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STORM WATER MANAGEMENT MODEL USER'S MANUAL Version II

National Environmental Research Center
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Cincinnati, Ohio 45268

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STORM WATER MANAGEMENT MODEL

USER'S MANUAL

Version II

By

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FOREWORD

Man and his environment must be protected from the adverse effects of pesticides, radiation, noise and other forms of pollution, and the unwise management of solid waste. Efforts to protect the environment require a focus that recognizes the interplay between the components of our physical environment--air, water, and land. The National Environmental Research Centers provide this multidisciplinary focus through programs engaged in

- studies on the effects of environmental contaminants on man and the biosphere, and

- a search for ways to prevent contamination and to recycle valuable resources.

This study describes the use of the EPA Storm Water Management Model (SWMM) for aiding in planning abatement alternatives due to overflows of combined sewer and storm water runoff in urban areas. The material supersedes the original User's Manual for the SWMM and reflects the latest updating and modifications to the Model.

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ABSTRACT

A comprehensive mathematical model (the EPA Storm Water Management Model (SWMM)) capable of representing urban stormwater runoff and combined sewer overflow phenoma was developed. SWMM portrays correctional devices in the form of user-selected options for storage and/or treatment with associated estimates of cost. Effectiveness is portrayed by computed treatment efficiencies and modeled changes in receiving water quality. The original project report published in 1971 is divided into four volumes: Volume I, "Final Report," Volume II, "Verification and Testing," Volume III, "User's Manual," and Volume IV, "Program Listing" (EPA Report Nos. 11024 DOC 07/71, 11024 DOC 08/71, 11024 DOC 09/71, and 11024 DOC 10/71, respectively).

Effort on modification and improvement of the SWMM has been, and is being continued since its release. As a result, this official "Release 2" of the SWMM includes additional program components, i.e., new runoff routine, urban erosion prediction, new treatment process performance and cost functions, and new receiving water quality. This report provides a revised and improved User's Manual to accompany "Release 2" program. As much as possible, instructions for input formats have been kept the same as in the original User's Manual, Volume III.

This report was submitted in partial fulfillment of Project R-802411 by the University of Florida under the sponsorship of the Environmental Protection Agency. Work was completed as of August 1974.

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ACKNOWLEDGEMENTS

The material presented in this report is based on extensions and revisions of the first version of the Storm Water Management Model, and that original work is gratefully acknowledged. Both Metcalf and Eddy, Incorporated and Water Resources Engineers, Incorporated have continued their model development efforts, and have contributed to the additional work performed at the University of Florida. In particular, Drs. Robert Shubinski and Larry Roesner of WRE and Mr. John Lager of M & E made many useful suggestions concerning program "bugs" and modifications and proposed alterations in the presentation format. In addition, the Release 2 version of the Runoff Model is based on development work by WRE for the Seattle District, Corps of Engineers.

The guidance and considerable interest of Mssrs. Harry Torno, Chi-Yuan Fan and Richard Field of the Environmental Protection Agency has been most beneficial and appreciated. Mssrs. M. T. Augustine and M. A. Ports of the State of Maryland, Department of Natural Resources were instrumental in obtaining useful information on the Universal Soil Loss Equation. Data for the Lancaster, Pennsylvania example were obtained through the courtesy of the City of Lancaster and Meridian Engineering, Incorporated of Philadelphia. Data for the St. Johns River example were obtained with the help of Frederic R. Harris, Incorporated of Jacksonville.

The extensive typing job was performed with dedication by Ms. Mary Polinski. Ms. Gena Ellis conscientiously drafted many new figures. Computations were performed at the Northeast Regional Data Center at the University of Florida.

SECTION 1

INTRODUCTION

PROBLEMS OF URBAN RUNOFF

An enormous pollution load is placed on streams and other receiving waters by combined and separate storm sewer overflows. It has been estimated that the total pounds of pollutants (BOD and suspended solids) contributed yearly to receiving waters by such overflows is of the same order of magnitude as that released by all secondary sewage treatment facilities (2,3). The Environmental Protection Agency (EPA) has recognized this problem and led and coordinated efforts to develop and demonstrate pollution abatement procedures. These procedures include not only improved treatment and storage facilities, but also possibilities for upstream abatement alternatives such as rooftop and parking lot retention, increased infiltration, improved street sweeping, retention basins and catchbasin cleaning or removal (2). The complexities and costs of proposed abatement procedures require much time and effort to be expended by municipalities and others charged with decision making for the solution of these problems.

It was recognized that an invaluable tool for decision makers would be a comprehensive mathematical computer simulation program that would accurately model quantity (flows) and quality (concentrations) during the total urban rainfall-runoff process. This model would not only provide an accurate representation of the physical system, but also provide an opportunity to determine the effect of proposed pollution abatement procedures. Alternatives could then be tested on the model, and least cost solutions could be developed.

The resulting EPA Storm Water Management Model is introduced below, and its use is the subject of this report. However, since its initial release in 1970, there has been an insurgence of urban runoff modeling, and it is worthwhile to review briefly objectives and options pertinent to management of urban stormwater runoff.

URBAN RUNOFF MODELS

Objectives

Models are generally used for studies of quantity and quality problems associated with urban runoff in which three broad objectives may be identified: planning, design and operation. Each objective typically produces models with somewhat different characteristics, and the different models overlap to some degree.

Planning Models

Planning models are used for an overall assessment of the urban runoff problem as well as estimates of the effectiveness and costs of abatement procedures. They may be used for "first cut" analyses of the rainfall-runoff process and illustrate trade-offs among various control options, e.g., treatment versus storage. They are typified by relatively large time steps (hours) and long simulation times (months and years). Data requirements are kept to a minimum and their mathematical complexity is low.

A current example of such a model is the Storage, Treatment, Overflow, and Runoff Model (STORM) (4,12) developed by the Corps of Engineers Hydrologic Engineering Center (HEC) and Water Resources Engineers, Incorporated (WRE) for the City of San Francisco. It utilizes hourly time steps and precipitation inputs and has simple quantity and quality prediction procedures based on such parameters as per cent imperviousness and land use. Included are the effects of snow melt and soil erosion as well as treatment and storage options. The output may be used to illustrate, for example, the frequency and/or volumes of discharges to receiving waters of untreated urban runoff for a given treatment-storage combination. STORM has been run for simulation periods of up to 25 years, depending upon the desired definition of return periods.

A planning model such as STORM may also be run to identify hydrologic events that may be of special interest for design or other purposes. These storm events may then be analyzed in detail using a more sophisticated design model. Planning or long-term models may also be used to generate initial conditions (i.e., antecedent conditions) for input to design models.

Design Models

Design models are oriented toward the detailed simulation of a single storm event. They provide a complete description of flow and pollutant routing from the point of rainfall through the entire urban runoff system and often into the receiving waters as well. Such models may be used for accurate predictions of flows and concentrations anywhere in the rainfall/runoff system and can illustrate the detailed and exact manner in which abatement procedures or design options affect them. As such, these models are a highly useful tool for determining least-cost abatement procedures for both quantity and quality problems in urban areas. Design models are generally used for simulation of a single storm event and are typified by short time steps (minutes) and short simulation times (hours). Data requirements may be moderate to very extensive depending upon the particular model employed.

The EPA Storm Water Management Model (8,9,10,11), frequently abbreviated "SWMM," is an example of a model developed specifically for simulation of urban quantity and quality processes and useful for the purposes mentioned above. It is also versatile enough to be used for certain planning studies or adapted to uses other than were originally intended. For instance, the surface runoff portion may be used to simulate natural drainage systems, and the receiving water portion may be applied to a variety of natural configurations independent of the urban runoff context. Use of the SWMM is described in detail in this report.

Many other urban runoff models have been described in the literature and are too numerous to enumerate here. Examples range from relatively simple models, e.g., RRL (15), Chicago (6), to highly complex models that utilize the complete dynamic equations of motion to simulate every aspect of the drainage systems, e.g., the WRE version of the SWMM (13), Hydrograph Volume Method (5), and Sogreah (14). Many of these other models lack quality calculations; of the aforementioned ones, quality routing is included only in the WRE version of the SWMM. Furthermore, many are either proprietary or ill-documented. The EPA SWMM is well documented, widely tested and of a fairly high level of sophistication. In addition, through its broad use, improvements and updating have been continuous. It is a widely accepted, detailed simulation model.

Operational Models

Operational models are used to produce actual control decisions during a storm event. Rainfall is entered from telemetered stations and the model is used to predict system responses a short time into the future. Various control options may then be employed, e.g., in-system storage, diversions, regulator settings.

These models are frequently developed from sophisticated design models and applied to a particular system. Examples are operational models designed for Minneapolis-St. Paul (1) and Seattle (7).

DEVELOPMENT OF THE STORM WATER MANAGEMENT MODEL

Under the sponsorship of the Environmental Protection Agency, a consortium of contractors -- Metcalf and Eddy, Incorporated, the University of Florida, and Water Resources Engineers, Incorporated -- developed in 1969-70 a comprehensive mathematical model capable of representing urban stormwater runoff and combined sewer overflow phenomena. The SWMM portrays correctional devices in the form of user-selected options for storage and/or treatment with associated estimates of cost. Effectiveness is portrayed by computed treatment efficiencies and modeled changes in receiving water quality.

The project report is divided into four volumes. Volume I, the "Final Report" (8), contains the background, justifications, judgments, and assumptions used in the model development. It further includes descriptions of unsuccessful modeling techniques that were attempted and recommendations for forms of user teams to implement systems analysis techniques most effectively. Although many modifications and improvements have since been added to the SWMM, the material in Volume I still accurately describes most of the theory behind updated versions.

Volume II, "Verification and Testing," (9), describes the methods and results of the application of the original model to four urban catchments.

Volume III, the "User's Manual" (10), contains program descriptions, flow charts, instructions on data preparation and program usage, and test examples. This present report will replace the old User's Manual and reflects the extensive updating that has occurred since the completion of the SWMM project in September, 1970.

Volume IV, "Program Listing" (11), lists the entire original program and Job Control Language (JCL) as used in the demonstration runs. Since many routines in the updated version are similar or identical to the original, it is still a useful reference.

All three original contractors have continued to modify and improve the SWMM, as have numerous other users since its release. Through EPA research grants, the University of Florida has conducted extensive research on urban runoff and SWMM development, and has evolved into an unofficial "clearinghouse" for SWMM improvements. As a result, an official "Release 2" of the SWMM has been made in August, 1974. Although it has been prepared for EPA by the University of Florida, it also relies heavily upon contributions by Water Resources Engineers and Metcalf and Eddy. This report provides a revised and improved User's Manual to accompany Release 2. As much as possible, instructions for input formats have been kept the same as in the original User's Manual, Volume III (10).

OVERALL SWMM DESCRIPTION

Overview

The comprehensive Storm Water Management Model uses a high speed digital computer to simulate real storm events on the basis of rainfall (hyetograph) inputs and system (catchment, conveyance, storage/treatment, and receiving water) characterization to predict outcomes in the form of quantity and quality values.

The simulation technique -- that is, the representation of the physical systems identifiable within the Model -- was selected because it permits relatively easy interpretation and because it permits the location of remedial devices (such as a storage tank or relief lines) and/or denotes localized problems (such as flooding) at a great number of points in the physical system.

Since the program objectives are particularly directed toward complete time and spatial effects, as opposed to simple maxima (such as the rational formula approach) or only gross effects (such as total pounds of pollutant discharged in a given storm), it is considered essential to work with continuous curves (magnitude versus time), referred to as hydrographs and "pollutographs." The units selected for quality representation, pounds per minute, identify the mass releases in a single term. Concentrations are also printed out within the program for comparisons with measured data.

An overview of the Model structure is shown in Figure 1-1. In simplest terms the program is built up as follows:

1) The input sources:

   RUNOFF generates surface runoff based on arbitrary rainfall hyetographs, antecedent conditions, land use, and topography.

   FILTH generates dry weather sanitary flow based on land use, population density, and other factors.

