William A. Rosenkranz
In: Combined Sewer Overflow Seminar Papers. Water Pollution Control Research Series, Report DAST-37, pp 1-8, 1970.

Descriptors: *Sewers, *Storm runoff, *Federal project policy, Grants, Research and development, Water pollution control.
Identifiers: *Combined sewers, Demonstration grants.

The background and history of the FWQA's combined sewer program and methods of applying for grants under the demonstration grant program established by the Water Quality Act of 1965 are discussed. Technical areas in which the FWQA Storm and Combined Sewer Pollution Control Branch are interested include: removal of storm flow and infiltration from sanitary sewers, through elimination of illicit storm water connections; pressure or vacuum sewers as an alternate means of sewer separation; infiltration control; improved materials and construction practices for sewers; and, treating and/or controlling urban runoff.

311
ENVIRONMENTAL HEALTH AND COMMUNITY PLANNING,

J. A. Salvato, Jr.
J Urban Planning Devel Div, Am Soc Civil Engrs, Vol 94, No UP1, pp 23-30, Aug 1968.

Descriptors: *Planning, *Environmental effects, Public health.

Effects are given of a type of planning which includes land use, water system and transportation, and prevention of problems caused. The health department responsibility for the issuance of permits and approval of operational results to protect public health is emphasized.

312
ENTERPRISING PROJECT AIMS AT BRINGING SEWER DESIGN UP TO DATE,

Mike Sumner
Water Pollution Control, Vol 107, No 1, p 25, Jan 1969.

Descriptors: *Hydraulic design.
Identifiers: *Sewer junctions.

A joint research project on hydraulic criteria is being carried out by the Borough of Scarborough and the University of Toronto. The project specifically is concerned with finding the best design modification to eliminate flooding at sewer junctions.

313
SYSTEM DESIGN,

George E. Symons
Water Wastes Eng, Vol 4, No 9, pp M3-M21, Sep 1967.

Descriptors: *Sewerage, *Sewers, *Design, *Hydraulics, *Installation, *Storage tanks, Sewage treatment, Design flow, Storm runoff, Overflow.
Identifiers: Combined sewers, Storm sewers.

This digest of information on sewerage systems includes definitions, explanations, and tabular data on a wide range of topics such as: sewer type classifications, considerations in sewer design, sanitary sewers, sewer hydraulics, storm and combined sewers, sewer appurtenances, and inplant piping systems. Conditions are enumerated under which sanitary sewers, combined sewers, or separate sewers should be installed. Storm sewers are recommended to relieve loads on existing combined sewers. Stormwater treatment is suggested unless an alternative can be employed such as sanitary wastes transport under pressure through small lines laid in existing combined sewers. The planning and design of storm and combined sewers is described including correct location and design capacity of such systems. Appurtenances relating to stormwater runoff, such as overflows and storm tanks, are defined and described. Storm tanks are more commonly used in combined systems in order that stormwater eventually be passed to sewage treatment works to avoid overflow of storm water into nearby bodies of water. Such tanks operate under gravity or pumping conditions. Tables, diagrams, and graphs in the digest include: sewer classification, sewer system layouts, population trends in the U.S., quantities of water and sewage flow in U.S. cities, amounts of hourly and daily sewage flow in a sample city, extreme flow rates as a function of population, filtration specifications, rates of flow using Bernoulli's, Manning's, and Hanzen-Williams' formulas, a sewer design slide rule, sewer hydraulic information, recommended minimum sewer grades, and design criteria for sewer appurtenances.

314
THE SEWERAGE AND DRAINAGE PROBLEM,

A. L. Tholin
In: Environmental Engineering and Metropolitan Planning, edited by John A. Logan, Paul Opperman, and Norman E. Tucker, Northwestern University Press, pp 91-109, 1963.

Descriptors: *Sewerage, *Drainage, *Urbanization, Conduits, Construction costs, Financing, Detention reservoirs, Gaging stations, Flood damage, Planning, Water pollution, Drainage systems, Public health, Sewage treatment.
Identifiers: *Combined sewers, *Sanitary sewers, *Storm sewers, Sewer design.

Recommendations are made regarding the sewerage and drainage problem. The desirable solution of the sewerage and drainage problem should include the following action: (1) convey spent water quickly by underground conduits to the place of treatment and disposal; (2) avoid combined sewers, if possible; (3) design so as to conserve and utilize energy of flow to achieve economy of construction cost; (4) detain storm-water near the origin, where possible; (5) interpret river gagings with a critical eye; (6) find out what flow-ways we need, establish and maintain them; and (7) have a master plan. Included in the paper are: a formal comment, a discussion, and a workshop regarding the subject matter.

315
RIVER CONSERVATION AND WATER CONSERVATION WORKS: CHAPTER 9 - THE USE OF BALANCING RESERVOIRS AND FLOW REGULATING RESERVOIRS IN DEALING WITH RUN-OFFS FROM URBAN AREAS,

G. Thompson
Butterworths, London, pp 132-141, 1966. 6 fig, 5 ref.

Descriptors: *Surface drainage, *Flow control, *Regulated flow, *River systems, *Design criteria, Sewers.
Identifiers: *Urban runoff, *Flow balancing.

This chapter attacks the problem of increased runoff from a river caused by urban development and the installation of surface water drainage. Such a problem ensues wherever more paved areas are directly connected by sewers to a river. As a solution, the author recommends flow balancing, which entails passing the flow through a natural or artificial lake with a restricted outflow, or flow regulation, in which part of the river flow is passed into specially-prepared areas. These plans can be economical, and they reduce peak flows and also channel sizes farther downstream. General design factors for implementing flow balancing and regulation are discussed; and then a scheme combining the two principles, which was applied to the River Cray, is described. Flow balancing is possible in new or undeveloped towns; whereas, it cannot usually be implemented in a built-up area unless lakes or disused mine workings are available. In such urban areas, flow regulation is readily applicable. (See abstract number 316).

316
RIVER ENGINEERING AND WATER CONSERVATION WORKS,

Roland Berkeley Thorn, editor
Butterworths, London, 1966. 520 p.

Descriptors: *Water supply, *Water conservation, *Engineering education, Legislation.
Identifiers: *River engineering.

The editor collected articles by twenty-three authors, and these, together with his own contributions, form a comprehensive introduction to basic information needed by river authority engineers. The book also includes topics related to water supply engineering and the soil mechanics of flood embankments. With the exception of the first chapter on water conservation and water supply legislation, the emphasis is on engineering subjects and the means for solving major problems arising in river engineering and water conservation works.

317
SPECIAL REQUIREMENTS FOR A FULL SCALE FIELD DEMONSTRATION OF THE ASCE COMBINED SEWER SEPARATION PROJECT SCHEME,

Donald H. Waller
ASCE Combined Sewer Separation Project, Technical Memorandum No 13, June 3, 1968. FWPCA Program No 11020EKO. 84 p, 12 fig, 13 tab, 10 ref.

Descriptors: *Benefits, *Costs, Anaerobic conditions, Legal aspects, Measurement, Overflow.
Identifiers: *Field demonstration planning, Obstructions to flow, Interviews, Sewer separation, Storage-grinder pump.

Matters that should be considered in planning a field demonstration of the ASCE Project pressure sewer scheme are summarized. These include: importance of connecting as many buildings as possible in the demonstration project area; need for protection from overflows of building storage-grinder pump units; relationship between occurrence of overflows from buildings and given levels of public inspection, detection and control; effectiveness of alarms on storage-grinder pump units; legal agreements with property owners; importance of complete records of project costs;

effectiveness of the project as a pollution control measure; possible benefits of elimination of infiltration from interceptors and treatment plants; detection and clearing of obstructions; use of polymer additives to reduce fluid friction; behavior of unground sewage including anaerobic decomposition; self-cleansing characteristics of flow; rate and extent of deterioration of friction factors; sewage flow variations and their relationship to water demands; handling of interruptions of service; and field tests on installations in walk-through combined sewers. The appendix is an assessment of the physical problems to be overcome in separation of plumbing on private property, with estimates of cost, based on information from officials in seven large cities having combined sewers, and from a consulting engineer and a recent American Public Works Association survey.

318
NON-MECHANICAL CONSIDERATIONS INVOLVED IN IMPLEMENTING PRESSURIZED SEWERAGE SYSTEMS,

Donald H. Waller
Combined Sewer Separation Project, Technical Memorandum No 12, May 31, 1968. FWPCA Program No 11020 EKO.

Descriptors: *Administration, *Economic justification, *Legal aspects.
Identifiers: *Interviews, Radcliff, Kentucky, Storage-grinder pump.

Installation of a storage-grinder pump unit in every home raises questions regarding: allocation of costs of the units; responsibility for malfunction of the units; arrangements for service of the units; and willingness of owners to accept the presence of units in their buildings. Twenty-five householders in Radcliff, Kentucky, whose houses are served by sewage ejector units were interviewed to obtain opinions about features of the units that appeared to represent potential sources of nuisance, inconvenience, or other liabilities. Also interviewed were the superintendent of the utility operating the Radcliff sewerage system, owners of five houses in Louisville, Kentucky, at which sewage sampling stations were located, and three consulting engineering firms who have considered schemes involving the installation of sewage pumping equipment on private properties. Opinions and practices reported reflect the view that sewage pumping equipment placed on private property as part of a public project should be purchased, installed, and serviced at public expense.

319
BRITAIN AND THE AMERICAN WATER QUALITY CRISIS

Richard Wood
Effluent Water Treat J, Vol 10, No 6, pp 316-317, 319-321, Jun 1970.

Descriptors: *United States, *Cost analysis, *Comparative costs, Equipment, Standards, Pollution abatement.
Identifiers: *Viewpoint, *Great Britain.

The author states that Britain's shortcomings with regard to water pollution control stem from a failure of financial investments in control plants to keep pace with the changing technology of industrial processes and their effects on both domestic and mixed-municipal sewage. A comparative cost analysis between Britain and the United States concerning water pollution control is discussed including: cost percents appropriated for equipment, industrial waste treatment, municipal sewage treatment, and river pollution abatement, Basic purification standards are included as well as effluent standards. The author expands on the idea that the exportation of pollution control equipment such as instrumentation and control systems to the United States is one area in which the British may contribute their technological advances in aiding both the United States and Britain.

320
FLOOD CONTROL PROMISED MAJOR BENEFITS,

Walter J. Wood and N. Christian Datwyler
Public Works, Vol 101, No 6, pp 67-68, Jun 1970.

Descriptors: *Drainage systems, *Flood control, *Storm drains, Overflow.
Identifiers: Connecting tunnel.

The Department of Housing and Urban Development recently granted funds to the Los Angeles County Flood Control District for the construction of a storm drainage system. Such a system will eliminate problems caused by accumulated stormwater sumps along the undulating terrain of the area. Such stormwater accumulations have caused drownings and mosquito proliferation, and they sometimes overflow and flood surrounding areas or infiltrate the sewer system creating a health hazard. The project consists of a tunnel connecting storm drains to the Pacific Ocean. The new drainage system will encourage redevelopment in the area by resolving the problems presently making the region an unattractive and often-dangerous place to live.

321
ENGINEERING ASPECTS OF WASTEWATER CONTRACTS,

Samuel I. Zack
J Sanit Eng Div, Am Soc Civil Engrs, Vol 95, No SA3, pp 465-480, Jun 1969.

Descriptors: *Engineers estimates, *Sewers, Engineering.

Engineering elements essential to the financing, construction, operation and maintenance of sewerage facilities for use by two or more parties are outlined. Contract terms, conditions and clauses in successful use which include the engineering basis for jointly sharing the capacities of sewage collection and treatment facilities, and for joint sharing of capital and annual operating and maintenance costs are covered. Definitions of engineering terms; regulations pertaining to conditions of wastewaters, both domestic and industrial, acceptable from the party being served; specific stipulations considered typical for excluding discharge of detrimental wastewaters and sewage which contains stormwater, drainage from stormwater inlets, floor drains, and from other direct sources; and how and when payments are made according to actual contracts in effect are given. The importance of scheduling payments to meet commitments is presented. Examples are cited to indicate how engineering factors and needs of a specific location affect the patterns of a contract. The fact that no lawyer should endeavor to write a contract without engineering consultation and that no engineer should write a contract without legal advice is emphasized.

Section 7

LEGISLATION AND STANDARDS

322
MUNICIPALS WANT NEW CENTRAL BODY FOR WATER AND SEWAGE,

Surveyor, Vol 85, pp 37 and 48, Apr 1970.

Descriptors: *Future planning (projected), *Legal aspects, *Regulation, *Administration.
Identifiers: *Viewpoint.

The setting up of a central body, with much wider responsibilities than those of the present Water Resources Board, to plan, initiate, or coordinate action over the whole field of water resources and sewage purification and disposal, is proposed by the Institution of Municipal Engineers. The following points were discussed: the inadequacy of the present form of organization for the future; water supply and effluent disposal planning; standards research; and the delegation and determination in regards to responsibilities of river boards and local government bodies (i.e. surface water sewerage, positioning of surface water overflows and outfalls).

323
MERSEY RA STANDARDS FOR EFFLUENTS,

Surveyor, Vol 84, No 4039, p 98, Nov 7, 1969.

Descriptors: *Standards, *Sewage effluents, *Sewage disposal, Overflow.
Identifiers: *Effluent standards, *Great Britain, Trade effluents, Storm sewage.

The Mersey and Weaver River Authority defined effluent standards in accordance with relevant local conditions. Standards were developed for the following areas: (1) purified sewage effluents discharged to inland rivers (normally applied to rates of flow up to 3 d.w.f.); (2) partially treated sewage effluents discharged to rivers (normally applied to rates of flow in excess of 3 d.w.f.); (3) untreated sewage effluents from storm sewage overflows; (4) sewage effluents discharged to tidal waters; and (5) trade effluents.

324
POWER TO ACQUIRE LAND, CONSTRUCT AND EQUIP SEWERAGE SYSTEM,

Conn Gen Stat Ann sec 7-247 (1960).

Descriptors: *Connecticut, *Sewage districts, *Condemnation, *Cities, Sewage, Sewage disposal, Sewage treatment, Sewers, Wastes, Environmental sanitation, Drainage systems, Storm drains, Regulation, Administrative agencies, Management, Storm runoff, Real property, Right of way, Eminent domain, Contracts, Control, Legislation, Local governments.

Any city may acquire, construct, and operate a sewerage system or systems. For that purpose, the city may enter upon and acquire property by purchase, condemnation, or other means. Cities may establish rules for the operation of the system, including regulation of discharge of sewer or any storm drain runoff into the system which they feel will adversely affect its operation. Cities may contract with any person or with any other city to provide or obtain sewerage system services for any sewage. The sewer authority shall: (1) establish rules for the transaction of its business; (2) keep records of its proceedings; and (3) designate an officer to be the custodian of its books.

325
HEALTH AND SAFETY,

Del Code Ann tit 16, secs 7907, 7929, 7930, 7931 (1953).

Descriptors: *Delaware, *Inspection, *Sewage, *Administrative agencies, Legislation, Evaluation, On-site investigations, On-site tests, Regulation, Water law, Legal aspects, Sewage disposal, Sewers, Cesspools, Waste disposal, Environmental sanitation, Potable water, Permits, Public health, Waste water (Pollution), Sanitary engineering, Social aspects, Water quality, Storm drains, Wells, Well permits, Water supply, Runoff, Plumbing.
Identifiers: Storm sewers, Storm sewage.

Agents of the State Board of Health inspect and supervise all water and sewer systems, building and house drainage systems, and their ventilation. Plumbing inspectors may enter any building or premises in the state when necessary for the performance of their duties and may inspect and order the removal of any plumbing fixture, pipe, or cesspool which they deem to be in an unsanitary condition. Storm waters must be drained into a storm water sewerage system or a combined sewerage system but not into a sanitary sewerage system intended for sewerage only. Privy vaults or cesspools are not permitted on premises accessible to a public sewer. Where a public water supply is available, dug wells or other sources of private water supply are unlawful unless approved in writing by the Board.

326
WESTERN AND ATLANTIC RAILROAD V HASSLER (DAMAGES CAUSED BY INADEQUATE CULVERT),

92 Ga App 278, 88 SE 2d 559-565 (1955).

Descriptors: *Georgia, *Flood damage, *Precipitation excess, *Rainfall intensity, Judicial decisions, Damages, Rainfall, Precipitation, Railroads, Culverts, Rainfall Disposition, Runoff, Drainage, Surface runoff, Floods, Cloudbursts, Streams, Nonnavigable waters, Mills, Riparian land, Natural flow.
Identifiers: Negligence.

Plaintiff owned a mill adjacent to a non-navigable creek. The creek flowed through a culvert under defendant's tracks approximately two thousand feet from the mill. The culvert was adequate in area to take care of the normal flow of the creek. The defendant raised its tracks two and one-half feet, and reinforced the culvert by adding several inches of new masonry, thereby reducing the flow of water through the culvert by about fifteen percent. The raising of the tracks prevented the overflow of the water in time of heavy rains. During such rains, plaintiff's mill and cotton gin were damaged because of flooding. The question presented was whether damage resulted from an act of God or through the fault of the railroad. The court held that this was a question for the jury. If the flood that did occur was so extraordinary and unprecedented that it could not have been foreseen and the damage could not have been prevented by prudential means, the railroad could not be held liable.

327
CITY OF MACON V CANNON (SURFACE WATER RUNOFF),

89 Ga App 484, 79 SE 2d 816-826 (1954).

Descriptors: *Georgia, *Storm drains, *Flooding, *Drainage water, Subsurface drains, Drainage engineering, Highways, Roadbeds, Drainage systems, Overland flow, Natural flow, Precipitation excess, Rainfall, Storm runoff, Legal aspects, Judicial decisions, Local governments.

Plaintiff brought action to recover for damages resulting from defendant city's maintenance of a nuisance. The alleged nuisance consisted of a sewer beneath plaintiff's land which lacked the capacity to handle increased surface runoff. Judgment was entered for the plaintiff and city appealed. The reviewing court affirmed the lower court, holding that the evidence presented by the plaintiff was sufficient to establish: (1) that plaintiff's premises became flooded even during normal rain due to the inadequate capacity of the sewer, (2) that the paving of a nearby highway greatly increased the runoff into the sewer in question; and that (3) the city was guilty of maintaining a nuisance by failure to enlarge the sewer system after notification by plaintiff of the increased flowage into the sewer.

328
CHICAGO SANITARY DISTRICT,

Ill Ann Stat ch 42, secs 326, 326aa, 326bb, 329a. 330, 336, 337, 339, 341, 342, 344-349, 351, 352, 354-359 (Smith-Hurd 1956), as amended, (Supp 1969).

Descriptors: *Illinois, *Sewage treatment, *Drainage systems, *Water pollution, Legislation, Administration, Administrative agencies, Drainage, Municipal wastes, Sewage disposal, Cities, Pollution abatement, Treatment facilities, Channels, Channel improvement, Engineering structures, Sewage, Waste water (Pollution), Assessments, Water resources, Eminent domain, Flood control, Regulation, Permits, Water control.
Identifiers: *Sanitary districts.

The authority of sanitary districts includes jurisdiction over drainage, sewage, and treatment works within their respective territories. Districts are charged with prevention and abatement of pollution by establishing standards, requiring permits for construction of municipal sewage systems and for changed systems, and initiating court action against violators. Financing of projects may be through sale of bonds. Authority of districts includes building docks, highways, bridges, approaches, and other works related to drainage canals and channels, and existing waterways may be improved to facilitate drainage. Districts have the power of eminent domain in most instances and are held liable for all damage caused by improvements. Specifications are made for size and capacity of sewage and drainage watercourses, for restrictions on the type of sewage discharge allowed, and for connecting facilities between districts. Districts which violate the act are subject to court action initiated by the Attorney General. Municipalities are required to share water sources that have been saved from pollution with other cities. There is provision for inspection of new channels. The city of Chicago is organized as a drainage district, and the statutory powers are conferred on the corporate authorities.

329
SANITARY DISTRICTS OUTSIDE OF MUNICIPALITIES,

Ill Ann Stat ch 42, secs 418, 421, 433, 437, 438, 439 (Smith-Hurd 1956), as amended, (Supp 1969).

Descriptors: *Illinois, *Administrative agencies, *Environmental sanitation, *Sewage disposal, Water purification, Sanitary engineering, Water law, Legislation, Legal aspects, Water policy, Administration, Financing, Taxation, Dams, Public health, Sewage treatment, Planning, Sewers, Sewage, Water utilization, Water pollution, Water pollution control, Water quality control.
Identifiers: *Sanitary districts.

The board of trustees of any sanitary district is responsible for the collection and disposal of sewage within their area and must protect the water supplied to their inhabitants from contamination. They may use such conduits, pipes and pumps as are necessary to construct an adequate sewage system for this purpose. They must also treat and purify all sewage before allowing same to flow into any lake, river or other water course. While real and personal property may be taken for the district's corporate purposes, whether by purchase or condemnation, adequate compensation must be paid therefore either by gross sum or annual rental. The district's sewers may pass along or under public roads or public ground and may have conduits and pipes laid under public waters, but in either case not in such a manner as to impede normal use thereof. A district has the power to keep its water courses free from pollution and may construct dams and remove debris from same in the interests of public health. The board may finance costs of such a system either through general taxation or special assessment.

330
DRAINAGE AND FLOOD CONTROL,

Ill Ann Stat ch 42, secs 472, 473, 481, 482 (Smith-Hurd Supp 1969).

Descriptors: *Illinois, *Flood control, *Administrative agencies, *Drainage, Legislation, Legal aspects. Water law, Water policy, Financing, Sewage disposal, Water utilization, Projects, Administration, Public health, Sewers, Drainage systems, Hydrographs, Drainage districts, Flood protection, Charts, Distribution patterns, Floods, Hydrograph analysis, Rainfall, Runoff, Mapping, Assessments.

The Department of Public Works and Buildings is responsible for making a survey and preparation of a master plan for drainage and flood control of all watershed areas of this state so that hazards to persons and property may be reduced. Such a plan includes the full hydrography of each watershed area including rainfall, runoff, frequency and severity of floods. A drainage district may construct a sewage disposal system to eliminate sewage which is a menace to public health. Such a system may be financed through assessments on the lands benefitted. Revenue bonds may be used to pay the initial costs of such construction, to be repaid solely from the revenue from the operation of such system. The Department is responsible for general coordination and supervision of the efforts of the individual districts. It may also enter agreements with the federal and local governments for the formulation of plans, including funding, and for the construction, operation and maintenance of improvements for flood control, drainage and utilization of water and water resources.

331
DUNLAP LAKE PROPERTY OWNERS ASS'N INC V CITY OF EDWARDSVILLE (ABATEMENT OF POLLUTION),

22 Ill App 2d 95, 159 NE 2d 4-6 (1959).

Descriptors: *Illinois, *Bypasses, *Sewers, *Pollution abatement, Judicial decisions, Local governments, Sewage districts, State governments, Sanitary engineering, Disposal, Effluents, Public health, Sewage, Waste water (Pollution), Lakes, Storm drains, Sewerage, Damages, Water pollution, Water pollution sources, Administrative agencies.

Plaintiff, a non-profit corporation, sued to enjoin defendant from further using a sanitary sewer bypass which allegedly caused sewage to flow into a private lake. The lake was used by area residents for all household purposes. The by-pass is part of the city's combined storm sewer and sanitary sewer system. When the level in the sanitary sewer reaches a certain height at the point of a bypass because of a stoppage or an overloading caused by heavy rain, the sanitary sewer overflows into the storm sewer. At one particular by-pass, the storm sewer empties into a natural watercourse or ditch which, in turn, empties into plaintiff's lake. The injunction was denied, because plaintiff had not demonstrated actual and substantial injury. The court held that speculative or anticipated damage, as shown in the instant case by plaintiff, is not properly the subject of a permanent injunction proceeding brought by individuals. While plaintiff had shown that the defendant had created a condition whereby diluted sewage could, on infrequent occasions, flow into plaintiff's lake, there was no actual evidence of pollution. The court concluded that pollution control and abatement are best left to the appropriate specialized state agency, except in cases of flagrant and obvious polltuion.

332
BROWN V CITY OF JOLIET,

247 NE2d 47-52 (Ill App Ct 1969).

Descriptors: *Illinois, *Surface drainage, *Storm drains, *Cities, Planning, Judicial decisions, Land use, Regulation, Drainage programs, Administrative agencies, Legal aspects, Project planning, Sewers, Surface runoff.
Identifiers: Joliet, Illinois.

Brown, a subdivision developer, sued to require the city of Joliet, Illinois to record her subdivision plat. Her plat had been down by the city planning commission and subsequently the city council because they felt she had failed to include adequate plans for surface runoff. The planning commission felt that development without adequate provision for storm drains would increase drainage problems in adjacent areas and would not drain her own development properly. Brown claimed that the requirement of more adequate provision for surface runoff was an illegal confiscation of her property. Judgment was entered for the city. The city had authority to make regulations for adequate water drainage before recording of a plat. There is a presumption of validity of these ordinances. There was sufficient evidence to show that Brown had not made adequate provision for surface drainage and that the city had acted properly under the ordinances. Brown was not deprived of property unconstitutionally as the problem required by the city to be remedied was a product of her own specific and unique activity. The problem was not one of the general community which the city is trying to force her to remedy at her own expense.

333
SEWERS AND DRAINS IN CITIES AND TOWNS,

Ind Ann Stat secs 48-3948 thru 48-3950 (Supp 1968).

Descriptors: *Indiana, *Local governments, *Drains, *Sewers, Administrative agencies, Construction, Benefits, Costs, Cost allocation, Cost-benefit theory, Cost-benefit analysis.

Whenever the Board of Public Works orders the construction of any local sewer or drain, it shall adopt a resolution to that effect. A hearing will be held, after which the Board shall decide if the benefits to be derived are worth the estimated cost.

334
WATER AND SEWERS,

Md Ann Code art 23B, secs 78-92 (1966), as amended, (1968).

Descriptors: *Maryland, *Cities, *Water supply, *Drainage, Sewage, Municipal wastes, Sanitary engineering, Sewers, Sewage treatment, Cesspools, Sewage disposal, Pipelines, Conduits, Drainage systems, Storm drains, Leakage, Water pollution, Water rates, Water wells, Surveys, Condemnation, Public health, Boundaries (property), Plumbing, Maintenance, Sewerage.

Any city may construct and maintain water systems, sewerage systems and drainage systems, and do all things necessary for the efficient operation of such systems. Any company placing or changing any structure in the public way must receive authorization from the city. Any structure impeding the city water pipes may be ordered removed by the city, and they can use their condemnation power if necessary. The city may enter upon the county public way for the purposes of constructing or maintaining its water systems without obtaining a permit. The city shall provide connections with water and sewer mains for abutting property owners and may order existing cesspools and wells filled for the benefit of public health. A uniform charge may be levied for these connections. The city may require changes in plumbing to prevent waste or improper use of water. The city may prohibit the operation of private water systems and provide for the sanitary maintenance of other private sewage systems. The city may extend its systems beyond the town boundaries. City employees may enter private property to examine the water systems. No person shall pollute water used in the water supply. Service rates for water may be charged and special assessments levied to pay for the systems.

335
FULTON V TOWN OF BELMONT (DAMAGE FROM OVERFLOW OF STORM DRAINS),

127 NE 2d 569-572 (Mass Sup Ct 1955).

Descriptors: *Massachusetts, *Surface drainage, *Drains, *Cities, Damages, Flood damage, Ditches, Pipes, Drainage systems, Conduits, Seepage, Percolating water, Storm drains, Drainage water, Surface runoff, Sewers, Culverts, Judicial decisions, Legal aspects, Overflow.
Identifiers: Injunctions (mandatory).

Plaintiffs were landowners in defendant town. Along the street on which plaintiffs reside was an elevation called a berm, designed to carry surface water to two catch basins at a low point in front of plaintiff's property. One of the catch basins was drained by a pipe running under plaintiffs' property. The drain and pipe had been requested and installed by plaintiffs' predecessor in title in order to conduct the surface and percolating water from the catch basins to the rear of the property. The city furnished the pipes for the drain. Subsequent owners, including plaintiffs, allowed the drain to remain. Plaintiff sought a mandatory injunction requiring removal of the drains and a damage award for flood damage due to faulty drainage. The court held that defendant had a right to build the catch basins in order to keep the street in repair and safe for travel and that it would not be liable for any water therefrom which floods nearby land. Adjoining landowners may erect drains to prevent flooding of their land, but the city is not responsible for negligent construction thereof because the drain is in the control of the landowner.

336
MUNICIPALITIES - PARTICULAR POWERS,

Mich Comp Laws Ann secs 124.251-124.294 (1967), as amended, (Supp 1968).

Descriptors: *Michigan, *Cities, *Water supply, *Sewage disposal, Contracts, Financing, Condemnation, Sewers, Storm drains, Taxes, Engineering, Income, Interest, Cost analysis, Local governments, Legislation, Water distribution (applied), Sanitary engineering.
Identifiers: *Trust indentures.

Any two or more municipalities may incorporate an authority to acquire and operate plants used or useful in obtaining, treating, and distributing water. Articles of incorporation shall set forth powers to fulfill the corporate purpose. The authority may acquire and transfer property within or without its corporate limits, including by condemnation. The authority may enter into contracts of up to 50 years duration in order to sell or purchase water and may supply water to corporate or private consumers. Municipalities may also incorporate authorities to acquire and operate storm and sanitary sewers and sewage treatment plants used or useful in collecting and disposing of sewage or industrial wastes. Incorporation shall be as provided in this act. Contracts for sewage service shall not exceed 40 years and charges by either authority may be classified or varied from time to time. No change of jurisdiction over any territory by any municipality shall impair the contract obligation for either water or sewage services. The programs and contracts outlined shall be financed according to this act.

337
JERUZAL V HERRICK (STATUTORY AUTHORITY OF DRAIN COMMISSIONER),

350 Mich 527,87 NW 2d 122-126 (1957).

Descriptors: *Michigan, *Drainage systems,*Sewers, *Legislation, Judicial decisions, Storm drains, Surface runoff, Surface waters, Jurisdiction, Administrative agencies, Public health, Remedies, Projects, Legal aspects, State governments, Local governments.
Identifiers: Mandamus.

A statute authorized the county drain commissioner to construct drains, and listed in its definition of 'drain' the term, "any sewer.' The commissioner proceeded with the planning and financing for a sanitary sewer for an area within the county. The commissioner stopped the proceedings until the legal question of whether he had authority to construct this sewer could be determined. The problem concerned the definition of 'drain' under the statute, and specifically, whether it included the system designed solely as a sanitary sewer, completely closed to surface or storm water drainage. Interested property owners filed application for a writ of mandamus to direct the commission to install the sewer. The court issued the writ, ruling that there was nothing in the language of the statute to preclude the commissioner from installing this particular sewer system.

338
WATER RESOURCES, CONSERVATION,

Minn Stat Ann secs 105.37 to 105.41 (1964), as amended (Supp 1968).

Descriptors: *Minnesota, *Legislation, *Administrative agencies, *Drains, Ditches, Runoff, Surface waters, Groundwater, Base flow, Tiles, Precipitation excess, Water resources development, Hydraulic structures, Adjudication procedure, Water conveyance, Water supply, Water conservation, Water utilization, Legal aspects, State governments, Permits, Regulation, Impounded wastes, Dams, Reservoirs, Condemnation, Eminent domain.

Subject to existing rights, all waters capable of substantial beneficial public use are declared to be public waters subject to state control. The Commissioner shall devise a water resources conservation program contemplating conservation, allocation, and development of all waters within the state, surface and underground. The Commissioner shall be guided by such a program in consideration of issuance of permits for construction of dams, reservoirs, and other control structures. The Commissioner is empowered to acquire property to implement this program by condemnation.

The Water Division Director shall make such engineering surveys and reports as the Commissioner shall direct. A report on all future public ditches shall be filed with the Director. The Director is required to publish runoff data and information concerning the capacity of the drains within the state. The Director is empowered to conduct inspections of manufacturing plants. The Director is authorized to appear as an expert witness on behalf of the state in any matter affecting water within the state.

339
CLARK V CITY OF SPRINGFIELD (NUISANCE ABATEMENT SEWAGE AND SURFACE WATER),

241 SW 2d 100-109 (Ct App Mo 1951).

Descriptors: *Missouri, *Pipes, *Surface runoff, *Rainfall, Drainage water, Surface waters, Sewage disposal, Sewage sludge, Sewers, Drainage systems, Waste water, Local governments, Nuisance (water law), Operations, Judicial decisions, Legal aspects, Damages, Diversion structures, Ditches, Operation and maintenance.

Plaintiff brought this action for damages alleged to have been caused by the overflow of surface and sewage waters onto and across his premises. The evidence indicated that plaintiff's property was directly in the path of the natural flow of surface water in the area but that the city had installed a storm drain channeling the surface runoff into a ditch running toward plaintiff's property and directly above the city's sanitary sewer line. The result of maintenance of these tandem ditches was to increase the pressure in the sewer pipes by the infiltration of surface water from the ditch. Consequently, in periods of even light rain, the sewage contained in the pipes would boil up, flow through manhole covers, and mix with the surface water which was running across plaintiff's premises. The court recognized the common enemy doctrine which allows an upland owner to divert water from his premises by casting it upon the land of another. The city was found to have artificially impounded the surface water and to have cast it upon the plaintiff's servient estate in a destructive manner, thus violating a recognized qualification of the doctrine. Accordingly, damages were awarded in favor of the plaintiff.

340
SEWERAGE - WATER WORKS,

Mo Ann Stat secs 250.010 thru 250.250 (1959).

Descriptors: *Missouri, *Public health, *Sewage districts, *Water pollution control, Legislation, Legal aspects, Cities, Construction, Maintenance, Treatment facilities, Waste disposal, Sewers, Water purification, Liquid wastes, Solid wastes, Industrial wastes, Domestic wastes, Administrative agencies, Costs, Assessments, Taxes, Financing, Rates, Planning, Leases, Pollution abatement, Water supply, Water quality.

Identifiers: *Bonds, *Sewer districts, Improvements, Storm sewers.

Cities and sewer districts are authorized to acquire, construct, improve, extent, maintain, and operate sewerage systems for the protection of the public health. 'Sewerage system' means storm water systems; sanitary systems; sewerage systems; sewerage treatment plants; and collection, purification, and disposal facilities. Two or more cities are authorized to operate combined water works and sewerage systems. Cities may delegate to their boards of public works the responsibility for and control of combined systems. The cost to any city or sewer district of acquiring, constructing, improving, or extending a sewerage system or combined system will be financed through tax levies, assessments, general revenue funds, or bond issuances. Cities and sewer districts are authorized to charge reasonable rates for the use of their sewerage systems. Cities may charge industrial establishments for the operation by the city of sewerage facilities to abate or reduce industrial water pollution. It is the purpose of this chapter to enable cities and sewer districts to protect the public health and welfare by preventing or abating water pollution and by supplying wholesome water. Cities and sewer districts are empowered to do all things necessary to carry out these purposes.

341
COOPERATION BY CITIES OF 100,000 INHABITANTS AND MORE WITH DRAINAGE DISTRICTS, ETC., FOR FLOOD PROTECTION,

Mo Ann Stat secs 70.330 thru 70.360 (1952).

Descriptors: *Missouri, *Cities, *Drainage districts, *Sewers, Legislation, Local governments, Watershed management, Flood control, Watersheds (basins), Public health, Environmental sanitation, Conveyance structures, Natural streams, Overflow, Flood damage, Eminent domain, Assessments, Cost-benefit theory, Costs, Cost repayment, Stream improvement, Cost allocation, Levees, Construction.
Identifiers: Storm sewers.

Cities with more than one hundred thousand inhabitants may contract with local drainage districts or other public corporations for cooperation or joint action in building sanitary and storm sewers in watersheds common to such cities and districts. These cities may also contract to construct levees or improve any natural watercourse to prevent overflow from injuring lands situated within their territorial limits. These cities may contract with the United States, private corporations, and any individuals owing lands subject to injury by overflow or in need of sewers. Where a watershed is located partially within an adjoining state, the preceeding activities may be carried on with the consent of the adjoining state if the public health and safety so require. These cities may acquire rights of way by purchase or eminent domain for any such sewers or watercourse improvements. The cities may pay for these works and rights of way out of their general funds or by imposition of special assessments upon benefited lands.

342
GOULD AND EBERHARDT, INC V CITY OF NEWARK (DISCHARGE OF SURFACE WATERS FROM STORM SEWER),

6 NJ 240, 78 A 2d 77-79 (1951).

Descriptors: *New Jersey, *Discharge (water), *Drainage water, *Drainage systems, Cities, Natural flow, Overflow, Alteration of flow, Storm drains, Surface waters, Storm runoff, Outlets, Remedies, Relative rights, Contracts, Construction, Projects.
Identifiers: *Equitable estoppel, Injunctions (prohibitory), Laches, Storm sewers.

Plaintiff brought this action against defendant city to enjoin the further discharge of storm and surface waters onto plaintiff's property from a storm sewer system constructed and maintained by defendant. Before undertaking the construction of the sewer system, the city consulted plaintiff and outlined its plans. After considering the project, plaintiff gave its consent. Over nineteen years passed before plaintiff expressed its dissatisfaction with the project. The city asserted that plaintiff should be estopped from claiming equitable relief because it had given its consent before the construction was undertaken. The court pointed out that a municipality's collection and discharge of surface waters upon private property in greater quantity than would occur from the natural flow is an active wrongdoing for which a court of equity can grant injunctive relief. However, while the court will not protect an active wrongdoer under the doctrine of equitable estoppel, in the present case, the city was not guilty of active wrongdoing since it was acting in reliance upon plaintiff's express consent. Therefore, the court held that plaintiff, having had knowledge of and having assented to the construction and having enjoyed the benefit of it for many years, was not entitled to the relief sought.

343
PETER WENDEL AND SONS V CITY OF NEWARK (DAMAGE FROM ARTIFICIAL DRAINAGE SYSTEM),

46 A 2d 793-794 (NJ Ct Ch 1946).

Descriptors: *New Jersey, *Drainage systems, *Surface drainage, *Storm drains, Cities, Streams, Drainage water, Drainage, Ditches, Riparian rights, Outlets, Urbanization, Surface runoff, Culverts, Storm runoff, Navigable waters.

Plaintiff's land was located downstream from defendant's storm drain outlet. Prior to 1928, drainage water from the outlet traveled over undeveloped farm land and emptied into 2 natural brooks. By the time the water reached plaintiff's land, it was in a navigable state. In 1928, defendant constructed a surface drainage system causing the drainage water to flow in greater quantity and force, inundating portions of plaintiff's land. The court held that where a city deliberately enters upon a scheme of drainage and, by artifical means, casts drainage water on private property which would not otherwise receive such water, it commits a wrong which equity will restrain.

344
PROTECTION OF WATER SUPPLY FROM POLLUTION,

NJ Stat Ann sec 40:62-67 (1967).

Descriptors: *New Jersey, *Water pollution, *Public health, *Drains, Sewers, Sewage disposal, Legislation, Local governments, Cities, Drainage districts, Drainage systems, Construction, Water pollution control, Water quality control, Administrative agencies.

