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Project Summary

Urban Rainfall-Runoff-Quality Data Base

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A common and basic need for mathematical models of urban hydrologic processes is for adequate data with which to calibrate and verify them. Such models are being used in many applications and the need for relevant data has intensified. An equally important data requirement arises from the need to characterize urban stormwater discharges and combined sewer overflows. Since 1974 EPA has supported the urban rainfall-runoff-quality data base with these needs in mind. The data base project, conducted by the University of Florida, was initiated to bring together in a consistent and accessible format the many data sources found in unpublished documents widely scattered throughout various firms, universities, and government agencies. Urban rainfall-runoff-quality data have been assembled on a storm event basis for 48 catchments in 16 urban areas. Urban hydrologic data without quality data have been assembled for an additional 25 catchments in 15 urban areas. Statistical analysis and descriptions of the catchments, parameters and sampling procedures are provided in the data base reports. For each storm event, the clock times, and the duration and volume of rainfall and runoff are given. For quality parameters, ranges, flow-weighted means, standard deviations, and loadings (i.e., pounds per acre-inch of runoff) are provided on an average basis across all events for each catchment. The same statistics are available for individual storm events on the data base magnetic tape. Actual data are on the magnetic tape and on the EPA STORET data retrieval system.

This Project Summary was developed by EPA's Municipal Environmental Research Laboratory, Cincinnati, OH, to announce key findings of the research project that are fully documented in separate reports (see Project Report ordering information at back).

Introduction

In an effort to provide useful planning and design tools for abatement of quantity and quality problems caused by urban stormwater discharges and combined sewer overflows, many mathematical models have been developed to simulate the various components of urban hydrologic processes. These models range from very simple to very sophisticated, yet all share a common need—adequate data for development, calibration, and verification. These data consist of detailed measurements of rainfall, runoff, and quality parameters taken at frequent intervals during storms, such that the full dynamic and spatially variable nature of the urban runoff may be studied. Many recent urban hydrologic models define the complete hydrograph or pollutograph during a storm event; thus, measurement of only, say, peak flows or average concentrations is usually inadequate for calibration of these models. Other modeling approaches are based on the statistical and probabilistic properties of urban hydrology and runoff quality. Characterization information is essential to execute these modeling approaches. Various examples of characterization needs are as follows:

- determination of rainfall and runoff volumes, intensities, peaks, durations, interevent times, and associated statistics;
- identification of quality parameters found in urban runoff;
- determination of ranges, arithmetic and flow-weighted means, medians, variances, and other statistics of quality parameters;
- computation of total mass emissions of quality parameters;
- computation of quality "loadings" such as pounds per acre, pounds per curb-mile, pounds per inch of rainfall, pounds per day, etc., and combinations, and;
- evaluation of causative relationships among rainfall, runoff, quality, demographic, and abatement factors.

Several of the above needs require collection of both runoff and quality data; e.g., calculation of total pollutant loads, flow-weighted averages, etc., requires simultaneous measurement of flows and concentrations. Thus, concentration data by themselves are insufficient for many required analyses.

Data collected for characterization purposes are not always compatible with needs of detailed models since infrequent sampling times and/or omission of key parameters are likely. Data suitable for model usage, however, are usually also well suited for characterization purposes provided enough of a sample exists. It is desirable that characterization data be representative of an entire year or season and thus result from samplings of many storms since one group of data may be used for model calibration and the remaining group may be used for verification.

This project has obtained data, collected by others, to fulfill both the detail modeling needs and the characterization needs. There have been a surprisingly large number of studies devoted to collection of data useful for modeling, although collection of good quality data is more difficult and lags the quantity data by a considerable degree.

The locations of urban areas incorporated in the data base are presented in Figure 1. Urban rainfall-runoff-quality data have been assembled on a storm event basis for 48 catchments in the following cities or counties: San Francisco, CA; Broward County, FL; Lincoln, NB; Durham, NC; Windsor, ONT; Lancaster, PA; Seattle, WA; Racine, WI; West Lafayette, IN; Greenfield, MA; Northampton, MA; Burlington, ONT; Chicago, IL; Denver, CO; Dade County, FL; and Toronto, ONT. Rainfall-runoff data have been assembled for 25 more catchments in 15 cities: Baltimore, MD; Chicago, IL; Champaign-Urbana, IL; Bucyrus, OH; Falls Church, VA; Los Angeles, CA; Portland, OR; Houston, TX; Salt Lake City, UT; Wichita, KS; Jackson, MS; Winston-Salem, NC; Philadelphia, PA; Westbury, NY; and Denver, CO.