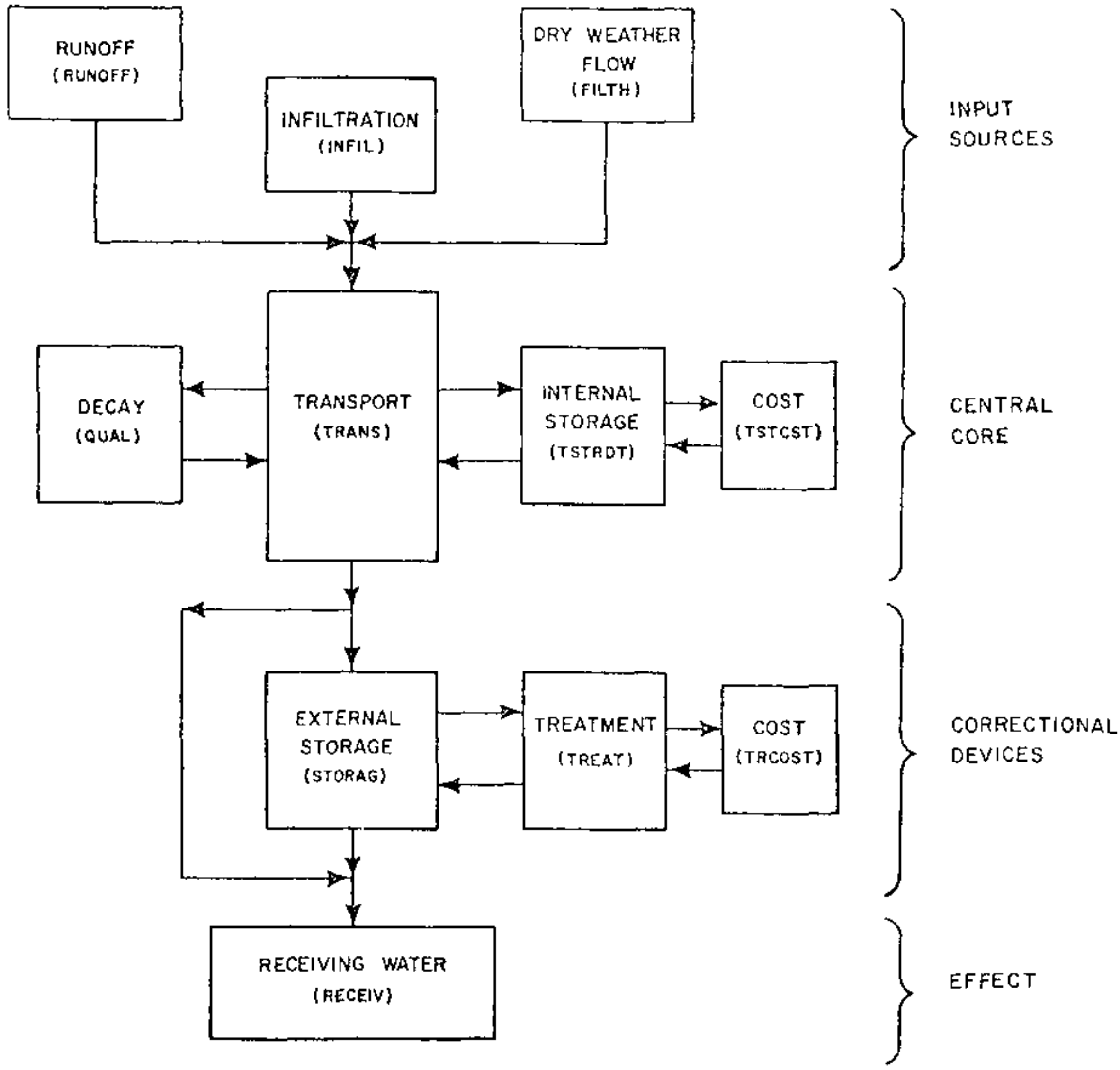
   INFIL generates infiltration into the sewer system based on available groundwater and sewer condition.

2) The central core:

   TRANS carries and combines the inputs through the sewer system using a modified kinematic wave approach in accordance with Manning's equation and continuity; it assumes complete mixing at various inlet points.

3) The correctional devices:

   TSTRDT, TSTCST, STORAG, TREAT, and TRCOST modify hydrographs and pollutographs at



Note: Subroutine names are shown in parentheses.

Figure 1-1. Overview of Model Structure

selected points in the sewer system, accounting for retention time, treatment efficiency, and other parameters; associated costs are computed also.

4) The effect (receiving waters):

RECEIV routes hydrographs and pollutographs through the receiving waters, which may consist of a stream, river, lake, estuary, or bay.

The quality constituents considered for simulation are the 5-day BOD, total suspended solids, total coliforms (represented as a conservative pollutant), and DO. These constituents were selected on the basis of available supporting data and importance in treatment effectiveness evaluation. In addition, the Runoff Block also models COD, settleable solids, total nitrogen, phosphate and grease. However, routing of these parameters through subsequent blocks usually involves special programming efforts. The contribution of suspended solids by urban erosion processes is also simulated by the program.

Program Blocks

The adopted programming arrangement consists of a main control and service block, the Executive Block, a service block (Combine), and four computational blocks: (1) Runoff Block, (2) Transport Block, (3) Storage Block, and (4) Receiving Water Block.

Executive Block --

The Executive Block assigns logical units (disk/tape/drum), determines the block or sequence of blocks to be executed, and, on call, produces graphs of selected results on the line printer. Thus, this Block does no computation as such, while each of the other four blocks are set up to carry through a major step in the quantity and quality computations. All access to the computational blocks and transfers between them must pass through subroutine MAIN of the Executive Block. Transfers are accomplished on offline devices (disk/tape/drum) which may be saved for multiple trials or permanent record.

Combine Block --

This block allows the manipulation of data sets (files stored on offline devices) in order to aggregate results of previous runs for input into subsequent blocks. In this manner large, complex drainage systems may be partitioned for simulation in smaller segments.

Runoff Block --

The Runoff Block computes the stormwater runoff and its characteristics for a given storm for each subcatchment and stores the results in the form of hydrographs and pollutographs at inlets to the main sewer system.

Transport Block --

The Transport Block sets up pre-storm conditions by computing DWF and infiltration and distributing them throughout the conveyance system. The block then performs its primary function of flow and quality routing, picking up the runoff results, and producing combined flow hydrographs and pollutographs for the total drainage basin and at selected intermediate points. Of course, the program may also be used strictly for stormwater routing, with neither DWF nor infiltration.

Storage Block --

The Storage Block uses the output of the Transport Block and modifies the flow and characteristics at a given point or points according to the predefined storage and treatment facilities provided. Costs associated with the construction and operation of the storage/treatment facilities are computed.

Receiving Water Block --

The Receiving Water Block accepts the output of the Transport or Runoff Blocks directly, or the modified output of the Storage Block, and computes the resulting hydrodynamics and concentration distributions in the receiving river, lake, estuary, or bay.

Total Simulation

In principle, the capability exists to run all blocks together in a given computer execution, although from a practical and sometimes necessary viewpoint (due to computer core limitations), typical runs usually involve only one or two computational blocks together with the Executive Block. Using this approach avoids overlay and, moreover, allows for examination of intermediate results before continuing the computations. Further, it permits the use of intermediate results as start-up data in subsequent execution runs, thereby avoiding the waste of repeating the computations already performed.

This manual expands on these block descriptions by providing for each block:

1) Descriptions of the program operation.

2) Instructions on data preparation with tables for data card input requirements and an alphabetical list of variables.

3) Examples of the application of procedure described with sample I/O information reproduced.

NOTE: Where maximum quantities (i.e., number of watersheds, number of elements, etc.) are specified, these represent the maximum array areas reserved by the program. These numbers cannot be exceeded without revising the appropriate common, dimension, and related statements. For special runs it may be desirable to reallocate this available array area (e.g., to increase the total number of time steps above 150).

USER REQUIREMENTS

Computer Facilities

A large, high-speed computer is required for operation of the SWMM such as an IBM 360, UNIVAC 1108 or CDC 6600. The largest of the blocks requires on the order of 90,000 words of storage. Through considerable efforts, users have been able to adapt portions of the program to small-core machines such as the IBM 1130, but only with extensive use of off-line storage and considerable increase in execution time.

Data Requirements

As will be seen from a review of following sections, the data requirements for the SWMM are extensive. Collection of the data from various municipal and other offices within a city is possible to accomplish within a few days. However, reduction of the data for input to the Model is time consuming and may take up to three man-weeks for a large area (e.g., greater than 2000 acres). On an optimistic note, however, most of the data reduction is straight forward (e.g., tabulation of slopes, lengths, diameters, etc., of the sewer system). The SWMM is flexible enough to allow different modeling approaches to the same area, and a specific, individual modeling decision upstream in the catchment will have little effect on the predicted results at the outfall.

Verification and Calibration

The SWMM is designed as a "deterministic" model, in that if all input parameters are accurate, the physics of the processes are simulated sufficiently well to produce accurate results without calibration. This concept may fail in practice because the input data or the numerical methods may not be accurate enough for most real applications. Furthermore, many computational procedures within the Model are based upon limited data themselves. For instance, surface quality predictions are based almost totally on data from Chicago, and are unlikely to be of universal applicability.

As a result it is essential that some local verification/calibration data be available at specific application sites to lend credibility to the predictions of any urban runoff model. These data are usually in the form of measured flows and concentrations at outfalls or combined sewer overflow locations. Note that quality measurements without accompanying flows are of little value. The SWMM has sufficient parameters that may be "adjusted," particularly in the Runoff Block, such that calibrating the Model against measured data is usually readily accomplished.

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SECTION 2

INITIAL JOB SET-UP

COMPUTER SYSTEM REQUIREMENTS

The Storm Water Management Model can be run on a machine having core storage capacity of at least 350K bytes (or equivalent) and using overlay. In addition, the program uses peripheral storage devices which may consist of disk, tape, or drum units, depending on the machine configuration. All parts of the original program were initially run on at least two machines, the UNIVAC 1108, IBM 360 and now an IBM 370/165.

PROGRAM COMPILATION AND EXECUTION TIME AND COST

A sample of the compilation and execution times with run costs for separate program blocks are shown on Table 2-1. This table illustrates the savings which were made by storing compiled blocks of the program in a permanent job library (Load Modules). At most computer installations, there is a daily or monthly charge for storing Load Modules. If the SWMM is going to be used more than a few times, it would be advisable to use Load Modules.

From the Central Processing Unit (CPU) and Execution times in this table a time and cost estimate can be arrived at for different machines. A systems analyst can obtain these figures.

JOB CONTROL LANGUAGE (JCL)

The assignment of logical units requires, in general, the provision for files to be written on specific physical devices. To accomplish this, the user must supply the necessary JCL. As a rule, JCL is highly machine dependent; in fact, it often differs on two identical machines at different installations. Therefore, the SWMM cannot include JCL that is universally applicable. The following remarks, however, may be useful in gaining insight into what is involved on systems such as an IBM 370/165.

It is convenient on these machines to use disk storage devices rather than tape units because of the inherently faster reading and writing speed of the former. At most installations, the logical unit

Table 2-1. SAMPLE PROGRAM COMPILATION AND EXECUTION TIME AND COST

Program blocks[c]	Uncompiled[a] CPU time[d] (sec)	Uncompiled[a] Execution time[e] (sec)	Uncompiled[a] Cost[f] ($)	Load module[b] CPU time[d] (sec)	Load module[b] Execution time[e] (sec)	Load module[b] Cost[f] ($)
Runoff[g]						
Quantity only	10.69	10.60	5.48	1.58	10.28	4.10
Quantity and Quality	11.12	18.56	6.46	1.73	18.89	5.61
Transport[h]						
Quantity only	29.57	18.04	11.11	2.10	21.14	4.70
Quantity and Quality	29.90	39.62	14.57	2.15	39.79	7.75
Storage/Treatment[i]						
Quantity and Quality				2.41	4.54	2.40
Receiving Water[j]						
Quantity only				2.17	78.53	14.00
Quantity and Quality	19.38	79.67	18.11	2.29	83.16	15.49

[a]Includes compile, link-edit, and execute.

[b]Includes compile, for dummy subroutines only, link-edit, and execute (all subroutines in object form on data set).

[c]All blocks include Executive Block (Load Module form), maximum core storage required for any one block and the Executive Block is 350K.

[d]Time required for compile and link-edit.

[e]Time required for execution only.

[f]Total cost for running block on University of Florida's IBM 370/165 computer at half the commercial rate.

[g]North Lancaster, Pennsylvania, Drainage District, Study No. 3, 100 time steps, integration period 5 minutes, 66 subcatchments and no gutter/pipe network.

[h]North Lancaster, Pennsylvania, Drainage District, Study No. 3, 100 time steps, integration period 5 minutes, 147 sewer elements, infiltration and sewage flows to be estimated by model.

[i]North Lancaster, Pennsylvania, Drainage District Treatment Plant, Study No. 3, 100 time steps, integration period 5 minutes, treatment control options used high rate disinfection device for overflow, bar racks, sedimentation, biological treatment, and contact tank (cost includes graphing input and output).

[j]Conestoga River, Lancaster, Pennsylvania, with input from North Treatment Plant and rainfall from Study No. 3, 3 days simulated, water quality cycles per day 24, length of integration step 60 seconds, 20 junctions and 19 channels.

corresponding to the card reader is given the number 5 and the line printer is given the number 6. The Storm Water Management Model is programmed on the assumption that units 5 and 6 are so used. Typically, the systems programmers have provided the necessary JCL for these units and also for the card punch (usually given the logical unit number of 7). Moreover, JCL may have been provided for scratch units, in which case the unit assignments for scratch files can take advantage of the existing JCL.

Usually, however, the data file and scratch file assignments require JCL to be supplied for each unit. The rules for such JCL must be ascertained from the systems programmers at the installation, since there is considerable variation in unit number availability, etc. In general, one should only set up the units needed in a given run, since there may be a charge for file space that is reserved, even if it is not used.