In municipalities having a public water supply obtained from a source beyond the municipal limits, the board or body having the control of such water supply may, when necessary to protect such water from pollution, construct, maintain, and operate, within this territory from which the water is derived or through which it flows, a system of drains and sewers for intercepting, taking off, and disposing of all sewage or other polluting matter. Every such system shall provide for the disposal of the sewage and other polluting matter taken up at a place and in a manner to render the same hamrless. The construction of such a system of drains and sewers shall not be commenced or entered upon unless and until the state department of health: shall approve the construction thereof as a sanitary measure; shall approve the plans therefore, which shall be submitted to it; and, shall define in a general way the limits of the district or territory within which or for which such system of drains of sewers shall be constructed.

345
STORMWATER SEWERS FOR COUNTY ROADS; MUNICIPAL COOPERATION,

N J Stat Ann sec 27:16-24 (1966).

Descriptors: *New Jersey, *Drainage systems, *Roads, Storm drains, Legislation, Local governments, Cities, Sewers, Legal aspects, Maintenance.

The board of chosen freeholders may direct the construction of a storm water drainage system in connection with the improvement or maintenance of a county road. The act provides the procedures to be followed in accomplishing such construction.

346
POWER OF CITIES,

N Y General City Law secs 20 (2), 20 (8), 20 (8a) (McKinney 1968).

Descriptors: *New York, *Cities, *Drainage, *Navigation, Legislation, State governments, Local governments, Sewers, Storm drains, Condemnation, Sewage disposal, Sewage, Water supply, Flood control, Right of way, Bridges, Beds, Navigable waters, Docks, Piers, Diversion, Public benefits

Cities may obtain and hold real and personal property within or without the city limits. They may condemn real property for the construction, maintenance, and operation of sewage disposal plants, water supply systems, and drainage channels and structures for flood control, as well as all necessary rights-of-way for the above projects, and for any public or municipal purpose. Land so obtained may be sold or conveyed, but the rights of a city in and to its waterfront, ferries, bridges, wharves, submerged lands, streets, parks and all other public places are inalienable, except where specifically permitted in this section. Cities may control the waterfront and waterways of the city, and may establish, operate, and regulate docks, piers, wharves, warehouses, and all adjuncts and facilities for navigation and commerce, and for the utilization of the waterfront, waterways, and adjacent property. Cities may control filling and diversion of water-courses, except when authorized by a state or federal agency, by requiring that permits be obtained before such activities are commenced. Such permits may be denied if the city determines that the proposed filling or diversion is detrimental to the drainage or welfare of the city.

347
PUBLIC HEALTH LAW (CLASSIFICATION OF WATERS AND PREVENTION OF POLLUTION),

N Y Public Health Law secs 1200, 1201, 1202 (b,c,d,e,f,i,l), 1205, 1220, 1221, 1225, 1250, 1251, 1252, 1260, 1261 (McKinney Supp 1968).

Descriptors: *New York, *Public health, *Water pollution control, *Sewage, Water resources development, Legislation, Water purification, Surface waters, Underground streams, Tidal waters, Organic wastes, Natural resources, Sewage disposal, Sewage treatment drainage, Conservation, Shellfish, Riparian rights, Industrial wastes.
Identifiers: Marine district.

The state of New York has passed extensive legislation dealing with the problem of water pollution and the protection of public health, fish, and wildlife. Their purpose is to safeguard the waters of the state from pollution. All waters of the state are included in the act. A water resources commission is set up to classify the waters and determine the standard of purity that should be maintained in each body of water. Water is classified according to its usage, i.e., drinking, bathing, fishing, and then assigned a standard of purity that must be maintained. Hearings by the commission to determine said standards are to be public. Pollution of water beyond the purity standard is made illegal as to both fresh and salt water. Permits must be obtained for the operation of a disposal system. Civil and criminal penalties are established for violation of these provisions and the use of injunctions are expressly authorized. No person other than the state acquires any actionable rights by virtue of the provision and it is in no way designed to create new or enlarge existing rights of riparian owners.

348
KUSHNER V PAZ CONSTR (STORM SEWER DRAINAGE),

171 NYS 2d 1007-1009 (S Ct 1958).

Descriptors: *New York, *Storm drains, *Obstructions to flow, Legal aspects, Judicial decisions, Manholes, Sewers, Drainage water, Flooding, Surface runoff, Natural flow, Relative rights.
Identifiers: Storm sewers.

Plaintiff sold the westerly portion of her parcel of land to the defendant. A storm sewer ran along the rear of both parcels and water in it naturally flowed in a westerly direction. The deed did not reserve an easement for the storm sewer in plaintiff's favor. To stop the flooding of his land due to a blockage of the sewer to the west of him, the defendant filled in a manhole located on his property.

This caused a flooding of plaintiff's cellar. The court held that plaintiff was not entitled to a temporary injunction to compel the defendant to remove the obstruction and that an easement for sewer drainage over defendant's land would not be implied by law.

349
GIBSON V STATE (CONSTRUCTION AND MAINTENANCE OF SEWERS),

64 NYS 2d 632-644 (Ct Cl 1946).

Descriptors: *New York, *Storm runoff, *Sewers, *Highway effects, Overflow, Floods, Drainage, Drainage engineering, Storms, Surface runoff, Surface waters, Damages, Remedies, Judicial decisions, Legal aspects, Operation and maintenance, Rainfall-runoff relationships, Cities, Local governments, State governments, Highways.

Following a severe rain storm, water flowed from a nearby highway intersection onto plaintiff's property, damaging said property rather extensively. Plaintiff brought suit, alleging that the damage resulted from defendant's negligence in building and maintaining a highway sewerage system. The court granted defendant's motion for dismissal. It found that the state was under no duty to provide drainage for plaintiff's property. However, when a municipal corporation puts a sewerage plan into operation, it becomes liable for damages resulting from negligence in the construction and/or the maintenance thereof. In the case at bar, the evidence failed to establish any such negligence. The court also held that a municipality is not liable for an increase in flow of surface waters resulting solely from the paving of streets and the placement of other improvements. Liability may exist if the state diverts the surface runoff of a watershed from the course of its natural flow or collects such runoff in an artificial channel and discharges it in great volume upon the lands of another. But, in this case, the evidence disclosed no accumulation of water beyond that which would normally result from the construction of streets and roadbeds.

350
ACCURATE DIE CASTING CO V CITY OF CLEVELAND (FLOOD DAMAGE FROM SUBSURFACE DRAINAGE),

113 NE 2d 401-407 (Ohio Ct App 1953).

Descriptors: *Ohio, *Flood damage, *Cities, *Sewers, Drainage systems, Judicial decisions, Flood control, Flood protection, Overflow, Storm drains, Excessive precipitation, Natural flow, Subsurface drainage, Surface waters, Drainage water, Local governments, Outlets.
Identifiers: *Evidence.

The plaintiff brought suit to recover for the flooding of his manufacturing plant, allegedly caused by the defendant's negligent sewer construction. The court found that the sewer outlets were not large enough to handle the accelerated water flow from a heavy rainfall. As a result of this condition, water was cast upon plaintiff's land in substantial quantities. The court found that the inadequacy of the drain to handle the accelerated waterflow was the proximate cause of the flooding and entered judgment for the plaintiff.

351
HOKE V CITY OF GREENSBURG (MUNICIPAL LIABILITY FOR DIVERSION OF SURFACE WATER THROUGH STORM SEWER).

42 Westmoreland County Law Journal, Vol 42, p 225-229 (Pa Ct C P 1959).

Descriptors: *Pennsylvania, *Surface drainage, *Diversion, *Storm drains, Sewers, Legal aspects, Judicial decisions, Channels, Damages, Drainage systems, Cities, Surface waters, Conveyance structures, Relative rights, Drainage effects, Water conveyance, Flooding, Artificial watercourses.
Identifiers: *Storm sewers.

The defendant City of Greensburg installed a 14 inch storm sewer that extended along the westerly edge of a city street in a southerly direction. The storm sewer was then extended in a westerly direction to a 48 inch storm sewer which passed in a general southerly direction to realestate owened by plaintiffs. Plaintiffs filed a suit to recover for damages resulting to their property when defendant diverted surface water through the system onto plaintiffs' land. The jury returned a verdict for the plaintiffs and the defendants moved for a new trial. On appeal, the court held that the determination of defendant's liability was properly left to the jury.

352
MASON V LAMP (ACTION TO RECOVER DAMAGES FROM SURFACE WATER RUNOFF ONTO PLAINTIFFS' PROPERTY),

189 Va 348,53 SE 2d 7-11 (1949).

Descriptors: *Surface waters, *Storm runoff, *Drainage, *Virginia, Relative rights, Watersheds, Drainage effects, Drainage practices, Ditches, Surface runoff, Flood control, Diversion, Surface drainage, Judicial decisions, Legal aspects, Flood damage.

Plaintiffs brought this action seeking damage for injuries to their land and building caused by surface water which was diverted onto their land when defendant filled a low area on his property. The depression, which filled with water after heavy rains, had been located mainly on defendant's property, but had also extended to plaintiffs' property and to parts of other lots. Defendant took no special steps to provide a new drainage receptacle or avenue for collection or conveyance of surface water. During subsequent heavy rains, surface water drained from defendant's lot, among others, and from plaintiffs' own lot into plaintiffs' building, causing considerable damage. The court found that under the common law as adopted by Virginia, each landowner may protect his property from surface water damage as he sees fit, so long as he does not act wantonly or carelessly at the expense of other landowners. Plaintiffs failed to show negligence in defendant's filling and grading. The court held that defendant need not maintain a catch basin on his property for plaintiffs' benefit.

353
MUNICIPAL AND COUNTY GOV'T (SEWAGE SYSTEM),

Vt Stat Ann tit 24, secs 3501-3508 (1959).

Descriptors: *Vermont, *Sewage, *Sewage disposal, *Cities, Legislation, Regulation, Waste disposal, Wastes, Sewage treatment, Administrative agencies, Facilities, Local governments, Utilities, Public utilities, Taxes, Water rates, Storm runoff.
Identifiers: Domestic sewage, Storm sewage, Sanitary sewage, Sanitary treatment.

A municipal corporation may construct, maintain, and operate a sewage system and is authorized to purchase or acquire necessary real estate and easements. The municipal corporation may contract to make disposal of domestic or storm water sewage. The property owner using the sewage system shall be liable for rent, such rent being a lien on the real estate furnished with the service. The municipal corporation may purchase and hold realty and personalty and may levy and collect taxes necessary for the payment of the expenses and indebtedness of such sewage system. A board of sewage systems commissioners is created to supervise the municipal systems and to establish all needed rates for rent, with rules and regulations for its control and operation.

354
BRATONJA V CITY OF MILWAUKEE (ACTION TO RECOVER DAMAGES DUE TO FLOODING FROM HEAVY RAIN),

3 Wisc 2d 120,87 NW 2d 775-780 (1958).

Descriptors: *Wisconsin, *Sewers, *Flood damage, Judicial decisions, Surface runoff, Surface waters, Storm runoff, Flood protection, Cloudbursts, Rain, Water law, Local governments, Cities, Legal aspects, Damages, Drainage systems.
Identifiers: Negligence, Storm sewers.

Plaintiffs owned buildings fronting on city streets. The area was within a natural saucer-like depression. A storm sewer in the area was laid in 1906. Improvements after that time mostly by the city, caused the level of the streets to be raised and soil by which rainfall would normally be absorbed to be covered. A relief sewer was later added. At least one plaintiff had suffered damages as a result of flooding due to a series of heavy rains. In 1949, another heavy rain fell, whereupon, several buildings in the area became flooded. Plaintiffs brought actions against the city, both on negligence and nuisance theories. The trial court found that there was no inadequacy or insufficiency in the original sewer plan, that the rainfall in 1949 was extraordinary, and that the city did not maintain the sewer system negligently. The appellate court affirmed, ruling that the city was under no obligation to collect the rainwater in the street; but if it actually took possession of such water and thereby assumed responsibility for it, it may have been liable for subsequently permitting it to escape on adjoining property. The plaintiffs failed to prove what part if any of their damage resulted from the backing up of the water in the sewer, contrasted with that from the flooding by surface water. The court held that attempting to label the condition a nuisance could not change the respective rights.

355
CREATION OF TOWN SANITARY DISTRICTS FOR POLLUTION CONTROL AND WASTE DISPOSAL,

Wis Stat Ann secs 60.30-60.304 (1957), as amended, (Supp 1969).

Descriptors: *Wisconsin, *Administrative agencies, *Drainage systems, *Waste disposal, Sewers, Sewage disposal, Sewage treatment, Drainage, Storm drains, Cities, Pumping, Construction, Jurisdiction, Real property, Public health, Legal aspects, Treatment facilities, Domestic wastes, Boundaries (property), Sewage districts.
Identifiers: *Sanitary districts.

Town sanitary districts may be created for the purpose of purchasing, establishing, or constructing surface or storm water sewers, drainage improvements, sanitary sewers, or a system of waterworks, sewerage, or garbage disposal. The districts may sue and be sued in furtherance of these purposes. 'Sewerage' includes all construction for collection, transportation, pumping, treatment, and final disposition of sewage. Procedure for creation of a town sanitary district is set forth. Town districts may be created within metropolitan sewerage districts since it is the intention of the legislature to permit auxiliary sewer construction in addition to the main and intercepting sewers constructed by metropolitan districts. Town boards are vested with jurisdiction to establish town sanitary districts. Petitions requesting such districts must be submitted by a fixed percentage of affected landowners to the town boards. Open hearings must be held by the town board before the creation of a district can be approved. Judicial review of the board's action is made available.

356
BOARD CONTROL OF REPAIR, CONSTRUCTION, AND IMPROVEMENT OF STREETS, SEWERS, SIDEWALKS, AND WATERCOURSES,

Wis Stat Ann sec 61.36 (1957), as amended, (Supp 1969).

Descriptors: *Wisconsin, *Local governments, *Sewers, Regulation, Watercourses (legal), Storm drains, Legislation, Administrative agencies, Drains, Structures, Canals, Legal aspects, Highways, Road construction, Construction, Drainage, Drainage practices.
Identifiers: Sanitary sewers, Storm sewers.

The village board may lay out, alter, extend, improve, repair, or discontinue any municipal roads, streets, alleys, sanitary and storm sewers, parks, and other public grounds. They may construct drains, canals, or sewers, and may alter, widen, or straighten watercourses. Their power extends to the building, alteration, repair, improvement, or discontinuance of any sidewalks and crosswalks as well as to the building and maintenance of roads and sidewalks required to connect the village with any transportation terminal or village property outside of its limits.

357
NEW AND PROPOSED LAWS,

Paul R. Bonderson
Paper presented at the Calif Water Pollution Control Assoc 42nd Annual Conference, Sacramento, Calif, Apr 29 to May 1, 1970.

Descriptors: *Legislation, *Water quality control, *Water pollution control, *Legal aspects, *California, *Water quality act.

The Porter-Cologne Water Quality Control Act, a complete revision of the State's water quality laws, became effective January 1, 1970. The Act accomplishes the following objectives: (1) grants the State Board expanded powers to provide more leadership and greater influence over activities of regional boards; (2) requires regional boards to adopt more restrictive water quality control plans and discharge requirements so that better pollution control will be achieved; and, (3) makes major changes in enforcement procedures, including court assessment of $6,000 per day fines, which will give boards much more effective means for taking enforcement actions. Indications are that over 1,000 environmental quality control bills will be considered during the current legislative session. Consideration will be given to having a State sewage construction grant program. Major proposed water pollution control legislation will be summarized.

358
ANALYTICAL PROCEDURES FOR MEASURING CHEMICALS IN THE PUBLIC HEALTH SERVICE DRINKING WATER STANDARDS, 1962,

Norman A. Clarke and John D. Weeks
J Amer Water Works Assoc, Vol 62, No 3, pp 172-176, Mar 1970.

Descriptors: *Standards, *Potable water, *Analytical techniques, *Measurement, *Chemical analysis.

The authors have compiled a list of chemical substances in the Drinking Water Standards and have defined recommended methods of analysis and sensitivity of techniques for measuring these chemicals. Also included are the methods of atomic absorption and spark emission spectroscopy, where applicable.

359
THE RESPONSIBILITY OF TREATMENT PLANT OPERATORS UNDER THE PORTER-COLOGNE WATER QUALITY CONTROL ACT,

Jerome B. Gilbert
Paper presented at the Calif Water Pollution Control Assoc 42nd Annual Conference, Sacramento, Calif, Apr 29 to May 1, 1970.

Descriptors: *Water quality act, *Water pollution control, *Water quality control, *Regulation, *Administrative agencies.

The State Water Resources Control Board and the nine California Regional Water Quality Control Boards are the state agencies responsible for control of water pollution and water quality. The Porter-Cologne Water Quality Control Act greatly strengthens and expands powers and duties of these agencies. Although there are many factors contributing to the degradation of water quality, discharges from municipal and industrial waste. treatment plants are still the principal cause of water quality problems. Under the new law, requirements will be made further restrictive, resulting in highly sophisticated and more complicated treatment plants. Exacting performance by operators in charge of plants will be needed to prevent violation of requirements and to collect fines up to $6,000 per day. To help assure that qualified operators will be in charge, the State Board will classify all treatment plants and specify the level of competence necessary to operate them. The Board will also specify the training necessary to qualify an operator for each level of competence. All operators should take advantage of training opportunities in order to qualify themselves for new levels of operating competence.

360
COORDINATION THROUGH COOPERATION,

A. J. Hanis
Public Works, Vol 99, No 11, pp 68-69, Nov 1968.

Descriptors: *Construction, *City planning, Sites, Storm drains.
Identifiers: *Construction projects, *Sanitary sewers, *Storm sewers.

The Greater Tampa Utilities Group formed in 1960 recommends standards for planning and locating public and utility construction projects such as electric, telephone, gas, water, and sanitary and storm sewer lines. Street diagrams showing proposed utility locations are included with sanitary sewers placed along center lines and storm sewer lines at approximately the quarter point on one side. Municipal storm drains are placed beneath the curb and county/state drains beneath the pavement at the quarter point.

361
WATER QUALITY CONTROL IN CALIFORNIA,

Norman B. Hume
J Sanit Eng Div, Am Soc Civil Engrs, Vol 96, No SA4, pp 873-874, Aug 1970.

Descriptors: *Legislation, *Water pollution control, *Water quality control, *Water resources, *Water rights, *Administration, *Pesticides, *Groundwater, *Water management (applied), *California.

A summary of the historical progression of water quality control legislation from 1949 through the present is given including: a description of the Dickey Water Pollution Act of 1949; reasons for combining the related functions of water rights determination, water pollution control, and water quality control; the responsibilities assigned to the State Water Resources Control Board; the regional approach to water resources control and management; the origin of pesticides; the methods for protection of groundwater; the water quality control study project and findings; and, the Porter-Cologne Water Quality Control Law of 1969.

362
ESTABLISHMENT OF WATER QUALITY STANDARDS IN THE CITY OF TAKAMATSU,

Takishi Ishibashi
Sangyo Kogai, Vol 6, No 6, pp 372-382, Jun 25, 1970.

Descriptors: *Standards, *Water quality, *Systems analysis, *Investigations, *Water pollution treatment.
Identifiers: Japan.

An urban river system was employed to establish water quality standards in the Takamatsu area. Normally the standard is established by an investigation of the individual source of pollutants. In large cities where numerous sources exist, an exhaustive investigation is impractical; consequently, an average water quality standard, based on a sampling investigation of primary sources of pollutants, together with considerations of the special properties of the water area are taken as a basis in establishing the individual standard. This new system was effective in expediting the formulation of the standard. The general situation of the water area in question, status of water utilization, water pollution, results of investigations on water quality, pollutants' source, planning of the public sewage system, and future prospects of water pollution are presented. Basic factors considered in establishing and finalizing the water quality standard are given. Discussions made at committee meetings for establishing the standard are also included.

363
BRITISH WATER POLLUTION CONTROL,

Samuel H. Jenkins
Environ Sci Technol, Vol 4, No 3, pp 204-209, Mar 1970.

Descriptors: *Discharge, *Pollution abatement, Legislation.
Identifiers: *Pollution control methods, Stormwater purification, Sewage purification.

Water pollution abatement is being realized in Great Britain due to the construction of varying types of purification plants which produce effluents fit for discharge to public sewers or rivers. Past and present legislation and national policy in the area is described along with techniques used in water pollution abatement. Major improvements have been made possible by granting complete power to municipal authorities to control industrial discharges, thus, insuring that mixtures of sewage and industrial effluents are treated in accordance with required standards. Pollution control procedures covered include: industrial water reuse, metal finishing waste treatment, sewage treatment plants, plastic filter media, and slude disposal. In Britain, maximum amounts of storm water are purified. Trunk sewers convey 6 d.w.f., but sewage treatment plants complete purification to only 3 d.w.f. The remainder spills into tanks of 6 hour d.w.f. capacity, and it is later pumped back for treatment.

364
THE SEWERAGE (SCOTLAND) ACT 1968,

Dugald McDonald
Surveyor, Vol 84, No 4036, pp 46-48, and 51-53, Oct 17, 1969. 3 fig.

Descriptors: *Legislation, *Sewerage, *Sewage disposal, *Sewers, *Prior appropriation, Jurisdiction, Local governments.
Identifiers: *Trade effluents, *Scotland.

This paper describes the Sewerage Scotland Act, a modern, comprehensive code governing sewerage, sewage disposal, and trade effluents. The act is divided into three parts: sewerage, trade effluents, and a supplemental part. The following subjects included in the act are discussed in the first part: local authority to provide sewerage, sewer maintenance, sewers vested in local authority, new sewer construction, sewer connections, joint sewerage and sewage disposal, highway drainage, septic tanks, adoption of private sewage works, defective drainage, abolition of special drainage districts, and prohibition on buildings erected on sewers. The part on trade effluents includes: the right to discharge to sewer, and existing and new discharges. The supplemental section reviews: the rights to sewage, powers of entry, sampling sewage, prohibition on harmful substances, application to the Crown, and settlement of appeals and disputes.

365
PORTER-COLOGNE ACT REVISITED,

Ronald B. Robie
Paper presented at the Calif Water Pollution Control Assoc 42nd Annual Conference, Sacramento, Calif, Apr 29 to May 1, 1970.

Descriptors: *Legislation, *California, *Water quality control, *Water quality act, *Legal aspects.

The Porter-Cologne Water Quality Control Act, effective January 1 this year, provides the State Water Resources Control Board and the nine California Regional Water Quality Control Boards with the "tools" to implement and carry out an effective water quality control program. The new law is geared to enhance the water environment as well as to prevent water pollution. This is evidenced by the inclusion of esthetic enjoyment and the preservation of fish, wildlife and other aquatic preserves among the water uses to be protected. Other major provisions of the new law include: civil fines up to $6,000 per day for violation of cease and desist orders relative to a waste discharge; payment of a filing fee not exceeding $1,000 to accompany a report of a proposed or material change in a waste discharge; mandatory cleanup of pollution by a violator with full liability for cleanup costs; and integration of water quality into consideration of water rights, including appropriation of water by storage to be released in order to protect or enhance water quality.

366
UTILIZATION OF STREAM FOR STORM DRAINAGE,

D. A. Schneider
Public Works, Vol 98, No 4, p 87, Apr 1967.

Descriptors: *Legislation, Drainage districts.
Identifiers: *North Carolina.

As the Court stated in a North Carolina case, municipalities can be held liable for damages caused by their failure to maintain proper sewer conditions including good drainage and freedom from obstruction. Thus, when a locality utilizes a natural waterway for sewerage and drainage, it is obligated to keep this water in proper condition, and it is liable under the law for damages resulting from neglect to perform this duty.

367
PHOSPHATES IN SURFACE WATER AND DETERGENTS,

P. J. Weaver
J Water Pollution Control Fed, Vol 41, No 9, pp 1647-1653, Sep 1967.

Descriptors: *Phosphates, *Surface runoff, Water pollution sources, Detergents.
Identifiers: Urban runoff, Stormwater.

The presence of phosphates in surface waters may be caused by municipal, industrial, and/or agricultural sources. Millions of pounds of phosphate enter lakes and streams each year. An estimated 120,000 to 200,000 lb (54,500 to 90,800 kg) of phosphorus (as P) were measured daily in the Maumee River Basin in Ohio. Agircultural sources, animal wastes, and lake bottom muds are important sources of the phosphate nutrients in addition to wastes encountered at wastewater treatment plants from domestic disposal systems, urban runoff and drainage, and stormwater overflow. The removal of P from treatment plants may be accomplished by chemical, chemical biological, and other methods. Phosphates are important ingredients of detergents because they soften water, sequester, emulsify, provide alkalinity and many other advantages.

Section 8

TREATMENT METHODS AND WATER REUSE

368
WASTE DISPOSAL -WATER TREATMENT PLANTS (JOINT DISCUSSION),

J Am Water Works Assoc, Vol 58, No 9, pp 1102-1116,
Sep 1966.

Descriptors: *Water treatment, *Waste disposal, *Sludge disposal, *Application methods.
Identifiers: *Detroit, Michigan, Back-wash water.

In a joint discussion at the annual conference of the AWWA in May 1966 several speakers discussed various aspects of the problem of disposing of wastes from water treatment plants without causing pollution. Local factors were taken into account when deciding whether or not such wastes were likely to have an adverse effect on the receiving water. The effects of Pennsylvania state water quality standards and of federal pollution-control legislation on the disposal of wastes from water works were considered, and the methods of disposal at Detroit, Michigan, were described by G.J. Remus. One of the Detroit works is situated on the banks of the Detroit river and the filter wash-water from this plant is discharged directly to the river; since the flow is rapid, the wash-water is dispersed rapidly and there is no evidence of sludge deposits. The wash-water is chlorinated before discharge and is bacteriologically of better quality than the river water. The other three water works are situated away from the river; at the largest of these the filter back-wash water is recirculated for reuse, while at the other two it is discharged to a sanitary sewer, and settled before discharge to a storm sewer, respectively. The sludges from the sedimentation tanks at all the plants are discharged to the sanitary sewers.

369
THE LARGEST BIOLOGICAL SEWAGE-TREATMENT PLANT ON THE CONTINENT,

Ber Abwassertech Ver (BABVAD), Vol 18, No 2, V, 1967.

Descriptors: *Biological treatment, *Sewage treatment, *Sludge treatment, Channels, Investigations.
Identifiers: Germany.

An account is given of plans for a large biological treatment plant to be built in Essen, Germany, to deal with the increasing quantities of sewage to relieve the existing Emscher plant. The new plant will be able to treat a load of 20 m^3 per second, and during rainfall this amount can be increased to 30 m^3 per second. Provisions have also been made to construct the influent and effluent channels of the mechanical stage in such a way that a loading of up to 45 m^3 per second would be possible. The section where the preliminary treatment is carried out is to be built below ground to that incoming sewage can enter without pumping; the biological stage will then be built above ground and the sewage will be pumped into individual tanks accomodated in 3 buildings. The plan for separate units applies to the whole plant for convenience of necessary repairs. Special provision is made for the separation of oil. Oxygen is supplied mechanically to the aeration tanks, which will have a total volume of 180,000 m; the final sedimentation tanks will also have a volume of 180,000 m^3. Primary sludge, amounting to about 60% of the total sludge, is to be transported to the sludge-drying plant in Essen-Karnap via a pressure pipeline. Experiments are at present being carried out on methods for disposal of excess activated sludge.

370
10,000 FT LONG SEA OUTFALL AT HASTINGS IN SUSSEX,

Civil Eng Public Works Rev, Vol 63, No 746, p 1003, Sep 1968.

Descriptors: *Outlets, *Pumping plants, Pollution abatement, Pretreatment (water), Construction, Sewage disposal.
Identifiers: *Great Britain, Stormwater sump.

A new sewage disposal scheme is under construction to eliminate sea-shore pollution caused by direct discharges to the ocean through two conventional outfalls. The plan involves pretreatment of sewage after which it is pumped through a long outfall pipe to a point two miles offshore. The pumping station will handle sewage flows up to 6 dwf or 7.5 mgd, and a combination storm weir and automatic pen-stock will pass excesses to the stormwater sump. A culvert will connect the stormwater sump to the foreshore, and for sea-levels below mid-tide the stormwater will discharge to the sea by gravity. At other times when the culvert is tide-locked, a stormwater pump will operate. Descriptions of physical characteristics, workings, and methods of construction of the long sea outfall and the pumping station are included along with a diagram of the new sewerage scheme.

371
RE-USING STORM RUN-OFF,

Environ Sci Technol, Vol 2, pp 1001-1005, 1968.

Descriptors: *Design, *Cost analysis, Lakes, Potable water, Runoff.
Identifiers: Columbia, Maryland.

A design and cost study of the 1100-acre Wilde lake watershed in Columbia, Md., which considers the treatment of runoff and its re-use as potable water, is described. The scheme includes the collection and storage of runoff in 10 small lakes and preliminary treatment there by sedimentation, chemical coagulation, and chlorination.

372
TRANSMISSION PLANT TREATS 100,000 GPD,

Modern Power Eng, Vol 64, No 6, pp 64-66, Jun 1970. 2 tab, 1 diag.

Descriptors: *Waste treatment, *Sewers, *Sewage treatment, *Industrial wastes, Separation techniques, Water distribution (applied), Storm runoff.
Identifiers: Interceptor sewer.

Prior to installing General Motors' automatic transmission treatment plant, plans were made for the separation of industrial wastes from other liquid wastes. Separation of sewage and sanitary wastes was accomplished by laying interceptor sewers from washrooms to connect to municipal sewers. Stormwater was separated through the construction of an overhead collection system connected to rainwater leaders from the roof. Clean cooling water from production operations was also pumped into this overhead collector and the contents fed to municipal storm systems. Industrial waste purification was accomplished through the installation of the complex waste treatment plant, which is described in detail and which, since September 1968, has passed only treated industrial wastes to municipal sewers.

373
PHASE 1 EXTENSION WILL CATER FOR EXTRA 1.7 M.G.D. FLOW,

Munic Eng (London), Vol 146, p 756, 1969.

Descriptors: *Sewage treatment, Humus, Sedimentation, Filtration.
Identifiers: * Great Britain, Storm tank.

An illustrated description is given of extensions in progress to the Tixall sewage works of the Stafford Borough Council, including humus, sedimentation, digestion, and storm sewage tanks, additional percolating filters, and a building to house filter presses. The extended works, which also treats sewage from an area administered by Stafford R.D.C., will have a treatment capacity of 3.7 m.g.d.

374
COMBINED SEWAGE WORKS OPERATING AT FARINGDON,

Munic Eng (London), Vol 146, p 1221, 1969.

Descriptors: *Sewage treatment, *Storm runoff, *Biocontrol.
Identifiers: *Combined sewers, *Effluent discharge, *Biological filtration, Great Britain.

An illustrated description is given of the new sewage works served by a combined sewerage system and provided by Faringdon R.D.C., Berks. Treatment is by biological filtration. The final effluent flows into a stream after discharge to a small irrigation area, and excess stormwater is distributed over a 5-acre seepage site from where it drains to the stream through a clinker bed. Crude sludge is dewatered in drying beds.

375
FULL TREATMENT CAPACITY INCREASED TO 3.36 M.G.D. BY 29,000-POUND EXTENSION,

Munic Eng (London), Vol 145, p 2090, 1968.

Descriptors: *Sewage treatment, Sludge disposal.
Identifiers: *Great Britain, Capacity, Storm sewage.

Recent extensions to the sewage works of Fleet, Hants., which have increased capacity to a dry-weather flow of 1.12 m.g.d., are described. Additional facilities include sludge-drying beds with mechanized removal of sludge, and modifications have been made to humus tanks and percolating filters to provide more working volume. The humus-tank effluent passes through microstrainers before discharge and storm sewage overflows are treated on the land before discharge to a stream.

376
LOWESTOFT CHOOSES TUNNEL FOR SEWAGE OUTFALL,

Surveyor, Vol 84, No 4030, p 18, Aug 29, 1969. 2 fig.

Descriptors: *Outlets, *Sewerage, *Construction, *Currents (water), *Costs, *Tunnel design, Discharge (water), Sewage treatment, Tunnel construction, Tunneling machines.

The sewage outfall project at Lowestoft is controversial in concept as well as in mode of construction. Problems of such outfalls include their frequent damage by heavy seas and their questionable ability to adequately disperse effluents. Sea currents at discharge points were investigated and found to be conducive to properly carrying effluent out to sea. The slightest beach pollution, however, will promote intense public distrust of the plan. Discharge shafts of the tunnel beneath the sea-bed will be raised through the use of massive hydraulic jacks, an unusual technique. Both the tunnel work and the shaft raising will be done employing compressed air. Dimensions of the tunnel and other construction techniques and problems are related. The scheme adopted is inexpensive with regard to capital and service costs. A complete sewage treatment works for the town would cost at least twice as much.

377
TIVERTON SEWAGE WORKS RECOGNIZES FLOOD HAZARD

Surveyor, Vol 84, No 4028, pp 30-32, Aug 15, 1969. 7 fig.

Descriptors: *Drainage systems, *Sewage disposal, *Sewers, Flood control, *Multiple-purpose projects, *Treatment facilities, Design criteria, Sludge treatment, Sewage treatment.
Identifiers: *Great Britain.

Extensive main drainage and sewage disposal schemes were completed at Tiverton, Devon. Plans involved relaying of the town's sewers, the provision and renovation of pumping stations, and the reconstruction of sewage disposal works. All three aspects of the work are fully described. Previous town sewers consisted of old brick culverts which were badly silted, and infiltration water entered in places. A complicating factor at Tiverton is that the works are susceptible to flooding from the nearby River Exe. This complication was considered in the design of the works, particularly with regard to sludge treatment. To overcome problems of drying sludge, a method of mechanical drying, called sludge pressing, was installed. A mixture of primary, humus, and stormwater sludges is passed to a chemical conditioning tank where lime and ferrous sulphate solutions are added and mixed with the sludge. The pressing, which takes about seven hours, is performed automatically. The entire procedure is outlined.

378
DUAL PURPOSE SETTLEMENT TANKS AT ANDOVER,

Surveyor, Vol 83, No 4013, pp 29 and 44, May 3, 1969. 1 fig

Descriptors: *Sewage treatment, *Treatment facilities, Design, Sediment control, Pumping plants, Weirs, City planning.
Identifiers: *Storm tank, *Storm overflows, *Great Britain.

Andover's new sewage treatment works embodies four unusual design features, namely, dual purpose primary sedimentation and stormwater tanks, double filtration, elutriation, and filter pressing. As a temporary extension, three sedimentation tanks were constructed to deal with an excess dry weather flow. The original pumping station was converted to a stormwater pumping station, and preliminary treatment units were replaced by an inlet works composed of coarse screens, a bypass channel, flow controlling weirs, and a storm overflow chamber. Flows up to 3 d.w.f. pass to the new main pumping station. Flows between 3 and 6 d.w.f. surcharge and pass to the old station converted for stormwater pumping. Flows exceeding 6 d.w.f. discharge into existing stormwater tanks. The rectangular sedimentation and stormwater tanks were combined into one unit of eight tanks, four back-to-back with a gallery between. Advantages of this system are cited. Descriptions are given of the previous facilities, effluent requirements, temporary extensions, the new main pumping station, the pumping main, the treatment works, primary and secondary treatment, final settlement, sludge digestion, elutriation and conditioning, filter pressing, and landscaping architecture.

379
ASHFORD (KENT) SEWAGE WORKS AFTER FOUR YEARS,

Surveyor, Vol 83, No 4000, pp 38-41, Jan 31, 1969. 3 fig, 1 tab.

Descriptors: *Construction, *Design, *Operations, *Sewage disposal, *Treatment facilities, *Sewage treatment, *Controlled drainage, *Sludge treatment, *Effluents, Storm runoff.
Identifiers: *Great Britain.

Major items are presented from a longer paper that described in detail the design, operation, and problems involved in construction of the Bybrook Sewage Disposal Works at Ashford in Kent. In one town served by the old Bybrook works, flows exceeding 6 d.w.f. discharged directly to the old River Stour. Old stormwater storage tanks, previously serving Bybrook only, were improved and a short weir constructed so that all flows pass through both tanks before discharge to the river. Two auto sludge scraping mechanisms aid removal of sludge which is returned along with the tank contents by a stormwater pump to the works for full treatment. The following topics relating to the new disposal works are discussed: trade wastes, the standard of effluent, inlet works, settlement tanks and filters, humus tanks, the irrigation area, stormwater, sludge treatment, commissioning techniques, percolating filters, the digestion plant, mechanical plant problems, the pumps' insides and filter arms grounding. The paper concentrates on early operational problems, but notes that the disposal works' effluent has proven to be excellent.

380
FARINGDON RDC NEW SEWAGE WORKS,

Surveyor, Vol 82, No 3980, pp 54-56, Sep 13, 1968. 5 fig.

Descriptors: *Treatment facilities, *Sewerage, *Sewers, *Overflow, *Controlled drainage, Storm runoff.
Identifiers: *Combined sewers, *Storm sewers, *Great Britain, Capacity.

A conventional treatment plant of modern design and large capacity, plus a new and extensive sewerage system replaced a formerly overloaded system at Faringdon in the Berkshires. Additional sewers were provided to relieve the existing system from surcharge and from extremely heavy flows from a new relief road constructed to overcome flooding. Faringdon has a combined sewerage system which must be of a size and capacity sufficient to handle the heaviest storm. The sewage disposal works and sewers leading to the works were designed to handle 3 x dwf. Provision was made for flows over 3 x dwf by constructing large diameter sewers which operate immediately when combined sewers run over. The stormwater sewers do not flow to the disposal works, but discharge onto a stormwater irrigation area. Advantages of this system over the previous one are reported. The new treatment works is described in general, in addition to the procedure used to treat storm flows over 3 x dwf.

381
LAUNCHING A TWO MILE SEWAGE OUTFALL,

Surveyor, Vol 82, No 3978, pp 16-17, Aug 30, 1968. 4 fig.

Descriptors: *Drainage systems, *Treatment facilities, Outlets, Water pollution sources, Construction, Pumping plants, Weirs, Storm runoff, Flow control, Costs, Design data.
Identifiers: *Great Britain

The Hastings western area main drainage scheme includes a sewerage outfall, two new pumping stations, a partial treatment works, and a pumping main. The scheme was designed to replace two conventional outfalls which caused pollution of the foreshore and shallow water because of insufficient length. The new outfall was built up into seven strings in a special assembly area, and these sections were joined successively before the entire pipe was launched into its final position on the sea bed. Further construction procedures are explained along with the means used to determine the proper length of the outfall. The new pumping station pumps sea sewage flows up to 6 d.w.f., and a discharge to a stormwater sump. The sump connects to the foreshore by a culvert and for sea levels below mid-tide, stormwater discharges to sea by gravity. At times when the culvert is tide-locked, a stormwater pump operates. Costs, dimensions, and other details of the entire scheme are included in the article.