Data Base Format

At least four types of information are relatively available for each location utilized as a data source:

1. physical, demographic etc., descriptions of the sites, plus maps, parameters, and sampling methods;
2. published reports and other written documentation;
3. the rainfall-runoff-quality data themselves; and
4. associated modeling data, e.g., maps, plans, photos, etc.

Item 1 is provided for each location in the published data base reports. A standardized tabular format is used for all sites. Item 2 is handled through a list of references for each location. Item 3 is handled separately wherein all data have been coded and placed on a magnetic tape and in the EPA STORET data retrieval systems. A limited amount of data needed for model input, item 4, is available for short-term loan by contacting the EPA Project Officer. The remainder of such data will have to be obtained by contacting individuals at each location. In addition, input data for the EPA Storm Water Management Model, SWMM, are available for several locations.

The emphasis of this project was not on the formulation of a sophisticated storage and retrieval system for the management of the data base. Rather, it was to obtain and document as much data as possible. Hence, the "data base" itself is merely a magnetic tape containing records of simple card images. Each quantity and quality parameter is identified with a relatively unambiguous STORET code. On the tape, rainfall-runoff-quality data are grouped by event and by catchment with one catchment per tape file. There are a total of 73 catchments for this edition of the data base.

Data may be used for comparison with modeling results simply by obtaining a listing via a "dump" utility of the tape contents. Alternatively, only selected parameters may be utilized for statistical analyses and characterization purposes, although in practice such manipulations will be better served after having placed the data onto a rapid-access storage device.

Statistical Analysis

The thousands of data entries assembled as part of the urban rainfall-runoff-quality data base represent a sample from the vast population of such data. As such, they may be used to obtain insight as to the statistical character of urban runoff through generation of means, standard deviations, ranges, loads, etc. These parameters may be used in turn to develop causative relationships among water quality parameters and hydrologic and demographic factor (e.g., used in regression analyses).

Data for all catchments subject to water quality monitoring have been analyzed statistically for flow and time-weighted means and standard deviations as well as ranges of parameters and surface loadings (i.e., pounds of pollutant per acre-inch of runoff). Summary values for each catchment and pollutant are given for each statistical parameter. Table 1 is an example of the quality summary information provided in the data base reports for each catchment. In addition, hydrologic information such as rainfall and runoff depth and duration is given for each storm event. This statistical summary information is also available directly on the magnetic tape, as are voluminous statistical summaries for each individual storm event for each catchment.

Summary

A common denominator of mathematical models of urban hydrologic processes is the need for adequate data with which to calibrate and verify model representations of physical processes. Such data need to be collected at short time intervals during several storms and are typically time consuming and expensive to obtain. However, the data also serve the very useful purposes of characterization of urban rainfall-runoff-quality processes in terms of statistics and loadings (e.g., pounds per acre) and extrapolation of such characteristics to ungaged catchments.

The data for 73 catchments in 20 urban areas represent an effort to aggregate available data into one accessible