Table 2-2 shows sample JCL, overlay and preliminary input data to run the SWMM from a tape. Many users may prefer to store a compiled version on a disk rather than run from the cards or tape. This example is for the University of Florida's IBM 370/165.

The following is a description of Table 2-2:

Line "0" is the job card unique to the University of Florida Computing Center.

Line "1" is the tape mount and setup card.

Lines "2-3" are for execution and overlay of the SWMM source program.

Lines "4-13" describe the files on the source tape called MASTER. Example: LABEL = 2 stands for the Runoff Block on the tape.

Lines "14-26" describe the overlay of each block of the SWMM used.

Lines "27-33" describe scratch disk files for use in running the SWMM. These could alternatively be set up as permanent files if the same input or output is to be used for another run, for example. An example of a tape or disk unit number: //GO.FXXF001 DD... where XX stands for the symbolic unit number.

Table 2-2. SAMPLE OF JCL REQUIRED TO RUN SWMM ON AN IBM 370/165

```
//SWMM  JOB     (1006,3422,30,15,0),'W. ALAN PELTZ',CLASS=L
/*SETUP            TAPE9,1,MASTER
// EXEC F4HCLM,PARM.FORT='SIZE=350K,NOSOURCE,NOMAP',
//     PARM.LKED='LIST,MAP,OVLY'
//FORT.SYSIN DD UNIT=TAPE9,VOL=SER=MASTER,DSN=MAIN,DISP=(OLD,PASS),
//     LABEL=1
//               DD UNIT=TAPE9,VOL=SER=MASTER,DSN=RUNOFF,DISP=(OLD,PASS),
//     LABEL=2
//               DD UNIT=TAPE9,VOL=SER=MASTER,DSN=TRANSPRT,DISP=(OLD,PASS),
//     LABEL=3
//               DD UNIT=TAPE9,VOL=SER=MASTER,DSN=STORAGE,DISP=(OLD,PASS),
//     LABEL=4
//               DD UNIT=TAPE9,VOL=SER=MASTER,DSN=RECEIVE,DISP=(OLD,PASS),
//     LABEL=5
//LKED.SYSIN DD *
   OVERLAY ALPHA
       INSERT  RUNOFF,HYDRO,RHYDRO,QSHED1,WSHED,GUTTER,GQUAL,HCURVE,RECAP
   OVERLAY ALPHA
       INSERT  TRANS,DEPTH,DPSI,DWLOAD,FILTH,FINDA,FIRST,INFIL,INITAL,PSI
       INSERT  NEWTON,PRINT,QUAL,RADH,ROUTE,SLOP,VEL,TSTRDT,TSTORG,TSTCST
       INSERT  TPLUGS,TSROUT,TINTRP,ACOS
   OVERLAY ALPHA
       INSERT  STORAG,TRTDAT,TRCHEK,INTERP,STRDAT,TREAT,BYPASS,TRLINK,KILL
       INSERT  SEDIM,HIGHRF,STRAGE,PLUGS,        SPRINT,TRCOST
   OVERLAY ALPHA
       INSERT  RECEIV,SWFLOW,MANING,INDATA,TIDCF,TRIAN,OUTPUT,PRTOUT
       INSERT  SWQUAL,INQUAL,LOOPQL,QPRINT
//GO.FT01F001 DD UNIT=SYSDA,SPACE=(CYL,(2,1))
//GO.FT02F001 DD UNIT=SYSDA,SPACE=(CYL,(2,1))
//GO.FT03F001 DD UNIT=SYSDA,SPACE=(CYL,(2,1))
//GO.FT04F001 DD UNIT=SYSDA,SPACE=(CYL,(2,1))
//GO.FT08F001 DD UNIT=SYSDA,SPACE=(CYL,(2,1))
//GO.FT09F001 DD UNIT=SYSDA,SPACE=(CYL,(2,1))
//GO.FT10F001 DD UNIT=SYSDA,SPACE=(CYL,(2,1))
//GO.SYSIN DD *
   0    9    9   10   10    9    9   10
   1    2    3    4    8
RUNOFF
     .
  (DATA FOR RUNOFF BLOCK)
     .
     .
TRANSPORT
     .
  (DATA FOR TRANSPORT BLOCK)
     .
     .
STORAGE
     .
  (DATA FOR STORAGE/TREATMENT BLOCK)
     .
     .
RECEIVING
     .
  (DATA FOR RECEIVING WATER BLOCK)
     .
     .
ENDPROGRAM
/*
```

OVERLAY PROCEDURES

In computers with small core capacity the technique of overlaying is most important. It reduces machine core storage which is necessary to run the model.

In Table 2-2, Lines "15-26" describe the overlay of each block of the model in its simplest form, but it can be broken down even further. A systems programmer would be most helpful in setting up the overlay.

DUMMY SUBROUTINES

Dummy subroutines are required if only a few of the blocks are to be used. A programmer would be most helpful in setting up the dummy subroutines (to avoid compiling unneeded large programs).

DATA SETS

Data sets for the SWMM are used to transfer information from one program block to another or to store and transfer information between subroutines. They are usually magnetic tapes or disks.

SCRATCH DATA SETS

Scratch data sets should be used almost exclusively when running the SWMM. The information on them is erased after the simulation is over. The following definitions are for scratch data sets used to make a typical run of the SWMM. The unit numbers assigned to the various data sets are arbitrary. Any desired values compatible with the descriptions of lines "27-33," Table 2-2, could be used. Furthermore, the following definitions assume Runoff, Transport, Storage/Treatment and Receiving are to be run in order. However, various sequences may be used, and the parameters would correspond to the sequence defined in lines "37-56" of Table 2-2:

JIN(1) = unit number of tape/disk input into the first block to be run (Runoff Block). JIN(1) = 0 means there is no tape/disk input.

Line "34" tells the computer that input data follow.

Line "35" is tape/disk assignments and corresponds to card group 1 of the Executive Block Card Data Section.

Line "35" may be interpreted as follows:

JIN(1),	JOUT(1),	JIN(2),	JOUT(2),	JIN(3),	JOUT(3),	JIN(4),	JOUT(4)
0	9	9	10	10	9	9	10

Here, JIN(N) = I refers to an input device or file and JOUT(N) = I refers to an output device or file. For example, a typical read statement in a FORTRAN program may be READ(I,80). The I is replaced by the symbolic unit number of an input device (e.g., card reader). On most computer systems, I is equal to 5 for reading cards and 6 or 7 for writing or punching output. The same applies for JIN(N) = I or JOUT(N) = I where I is substituted with the symbolic unit number of an input or output device such as a tape or disk unit, as defined by lines "27-33." Since the numbers 5, 6, and 7 have standard meanings, their descriptions are omitted.

Line "36" is scratch tape/disk assignments and corresponds to card group 2 of the Executive Block Card Data Section. Line "36" may be interpreted as follows:

NSCRAT(1),	NSCRAT(2),	NSCRAT(3),	NSCRAT(4),	NSCRAT(5)
1	2	3	4	8

Here, NSCRAT(N) = I refers to an input/output device or file. I is substituted with the symbolic unit number of an input/output device such as a tape or disk unit defined in lines "27-33." There should be a scratch tape/disk assignment for NSCRAT(1) through NSCRAT(5). Most blocks do not use all NSCRAT(I) tape/disk assignments; however, there is no storage or CPU time charged for the ones not used at most installations.

JOUT(1) = unit number of tape/disk output from the first block to be run (Runoff Block). JOUT(1) = 9 means there is such output to be saved and line "32" describes the disk utilized.

JIN(2) = unit number of tape/disk input to the second block to be run (Transport Block). (This is normally the same as the output number from the preceeding block.) JIN(2) = 9 means there is such input (from the Runoff Block) and line "32" describes the disk utilized.

JOUT(2) = unit number of tape/disk output from the second block to be run (Transport Block). JOUT(2) = 10 means there is such output to be saved and line "32" describes the disk utilized.

JIN(3) = unit number of the tape/disk input to the third block to be run (Storage/Treatment Block). (This is normally the same as the output unit number from the preceeding block.) JIN(3) = 10 means there is such input (from the Transport Block) and line "33" describes the disk utilized.

JOUT(3) = unit number of the tape/disk output from the third block to be run (Storage/Treatment Block). JOUT(3) = 9 means there is such output to be saved and line "32" describes the disk utilized. (Note that Runoff output will be written over.)

JIN(4) = unit number of the tape/disk input to the fourth block to be run (Receiving Block). (This is normally the same as the output unit number from the preceeding block) and line "32" describes the disk utilized.

JOUT(4) = unit number of tape/disk output from the fourth block to be run (Receiving Block). JOUT(4) = 10 means there is such output and line "33" describes the disk utilized. (Note that Transport output will be written over.)

JIN(5) - JIN(10) and JOUT(5) - JOUT(10) allow more than just four blocks to be run sequentially and are defined similarly if required.

PERMANENT DATA SETS

Permanent data sets should be used only when the output from a block is to be saved for later runs. The JCL for set up of these data sets is not included because of the differences in computer systems.

SECTION 3

EXECUTIVE BLOCK

BLOCK DESCRIPTION

The Executive Block performs three functions:

1) Assignment of logical units and files

2) Control of the computational block(s)

3) Graphing of data files by line printer.

No computations as such are performed. A flow chart of the Executive Block is shown in Figure 3-1.

Program Operation

The Executive Block assigns logical units and files, and controls the computational block(s) to be executed. These functions depend on reading in a few data cards which must be supplied according to the needs of a given computer run.

Since the various blocks use logical devices for input and output of computations, the Executive Block has provision for assigning logical unit numbers by reading two data cards. (Logical units and data sets have been discussed in Section 2.) The first card may contain up to 20 integer numbers, corresponding to 10 input and 10 output units. It is not necessary, however, to make such a large number of assignments for the usual run; in fact, there have been few occasions during the development and testing of the model when more than four units have been needed. The files that are produced on these units are saved for use by a subsequent computational block; also, the information contained in them can be examined directly by using the graphing capability of the Executive Block. The other unit assignments on the second data card are for scratch files, i.e., files that are generated and used during execution of the program, and are erased at the end of the run. Again, there is provision for up to five such units, but only one or two are typically needed. The unit numbers are passed from the Executive Block to all pertinent blocks. The graphing subroutines enable hydrographs and pollutographs

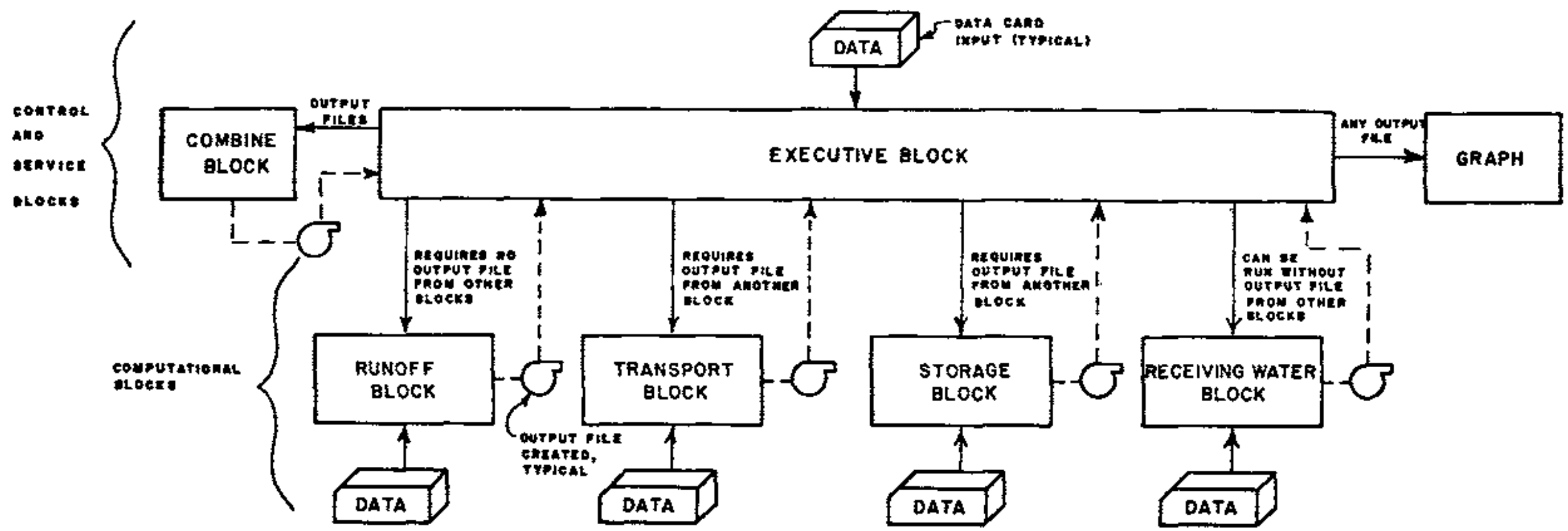

Figure 3-1. Master Programming Routine

to be plotted on the printer for selected locations on the data file. The subroutine GRAPH (IC) operates on two modes which are dependent upon the value of IC in the calling sequence. If IC = 0 (when called by the Runoff Block), control information is read from cards. If IC = 1 (when called in the Executive Block), both control information and title information are read from cards.