382
NEW SEWAGE DISPOSAL WORKS FOR OAKENGATES U.D.C.,

Surveyor Munic City Engrs, Vol 129, No 3920, pp 31-32, 1967.

Descriptors: *Sludge treatment, *Sewage treatment.
Identifiers: *Great Britain, *Storm tank, *Biological filtration.

An illustrated description is given of a new sewage works at Oakengates, Salop., which provides complete treatment by biological filtration for up to 3 times the dry-weather-flow of 0.8 m.g.d. Primary sludge and sludge from stormwater tanks are discharged to thickening tanks, and secondary sludge is returned for treatment or pumped to the thickening tanks if required. After thickening, sludge is dewatered on beds.

383
AWARD WINNING INDUSTRIAL WASTE TREATMENT PLANT,

Water Pollution Control, Vol 107, No 7, p 18, Jul 1969.

Descriptors: *Waste treatment, Ponds, Storm runoff
Identifiers: *Stormwater pond.

Chrysler's industrial waste treatment plant handles combined storm and industrial wastewater. The plant is designed to remove and dispose of free and emulsified oils, detergents, caustic strippers, and acid rinses. A stormwater holding pond of three million gallons stores excess flow from the industrial plant under storm conditions. Exceptionally long and heavy rainfalls could cause the pond to overflow; however, a sufficient detention time would still allow suspended solids to settle out. Stored stormwater is treated later when the plant sewage load has decreased

384
WILMINGTON GOES ON LINE WITH MODERN NEW SECONDARY TREATMENT PLANT,

Water Sewage Works, Vol 116, No 12, pp 471-473, Dec 1969.

Descriptors: *Sewage treatment, *Sewerage, Sewers, Water pollution.
Identifiers: *Sewer hydraulics, Combined sewers, Wilmington, Delaware.

Wilmington Delaware's recently-built secondary sewage treatment plant will allow the city to meet federal regulations regarding water pollution. Although the city has a combined sanitary, industrial wastes, and stormwater sewerage system, entire flows are given primary treatment before passing to the river. During periods of rainfall, sewage pumping stations discharge approximately 120 mgd with three pumps in operation. The structure of the new sewage treatment plant is described along with the advantages it provides.

385
OXFORD SEWAGE TREATMENT PLANT,

Water Waste Treat, Vol 12, No 9, pp 280-281, Sep/Oct 1969.

Descriptors: *Treatment facilities, *Overflow, Sewage treatment, Regulation.
Identifiers: Great Britain,

Extensions of the Oxford Sewage Treatment Plant were required when overloads reached 2 million gallons per day. Now all flows, after preliminary treatment, are pumped to the inlet channel where two-thirds are sent to the old works and one-third to the new works with peak flow/storm balancing tanks acting progressively above 7,000 g.p.m. The dimensions and workings of new units are described. Additions to the plant include: three peak flow/storm balancing tanks, an aeration plant unit, side wall unit extensions to the original flat bottom tanks, infinitely variable speed pumps serving the return activated sludge plant, two hopper bottom tanks, a secondary sludge digestion unit, and three tanker vehicles for conveying consolidated activated sludge.

386
NEW PUMPING STATION FOR LIVERPOOL,

Water Waste Treat, Vol 12, No 9, p 297, Sep/Oct 1969.

Descriptors: *Pumping plants, *Treatment facilities, *Pumps.
Identifiers: *Great Britain, *Storm tank.

The new pumping station for Liverpool is part of a major extension program which provides further sedimentation tanks, stormwater tanks, and increased biological filtration capacity. The station is designed to accomodate seven vertical sewage pumps, four of which (dryweather pumps) are arranged so as to deliver sewage through one rising main to the primary sedimentation tanks. The three remaining pumps (stormwater pumps) deliver sewage through a second rising main to the stormwater tanks. The operation and output of the pumps are described. Ultraviolet lamps are used to suppress odor and retard any fungoid growth which may occur in the pump house basement.

387
INSTRUMENTATION AND CONTROL AT DALMARNOCK SEWAGE DISPOSAL WORKS,

Water Waste Treat, Vol 12, No 1, pp 19-20, May/Jun 1968.

Descriptors: *Sewage treatment, *Flow measurement, Sludge treatment, Effluents.
Identifiers: *Scotland.

The instrumentation and control provided by the Lea Recorder Co. for the new activated-sludge plant at Dalmarnock, Glasgow, are described in detail. Provision has been made for automatic sampling at various stages of treatment, as well as for the control and recording of the flows of sewage, stormwater, and effluent. The final effluent is discharged to the River Clyde.

388
SALISBURY SEWAGE WORKS,

Water Pollution Control, Vol 97, No 5, pp 536-538, Sep 1968.

Descriptors: *Design, *Sewerage, Storm runoff, Sewage treatment.
Identifiers: *Storm tank, Sewage system.

The workings of the Salisbury Sewage system are described. In the case of heavy rainfall (flows in excess of 3 d.w.f) storm sewage passes to 4 storm tanks with a combined capacity of 700,000 gal., serving a design population of 46,000. After the storm, the contents are returned for full treatment and the tanks are cleaned by high-pressure hose jets.

389
SHREWSBURY SEWAGE WORKS,

Water Pollution Control, Vol 67, No 4, p 400, 1968.

Descriptors: *Design, *Sewerage, Storm runoff, Sewage treatment.
Identifiers: *Storm tank, Sewage system.

The new Shrewsbury sewage works opened in 1964 is described. Flows exceeding 6 x d.w.f. are discharged over a double-sided weir and pass directly into a nearby river. Flows in excess of 3 x d.w.f. pass to the storm tanks which have a combined capacity equivalent to 6 h d.w.f.

390
WATER RE-USE,

Chem Eng Program, Symposium Series, Vol 63, No 78, 1967. 284 p.

Descriptors: *Water reuse, *Water pollution control, *Waste water treatment, *Application methods, *Analytical techniques, Design, Sewers, Sewage treatment.

This publication contains the papers presented at the 59th annual meeting of the American Institute of Chemical Engineers in Detroit, Michigan, during an international conference on the conservation of waste water by reuse, and additional papers from other meetings of the Institute are also included to give broad coverage of the subject. Information on the reuse of waste water for industrial or municipal supplies is presented for 9 countries and consideration is also given to the role of water reuse in the prevention of pollution, management of water resources, and design of sewerage systems; medical, legal, and economic aspects; internal reuse of water in factories; treatment for reuse, including the use of chemicals, ionizing radiation, activated carbon, and biological processes; removal of viruses, phosphates, and nitrogen compounds; reuse in spaceships; recovery of chemicals; analytical techniques; disposal of sludges; and complete reuse of all waste waters including storm sewage.

391
MERSEY AND WEAVER RIVER AUTHORITY. FIRST ANNUAL REPORT 1965-1966,

Descriptors: *Water resources, *Fisheries, *Sewage treatment, Quality control, Activated sludge, Effluents, Investigations.
Identifiers: Storm sewers, Suspended solids.

This report contains information on water resources, including the preparation of a hydrometric scheme and a survey of water demand in connection with the investigation of the Morecambe Bay Barrage Scheme; fisheries and causes of fish mortalities; and pollution prevention, including the results of chemical surveys of the major rivers. The policy of closing the smaller sewage works and treating all the sewage at larger, improved, works, which also treat trade wastewaters, is proving successful. The policy of recommending separate sewerage systems wherever circumstances permit has been vindicated by results of investigations on the characteristics of discharges from the stormwater sewers, which are relatively free from organic matter although they contain inert suspended solids. Laboratory studies have shown that most effluents from textile and paper mills can be treated by the activated-sludge process, producing an effluent of high quality, providing nitrogenous and phosphate nutrients are added as necessary. A new plant used for the treatment of textile waste-waters by chemical precipitation and sedimentation operates on a "fill-and-draw" system using a series of 3 tanks. While one tank is filling, liquid in a second tank is being mixed, neutralized, and coagulated and settled liquor is being decanted from a third tank. A well-clarified effluent is produced.

392
PROBLEMS OF WATER TREATMENT IN DEVELOPING COUNTRIES,

D. Anderson
Effluent Water Treat, Vol 8, No 10, pp 513-516, Oct 1968

Descriptors: *Water treatment, Waste water (pollution), Sewage.
Identifiers: Developing countries.

There will be an increase in the volume of wastewater and in the concentration of pollutants due to the increase in the total use of water for municipal, agricultural, and industrial purposes. The problems created by this increase include: development of water resources investigating river morphology and irrigation; sewage waste stressing the reduction of the oxygen consumable in sewage; trade wastewater caused by a rapid program of industrialization; equipment and processes wherein design standards used in industrial countries were also applied to developing countries, citing the installation of a treatment plant and an inadequate stormwater system; water and wastewater management; and water-borne disease. Research information is needed for combatting the water treatment problems.

393
EXTRACTS FROM THE ANNALS OF A SEWAGE-WORKS MANAGER, 1950-1966,

T.A. Austin
Paper presented at a meeting of the Institute of Water Pollution Control, Birmingham, November 1967.

Descriptors: *Sewage treatment, Effluents, Water pollution, Water reuse, Investigations, Biochemical oxygen demand.
Identifiers: *Great Britain, Storm sewage, Suspended solids.

An historical account is given of the development of sewage works at Leamington Spa with special reference to the problems encountered. Aspects considered include: the system adopted for charging, conveying, and treating trade wastewaters; raising of weirs on storm sewage overflows to overcome pollution of the River Leam; and experiments on the treatment of effluent to permit reuse for industrial purposes. The works now serve a population of 58,000 and treat an average flow of 4.5 m.g.d., with an efficiency of 93.7 per cent (based on BOD). In view of continually increasing loads, a scheme is being developed for a new works, together with a new Avon valley sewer. Trials were carried out using spray-irrigation of screnned sewage on grass plots with underdrains which removed 89 per cent of the BOD and 95 per cent of the suspended solids.

394
SEPARATION OF SEWAGE FROM STORMWATER,

V.W. Bacon, R. Leland, and B. Sosewitz
In: Symposium on Storm Sewage Overflow, Inst of Civil Engrs, pp 143-152, 1967.

Descriptors: *Sewers, *Water pollution sources, Storage, Design, Investigations.
Identifiers: *Storm sewage, *Chicago.

In the U.S., since the conversion from existing combined sewage systems to separate systems would not be economical, various alternate methods of preventing pollution by storm sewage have been investigated. The Chicago underground storage plan followed by back-pumping to surface reservoirs for sedimentation and chlorination is discussed.

395
STORAGE AND TREATMENT OF COMBINED SEWAGE AS AN ALTERNATE TO SEPARATION,

A.W. Banister
In: Combined Sewer Overflow Seminar Papers, Edison, N.J., Nov 4-5,1969. Water Pollution Control Research Series, DAST-37, pp 19-36, Mar 1970. 4 fig.

Descriptors: *Separation techniques, *Storm runoff, *Treatment facilities, *Project planning.
Identifiers: *Chippewa Falls, Wisconsin.

The city of Chippewa Falls, Wisconsin needed to complete a program of separating stormwater from its sanitary sewage and waste collection and treatment facilities, or to provide a method of treating the combined sewage and wastes. The project selected consisted of certain combined trunk sewers, certain minor separate storm sewers, a combined sewage pumping station, and a combined sewage storage pond. A detailed description of the project operations and results is given.

396
HYDROGEOLOGIC STUDIES ARE KEY TO SAFETY IN WASTE MANAGEMENT PROGRAMS,

Robert E. Bergstrom
Water Sewage Works, Vol 116, No 4 pp 149-155, Apr 1969. 7 fig, 7 ref.

Descriptors: *Groundwater, *Waste disposal, *Water pollution, *Illinois, *Treatment facilities, *Tunnels, Flow control, Aquifers, Data collections, Investigations, *Hydrogeology.
Identifiers: *Disposal operations, *Storm tunnels, *Waste management, Deep tunnel plan, Chicago.

Waste disposal is explored as a possible factor in groundwater contamination. State-reviewed disposal operations in Illinois that are specifically discussed include: landfills and dumps, radioactive waste burial grounds, sewage treatment and waste storage ponds, disposal wells, and sewage-stormwater tunnels. The Chicago Sanitary District's tunnel plan for the prevention of stormwater and raw sewage bypassing treatment plants and polluting streams is described. Initial reports concluded that stormwater and sewage would not pollute the groundwater reservoir because the rock in which the tunnel was bored is tight, and head relations provide that water only moves into and not out of the tunnel. Possible problems created by this project are mentioned. The following suggestions are proposed to aid groundwater practitioners in waste management; (1) the selection of sites for waste disposal based on hydrogeologic conditions which indicate natural safeguards and the protection of health and resources; (2) procurement of data needed to develop criteria for determining geologic conditions and beneficial engineering practices; and (3) the study of investigations relating to waste management topics such as saturation and water movement in typical geologic terrains that might be used for waste disposal.

397
THE DESIGN AND CONSTRUCTION OF REGIONAL SEWERAGE AND SEWAGE TREATMENT WORKS FOR LIVINGSTON NEW TOWN INCLUDING ITS ENVIRONS AND FOR THE NEWBRIDGE AREA,

T.A.C. Brownlie and W. Ferguson
J Inst Public Health Engrs, Vol 68, Part 3, pp 160-188, Jul 1969.

Descriptors: *Sewerage, Sewage treatment, Design, Overflow.
Identifiers: *Storm sewers, *Combined sewers, Treatment methods, Storm tank, Great Britain.

Described in detail are plans for Livingston New Town and its environs and Newbridge. Separate sewers were adopted for the New Town while existing combined systems were re-sewered for separation only when redevelopment took place. Overflows were suggested where major existing sewers were to be connected to newer sewers, and at least 6 d.w.f. will be passed to the new sewer. Primary tanks of the existing sewage treatment works will be converted to storm water tanks and pumps installed to convey stored sewage back to the new sewer. No flows below 18 d.w.f. should reach rivers without treatment. Surface water storm sewers will be built according to the size necessary to drain the "once a year storm," even though rain of this intensity and duration is not likely to occur more than once in three or five years. Descriptions are given of the size, capacity, and mode of treatment and operation for the numerous parts of the sewage treatment plants proposed. No storm water settling tank is envisaged for the first development, and future expansion and increase in population will determine whether a storm settling tank is required. Partial treatment of 6 x d.w.f. or more will be possible. Capital and operating costs for both treatment plants are tabled as are data concerning capacities and dimensions of each treatment mechanism.

398
OPERATING EXPERIENCES AT SWINDON, 1962-1967,

W.F. Carmichael
Water Pollution Control, Vol 68, No 4, pp 458-464, Jul 1969.

Descriptors: *Sewerage, *Sewage treatment, Sludge treatment, Overflow.
Identifiers: *Storm sewage, Combined sewers, Great Britain.

The sewerage system of Swindon is constructed as a combined system from pre-war days, and as a separate sewerage system for expansion areas. The report stresses sludge treatment and disposal, power generation, and sewage treatment which emphasizes biological filters, screens, primary settling tanks, and storm sewage treatment. The operation of the storm sewage treatment as well as analysis data concerning overflows onto underdrained land are given.

399
COMPLETE WATER RE-USE,

L.K. Cecil
Chem Eng Program, Symposium Series, Vol 63, No 78, pp 258-261, 1967.

Descriptors: *Water reuse, Water pollution control, Activated sludge, Phosphates, Chemical precipitation.

Identifiers: *Treatment methods.

The author outlines a system of water pollution control in which all wastewaters from the area are treated for reuse as municipal or industrial water supplies. No wastewaters are discharged to public watercourses, and water is drawn from natural sources only to replenish losses by evaporation and other processes. The choice between combined and separate sewerage systems in such an area and the selection of a treatment system for the wastewaters are considered, and a practical system of treatment is described comprising removal of grit and sand. Simultaneous removal of carbonaceous and nitrogenous compounds and reduction of phosphate by activated sludge with incineration of excess sludge to ensure removal of phosphate from the system is examined; as well as chemical precipitation to reduce carbonate hardness, COD, phosphates, silica, boron, fluorides, and viruses, followed by filtration through diatomaceous earth. The removal of dissolved solids in a series of five units consisting of hydrogen cation-exchange column, three activated-carbon columns, and an anion-exchange column is explored. The system recovers about 95 per cent of the initial water. Water can be removed from the system at several stages for selected purposes.

400
OVERVIEW OF CONTROL METHODS,

Francis J. Condon
In: Combined Sewer Overflow Seminar Papers, Edison, N.J., Nov 4-5, 1969. Water Pollution Control Research Series, DAST-37, pp 9-17, Mar 1970.

Descriptors: *Water pollution sources, *Sewers, *Infiltration, *Control systems, Treatment facilities, Control structures.
Identifiers: *Overview.

Pollution problems caused by combined sewers and separate sewers that act as combined ones because of widespread infiltration and malfunctioning regulators are examined. Methods of control which are presently being investigated are discussed herein.

401
CITY OF NORWICH SEWAGE WORKS,

P. Cotton
Water Pollution Control, Vol 67, No 4, pp 454-457, 1968.

Descriptors: *Sewage treatment, *Biocontrol, *Sludge treatment.
Identifiers: *Great Britain, *Biological filtration, Storm tank.

An illustrated description is given of the sewage works of Norwich, which are designed to treat a dry-weather flow of 7.5 m.g.d. by biological filtration with recirculation of effluent. Flows in excess of three times design flow are settled in storm tanks. Sludge is thickened by sedimentation before digestion and digested sludge is passed to a storage lagoon before being dried on beds, disposed of on land in liquid form, or distributed by tanker to surrounding farms.

402
SEWERAGE PLANNING IN GREATER STOCKHOLM AREA,

Anders Cronstrom
Water Sewage Works, Vol 116, No 9, pp 356-358, Sep 1969.

Descriptors: *Sewerage, *Sewage treatment, *Biological treatment, *Planning, *Design, *Treatment facilities, *Tunnel design, *Tunnels.
Identifiers: *Sweden.

An intensive redistribution within and to the Greater-Stockholm area is expected by the year 2000, and consequently large and difficult sewerage problems are created. The problems caused by sewerage and sewage discharge in the surrounding area of Stockholm are discussed in relation to treatment facilities now in use. Two courses of problem solving are described as: 1) tunnel systems for sewage collecting from catchment areas which would carry the sewage for the whole region to a common sewage treatment plant with ocean discharge; and, 2) a tunnel system constructed as an outlet conduit to better receiving waters for the biologically treated sewage from various existing sewage treatment plants. No decision has been made as to which method will be employed

403
ASSESSMENT OF ALTERNATIVE METHODS FOR CONTROL/TREATMENT OF COMBINED SEWER OVERFLOWS FOR WASHINGTON, D.C.,

John A. DeFilippi
In: Combined Sewer Overflow Seminar Papers, Edison, N.J., Nov 4-5, 1969. Water Pollution Control Research Series, Report DAST-37, pp 123-138, Mar 1970. 1 tab.

Descriptors: *Overflow, *Control systems, *Laboratory tests, Hydraulic models.
Identifiers: *Treatment methods, *Combined sewers, *Comparative analysis, *High-rate filtration, *Washington, D. C.

An investigation, which deals with the assessment of alternate methods for control/treatment of combined sewer overflows for the District of Columbia, is presented herein and has the following three components: 1) problem definition, 2) the study of the feasibility of high-rate filtration for treatment of combined sewer flows, and 3) the study of alternative methods of solution. Problem definition dealt with attempting to define hydraulic properties and water quality characteristics of combined and separated storm sewer flows. The second major area of study, high-rate filtration, was investigated by bench-scale laboratory experiments. The third part of the investigation was accomplished by analyzing various approaches used in other parts of the country relative to their applicability to the Washington, D.C. system. This paper presents a discussion of the three major portions of the investigation. The approaches are described and appropriate conclusions presented.

404
MICROSTRAINING OF SEWAGE EFFLUENTS IN THE USA,

E.W.J. Diaper and M.R. Lowndes
Effluent Water Treat, Vol 10, No 6, pp 323-325, 327,328, Jun 1970.

Descriptors: *Filtration, *Waste water treatment, *Pollution abatement, *Investigations, Pollutant identification, Economic justification, Standards, Legislation, Suspended load, Chlorination, Ozone.
Identifiers: *Microstraining, Storm overflows, Chicago, Lebanon, Ohio.

Emphasis has recently been placed on up-grading effluent standards to maintain, or improve, river quality in lieu of increasing contamination from municipal and industrial discharges. Each state must formulate standards for waste water treatment as a result of legislation introduced by the Federal Government. Increased attention has been paid to the compounds of phosphorus and nitrogen in effluents since these chemicals provide nutrients for plant life in the receiving stream. The basic operating principles of a typical microstraining installation are reviewed. The article outlines the results from three investigations in which microstraining has been assessed as an economic aid in preventing pollution in: 1) Lebanon, Ohio -where methods of removing suspended matter that tend to overload advanced waste treatment processes were explored; 2) Chicago - where the necessary tertiary treatment stage at three plants is being determined in order to meet state standards; and, 3) the Cochrane Division of the Crane Co. - where the removal of suspended solids in stormwater overflows by microstraining and the reduction of bacteria in these effluents by chlorination and ozonation are being evaluated.

405
NEW APPROACHES TO WASTEWATER TREATMENT,

Discussions by E.W.J. Diaper and Russell L. Culp
J Sanit Eng Div, Am Soc Civil Engr, Vol 95, No SA 5, pp 978-980,

Descriptors: *Sewage treatment, Storm runoff.
Identifiers: Combined sewers, Philadelphia.

In his comments, E.W.J. Diaper mentions the fact that the combination of microstraining and ozonation for the treatment of combined sewer stormwater overflows is being evaluated in Philadelphia, Pennsylvania.

406
NEW ACTIVATED SLUDGE PLANT TO SERVE THREE WARWICKSHIRE VILLAGES,

Brian M. Dumbleton
Surveyor, Vol 82, No 3972, pp 31-33, Jul 19, 1968. 5 fig.

Descriptors: *Sewage treatment, *Treatment facilities, *Separation techniques, Sewers, Drainage programs, Design, Overflow.
Identifiers: *Great Britain, Trunk sewer, Storm tank.

The Atherston Rural District Council constructed a new sewage treatment works and installed several miles of trunk sewers to supercede three existing, overloaded works and to provide for mains drainage in two towns not previously sewered. An activated sludge plant was also proposed for construction. The partially separate sewers in most of the villages were adequate for even anticipated future flows, but in a few instances where surcharging occurred, new sewers were laid. In one area, storm overflows on the sewers were considered to reduce flow to the new works, but separation at the site of the works was found to be preferable. A complete description of the design of the new works is given. Storm tanks can hold the equivalent of 12 hours d.w.f. At times of very heavy rainfall, tanks overflow to Penmire Brook. After a storm, contents of the tanks are returned to the pumping station to be lifted to the works for treatment. The treatment process and sludge handling are described.

407
SUBMARINE PIPELINE TO DISCHARGE TREATED EFFLUENT AT SPILSBY RDC,

Nigel East
Surveyor, Vol 85. No 4053, pp 38-40, Feb 13, 1970. 10 fig.

Descriptors: *Sewage treatment, *Treatment facilities, *Separation techniques, *Steel pipes, Construction, Outlets, Storm runoff, Sewers, Sewerage, Effluents
Identifiers: *Great Britain, Storm tank.

Spilsby RDC's sewerage scheme involves two sewage treatment works and construction of a 1.5 mile outfall sewer to dispose of effluent from both works. In one works, storm flows exceeding 3 d.w.f. are separated and passed to storm tanks and additional flows screened only before passing to the final effluent sump. The previous raw sewage, stormwater, and effluent pumping plant was augmented and the filter distributer arms replaced with others of greater capacity. The outlet sewer system was revised to take the effluent to the submarine outfall. Modifications of the second works provided a degree of treatment similar to that at the first works. The bitumen enamel-coated steel submarine pipeline is described in addition to methods used for trench excavation and launching.

408
TREATMENT OF URBAN STORMWATER RUNOFF,

F.L. Evans, E.E. Geldreich, S.R. Weibel, and G.G. Roebeck
J Water Pollution Control Fed, Vol 40, No 5, Res Suppl, R162-170, 1968.

Descriptors: *Sedimentation, *Chlorination, *Laboratory tests, Microorganisms.
Identifiers: *Cincinnati, Ohio, Runoff treatment.

Tabulated and graphical results are given of laboratory studies on treatment by sedimentation and chlorination of runoff from an urban area of Cincinnati which is sewered on the separate system. Plain sedimentation for less than one hour was not effective in reducing COD, BOD, concentrations of nitrogen, phosphate and solids, or the total counts of three bacterial indicators, but improved removals were obtained with sedimentation for four hours. A dose of 2-6 mg of chlorine per litre applied for 20 min was neccessary to effect a 99.99 per cent kill of total coliform organisms, faecal coliform organisms, and faecal streptococci. Even with such high doses of chlorine and the presence of free residual chlorine after treatment, aftergrowth of total coliform organisms occurred in 24-72 hours; however, there was no significant aftergrowth of faecal organisms. From these results it is suggested that the count of faecal coliform organisms rather than total coliform organisms is more realistic indicator of the downstream effects of chlorinated discharges.

409
WATER REUSE IN INDUSTRY,

E.F. Gloyna, D.L. Ford, and J.M. Eller
J Water Pollution Control Fed, Vol 42, No 2, pp 237-242, Feb 1970
3 diag, 3 graphs, 2 tab.

Descriptors: *Liquid wastes, *Pollutants, *Storm runoff, *Water reuse, *Industrial wastes, Waste treatment, Separation techniques.
Identifiers: *Cresylic acid, *Sodium sulfide solutions, *Collection system.

A system designed to treat liquid wastes from oil refineries and produce a salable product is described. The waste material is shipped to the treatment plant. Pollutants in the waste material include phenols, cresols, cresylic acid, mercaptans, sulfides, thiophenols, caustic soda, and heavy metals. The finished products are cresylic acid and sodium sulfide solutions. Stormwater runoff is utilized after separation into contaminated and uncontaminated portions. The wastewater collection system consists of a comprehensive network of drip pans, collection troughs, dikes, and tanks. The network is interconnected to the process system and cooling towers.

410
KAPPALA UNDERGROUND SEWAGE WORKS, STOCKHOLM,

E. Isgard and A. Rosander
Civil Eng Public Works Rev, Vol 65, No 766, pp 517-520,
May 1970. 4 diag, 1 map, 1 tab.

Descriptors: *Sewage disposal, *Tunnels, *Treatment facilities, Construction, Planning, Cost analysis, Infiltration, Storm runoff.
Identifiers: *Gravity sewer, Sweden.

Ten suburban communities north of Stockholm formed the Kappala Union to deal with their sewage problems. They planned to convey sewage to a sewage treatment plant on Lidingö Island, enabling effluent to discharge into the main stream of water. Plans are described for the establishment of a system of gravity sewer tunnels to convey wastewater to the plant. The flow was intended to consist of municipal sewage and groundwater infiltration without much stormwater. Construction techniques for the sewage tunnels and the treatment plant are discussed, as is the planning of the plant and main pumping station. Total costs for the project are given in a table.

411
TECHNIQUES AND RECENT DEVELOPMENTS IN SEWAGE WORKS DESIGN,

R.P. Boyd James
Water Pollution Control, Vol 69, No 1, pp 62-66, 1970.

Descriptors: *Sewage treatment, Sludge treatment, Evaluation, Overflow.
Identifiers: *Storm tank, *Treatment processes, Storm sewage.

New techniques and developments in three different areas are discussed, the areas being: sewage treatment and its effect on operators and others, the effectiveness of sewage treatment, and the efficiency of the process. Developments in sludge dewatering and aerial nuisance decrease the unattractiveness of sewage treatment to operators and other employees. The advances and deficiencies of tertiary treatment, biological treatment, and preliminary treatment and sedimentation are presented in relation to the influences they have on the effectiveness of sewage treatment. Also in this area, the failings of storm sewage treatment are enumerated, and the author strongly recommends that provisions for storm tanks or irrigation areas be made in order to reduce pollution from overflows. He asserts that it is better to intercept a 40 d.w.f. flow in a storm tank than to given full treatment to a mere 6 d.w.f., allowing the remainder to overflow. F.W. Allen in the "Discussion," suggests that storm tank treatment could be improved if full use were made of the storage capacity of sewers and if one storm has no outlet to the river so that the first storm flush could be stored there and later sent back for treatment. He also recommends that overflows sited on a sewer near a trade effluent discharge be upstream of the discharge to allow the trade effluent to pass to the sewage works. New techniques in the efficiency area of sewage treatment are also described in addition to civil engineering developments that speed construction.

412
MICROSTRAINING - WITH OZONATION OR CHLORINATION - OF COMBINED SEWER OVERFLOWS,

W.A. Keilbaugh, G.E. Glover, and P.M. Yatsuk
In: Combined Sewer Overflow Seminar Papers, Edison, N.J., Nov 4-5, 1969. Water Pollution Control Research Series, Report DAST-37, pp 59-99, Mar 1970. 11 fig, 5 tab, 10 ref.

Descriptors: *Overflow, *Suspended load, *Sewers, *Ozonation, *Chlorination, Estimated costs.
Identifiers: *Microstraining, *Philadelphia, Combined sewers, Treatment methods.

Microstraining, using a nominal 23 micron aperture Microstrainer screen, has removed up to 98% of the suspended solids from the combined sewer overflow which serves a residential area of 11 acres in the city of Philadelphia. BOD removals and coliform bacteria concentrations in the microstrained effluents have varied widely. Results to date indicate that there is a slightly better colon group bacterial kill with chlorine in the microstrainer effluents then when ozone is used. Preliminary estimates have been made for the costs of treatment for a combined sewer via the microstraining process. It is estimated that the costs per acre of of drainage for a full scale plant in our test area would range from approximately $9,500 to $11,800 for microstraining alone, $10,500 to $12,800 for microstraining plus chlorination, and $18,000 to $21,300 for microstraining plus ozonation.

413
NON-LINEAR PROGRAMMING AS A METHOD OF DESIGN OF TREATMENT FACILITIES FOR COMBINED SEWER EFFLUENT,

Charles A. Kohlhaas
Stanford Univ Engineer Thesis, Sep 1969

Descriptors: *Optimization, *Storm drains, *Treatment, *Mathematical models, Computer programs.
Identifiers: *Storm Sewage, *Combined sewers, *Non-linear programming, Sensitivity analysis.

Due to the high flows experienced in combined sewer systems, treatment can seldom be provided for the entire volume of combined sewage. This leads to the problem of determining the optimum-partial treatment needed to meet water quality objectives. Non-linear programming is used to determine the optimum combination of primary and secondary treatment to be provided for combined sewer effluent. Water quality requirements limiting floating solids, grit, settleable solids, suspended solids, and BOD are considered as constraints against an objective function composed of the cost of preliminary, primary and secondary treatment. The nature of the problem allows a graphical solution. The sensitivity of the solution to a number of input variables is performed. The response of cost to the levels of water quality specified by water quality regulations is also investigated. The graphical solution of the non-linear program gives insight into the nature of objective and constraint functions encountered in water pollution control work. In spite of the very non-linear nature of the constraint functions in a mathematical sense, the plots of such functions proved to be largely linear.

414
SILT REMOVAL FROM COMPINED SEWERS,

D. Laredo and E.A. Bryant
Water Sewage Works, Vol 115, No 12, pp 561-564, Dec 1968.

Descriptors: *Massachusetts, *Sewage treatment, *Chlorination, Storm runoff.
Identifiers: *Degritting tank.

At the 50-m.g.d. primary sewage works of Fall River Mass., which is served by combined sewers, a degritting tank and facilities for preliminary additional chlorination have been installed to treat storm flows which previously had to bypass the works because they fouled the sedimentation tanks. The design, operation, and performance of the degritting tank are described.

415
THE SEWAGE DISPOSAL AT VELDEN ON LAKE WORTHER,

W. Lengyel
Oesterr Wasserwirtsch (OSWAAI), Vol 20, No 9/10, pp 204-210, Sep/Oct 1968.

Descriptors: *Pollution abatement, *Sewage treatment, Pumping plants, Pressure conduits.
Identifiers: *Lake Worther, Germany, Combined sewers, Separate system.

To prevent and control polluting loads from entering Lake Worther, additional sewage works were constructed to serve the health resort of Velden. These works provide primary treatment for domestic sewage and trade wastewaters in tanks and have facilities for sludge digestion and mixing of sludge and garbage. Owing to the complex geographical conditions of the area, a central pumping station had to be provided to pump the sewage via a long pressure pipe 65 m above water level to the lake. The author outlines the factors which affect the use of combined sewerage systems as compared with separate systems and discusses the advantages and disadvantages. In the case of Lake Worther the separate sewerage system is recommended, but strict control should be kept on the number of dwellings served.

416
HIGH-LEVEL INACTIVATION OF VIRUSES BY CHLORINATION,

T.L. Lothrop and O.J. Sproul
J Water Pollution Control Fed, Vol 41, No 4, pp 567-575, Apr 1969.

Descriptors: *Biocontrol, *Chlorination, *Testing, *Waste water treatment, Viruses.

Identifiers: *Stormwater treatment.

Laboratory tests were performed on Type 1 poliovirus and Type 2 bacteriophage with varying chlorine dosages to determine the chlorine residuals necessary to insure high-level virus inactivation in settled raw wastewater and stormwater overflow. Conclusions drawn from the study showed that high-level inactivation of viruses is possible in treated and untreated domestic wastewaters, but that present chlorination practices do not accomplish this feat. In the experimental runs with synthesized stormwater overflow, a 100-percent inactivation of Type 1 poliovirus was achieved by providing a free chlorine residual. In all runs, the T2 bacteriophage was much less sensitive to combined chlorine residuals than was the coliform organism and was more sensitive than the poliovirus to combined chlorine residuals.

417
ROTARY VIBRATORY FINE SCREENING OF COMBINED SEWER OVERFLOWS; Primary Treatment of Storm Water Overflow from Combined Sewers by High-Rate, Fine-Mesh Screens,

Donald M. Marske
In: Combined Sewer Overflow Abatement Technology. Water Pollution Control Research Series, Report 11024--06/70, pp 57-106, Jun 1970. 13 fig, 6 tab, 2 ref.

Descriptors: *Sewage treatment, *Overflow, *Storm runoff, *Screens, Economic feasibility, Treatment facilities.
Identifiers: *Combined sewers.

The feasibility, effectiveness, and economics of employing high-mesh screening for primary treatment of stormwater overflow from combined sewer systems is detailed herein. Based on final performance tests run on dry-weather sewage, the unit (63 inches high and an outside diameter of 80 inches) is capable of 99% removal of floatable and settleable solids, 34% removal of total suspended solids, and 27% removal of COD. The screened effluent is typically 92% of the influent flow. The estimated cost of treatment is 22 cents/1000 gallons for a scale-up design of a 25 mgd screening facility. It was observed that the proposed screening facility required 1/10 to 1/20 the land required by a conventional primary treatment plant.

418
THE USE OF SCREENING/DISSOLVED - AIR FLOTATION FOR TREATING COMBINED SEWER OVERFLOWS,

Donald G. Mason
In: Combined Sewer Overflow Abatement Technology. Water Pollution Control Research Series, Report 11024--06/70, pp 123-138, Jun 1970. 9 fig.

Descriptors: *Separation techniques, *Overflow, *Estimated costs, *Laboratory tests.
Identifiers: *Combined sewers, *Screening/flotation system.

This report documents a study on the treatment of combined sewer overflow by screening and dissolved-air flotation. The objectives of the project determined the effectiveness and cost of a screening/flotation system. A combined sewer in Milwaukee, Wisconsin was monitored and testing was performed. The results of the laboratory tests indicated a combination of screening/flotation provided a feasible system and a prototype demonstration unit with a 5 mgd capacity was designed and installed. The system has been operated on 30 overflows. Removal of BOD, COD, SS, and VSS have ranged between 50 and 75 per cent. Cost estimates indicate a total installed cost of $12,000 per mgd capacity. Operating costs are estimated at 1.0¢/1000 gallons without chemical flocculant addition.

419
OPERATION AND MAINTENANCE OF MUNICIPAL WASTE TREATMENT PLANTS,

R.L. Michel, A.L. Pelmoter, and R.C. Palange
J Water Pollution Control Fed, Vol 41, No 3, pp 335-354, 1969.

Descriptors: *Waste water treatment, *Maintenance, *Statistics, *Mathematical studies, Infiltration, Storm runoff, Analysis.
Identifiers: *Treatment methods, Storm sewage.

When grants for wastewater treatment plants are made under the U.S. Federal Water Pollution Control Act, efficient operation and maintenance of these plants must be provided. To ensure compliance with this requirement, an appropriate audit is made at each plant after it has operated for about one year. In this report, the data from 1500 audits in the period July 1962 to December 1964 are summarized and analysed statistically showing mathematical relations between several of the variables examined. These relations include: population, quantity and strength of wastewaters, operating costs, and type of treatment. Problems encountered are also summarized, with particular reference to the bypassing of untreated wastewater as a result of storm sewage flow or infiltration into the sewers.

420
THE UNABATED GROWTH OF WATER POLLUTION ABATEMENT ACTIVITIES,

Austin H. Montgomery, Jr.
Consulting Engr, Vol 33, No 5, pp 114-117, Nov 1969. 10 ref.

Descriptors: *Methodology, *Pollution abatement, *Sewers, *Costs, *Separation techniques, *Engineering personnel, Water resuse,
Identifiers: *Treatment methods.

Water pollution abatement activities were given authority and direction by the Federal Water Quality Act of 1965. An estimated cost of $48 billion is necessary for the separation of combined sanitary and storm sewers. The traditional primary-secondary treatment plants' objectives and achievements usually have been not to restore but to slow down or prevent further degradation. Lack of knowledge of the extent and means of treating pollution sources such as pesticides, acid, erosion, fertilizers, and mine drainage, is a factor in delaying the abatement program. A list of consulting engineering firms, which have been awarded research and development grants and contracts for advanced wastewater treatment techniques, is given. The trend in the reuse rather than discharge of wastewater is well under way, and the most widespread reuse today is that of secondary treatment effluent as a water source for industry and agriculture. A need for professional water pollution control is emphasized.

421
RECONSTRUCTION OF OFFERTON SEWAGE WORKS OF HAZEL GROVE AND BRAMHALL U.D.C.,

J. Morton and F. Summerfield
Water Pollution Control, Vol 68, No 1, pp 85-92, 1969.

Descriptors: *Sewage treatment, *Aerobic treatment, *Sludge digestion, Screens, Sludge disposal.
Identifiers: Storm tank, Sedimentation tank, Gas recirculation system.

Previous extensions to the Offerton sewage works of Hazel Grove and Bramhall U.D.C., Cheshire, proved inadequate by 1964, and further extensions are now being planned. These will include aeration with Simplex cones for secondary treatment by the activated-sludge process, together with new screens, stormwater tanks, and sedimentation tanks. Automatic control systems will also be installed. To improve the performance of the sludge digestion unit, which consists of two concentric tanks, it is planned to install a gas recirculation system to give better mixing. Disposal of liquid digested sludge on farmland, which was begun in 1963 will be expanded.