Table 1. Example of the quality data statistical summaries.

```
******************************
*     STATISTICAL SUMMARY    *
******************************
*     CATCHMENT FILE : 88    *
************************************************************
* SEATTLE, WASHINGTON. CENTRAL BUSINESS DISTRICT.   (WA 1 7) *
************************************************************
* COMBINED SEWERED AREA        CATCHMENT AREA   27.80 ACRES *
************************************************************
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	10 WATER TEMP CENT	70 TURB JKSN JTU	94 CNDUCTVY FIELD MICROMHO	300 DO MG/L	310 BOD 5 DAY MG/L	340 COD HI LEVEL MG/L	400 PH SU	515 RESIDUE DISS-105 C MG/L
MEAN..............................	17.500	43.700	167.000	7.670	64.300	176.000	6.490	150.000
STANDARD DEVIATION.............	1.700	6.630	86.900	2.340	37.700	67.900	0.755	47.600
COEF. OF VARIATION.............	0.097	0.152	0.521	0.305	0.585	0.386	0.116	0.317
PARAMETER RANGE								
MIN...................	11.200	10.000	25.000	1.800	9.000	31.000	3.900	1.000
MAX...................	20.700	180.000	430.000	11.900	220.000	480.000	7.700	2300.000
# OF EVENTS.....................	4	5	5	5	5	5	5	5
TOTAL FLOW VOLUME(INCH).........	0.492	0.822	0.822	0.785	0.785	0.785	0.785	0.822
TOTAL MASS LOAD(LBS)............	**********	**********	**********	37.900	318.000	870.000	**********	778.000
CONCENTRATION(LBS/AC-IN)........	**********	**********	**********	1.740	14.600	39.900	**********	34.000

	530 RESIDUE TOT NFLT MG/L	546 RESIDUE SETTLBLE MG/L	552 GREASE HEX SOL MG/L	610 NH3-N TOTAL MG/L	615 NO2-N TOTAL MG/L	625 TOT KJEL N MG/L	630 NO2&NO3 N-TOTAL MG/L	669 PHOS-T HYDRO MG/L P
MEAN..............................	162.000	101.000	18.200	2.300	0.104	8.660	0.719	1.560
STANDARD DEVIATION.............	21.700	28.500	8.910	2.240	0.060	5.940	0.278	1.210
COEF. OF VARIATION.............	0.134	0.284	0.490	0.974	0.573	0.685	0.387	0.774
PARAMETER RANGE								
MIN...................	4.000	0.100	1.000	0.080	0.010	0.270	0.150	0.000
MAX...................	724.000	570.000	140.000	18.000	0.300	31.000	2.100	15.200
# OF EVENTS.....................	5	5	5	5	5	5	5	5
TOTAL FLOW VOLUME(INCH).........	0.785	0.822	0.822	0.822	0.822	0.822	0.822	0.822
TOTAL MASS LOAD(LBS)............	800.000	521.000	94.100	11.900	0.540	44.900	3.720	8.070
CONCENTRATION(LBS/AC-IN)........	36.700	22.800	4.120	0.520	0.024	1.960	0.163	0.353

	940 CHLORIDE CL MG/L	945 SULFATE SO4 MG/L	1002 ARSENIC AS.TOT UG/L	1027 CADMIUM CD.TOT UG/L	1034 CHROMIUM CR.TOT UG/L	1042 COPPER CU.TOT UG/L	1045 IRON TOTAL UG/L	1051 LEAD PB.TOT UG/L