The subroutine CURVE performs the following operations:

1) Determines maximum and minimum of arrays to be plotted.

2) Calculates the range of values and selects appropriate scale intervals.

3) Computes vertical axis labels based upon the calculated scales.

4) Computes horizontal axis labels based upon the calculated scales.

5) Joins individual parts of the curve by subroutine PINE.

6) Outputs final plot.

Subroutine PINE joins two coordinate locations with appropriate characters in the output image array A of PPLOT. Subroutine PPLOT initializes the plotting array, stores individual locations, and outputs the final image array A for the printer plot.

INSTRUCTIONS FOR DATA PREPARATION

The instructions for data preparation are divided into two parts corresponding to control of the SWMM block selection and capability. Figure 3-2 and Tables 3-2 and 3-3 at the end of these instructions give the procedure for data card preparation and list the variables that are used.

Block Selection

The program controls the computation block(s) to be executed by reading alphameric information, CNAME, on sentinel cards. Thus, for example, CNAME might be RUNOFF. The program compares this word with a dictionary of such words. If a match is found, as it would be in this case, control is passed to the appropriate block. Here, for example, a call would be made to the Runoff Block. After execution of the Runoff Block, control is eventually returned to the Executive Block.

The program again reads a sentinel data card, which might indicate that another block is to be executed. For example, if the Transport Block is to be executed, the control word TRANSPORT would be given, etc. If results are to be graphed, the control word GRAPH would be on the sentinel card, or, if the run is to be terminated, the word ENDPROGRAM is given on the card. A summary of the control words and corresponding action is given in Table 3-1.

The use of control words on sentinel cards allows considerable flexibility in utilization of the Storm Water Management Model. The most common type of run involves execution of one of the computational blocks along with the graphing of results on the line printer. Thus, for the Runoff Block, such a run would be made by appropriate use of the words RUNOFF, GRAPH, and ENDPROGRAM. If the entire model were to be run with graphical output at the end of, say for example, the Transport and Storage Blocks, the sequence would be RUNOFF, TRANSPORT, GRAPH, STORAGE, GRAPH, RECEIVING and ENDPROGRAM.

Graph Routine

The data cards required for graphing are minimal. The first card supplies control information, such as in which tape/disk the hydrographs and pollutographs are stored, the number of curves per graph, and number of pollutants. Element numbers of which plots are to be made are given on the next card. The last three cards supply the titles for the curves, the horizontal axis label, and the vertical axis label. The vertical axis label card is repeated for each pollutant to be plotted and for the hydrograph in the order in which they are to be printed out.

Table 3-1. SUMMARY OF CONTROL WORDS AND CORRESPONDING ACTION FOR MAIN PROGRAM

Control word	Action to be taken
RUNOFF	Execute Runoff Block
TRANSPORT	Execute Transport Block
STORAGE	Execute Storage Block
RECEIVING	Execute Receiving Water Block
COMBINE	Execute Combine Block
GRAPH	Produce graphs on line printer
ENDPROGRAM	Terminate run
Any other word	Terminate run

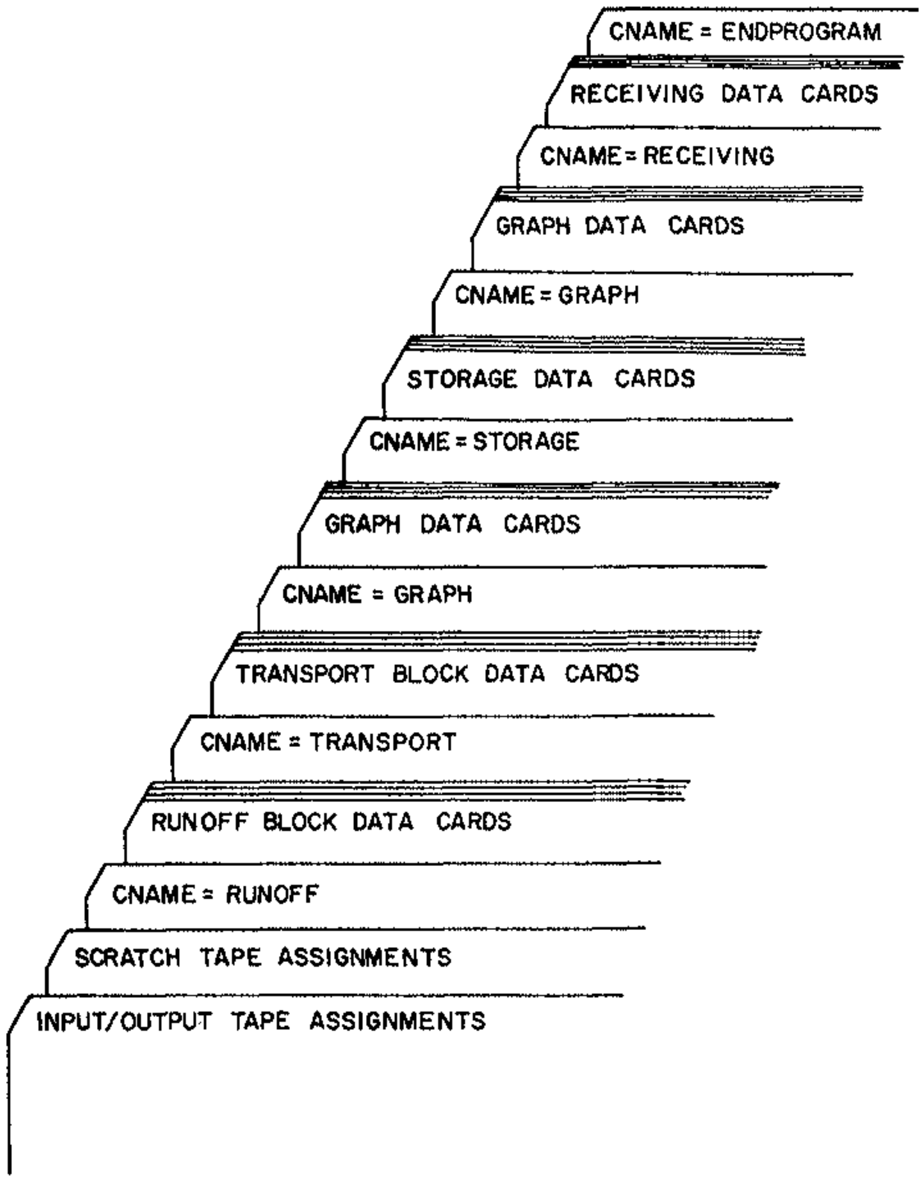

Figure 3-2. Data Deck for the Executive Block

Table 3-2. EXECUTIVE BLOCK CARD DATA

Card group	Format	Card columns	Description	Variable name	Default value
1			I/O tape/disk assignments.		
	20I4	1-4	Input tape assignment for first block to be run.	JIN(1)	0
		5-8	Output tape assignment for first block to be run.	JOUT(1)	0
		9-12	Input tape assignment for second block to be run (usually the same as the output tape from first block).	JIN(2)	0
		13-16	Output tape for second block to be run.	JOUT(2)	0
		.		.	
		.		.	
		.		.	
		.		.	
		77-80	Output tape for tenth block to be run.	JOUT(10)	0
2			Scratch tape-disk assignments.		
	5I4	1-4	First scratch tape assignment.	NSCRAT(1)	0
		5-8	Second scratch tape assignment.	NSCRAT(2)	0
		9-12	Third scratch tape assignment.	NSCRAT(3)	0
		13-16	Fourth scratch tape assignment.	NSCRAT(4)	0
		17-20	Fifth scratch tape assignment.	NSCRAT(5)	0
			REPEAT CARD 6 FOR EACH BLOCK TO BE CALLED.		
3			Control cards indicating which blocks in the program are to be called.		
	3A4	1-12	Name of block to be called.[a]	CNAME	None

[a]Names must start in column 1. All blocks may be called more than once if overlay is not used or if overlay is used one or more blocks may be repeated if overlay is set up for this. See Section 2, Initial Job Set-Up.

NOTE: All non-decimal numbers must be right-adjusted.

Table 3-2 (continued). EXECUTIVE BLOCK CARD DATA

Card group	Format	Card columns	Description	Variable name	Default value
			CNAME = RUNOFF for Runoff Block,		
			= TRANSPORT for Transport Block,		
			= RECEIVING for Receiving Water Block		
			= STORAGE for Storage Block,		
			= COMBINE for Combine Block,		
			= GRAPH for GRAPH subroutine,		
			= ENDPROGRAM for ending the storm water simulation.		
			INSERT THESE CARDS AFTER EACH CNAME = GRAPH IN CARD GROUP 3.		
4			Control card.		
	4I5	1-5	Tape/disk (logical unit) assignment where graph information is stored.	NTAPE	None
		6-10	Number of curves of a graph. (maximum = 5)[a]	NPCV	5
		11-15	Number of pollutants to be plotted.	NQP	0
		16-20	Number of inlets to be plotted. (If NPLOT = 0 plots all curves on file)	NPLOT	0
			IF NPLOT = 0 DELETE THIS CARD.		
5			Inlet selection card.		
	16I5	1-5	First inlet number to be plotted.	IPLOT(1)	None
		6-10	Second inlet number to be plotted.	IPLOT(2)	None
		.		.	
		.		.	
		.		.	
		.		.	
		.	Last inlet number to be plotted.	IPLOT(NPLOT)	None

[a] This refers to the number of different inlets (curves) that will be plotted on one graph; e.g. if NPCV = 3, hydrographs, say, from three inlets will be overlayed on one graph.

Table 3-2 (continued). EXECUTIVE BLOCK CARD DATA

Card group	Format	Card columns	Description	Variable name	Default value
6			Title card.		
	18A4	1-72	Title printed with the plots.	TITL	None
7			Horizontal axis label.		
	20A4	1-80	Horizontal axis label.	HRIZ	None
			REPEAT NQP + 1 TIMES.		
8			Vertical axis label.[a]		
	2A4	1-8	Line 1 of vertical axis label.	VERT(1)	None
		9-16	Line 2 of vertical axis label.	VERT(2)	None
	3A4	17-28	Line 3 of vemtical axis label.	VERT(3)	None

[a]The first plot to be printed is a flow hydrograph, the second is BOD, the third is SS, and the last is coliform.

Table 3-3. EXECUTIVE BLOCK VARIABLES[a]

Variable Name	C*	Description	Unit
A		The log base 10 of the range of values of y coordinate to be plotted (subroutine CURVE)	
ACRES		Number of acres of study drainage basin	acres
ADDWF		Average DWF	cfs
AXA		X-coordinate of value previously plotted	
AXB		X-coordinate of value to be plotted	
AYA		Y-coordinate of value previously plotted	
AYB		Y-coordinate of value to be plotted	
CURVE		Name of subroutine	
CNAME	C	Computational block name read from data cards	
DESFLO		Design flow rate (of main trunk)	cfs
DUMMY	C	Dummy location to fill data record	
FRANG		Expanded range (even intervals) of y coordinates of curve to be plotted	
GRAPH		Name of subroutine	
HORIZ	C	Horizontal label of curve	
I		The Block selection counter (MAIN)	
IC		Calling sequence control parameter	
ILAB		Output label with plot	

Variable Name	C*	Description	Unit
INCNT	C	Array of input logical data file number	
IOUTCT	C	Array of output logical data file number	
IPLOT	C	Array of nodes to be plotted	
ITAB	C	Array indicating which locations of the data file are to be plotted	
IX		Dummy variable	
IXA		Integer value of AXA	
IXB		Integer value of AXB	
IY		Dummy variable	
IYA		Integer value of AYA	
IYB		Integer value of AYB	
J		Subscript counter	
JJ		Subscript counter	
JIN		Array of input disk/tape units	
JOUT	C	Array of output disk/tape units	
K		Subscript counter	
L		Subscript counter	
LX		Transfer location from data file to plot storage	

[a]Does not include variables added during updating.
*Variable names shared in common blocks.