422
SPECIAL OPERATIONAL RESULTS FROM OXIDATION CHANNELS,

J. Muskat
Oesterr Abwasser-Rundschau (OERAV), Vol 12, No 1, pp 3-7, 1967.

Descriptors: *Sewage treatment, *Investigations, Nitrification, Analysis.

Identifiers: *Oxidation channels.

The advantages of oxidation channels for the treatment of sewage are discussed with special reference to the satisfactory results obtained when dealing with shock loads and with rainwater. The principles of action in straight, circular, and mixed oxidation channels are outlined including the difference in the biological conditions of each plant. The importance of dilution for the biocenose in circular channels is considered as well as the factors which affect nitrification and denitrification in straight and in circular channels.

423
RIVER ENGINEERING AND WATER CONSERVATION WORKS: CHAPTER 6 - APPLIED FLOOD HYDROLOGY,

J.E. Nash
Butterworths, London, pp 63-110, 1966. 22 fig, 1 tab, 23 ref.

Descriptors: *Flood routing, *Rainfall, *Frequency analysis, *Discharge (water), *Hydrograph analysis, *Unit hydrograph, Storm runoff, Rainfall-runoff relationships.

The author deals with two problems in flood hydrology: (1) predicting peak discharges from rainfall data and such other factors as are found necessary; and (2) the determination of the frequency of exceedence of a discharge when records of discharge over several years exist or in the absence of such records. The chapter attempts to designate the tools available for solving such problems and the usefullness and limitations of these tools. Topics discussed under hydrograph analysis are: storm runoff from individual storms, rainfall and effective rainfall, the unit hydrograph hypothesis, changing the duration of a unit hydrograph, use of the S curve, calculation of unit hydrographs from rainfall and stream flow records, and uses of a unit hydrograph. The relation between the unit hydrograph and the catchment is explained, as is the volumetric relation between rainfall and runoff. The last two sections explore flood frequency and the relation of flood frequency to catchment characteristics. (See abstract number 316).

424
WATER AND WASTE WATER DISTRICTS IN SUBURBIA,

Myron K. Nelson and R.L. Chandler
J Sanit Eng Div, Am Soc Civil Eng, Vol 96, No SA2, pp 593-604, Apr 1970.

Descriptors: *Water districts, *Sewage treatment, Sewers, Chlorination, Effluents, Storm runoff.

The formation of water and sewer districts in a highly urbanized area composed of fourteen cities is described. The economical and functional advantages of such districts are enumerated. Separate rather than combined sewers are recommended, but the problem of surcharging sanitary sewers during heavy rainfall still remains. This problem is now being combatted through the installation of additional sewers and holding stations which function as primary treatment plants when sanitary sewers are surcharged. Skimmings and settled material are continually removed and discharged back to normal sewers, and all incoming wastewater is chlorinated. Effluent is conveyed to the receiving stream after treatment. This system appears to be successful in that incoming sewage is highly diluted with stormwater and receiving streams carry normal flows during discharge periods. The physical growth of water resources properties is tabled and long range plants for the area are discussed.

425
RECLAMATION AND REUSE - THE STATE OF THE ART,

John D. Parkhurst
Report No 16, Proc Water Quality Management Symposium, University of California, Davis, Jun 1969. 12 p, 2 tab.

Descriptors: *Reclaimed water, *Water reuse, *Waste water treatment, Reviews Water treatment, Demineralization, Electrodialysis, Treatment facilities, Sanitary engineering, Separation techniques, Water quality, Filtration, Ion exchange, Tertiary treatment, Nutrients, Nitrates, Phosphates, Reverse osmosis.

Identifiers: Renovating.

The sewerage system of the Los Angeles County Sanitation Districts serves about 4 million people in 71 incorporated cities and large tracts of unincorporated areas. Because of the serious problems caused by water shortage in these heavily populated areas, the sanitation districts have instituted the latest techniques and facilities in water reclamation. The Whittier Narrows Plant, the Pomona research and demonstration program and the Lancaster project provide sound data for future planning of similar facilities. The initial stages of the 40-yr master plan that will provide approximately 440 mgd of potentially reusable water in the districts' system are underway. The sanitation districts in Los Angeles County are pursuing research and pilot scale operations of various tertiary treatment processes to provide reclaimed water of any desired quality. Descriptions are given of the processes being used.

426
STORMWATER DISINFECTION AT NEW ORLEANS,

Edgar H. Pavia, and Crawford J. Powell
J Water Fed, Vol 41, No 4, p 591-606, Apr 1969. 10 fig, 1 ref.

Descriptors: *Chlorination, *Storm runoff, *Disinfection, Chlorine, Design, Pumping plants, Coliforms.
Identifiers: *Hypothlorites, *New Orleans, Louisiana, *Lake Ponchartrain, Louisiana, Open channels.

A progress report is given on a project to disinfect storm waters in New Orleans. The project aims to show the feasibility of reducing the coliform count by adding chlorine or hypochlorite at pumping stations and letting disinfection take place in open channels of populated areas. The study will encompass the effect of such treated storm waters when they are discharged into body contact recreational areas. The Lake Ponchartrain area of New Orleans is the site of the test to begin in early 1969.

427
DETROIT'S METROPOLITAN WATER POLLUTION CONTROL PROGRAM - IN ACTION,

Gerald J. Remus
The Engineer and the City, pp 91-96, 1969.
A symposium sponsored by the National Academy of Engineering at its 5th Annual Meeting, Oct 22-23, 1969.

Descriptors: *Water pollution control, *Cities, *Project planning, *Multiple-purpose projects, *Sewerage, *Storm runoff, *Control systems, *Sewage disposal, *Estimated costs, *Construction costs, Instrumentation.
Identifiers: *Detroit, *Combined sewers.

The adoption of metropolitan programs for water supply, pollution control, and sewage treatment in the Detroit area received its impetus in 1959. A brief review of the growing acceptance of the programs is given. The sewage system for Detroit operates on a combined stormwater-sanitary sewage basis with the use of remote controls, automatic alarms, and computer recordings (including records on how a storm crosses a metropolitan area). The stormflow dirt deposit to the Detroit River has been reduced by at least 15%; and because of the sewer control instruments flooding of the activated sludge process at the plant. Approximately $371 million will be spent from 1966 to 1975 on this water pollution control program. Recommendations for further studies and programs are made by the author, and an estimated cost list on the sewage disposal construction (1968-1970) is given.

428
OVERVIEW OF COMBINED CONTROL AND TREATMENT METHODS,

William A. Rosenkranz
In: Combined Sewer Overflow Seminar Papers, Edison, N.J., Nov 4-5, 1969. Water Pollution Control Research Series, Report DAST-37, pp 119-121, Mar 1970.

Descriptors: *Control systems, *Storage.
Identifiers: *Overview, *Treatment methods, *Combined sewers.

The author contends that there is no single method of either control or treatment applicable as a complete answer to combined sewer problems. He further holds that engineering studies must consider all potential alternatives when seeking to determine a treatment method, and that physical control by storage must be considered in conjunction with potentially applicable treatment methods in order to achieve an optimal system.

429
DEVELOPMENTS IN STORM AND COMBINED SEWER POLLUTION CONTROL,

William A. Rosenkranz
Paper presented at the Spring Meeting of the New England Water Pollution Control Association, Jun 11, 1968.

Descriptors: *Water pollution control, *Sewage treatment, Application methods.
Identifiers: *Stormwater pollution, *Combined sewage, Sewer separation, Storm sewers.

Three basic approaches used to minimize combined sewage or stormwater pollution are defined as: (1) control, (2) treatment, and (3) combinations of the two. Examples are given under each category. Considering progress thus far, it is unlikely that any single control or treatment method developed will successfully solve combined sewer or stormwater pollution problems. Instead, methods providing whole or partial solutions based on particular circumstances of the area will be integrated into the combined sewer or stormwater project. Methods of control and/or treatment described include: screening, disinfection, sedimentation, in-system storage, off-system storage, chemical treatment, automated regulators, and sewer separation. Sewer separation continues to maintain the widest amount of present and planned use and predicted applicability.

430
TAHOE AND WINDHOEK: PROMISE AND PROOF OF CLEAN WATER,

Frank P. Sebastian
Paper presented at the Third Annual National Pollution Control Conference and Exposition, San Francisco, California, Apr 1-3, 1970.

Descriptors: *Sewage treatment, *Water purification, *Treatment facilities, *Water reuse, Cost analysis.
Identifiers: *Tahoe treatment plant, *Windhoek treatment plant.

Two sewage treatment plants have shown that technology does exist to meet the stringent environmental quality standards on wastewater. By 1970, the Tahoe plant will have pumped one and one-half billion gallons of purified waste water into a new reservoir for water sports and irrigation; and, the Windhoek (South West Africa) sewage purification plant, using a different system, will have supplied nearly one-third of the drinking water for a city of 30,000 people for more than a year. The paper presents illustrations, flowsheets, and cost data on the world's two most advanced waste water treatment plants.

431
THE REUSE OF TREATED MUNICIPAL WASTE BY THE MIDLAND DIVISION, THE DOW CHEMICAL COMPANY,

E.S. Shannon and A. Maass
Paper presented at the Am Water Works Assoc, Annual Conference, Washington, D.C., Jun 21-26, 1970.

Descriptors: *Sewage treatment, *Chlorination, *Estimated costs, Water supply, *Water reuse, Water quality, Trickling filters.
Identifiers: *Midland, Michigan.

In June 1969, the Dow Chemical Company started to take into its cooling water and fire protection system the treated sewage from the city of Midland, Michigan. The supplemental water supply will provide up to seven million gallons per day of relatively high quality water and the reservoir will provide a three million gallon fire water supply. The Midland waste water treatment system consists of primary, and two stage trickling filter secondary treatment, followed by chlorination. There is also a three million gallon reservoir, two six thousand gallon per minute pumps, and associated controls and piping. The total cost of the project is estimated at $500,000.

432
NEW INFORMATION NEEDS FOR WATER MANAGEMENT IN URBAN REGIONS,

John R. Sheaffer
Paper presented at the Am Geophys Union - 1969 National Fall Meeting.

Descriptors: *Water management (applied), *Investigations, *Michigan, *Water resources, Pollutants, Planning.
Identifiers: *Urban water resource management.

To illustrate the new information needs for water management in urban areas, a case study of a waste water management plan is described and the types of data required in the formulation of the plan are identified. Muskegon County, Michigan, is the study area. The basic management concept set forth in the research creates new information needs. The concept is one of utilizing pollutants as resources out of place and, thus, converting them into economic goods. This goal is accomplished by taking the waste from the water, processing it, and putting it on the land, where it becomes useful and valuable. The environmental implications and the data needs for such a program can be viewed readily in the context of this new type of urban water resource management. It is obvious that adjustments in mapping techniques will be necessary to accommodate future management efforts.

433
SEWERAGE AND SEWAGE TREATMENT,

Ralph Stone
"Sewerage and Sewage treatment: State-of-the-Art Abstracts",
J Sanit Eng Div, Am Soc Civil Engr, Vol 96, SA1, pp 35-48, Feb 1970.

Descriptors: *Waste treatment, *Sewage treatment.
Identifiers: *Abstracts.

Abstracts of 13 on-going research projects are given. The summaries consider activated sludge effluent, clarification processes, ecology in waste stabilization ponds, wastewater treatment by ion-exchange resins, plant operating costs, fly ash filters, wastewater aeration, individual home waste treatment systems, oxygenation, sulphides, and other problems. This paper has been prepared as an activity of the Committee with significant information on waste treatment, inclusive of subjects of research and demonstration projects.

434
SEWAGE-TREATMENT PLANT,

G. Talon
Abwass, Vol 14, No 12, pp 17-18, 1967.

Descriptors: *Sewage treatment, *Aeration, *Storage tanks, *Equipment, Flow control.
Identifiers: *Compressed-air lift.

Modifications are examined in relation to preliminary aeration equipment in a sewage-treatment plant. The incoming sewage, instead of passing through a grit chamber and storm-sewage overflow, is conveyed directly to a holding tank, inside of which is a container whose upper rim is at the same height as that of the plant itself. A compressed-air lift, mounted in the holding tank above the bottom of the tank, comprises a vertical shaft with aeration jets. This compressed-air lift has a two-fold effect: it lifts the sewage into the treatment tank, and it provides primary aeration.

435
SOME STRUCTURAL DESIGN CONSIDERATIONS IN OXFORD SEWAGE WORKS EXTENSIONS,

M.G. Tassell
Surveyor, Vol 85, No 4047, pp 31-34,36, Jan 2, 1970. 7 fig.

Descriptors: *Sewage treatment, *Treatment facilities, *Structural design, *Structural engineering.
Identifiers: *Great Britain.

This article discusses extensions to the Oxford sewage purification works. The design approach to two widely differing water retaining structures, the primary settlement and storm/balancing tanks and the elevated wash water tank to the sand filtration unit, are considered in some detail. The common thread was the elimination, where possible, of complex stresses either by introducing hinges or movement joints. Shrinkage cracking is more difficult to avoid. Possible methods of reducing such cracking are discussed. The importance of efficient and continuous curing from the moment the shuttering is struck, or in the case of slabs, from the time of initial set is emphasized.

436
NEW CONSTRUCTION AND PLANS FOR THE TOWN DRAINAGE OF FLENSBURG,

H. Wagner
Ber Abwassertech Ver (BABVAD), No 17, pp 27-37, 1964.

Descriptors: *Design, *Drainage programs, *Sewage treatment, *Sewerage, Sludge treatment.
Identifiers: *Germany.

After a brief description of existing sewage works for the town of Flensburg, the author outlines plans for expansion of the sewerage water overflow of 960 litres per sec, also receives heavily polluted wastewaters from nearby slaughterhouses, increasing the five-day BOD system in this area. The plant, which at present serves a population of 90,000 with a dry-weather flow of 320 litres per sec, and a storm-to 1200 mg per litre. To reduce the heavy load, the plan includes: additional pumping stations at Galwick; the extension of the pressure pipeline to a length of 1450 m; and a treatment plant equipped for the activated-sludge process, with sludge digestion followed by thickening and drying on beds, and disposal at sea by ships.

437
RIVER ENGINEERING AND WATER CONSERVATION WORKS: CHAPTER 7 - RUNOFF FROM COMBINED RURAL AND URBAN AREAS,

L.H. Watkins
Butterworths, London, pp 111-121, 1966. 5 fig, 4 tab, 4 ref.

Descriptors: *Hydrographs, *Hydrologic aspects, Rational formula, Rainfall.
Identifiers: *Urban runoff, *Great Britain, RRL.

Hydrologic principles of the calculation of runoff from rural areas are also applicable to urban and combined rural and urban catchments. However, traditionally urban runoff has been calculated by a variation of the basic method called the Rational Formula or the Lloyd-Davies formula. This formula has been shown to be reliable only for very small urban catchments, and it is being replaced by the R.R.L. Hydrograph method. This chapter discusses the R.R.L. Hydrograph method based on climatic conditions in Great Britain. In order for this method to be applied elsewhere, suitable rainfall data must be employed and adequate allowance made for increased impermeability of natural surfaces, particularly under conditions of tropical rainfall. (See abstract number 316)

438
OVERVIEW OF TREATMENT METHODS,

Darwin R. Wright
In: Combined Sewer Overflow Seminar Papers, Edison, N.J., Nov 4-5, 1969 Water Pollution Control Research Series, Report DAST-37, pp 53-58, Mar 1970.

Descriptors: *Overflow, *Treatment.
Identifiers: *Overview, Combined sewers, Treatment methods.

The importance of a varying waste is emphasized in relation to the treatment of combined sewer overflows. The three different treatment methods employed are: physical treatment, biological treatment, and chemical-physical treatment. Examples of these methods are included along with discussions on their results.

Section 9

HYDROLOGY

439
BASIC DATA FOR URBAN HYDROLOGY STUDY, DALLAS, TEXAS - 1967,

Geol Surv Open-file Rep, 1969. 80 p, 3 fig, 1 tab, 6 ref, append.

Descriptors: *Floods, *Hydrologic data, *Data collections, *Texas, *Urbanization, Rainfall-runoff relationships, Runoff, Streamflow, Hydrographs, Storm runoff.
Identifiers: *Dallas, Texas, *Urban hydrology.

This report presents the basic hydrologic data collected during the 1967 water year (October 1, 1966, to September 30, 1967). Basic data were collected for urban hydrology studies to: determine the magnitude, frequency, and areal extent of flooding; document and define floods of greater than ordinary magnitude; and, determine the effect of urban development on flood peaks and volume on small streams in Dallas, Texas.

440
COMPILATION OF HYDROLOGIC DATA, GREEN CREEK, BRAZOS RIVER BASIN, TEXAS - 1967,

Geol Surv Open-file Rep, 1969. 34 p, 2 fig, 3 tab, append.

Descriptors: *Small watersheds, *Rainfall-runoff relationships, *Data collections, *Hydrologic data, *Texas, Streamflow, Stage-discharge relations, Storm runoff, Flood control, Floods, Stream gages, Gaging stations, Flow characteristics, Low flow, Peak discharge, Hydrographs, Mass curves, Duration curves, Storm drains.
Identifiers: Green Creek, Texas, Brazos River basin, Texas.

Rainfall and runoff data were collected during the 1967 water year for the 46.1-square-mile area above the stream-gaging station Green Creek near Alexander, Texas. The locations of floodwater-retarding structures and hydrologic instruments in the area are shown on a map. Data are to be used to determine the net effect of floodwater-retarding structures on the regimen of streamflow at downstream points, to develop computation techniques that will provide more accurate estimates of runoff resulting from a given amount of rainfall on small watersheds, and to develop relationships between maximum rates of runoff and rainfall in small watersheds that will enable more accurate design of small storm-drainage structures.

441
COMPILATION OF HYDROLOGIC DATA, HONEY CREEK, TRINITY RIVER BASIN, TEXAS - 1967,

Geol Surv Open-file Rep, 1969. 68 p, 2 fig, 3 tab, append.

Descriptors: *Small watersheds, *Rainfall-runoff relationships, *Data collections, *Hydrologic data, *Texas, Streamflow, Stage-discharge relations, Storm runoff, Flood control, Floods, Stream gages, Gaging stations, Flow characteristics, Low flow, Peak discharge, Hydrographs, Mass curves, Duration curves.
Identifiers: Honey Creek, Texas, Trinity River basin, Texas.

Rainfall and runoff data were collected during the 1967 water year for the 39.0-square-mile area above the stream-gaging station Honey Creek near McKinney, Texas. The location of floodwater-retarding structures and hydrologic instruments in the area are shown on maps. Data are to be used to determine the net effect of floodwater-retarding structures on the regimen of streamflow, to determine the effect of the structures on the sediment yield of the basin and to determine the trap efficiency of the structures, to develop computation techniques that will provide more accurate estimates of runoff, to develop relationships between maximum rates of runoff and rainfall to enable more accurate design of small storm-drainage structures, to determine the minimum instrumentation necessary, and to determine the quality of the water, its suitability for use, and its flocculating characteristics as they affect the sediment-trap efficiency of the pools.

442
COMPILATION OF HYDROLOGIC DATA, MUKEWATER CREEK, COLORADO RIVER BASIN, TEXAS - 1967,

Geol Surv Open-file Rep, 1969. 87 p, 2 fig, 3 tab, append.

Descriptors: *Small watersheds, *Rainfall-runoff relationships, *Data collections, *Hydrologic data, *Texas, Streamflow, Stage-discharge relations, Storm runoff, Flood control, Floods, Stream gages, Gaging stations, Flow characteristics, Low flow, Peak discharge, Hydrographs, Mass curves, Duration curves.
Identifiers: Mukewater Creek, Texas, Colorado River basin, Texas.

Rainfall and runoff data were collected during the 1967 water year for the 70.0-square-mile area above the stream-gaging station on Mukewater Creek at Trickham, Texas. The location of floodwater-retarding structures and hydrologic instruments in the area are shown on a map. Data are to be used to determine the net effect of floodwater-retarding structures on the regimen of streamflow at downstream points, to develop computation techniques that will provide more accurate estimates of runoff, to develop relationships between maximum rates of runoff and rainfall in small watersheds that will enable more accurate design of small storm-drainage structures, to determine the minimum instrumentation necessary to make reliable estimates of total storm inflow to the structures, and to determine the quality of the water, its suitability for use, and its flocculating characteristics as they affect the sediment-trap efficiency of the pools.

443
COMPILATION OF HYDROLOGIC DATA, NORTH CREEK, TRINITY RIVER BASIN, TEXAS - 1967,

Geol Surv Open-file Rep, 1969. 27 p, 2 fig, 2 tab, append.

Descriptors: *Small watersheds, *Rainfall-runoff relationships, *Data collections, *Hydrologic data, *Texas, Streamflow, Stage-discharge relations, Storm runoff, Flood control, Floods, Stream gages, Gaging stations, Flow characteristics, Low flow, Peak discharge, Hydrographs, Mass curves, Duration curves, Storm drains.
Identifiers: North Creek, Texas, Trinity River basin, Texas.

Rainfall and runoff data were collected during the 1967 water year for the 21.6-square-mile area above the stream-gaging station North Creek near Jackson, Texas. The location of proposed floodwater-retarding structures and hydrologic instruments in the area are shown on a map. Data are to be used to determine the net effect of floodwater-retarding structures on the regimen of streamflow at downstream points, to develop computation techniques that will provide more accurate estimates of runoff resulting from a given amount of rainfall, to develop relationships between maximum rates of runoff and rainfall in small watersheds that will enable more accurate design of small storm-drainage structures, to check the applicability of flood-routing procedures and techniques for small watersheds, and to determine the quality of the water, its suitability for use, and its flocculating characteristics as they affect the sediment-trap efficiency of the pools.

444
COMPILATION OF HYDROLOGIC DATA, PIN OAK CREEK, TRINITY RIVER BASIN, TEXAS - 1967,

Geol Surv Open-file Rep, 1969. 25 p, 2 fig, 5 tab, append.

Descriptors: *Small watersheds, *Rainfall-runoff relationships, *Data collections, *Hydrologic data, *Texas, Streamflow, Stage-discharge relations, Storm runoff, Flood control, Floods, Stream gages, Gaging stations, Flow characteristics, Low flow, Peak discharge, Hydrographs, Mass curves, Duration curves.
Identifiers: Pin Oak Creek, Texas, Trinity River basin, Texas.

Rainfall and runoff data were collected during the 1967 water year for the 17.6-square-mile area above the stream-gaging station in Pin Oak Creek near Hubbard, Texas. The location of floodwater-retarding structures and hydrologic instruments in the area are shown on a map. Data are to be used to determine the net effect of floodwater-retarding structures on the regimen of streamflow at downstream points, to determine the effect of the structures on the sediment yield of the basin and to determine the trap efficiency of the structures, to develop computation techniques that will provide more accurate estimates of runoff, to develop relationships between maximum rates of runoff and rainfall in small watersheds that will enable more accurate design of small storm-drainage structures, to determine the minimum instrumentation necessary to make reliable estimates of total storm inflow to the structures, and to determine the quality of the water, its suitability for use, and its flocculating characteristics as they affect the sediment-trap efficiency of the pools.

445
COMPILATION OF HYDROLOGIC DATA, WALLER AND WILBARGER CREEKS, COLORADO RIVER BASIN, TEXAS - 1966,

Geol Surv Open-file Basic-data Rep, 1968.

Descriptors: *Data collections, *Streamflow, *Urbanization, Stream gages, Rainfall-runoff relationships, Texas, Hydrologic data, Water year, Small watersheds, Hydrographs.
Identifiers: Austin, Texas, Waller Creek, Texas, Wilbarger Creek, Texas, Urban hydrology.

Streamflow data are compiled for comparison of Waller Creek, an entirely urban stream in Austin, Texas, and Wilbarger Creek, in a geologically and topographically similar setting in a rural area, for urban hydrological studies. Data are tabulated on a regular daily basis and for individual storms for the water year 1966. Each stream gaging station record includes location, drainage area, availability of records, gage type, extreme flow events, remarks, and daily gage records for the year. Hydrographs are used to show storm rainfall-runoff relationships.

446
CALIFORNIA HIGH WATER, 1965-1966,

California, Dept Water Resources--Bul 69-66, Aug 1967.

Descriptors: *California, *Rainfall, *Runoff, *Meteorological data, Storms, Flood damage, Storm runoff.

The report provides information on meteorology, rainfall-runoff, and damages resulting from major storms of the 1965-66 water year. It describes general weather patterns preceding and during storm periods (including precipitation characteristics), and discusses resulting runoff in seven hydrograph areas of state. The report presents information on flooded areas and the damages encountered.

447
HYDROLOGY ANNUAL NO. 14 - 1966,

Soil Conserv and Rivers Control Council Annual Hydrol Rep, 1968. 247 p, 5 fig, 19 ref.

Descriptors: *Data collections, *Hydrologic data, *Bibliographies, Streamflow, Stream gages, Snow surveys, Snow cover, Low flow, Floods, Discharge (water), Recession curves, Sediment load, Suspended load, Water quality, Channel morphology, Stage-discharge relations.
Identifiers: *New Zealand.

Hydrologic data collected at 25 stations in New Zealand in 1966 are tabulated. Collected data include a list of streamflow stations, precipitation gages, sediment gages, water quality stations, snow courses, groundwater observation sites, representative and experimental basins, streamflow tables, snow survey data, recession curves, suspended sediment rating curves, water quality data, flood data, and channel morphology and efficiency surveys. An annotated bibliography of hydrological papers about New Zealand and by New Zealand authors is included. Addresses of all local hydrological and meteorological authorities and agencies collecting data are also included.

448
THAI AIR BASE FLOOD CONTROL,

T. L. Adams and A. C. McNulty
Military Engr, Vol 61, No 403, pp 361-362, Sep-Oct 1969. 1 diag.

Descriptors: *Flood control, *Drainage systems, *Design storm, *Reservoir storage, Runoff.

Expansion of a Royal Thai Air Force Base necessitated development of a flood control system to alleviate drainage problems. An area-wide drainage study considered four possible solutions: (1) a concrete-lined trapezoidal channel to carry runoff around the new runway overrun; (2) a collection basin and pump near the runway; (3) a multicell box culvert under the runway extension; and (4) a flood control storage reservoir with controlled discharge. The economics and feasibility of the four plans were discussed based on a two-year design storm condition, and the storage reservoir method was decided upon. Interior base drainage consisted of a system of ditches, collection channels, and storage basins, plus three pump stations. The new flood control system will also somewhat relieve flooding of the neighboring city by decreasing the runoff rate to it.

449

ADAPTION OF ELECTRONIC COMPUTER FOR IMPROVED METHOD OF MODELING SURFACE RUNOFF FROM RAINFALL FOR SMALL WATERSHEDS,

Roger A. Amisial and J. Paul Riley
Symp on Use of Analog and Digital Computers in Hydrol, Dec 1968, Vol 2, Int Assoc Sci Hydrol, Publ No 81, p 392-404, 1968.

Descriptors: *Model studies, *Rainfall-runoff relationships, *Small watersheds, *Analog models, *Arizona, Routing, Streamflow forecasting, Mathematical models, Streamflow, Hydrographs, Synthetic hydrology, Analog computers, Overland flow.
Identifiers: Walnut Gulch, Arizona.

In the field of surface water hydrology, the fundamental equations of motion and continuity adequately portray the overland and channel flow phenomena. The differential equations, however, are not easily amenable to solution, and their integration in closed form can be obtained only for extremely simplified cases. Techniques of integration by numerical methods have been developed, which can be handled by use of electronic computers. Combined with basic mathematical operations, the electronic analog computer can be successfully employed in the solution of surface runoff models described in terms of the 2 fundamental equations. The watershed is divided into subzones based on topography or physiography. The subzone is simulated by an equivalent rectangular basin transected by the main stream channel. Using the 2 fundamental equations of flow, the water is routed over the basin slopes with the rainfall as input and through the channel system which receives lateral flow from the basin slopes. Models based on the derived equations and on simplified forms of these equations are being developed in an attempt to assess the validity of these equations for some simplifying assumptions made in the usual routing procedures. Tests of the mathematical models are being made by simulating subbasins of the Walnut Gulch Experimental Watershed near Tombstone, Arizona.

450
GENERALIZED ANALYSIS OF SMALL WATERSHED RESPONSES,

J. Amorocho
Technical Completion Report WRC No 133, California Water Resources Center, Nov 1969. 5 p, 5 ref. OWRR Project B-005-CAL.

Descriptors: *Small watersheds, *Surface runoff, *Rainfall-runoff relationships, *Model studies, Storm runoff, Streamflow, Flood prediction, Snowmelt, Demonstration watersheds.

Several topics were investigated under the general heading 'Generalized Analysis of Small Watershed Responses.' Each topic resulted in a self-contained report: (1) The functional series representation for nonlinear physical system was used to develop a method permitting the determination of a nonlinear prediction equation and the nonlinear response functions for hydrologic systems. The method was tested successfully using rainfall and stream flow data of a small California watershed. (2) A method of curve fitting was applied to precipitation data of an array of rain gages in a small California watershed to obtain a functional representation of the time and space distribution of storm rainfall. This method may be used for the establishment of criteria for precipitation network design and for the analysis of watersheds and nonlinear systems with distributed input fields. (3) A simply cascade model of the rainfall-runoff process was developed to test whether the design of more complex mathematical models is justified from the standpoint of runoff prediction. (4) A detailed mathematical model of the physical processes producing snowmelt was developed. It is suitable for the prediction of net watershed inputs due to the fusion of snowfields, and may be incorporated into a comprehensive watershed model. (5) A study of the accuracy of the prediction of floods of high return period was conducted. It provided expressions for the standard errors of sample estimates of flood magnitudes corresponding to given return periods for normal and double exponential universes. Jointly these topics contribute to a better understanding of various statistical and physical aspects of small watershed behavior.

451
THE NONLINEAR PREDICTION PROBLEM IN THE STUDY OF THE RUNOFF CYCLE,

J. Amorocho
Water Resources Res, Vol 3, No 3, pp 861-880, 1967. 20 p, 12 fig, 32 ref.

Descriptors: *Forecasting, *Rainfall-runoff relationships, *Synthetic hydrology, *Sequential generation, Mathematical models, Simulation analysis.
Identifiers: *Hydrologic systems, Nonlinear systems, Nonlinear synthesis, Uncertainty.

The general theory of nonlinear synthesis and analysis in hydrology is discussed, with particular reference to the problems of predictive uncertainty. These problems are associated with incomplete descriptions of the hydrologic systems, limited model-prototype equivalences, system variability in time, and system nonlinearity. Solutions to the nonlinear analysis problem of hydrologic systems under the assumption of approximate time invariance, based on complex cascade network approximations, power series and polynomial expansions, and variable response function approximations are presented. The relations between present theoretical knowledge and its practical application are summarized.

452
DISCUSSION ON PAPER BY J. AMOROCHO, "THE NONLINEAR PREDICTION PROBLEM IN THE STUDY OF THE RUNOFF CYCLE",

J. Amorocho, Ray K. Linsley, and Norman H. Crawford
Water Resources Res, Vol 4, No 3, pp 684-688, Jun 1968. 3 ref.

Descriptors: *Synthetic hydrology, Mathematical models.
Identifiers: *Probability distribution, *Output comparison, *Heisenberg principle.

R. K. Linsley and N. H. Crawford: The authors uphold and dispute some of the conclusions of Amorocho's paper. They dispute the application of Heisenberg's uncertainty principle to hydrology. Also, they question Amorocho's suggestion for an evaluation of the probability distribution of the difference between outputs computed by a model and outputs measured in the prototype system. The authors support the opinion regarding the futility of pursuing strict determinism in hydrologic research. J. Amorocho: In response to the above objections to the application of the Heisenberg principle to hydrology, he supports his statements with examples. He also defends his other conclusions, and he agrees with the discussers' opinion regarding the advantages of some knowledge of the structure of hydrologic processes.

453
A CRITIQUE OF CURRENT METHODS IN HYDROLOGIC SYSTEMS INVESTIGATION,

J. Amorocho and W. E. Hart
Trans Am Geophys Union, Vol 45, No 2, pp 307-321, Jun 1964.

Descriptors: *Parametric hydrology, *Synthetic hydrology, *Correlation analysis, *Synthesis, *Statistical models, Rainfall-runoff relationships.
Identifiers: *Nonlinear analysis.

The paper presents a critical review of current methods employed for the establishment of quantitative relationships between precipitation and runoff in hydrology. These procedures, which are classified under the general categories of "parametric" and "stochastic" hydrologies, include the methods of correlation analysis, partial and general synthesis, general nonlinear analysis, and statistical simulation. They are studied as mathematical models of the hydrologic systems, having specific theoretical properties and limitations. The structures of these models are examined with the aid of flow charts, and the areas of their optimum application are suggested.

454
EFFECTS OF URBAN DEVELOPMENT ON FLOODS IN NORTHERN VIRGINIA,

Daniel G. Anderson
Geol Surv Open-file Rep, 1968. 26 p, 5 fig, 5 tab, 9 ref.

Descriptors: *Floods, *Urbanization, *Virginia, *Flood routing, Drainage systems, Storm runoff, Hydrographs, Hydrograph analysis, Routing, Forecasting, Time lag.
Identifiers: Urban hydrology, Urban floods, Flood peaks.

Graphical and mathematical relations are presented to estimate the flood peak magnitudes having recurrence intervals ranging up to 100 yr for drainage basins with various degrees of urban or suburban development. Five independent variables are required for use of the relations. They are basin size, length, and slope which may be measured from maps, and percentage of impervious surface and type of drainage system which may be evaluated by a basin inspection, but which in actual practice will usually be estimated for future developed conditions. The estimating relations are based upon analysis of flood information for 81 sites, 59 of which are in the Washington, D. C. metropolitan area. The relations are judged to be of adequate accuracy for design of drainage systems and for definition of flood limits. Urban and suburban development are shown to significantly affect flood flows. Improvements to 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 2 to nearly 8. The flood peak increase depends upon the drainage basin characteristics and the flood-recurrence interval.

455
RAINFALL AND STREAMFLOW FROM SMALL TREE-COVERED AND FERN-COVERED AND BURNED WATERSHEDS IN HAWAII,

H. W. Anderson, P. D. Duffy, and Teruo Yamamoto
US Forest Service Research Paper PSW-34, pp 1-10, 1967.

Descriptors: *Rainfall-runoff relationships, *Peak discharge, *Storm runoff, *Hydrologic properties, *Watershed management, *Burning, Reforestation, Ferns, Trees, Analytical techniques, Hawaii.
Identifiers: Principal components analysis.

Streamflow from two 30-acre watersheds near Honolulu was studied by using principal components regression analysis. Models using data on monthly, storm, and peak discharges were tested against several variables expressing amount and intensity of rainfall, and against variables expressing antecedent rainfall. Explained variation ranged from 78 to 94 percent. The analysis provided some clues as to the dominant hydrologic processes under three different watershed conditions. The lack of change in the coefficients relating precipitation to runoff in the pre- and post-fire periods may be interpreted as indicating that the burning of the watershed had little effect on the infiltration of percolating capacity--at least not in the range such as to affect rainfall excess or storm interflow or both. On the other hand, the increase in the regression constant indicates that the burning of the watershed had its expected effect in reducing any storage that was readily available for evaporation, such as the interception storage.

456
REAL-TIME COMPUTER CONTROL OF URBAN RUNOFF,

James J. Anderson
J Hydraul Div, Am Soc Civil Engrs, Vol 96, No HY1, pp 153-164, Jan 1970. 19 fig, 10 ref. FWPCA Grant No 1-Minn.-1. Paper presented at the ASCE Hydraulics Division Conference, M. I. T., Cambridge, Massachusetts, Aug 21-23, 1968.

Descriptors: *Runoff, *Hydraulics, *Mathematical models, *Urbanization, *Water control, *Digital computers, *Separation techniques, Drainage systems, Flow control, Monitoring, Gaging stations, Water management (applied).
Identifiers: *Combined sewers, Interceptor sewer, Computer control.

A real-time process computer control is being built in the Minneapolis - St. Paul Sanitary District to drastically reduce combined sewer overflows without incurring the huge cost and lengthy construction time involved in installing a separate sewage system in place of combined sewers. The use of the mathematical model of this interceptor sewer system will aid remote operation of gate settlings and runoff diversion devices via a computerized supervisory system. Through data processing techniques a river quality monitoring program, the amount, nature, and effects of overflow wastes of the Mississippi River will be evaluated. Diagrams of the format for the new system are included in addition to data predicting its future effectiveness.

457
A PORTABLE RAINFALL SIMULATOR AND RUNOFF SAMPLER,

J. U. Anderson, A. E. Stewart, and P. C. Gregory
N Mex Agricultural Experiment Station Res Rept 143, October 1968. 8 p, 7 photo, 1 tab, 5 ref. OWRR Project A-004-NMEX.

Descriptors: *Rainfall simulators, Surface runoff, Water yield, Sediment yield, Equipment.

The device applies water to 16 x 20 foot plots at rates up to 8 inches per hour with kinetic energy approximating that of natural rainfall. It also samples and records the rate of runoff in such a way that sediment production can be measured accurately. The major components are: (1) a 1500 gallon tank truck for transporting water and apparatus, (2) a demountable aluminum framework and moving spray assembly for applying water, and (3) a device for sampling and measuring the rate of runoff. Two men can assemble it and put it in operation in one and a half hours. The sampler takes representative 1.76 plus or minus .03% or 10.68 plus or minus .04% samples.

458
VARIATION IN LAG TIME FOR NATURAL CATCHMENTS,

Arthur J. Askew
J Hydraul Div, Am Soc Civil Engrs, Vol 96, No HY2, pp 317-330, Feb 1970.

Descriptors: *Runoff forecasting, Rainfall-runoff relationships, Time lag.

Lag time for a catchment is shown to be a variable which is strongly correlated with flood magnitude, and the use of direct rather than surface runoff increased the degree of this correlation and offered other potential advantages. Values for various parameters of rainfall and runoff were derived from the analysis of records for five small catchment areas. Lag time is defined as the time between the centers of mass of excess rainfall and direct runoff. Weighted mean discharge is used as the measure of average streamflow magnitude. No significant correlation is found between the lag and various characteristics of the areal and temporal distribution of rainfall. Therefore, the lag-weighted mean discharge equations best represent the variable lag time for the catchments studied.

459
LAG TIME OF NATURAL CATCHMENTS,

Arthur J. Askew
New South Wales Univ Water Res Lab Rep No 107, July 1968. 209 p, 42 fig, 10 tab, 52 ref, 5 append.

Descriptors: *Rainfall-runoff relationships, *Routing, *Runoff forecasting, *Mathematical models, *Computer programs, Hydrographs, Hyetographs, Hydrograph analysis, Synthetic hydrology, Time lag
Identifiers: *Australia.