MEAN..............................	65.700	20.400	49.800	27.400	598.000	353.000	1470.000	299.000
STANDARD DEVIATION.............	163.000	11.300	0.543	47.300	693.000	285.000	965.000	163.000
COEF. OF VARIATION.............	2.475	0.554	0.011	1.724	1.160	0.808	0.656	0.545
PARAMETER RANGE								
MIN...................	4.000	2.000	49.000	3.900	10.000	20.000	110.000	90.000
MAX...................	3000.000	55.000	60.000	1600.000	4200.000	4200.000	13000.000	1800.000
# OF EVENTS.....................	5	5	3	5	5	5	5	5
TOTAL FLOW VOLUME(INCH).........	0.785	0.813	0.439	0.785	0.785	0.785	0.822	0.785
TOTAL MASS LOAD(LBS)............	325.000	104.000	0.138	0.136	2.950	1.740	7.610	1.480
CONCENTRATION(LBS/AC-IN)........	14.900	4.620	0.011	0.006	0.135	0.080	0.333	0.068

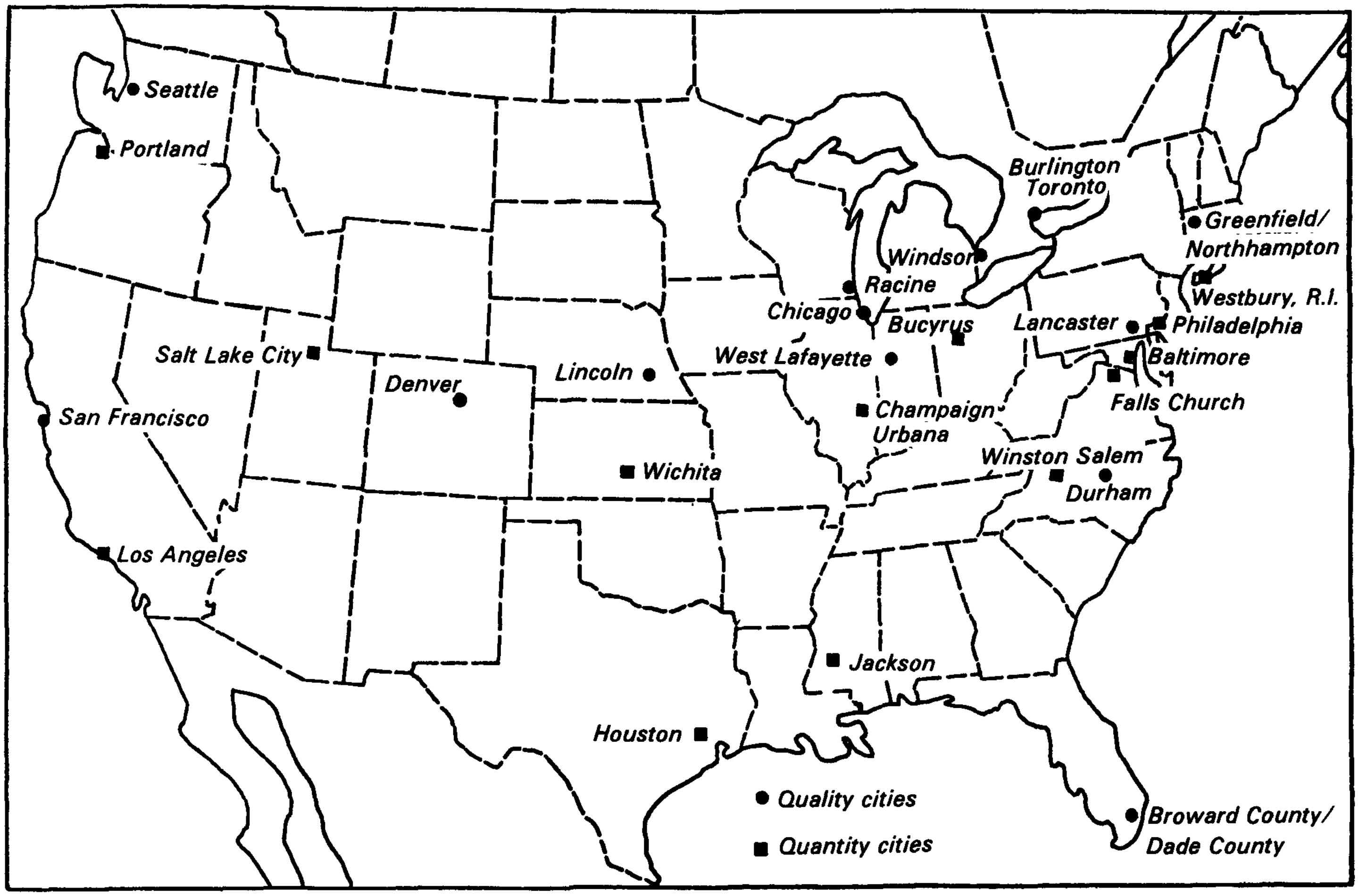

Figure 1. Location map for urban areas with rainfall-runoff-quality data (quality cities) and rainfall-runoff data (quantity cities).

data base. The data base itself consists of a magnetic tape with data organized in a readily accessible format. The emphasis has been on assembling and processing of data rather than constructing a sophisticated computerized data storage and retrieval system. The EPA STORET system is available for the latter purpose.

The project results are provided in three forms:

1. The data base reports that include descriptions and references of data sources used and pending and statistical analyses.
2. A magnetic tape containing the actual rainfall-runoff-quality data from each source on a storm event basis. Copies of the tape will be provided at cost. In addition, all data are on the EPA STORET data retrieval system for additional accessibility.
3. A limited amount of in-house modeling data (maps, plans, photos, etc.) available for short-term loan by contacting the EPA Project Officer.

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***Douglas C. Ammon** is the EPA Project Officer (see below).*
The complete reports, entitled:
"Urban Rainfall-Runoff-Quality Data Base Update with Statistical Analysis," (Order No. PB 80-113 384; Cost: $21.00, subject to change)
"Urban Rainfall-Runoff-Quality Data Base," (Order No. PB 82-221 094; Cost: $37.50, subject to change)
The above reports will be available only from:
National Technical Information Service
5285 Port Royal Road
Springfield, VA 22161
Telephone: 703-487-4650
The EPA Project Officer can be contacted at:
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