Table 3-3 (continued). EXECUTIVE BLOCK VARIABLES

Variable Name	C*	Description	Unit
M		Subscript counter	
MC		Do loop counter	
MM		Subscript counter	
N		Subscript counter	
NCT		Number of plots	
NCURVE		Number of curves to be plotted	
NCV		Number of curves/plot	
NDESYR		Frequency of design flow	yr
NLP		Number of types of plot (hydrographs and pollutographs)	
NLOC	C	Node number of hydrograph point	
NPCV		Maximum number of curves/plot	
NN		Subscript counter	
NPLOT		Number of plots	
NPOINT		Number of points on a plot	
NPT		Number of point/curve (array) (CURVE)	
NPT	C	Array containing number of points to be plotted (GRAPH)	
NPTM		Numerical value of NPT	
NQP		Number of quality constituents to be plotted	
NQUAL		Number of quality constituents on data file	
NR		Subscript counter	
NSCRAT	C	Array of variable scratch units	
NSERYS		Demonstration series number	
NSTEPS		Number of steps in plot	
NSTRMS		Number of storms being studied	
NSYM		Plot number	
NTAPE		Input tape number for plotting	
NVAL		Number of points/data record on a file	
N5		Card input unit number	
N6		Print output unit number	
PINE		Subroutine name	
PNAME		Name used to call the blocks of the Storm Water Model	
PPLOT		Subroutine name	
QTRUNK		Maximum flow rate possible in trunk sewer	cfs
RAIN		Amount of rainfall for a storm	
RANGE		Range of y values to be plotted	
RECEIV		Subroutine name	
RUNOFF		Subroutine name	
STORAG		Subroutine name	
STORM		Date of storm	

Table 3-3 (continued). EXECUTIVE BLOCK VARIABLES

Variable Name	C*	Description	Unit
TDELT		Time-step interval	
TIMES		Time-step interval	sec
TITL	C	Title printed out with graphs	
TITLE	C	Title printed out on curves	
TITLE1		Title of drainage basin	
TRANS		Subroutine name	
TZERO		Zero time	sec
VERT	C	Vertical label	
X		X coordinate array (CURVE)	
X	C	X coordinate array (GRAPH)	
XA		X increment used for interpolation	
XINT		Label interval for X	
XMAX		Maximum X value	
XMIN		Minimum X value	
XLAB	C	Numerical scale labels for X	
XO		Start point of line (X coordinate)	
XSCAL		X scale factor	
XT		End point of line (X coordinate)	
X1		Same as XO	
X2		Same as XT	
YINT		Label interval for Y	
Y		Y coordinates of curves to be drawn	
Y	C	Y coordinates of curves to be drawn	
YA		Y increment used for interpolation	

Variable Name	C*	Description	Unit
YLAB		Numerical scale labels for Y	
YMAX		Maximum Y value	
YMIN		Minimum Y value	
YO		Start point of line (Y coordinate)	
YSCAL		Y scale factor	
YT		End point of line (Y coordinate)	
YT	C	Hydrograph-pollutograph information on data file	
Y1		Same as YO	
Y2		Same as YT	

Example

A test area, North Lancaster, Pennsylvania, Drainage District, is used to show the data input and portions of the resulting output as required and accomplished by the Executive Block. Table 3-4 is an example of the data deck. The first two cards are the tape/disk (file) assignments for transferring information from one program block to another, and the scratch tape/disk assignments, respectively. On the first card the first two numbers, zero and eight, refer to the input and output files for the Runoff Block. Since an input file for this Block is not required, the first number is zero. The output file for Runoff is also the input file for Transport and therefore eight is the first number in the next group of two numbers denoting Transport Block's tape/disk assignments. Nine is the Transport output file. When no other blocks are to be called, the rest of the card is left blank or replaced with zeros. The numbers on the second card refer to the scratch files. A maximum of two may be required when using the Transport Block. (Note: All required tape/disk assignments must be properly defined with JCL cards.) This first group of data cards is used by the Executive Block for the logical unit assignment (tape/disk) and title information for the Storm Water Management Model. The succeeding groups of cards are preceded with a control card used by the Executive Block. This card transfers control to the appropriate program block. In this example, seven such cards exist, RUNOFF, TRANSPORT, GRAPH, STORAGE, GRAPH and ENDPROGRAM. The data following the first two control cards have been deleted for clarity. The GRAPH cards are followed by input data for the plotting of output found on tape/disk nine and eight. ENDPROGRAM needs no succeeding cards.

Table 3-4. DATA INPUT FOR NORTH LANCASTER PENNSYLVANIA DRAINAGE DISTRICT

DATA	CARD GROUP NO.
0 8 8 9 9 8 8 9	1
1 2 3 4 0	2
RUNOFF . . . . TRANSPORT . . . . GRAPH	3
9 1 3 0	4
OUTPUT FROM TRANSPORT BLOCK NORTH LANCASTER, PA. DRAINAGE DISTRICT	6
TIME IN HOURS	7
FLOW IN CFS BOD LBS/MIN SS LBS/MIN COLIFORM MPN/MIN	8
STORAGE . . . . GRAPH	3
8 1 3 0	4
OUTPUT FROM STORAGE/TREATMENT BLOCK NORTH LANCASTER, PA. DRAINAGE DISTRICT	6
TIME IN HOURS	7
FLOW IN CFS BOD LBS/MIN SS LBS/MIN COLIFORM MPN/MIN	8
RECEIVING . . . . ENDPROGRAM	3

SECTION 4

COMBINE BLOCK

BLOCK DESCRIPTION

In order to add the capability of modeling larger areas, the Combine Block has been added to the Storm Water Management Model. This block has two main objectives.

The first objective is to collate different data sets into one, e.g., three separate output data sets, two Transports and one Storage/Treatment, are to be inputted into the Receiving Water Block. The Combine Block would be used to collate the three output data sets into one which, in turn, would be input into the Receiving Water Block.

The second objective is to combine different data sets and nodes into a single data set and one node, e.g., using the Transport Block on two different drainage networks gives two separate output data sets. Both data sets go to the same treatment facility at the same inlet node. This program would be used to combine the two different Transport output data sets into one data set with a single node which then could be inputted into the Storage/Treatment Block.

The Combine Block can be used in a number of different ways and now gives the Storm Water Management Model the capability of simulating the largest and most diverse cities. For example, Figure 4-1 shows how the Combine Block was used on a combination of SWMM runs for Lancaster, Pennsylvania.

INSTRUCTIONS FOR DATA PREPARATION

Instructions on the use of the Combine Block are divided into two sections, Collate and Combine.

Collate

The first objective is to collate two or more different output data sets from Runoff, Transport, Storage/Treatment, or any combination thereof. This new data set could then be used as input into any block (Transport, Storage/Treatment or Receiving Water), except

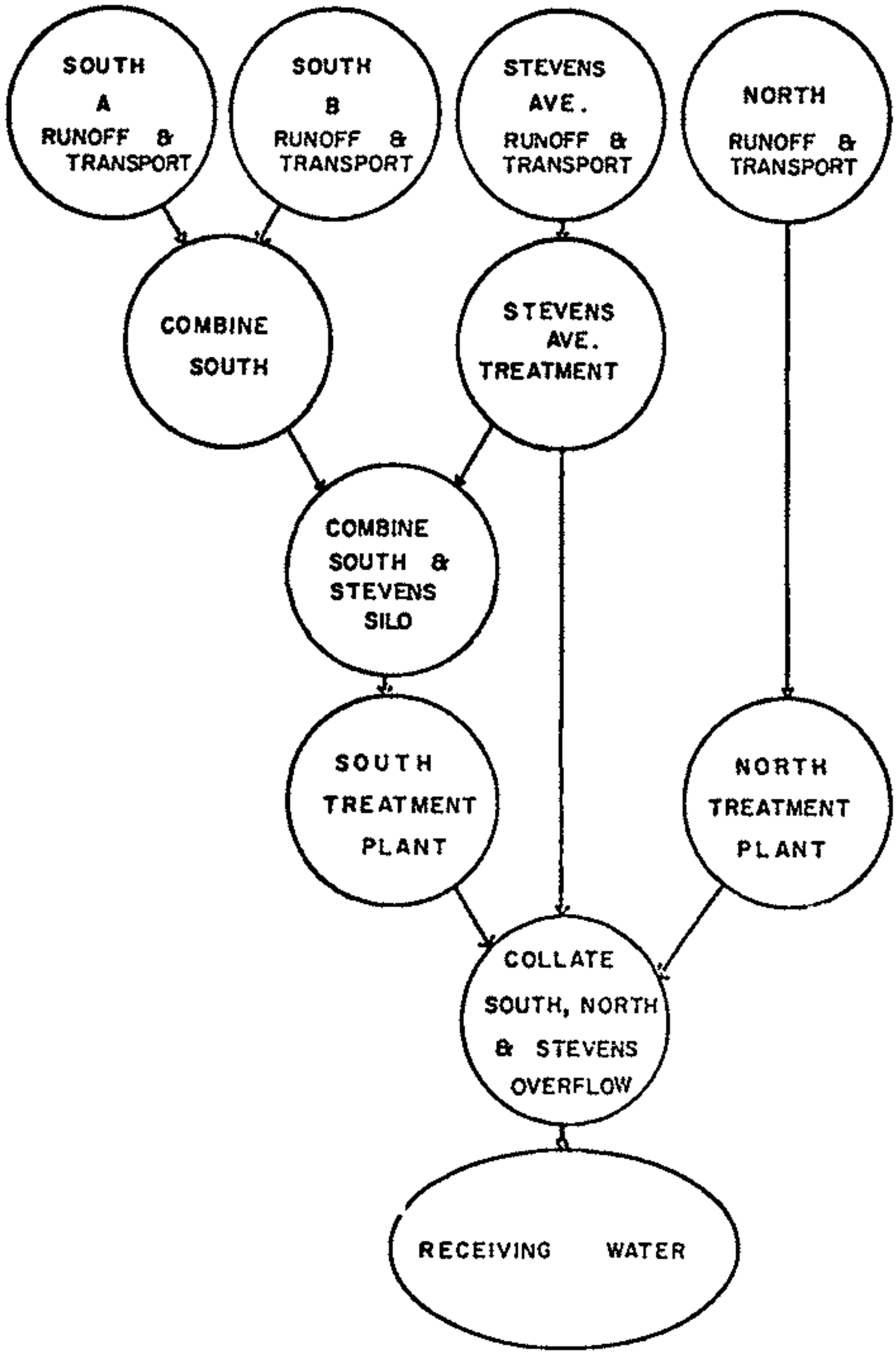

Figure 4-1. Combination of SWMM Runs for Overall Lancaster Simulation

Runoff. For example (Figure 4-2), an output data set from Transport area 'A' with manhole numbers 5, 6, 12 was collated with an output data set from Transport area 'B' with manhole numbers 1, 3, 6, 19. Manhole number 6 is common between both output data sets, therefore the hydrographs and pollutographs from both manholes are added together. The new output data sets produced from the Combine Block has manhole numbers 1, 3, 5, 6, 12, 19. This new data set could then be used as input to either the Transport, Storage/Treatment, or Receiving Water Blocks.

Combine

The Combine section combines different data sets and manholes into a single data set with one manhole. For example (Figure 4-3), an output data set from Transport area 'X' with manhole number 16 and an output data set from Transport area 'Y' with manhole number 23 are to be used as input into the Receiving Water Block junction[a] number 14. The Combine portion of the Combine Block would be used to combine the two output data sets into one data set with one manhole. This manhole number would correspond to the junction number of the Receiving Water Block. The Combine Block card data are shown in Table 4-1.

---

[a]Junction number and manhole number are synonymous.