An investigation was made of the values of lag time for natural catchment areas, as measured from center of mass of excess-rainfall to center of mass of resulting runoff. Any variation in this value for an individual catchment is an indication of a nonlinear response. Values of lag were measured for a range of floods on 5 catchment areas. The difference in value between catchments was found to be a function of the catchments' characteristics, while variation in the values for an individual catchment was strongly related to the magnitude of the floods. As the degree of this variation was fairly constant for the areas studied, the degree of nonlinearity was also considered to differ little between the catchments. The development of 3 general formulae required a detailed analysis to be made of a large volume of hydrologic data by an objective systematic procedure. For this purpose lag was measured to the center of mass of direct runoff and a weighted mean discharge measure of flood magnitude was devised. Numerous hyetograph characteristics were measured and studied, but none appeared to have any significant influence on the value of lag time. Computer program listings for computing lag-discharge relationships and for regression analysis of lag-discharge relationships are included.

460
MAN'S INFLUENCE ON HYDROLOGICAL PHENOMENA,

J. Balogh and I. Matrai
2nd Int Postgrad Course on Hydrol Methods for Develop Water Resources Mange, Budapest, Hungary, Manual No 14, 1968.

Descriptors: *Water management (applied), *Flood control, *River training, Irrigation, Drainage systems, Land management, Reservoir operation, Water demand, Watershed management, Water utilization, Water quality, Forest management, Runoff, Streamflow, Ice, Navigation, Water pollution, Urbanization, Industries, Agriculture.
Identifiers: *Technical manuals.

The effects on the hydrologic cycle of human water-controlling activities, which include urbanization, agriculture, forestry, industry, and commerce, are examined in this technical manual. Agricultural and forestry activities modify the water budgets of entire drainage basins, which change runoff precipitation, and other quantitative factors, but they have relatively little effect on quality. Commercial, industrial, and urbanization activities have much less effect on quantity than on water quality. Much of man's water demand must be met by use of groundwater. The effects of flood control and river training works on stream hydrology and the effect of human uses of catchment areas are discussed in detail. Water management efficiency and various management techniques are evaluated.

461
ESTIMATING DESIGN FLOODS FROM EXTREME RAINFALL,

Frederick C. Bell
Colorado State Univ, Hydrol Paper No 29, Jul 1968. 21 p, 20 fig, 5 tab. ~' ref.

D scriptors: *Design flood, *Rainfall, *Precipitation (atmospheric), *Forecasting, *Storm runoff, Watersheds (basins), Drainage basins, Bibliographies, Hydrology, Floods, Small watersheds, Hydrologic data, Time lag, Flood forecasting, Flood hydrographs, Flood peaks, Design storm, Rainfall-runoff relationships, Rational formula.
Identifiers: Flood hydrology.

Distinct differences exist between estimating specific floods from data on specific rainfall events and estimating design or representative floods from rainfall statistics. The latter should be regarded as a more generalized procedure in which high accuracy cannot be expected. Many physical details of specific events are irrelevant for estimating representative events. A single parameter is sufficient to express the time-distributing characteristics of a watershed for design purposes. The suggested parameter is the representative lag, closely related to the volume/peak ratio. For small watersheds in the western U. S., the same return period may be assigned to the design flood and the corresponding extreme rainfall. This finding is not expected to apply to all climatic situations, but may be a reasonable assumption in the absence of any other information. The rational-loss rate method is suggested for estimating extreme floods from extreme rainfall because of its simplicity, flexibility, and consistency with the requirements and limitations of the problem. This method does not give satisfactory reproductions of the 10-yr floods on the test watersheds and cannot be strongly supported by this performance.

462
USING ANALYTICAL METHODS TO DEVELOP A SURFACE-RUNOFF MODEL,

Roger P. Betson, Russell L. Tucker, and Faye M. Haller
Water Resources Res, Vol 5, No 1, pp 103-111, Feb 1969. 9 p, 5 fig, 2 tab, 5 ref.

Descriptors: *Rainfall-runoff relationships, *Runoff forecasting, *Analytical techniques, Rainfall intensity, Antecedent precipitation, Meteorology, Mathematical models, Computer models, Digital computers, Surface runoff, Graphical analysis.
Identifiers: Analytical models.

By using analytical methods, successive restrictions were imposed on a mathematical version of the U. S. Weather Bureau's graphical surface-runoff model to develop an analytical model that expresses the API (Antecedent precipitation index)-runoff relations with 2 equations and

5 coefficients. The analytical model is similar in concept to the graphical model in that both relate rainfall, week number, and the API measure to surface runoff. The concise relations of the analytical model, however, can be rapidly derived from a historical storm list by computer. When tested, runoff relations, derived with the analytical model over selected watersheds, predicted surface runoff from those watersheds somewhat better than the regional, graphical relations developed for the Tennessee Valley.

463
ANALYTICALLY DERIVED UNIT GRAPH AND RUNOFF,

Roger P. Betson and Ralph F. Green
J Hydraul Div, Am Soc Civil Engrs, Vol 94, No HY6, pp 1489-1505, Nov 1968.

Descriptors: *Runoff, Hydrologic aspects.
Identifiers: Parametrics.

A technique has been programmed to solve analytically for measures of precipitation excess and unit graph shape parameters. The optimization procedures achieved a very high degree of adjustment of the model to data, but the results were inconsistent. The development of an objective fitting technique is described. A two-step fitting procedure was devised which substantially increased the objectivity of the fitting technique. The two shape parameters were first individually corrected by a univariate technique to near-optimum values. This reduced the effect of the higher-order partial derivatives with respect to the shape parameters. The simultaneous differential correction technique was then used to obtain corrections for both the shape parameters and the runoff parameters. While this two-step solution technique does not yield exact results, they are close enough to the desired values and can be obtained consistently from different starting points.

464
EFFECTS OF URBANIZATION ON PEAK FLOWS,

E. F. Brater and Suresh Sangal
In: Effects of Watershed Changes on Streamflow, Water Resources Symposium No 2, Austin, Texas, October 1968, University of Texas Press, Austin and London, pp 201-214, 1969. 14 p, 8 fig, 36 ref.

Descriptors: *Urbanization, *Rainfall-runoff relationships, *Storm runoff, *Routing, Hydrograph analysis, Model studies, Mathematical models, Simulation analysis, Infiltration, Runoff, Overland flow, Peak discharge, Floods.
Identifiers: Urban hydrology.

Study of the effect of urbanization on peak flows requires the best possible knowledge of the runoff process. The volume of surface runoff is the rainfall minus infiltration and permanent retention. Some of the impermeable portions of basins result from urbanization and their magnitude must be considered in computing the infiltration capacity. Hydrologically significant impermeable area is probably smaller than the actual impermeable area, and there is evidence that it is related to population density. For basins near Detroit the significant value varies from 1% to 10%, for population densities varying from about 500 to 7,000 per square mile. Many routing techniques may provide the basis for a mathematical model of the hydraulics of storm runoff. One method of evaluating the influence of urbanization on the runoff hydrograph is to study relationships between unit hydrograph shape parameters and some measures of drainage basin characteristics. Much work has been and is being done to help find better ways of predicting peak flows from rainfall, and more emphasis is being placed on the determination of the effect of urbanization.

465
RAINFALL-RUNOFF RELATIONS FOR SOUTHEASTERN LOUISIANA AND SOUTHWESTERN MISSISSIPPI,

Anthony J. Calandro
Louisiana State Dep Public Works Tech Rep No 2a, 1967. 61 p, 2 fig, 3 tab, 11 ref, append.

Descriptors: *Rainfall-runoff relationships, *Louisiana, *Mississippi, Hydrographs, Hydrograph analysis, Data collections, Rainfall, Runoff, Statistical models, Regression analysis, Antecedent precipitation, Duration curves, Runoff forecasting, Rain gages, Storm runoff
Identifiers: Thiessen methods.

A method for estimating storm runoff from rainfall records is presented for southeastern Louisiana and southwestern Mississippi. A rainfall-runoff relationship generally useful in the study area relates storm runoff to storm rainfall and the week of its occurrence. Values of weekly coefficients and exponents are tabulated. The standard error of estimate of this relationship for all storm is about 40%; for storm rainfalls greater than 4 inches, the standard error decreases to about 25%. With these limitations, the rainfall-runoff relations can also be used to distribute incremental rainfall excess with time. Records for 20 stream-gaging stations and 34 rainfall stations in the area studied were used to compute antecedent rainfall parameters, rainfall duration, total storm rainfall, and total runoff for 959 storm hydrographs. Graphical analysis indicates that regressions of rainfall versus runoff for each week of the year are as good as or better than regressions involving parameters of antecedent conditions and rainfall duration for estimating storm runoff. Apparently, the week-of-year factor accounts for seasonal variations in duration and antecedent conditions, and use of the seasonal factor alone will provide useful estimates of storm runoff in the area studied.

466
EXTENSION OF ROLE OF LINEAR SYSTEMS ANALYSIS IN HYDROGRAPH THEORY,

A. B. Carrasquilla and F. E. Perkins
M.I.T., Dept Civil Eng, Hydrodynamics Laboratory Report 106, Sept 1967.

Descriptors: Optimization, Mathematical studies, Systems analysis, Analytical techniques.

The extension of techniques developed for the identification of response characteristics from past rainfall-runoff records to the most general case within the framework of a single input-single output linear system theory--time variant system with nonzero initial conditions is discussed. The identification process is formulated as the optimization problem for minimization of the mean square error between predicted and observed outputs. It is shown that the representation of a kernel in linear parametric form reduces the optimization problem to a solution of a set of optimization formulation were developed.

467
HANDBOOK OF APPLIED HYDROLOGY,

Ven Te Chow, editor
McGraw-Hill Book Company, New York, 1964. 1491 p.

Descriptors: *Hydrology, *Water resources development, Oceanography, Hydrogeology, Geomorphology, Soil physics, Statistics, Water quality, Planning, Legislation.

This handbook contains a vast range of information on hydrology and water-resources technology with interdisciplinary coverage of information to date. Sections of the book, each authored separately, can be divided into four groups: (1) closely-related sciences upon which hydrology depends including oceanography, hydrogeology, geomorphology, soil physics, plant ecology, silviculture, fluid mechanics, statistics, probability, operations research, and electronic computers; (2) phases of the hydrologic cycle such as rainfall, snow, evapotranspiration, infiltration, groundwater, runoff, ice and glaciers, reservoir and river sedimentation, droughts and low streamflow, and water quality; (3) practice and application of hydrology including flow determination, flood routing, streamflow measurement, reservoir regulation, river forecasting, urban hydrology, agricultural lands, forests and rangelands, lakes and swamps, and arid and semiarid regions; and (4) socio-economic aspects of hydrology such as water resources planning and development, flood-plain adjustment and regulation, and water law and policy.

468
HANDBOOK OF APPLIED HYDROLOGY, SECTION 14, RUNOFF,

Ven Te Chow
McGraw-Hill Book Company, New York, pp 14:1 to 14:54, 1964. 15 graphs, 9 tab, 7 diag, 147 ref.

Descriptors: *Runoff, Surface runoff, Overland flow, Storm runoff.

The introduction to this section briefly defines terms such as surface runoff, overland flow, storm flow, groundwater runoff, storm runoff, etc. The rest of the section deals with the basic aspects of runoff including terminology, runoff phenomena, time and space distributions, variability, and other aspects not discussed elsewhere in the handbook. (See abstract number 467).

469
THE SPATIAL DISTRIBUTION OF STORM RAINFALL,

V. K. Collinge and D. G. Jamieson
J Hydrology, Vol 6, No 1, pp 45-47, 1968.

Descriptors: *Rain gages, *Storms, Topography, Hydrograph analysis.
Identifiers: *Storm rainfall, Rainfall-surface wind relationship, Great Britain.

This investigation employed a network of rain-gages to ascertain the average areal precipitation on major zones of the Tyne catchment in Northern England. The actual rainfall for each storm was compared to the predicted rainfall which was obtained by using past rainfall figures and surface-wind speed and direction for each storm. Errors between actual and predicted rainfall are tabulated, the mean percentage of error being 4.6%. In spite of the sparsity of rain-gage equipment and the small number of storms studied, this investigation demonstrated the direct relationship between spatial rainfall distribution and surface wind and topography. Using such parameters, estimations can be made of the average areal storm rainfall over subcatchments. This process could be extended to predict flood hydrographs at particular parts of a drainage system.

470
EFFECT OF URBANIZATION ON STORM WATER PEAK FLOWS,

Pedro C. C. Da Costa
J Sanit Eng Div, Am Soc Civil Engrs, Vol 96, No SA2, pp 187-193, Apr 1970.

Descriptors: *Rational formula, *Storm runoff, *Hydrology, Urbanization, Rainfall intensity.
Identifiers: *Storm sewers, Rainfall-runoff relationships, Sewer hydraulics

The rational formula, Q = c i A, may be considered a rough expression of the influence of urbanization on stormwater sewer flows. The unique runoff coefficient, c, is the product of three factors, each one having some correlation with the degree of urbanization given to the watershed. The presented general rational formula is related to the other rainfall - runoff relationships derived by Snyder and Horner - Flynt. Results from the formula are compared with those obtainable by the Chicago method. Modifications by urbanization are graphed. Variability of rainfall frequency is attributed to topographic and urban conditions.

471

POTENTIALLY BIGGEST RUNOFF FROM TORRENTIAL RAINFALLS,

Kazimierz Debski

Rozpr Hydrotech, Polska Akad Nauk, Part 23, pp 51-64, 1969. 14 p, 4 fig, 4 tab, 9 ref.

Descriptors: *Rainfall, *Runoff, *Streamflow, Watersheds (basins), Topography, Forecasting, Storm runoff, Synoptic analysis, Mathematical studies.
Identifiers: *Poland.

Stream runoff, as a result of torrential rainfalls, was analyzed on the basis of the data recorded by Polish hydrological gaging stations. The maximum runoff, as a result of a torrential rain is very different from a runoff formed by spreading rains. These 2 types of rain runoff cannot be expressed by a single formula common to these 2 phenomena. The peak rate of storm runoff increases with the growth of water basin and can be well represented by a definite monotonic function, whereas the peak runoff from a spreading rain increases with an increase in the water basin area, according to a definite parabolic function. The study also shows that under the same physiographic conditions the peak rate of a storm runoff in small basins is greater than that from spreading rains. In evaluating the runoffs from their corresponding rainfalls the Pagliari formula was adapted as the most suitable for the hydrogeological conditions prevailing in the Polish areas.

472

EVALUATION OF SEGMENTED IUH FROM DERIVATIVES,

M. H. Diskin

J Hydraul Div, Am Soc Civil Engrs, Vol 95, No HY1, pp 329-346, Jan 1969.

Descriptors: *Analytical techniques, Hyetographs, Hydrographs, Surface runoff, Precipitation excess.

A new method for analysis of rainfall excess hyetographs and direct surface runoff hydrographs, and for the derivation of instantaneous unit hydrographs is explained. The method is based on a theorem for the convolution of derivatives of functions and shows how derivatives of an assumed instantaneous unit hydrograph can be obtained from analysis of the shapes of an available rainfall excess hyetograph and a direct surface runoff hydrograph. Numerical examples accompany the development of the method and an example illustrating the application of the method is included.

473
RAIN-GAUGING PROGRAM TO PROVIDE GUIDE TO STORM SEWER DESIGN,

Harvey W. Duff, Russ L. Tobey, and George C. C. Hsieh
Water Sewage Works, Vol 116, No 11, pp 420-424, Nov 1969.

Descriptors: *Rain gages, *Data collections, *Storm drains, *Design criteria, *Electronic equipment, Computers.
Identifiers: *Rain data, *Storm sewers, *Seattle, Washington.

The Sewage and Drainage Section, Design Division of the Seattle, Washington, Engineering Department, is conducting a rain gaging program to provide sufficient precipitation data and storm data for urban-water studies for the purpose of determining a more realistic basis for the design of storm drain systems. Data for the program are obtained from electronic instruments and handled by a computer. It is estimated that only 0.2 percent of the possible data covering a four-year period is missing.

474
URBAN EFFECTS ON THE UNIT HYDROGRAPH,

William H. Espey, Jr., David E. Winslow, and Carl W. Morgan
In: Effects of Watershed Changes on Streamflow, Water Resource Symposium No 2, Austin, Texas, October 1968, University of Texas Press, Austin and London, pp 215-228, 1969. 14 p, 10 fig, 4 tab, 15 ref.
OWRR Project C-1098.

Descriptors: *Urbanization, *Storm runoff, *Hydrograph analysis, *Frequency analysis, Hydrology, Rainfall-runoff relationships, Peak discharge, Floods, Unit hydrograph, Flow.
Identifiers: Urban hydrology, Houston, Texas.

Summaries are presented of work concerning peak floods for urban areas and of a recent study concerning watersheds in Houston, Texas. Increased urbanization results in increased peak flows and accentuated high and low flows. Equations presented show that peak flows may be expected to increase from two to four times that of the flow from the undeveloped watersheds, depending upon the type of channel improvement, amount of vegetation in the channel, and the type of secondary drainage system. The capacity of the secondary drainage facilities may have a limiting effect on the peak discharge.

475
EFFECTS OF STORM RAINFALL VARIABILITY ON RUNOFF FROM SMALL SEMIARID WATERSHEDS,

M. M. Fogel
Trans Am Soc Agricultural Engrs, Vol 12, No 6, pp 808-812, Nov/Dec 1969.

Descriptors: *Frequency analysis, *Rainfall-runoff relationships, Data collections, Storms.
Identifiers: Storm analysis, Convective storms.

The relation between rainfall frequency and runoff frequency is examined and a rainfall-runoff relationship for convective storms is presented. The analysis of 13 years of rainfall and runoff data collected on the Atterbury experimental watershed formed the basis for study. A linear multiple-regression model was used to determine the relative effects of the storm depth of rainfall and the positioning of the storm on the watershed.

476
STATISTICAL TREATMENT OF RAIN GAUGE CALIBRATION DATA,

A. E. Freeny
Bell System Tech J, Vol 48, No 6, pp 1757-1766, Jul-Aug 1969.

Descriptors: *Calibrations, *Statistical models, Parametric hydrology, Gages, Measurement.
Identifiers: *Holmdel, New Jersey, *Capacitance gages.

Statistical treatment of calibration data of capacitance gages used for the measurement of rain rates in a rain gage network set up in a 160 sq km area surrounding Crawford Hill, Holmdel, N. J., is described. The distribution of parameters and residuals is discussed and the refinement, which corrects for fitting bias, is given.

477
RAINFALL-RUNOFF RELATIONSHIPS EXPRESSED BY DISTRIBUTION PARAMETERS,

Emil O. Frind
J Hydrology, Vol 9, No 4, pp 405-426, Dec 1969. 11 graphs, 1 tab, 15 ref.

Descriptors: *Rainfall-runoff relationships, *Parametric hydrology, *Input-output analysis, Computer models.
Identifiers: *Statistical parameters.

This study is concerned with statistical parameters of precipitation and runoff and the interrelations between corresponding parameters. Three processes are considered: the input process (mean annual effective precipitation), the transformation process (basin storage), and the output process (mean annual runoff). The input is assumed to be a pure-random series with known statistical parameters. The transformation is characterized by an exponential recession curve with one parameter. With these assumptions, equations are developed expressing statistical parameters of the output for any simulated series, which are analyzed for their moments. The type of distribution of the output is also established.

478
THE YEARLY DISTRIBUTION OF RAINFALL INTENSITIES,

A. L. H. Gameson and R. D. Quaife
Meteorol Mag, Vol 94, No 1115, pp 173-180, 1965.

Descriptors: *Rain gages, *Rainfall-runoff relationships, *Hydrologic data.
Identifiers: *Storm sewage, *Great Britain.

Autographic rain-gages were installed at Bradford and Brighouse, Yorks., and Northampton during investigations of the flow and composition of storm sewage. The Northampton data were studied in detail in an attempt to compare the observed runoff distribution from an impermeable area of 115 acres with that calculated from the rainfall pattern. An equation used in the calculation of the probable yearly duration of rainfall intensities exceeding any particular value in inches per hour at a station with a given annual rainfall is presented.

479
AVERAGE INTENSITY OF RAINFALL FOR USE IN THE RATIONAL FORMULA,

H. M. Gifft and George E. Symons
Water Wastes Eng, Vol 5, No 12, pp 44-45, Dec 1968.

Descriptors: *Hydraulics, *Storm runoff, *Rational formula, *Rainfall intensity.
Identifiers: *Nomograms.

For convenience in design problems concerned with storm flow runoff where climatological data are not available, the attached nomogram and the map of iso intensities are applicable to the following formula, $R = 5.5 \times H_5 F^{\cdot 2} T^{\cdot 5}$ where:

R = rainfall intensity (in./hr.)
H_5= rainfall intensity (in./hr., 5-year frequency)
F = frequency of storms (years)
T = time of concentration (min.).

480
HANDBOOK OF APPLIED HYDROLOGY, SECTION 9, RAINFALL,

Charles S. Gilman
McGraw-Hill Book Company, New York, pp 9:1 to 9:68, 1964. 34 diag, 24 graphs, 79 ref.

Descriptors: *Meteorology, *Rainfall, Simulated rainfall.
Identifiers: *Rainfall data applications.

This section seeks to aid the hydrologist in understanding the meteorology of rainfall, to enable him to appreciate the overlap between the two fields, and to inform him of the sources of further knowledge. The first subsection deals with rainfall measurement, the basis for all hydrologic and hydrometeorological work. The second treats the physics and hydrodynamics of rain, including the artificial inducement of precipitation. The third subsection, on the synoptic meteorology of rain, includes tropical rainfall, local convective thunderstorms, and quantitative precipitation forecasting. The next subsection details space-time relationships of rainfall. The last subsection, on design applications of rainfall data, includes frequency analysis, which is utilized in designing urban storm sewers; storm transposition; predicted maximum precipitation; and specifications of standard project storms. (See abstract number 467).

481
A MODEL FOR GENERATING SYNTHETIC SEQUENCES OF SHORT-TIME-INTERVAL RAINFALL DEPTHS,

R. A. Grace and P. S. Eagleson
Proceedings of International Hydrology Symposium, Sept 6-8, 1967, Colorado State Univ, Fort Collins, Vol 1, Paper 35, pp 268-276, 1967. 9 p, 4 fig, 1 tab, 5 ref.

Descriptors: *Rainfall, *Forecasting, *Synthetic hydrology, *Simulated rainfall, *Mathematical models, Simulation analysis, Digital computers, Computer programs, Computer models.
Identifiers: Rainfall data.

An analytical model is developed for the synthesis of short-time-interval sequences of rainfall data. The model uses the probability distribution of the time between storms and the storm duration as well as an equivalent joint distribution of storm rainfall depth and duration to generate sequences of lumped storms which retain the stochastic features of the historical storm data. The prescribed total storm depths are then distributed over their respective durations by using a special type of urn model in such a way that the short-time-increment rainfall sequences within synthetic storms possess, on the average, the same serial correlation and percentage mass characteristics as their historical counterparts. Probability distributions and storm characteristics are obtained from 10-min summer rainfall data for a period of 5 years at St. Johnsbury, Vermont. These sequences are extended synthetically, and the characteristics of the synthetic storm are shown to agree adequately with the historical attributes. Not only does the model give valid results, but it does so quickly, since it is possible to compile the necessary computer programs and then generate 15 summers of lumped storms or 5 summers of 10-min data in 3 minutes.

482
RUNOFF VOLUME PREDICTION FROM DAILY CLIMATIC DATA,

Monroe A. Hartman, Walter G. Knisel, Jr., and Ralph W. Baird
Water Resources Res, Vol 5, No 2, pp 84-94, Feb 1969. 11 p, 8 fig, 9 ref.

Descriptors: *Rainfall-runoff relationships, *Soil moisture, *Runoff forecasting, Model studies, Mathematical models, Digital computers, Discharge (water), Infiltration, Inflow, Streamflow, Water balance, Evaporation, Duration curves, Hydrograph analysis, Hydrographs.

A two-soil-moisture-reservoir model is developed to improve the estimate accuracy of a runoff-volume-prediction model. Soil moisture accounting in the two reservoirs is an intermediate step to runoff prediction. A decay-type function describes the moisture depletion between days of rainfall. The moisture depletion constant in the function varies by season with soil moisture, pan evaporation, and mean daily temperature. The runoff-prediction equation relates runoff to rainfall and soil moisture at the beginning of the storm. Computed runoff volumes are compared with values observed on a 3-acre native grass-meadow watershed for an 11-year period. Accumulated computed amounts for the period agree within 1% of the accumulated observed amounts.

483
A NOTE ON AREAL RAINFALL DEFINITION,

David M. Hershfield
Water Resources Bul, Vol 5, No 4, pp 49-55, Dec 1969. 7 p, 4 fig, 1 tab, 2 ref.

Descriptors: *Rainfall, *Distribution patterns, Sampling, Mathematical studies, Instrumentation, Networks, Data collections, Rainfall disposition, Hydrology, Correlation analysis, Rain gages.

Sources of error in defining areal rainfall on a storm basis include the instrumental error, sampling fluctuations over the area, and network density. Analysis of dense rain gage data show the magnitude of the errors resulting from the natural variability of rainfall. Except for one watershed in Arizona, the coefficient of variation, based on a sample of storm totals from the individual gages in various size areas, remains relatively constant with increasing area for a particular storm. The error due to rainfall variability over the area is probably the most important and must be considered in experiments which attempt to resolve small-area hydrologic problems.

484
JOINT PROBABILITIES IN RAINFALL-RUNOFF RELATION,

L. A. V. Hiemstra
Nat Acad Sciences--Nat Research Council--Highway Research Rec, No 261, pp 1-17, 1969.

Descriptors: *Rainfall-runoff relationships, *Surface drainage, Runoff, Rainfall intensity, Runoff forecasting.

A study of the problem in surface drainage of highways deals with peak rates and total volumes of runoff predicted from rainfall with known probability of occurrence. A deterministic water budget approach makes it possible to translate the rainfall input into a runoff hydrograph. It was possible to describe a time pattern of rainfall intensity by means of an incomplete beta-function. A two-parameter, log-normal, distribution function was a suitable descriptor for all necessary probability distributions.

485
RUNOFF HYDROGRAPH AS A FUNCTION OF RAINFALL EXCESS,

I. K. Hill
Water Resources Res, Vol 5, No 1, pp 95-102, Feb 1969. 8 p, 5 fig, 6 ref.

Descriptors: *Rainfall-runoff relationships, *Mathematical models, *Runoff forecasting, *Streamflow forecasting, *Hydrographs, Duration curves, Rainfall intensity, Hyetographs, Precipitation excess, Surface runoff, Overland flow, Storm runoff.
Identifiers: Kinematic wave theory.

A set of differential equations has been obtained for the overland runoff from an arbitrary catchment when the rainfall excess over the catchment is known as a function of space and time. An analytical solution is given for a steady rain of finite duration. The differential equations obtained are also solved analytically for a moving top-hat storm over a plane catchment, and the maximum depth is obtained explicitly as a function of the storm duration and catchment length. The results for all plane catchments with a given resistance formula are reduced to a single curve. It is found that the depth is increased if the storm moves downstream and decreased if the storm moves upstream the slower the storm the greater being the change. Finally, it is shown that all the results apply qualitatively to open channel flow where the kinematic wave approach is suitable. If the lateral inflow replaces the rainfall excess, it is found that the form of the curve describing the variation of depth with time is a function of the cross-section geometry but is qualitatively similar to the overland flow curve described above.

486
AVERAGE ANTECEDENT TEMPERATURES AS A FACTOR IN PREDICTING RUNOFF FROM STORM RAINFALL,

Charles D. Hopkins, Jr. and Dale O. Hackett
J Geophys Res, Vol 66, No 10, pp 3313-3318, Oct 1961.

Descriptors: *Rainfall-runoff relationships, *New York, *New England, *Basins, *Storms, Rainfall, Storm runoff, Runoff forecasting.
Identifiers: *Elevation-temperature relationships.

Rainfall-runoff relations in New England and New York have been shown to vary widely from basin to basin in a manner related to average basin latitudes and elevations. Station elevations and latitudes have been shown to be related to average temperatures. Average monthly and annual temperatures were computed for each basin sampled and average weekly basin temperatures estimated. These weekly temperatures were used to derive an index of average antecedent basin temperature based on a logarithmic recession. Two rainfall-runoff relationships were derived in which the index of antecedent basin precipitation, the index of average antecedent basin temperatures corresponding to the season of the storm, the average annual basin temperature, storm rainfall, and storm runoff were used. One of these relations applied to the spring and summer, the other to the fall and winter. Testing showed that a large part of the variation in the rainfall-runoff relationship had been removed. It was concluded that average basin temperatures can be used with profit in computing runoff in New England and New York.

487
TIME DISTRIBUTION CHARACTERISTICS OF RAINFALL RATES,

F. A. Huff
Water Resources Res, Vol 6, No 2, pp 447-454, Apr 1970. 2 tab, 6 graphs, 6 ref.

Descriptors: *Illinois, *Rainfall intensity, *Mathematical studies, *Time series analysis.
Identifiers: *Warm-season storms, *Variability analysis.

Data from a 50-storm sample on two dense networks in Illinois were used to investigate the time distribution of 1-minute rainfall rates in warm-season storms. Absolute and relative variability were analyzed for point and mean rates on areas from 25 to 100 square miles. Several variability measures were employed including sequential variability that uses both the magnitude and the sequence of rates in characterizing the time distribution. Since the variability parameters were found to fit closely a log normal distribution, probability distributions were constructed to define interstorm variability relations. Both absolute and relative variability showed a wide range within and between storms, and between areas of different size. Little difference in variability properties was noted between rain and synoptic weather types associated most frequently with warm-season storms. No evidence of regular oscillations in the time distribution of rainfall rates in convective storms was shown by lag correlation analyses.

488
SPATIAL DISTRIBUTION OF RAINFALL RATES,

F. A. Huff
Water Resources Res, Vol 6, No 1, pp 254-260, Feb 1970. 2 diag, 3 tab, 2 graphs, 6 ref.

Descriptors: *Illinois, *Rain gages, *Rainfall intensity, *Instrumentation, *Radar, *Measurement, *Spatial distribution.
Identifiers: *Warm-season storms.

A 29-storm sample of 1-minute rainfall rates was obtained with an Illinois network of 50 recording gages in 100 square miles during the warm seasons of 1952 and 1953. These gages were equipped with enlarged orifices and 6-hour charts to provide nearly instantaneous spatial patterns of rainfall intensity on the network. The data were used to determine quantitative estimates of rainfall rate gradients, sampling errors in the measurement of mean areal rates, and spatial correlation patterns. The derived relations are considered first approximations for midwestern warm-season storms. It was concluded that the spatial variability of rainfall

rates is frequently so great within and between convective storms that the rain gaging equipment and operational requirements for accurate rate measurements may be prohibitive for most users when sampling areas are 100 square miles or greater. Consequently, it is recommended that the use of radar in combination with recording gages be investigated as a possible solution to the measurement problem.

489
SPATIAL CORRELATIONS OF STORM, MONTHLY AND SEASONAL PRECIPITATION,

F. A. Huff and W. L. Shipp
J Appl Meteorol, Vol 8, No 4, pp 542-550, Aug 1969. 7 diag, 6 tab, 1 graph, 7 ref.

Descriptors: *Precipitation, *Measurement, *Statistical models, *Rainfall disposition, *Spatial distribution, *Correlation analysis, *Storms, *Rainfall intensity, *Illinois.

One approach to defining sampling requirements for precipitation measurement networks is through statistical correlation methods. Data from three dense rain gage networks in Illinois were used with this method on rainfall measurements ranging from 1-minute rates to total storm, monthly and seasonal amounts. Effects of rain type, synoptic storm type, and other factors on spatial correlations were studied. Correlation decay with distance used to indicate sampling requirements was greatest in thunderstorms, rain showers and air mass storms. Conversely, minimum decay occurred with steady rain and the passage of low pressure centers. Seasonally, the decay rate is much greater in May-September storms than in cold season precipitation. Sampling requirements are extreme in measuring rainfall rates; thus, assuming a minimum acceptance of 75% explained variance between sampling points, a gage spacing of 0.3 minutes is needed for 1-minute rain rates compared with 7.5 minutes for total storm rainfall in summer storms.

490
MESOSCALE SPATIAL VARIABILITY IN MIDWESTERN PRECIPITATION,

F. A. Huff and W. L. Shipp
J Appl Meteorol, Vol 7, No 5, pp 886-891, Oct 1968.

Descriptors: *Rain gages, *Precipitation (atmospheric), Illinois.
Identifiers: *Variability analysis.

Data from four dense rain gage networks operated for periods of 7 to 12 years on areas of 10 to 550 sq mi in Illinois were used to determine spatial relative variability of monthly and extended period precipitation of storms in continental climate typical of midwestern United States. The relation of storm variability to areal mean precipitation, storm duration, precipitation type, synoptic weather type, season, and size of sampling area was investigated.

491
SOME APPLICATIONS OF CROSS-SPECTRAL ANALYSES IN HYDROLOGY: RAINFALL AND RUNOFF,

I. R. Iturbe and C. F. Nordin
Water Resources Res, Vol 5, No 3, pp 608-621, 1969.

Descriptors: *Water circulation, Rainfall, Runoff.
Identifiers: *Rainfall cycle, *Runoff cycle.

Correlations between yearly cycles of rainfall and also runoff, for stations in the Pacific coast region of U.S.A. were obtained from cross-analysis of the monthly records. It was found that for stations within 1000 km of each other the precipitation cycle was virtually the same, and that there was a similar although less coherent relation for the runoff cycle. It was also found that the yearly temperature cycle was highly correlated with the yearly rainfall cycle but that the yearly cycle in atmospheric pressure appeared related to the rainfall cycle only through the temperature cycle.

492
HANDBOOK OF APPLIED HYDROLOGY, SECTION 20, HYDROLOGY OF URBAN AREAS,

Stifel W. Jens and M. B. McPherson
McGraw-Hill Company, New York, pp 20:1 to 20:45, 1964. 19 graphs, 9 tab , 2 diag, 58 ref.

Descriptors: *Hydrologic data, *Storm runoff, *Design storm, *Methodology, *Surface drainage, Rational formula, Waste water (pollution), Water supply, Drainage engineering.
Identifiers: *Urban hydrology.

This section outlines current uses of hydrologic data and methods of solution of urban water problems and needs. Stormwater drainage is emphasized, and the utilization of urban hydrology in the areas of flooding, water supply, pollution, airports, and expressways is mentioned. The first subsection, involving qualitative descriptions of urban stormwater runoff, explains the hydrologic cycle in terms of runoff-producing storms in order to aid engineers in designing collection and disposal facilities for stormwater. The next subsection on the quantitative determination of urban stormwater runoff includes empirical formulas for determining design storm drain discharges, the rational method, correlation studies of rainfall and runoff, the hydrograph method, the inlet method, and the hydraulics of inlets and gutter flow. The next three shorter subsections deal with urban flooding, water supply, and pollution from inadequately treated wastes. Subsection VII explores the objectives, hydrologic data, subsurface and surface drainage of airports, and Subsection VIII concerns the hydrology of urban expressways. (See abstract number 467).

493
URBAN HYDROLOGY OF THE HOUSTON, TEXAS METROPOLITAN AREA-COMPILATION OF BASIC DATA-1966,

S. L. Johnson
Geol Surv Duplicated Basic-Data Rep, 1968. 275 p, 13 fig, 12 tab, Charts, Hydrographs.

Descriptors: *Data collections, *Urbanization, *Hydrologic data, *Texas, Rainfall, Runoff, Stream gages, Hydrographs, Streamflow.
Identifiers: Houston, Texas.

Basic data of the urban hydrology of Houston, Texas, 1965-66, are compiled. Surface-water records are from gaging stations, crest-stage partial-record stations; rain gages, and miscellaneous sites. Each gaging-station record includes location, drainage area, gage type and history, average discharge, extremes, remarks; daily discharge, total discharge, mean discharge, annual maximum, minimum, and mean discharges, and peak discharges. Runoff and rainfall are computed for each drainage basin and hydrographs and mass curves are drawn. A map of each basin shows locations of all gages.

494
LOSS RATES ON SELECTED CATCHMENTS IN VICTORIA,

A. Karoly
Water Res Found of Australia Bull No 13, 1965. 48 p, 22 fig, 10 tab, 8 ref.

Descriptors: *Rainfall-runoff relationships, *Surface-groundwater relationships, *Rainfall disposition, Base flow, Infiltration, Runoff coefficient, Small watersheds.
Identifiers: *Australia.

Storm rainfalls on 9 catchments in Victoria, Australia were analyzed for rainfall-runoff relationships and 137 loss rates were derived. Loss rate is defined as the average rate of potential infiltration loss to surface runoff during the supply period of a storm. Relationships between loss rates and some hydraulic factors of the drainage basins were calculated. Frequency distributions and seasonal variations of loss rate were calculated and compared with U.S. and other Australian rates.

495
A NONLINEAR APPROACH TO RUNOFF STUDIES,

V. C. Kulandaiswamy and C. V. Subramanian
Proceedings of International Hydrology Symposium, Sep 6-8, 1967, Vol 1, Paper 10, p 72-79, 1967. 8 p, 5 fig, 1 tab, 4 ref.

Descriptors: *Rainfall-runoff relationships, *Mathematical models, *Runoff forecasting, Computer models, Streamflow forecasting, Simulation analysis, Rainfall disposition, Unit hydrograph, Hydrograph analysis.
Identifiers: Watershed models.

The process of conversion of rainfall excess into surface runoff is studied by treating drainage basins as lumped systems. The rainfall excess is considered as inflow and the surface runoff as outflow. Making use of the equation of continuity, a differential equation used with field data indicates that the system behavior is nonlinear but can, however be treated as linear by approximation in the case of major floods. The proposed equation is verified by applying it to observed storms, and the results are found to be very encouraging. This method of approach provides considerable scope for an analytical treatment of rainfall excess-surface runoff relationship.

496
THE ESTIMATION OF RUNOFF FROM RAINFALL FOR NEW BRUNSWICK WATERSHEDS,

J. Lee and D. I. Bray
J Hydrology, Vol 9, No 4, pp 427-437, Dec 1969. 4 tab, 11 ref.

Descriptors: *Runoff forecasting, *Watersheds (basins), *Storm runoff, *Storms, *Estimating equations, Analysis.
Identifiers: *Canada.

Prediction equations have been derived for forecasting runoff volume for regions within the Province of New Brunswick. Five basins were selected so as to provide a regionally representative distribution over the province. The prediction equations are based on the storm rainfall, antecedent precipitation index, base flow, and week number in which the storm occurred. Statistical methods were used to obtain the least-squares multiple linear regression equation, correlation coefficient, and the standard error for each of the techniques used for the watersheds. The number of storms varied from 8 to 23 for the basins studied. The standard error of the optimum prediction equations for runoff ranged from 0.065 inches to 0.212 inches and the multiple correlation coefficient (R) varied from 0.556 to 0.963. Results of the regression equations developed for one basin were extended to a neighboring basin of similar hydrological characteristics, but with only recent streamflow records.

497
HYDROLOGY FOR URBAN LAND PLANNING—A GUIDEBOOK ON THE HYDROLOGIC EFFECTS OF URBAN LAND USE,

Luna B. Leopold
Geol Surv Circ 554, 1968. 18 p, 8 fig, 1 tab, 28 ref.