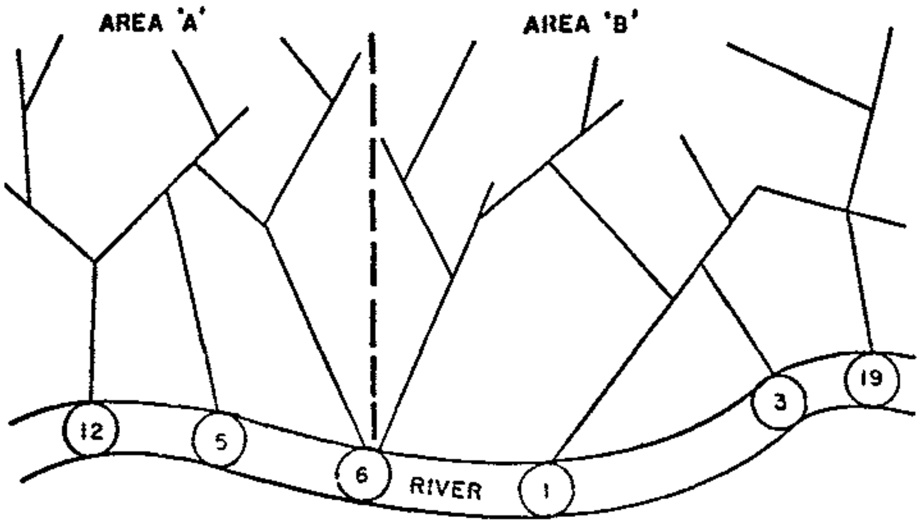

Figure 4-2. Hypothetical Drainage Network

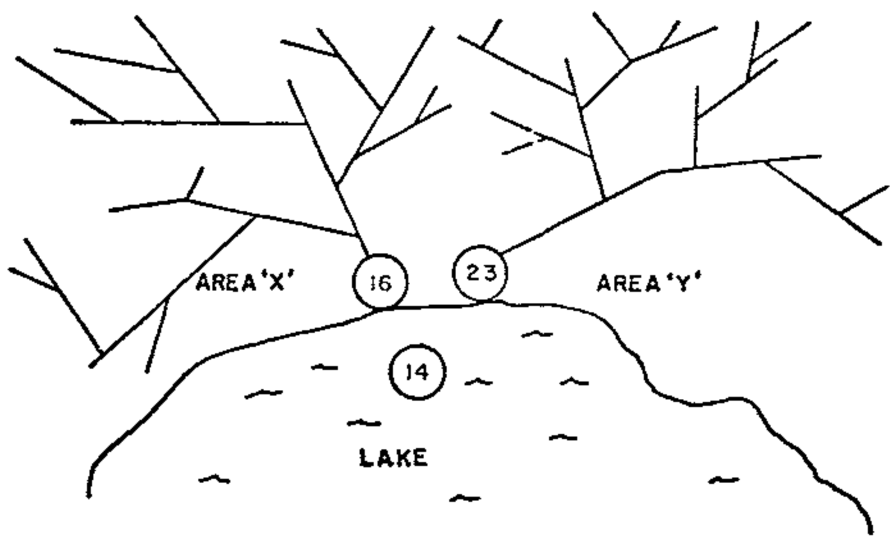

Figure 4-3. Hypothetical Drainage Network

Table 4-1. COMBINE BLOCK CARD DATA

Card group	Format	Card columns	Description	Variable name	Default value
1	I5	1-5	Program Control.[a]	ICOMB	1
			= 1, Collate only,		
			= 2, Collate and then combine,		
			= 3, Combine only,		
			= 4, Combine then collate.		
2			IF ICOMB = 1, INCLUDE CARDS 2, 3 AND 4 ONLY.		
			IF ICOMB = 2, INCLUDE CARDS IN THE FOLLOWING ORDER: 2, 3, 4, 5, 6, 7.		
			IF ICOMB = 3 OR 4, SKIP TO CARD 5 FIRST.		
	20A4	1-80	Title cards: two cards with heading to be printed on output.	TITLE	None
3	2I5	1-5	Output data set number.[b]	NDOUT	None
		6-10	Number of input data sets. (maximum = 16)	NIN	None
			Input data set numbers.[b]	NDATAS	
4	16I5	1-5	First input data set number.	NDATAS(1)	
		6-10	.	NDATAS(2)	
		.	.	.	
		76-80	N^{th} input data set number.	NDATAS(NIN)	
5			IF ICOMB = 1, SKIP CARDS 5, 6, AND 7 IF ICOMB = 3, INCLUDE CARDS 5, 6, AND 7 ONLY.		

[a] The collate portion of the Combine Block uses two scratch data-sets.
It is desirable to use the Graphing Routine in the Executive Block after the Combine Block has been run.

[b] See Section 2, Initial Job Set-up, for discussion of data sets and input/output files.

Table 4-1 (continued). COMBINE BLOCK CARD DATA

Card group	Format	Card columns	Description	Variable name	Default value
			IF ICOMB = 4, INCLUDE CARDS IN THE FOLLOWING ORDER: 5, 6, 7, 2, 3, 4.		
	20A4	1-80	Title cards: two cards with heading to be printed on output.	TITLE	None
6	3I5	1-5	Node number for output.	NODEOT	None
		6-10	Output data set number.[a]	NDOUT	None
		11-15	Number of input data sets. (maximum = 16)	NIN	None
7	16I5		Input data set numbers.[a]	NDATAS	
		1-5	First input data set number.	NDATAS(1)	
		6-10	.	NDATAS(2)	
		.	.	.	
		76-80	N^{th} input data set number.	NDATAS(NIN)	

[a]See Section 2, Initial Job Set-up, for discussion of data sets and input/output files.

SECTION 5

RUNOFF BLOCK

BLOCK DESCRIPTION

Introduction

The Runoff Block has been developed to simulate both the quantity and quality runoff phenomena of a drainage basin and the routing of flows and contaminants to the major sewer lines. It represents the basin by an aggregate of idealized subcatchments and gutters. The program accepts an arbitrary rainfall hyetograph and makes a step by step accounting of rainfall infiltration losses in pervious areas, surface detention, overland flow, gutter flow, and the contaminants washed into the inlet manholes leading to the calculation of a number of inlet hydrographs and pollutographs.

The drainage basin may be subdivided into a maximum of 200 subcatchment areas. These, in turn, may drain into a maximum of 200 gutters or pipes which finally connect to the inlet points for the Transport Model. However, the user must be cautioned that if the Transport Model is to be run also, the total number of sewer elements (conduit and non-conduit) must not exceed 160.[a] The maximum number of non-conduit elements (manholes) into which there can be input hydrographs and pollutographs[b] is 70 for the Transport Model. The maximum number of time steps that may be computed is 150 for both Runoff and Transport.

This section describes the program operation of the Runoff Block, provides instructions on data preparation and input data card formats, defines Runoff Block variables, shows sample runs, and presents the results of a calibration of the Runoff Block.

Program Operation

The relationships among the subroutines which make up the Runoff Block are shown in Figure 5-1. The subroutine RUNOFF is called by the Executive Block to gain entrance to the Runoff Block. The

[a]This is the total for the Transport Model only. Up to 200 additional gutter/pipes may be contained in Runoff.

[b]These correspond to inlets in the Runoff Model.

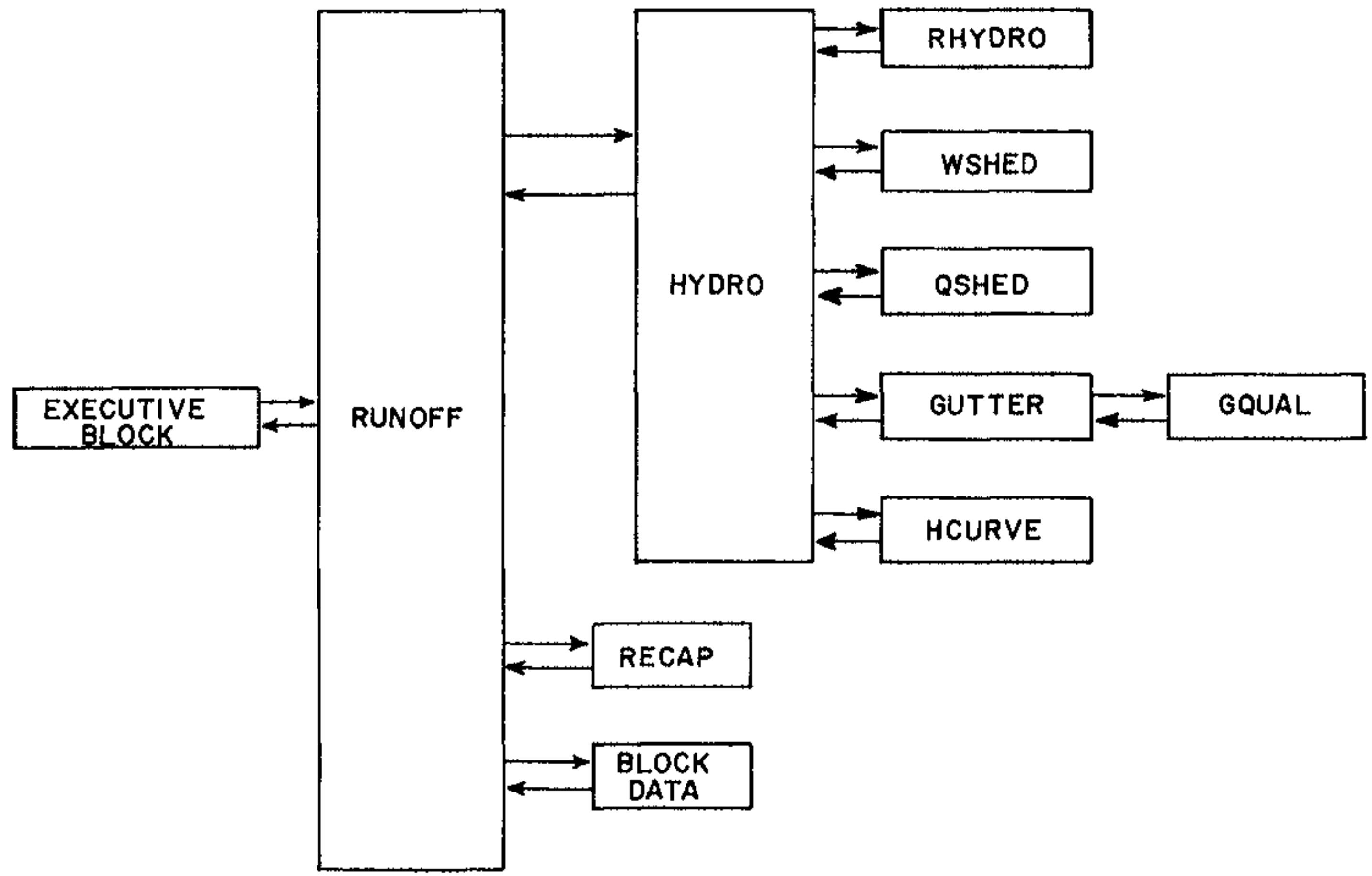

Figure 5-1. Runoff Block

program prints "ENTRY MADE TO RUNOFF MODEL" and then acts as the driver routine for the block. Subroutine Runoff directly calls subroutines HYDRO and RECAP. Although BLOCK DATA is not actually a subroutine, it is automatically activated by RUNOFF. Its main function is to set the initial pollution loadings such as pounds of pollutant per day per 100 feet of curb, and milligrams of pollutant per gram of dust and dirt. Subroutine RECAP reads tape headers, and prints the table headings and results of the quantity and quality simulations.

Subroutine HYDRO computes the hydrograph coordinates and the watershed quality contributions with the assistance of four core subroutines, i.e., RHYDRO, WSHED, QSHED, and GUTTER. It initializes all the variables to zero before calling RHYDRO to read in the rainfall hyetograph and information concerning the inlet drainage basin. Next HYDRO sets up an ordering array to sequence the computational order for gutters/pipes according to the upstream and downstream relationships. If quality is to be simulated, QSHED is called to initialize the watershed pollution loads.

HYDRO then sets up a DO loop to compute the hydrograph coordinate for each incremental time step. In each step, subroutine WSHED is first called to calculate the rate of water flowing out of the idealized subcatchments. If quality is to be simulated, QSHED is called to compute the watershed quality contributions from catchbasins, erosion, dust and dirt, and other sources. GUTTER is then called to compute the instantaneous water depth and flow rate for the gutters/pipes and to route the flow. Water flowing into the inlet point, be it from gutters/pipes or direct drainage from subcatchments, is added up for a hydrograph coordinate. A continuity check is then made for the deposition of rainfall water in the form of runoff, detention, and infiltration loss. The error in continuity is computed and printed as a percentage of rainfall. With the assistance of subroutine HCURVE, HYDRO plots the rainfall hyetograph and the runoff hydrograph for the drainage basin. Subroutine GQUAL routes quality in each gutter/pipe for the flow values computed in subroutine GUTTER.

Surface Flows

The core of the Runoff Model is the routing of hydrographs through the system. This is accomplished by a combination of overland flow and pipe routing.

Three types of elements are available to the user:

1) Subcatchment elements (overland flow)

2) Gutter elements (channel flow)

3) Pipe elements (special case of channel flow).

Flow from subcatchment elements is always into gutter/pipe elements, or inlet manholes. The subcatchment elements receive rainfall, account for infiltration loss using Horton's equation, and permit surface storage such as ponding or retention on grass or shrubbery. If gutter/pipe elements are used, these route the hydrographs from the watershed elements to the entry to the main sewer system. Pipes are permitted to surcharge when full.

Surface Quality

The quality of the inlet flows is determined as explained under Program Operation (subroutine QSHED). The quantity of pollutants washed off the land surface of the drainage basin is added to gutter/pipes or inlet manholes. Initially the program calculates the amount of contaminants allowed to accumulate on the ground prior to the storm, and then, taking into account rainfall intensity, major land use, and land slope, the washed off pollutants are routed through any gutter/pipes to generate pollutographs at inlet manholes.

Output from the program consists of hydrographs and pollutographs on tape/disk for use in the Transport Block and printed and/or plotted information for the user.

INSTRUCTIONS FOR DATA PREPARATION

Instructions on the use of the Runoff Block are divided into two sections, surface flows and surface quality.

Surface Flows

Use of the surface flows portion of the Runoff Block requires three basic steps:

Step 1 - Geometric representation of the drainage basin

Step 2 - Estimate of coefficients

Step 3 - Preparation of data cards for the computer program.

Step 1. Method of Discretization --

Discretization is a procedure for the mathematical abstraction of the physical drainage system. For the computation of hydrographs, the drainage basin may be conceptually represented by a network of hydraulic elements, i.e., subcatchments, gutters, and pipes. Hydraulic properties of each element are then characterized by various parameters, such as size, slope, and roughness coefficient.

Discretization begins with the identification of drainage boundaries, the location of major sewer inlets, and the selection of those gutters/pipes to be included in the system. This is best shown by an example. Figures 5-2 and 5-3 indicate possible discretizations of the Northwood section of Baltimore, Maryland. In Figure 5-2, a "fine" approach was used resulting in 12 subcatchments and 13 pipes leading to the inlet. In Figure 5-3, a "coarse" discretization was used resulting in 5 subcatchment areas and no pipes or gutters. In both cases, the outfall to the creek represents the downstream point in the Runoff Model. This could lead, in a larger system, to inlets in the Transport Model. The criteria for breaking between major sewer lines (Transport Model) and the Runoff Model are determined by three factors:

1) If backwater effects are significant, the Transport Model must be used.

2) If hydraulic elements other than pipes and gutters, such as pumps, are used, the Transport Model is required.

3) If solids deposition or suspension is important (e.g., to simulate a first flush phenomenon), the Transport Model should be used.

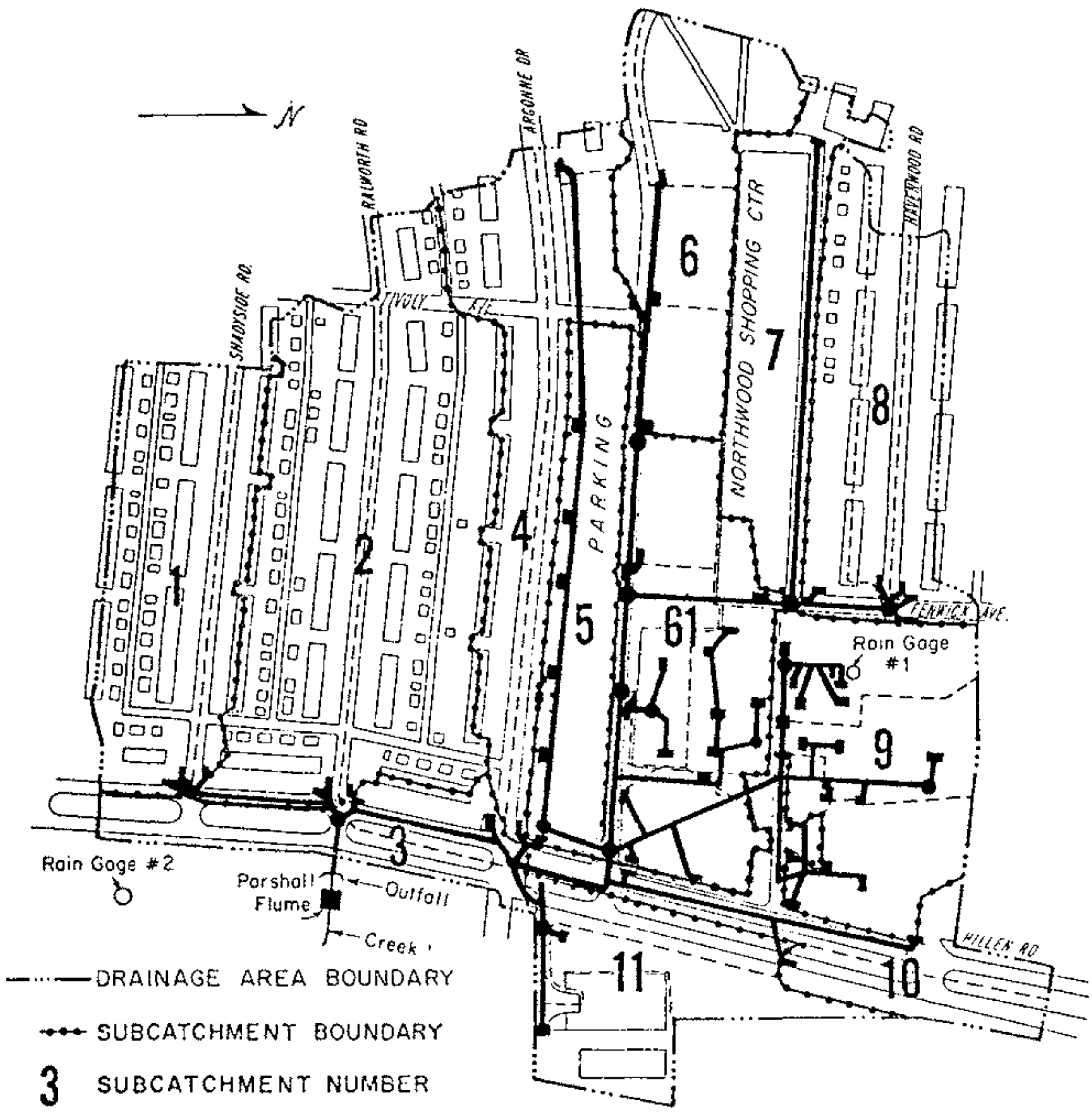

Figure 5-2. Northwood (Baltimore) Drainage Basin "Fine" Plan
(9)

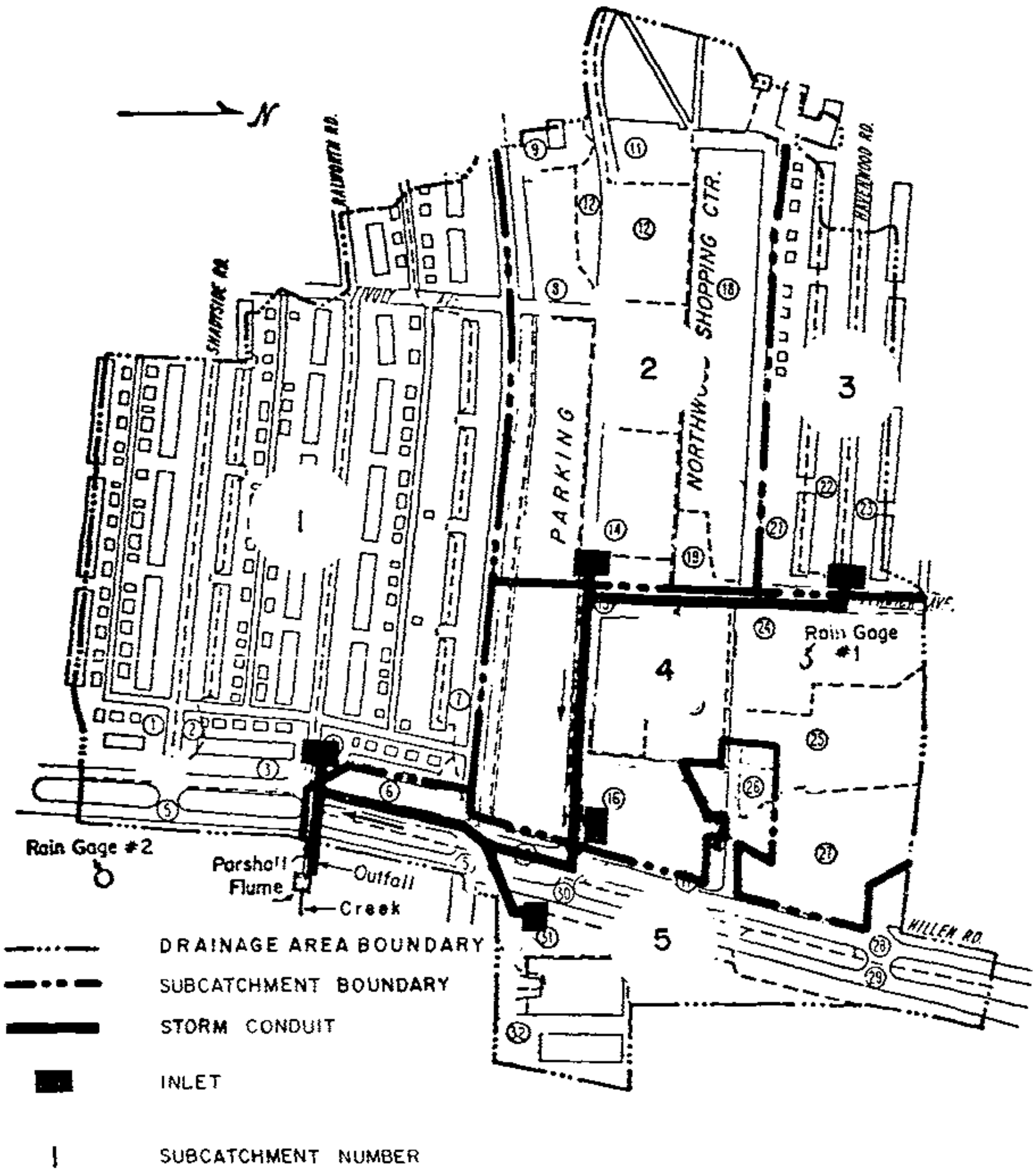

Figure 5-3. Northwood (Baltimore) Drainage Basin "Coarse" Plan (9)

Subcatchments represent idealized runoff areas with uniform slope. Parameters such as roughness values, detention depths and infiltration values are taken as constant for the area and usually represent averages, although pervious and impervious areas have different characteristics within the model. If roofs drain onto pervious areas, such as lawns, they are usually considered part of the pervious area, although conceivably, they could be treated as miniature subcatchments themselves.

While the subdivision described can be taken to infinitesimal detail in theory, computation time and manpower requirements become prohibitive in practice. No ready rule for the subdivision can be offered, but a minimum of five subcatchments per drainage basin is recommended. This permits flow routing (time offset) between hydrographs.

Step 2. Estimate of Coefficients --

Coefficients and parameters necessary to characterize the hydraulic properties of a subcatchment include surface area, approximate total width of overland flow, ground slope, roughness coefficients, detention depths, infiltration rates (maximum, minimum, and decay rate), and percent imperviousness. For a given amount of rainfall over the subcatchment, these parameters ultimately determine the outflow rate of surface runoff and the transient water depth over the subcatchment. Since real subcatchments are not rectangular areas experiencing uniform overland flow, average values must be selected for computation purposes.

For the roughness coefficient, the values given in Table 5-1, as suggested by Crawford and Linsley (3), may be used. Detention depths (retention storage) are taken by the program as 0.062 inch for impervious areas and 0.184 inch for pervious areas, unless otherwise specified by the user. Infiltration rates can be estimated from "standard infiltration capacity curves" as shown in Figure 5-4, which was produced by the American Society of Civil Engineers (ASCE). The program calculates the amount of infiltration loss using Horton's equation (subroutine WSHED):

$$\text{Infiltration loss } I_t = f_o + (f_i - f_o)e^{-\alpha t} \qquad (5\text{-}1)$$

where f_o = minimum infiltration rate (WLMIN), inches/hour

Table 5-1. ESTIMATE OF MANNING'S ROUGHNESS COEFFICIENTS (3)

Ground Cover	Manning's n for Overland Flow
Smooth asphalt	0.012
Asphalt or concrete paving	0.014
Packed clay	0.03
Light turf	0.20
Dense turf	0.35
Dense shrubbery and forest litter	0.4

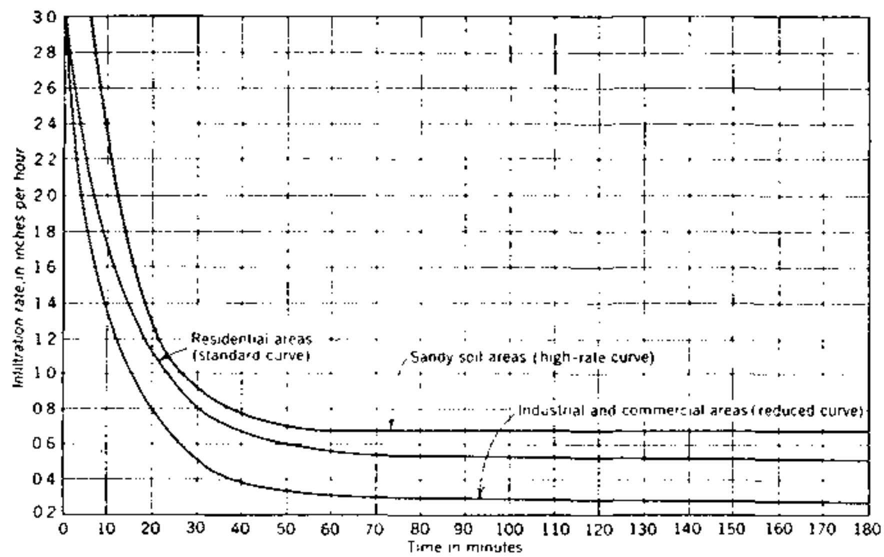

Figure 5-4. Standard Infiltration-Capacity Curves for Pervious Surface (2)

f_i = maximum infiltration rate (WLMAX), inches/hour

α = decay rate of infiltration (DECAY), 1/second

t = time from the start of rainfall, seconds

The user specifies WLMAX, WLMIN, and DECAY; otherwise, the program defaults to 3.00 inches/hour, 0.52 inch/hour, and 0.00115 second^{-1}, respectively. The loss is compared with the amount of water existing on the subcatchment plus the rainfall. If the loss is larger, it is set equal to the amount available and the remainder of the computation is skipped. Resistance factors for the pervious and impervious parts of a subcatchment are specified separately with default values of 0.250 and 0.013 (Manning's n for overland flow) being taken in the absence of other information.