Descriptors: *Urbanization, *Hydrologic aspects, Hydrographs, Hydrograph analysis, Storage, Sediment yield, Water temperature, Water pollution.
Identifiers: Urban hydrology.

The effects of urbanization on hydrologic factors are discussed and rainfall-runoff relations of urbanized and unurbanized watersheds are compared. Urbanization increases the amount of impervious area in a watershed so that the intensity and amount of runoff increase and peak discharges occur sooner. Sediment yields are 10-100 times larger in urbanized watersheds, water quality decreases, water values usually decrease. Hydrographs, frequency curves, and sediment yield-discharge curves, are used to show typical effects of urbanization on streams.

498
RAINFALL-RUNOFF MODEL FOR SMALL BASIN FLOOD HYDROGRAPH SIMULATION,

R. W. Lichty, D. R. Dawdy, and J. M. Bergmann
Symp on Use of Analog and Digital Computers in Hydrol, Tucson, Ariz, Dec 1968, Vol 2, Int Ass Sci Hydrol Publ No 81, pp 356-367, 1968. 12 p, 6 fig, 2 tab, 10 ref.

Descriptors: *Rainfall-runoff relationships, *Flood forecasting, *Mathematical models, Digital computers, Computer programs, Streamflow forecasting, Parametric hydrology, Infiltration, Surface-groundwater relationships, Simulation analysis, Optimization, Runoff forecasting.
Identifiers: Philips equation.

A simplified, mathematical model of the surface runoff component of streamflow response to storm rainfall was developed and programmed for digital computer solution. The model uses an infiltration component based on an equation by Philip to determine rainfall excess, which is transformed by a linear basin-response function to simulate the flood hydrograph. An objective-fitting procedure that emphasizes the simulation of peak-discharge rate was used to identify optimum model parameters in a pilot study of a 5-sq mi drainage basin in North Carolina. Split-sample fitting and testing showed that predictive capability varied for 3 samples of flood events. Results of simulation for 2 test samples of pre-1948 flood events showed reasonable correspondence between simulated and observed flood peaks. The post-1948 test sample showed wide scattering between simulated and observed flood peaks. Sensitivity analysis of objective-function response to parameter incrementation showed that antecedent moisture accounting grossly controlled the results of optimization.

499
URBAN RUNOFF BY ROAD RESEARCH LABORATORY METHOD,

Ray K. Linsley (discussion)
J Hydraul Div, Am Soc Civil Engrs, Vol 96, No HY4, pp 1100-1102, Apr 1970. 5 ref.

Descriptors: *Hydrographs, *Runoff forecasting, Flood routing, Computers, Methodology.
Identifiers: *Rainfall characteristics, *RRL.

The author compares various methods of deriving hydrographs for urban drainage studies, and explains why the lag and route method is superior to the unit hydrograph. Computer use is suggested to aid in estimating runoff from pervious areas and to help integrate characteristics of rainfall into calculated flows and simplify the problem of determining frequency of computed peak flows. This method would aid testing of the RRL procedure described in the original paper.

500
COMMITTEE ON STATUS AND NEEDS IN HYDROLOGY - MEETING OF AGU COMMITTEE ON STATUS AND NEEDS IN HYDROLOGY,

Ray K. Linsley
Trans Am Geophys Union, Vol 45, No 3, pp 693-698, Sep 1964.

Descriptors: *Hydrology, *Water quality, Base flow, Investigations.
Identifiers: *Hydrologic research.

The Committee on Status and Needs in Hydrology investigated research needs in hydrology and their report is summarized in this article. They conclude that within hydrology, water quality requires increasing attention. Also, the position of biological rather than physical processes of the hydrologic cycle needs to be studied, and efforts should be made to research chemical, physical, and biological phenomena associated with flow in permeable media in and near the ground surface. A list of sixty-three research topics, compiled by the Committee, encompass these points. The order of the list conveys the relative importance of needed research in the overall field of hydrology, rather than a judgement of intrinsic scientific merit. Rainfall-runoff relations, areal distribution of storm precipitation, hydrologic systems analysis, unit-hydrograph simulation, and processing of hydrologic data are examples of topics listed.

501

ANALYSIS OF FORMING AND DETERMINATION OF RAINFALL-RUNOFF LOSSES IN EASTERN CARPATHIANS,

P. M. Lyutik

Sb Rab Gidrol (SGGGAI), No 7, pp 60-75, 1967. 16 p, 7 fig, 2 tab, 15 ref.

Descriptors: *Rain, *Runoff, *Water loss, *Rainfall-runoff relationships, Floods, River basins, Precipitation (atmospheric), Discharge (water), Hydrologic properties, Drainage districts, Infiltration, Evaporation, Hydrograph analysis, Climatic zones, Storm runoff, Frequency.
Identifiers: *USSR, Carpathian Rivers.

On the basis of discharge and precipitation data recorded at several gaging stations of the Carpathian Rivers, the rainfall-runoff losses were analyzed by using the standard technique of subdividing a river discharge into the total and basic parts. Flood frequencies, runoff coefficients, precipitation, and water loss volumes were calculated and expressed by charts and tables. The analysis of runoff coefficients indicates an initial loss of water equal to a layer of 40-50 mm in thickness for summer floods and 10-15 mm for spring and fall floods. The hydrologic data record at the Transcarpathian gaging station shows the greatest losses (as much as 90%) after isolated rainfalls in river basins of small areal extent. The smallest losses occur after long intensive rainfall or after a long rainfall period. The majority of rainfalls characterized by maximum discharges have high rainfall-coefficient values (0.60 - 0.90) and occur during the spring and fall months.

502
AN ANALYSIS OF NATIONAL BASIC INFORMATION NEEDS IN URBAN HYDROLOGY,

M. B. McPherson, D. C. Taylor, and L. S. Tucker
Am Soc Civil Eng Basic Inform Rep, Apr 1969. 112 p, 14 fig, 4 tab, 73 ref.

Descriptors: *Rainfall-runoff relationships, *Urbanization, Drainage systems, Instrumentation, Hydrologic data, Measurement, Networks, Meteorological data, Surveys, Data processing, Water quality.
Identifiers: *Urban hydrology, Storm sewers.

The article focuses on data needs, data devices and data networks. Primarily aimed at improvement in design of storm drainage, an intensive study was made of the data requirements for analyzing rainfall-runoff-quality relationships and of suitable data collection instrumentation, with consideration of the types of networks required for the collection of adequate data. Suitable data collected with properly coordinated instrumentation in networks representing a variety of climatic, topographic, and land-use conditions, are virtually non-existent. There are very meager amounts of performance data with which existing or proposed storm drainage facilities can be checked or designed. Transfer of data findings between metropolitan regions is a central and primary objective. Recommendations centered on hydrologic information needs are related to storm sewers. The replacement value of existing storm sewerage systems in the United States is at least $22 billion, and it is estimated that an average of about $3.5 billion per year will be spent on construction of new storm sewerage systems over the next several years. The plan recommended for a minimum national program of urban storm drainage research would cost on the order of 1/3% of this average annual construction cost.

503
SOME NOTES ON THE RATIONAL METHOD OF STORM DRAIN DESIGN,

M. B. McPherson
ASCE Urban Water Resources Res Prog Tech Mem No 6, Jan 22, 1969. 84 p, 9 fig, 3 tab, 42 ref, 2 append. USGS Contract No. 14-08-0001-11257.

Descriptors: *Urbanization, *Storm drains, *Rainfall-runoff relationships, *Rational formula, *Storm runoff, *Design, Drainage systems, Surface runoff, Routing, Hydrographs, Runoff, Hydraulic design, Design flood, Systems analysis, Stream gages, Gaging stations.

Because the 'rational method' of designing urban storm drainage facilities has substantial liabilities, new design procedures are discussed and the urgent need for more field stream gaging data is stressed. The limitations of the rational method consist mainly of the weaknesses of projecting standard values of the rainfall-runoff relationship over wide geographical areas, the use of too many standardized assumptions, and using the same runoff routing methods in too many dissimilar situations. Suggested improved design methods would use on-site gaged rainfall-runoff relations to determine flow probabilities in mathematical models so that the optimum drainage system for each particular case may be designed. Presently there are no gaging programs of sufficient scope in operation. Other suggestions include the use of surface detention to flatten runoff peaks, storage of urban runoff for water supply use, or use of urban runoff as a source of recreational water.

504
THE NATURE OF CHANGES IN URBAN WATERSHEDS AND THEIR IMPORTANCE IN THE DECADES AHEAD,

M. B. McPherson
ASCE Tech Mem No 5, Urban Water Resources Res Program, Dec 1968. 18 p, 3 tab, 23 ref. OWRR Contract No. 14-01-0001-1585, USGS Contract No. 14-08-0001-11257.

Descriptors: *Urbanization, *Urban sociology, *Water resources development, Social aspects, Drainage systems, Land use, Sewers, Utilities, Water utilization, Water supply, Water reuse, Water quality.
Identifiers: Urban hydrology.

Urban changes, largely social and economic, that affect urban hydrology are discussed in a survey and bibliography of urban sociology and recent urban history largely consisting of quotations and reviews of non-engineering and non-hydrological literature. Urban expansion is considered largely a function of development of new forms and trends of use of high-speed urban transport. The urban areas of the country are growing rapidly with trends of increasing urbanization added to increasing growth of suburbs. Urban problems of crowding, water supply, waste disposal, and general environmental quality are growing even faster than the cities. The need for comprehensive planning rather than solving single problems such as waste disposal or water supply is stressed. The environment of cities is a function of all social and physical factors. Hydrological problems can be solved only as part of the total environmental problem.

505
URBAN WATER RESOURCES RESEARCH,

M. B. McPherson
Am Soc Civil Eng Annual Prog Rep, 1968. 43 p, 4 fig, 3 tab, 38 ref, 11 append. L. S. Tucker, Director. Work supported by OWRR, Dept of Interior. OWRR Contract No. 14-01-0001-1585.

Activities in urban water resources research by ASCE in 1967-1968 are reported. The objective of the research is to provide guidelines for initiating and expanding a program of long-range studies in urban water problems. Considerable attention was given to storm drainage to arrive at mathematical descriptions of the rainfall-runoff relationship, to predict pollution loads, and to develop methods of planning water quantity, quality, and drainage development. Data collection system design and data requirements are discussed. Systems analysis, statistical studies, and model studies are being initiated. Considerable attention was given to research needs in political, economic, social, legal, and related aspects of urban hydrology. Appendices contain technical and feasibility studies of modeling, flood damages, non-hydrological aspects, research needs, systems engineering, and economics.

506
GENERALIZED CHARTS OF HYDROLOGIC FACTORS USEFUL IN URBAN PLANNING,

John F. Miller
Paper presented at the Am Geophys Union - 1969 National Fall Meeting.

Descriptors: *Urban renewal, *Hydrologic data, *Planning.
Identifiers: *Urban hydrology, *Tables.

The Environmental Science Services Administration prepares maps and tables of average and extreme values for various climatic and hydrologic factors. Many of these products are useful to the urban planner. A brief description is given of the meteorological or climatological basis for some of these products and examples are shown of possible applications to urban hydrology.

507
EFFECTS OF WATERSHED CHANGES ON STREAMFLOW,

Walter L. Moore and Carl W. Morgan
Water Resources Symposium No 2, Austin, Texas, October 1968. Published by Univ of Texas Press, Austin and London, 1969. 289 p.

Descriptors: *Urbanization, *Rainfall-runoff relationships, *Hydrograph analysis, *Water quality, Flood control, Reservoirs, Water yield, Planning, Water management (applied), Hydrology, Floods, Peak discharge, Model studies, Hydraulic models, Mathematical models, Computer models, Analog models.
Identifiers: Urban hydrology.

This special lecture series was arranged to present the most advanced approaches to evaluating the effects of watershed changes on streamflow. To an increasing degree man's activities are altering the hydrologic characteristics of watersheds, both rural and urban, and it is urgent to know the character and extent of the changes and how they affect plans for development. Numerous field studies designed to evaluate the effect of specific watershed changes by comparisons between watersheds have been in operation for sufficient time to build up a significant length of record. New methods of computer simulation of watersheds have reached a stage of development to offer an attractive tool for attacking the problem in new ways. The effects of the changes can best be evaluated when the entire performance of the watershed is understood in detail. Then all of the physical processes can be followed and the performance of the watershed can be simulated by numerical or analog techniques which correspond to the physical processes. Watershed changes produce effects on both the amount and the quality of streamflow. The topics discussed include model studies, land treatment in rural watersheds, flood control structures, rural pollution, the effects of urbanization on peak flow, the effects of urbanization on water yield, and urban water quality changes.

508
SOME EFFECTS OF URBANIZATION ON RUNOFF AS EVALUATED BY THORNTHWAITE WATER BALANCE MODELS,

Robert A. Muller
Proc 3rd Annual Amer Water Resources Conf, Nov 8-10, 1967, San Francisco, Calif, pp 127-136, 1967. 10 p, 4 fig, 5 tab, 5 ref.

Descriptors: *Rainfall-runoff relationships, *Water balance, *Urbanization, New Jersey, Evaporation, Rainfall, Runoff, Infiltration, Flood control.
Identifiers: Thornthwaite method, Raritan River basin, New Jersey.

Water balance methodology (including the Thornthwaite potential evapotranspiration) and water balance models are applied to the Raritan River basin in New Jersey. In order to gain some understanding of hydroclimatological processes and interrelationships associated with urbanization of drainage basin. The precise objectives are: to compare and contrast selected Thornthwaite water balance components as calculated by several more or less 'standard' techniques; to demonstrate that potential evapotranspiration and water balance models can be utilized as hydroclimatological controls to obtain first approximations of the consequences of land cover type change, or urbanization within a river basin; and, to explore generated water balance data based on the assumption of the transformation of a watershed from rural to urban. Calculated runoff takes into account the monthly and seasonal variation of precipitation and soil moisture storage as well as energy availability for evapotranspiration loss. Measured runoff not only includes the climatic variation but in addition the effects of land use change. Hence, the differences between calculated and measured runoff overtime should be a measure of the effects of land use change on runoff.

509
HANDBOOK OF APPLIED HYDROLOGY, SECTION 12, INFILTRATION,

G. W. Musgrave and H. N. Holtan
McGraw-Hill Book Company, New York, pp 12:1 to 12:30, 1964. 18 graphs, 7 tab, 4 diag, 19 ref.

Descriptors: *Infiltration, *Flow, Hydrograph analysis, Rainfall-runoff relationships, Runoff.
Identifiers: *Infiltration index, Infiltration research.

The first two subsections of this part concern early concepts and factors affecting water flow through the soil surface or infiltration. The subsection on infiltration measurement includes descriptions of rainfall simulators and flooding type infiltrometers, plus three methods of runoff hydrograph analyses to estimate infiltration. The role of infiltration in the rainfall-runoff relationship is explored generally, based on data from small agricultural watersheds. Infiltration in computations of runoff is discussed in the next subsection in relation to small-area projects such as urban drainage, airports, etc. and also in relation to larger watersheds. Infiltration indexes, which express infiltration as an average rate throughout a storm, are explained in another subsection, and lastly, some forecasts are made regarding future research in infiltration. (See abstract number 467).

510
HANDBOOK OF APPLIED HYDROLOGY, SECTION 25-IV, HYDROLOGY OF FLOW CONTROL, PART IV, RIVER FORECASTING,

T. J. Nordenson and M. M. Richards
McGraw-Hill Book Company, New York, pp 25:98 to 25:111, 1964. 5 graphs, 5 tab, 2 diag, 13 ref.

Descriptors: *River forecasting, *Flood control, Operations, Rainfall-runoff relationships, Hydrographs, Forecasting.

Basic river forecasting procedures utilized by the U.S. Weather Bureau are described along with discussions of common operational problems. Day-to-day river forecasts of inflow to reservoirs and discharges are needed for those studying flood control, navigation, water supply, stream pollution, etc. Tools of the river forecaster include rainfall-runoff relations, unit hydrographs, routing methods, recession curves, and stage-discharge relations. In one subsection, a specific river forecasting example of a hypothetical river basin is studied for runoff computations and forecasts of headwater and downstream points. The final subsection involves special forecasts such as flash flood warnings, and water supply and low flow predictions. (See abstract number 467).

511
ANALYSIS OF TWO MAJOR RUNOFF-PRODUCING SOUTHWEST THUNDERSTORMS,

H. B. Osborn and K. G. Renard
J Hydrology, Vol 8, No 3, pp 282-302, Jul 1969. 21 p, 20 fig, 1 tab, 5 ref.

Descriptors: *Rainfall-runoff relationships, *Thunderstorms, *Storm structure, Arizona, Hyetographs, Hydrographs, Storm runoff, Runoff forecasting, Meteorology, Demonstration watersheds, Small watersheds.
Identifiers: Walnut Gulch Experimental Watershed.

The two largest runoff-producing storms for 10 yr of records, the first in 1964 and the second in 1967, recorded on the Walnut Gulch Experimental Watershed in southeastern Arizona are analyzed and compared. Both storms were non-frontal thunderstorms which produced peak discharges on the order of 1500 cfs per sq mi; in 1964 from a 2000-acre subwatershed, and in 1967 from an 84-acre subwatershed. During the 1967 storm rainfall of 3.35 inches in 45 min was recorded at one point on the watershed. Approximately 18 acre-ft of runoff was produced on the 84-acre subwatershed in the 1967 storm. Runoff-producing rainfall lasted for less than 60 minutes for both storms. For both storms, runoff per unit area decreased with increasing subwatershed size because of the large transmission losses in the ephemeral channels and because of the limited areal extent of the runoff-producing rainfall.

512
URBAN HYDROLOGY, STORM DRAINAGE, AND FLOOD PLAIN MANAGEMENT IN METROPOLITAN AREAS OF THE UNITED STATES,

Herbert G. Poertner
Georgia Institute of Technology Water Resources Center Report, Aug 1968. 28 p. OWRR Project X-102.

Descriptors: *Water management (applied), *Planning, *Government, *Urbanization, Storm runoff, Water supply, Legislation, Regulation, Reviews.
Identifiers: *Urban hydrology.

Current practices in urban hydrology, storm drainage, and flood plain management are reviewed. These practices have characteristics which not only limit solutions to present problems but contribute to future problems. An illustration is the opposition by land owners and tax authorities to flood plain zoning. One alternative to the present unsatisfactory state of management is to establish a program responsive to all segments of the population. Major limitations of present practices in engineering and design are deficiencies in knowledge of urban hydrology, lack of analyses of accumulated data, and ineffective use of data for producing optimum designs of integrated drainage systems. Problems of urban drainage are primarily institutional. Enabling legislation is needed for management of water in entire metropolitan areas by a single authority. Programs on federal, state, and local levels for correction of deficiencies within present flood plains and drainage systems need development to serve existing communities as well as those that may emerge in the surrounding area.

513
A NONLINEAR HYDROLOGIC SYSTEM RESPONSE MODEL,

Ramanand Prasad
J Hydraul Div, Am Soc Civil Eng, Vol 93, No HY4, pp 201-221, Jul 1967. 21 p, 9 fig, 2 tab, 15 ref, 2 append.

Descriptors: *Simulation analysis *Analog computers, *River basins, Mathematical models, Numerical analysis, Rainfall-runoff relationship, Reservoirs, Storm runoff, Illinois.

The effects of the physical factors responsible for the transformation of rainfall excess into direct runoff were simulated by the action of a conceptual nonlinear reservoir. A nonlinear differential equation of the basin response was derived. Because no analytical solution for the system response equation existed, solutions were found by means of an electronic analog computer and a numerical method. Model parameters were found to be correlated with basin, main channel, and rainfall characteristics for seven east central Illinois basins. The consistency of the results obtained from an analysis of storms over those basins indicated that the proposed model could be adopted for nonlinear simulation of the hydrologic system response.

514
AN EXPERIMENTAL INVESTIGATION OF PARTIAL AREA CONTRIBUTIONS,

Robert M. Ragan
Intern Assoc Sci Hydrol Pub No 76, pp 241-251, 1968. Symp on Hydrol Aspects of Util of Water, Bern, Sept 25-Oct 7, 1967. 11 p, 5 fig, 8 ref.

Descriptors: *Routing, *Runoff, *Rainfall-runoff relationships, Subsurface runoff, Flood routing, Surface-groundwater relationships, Hydrographs, Discharge (water), Infiltration, Rainfall intensity, Storm runoff, Interception, Vermont.

The paper describes a detailed experimental-numerical investigation of the concept of partial area contributions to storm hydrographs. A computer solution of a numerical flood routing technique was used to isolate the time-spatial distribution of local runoff entering the main channel of a small watershed. Extensive experimental information collected in the vicinity of the 619 ft length of second order stream provided a means of interpreting these land-phase hydrographs. Analysis of a series of storms showed that only a small portion of the watershed ever contributed flow to the storm hydrograph. The contributing area was found to be a function of the storm duration and intensity and, rather than being uniformly distributed along the length of the channel, it existed in the form of localized zones of intense contribution. In a given storm, the contributing area was found to fluctuate with changes in the rainfall intensity. During periods of low intensity, most of the flow came from channel precipitation and rain falling on the wet areas surrounding a series of seeps. If a period of high intensity occurred, flow developed through the forest litter on the hillsides and thereby created a larger contributing area. No interflow in the soil mass above the water table was encountered. A rapid response of the groundwater at some points along the channel, however might have been interpreted as interflow if extensive measurements had not been taken. The behavior of the watershed was quite logical when the fundamentals of the individual processes were considered. The results of the study illustrate that there is a need for a reevaluation of some of the traditional methods used for runoff computations. Further, any parametric model developed for the synthesis of hydrologic events should be able to reflect partial area contributions.

515
FREQUENCY ANALYSIS OF RAINFALL INTENSITIES FOR CALCUTTA,

V. Raman and M. Bandyopadhya
J Sanit Eng Div, Am Soc Civil Engrs, Vol 95, No SA6, pp 1013-1030, Dec 1969. 18 p, 10 fig, 9 tab, 7 ref, append.

Descriptors: *Rainfall disposition, *Frequency analysis, *Duration curves, *Depth-area-duration analysis, Rainfall intensity, Statistical methods, Runoff, Rational formula, Rainfall-runoff relationships, Storm runoff, Storm drains, Drainage engineering.
Identifiers: *India, Storm sewers.

Analysis of the point rainfall data in Calcutta, India for 23 yr yields a procedure for arriving at the relationship between the average intensity of excessive rainfall, the corresponding duration the rain continued to fall at the average rate, and the frequency with which these combinations of intensity and duration of such storms occur. Probability methods based on annual maximum events and partial duration series, and mathematical and graphical curve fitting, based on frequency analysis, are employed for developing the relationships. Intensity duration frequency relations are expressed in tabular and graphical forms and as mathematical equations. The various methods do not give exactly identical results, and discretion must be used to choose between them for application in the design of a storm sewer system. No particular method can be considered as the best for rainfall frequency determination.

516
URBAN SPRAWL AND FLOODING IN SOUTHERN CALIFORNIA,

S. E. Rantz
Geol Surv Circular No. 601-B, Washington, 1970. 11 p, 1 fig, 1 map, 5 photo, 3 tab.

Descriptors: *Urbanization, *Flooding, *Flood control, Storm runoff, Land use, Landslide.
Identifiers: *Urban sprawl.

The floods of January 1969 in south-coastal California provide a timely example of the effect of urban sprawl on flood damage. Despite record breaking, or near record breaking, stream discharges, damage was minimal in the older developed areas that are protected against inundation and debris damage by carefully planned flood-control facilities, including debris basins and flood-conveyance channels. By contrast, heavy damage occurred in areas of more recent urban sprawl where the hazards of inundation and debris or landslide damage have not been taken into consideration, and where the improvement and development of drainage or flood control facilities have not kept pace with expanding urbanization.

517
SYNTHESIS OF URBAN RAINFALL,

A. J. Raudkivi and N. Lawgun
Water Resources Res, Vol 6, No 2, pp 455-464, Apr 1970. 8 tab, 6 graphs, 3 ref.

Descriptors: *Computer models, *Depth-area-duration analysis, *Markov processes, *Parametric hydrology.
Identifiers: *Urban hydrology, *New Zealand.

A statistical analysis of rainfall records is used to develop a computer model for generation of a sequence of short period rainfalls. Time intervals between rainfalls are generated by sampling from a frequency distribution fitted to historical data. The model also uses a first order Markov process in addition to random sampling from a frequency distribution in order to obtain the rainfall durations. Rainfall depths are obtained by sampling from the joint distribution of rainfall depths and durations. Model parameters are based on meterologic conditions of the Auckland area, and all statistical tests were performed at a 5% level of significance. The model produces comparable time intervals between storms and a linear correlation between rainfall depths and durations, but extreme values of rainfall depths and durations are absent from the generated data.

518
EFFECT OF A COMMERCIAL CLEARCUTTING IN WEST VIRGINIA ON OVERLAND FLOW AND STORM RUNOFF,

Kenneth G. Reinhart
J Forest, Vol 62, No 3, pp 167-171, 1964.

Descriptors: *Rainfall-runoff relationships, *Watershed management, Watersheds (basins), Overland flow, Storm runoff, West Virginia, Infiltration, Hydrologic aspects.
Identifiers: Experimental watersheds.

A commercial clearcutting was made on a 74-acre gaged watershed on the Fernow Experimental Forest; skidroads were loggers' choice--without limitations as to grade or provisions for drainage. After-logging infiltration rates in the watershed remained well above maximum rainfall intensities except on portions of the skidroads. Overland flow occurred only from the skidroads; it resulted from the combination of rain directly on the skidroads and interception of subsurface flow by the road cuts. Increased storm runoff in the growing seasons--up to a maximum of about 1/2 area-inch in any one storm--was largely the result of decreases in field-moisture deficiency rather than changes in the proportions of surface and subsurface flow. This study indicates that, in judging hydrologic condition of logged areas, perhaps as much emphasis should be placed upon road conditions and forest-floor disturbance as upon the amount of timber cut and condition of the stand.

519
MODELING THE RUNOFF CHARACTERISTICS OF AN URBAN WATERSHED BY MEANS OF AN ANALOG COMPUTER,

J. Paul Riley and V. V. Dhruva Narayana
In: Effects of Watershed Changes on Streamflow, Water Resources Symposium No 2, Austin, Texas, pp 183-200, October 1968, University of Texas Press, Austin and London, 1969. 18 p, 14 fig, 3 tab, 7 ref.

Descriptors: *Urbanization, *Rainfall-runoff relationships, *Computer models, *Analog models, Analog computers, Simulation analysis, Hydrograph analysis, Storm runoff, Peak discharge.
Identifiers: Urban hydrology, Austin, Texas.

In the synthesis of hydrograph characteristics of small urban watersheds, the distribution of the water among the various phases of the runoff process is attempted by the concept of 'equivalent rural watershed.' For a given input into both the models, the outputs must be identical. The hydrograph of outflow from an urban watershed is obtained by chronologically deducting the losses due to interception, infiltration, and depression storage from precipitation on the equivalent rural watershed and then routing it through the surface and channel storages. This is being approached by computer simulation. Testing and verification of the basic mathematical model is being done by using observed rainfall and runoff data from well-instrumented runoff areas. Coefficients representing interception, depression storage, and infiltration are determined by the trial and error process on the analog computer in such a way that the outflow hydrograph predicted by the model is nearly identical to the measured prototype hydrograph. Relationships between these coefficients and various urbanization characteristics or parameters are established. Sensitivity studies which investigate the significance of each of the watershed coefficients on the outflow characteristics are also undertaken.

520
CORRESPONDENCE: "The analysis of urban rainfall runoff and discharge,"

E. J. Sarginson, D. E. Bourne, and L. H. Watkins
J Inst Munic Engrs, Vol 96, No 6, p 181, Jun 1969.

Descriptors: *Hydrographs, *Analytical techniques.

L. H. Watkins: The author contends that there are two misconceptions about the RRL hydrograph method: 1) the method does not currently assume uniform proportional depth in the whole sewer system; and, 2) the routine technique as applied to an areal/time calculated hydrograph is not illogical. The use of computer service is advocated.
E. J. Sarginson and D. E. Bourne: In reply to Watkins' comments, the authors insist that their analysis can be modified to allow for variations

in proportional depth from pipe to pipe. They further contend that the method they have proposed separates the effects of ground and pipe storage, and the resulting hydrograph simultaneously gives the attenuation in the peak discharge and the delay in the time of its occurrence resulting from the combined effects of overland flow and flow in the sewer.

521
ANALYSIS OF URBAN RAINFALL-RUN-OFF AND DISCHARGE,

E. J. Sarginson and D. E. Bourne
J Inst Munic Engrs, Vol 96, No 3, pp 81-85, Mar 1969.

Descriptors: *Hydrographs, *Rainfall, *Analytical techniques, *Design standards, *Discharge measurement.

This paper considers phenomena which modify a rainfall hydrograph for an urban catchment, and it examines the extent to which these modifications are satisfied by existing design methods. The theory presented accounts for phenomena concerned. A method for analysis of existing urban rainfall and discharge records is given. This design method was developed with the hydrograph based on a standard storm which is successively routed over the ground and through a sewer, assuming a linear storage-flow relation for each.

522
CORRESPONDENCE: "The Analysis of Urban Rainfall Run-off and Discharge,"

E. J. Sarginson, D. E. Bourne, and M. V. King
J Inst Munic Engrs, Vol 96, No 5, pp 155-156, May 1969.

Descriptors: *Storm runoff, *Hydrographs, Rainfall, Discharge measurement.
Identifiers: Sewer hydraulics.

M. V. King: The author disputes certain parts of the paper by D. E. Bourne and E. J. Sarginson. He corrects the misconception that the equation $i=e^{-3/4}/4$ is the Meteorological Office equation, and he argues that storm runoff should be considered with regard to time of flow through the sewer. He holds that the authors' rainfall hydrographs are valid only if the drainage area had zero time of concentration. He exposes the weakness of the authors' hydrograph method, and he explains and defends his proposed method.
E. J. Sarginson and D. E. Bourne: Replying to King's criticisms, they dispute his assertion that their rainfall hydrographs hold only if the drainage area had zero time of concentration. They also do not consider

velocities of flow necessary to their analyses; instead, they cite the important factors as being volumetric rates of runoff and discharge. They discuss King's method, but continue to support their original statements.

523
A PROGRAM IN URBAN HYDROLOGY. PART II: AN EVALUATION OF RAINFALL-RUNOFF MODELS FOR SMALL WATERSHEDS AND THE EFFECTS OF URBANIZATION ON RUNOFF,

P. B. S. Sarma, J. W. Delleur, and A. R. Rao
Purdue University Water Resources Research Center Technical Report No 9, Oct 1969. 240 p, 58 fig, 30 tab, 105 ref, 3 append. OWRR Project B-002-IND.

Descriptors: *Urbanization, *Storm runoff, *Watersheds (basins), *Rainfall-runoff relationships, *Time lag, *Model studies, Water yield, Runoff, Hydrographs, Rainfall, Runoff coefficient, Indiana, Routing.
Identifiers: Nash model, West Lafayette Watershed.

The data for this study were taken from four watersheds with varying degrees of urbanization located in West Lafayette, Indiana. The analytical approach adopted was the linear (time variant, lumped) system analysis. The conceptual linear systems considered in the analysis of the data were the single linear reservoir model, the double routing method, the Nash model, and the single linear-reservoir with linear-channel model. The single linear reservoir model was selected to simulate the rainfall-runoff process on small urban watersheds (less than 5 square miles) based on the larger watersheds (between 5 and 20 square miles). The relationship of the degree of urbanization and the time lag, the magnitude of the peak discharge, and the frequency of peak discharge were studied. Studies will be continued with linear models and, in addition, nonlinear models will be considered in the hydrologic simulation of the larger watersheds in order to develop design methods and criteria for predicting runoff from areas with varying degrees of urbanization.

524
APPLICATION OF THE LINEAR CONVOLUTION MODEL IN DESCRIBING THE RAINFALL - RUNOFF RELATIONSHIP OF AN URBAN DRAINAGE BASIN,

Fred A. Schmer, Robert A. Clark, and Edward A. Hiler
Paper presented at the Am Geophys Union - 1969 National Fall Meeting.

Descriptors: *Rainfall-runoff relationships, *Watersheds (basins), *Systems analysis, *Hydrologic aspects, *Input-output analysis, *Testing.
Identifiers: *Urban hydrology, *Convolution relationship.

This investigation is concerned with the applicability of the linear convolution relationship for approximating the rainfall-runoff phenomenon for an urban drainage basin. A solution for the transfer function of the convolution relationship is obtained by employing discrete mathematics similar to the Wiener-Hopf equation. The solution is obtained, based on the restraints of the physical system by linear programming. In this investigation, the hydrologic system is analyzed as a truly linear system. Recorded rainfall intensity is the *input* of the system, and recorded runoff the *output*. A major concern of the study involves the effects of antecedent moisture conditions on the transfer function. Results are presented which substantiate the use of the proposed linear model as an approximation to the hydrologic system. Generalized transfer functions are developed for each basin and tested with independent events. Antecedent moisture conditions are shown to have a definite predictable effect on the transfer function, and rainfall events are classified with an antecedent moisture condition criteria in order to select the proper transfer function for the event. Comparisons are made with more conventional hydrologic analysis.

525
THE U. S. GEOLOGICAL SURVEY URBAN WATER PROGRAM,

William J. Schneider
In: Effects of Watershed Changes on Streamflow, Water Resources Symposium, No 2, p 165-168, October 1968, University of Texas Press, 1969.

Descriptors: *Planning, *Urbanization, *Data collections, *Water management (applied), Research and development, Water resources development, Water supply, Waste disposal, Storm runoff.
Identifiers: Urban hydrology.

The Water Resources Division of the U.S. Geological Survey is currently expanding its role in urban hydrology as rapidly as possible to meet new demands. Almost since the first stream gaging stations were established, more than 80 years ago, water resources data have been collected in urban areas. Today, some data are available for every one of the 222 standard metropolitan areas in the United States. In addition to the collection of basic data, the Water Resources Division has conducted studies either within or including urban areas. These have resulted in numerous reports published in the Survey publication series and in outside technical journals. In recent years, the emphasis of these studies has been on the assessment of changes in the water resources caused by urbanization. Storm drainage today is still largely designed on the basis of the empirical rational formula using rainfall intensity modified by a coefficient of runoff. The inefficiency of this method is well recognized. Greater knowledge of the part of the hydrologic cycle involving rainfall-runoff relations in urban environments is needed. A study, currently under way, will consider the data needs for urban runoff studies, appraise available and needed instrumentation for collection of these data, and advise on types of networks for collection of these data. The study is for design of pilot areas.

526
EFFECTS OF URBAN DEVELOPMENT ON DIRECT RUNOFF TO EAST MEADOW BROOK, NASSAU COUNTY, LONG ISLAND, NEW YORK,

G. E. Seaburn
Geological Survey Professional Paper 627-B, p B1-B14, 1970. 14 p, 5 fig, 1 plate, 8 tab, 18 ref.

Descriptors: *Rainfall-runoff relationships, *New York, *Urbanization, *Storm runoff, Storm drains, Unit hydrograph, Duration curves, Hydrographs, Hydrology.
Identifiers: Nassau County, New York, Long Island, New York, Urban hydrology.

The effects of intensive urban development on direct runoff to East Meadow Brook, a southwardflowing stream in central Nassau County, N.Y., during the period 1937-66, are described. The special objectives of the study were to relate indices of urban development to increases in the volume of annual direct runoff to the stream; to compare hydrograph features at different periods during the transition of the drainage basin from rural to urban conditions; and to compare the rainfall-runoff relations for periods before and after urban development. Periods of housing and street construction in the drainage basin correspond to 3 distinct periods of increased direct runoff. During each period, the average annual direct runoff increased because of an increase in the area served by storm sewers that discharged into East Meadow Brook. The amount of land served by sewers increased from about 570 acres in 1943 to about 3,600 acres in 1962, or about 530 percent. During this same period, the average annual direct runoff increased from about 920 acre-feet per year to about 3,400 acre-feet per year, or about 270 percent.

527
SUMMARY REPORT STORMS OF 1969,

Larry D. Simpson
Los Angeles County Flood Control District Summary Report, Jun 1969. 55 p, 30 photo, 1 plate, 3 tab.

Descriptors: *Floods, *California, *Flood control, *Reservoirs, Peak discharge, Storm runoff, Urbanization, Flood protection, Channel improvement, Flood damage, Streamflow, Rainfall-runoff relationships, Stage-discharge relations.
Identifiers: Los Angeles County, California.

Data on flood-producing storms of 1969 in Los Angeles County, California, are tabulated. During the months of January and February of 1969, storms occurred over the southern California area which were of such a magnitude as to tax the capacities of a number of the facilities of the district and to cause significant damage to public and private property in those areas where complete flood protection had not yet been attained. These storms began with a two-phase storm which occurred between January 18 and 26, 1969. The effects of these storms on the Los Angeles County Flood Control District and the communities within Los Angeles County are discussed.

528
EFFECT OF URBAN DEVELOPMENT ON FLOOD DISCHARGES-CURRENT KNOWLEDGE AND FUTURE NEEDS,

H. F. Smith
J Hydraulics Div, Am Soc Civil Engrs, Vol 95, No HY1, pp 287-309, Jan 1969.
23 p, 2 append.

Descriptors: *Bibliographies, *Urbanization, *Hydrology, Information retrieval, Discharge (water), Floods, Hydraulics, Runoff, Surface runoff, Streamflow.

This Progress Report by the Task Force on Effect of Urban Development on Flood Discharges, Committee on Flood Control, Hydraulics Division, ASCE attempts to provide, as a guide for engineers, planners, governmental officials, and all others interested in the problems of urban runoff, an annotated up-to-date bibliography of reports, papers, and other material pertaining to the effect of urban development on flood discharges. The report includes a brief discussion of the impact on flood runoff which can be expected by urban development and the factors directly affecting the runoff regimen of a drainage area, as suburbs and cities replace the rural landscape. Included is a listing of pertinent research projects which are underway with identification of areas where, in the opinion of the Task Force, additional research is required.

529
THE ROLE OF SOLID AND LIQUID PRECIPITATIONS IN RUNOFF FORMATION,

I. S. Sosedov
Tr Inst Gidrogeol Gidrofiziki (TIGDB), Vol. 2, p 101-109, 1969.

Descriptors: *Precipitation (atmospheric), *Rain, *Snow, *Runoff, Surface runoff, Erosion, Water supply, Water balance, Mathematical studies, Soil water, Rain gages, Snow cover, Snowmelt.
Identifiers: *USSR.

Sources of surface runoff were investigated on the basis of a water balance equation in the Transilian Ala Tau region. Evaluation of the effects of altitude, snow cover, geographical location, vegetation, and slope orientation yields coefficients of runoff formed by solid (snow) and liquid (rain) precipitation.

530
SYNTHETIC HYDROGRAPHS: EFFECTS OF NETWORK GEOMETRY,

A. J. Surkan
Water Resources Res, Vol 5, No 1, pp 112-128, Feb 1969.

Descriptors: *Mathematical models, *Unit hydrograph, Simulation analysis, Storms.
Identifiers: *Storm analysis.

A mathematical model for channel networks (represented by directed graphs on a rectangular grid) is used to generate synthetic hydrographs. This makes possible the simulation of effects of changes in geometric factors specified by shape and connectivity, while keeping a fixed prescribed temporal and spatial precipitation pattern. Alternatively, this model may be used with fixed networks of interest to study the effects of different types and motions of storms. The model provides for a discrete approximation of the distributed network, and transformation relating a runoff hydrograph to input precipitation.

531
HIGH WATER RESPONSE PLAN FOR FLOOD CONTROL,

John Teipel
Public Works, Vol 100, No 7, pp 82-83, Jul 1969.

Descriptors: *Runoff, *Rainfall, *Planning, *Forecasting, *Operations, *Overflow.
Identifiers: *Storm sewers.

Dallas, Texas has instituted a high water response plan in order to cope with runoff from overloaded storm sewers and flash flooding from small creeks which cause problems during heavy rainfalls. Planned operations begin with initial forecasts of severe weather followed by mobilization of forces to serve areas called Phase Locations which are classified according to their particular difficulties. Phase I forces handle local downpour locations; Phase II forces handle major creek locations; and Phase III forces handle locations affected by river flooding, including operation of six flood control pump stations. Other actions taken to alleviate problems before, during, and after the storm are explained.

532
URBAN RUNOFF BY ROAD RESEARCH LABORATORY METHOD,

Michael L. Terstriep and John B. Stall
J Hydraulics Div, Am Soc Civil Engrs, Vol 95 No HY6, p 1809-1834, Nov 1969

Descriptors: *Storm runoff, *Urbanization, *Mathematical models, Rainfall-runoff relationships, Roads, Model studies, Storm drains, Hydraulics, Hydrology, Sewers, Streamflow, Planning.
Identifiers: Urban hydrology.

A simple mathematical model of an urban basin presented in 1962 by the British Road Research Laboratory is tested on three urban watersheds in the United States. The basins are located in Baltimore, Md. and Chicago, and Campaign, Ill. They contain 0.395, 12.5, and 2290 acres respectively. The model produces a runoff hydrograph by applying rainfall to only the directly connected impervious area of the basin. The basin is described by a time-area diagram and a discharge-storage relationship. The peak discharges of actual and predicted hydrographs are shown for 8 of these. To apply the model to a basin, the pattern of impervious areas must be known in detail, as well as the slopes and sizes of all surface and subsurface drains.

533
AVAILABILITY OF RAINFALL-RUNOFF DATA FOR PARTLY SEWERED URBAN DRAINAGE CATCHMENTS,

L. S. Tucker
ASCE Technical Memorandum No 13, Urban Water Resources Research Program, Mar 1970. 156 p, 24 fig, 15 tab, 49 ref. append. OWRR Project C-1536 (No 1992) (3).

Descriptors: *Data collections, *Rainfall-runoff relationships, *Cities, *Storm runoff, *Stream gages, Sewers, Open channels, Urbanization, Hydrologic data, Runoff, Drainage systems, Storm drains.
Identifiers: Japan, Urban runoff.

Available rainfall-runoff data for partially sewered urban drainage catchments are identified to facilitate model development by researchers. Information on the availability of rainfall-runoff data from 64 developed partially sewered urban drainage catchments in U.S. and 8 in Japan is summarized. The 64 catchments in the U.S. are concentrated in 8 states, and the locations of these instrumented catahments are shown by a map. Rainfall-runoff data for most of the catchments are available from the agencies collecting the data. A summary of information on the 64 instrumented, highly-developed, partially sewered urban drainage catchments in the U.S. is presented. Additional details such as availability of data, how to obtain further information about catchments and data, gage locations, and maps of catchments are presented.

534
SEWERED DRAINAGE CATCHMENTS IN MAJOR CITIES,

L. S. Tucker
ASCE Urban Water Resources Res Program Tech Mem No 10, Mar 31, 1969.
71 p, 34 fig, 4 tab, 13 ref. USGS Contract No. 14-08-0001-11257.

Descriptors: *Cities, *Rainfall-runoff relationships, *Storm drains, *Sewers, Storm runoff, Drainage systems, Water quality control, Water pollution control.
Identifiers: Combined sewers.

The size distribution and number of sewered drainage catchments in San Francisco, Washington, D.C., Milwaukee, Houston, and Philadelphia are summarized to provide data for urban rainfall-runoff-water quality studies. The 4 cities are in 4 distinctly different regions of the US, and are different topographically. The sizes of all sewered drainage catchments are tabulated, maps show catchment boundaries, and supporting discussions are presented. Only the drainage catchments served entirely by storm or combined sewers are discussed, and partially sewered urban drainage catchments are omitted. The distribution of sewered drainage catchment size is unique for each city. The number of catchments varies from 42 in San Francisco to 1,283 in Houston. The largest catchment varies from 1,820 acres in Milwaukee to 6,180 acres in Washington, D.C. The average catchment size varies from 65 acres in Houston to 560 acres in San Francisco. The median catchment size varies from 6 acres in Houston, to 190 acres in San Francisco. In Washington, D.C., drainage catchments varying in size from 1 to 50 acres account for 46% of the total number of catchments varying in size from 1 to 50 acres account for 46% of the total number of catchments, but their cumulative area served by sewers. On the other hand, over 50% of the total District area served by sewers is accounted for by the 5 largest drainage catchments, which are only 5% of the total of 93 catchments.

535
AVAILABILITY OF RAINFALL-RUNOFF DATA FOR SEWERED DRAINAGE CATCHMENTS,

L. S. Tucker
ASCE Urban Water Resources Res Program Tech Mem No 8, Mar 3, 1969.
43 p, 14 fig, 5 tab, 18 ref. USGS Contract No 14-08-0001-11257. OWRR Contract No 14-01-0001-1585.

Descriptors: *Data collections, *Gaging stations, *Cities, *Rainfall-runoff relationships, *Urbanization, Drainage systems, Runoff, Storm drains, Sewers, Storm runoff, Flow rates, United States.

Data on the availability of rainfall-runoff data from gaged, sewered urban catchments are compiled. Only 13 completely sewered catchments in the U. S. are gaged. Runoff is measured by flume in Northwood, Gray Haven, and Swansea, all in Baltimore, Md. Reduced data from 29 Gray Haven Storms are tabulated. The 13 catchments are summarized in a table giving name, size, data collected, type of flowmeter, type of storm sewer, data available, operator of the installation, location, and period of operation. Each installation and catchment is described in detail. Baltimore has 3 gaged catchments, Cincinnatti, Ohio has 1, St. Louis, Mo. has 3, Chicago, Ill. has 1, Philadelphia, Pa. has 1, New York City has 4, and Washington D.C. has 1.

536
OAKDALE GAGING INSTALLATION, CHICAGO-INSTRUMENTATION AND DATA,

L. S. Tucker
ASCE Tech Mem No 2, Urban Water Resources Res Program, Aug 15, 1968.
14 p, 8 fig, 2 tab, 2 append. OWRR: 14-01-0001-1585, USGS: 14-08-0001-11257.

Descriptors: *Data collections, *Storm runoff, *Rainfall, *Rainfall-runoff relationships, *Urbanization, Watersheds (basins), Stream gages, Flumes, Rain gages, Land use, Drainage, Discharge (water), Runoff, Hydrographs, Hyetographs, Sewers.
Identifiers: *Urban hydrology, Chicago, Illinois.

An instrumented 12.9 acre urban drainage area in Chicago, Illinois is described. Rainfall and runoff data for storms for which data are reliable are tabulated and presented. The area is 2 1/2 blocks by 1 block wide and consists entirely of detached family dwellings. The drainage system is a 30-in. combined sewer draining into a 10.5 ft square concrete trunk sewer. Runoff is measured by a parabolic flume in an underground vault. A tipping bucket rain gage is located about 1 block north of the drainage area. The rain and flume gages are connected to recorders by telephone lines. Rainfall and runoff records from storms are shown in tables, hyetographs, and hydrographs. Copies of some of the original recorder charts are included.

537
NORTHWOOD GAGING INSTALLATION, BALTIMORE-INSTRUMENTATION AND DATA,

L. S. Tucker
ASCE Tech Mem No 1, Urban Water Resources Res Program, Aug 1, 1968.
16 p, 11 fig, 2 tab, 3 append. OWRR: 14-01-0001-1585 and USGS-14-08-0001-11257.

Descriptors: *Rainfall-runoff relationships, *Data collections, *Storm runoff, *Urbanization, Watersheds (basins), Stream gages, Flumes, Rain gages, Land use, Discharge (water), Runoff, Hydrographs, Hyetographs, Evaporation, Rainfall.
Identifiers: *Urban hydrology, Baltimore, Maryland.

Detailed data of the hydrology of Northwood, a small urban drainage area in Baltimore, Maryland, are presented. Northwood is one of the few sewered catchments in the U.S. that is gaged with flumes. The 47.4 acre drainage area is about 4 mi north of downtown Baltimore in a residential suburban area. It contains a 17.4 acre shopping center and 30 acres of residential development. Buildings in the residential area are very uniformly grouped houses with 3-4 houses per group. The average imperviousness of the drainage area is 68%. Ground slopes average 3%. A weighing bucket rain gage and a Parshall flume were installed in 1959, and the rain gage was replaced with a tipping bucket gage in 1963. Both in the rain gage and stream gage have recorders. Runoff is estimated to be within 5% of actual flow 95% of the time for flume depths over 4 in. Reduced rainfall and runoff data for 14 storms, hourly precipitation, and daily pan evaporation data are tabulated. Hyetographs and hydrographs illustrate the rapid response of the drainage area.

538
BASIC DATA FOR URBAN HYDROLOGY STUDY, DALLAS, TEXAS - 1966,

Trigg Twitchell
Geol Surv Open-file Rep, 1966. 203 p, 3 fig, 1 tab.

Descriptors: *Rainfall-runoff relationships, *Urbanization, *Data collections, *Texas, Streamflow, Runoff, Hydrographs, Rainfall, Surface waters, Hydrologic data, Depth-area-duration analysis.
Identifiers: Dallas, Texas, Urban hydrology.

Basic hydrologic data compiled for the study of urban hydrology in Dallas, Texas include data from raingages, stream gages, and flood-profile partial-record stations. Hydrographs and mass curves are given for major storms at each station.

539
USING RUNOFF EVENTS TO CALIBRATE SMALL FORESTED CATCHMENTS,

S. J. Ursic and T. W. Popham
In: 14th Congr Proc, Int Union Forest Res Organ, Vol 1, pp 319-324, 1967.

Descriptors: *Calibrations, *Rainfall-runoff relationships, *Storm runoff, Water measurement, Mathematical models, Watershed management, Hydrologic aspects, Mississippi.
Identifiers: *Experimental watersheds.

Calibration and analysis based on individual runoff events appear efficient for evaluating changes in the hydrologic performance of small paired catchments. The approach is particularly useful where effects of watershed treatment on changes in ephemeral flow phenomena are of primary concern.

540
EXPERIENCE WITH THE EVALUATION OF URBAN EFFECTS FOR DRAINAGE DESIGN,

Donald VanSickle
In: Effects of Watershed Changes on Streamflow, Water Resources Symposium

No 2, p 229-254, October 1968. University of Texas Press, Austin and London, 1969. 26 p, 17 fig, 4 tab, 17 ref.

Descriptors: *Urbanization, *Rainfall-runoff relationships, *Unit hydrograph, *Synthetic hydrology, Rational formula, Storm runoff, Peak discharge, Floods, Hydrograph analysis, Routing.
Identifiers: Houston, Texas, Urban hydrology.

An example is given of the adaptation of preliminary research data to the development of new drainage design criteria for a major metropolitan area. The new criteria should be closer to the actual needs than the old rational method criteria. The Houston metropolitan area, one of the most rapidly urbanizing areas in the United States, was used to establish and test new urban runoff criteria. In order to apply urbanization factor data to design, the following procedures are followed: (1) develop the mean basin length and mean basin slope values from topographic maps; (2) estimate the degree of development anticipated in the watershed for the period of design; (3) estimate drainage density for each of the areas of use; (4) multiply the drainage density by the area for each type of land use to get total channel length; (5) determine the basin factor; (6) from the curves, determine the time to peak and the unit hydrograph peak for the degree of development involved; and (7) develop the unit hydrograph. A simpler way to use the criteria is to develop them as empirical curves of drainage area versus discharge, of specific use only in the urban area and for the storm frequencies for which they are designed. Synthetic unit hydrographs were prepared and tested for about 50 drainage areas in the Houston areas.

541
URBAN STORM RUNOFF RELATIONS,

Warren Viessman, Jr., Walter R. Keating, and Kalkunte N. Srinivasa
Water Resources Res, Vol 6, No 1, pp 275-279, Feb 1970. 1 diag, 2 graphs, 1 tab, 7 ref.

Descriptors: *Storm runoff, *Model studies, *Data collections, Rainfall-runoff relationships.
Identifiers: *Urban hydrology, *Comparative analysis, *Baltimore, Maryland.

A model incorporating the hydrologic and hydraulic phases of stormwater flows to estimate the runoff from a 23-acre residential area has prediction errors that are generally less than 10% when the peak flow is used as the criterion for comparison. The data for this study were derived from rainfall and runoff records of the Gray Haven drainage area in Baltimore, Maryland.

542
ESTIMATING THE GROUND-WATER CONTRIBUTION TO STORM RUNOFF BY THE ELECTRICAL CONDUCTANCE METHOD,

Adrian P. Visocky
Ground Water, Vol 8, No 2, pp 5-10, Mar-Apr 1970. 7 fig, 12 ref.

Descriptors: *Storm runoff, *Base flow, *Monitoring, *Water quality, Leaching, Infiltration, Rainfall-runoff relationships, Surface-groundwater relationships, Hydrographs, Peak discharge.

The feasibility of determining the groundwater contribution to stream flow during periods of storm runoff by continuous monitoring of a stream's electrical conductance was investigated. The groundwater contribution can be estimated if stream flow and the conductance of surface water and of groundwater are known. The conductance method was tested on a 95-square-mile basin in north-central Illinois. Continuous records of stream flow, stream-flow conductance, and groundwater stage within the basin were collected. A rating curve of base flow versus mean groundwater stage was constructed, and groundwater discharges determined from the rating curve were compared with those computed from conductance data. The conductance method normally gave a lower estimate of the groundwater contribution than did the rating-curve method. However, analyses of storms which were preceded by extended dry periods resulted in much lower estimates of groundwater discharge by the rating-curve method than by the conductance method. The conductance method offers a simple alternative for use in areas where observation wells are unavailable or where rating curves are difficult to construct.

543
URBAN EFFECTS ON WATER YIELD,

Arvi O. Waananen
In: Effects of Watershed Changes on Streamflow, Water Resources Symposium No 2, p 169-182, Oct 1968. University of Texas Press, Austin and London, 1969. 14 p, 7 fig, 2 tab, 16 ref.

Descriptors: *Urbanization, *Rainfall-runoff relationships, *Storm runoff, *Water supply, Land use, Water yield, Hydrology, Hydrographs, Peak discharge, Hydrograph analysis, Meteorology, Sewers, Storm drains, Sewage disposal, Waste disposal.
Identifiers: Urban hydrology.

Urban development has a significant impact on hydrologic relations. The results of various studies demonstrate the type and magnitude of many of the effects on yield. These may be summarized as including: (1) increase in total yield from stormflow and in annual discharge; (2) decrease in base flow of those streams that remain under generally natural conditions; (3) modification of low flow of streams influenced by the importation of water, the use of which results in discharge of wastewater. This includes the increase of low flow in streams that receive septic-tank drainage, or effluents from sewage-treatment plants, or from industrial plants; (4) decrease in recharge to the underlying ground-water basins; and (5) increase in precipitation in urban areas and corresponding increase in yield. The principal effect of urban development on yield is an increase in direct runoff. The cumulative effect of increase in stormflow from urban areas, particularly in regions of strip cities and the megalopolitan complexes developing in several areas, may be substantial on downstream receiving channels.

544
LOS ANGELES COUNTY FLOOD CONTROL SYSTEM AND THE EARLY 1969 STORMS,

Walter J. Wood
Civil Eng, Vol 40, No 1, pp 58-61, Jan 1970.

Descriptors: *Rainfall-runoff relationships, *Urbanization, *Overflow.
Identifiers: *Los Angeles, Flood control.

The Los Angeles flood control system, comprised of 19 dams, 72 debris basins, 390 miles of channels, and 1200 miles of storm drains, faired well during the floods of January and February 1969. Although the rainfall intensities did not equal that from the storm of 1938, the high runoff is attributed to the urbanization of the affected area and to the quicker delivery of valley flows by the network of storm drains and collector channels. The storm experience reaffirmed the adequacy of the general design of the system. The effective handling methods of dams, debris basins, and channels in relation to runoff are discussed.

545
A LABORATORY STUDY OF SURFACE RUNOFF DUE TO MOVING RAINSTORMS,

Ben Chie Yen and Ven Te Chow
Water Resources Res, Vol 5, No 5, p 989-1006, Oct 1969. 18 p, 7 fig, 13 ref. NSF Grant GK-1155.

Descriptors: *Rainfall-runoff relationships, *Runoff forecasting, *Rainfall disposition, Hydrographs, Hydrograph analysis, Distribution patterns, Mathematical models.

The movement of a rainstorm determines the spatial and temporal distributions of the rainfall over a watershed and hence affects the characteristics of the flow on the watershed. In this study the importance of the movement of rainstorms on the time distribution of the surface runoff from watersheds is demonstrated through the use of a laboratory watershed experimentational system. Experiments were performed on the impervious square watershed for 2 rainfall intensities, 4 surface slopes, and 14 rainstorm velocities. Analysis of the mechanics of water flowing on watersheds is attempted to explain the influence of movement of rainstorms on the characteristics of surface runoff hydrographs.

546
THE HYDROGEOLOGIST'S RESPONSIBILITY-METROPOLITAN WATER RESOURCE PLANNING,

Arthur J. Zeizel
Trans Am Geophys Union, Vol 49, No 3, pp 543-547, Sep 1968. 2 ref.

Descriptors: *Urbanization, *Water resources development, Planning, *Water management (applied).
Identifiers: *Urban hydrology.

As the population of the United States is changing from a predominantly rural to urban society, so the traditional role of the hydrogeologist is changing. Needs for this services are reflecting the requirements of comprehensive water resources management programs. This trend toward urbanization is also creating complex water problems and related land problems. Comprehensive water resources planning offers a means of solving these problems and improving the living environment. Its emphasis is on alternative management measures that can best be planned and evaluated by interdisciplinary study teams, teams that should include the hydrogeologist. Urban drainage management programs need additional supporting research in urban hydrology, and the hydrogeologist can contribute broadly in planning these research and management activities, particularly for projects in stormwater storage, infiltration, and reuse. Hydrogeologists can also assist in solving engineering problems encountered during construction of dams, tunnels, reservoirs, lakes, and canals. The inadequate communication that now exists between the hydrogeologist and the planner can be improved by a closer working relationship.

Section 10

TUNNELS: TECHNOLOGY AND EQUIPMENT

547
CHICAGO SANITARY DISTRICT IN NEW POLLUTION FIGHT,

Civil Eng, Vol 37, No 10, p 98, Oct 1967.

Descriptors: *Tunnel construction, *Storm runoff, *Sewage, *Tunnels.
Identifiers: *Chicago, Illinois.

As part of Metropolitan Chicago's ten-year program to combat water pollution, a deep tunnel sewage plant is being proposed for completion by 1972 to store excess floodwaters from severe rainstorms in underground chambers. Stormwater runoff will be prevented from entering sanitary sewers, and the water will later be released under controlled conditions. The estimated cost of the deep tunnel project is $750 million, which is much less than the $3-billion it would cost to construct separate storm and sanitary sewage systems. Other proposed programs include chlorination of all facilities by 1968, elimination of visible solids by 1969, and construction of a tertiary waste-treatment plant in Hanover, Ill. by 1971.

548
BREAKTHROUGH ON SECOND MERSEY ROAD TUNNEL AS WORK COMMENCES ON DUPLICATE,

Civil Eng Public Works Rev, Vol 65, No 765, p 378, Apr 1970.

Descriptors: *Tunneling, *Tunneling machines, *Tunnel linings, *Linings, *Concretes, *Steel, *Epoxy resins, Construction equipment.
Identifiers: *Great Britain, *Mole, *Mini Mole.

A mole tunneling machine was used to excavate through sandstone rock between Liverpool and Birkenhead. The tunnel was lined with a segmented type of lining made up of reinforced concrete acting compositely with an inner steel skin. It was then covered with a high-build epoxy protective coating. A duplication of the tunnel is to be built for which a Mini Mole has been desinged for driving a 2,202- yard pilot tunnel. A description of the Mini Mole is given.

549
STANDARD EQUIPMENT, MODIFIED TECHNIQUES DRILL HOLES IN ROCK,

Construct Methods Equip, Vol 52, No 3, pp 100-101, Mar 1970. 4 fig.

Descriptors: *Rock excavation, *Drilling equipment, *Pipelines, *Tunnels, Tunnel construction.
Identifiers: *Sanitary sewers, *Skokie, Illinois.

Kenny Construction Co. in Skokie, Illinois undertook the horizontal boring of over 500 feet of major-size holes through tough rock. The tunnels will carry fire lines, pipelines for petroleum products, and sanitary sewers. The job was completed successfully with conventional overburden drilling machines. Special effort and skill was used in applying and maintaining cutting heads, keeping the bore aligned, and strengthening an auger to carry cuttings back to an ejector.

550
EXCAVATOR OPENS BORE WITH CLEAN SWEEP FORE AND AFT,

Construct Methods Equip, Vol 50, No 10, pp 64-65, 67-68, Oct 1969. 2 fig.

Descriptors: *Drilling, *Tunnels, *Tunnel construction, Control systems, Hydraulic equipment, Tunnel linings, Concrete construction, Tunneling machines.
Identifiers: *Sewer tunnel, *Akron, Ohio.

Drilling and shooting operations drove a tunnel borer through sandstone while an hydraulic-excavator worked in the earth section of sand, clay, and gravel to complete a sewer tunnel in Akron, Ohio. The excavator had a boom-mounted blade dig and then sweep muck to a conveyor that dumped into a skip on rails. Hydraulic jacks thrust the excavator forward and steered it laterally and vertically. Laser beam sightings kept the machine on course. Techniques used to bore the tunnel are described in detail. Once the tunnel was driven, sewer pipe was pulled in and laid on a poured concrete cradle. Concrete was then pumped down shafts into the space between the pipe and tunnel lining.

551
JACKS SAVE DAY FOR TEXAS TUNNELER,

Construct Methods Equip, Vol 51, No 9, pp 90-93, Sep 1969. 7 fig.

Descriptors: *Tunneling, *Tunnel construction, *Tunneling machines.
Identifiers: *Pipe jacking, *Reaming auger, Houston, Texas.

To tunnel and line three oversized utility conduits under a Houston street, the subcontractor resorted to pipe-jacking instead of machine-tunneling when crews were unable to hold the boring rig on the center-line. The subcontractor planned to use a rig that was custom-built for a Dallas storm-drain project. With the addition of a shield over the auger, the job was attempted in Houston's soft earth. After the centering trouble stopped work, the remaining tunnels were completed by mining with pneumatic shovels and jacking the liners into place with the subcontractor's designed equipment.

552
PIPELAYER MINIMIZES TRENCHING AND BACKFILLING,

Construct Methods Equip, Vol 51, No 8, pp 42-45, Aug 1969.

Descriptors: *Tunneling, *Tunnel construction, *Tunneling machines, *Installation, Pipelines.
Identifiers: *Badger Minor, *Tugmaster, *Galveston, Texas.

The first domestic water system for the Gulf Coast resort area near Galveston is being installed with two trenchless pipelaying methods known as the "pull through" and the "slow in" techniques. Basically, both involve tunneling through the ground and pulling long strings of pipe through the bore with very little disturbance of the ground at the surface. The principal pieces of equipment used on this job are the Badger Minor and the Tugmaster. The functions of these pieces are described and the two methods of pipe installation are explained.

553
THE ART OF TUNNELING,

Construct Methods Equip, Vol 51, No 7, pp 143-146, Jul 1969. 1 fig.

Descriptors: *Tunneling.
Identifiers: *Mechanical tunneling, *Tunneling techniques, *Tunneling analysis.

Present and future demands for tunneling are enormous, especially for construction of rail lines, highways, sewers, and water-lines. These demands require that costs be cut and processes speeded up. Mechanical tunneling seems to answer these needs, but problems with it remain to be solved. Mechanical moles do not run at the high speed desired, and hard rock often resists machines' efforts. Other problems cited include: inadequate muck-handling systems, a need for development of geological techniques to provide tunnelers with better information as to what is lying ahead, a need for better rock-mechanics techniques for measuring subsurface stresses around boreholes and tunnels, and improvement in methods for supporting tunnels and shafts against cave-ins. The following new techniques for tunneling are discussed: use of surface-active chemical agents or lasers to weaken the rock face, electron beams for cutting rock, pulsed supersonic water jets from an air-powered cannon, and electrohydarulics--a method of converting electrical energy into mechanical energy.

554
PRODUCTION UP, COST DOWN,

Construct Methods Equip, Vol 51, No 5, pp 54-58, May 1969. 8 fig.

Descriptors: *Sewers, *Installation, Control systems, Comparative costs, Concrete pipes.
Identifiers: *Chicago, *Mole.

A mechanical mole is breaking the way for the placement and jacking of a two-mile sewer project in the Metropolitan Sanitary District of Greater Chicago (MSD). Long jacking distances are achieved by overmining a few inches and using bentonite slurry as a pipe lubricant. Part of the good production rate can be attributed to installation of track for mucking equipment inside the pipe before it is lowered through access shafts to crews below. Workings of the mole and jack are explained. An electric-gas laser provides accurate control for rapid mining and jacking operation, as its beam is sloped to follow the required grade. The laser also aligns the pipe vertically and horizontally. District engineers com-

pared costs of installing the 5½-foot precast-concrete pipe using the jacking method against the cost of installing the 5½-foot monolithic concrete sewer in a tunnel using conventional methods of machine mining, and the jacking method was found to be less expensive.

555
SEWER MOLE TRIMS COST OF TUNNEL RIBS AND CONCRETE,

Construct Methods Equip, Vol 48, No 5, pp 93-95, May 1966.

Descriptors: *Tunneling, *Tunneling machines, *Investigations, *Tunnel construction.
Identifiers: *Sewer tunnel, St. Louis, Missouri.

In a comparative study between the mechanical tunneling method and the drill-and-shoot method, five distinct advantages in mechanical boring were reported by Victor J. Scaravilli, a contractor on a St. Louis sewer tunnel. A description of the 23,000-foot sewer tunnel which the S&M Constructors of Cleveland are boring for the Metropolitan St. Louis Sewer District is included.

556
PAVED WAY FOR TRANSCONA'S LONG HOLE,

Eng Contract Record, Vol 82, No 10, pp 58-60, Oct 1969. 1 diag.

Descriptors: *Sewers, *Tunnels, *Tunneling, *Tunnel design, Planning, Construction.
Identifiers: *Storm sewer, Canada.

BACM Industries Ltd. in Winnipeg built the largest and longest sewer tunnel ever contracted in Manitoba. This storm relief project is described in a brochure they mailed to all residents in the area. The basic construction plan involved the sinking of 10 shafts to a depth of 34 feet at regular intervals, the sewer being tunnelled outward from each shaft and connected to form one long tunnel. The soft-mining method was employed, and no problems were encountered except for the high water table created during spring because of flooding conditions above ground. This was overcome by boxing off the area and using sump pumps to divert the water until workers were finished in that area. Tunneling procedures used are discussed, including the open cut method employed for a portion of the storm relief sewer.

557
JET, MOLE TEAM SEEKS TUNNELING BREAKTHROUGH,

Eng News-Record, Vol 184, No 4, p 48, Jan 22, 1970.

Descriptors: *Tunneling machines, *Construction equipment.
Identifiers: *Mole.

A mole that uses high velocity jets of water to cut rock has been produced. The machines are pulsed devices in which gas, after being compressed in a cylinder, is suddenly released to act as a piston. The piston drives against water in a pressure head to force it out through a nozzle in a jet. Two versions of this tunneling device are examined.

558
LASER STEERS BIG MOLE IN BAD ROCK UNDER LAKE,

Eng News-Record, Vol 184, No 2, pp 26-28, Jan 8, 1970. 1 diag.

Descriptors: *Tunneling, *Tunneling machines, *Tunnels, *Control systems.
Identifiers: *Mole, *Laser beam control, *Lake Huron.

A mole tunneling machine, the biggest and most sophisticated ever built by Lawrence Manufacturing Company, is rapidly boring a six-mile tunnel out under Lake Huron for water conveyance to Detroit. Dimensions and operating techniques for the mole are described. Called an Alkirk Hard Rock Tunneler, the rig is unusual because of the 24-in.-dia. pilot bit and anchor jutting out of its main cutterhead which mounts carbide cutters. Laser guiding of the mole is used; in effect, the laser beam controls the machine. Should something interrupt the beam, or the laser itself fail to function, four potentiometers act as a holding mechanism that maintains the mole on the last recorded position for fifteen minutes. Completion of the tunnel is expected to be by 1971, but ground conditions and legal entanglements have placed the project behind schedule. It is hoped that the mole will improve this situation.

559
THOMPSON RIVER MOLE BORE IS THE LONGEST IN HARD ROCK,

Eng News-Record, Vol 183, No 5, p 18, Jul 31, 1969.

Descriptors: *Tunneling, *Tunneling machines, *Tunnel design, *Construction equipment, *Tunnels.
Identifiers: *Mole, *Australia.

A 12-mile tunnel, which will divert water from the Thompson River through 3,600-ft. Mount Gregory to the Yarra River, is a 24 million dollar project. The project has three stages: 1) excavation of the Thompson and Yarra adits (totaling 3,260 feet); 2) excavation of the 1,390 foot Easton adit, and a 2.9 mile section of the main tunnel between the Easton and Thompson adits; and, 3) boring of the 9.1 mile main tunnel using the mole.

560
MOLE BREAKS THROUGH AFTER 293-FT. DAY AND 1,114-FT WEEK,

Eng News-Record, Vol 183, No 4, pp 28-29, Jul 24, 1969.

Descriptors: *Bids, *Tunnel construction, *Tunneling machines, Tunnel design, Cost comparisons.
Identifiers: *Mole.

The Utah Construction and Mining Co.'s mole boring machine, called Jarva Mark 11-1200, averaged 109 feet per day at an estimated $15/ft. cutter cost. Remarks made by the project manager which encompass the operation of the mole and the construction design, are included. A cost comparison of the different contract bids is given.

561
PIPES JACKED BEHIND MINI-MOLE,

Eng News-Record, Vol 182, No 20, pp 45-46, May 15, 1969.

Descriptors: *Sewers, *Cost comparisons, *Tunneling machines, *Tunneling.
Identifiers: *Mini Mole, *Chicago, *Mole.

A mining machine, which jacks concrete pipe sections immediately behind it, is being used to build a sewer in suburban Chicago. The technique, commonly used to avoid cut-and-cover construction across highways and railroads, entails building a two mile sanitary sewer under a $2.9 million contract. The procedure involved is explained, and a cost comparison study of mining and jacking the 66-inch diameter pipe into place, with a 78-inch-ID reinforced concrete sewer using conventional methods of machine mining, ribs, lagging and monolithically placed concrete, is given.

562
MOLE MAKES MONKEY OF MOUNTAIN,

Eng News-Record, Vol 181, No 50, p 19, Dec 12, 1968.

Descriptors: *Nevada, *Drilling, *Tunneling machines, *Construction equipment.
Identifiers: *Mole.

A mole machine, working in everchanging igneous formations that range in compressive strength from 1500 to 1700 psi, is driving a tunnel through a Nevada mountain. Called the Jarva Mark 11/14, the unit develops 866,000 lb. of thrust, and has an adjustable cutterhead that will handle tunnels from 11 to 14 feet in diameter.

563
PIPELAYER PLOWS SEWER IN QUICKLY,

Eng News-Record, Vol 181, No 5, p 44, Aug 1, 1968.

Descriptors: *Tunneling machines, *Tunnel construction, Tunneling.
Identifiers: *Great Britain.

A British company has applied the principle of the cablelaying plow to place pipes, and claims to have halved the cost of a sewer project in northeast England. The track-mounted machine, called a Badger Major, forces a passage through the ground without removing any soil. Then plastic pipe is snaked through the tunnel, which has a wall surface free of sharp stones that might damage the pipe. A hydraulic winch, guided by an infrared beam emitted from a portable transmitter mounted atop of the winch, hauls the plow forward. The rig will work in all types of ground except rock.

564
MOLE BORES AT 16 FEET PER HOUR,

Eng News-Record, Vol 179, No 42, p 29, Oct 19, 1967.

Descriptors: *Drilling, *Drilling equipment, *Tunnel construction.
Identifiers: *Mole, West Germany.

A mechanical mole excavating under West Germany's Swabian Jura range has a cutting head made up of four rotating steel-toothed cutting wheels mounted on a rotating base. On the vertical axis, the operator of the mole steers by raising or lowering the cutting head; and horizontally, the mole is steered with the aid of small crawler tracks. A laser control system keeps the mole on course.

565
DEEP TUNNEL STORAGE MAY SOLVE CITY STORM WATER PROBLEM,

Environ Sci Technol, Vol 3, No 3, pp 209-211, Mar 1969.

Descriptors: *Storm runoff, *Pollution abatement, *Sewage treatment, *Runoff, *Cost comparisons, *Cost analysis, *Water quality, Overflow, Biochemical oxygen demand.
Identifiers: *Deep tunnel plan, *Chicago, Combined sewers.

The Metropolitan Sanitary District of Greater Chicago (MSD) has a plan devised for the control of pollution from storm and combined sewer water runoff -- the Chicagoland Deep Tunnel Project. This plan would: capture flow from a 300 square-mile section; cost approximately $1.02 billion ($.02 billion more than the present sewage treatment facilities' cost); and, almost completely remove BOD from the stormwater runoff at ¼ the cost of available alternatives. The Harza Engineering Co. and Bauer Engineering Inc. are the two consulting firms working on the project which may develop into a $2.2 billion water quality program. Comments by Vinton Bacon, general manager of the sanitary district, are made on the urgency of the project, the necessary reasons for the project, and the benefits from the project. A cost list is given as well as a short description of the tunnel system layout.

566
MODERN TUNNELING METHODS USED ON BOLTON SEWER,

Surveyor, Vol 85, No 4049, p 38, Jan 16, 1970. 1 fig.

Descriptors: *Tunneling, *Sewers, *Tunnel construction, *Tunnel design, *Tunneling machines.
Identifiers: *Great Britain.

Fifteen years ago, a Radcliff sewer connection by tunnel was more expensive than a riverside route on the surface. However, developments in tunneling made it possible for a tunnel route to provide savings over the sewer's probable life. So, a ¾-mile long sewage tunnel was constructed. Blasting was used for the greater part of the length, and excavated materials were removed by means of an electrically-driven small gauge railway. Instead of employing compressed air for shaft sinking, a recently developed boring technique was used. The method is fully described along with other construction and installation procedures.

567
METRO TORONTO TO START $22 MILLION SEWER PROJECT,

Water Pollution Control, Vol 108, No 3, p 38, Mar 1970.

Descriptors: *Design, *Tunnel construction, *Tunnel linings, *Urbanization, Contracts.
Identifiers: *Interceptor sewer, *Storm sewers, *Canada.

McNally Construction was recently awarded a $5 million contract for the first phase of work on a 10-foot diameter mid-Toronto storm sewer interceptor. $22 million is the estimated cost of the 8.5 mile project which consists of a 100-foot below surface tunnel. Concrete will be used for tunnel lining and can be poured at any time except when boring under the Don River when it must be poured immediately to prevent cave-ins. A pumping station will be rebuild to connect the low and high level interceptors to the project interceptor, thus relieving pressure on the two older storm sewers.

568
MOLE SETS FAST PACE IN NEVADA ROCK,

Western Construct, Vol 43, No 12, pp 38-39 and 52, Dec 1968.

Descriptors: *Mechanical equipment, *Nevada.
Identifiers: Mole.

The rotary mining machine, driving the River Mountains' Tunnel of the Southern Nevada Water Project, is advancing 200 feet per day through barrier mountains bounding Lake Mead. The Jarva mole, which is 12 feet in diameter and has a cutting head with 26 hardened steel disk cutting wheels and 1 center and 4 tri-cone gage cutters of carbide steel, is used to drill through the rock. The business end of the mole is held in place during operation by four hydraulic feet behind the cutting collar.

569
THE IMPACT OF THE DEEP TUNNEL PLAN ON THE WATER RESOURCES OF NORTHEAST ILLINOIS,
Harza Engineering Co and Bauer Engineering, Inc.

Rep to Chicago Metrop Sanit Dist, Feb 1969. 20 p, 6 fig, 1 append.

Descriptors: *Water pollution control, *Storm runoff, *Tunnels, *Hydrologic aspects, Storm drains, Pumped storage, Groundwater, Aquifers, Illinois, Cities, Urbanization.
Identifiers: *Chicago, Deep tunnel plan, Combined sewers.

The possible effects of the proposed Chicago deep tunnel urban runoff retention scheme on the water resources of northeastern Illinois were estimated by surveying the hydrogeology, surface water hydrology, and groundwater development of the area. Chicago has a combined sewer system, and storm runoff overloads cause discharge of raw sewage to waterways including recreational areas of Lake Michigan. A system of deep tunnels and protective recharge wells is proposed for temporary storage of peak combined loads. The system is expected to release treated storm runoff at a steady rate, greatly regulating the streamflow of receiving streams. High groundwater heads must be maintained to prevent loss of contaminated water from the tunnels, requiring good groundwater management practices for the entire area.

570
CHICAGOLAND DEEP TUNNEL SYSTEM FOR POLLUTION AND FLOOD CONTROL: FIRST CONSTRUCTION ZONE, DEFINITE PROJECT REPORT,
Harza Engineering Co and Bauer Engineering Inc, May 1968.

Work performed for Metropolitan Sanitary District of Greater Chicago. 199 p, 10 map, 15 dwg, 26 tab, 14 chart.

Descriptors: *Multiple-purpose projects, *Pollution abatement, *Flood control, Overflow, Pumped storage, Operations, Sewerage, Water quality, Reservoir operation, Water treatment, Costs, Financing.
Identifiers: *Deep tunnel plan, *Calumet Area, Illinois, *Chicago, Illinois, Storm overflows.

The deep tunnel system is a multipurpose project to capture polluted storm overflows, treat them, and gradually return them to the waterways. The system, when not in use, pumps water to generate power. Chapter one briefly describes the program for the entire Chicago area. Selection of the Calumet area as the first construction zone is justified. The investigations program for the zone is described. Chapter Two gives the general concept of the plan, summarily describes project features, and discusses operation of the entire system. Chapter Three discusses existing waterflows. It examines the service area, waterways, the existing combined sewer system, flooding problems, hydrological aspects of combined sewer overflows, and quality of overflows. Chapter Four through Eight discusses project features at length; chapter Four covering the interception and conveyance structures; Five, the mined storage reservoir; Six, the pumping-generating station; Seven, the surface reservoir and regulating facilities; and Eight, water treatment facilities and processes. Chapter Nine discusses overall system operation. Chapter Ten defines alternatives and provisions for expansion. Chapter Eleven outlines project implementation and cost estimates. The last two chapters summarize and justify the project, and discuss its financing.

571
UNDERFLOW PLAN FOR POLLUTION AND FLOOD CONTROL IN THE CHICAGO METROPOLITAN AREA,
Depart of Public Works, City of Chicago, Metro Sanit District of Greater Chicago, and Depart of Public Works and Buildings, State of Illinois.

In: Combined Sewer Overflow Abatement Technology. Water Pollution Control Research Series, Report 11024--06/70, pp 139-218, Jun 1970. 20 fig, 9 tab, 8 ref.

Descriptors: *Project planning, *Overflow, *Waste water treatment, *Tunnels, Water pollution control, Flood control, Storm runoff, Sewers, Cost analysis.
Identifiers: *Chicago, Combined sewers.

The spillages of polluted water from combined sewers in time of storms has been the subject of this report. Three separate schemes have been described for solving these flooding and pollution problems in the Chicago area, namely: Underflow Storage Plan, the Deep Tunnel Plan, and the Chicago Drainage Plan. A complete description of the Underflow-Storage Plan has been presented which will reduce the spillage of pollutants to the surface waterways by over 98.5% and provide the necessary flood control to handle the 100-year frequency storm. Recommendation for the starting of the First Phase of this plan is emphasized, and the estimated costs involved are given.

572
COMBINED UNDERFLOW-STORAGE PLAN FOR POLLUTION AND FLOOD CONTROL IN THE CHICAGO METROPOLITAN AREA,
Depart of Public Works, Chicago, Ill. Bureau of Eng

City of Chicago Dep Public Works, Bur Eng Rep, Sep 1969. 43 p, 13 exhibit, 6 tab.

Descriptors: *Storm runoff, *Waste water treatment, *Water pollution control, *Tunnels, *Illinois, Urbanization, Sewers, Sewage treatment, Drainage systems, Storm drains, Cost analysis.
Identifiers: Combined sewers, Chicago.

The basic concept of the Chicago Underflow-Storage Plan for Pollution and Flood Control is the use of a pattern of underground tunnels. These tunnels would be sized to provide a linear distribution of storage volume, and a conveyance capacity in a single pattern of cleansable tunnels without the necessity for supplemental storage or power development. All water remaining in the underground tunnels after each storm period will be pumped directly to the existing treatment works. The underflow-conveyance capacity takes advantage of the lowered water levels to be established in the Illinois Waterway at Lockport for flood control and improved navigation. The basic features of the Underflow-Storage Plan include: (1) 18,000 acre-feet of underground storage; (2) a combined outflow capacity by underflow and overflow of about 43,000 cfs; (3) sufficient underground storage for any storm having a frequency of recurrence up to 100 years. The total capital cost of the proposed Combined Underflow-Storage Plan is estimated to be $650,000,000.

573
FLOOD AND POLLUTION CONTROL: A DEEP TUNNEL PLAN FOR THE CHICAGOLAND AREA,
Metropolitan Sanitary District of Greater Chicago, Ill.

Prefeasibility Report, May 1966. 61 p, 11 map, 5 tab, 7 append.

Descriptors: *Flood control, *Pollution abatement, *Underground storage, *Cost comparisons, *Estimated costs, Design criteria, Sewers, Drains, Reservoirs, Feasibility studies, Overflow, Project planning, Comparative benefits, Estimated benefits, Pumped storage.
Identifiers: *Deep tunnel plan, *Chicago.

The prefeasibility report reviews six alternative underground storage plans and recommends a comprehensive deep tunnel plan. Engineering design criteria for the plan are considered, which include lateral sewers, new main sewers, vertical drains, an underground reservoir, pumped-storage power, a surface reservoir, and pollution treatment. The costs of underground excavation, of plan components, and of contingency and overhead are given. Comparative flood control benefits are discussed in terms of basement flooding, flooding of industrial areas, land enhancement, and flood reduction on the waterway system. Alternative costs are given. The report gives comparative costs for two methods of storing and treating combined overflows. Possibilities of a better scheme of separating storm and sanitary sewers must be investigated. Potential benefits and costs of tertiary and space treatment require further investigation. Appendices discuss extensively hydrology, geology, water quality, aquifer protection, power, costs, and benefits.

574
CHICAGO TUNNEL DRAINAGE PROJECT: PRELIMINARY EVALUATION OF FEASIBILITY, Metro politan Sanitary District of Greater Chicago, Ill.

Preliminary Study, May 1964. 33 p, 5 map, 9 tab, 3 chart.

Descriptors: *Project planning, *Drainage programs, *Underground storage, *Flood protection, Sewerage, Storage capacity, Construction, Reservoirs, Construction costs, Annual costs, Financing, Pollution abatement, Sediment control.
Identifiers: *Chicago, Illinois.

Approximately a third of the preliminary study describes the project plan, another third economics, and the final third problems for investigation. It recommends that an underground storage system, combined with storage in a higher level sewer system, be designed for the Chicago flood of record. Capacities, types, and construction of proposed storage structures are discussed. The pumped storage facilities of the project would release water to the lower reservoir during peak power load periods and pump it back to the upper reservoir during off-peak hours. Layout, storage capacity, and alternative locations are discussed.

575
DEVELOPMENT OF TUNNELING METHODS AND CONTROLS FOR WATER RESOURCE PROJECTS,

Ellis L. Armstrong
Paper presented at the ASCE--Water Resources Eng Conf, Feb 1969.

Descriptors: *Tunnel construction, *Tunneling, *Tunneling machines, Tunnel failure, Tunnel linings, Tunnels, Cost comparisons, Laser, Cost trends, Rock bolts.
Identifiers: Tunnel supports, Blasting.

Improvements in equipment and methods during the past 15 yr have kept tunnel excavation costs from appreciable increases while the general construction cost index has doubled. Tunnel drilling rates have increased to about 300 ft/wk today. The concept of boring machines to drill tunnels has made the greatest advance in the last 5 years. A table lists the major completed mole tunneling projects. Cost savings up to 40% over conventional drill-shootmuck cycle methods can be proven. The requirement for and types of tunnel supports being used are discussed. Improvements and advances are expected in tunnel linings because the excavation rate has surpassed the lining rate. A laser beam is an excellent control method for precision drilling with a boring machine. Tunneling safety has progressed to a satisfactory level.

576
STORM DRAINAGE ASPECTS OF THE DEEP TUNNEL PLAN,

W. J. Bauer
Proc AISI Seminar, Ill Inst Technol, Oct 8, 1968. 29 p, 10 fig, 5 tab.

Descriptors: *Water pollution control, *Storm runoff, *Pumped storage, *Tunnels, *Illinois, Hydroelectric power, Costs, Cost-benefit analysis, Storm drains.
Identifiers: *Chicago.

The proposed Chicago deep tunnel plan would provide temporary storage of storm runoff from combined sewers to allow steady low-volume treatment and prevent discharge of raw sewage to surface waters. The total cost is estimated to be 242-446 million dollars. Operating costs are expected to be very low because the facility will be large enough to use profitably as a peak-demand pumped storage hydroelectric plants. Storm runoff will be only a small part of the total movement of water. The design and cost analysis of the project are described briefly.

577
RECENT TUNNEL EXCAVATION WITH BORING MACHINES,

D. E. Cannon
Civil Eng, Vol 37, No 8, pp 45-48, Aug 1967. 3 tab.

Descriptors: *Tunneling machines, *Drilling, *Routing, *Rock excavation, *Tunneling.
Identifiers: *Mole, *Machine comparison.

Mole boring machines are making tunnel excavation records on the U.S. Bureau of Reclamation's San-Chama Project for additional water supply routes to Rocky Mountain cities of north central New Mexico. A series of three tunnels are required for this project. Geology reports indicated that the rock to be encountered--shale and sandstone--could be economically excavated by a mole. Drilling was performed from the surface along the tunnel alignments at roughly one mile intervals. A main concern was whether igneous dikes or sills existed at tunnel elevation which might preclude using a boring machine. Results of the exploration program were encouraging and did not indicate presence of igneous intrusions. Advantages cited of boring machines over conventional tunneling methods include: higher excavation rate, reduction in concrete needs, fewer personnel requirements, safer operations, reduction in required supports and in clean-up time. Disadvantages of mole boring include: high initial investment; long delivery period; restriction to softer rocks; and the requirement for a well maintained ventilation system, an accurate guidance system, and expert surveying technicians.

578
'MOLE' KEEPS TRAFFIC ON THE MOVE,

Don Carter
Public Works, Vol 101, No 2, pp 82-83, Feb 1970.

Descriptors: *Drainage, *Storm runoff, *Tunneling machines, Tunnel construction, Repairing.
Identifiers: *Tulsa, Oklahoma, *Mole, Storm sewers, Laser beam control.

The first application of large bore horizontal drilling in Oklahoma occurred in Tulsa to alleviate the storm sewer complex by tunneling a drain which will carry off the water from accumulated storm runoffs. The problems encountered such as breakdowns, cave-ins, and ventilation are discussed. The laser beams and targets used to set vertical and horizontal guides, and grade alignment are mentioned as the most unique parts of the machine.

579
TUNNELING SOLVES TOUGH SEWER - CONSTRUCTION PROBLEM,

T. W. Clapham
Am City, Vol 85, No 2, pp 105-114, Feb 1970.

Descriptors: *Sewers, *Tunneling, *Tunnel construction, Tunnel linings.
Identifiers: *Interceptor sewer, *Little Rock, Arkansas.

The encasement tunneling technique was employed when constructing a major section of a ten-mile sanitary interceptor sewer in Little Rock, Arkansas. The tunnel, totalling 1,776 feet in length, is discussed in relation to its sectional variations in length, diameter, and depth. Round-shaped, corrugated steel plates with flanges along two sides, permitting them to be bolted together from the inside to form adjacent rings, were used for building the encasement. After each tunnel was complete the concrete sewer pipe was installed.

580
MECHANIZATION OF UNDERGROUND DRAINAGE WORK,

J. Dunglas
Houille Blanch (HOBLAB), Vol 23, No 6, pp 529-538, 1968.

Descriptors: *Equipment, *Mole drainage, *Piping systems (mechanical).
Identifiers: *Deep drainage.

The advantages of mechanized pipe-laying equipment for deep drainage systems are reviewed and technical features of trenching machines with optical depth-setting and built-in pipe laying systems are described. The adaptation of drainage system design to allow for use of mole-plow type machines is examined.

581
WHAT'S AHEAD FOR TUNNELING MACHINES,

George Hill
J Construct Div, Am Soc Civil Engrs, Vol 94, No CO2, pp 211-231, Oct 1968. 7 graphs, 4 tab, 2 diag.

Descriptors: *Tunneling, *Tunneling machines, *Tunnels, *Data Collections, *Construction, *Drilling, Cost analysis.
Identifiers: *Tunnel use, Tunnel forecasting.

Ten years of tunnel construction data from 1955 to 1965 are reviewed to establish particular characteristics of the past-tunneling market. These characteristics include: (1) total footage of tunnel construction completed each year; (2) a breakdown of these tunnels according to use (water transportation, vehicle tunnels, railroad and subway tunnels and mining tunnels); and, (3) a profile of the 1955-1965 history of tunneling activity and growth rates which were used in conjunction with expert opinions and announced future tunneling expectations to develop a forecast of 3,000 miles of worldwide-tunneling activity from 1966 to 1976. To estimate the impact of tunneling machines on the total market, a detailed cost analysis is outlined for Drill and Blast versus Mechanical Boring. The economic comparison showed tunneling machines to be an effective economic alternative in a significant portion of the future tunneling. It is estimated that tunneling machines will complete 1,000 miles of the total 3,000 miles forecasted between 1966 and 1976.

582
THE DEEP TUNNEL PLAN FOR THE BOSTON AREA,

David R. Horsefield
J Boston Soc Civil Engrs, Vol 55, No 4, pp 231-252, Oct 1968.
2 tab, 2 graphs, 2 maps, 29 ref.

Descriptors: *Storm runoff, *Overflow, *Water pollution sources, *Discharge (water), Surface runoff, *Water analysis, *Statistics, *Water quality, *Standards, Cost comparisons, *Tunnel design, *Costs, *Tunnel construction, *Sewers, *Massachusetts, Rainfall intensity, Pollution abatement.
Identifiers: *Combined sewers, *Deept tunnel plan, *Boston.

The Boston drainage system is discussed. The inadequacies of the combined sewer system are explored and it is concluded that the overflow of mixed sewage and stormwater from combined sewers into the waters of Boston Harbor and adjacent waters constitutes a serious hazard to public health. The deep tunnel plan is compared in regards to cost analysis with other pollution control methods. As a solution to the combined sewer problem, the deep tunnel plan will be employed so as to eliminate pollution from waters of the Boston area and to provide a more healthful environment.

583
HYDRAULIC DESIGN OF UNLINED ROCK TUNNELS,

Carl J. Huval
J Hydraulics Div, Am Soc Civil Engrs, Vol 95, No HY4, p 1235-1246, Jul 1969. 12 p, 5 fig, 2 tab, 24 ref, 2 append.

Descriptors: *Tunnel hydraulics, *Tunnels, *Hydraulic design, *Tunnel design, Hydraulics, Mannings equation, Roughness coefficient, Hydraulic structures. Overexcavation, Diversion structures, Hydroelectric power, Water tunnels (conveyance), Water tunnels (testing), Bibliographies, Rocks.
Identifiers: *Unlined tunnels.

Many unlined rock tunnels have been built for flood flow diversion and for hydropower tunnels where the rock is of sound quality and not greatly jointed and fractured. The number of unlined rock tunnels will increase in the years ahead because new methods of drilling, blasting, and muck removal have been developed and improved to make tunnel construction more economical. Methods of tunnel stabilization, such as grouting and use of rock bolts, have been improved so that many kinds of rock and difficult driving conditions can be handled more flexibly. Savings of unlined rock tunnels in time and cost of construction have been demonstrated by the ready acceptance of this type of tunnel in Sweden, Norway, Australia, and the United States. Unlined rock tunnel resistance coefficients can be predicted by using a rock overbreak parameter. The important considerations entering into design of unlined rock tunnels are summarized. The present method of predicting hydraulic resistance is inadequate. A study of tunnel rock overbreak experience leads to a relation between rock overbreak and tunnel size. This measure of rock overbreak provides a simple correlation of flow resistance test results based on the fully rough flow equation.

584
THE CHICAGO AREA DEEP TUNNEL PROJECT-A USE OF THE UNDERGROUND STORAGE RESOURCE,

V. A. Koelzer, W. J. Bauer, and F. E. Dalton.
J Water Pollution Control Fed, Vol 41, No 4, pp 515-534, Apr 1969.
20 p, 17 fig, 1 tab.

Descriptors: *Water pollution control, *Storm drains, *Underground storage, *Illinois, Water pollution sources, Municipal wastes, Industrial wastes, Sewage, Sewage treatment, Sewage disposal, Subsurface drainage.
Identifiers: Chicago.

The Greater Chicago area is plagued with recurring water pollution and flood problems stemming from 3 sources--industry, wastewater treatment plant effluent, and combined storm and sanitary sewer overflows. A solution to all three sources is the Deep Tunnel Project. It will capture stormwater overflows from combined sewers, dropping them through vertical shafts to a tunnel network. The polluted water will be conveyed for temporary storage in a large mined underground reservoir 800 ft. (242 m) below the surface. Preliminary design studies including project features, feasibility, costs, performance, and benefits, as well as operation, are discussed. Tunneling methods are included.

585
MOLE ANCHORS IN PILOT HOLE AND PULLS ITSELF AHEAD,

Michael Kolbenschlag
Construct Methods Equip, Vol 52, No 4, pp 87-88, 90-91, 94-95, Apr 1970. 5 fig.

Descriptors: *Tunneling machines, *Drilling, *Tunnels, *Drill holes.
Identifiers: *Mole, *Mole structure, Laser beam.

Instead of advancing by having the cutterhead jacked against the face, as most tunneling machines do, a Detroit hydraulic rig used a reverse technique. This mole drilled a pilot hole in the center of the face, locked in place an anchor concentric with the pilot-drill stem, and then pulled itself forward hydraulically against resistance of the anchor. The main cutterhead and pilot drill advanced simultaneously. Water and fault zones complicated early stages of work on the water tunnel, but the contractor hoped to make up time with the new method. Complete descriptions are given of the structure of the machine, mucking operations, laser guidance, and the mole's power source.

586
SUCCESSFUL OPERATION OF THE HABEGGER TUNNEL-BORING MACHINE IN HARD ROCK,

E. Lauber and H.W. Brodbeck
Schweiz Bauz (SWBAAJ), Vol 86, No 51, p 917-924, Dec, 1968. Transl from Ger Bur Reclam Transl 812, Apr 1969. 21 p, 14 fig, 2 tab.

Descriptors: *Tunneling machines, *Tunneling, *Tunnel construction, *Boring machines, Tunnels, Engineering geology, Rock excavation, Rocks, Foreign construction, Pressure tunnels.
Identifiers: Switzerland.

The Habegger hard-rock tunneling machine was used in boring the high-pressure water tunnel for the Juliawerk Tiefencastel Project, Switzerland. Experiences in tunneling, machine operation, and rock cutting are discussed. Improvements in designing cutters and developing cooled cutters are described. The machine steering system and a helium laser directional guide held horizontal and vertical deviations within 4 cm over 800 m. A scraper conveyor system was modified to successfully leave a clean floor while working in groundwater. Comparing mechanical with conventional tunneling indicated that rock excavation costs are approximately equal. Problems of what is hard rock in regard to tunneling machines, rock properties for evaluation of rock cutting, and wear of cutters are covered.

587
HYDRAULIC DESIGN OF SELF-CLEANING SEWAGE TUNNELS,

D.K. Lysne
J Sanit Eng Div, Am Soc Civil Engrs, Vol 95, No SA1, pp 17-36, 1969.

Descriptors: *Tunnels, *Tunnel design, Tunnel hydraulics.
Identifiers: *Tunnel cleaning method.

When planning sewerage facilities for large areas, there is now a tendency to use tunnels in place of trunk sewers, making it feasible to transport sewage over longer distances. The author describes a method for the hydraulic design of such tunnels, designed to be self-cleaning; and he gives design graphs for convenience. It is pointed out, however, that the self-cleaning feature does not necessarily determine the optimal tunnel area. Economic considerations may be the determining factor in regard to the self-cleaning feature, particularly for larger tunnels.

588
LASER BEAM ON MOLE SPEEDS SEWER WORK,

Alex Mair
Eng Contract Record, Vol 83, No 2, pp 44-45, Feb 1970.

Descriptors: *Instrumentation, *Tunneling machines, Tunneling, Operations.
Identifiers: *Mole, *Laser beam control.

A tunnel in Edmonton is being produced at an average of 120 ft/day. A tunnel mole and the use of a laser beam have hastened the procedure. The practical limit on the distance the beam can travel depends on two things: changes in direction of the line, and the amount of dust and fog in the air in the tunnel. The mole consists of a set of rotating arms with cutting teeth and a bucket wheel for catching the loosened material. The workings of the tunnel operation are given.

589
GROUNDWATER STUDIES--CHICAGOLAND DEEP TUNNEL SYSTEM.

I.S. Papadopulos, William R. Larsen, and Forest C. Neil.
Ground Water, Vol 7, No 5, p 3-15, Sep-Oct 1969. 13 p, 16 fig, 4 tab, 10 ref.

Descriptors: *Hydrogeology, *Storm runoff, *Cities, *Illinois, Waste water treatment, Waste water disposal, Groundwater, Water levels, Seepage, Discharge (water), Hydrologic data, Aquifers, Pumped storage, Analog models.
Identifiers: *Chicago, Deep tunnel plan.

The Deep Tunnel System planned by the Metropolitan Sanitary District of Greater Chicago will provide flood and pollution control for the combined sewer areas of the Chicago region. Elements of the Deep Tunnel System that are of main concern to the groundwater resources of the area are: the conveyance tunnels; and the mined storage reservoir, which will convey and store polluted stormwater overflows. The Silurian and the Cambrian-Ordovician aquifers, in units of which these elements will be located, will be protected from any deleterious effects of the System by ensuring that a positive hydraulic head, causing an inward flow, is continuously maintained around the tunnels and the mined reservoir. In the Cambrian-Ordovician aquifer, this necessitates that groundwater levels are maintained by artificial recharge. Extensive groundwater studies were conducted to (1) demonstrate the feasibility of aquifer protection by recharge, (2) determine the needed amounts of recharge water, and (3) estimate the seepage of groundwater into the tunnels and mined reservoir. The studies included field investigations, analog computer analyses and office evaluation of the collected data and analog results. The results indicated (1) the proposed aquifer protection is feasible, (2) the recharge requirements will vary from 1.4 mgd in 1976 to 6.0 mgd in 2010, and (3) seepage into the tunnels will be small, in amounts that can be easily controlled.

590
INVESTIGATION PROGRAM FOR AQUIFER PROTECTION REQUIREMENTS, CHICAGOLAND DEEP TUNNEL PLAN,

I.S. Papadopulos and R.E. Aten
Ground Water, Vol 6, No 3, pp 4-9, May-Jun 1968.

Descriptors: *Tunnel design, *Investigations, *Storage, Overflow, Testing.
Identifiers: *Chicago, Illinois.

This plan envisions temporary storage of combined sewer overflows in a systems of tunnels excavated in solid rock, deep under the City. After the end of a storm, stored water would be pumped to the surface where it would be treated to remove pollution before being discharged into waterways. Preliminary investigations indicated that aquifer protection can be provided by a system of recharge wells. Further detailed studies, now in progress, include detailed exploratory drilling, controlled aquifer tests in selected zones, pumping tests for specific capacity in a zone to be tunneled, recharge injection tests, and analog model analysis.

591
SHAFT BUILDERS MATCH METHODS WITH MACHINES,

Gerald Parkinson
Construct Methods Equip, Vol 51, No 4, pp 72-73, 76-77, 80-81, Apr 1969. 11 fig.

Descriptors: *Installation, *Sewers, *Storm drains, *Tunneling, *Shafts (excavation), *Slurries, Concrete construction.
Identifiers: *Mole, *Mexico.

In Mexico City, an area that once engulfed a lake and inherited the problems of building on unstable ground, contractors worked to install a new system of sewers and storm drains. To prepare for three big moles that performed the tunneling, deep access shafts were sunk into the ground that varies from jelly-like volcanic ash to solid rock. Most of the contractors adopted variations of the slurry-trench system to construct concrete walls for the access shafts. One company used a method called "controlled flotation," by which the shaft is formed and concreted in a series of steps--all performed at ground level, and then it is sunk toward its final position as wall sections are added on top. This method is described in detail as are variations used in the slurry-displacement method. Several solutions to groundwater problems are outlined.

592
BUILDING FOR THE FUTURE--THE BOSTON DEEP-TUNNEL PLAN,

C.A. Parthum
J Water Pollution Control Fed, Vol 42, No 4, pp 500-510, Apr 1970.
2 tab, 2 graphs, 1 diag.

Descriptors: *Overflow, *Storm runoff, *Tunnels, *Sewage disposal, *Sewers, *Underground storage, Sewage, Separation techniques, Chlorination.
Identifiers: *Deep tunnel plan, *Boston, Combined sewers, Holding tanks.

A deep tunnel storage plan has been proposed to prevent pollution due to discharge of wastewater overflows and mixed wastewater and stormwater from the combined sewers of Boston and adjacent municipalities. Other methods such as complete sewer separation, chlorination tanks, and holding tanks were considered, but the deep tunnel system appeared most economical. Construction costs were estimated at $66 million. The proposed system consists of 17.2 miles (27 km) of 33-ft (10-m) diam deep tunnels in a radial pattern, a pumping capacity of 2,400 cfs (4,100 cu m/min), and a 45,000-ft (13,700-m) ocean outfall with diffusers. The system is designed to handle runoff from the 15-year-frequency storm of 24-hour duration within 2 days, without surcharging, and the maximum recorded storm for Boston if surcharging is permitted.

593
HYDRAULIC PROPERTIES OF SMALL UNLINED ROCK TUNNELS,

Seppo Priha
J Hydraulics Div, Am Soc Civil Eng, Vol 95, No HY4, p 1181-1209, Jul, 1969. 29 p, 27 fig, 9 tab, 10 ref, 2 append.

Descriptors: *Water tunnels (conveyance), *Tunnel hydraulics, *Tunnels, *Roughness (hydraulic), *Hydraulic properties, Model tests, Pressure tunnels, Hydraulic models.
Identifiers: *Unlined tunnels, Finland.

Factors influencing hydraulic characteristics of small unlined tunnel cross sections are presented. Investigations were performed in rock tunnels constructed by the Helsinki City Waterworks for conveying raw water. The length of the Silvola Reservoir entrance tunnel is 1.8 km; the theoretical cross section is 4:5 sq m. The length of the Silvola-Vanhakaupunki raw water tunnel is 7.6 km; the theoretical cross section is 6 sq. m. Vertical shafts divided both tunnels into 3 parts, in all of which cross-sectional measurements and pressure loss measurements for different discharges were accomplished using measuring weirs and Siemens Venturi meters. All 3 tunnels were excavated by the so-called Swedish method in the most usual type of rock in Finland, composed mostly of granite and gneiss.

594
HYDRAULIC PROPERTIES OF SMALL UNLINED ROCK TUNNELS,

David Ellis Wright (Discussion)
J Hydraulics Div. Am Soc Civil Engrs, Vol 96, No HY4, pp 1047-1050, Apr 1970. 3 ref.

Descriptors: *Rock properties, *Hydraulic properties.
Identifiers: Unlined tunnels.

The writer congratulates Seppo Priha, the original author, for presenting further data on the hydraulic resistance of unlined rock tunnels. He also asks several questions in order to clarify certain facts relating to the original article. Next he discusses various assumptions and derivations in the original such as: (1) the effect of section spacing on the variation of areas; (2) the variation of overbreak with tunnel size; (3) the relation between the resistance coefficient and the variation of area; and (4) the effect of lining slabs on resistance.

595
HYDRAULIC DESIGN OF UNLINED ROCK TUNNELS,

Skrikrishna V. Chitale, K.S. Rajagopalan, and David Ellis Wright (Discussion)
J Hydraulics Div, Am Soc Civil Engrs, Vol 96, No HY4, pp 1060-1065, Apr 1970. 1 fig, 3 ref.

Descriptors: *Rock properties, Hydraulic design, Roughness (hydraulic).
Identifiers: *Unlined tunnels.

S.V. Chitale and K.S. Rajagopalan comment on Figures 2 and 3 of the original article. Fig. 2 shows a plot of resistance coefficients for unlined rock tunnels, and considerable scatter of data is apparent. The authors list reasons for this scatter. Fig. 3 gives tunnel overbreak for various tunnel sizes. The authors note the difficulty involved in using this figure to estimate overbreak depth because of the presence of considerable scatter, and they suggest a way to improve this situation. David Ellis Wright notes that progress will be made in designing unlined rock tunnels only if a critical comparison is made of results on prototype tunnels. He lists requirements to be satisfied in order that these results be of wider design use. He also defines terms such as tunnel size, overbreak, relative roughness, and equivalent sand grain diameter, which he uses in his commentary on the original paper. His comments include opinions on the resistance equation, the relation between resistance and roughness, partly-lined conduits, and data in Table 2 of the original paper.

596
STABILITY OF TUNNELS UNDER ROCK LOAD,

L.V. Rabcewict
Water Power, Vol 21, No 6, 7, 8, p 225-229, 266-273, 297-302, Jun, Jul, Aug, 1969. 19 p, 41 fig, 22 ref.

Descriptors: *Tunnel construction, *Tunneling, *Tunnel linings, Tunnel failure, Tunnel design, Theoretical analysis, Bibliographies, Model studies, Tunnels, Structural design, Stability.
Identifiers: *Austrian Tunneling Method, *Tunnel supports, Austria.

The salient feature of the New Austrian Tunneling Method is a semirigid lining applied to the rock before it is damaged by loosening. The lining, designed to reach permanent equilibrium after adjusting to rearrangement forces, may be any material or combinations of materials suited to the purpose. Tunnels should be driven full face where possible in a minimum of time. Practical experience and theoretical investigations have proved that by using the method, rock surrounding a cavity can be transformed into an effective carrying member. Failure by shear is the only mode of collapse of a tunnel lining when the lining extends around the entire periphery of the tunnel section. Principles for designing linings based on failure by shear are explained and proved by model tests. Some theoretical analyses of the strength of linings and anchors are presented and a design method based on data collected on shear failure is discussed. The effect of contact between lining and rock on tunnel behavior is examined. A type of strengthening consists of system anchoring combined with shotcrete, taking advantage of the property of rock to stabilize by yielding, is described. A tunnel and an underground powerhouse constructed in accordance with the New Austrian Tunneling Method are described.

597
A FLOODED TUNNEL INTERCEPTOR SYSTEM FOR THE METROPOLITAN ST. LOUIS SEWER DISTRICT,

W.G. Shifrin, G.K. Hasegawa, and V.C. Lischer, Jr.
J Water Pollution Control Fed, Vol 39, No 3, pp 313-333, Mar 1967.
2 tab, 3 maps, 5 diag, 1 graph, 3 ref.

Descriptors: *Tunnel construction, *Drilling equipment, *Tunneling, *Sewers, Drilling, Operations, Design.
Identifiers: *St. Louis, Missouri, *Interceptor sewer, Combined sewers

Preliminary studies showed that a flooded tunnel interceptor system would be the most advantageous type for an area of St. Louis, Missouri.

Interceptors were designed to carry ultimate peak dry-weather flows only, since the city has many combined sewers. The interceptors will exclude backwater from the Mississippi River at low to moderately high river stages. A boring machine was used for parts of the tunneling during construction. Operation of the system will depend on river stage, rainfall, and the operation of an interconnected flood protection system. Drawdown of the wet well at the terminal pumping station will be necessary periodically to promote cleansing of the tunnels. The system is furnished with telemetering devices and central controls.

598
AUGER TEAMS WITH SHIELD TO CUT MIXED TUNNEL FACE,

Lorraine Smith
Construct Methods Equip, Vol 52, No 1, pp 104-106, Jan 1970.

Descriptors: *Tunneling, *Tunneling machines, *Tunnel construction.
Identifiers: *Reaming auger, *Pipe jacking.

A tunneling rig, which more than tripled production of similar equipment through rock when first used on a storm drain in 1968, has been specially built to bore through white limestone known as "Austin chalk". A special reaming auger and shield to allow the rig to work through a combination of soft limestone and crumbling clay was designed by Joe B. Byrd, of the Boring & Tunneling Co. of America, Inc. A detailed analysis of the boring by the rig followed by the jacking of concrete pipes is given.

599
LARGE AGGREGATE SHOTCRETE CHALLENGES STEEL RIBS AS A TUNNEL SUPPORT,

Harry Sutcliffe and Cole R. McClure
Civil Eng, Vol 39, No 11, p 51-55, Nov 1969. 5 p, 3 fig, 3 photo.

Descriptors: *Tunnel linings, *Pumped concrete, *Tunnel construction, Construction, Tunneling, Aggregates, Underground structures, Durability, Concretes.
Identifiers: *Tunnel supports.

A growing need for underground construction exists in transportation, pumped storage, pollution control, and defense works. The rate of growth of tunnel construction is limited only by the higher cost when compared to above-ground construction. A substantial portion of the cost of underground work is in the support and lining of the excavation, and making this area more economical is important. Any acceleration of the rate that support or lining can be placed permits the use of faster tunneling machines and reduces costs. Gunite, a pneumatically applied cement mortar used in canal linings, has been used with wire-mesh reinforcement in tunnels to prevent slaking and spalling of the ground, with good durability and resistance to abuse. The spraying of large-aggregate concrete was only mildly successful until European research with chemical accelerators provided a means of controlling the rate of strength buildup of the sprayed material. Use of accelerators started the changes in application practices and furthered the acceptance of shotcrete in underground work. First used in combination with steel ribs and wire mesh shotcrete is used more frequently unreinforced.

SUBJECT INDEX

AUTHOR INDEX

JOURNAL LIST

Abbreviation	Full Title
1. Abwass	1. Abwasser
2. Am City	2. The American City
3. Appl Microbiol	3. Applied Microbiology
4. Australian Civil Eng	4. Australian Civil Engineering
5. Bell System Tech J	5. Bell System Technical Journal
6. Ber Abwassertech Ver	6. Berichte der Abwassertechnischen Vereiningung
7. Civil Eng	7. Civil Engineering
8. Civil Eng Public Works Rev	8. Civil Engineering and Public Works Review
9. Construct Methods Equip	9. Construction Methods and Equipment
10. Consulting Engr	10. Consulting Engineer
11. Effluent Water Treat J	11. Effluent and Water Treatment Journal
12. Eng Contract Record	12. Engineering and Contract Record
13. Eng J	13. Engineering Journal
14. Eng News-Record	14. Engineering News-Record
15. Environ Sci Technol	15. Environmental Science and Technology
16. Gas Wasserfach	16. Gas- und Wasserfach
17. Gesundh Ingr	17. Gesundheits Ingenieur
18. Giorn Genio Civile	18. Giornale del Genio Civile
19. Ground Water	19. Ground Water
20. Houille Blanch	20. Houille Blanche
21. Ind Water Eng	21. Industrial Water Engineering
22. Inst Civil Engrs (London)	22. Institution of Civil Engineers (London)
23. Inst Engrs (Australia)	23. Institution of Engineers (Australia)
24. Inst Public Health Engrs	24. Institution of Public Health Engineers
25. Inst Sewage Purification, J Proc	25. Institution of Sewage Purification, Journal and Proceedings
26. J Am Water Works Assoc	26. Journal of the American Water Works Association
27. J Appl Meteorol	27. Journal of Applied Meteorology
28. J Boston Soc Civil Engrs	28. Journal of the Boston Society of Civil Engineers
29. J. Construct Div, Am Soc Civil Engrs	29. Journal of the Construction Division, American Society of Civil Engineers
30. J Forest	30. Journal of Forestry

31. J Geophys Res	31. Journal of Geophysical Research
32. J Hydraulics Div, Am Soc Civil Engrs	32. Journal of the Hydraulics Division, American Society of Civil Engineers
33. J Hydrol	33. Journal of Hydrology
34. J Inst Munic Engrs	34. Journal of the Institute of Municipal Engineers
35. J Irrigation Drainage Div, Am Soc Civil Engrs	35. Journal of the Irrigation and Drainage Division, American Society of Civil Engineers
36. J New England Water Works Assoc	36. Journal of the New England Water Works Association
37. J Sanit Eng Div, Am Soc Civil Engrs	37. Journal of the Sanitary Engineering Division, American Society of Civil Engineers
38. J Soil Water Conserv	38. Journal of Soil and Water Conservation
39. J Urban Planning Develop Div, Am Soc Civil Engrs	39. Journal of the Urban Planning and Development Division, American Society of Civil Engineers
40. J Water Pollution Control Fed	40. Journal of the Water Pollution Control Federation
41. J Water Works Assoc	41. Journal of the Water Works Association
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44. Meteorol Mag	44. Meteorological Magazine
45. Military Engr	45. Military Engineer
46. Mod Power Eng	46. Modern Power and Engineering
47. Munic Eng (London)	47. Municipal Engineering (London)
48. Oesterr Abwasser - Rundschau	48. Oesterreichische Abwasser - Rundschau
49. Oesterr Wasserwirtsch	49. Oesterreichische Wasserwirtschaft
50. Pipes Pipelines Intern	50. Pipes and Pipelines International
51. Rozpr Hydrotech, Polska Akad Nauk	51. Rozpravy Hydrotechniczne, Polska Akademia Nauk
52. Public Works	52. Public Works
53. Roads Road Construct	53. Roads and Road Construction
54. Rubber World	54. Rubber World
55. Sangyo Kogai	55. Sangyo Kogai
56. Sb Rab Gidrol	56. Sbornik Rabot po Gidrologii
57. Schweiz Bauztg	57. Schweizerische Bauzeitung

58. Science News	58. Science News
59. Sov Hydrol	59. Soviet Hydrology
60. Staedtehyg	60. Staedtehygiene
61. Surveyor	61. Surveyor
62. Surveyor Munic City Engrs	62. Surveyor and Municipal City Engineers
63. Trans, Am Geophys Union	63. Transactions, American Geophysical Union
64. Trans, Am Soc Agr Engrs	64. Transactions, American Society of Agricultural Engineers
65. Trans, Japan Soc Civil Engrs	65. Transactions, Japan Society of Civil Engineers
66. Tr Inst Gidrogeol Gidrofiziki	66. Trudy Instituta Gidrogeologii i Gidrofiziki
67. Vodosnab Sanit Tekh	67. Vodosnabzheinie i Sanitarnaya Tekhnika
68. Wasserwirtsch - wassertech	68. Wasserwirtschaft - Wassertechnik
69. Water	69. Water
70. Water Pollution Control	70. Water and Pollution Control
71. Water Power	71. Water Power
72. Water Res	72. Water Research
73. Water Resources Res	73. Water Resources Research
74. Water Sewage Works	74. Water and Sewage Works
75. Water Waste Treat	75. Water and Waste Treatment
76. Water Wastes Eng	76. Water and Wastes Engineering
77. Western Construct	77. Western Construction

BIBLIOGRAPHIC: Franklin Institute Research Laboratories. Selected Urban Storm Water Runoff Abstracts FWQA Publication No. 11024EJC07/70

ABSTRACTS: A compilation of abstracts summarizing articles from a variety of technical publications constituting the problem of urban drainage was developed by the Franklin Institute Research Laboratories. The present work includes 599 abstracts of documents published for the most part from July 1968 through June 1970. The abstracts are classed in ten sub-topic categories and arranged alphabetically by author and numerically by abstract number within each category. Each item includes a bibliographic citation, an abstract, and a set of indexing descriptors and identifiers. A cumulative subject index at the end of the volume provides the necessary access to individual concepts. An author index and journal list are also included. This work was submitted in fulfillment of Contract 14-12-904 between the Federal Water Quality Administration and the Franklin Institute Research Laboratories.

KEY WORDS

Storm runoff
Urbanization
Drainage systems
Overflow
Rainfall-runoff relationships
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Water pollution control

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22 *Citation*
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23 *Descriptors (Starred First)*

*Storm runoff, *Urbanization, Drainage systems, Overflow, Rainfall-runoff relationships
Sewers, Sewage treatment, Water pollution control.

25 *Identifiers (Starred First)*
*Combined sewers, *Storm sewers.

27 *Abstract*
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Abstractor Dorothy A. Ortner | *Institution* Franklin Institute Research Laboratories

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