The water depth over the subcatchment will thus increase without inducing an outflow until it reaches the specified detention requirement. If and when the resulting water depth of the subcatchment, D_r, is larger than the specified detention requirement, D_d, an outflow rate is computed using Manning's equation:

$$V = \frac{1.49}{n}(D_r - D_d)^{2/3}s^{1/2} \tag{5-2}$$

and

$$Q_w = VW(D_r - D_d) \tag{5-3}$$

where V = velocity

n = Manning's coefficient

s = ground slope

W = width of overland flow

Q_w = outflow rate

The parameter W, width of overland flow, must be supplied by the user for each subcatchment. This value is read in by subroutine RHYDRO along with other physical descriptors of the subcatchment. In RHYDRO, the width is lumped with all of the constants in Manning's equation into a single watershed constant. This constant multiplies the water depth (used as the hydraulic radius) in the subcatchment per time interval in subroutine WSHED. The change in depth due to outflow rate is determined by the continuity equation.

The definition of what constitutes the width of overland flow in a subcatchment is best visualized by the use of several examples. In Figure 5-5, an idealized rectangular subcatchment experiencing uniform overland flow is shown. The total width of overland flow is twice the length of the drainage gutter, since <u>two</u> plane catchments contribute flow along a distance L. Overland flow is perpendicular to gutter flow. In Figure 5-6, irregular-shaped subcatchments are shown, but the same principle applies. These approximations are accurate enough, since the continuity equation adjusts the water depth and outflow rate during each time interval.

<u>Step 3. Data Card Preparation</u> --

The data cards should be prepared according to Figure 5-8 and Tables 5-7 and 5-8 found at the end of this subsection. Figure 5-8 shows the layout of the data cards, including those for the quality routines, in the order in which they must appear. Tables 5-7 and 5-8, respectively, show how the data cards are to be punched and list the description of variables used in this program block.

The first step in the data preparation is the determination of the number of time steps to be used and the length of each time step (see Table 5-7, card group 2). The time step length (integration period) is usually 3 or 5 minutes, but may range from 1 to 30 minutes, depending on the length and intensity of the storm and the degree of accuracy required. The number of time steps is limited to a maximum of 150. Enough time steps should be allowed to extend the simulation past the storm termination and thus account adequately for the storm runoff. Along with the input of time steps, the number of hyetographs for the drainage basin is required. If the percent impervious area with zero detention is known, this value must be supplied; otherwise, the Model uses a

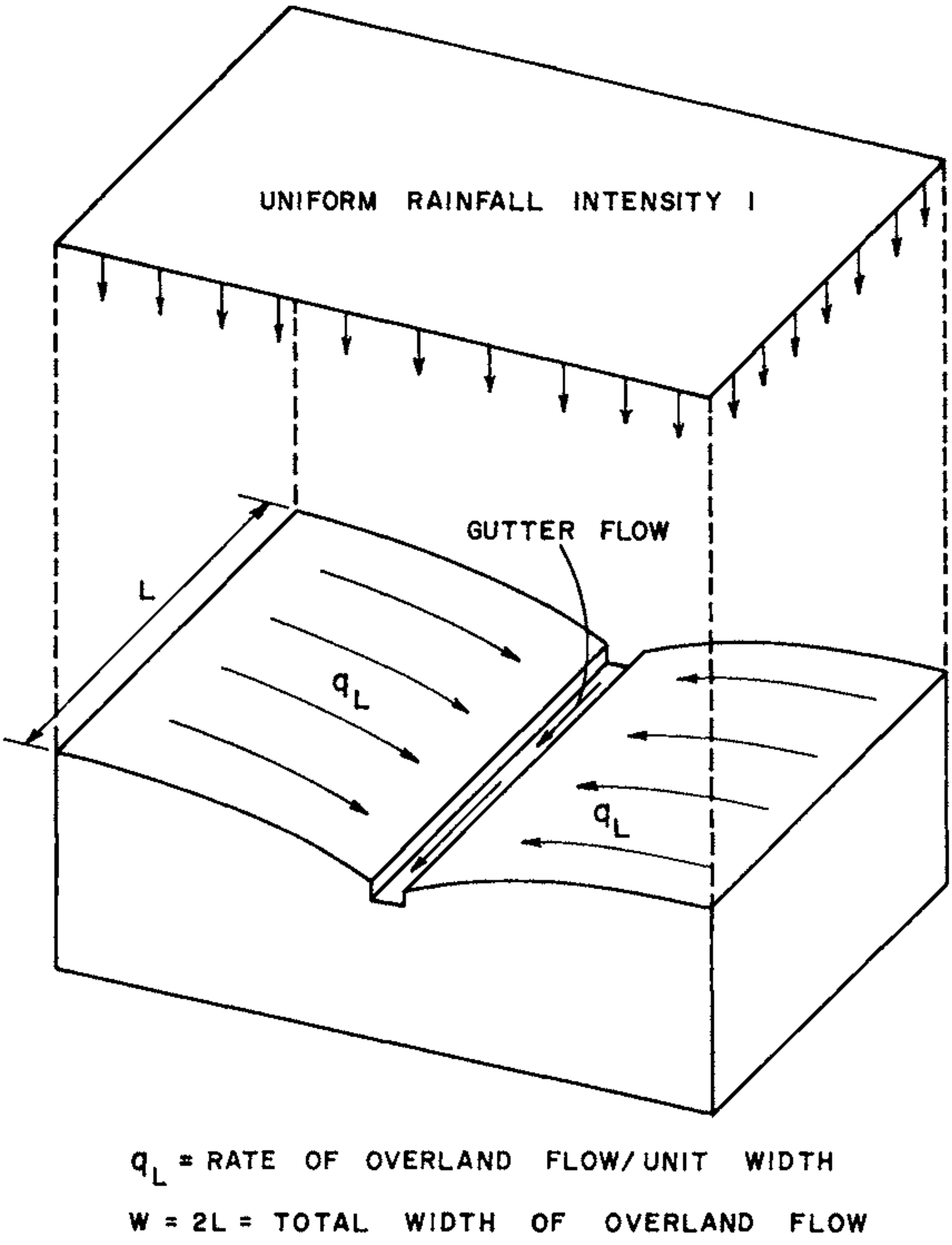

Figure 5-5. Idealized Subcatchment-Gutter Arrangement

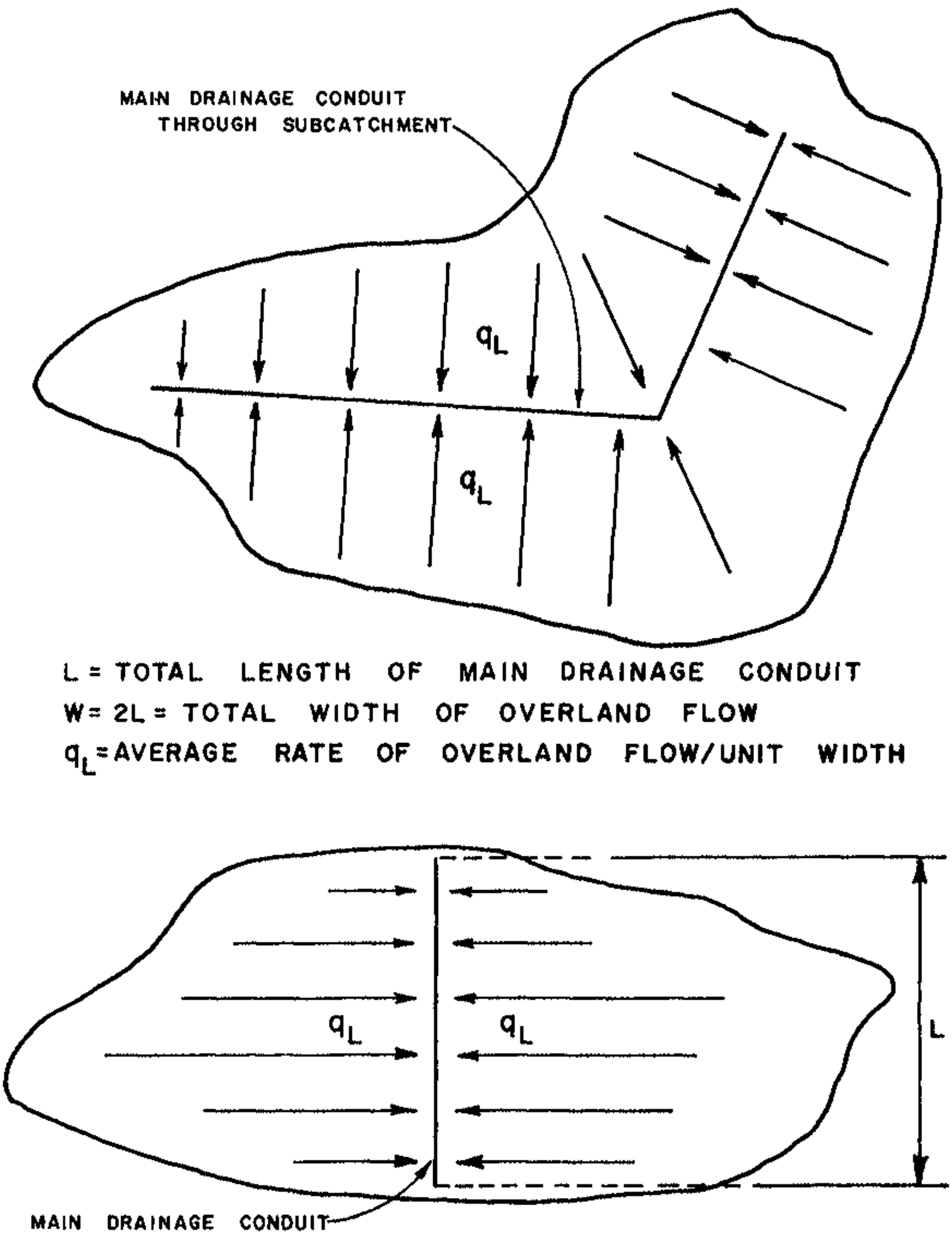

Figure 5-6. Irregular-Shaped Subcatchment-Drainage Conduit Arrangement

default value of 25 percent. This insures an immediate runoff response and a steep rising limb on the inlet hydrograph for the basin. If erosion is to be included in the quality simulation, it must be so stated in card group 2, and the highest average 30-minute rainfall intensity in inches per hour provided. It is convenient to do so because erosion is a function of a rainfall factor which is in turn a function of time interval, intensity, total depth per interval, and the 30-minute rainfall intensity.

The rainfall data cards are then prepared for each hyetograph from rainfall records or are assumed if a hypothetical test case is being run. The time interval need not be the same as the integration period in the quantity and quality portions of the Runoff Block. If 5-minute interval rainfall data are available, they would be preferred over 15-minute interval data because a more accurate runoff hydrograph would be produced. Up to one different hyetograph for each subcatchment may be provided by the user. However, the number of data points and the time interval between values for each hyetograph must remain constant, as specified by the rainfall control card.

For larger catchments, runoff and consequent model predictions are very sensitive to spatial variations of the rainfall. For instance, summer thunderstorms may be very localized, and nearby gages may have very dissimilar readings. For modeling accuracy, it is thus essential that rain gages be located within the catchment. Averages of gages surrounding the catchment will produce much less satisfactory results unless the storm is uniform spatially.

The major preparation is forming the tree structure sewer system and dividing the drainage basin into subcatchments. The sewer network is obtained from sewer maps. Pipes smaller than 2 to 3 feet with no backwater effects, flow dividers, or lift stations are usually designated as gutters/pipes for computation by the Rnnoff Block. These pipes are not connected to one another by manholes but join directly and lead to an inlet manhole for further routing by TRANSPORT. The elements (gutters, larger pipes, manholes) may be numbered by any scheme, for example:

- 001-100 : Existing manholes (known invert elevations)
- 200's: Pipe elements leaving an imaginary manhole; for example, 246 carries flow out of imaginary manhole 546 (where two large pipes come together and no manhole is indicated)

300's: Large pipe elements carrying flow out of existing manholes (350 leaves MH 50)

400's: Gutters/pipes carrying runoff into system (460 flows into MH 60)

500's: Imaginary manholes.

Once the sewer system is labeled with numbers less than 1000, the subcatchment areas are formed reflecting the existing sewer network, ground cover, and land slope. The gutter/pipe cards are then punched giving the required information. Next, data cards are made up for each numbered subcatchment, defined by its width, area, slope, percent imperviousness, etc., along with the gutter/pipe or inlet manhole into which the flows are routed. Care must be exercised by the user to specify the hyetograph number (based on the order in which they are read in) which applies to each subcatchment if this number is other than one (default value). The manhole number specified for drainage in card group 7, for each subcatchment, automatically designates the inlet manholes to which inlet hydrographs and pollutographs are routed for further simulation by the Transport Block.

Surface Quality

Data input to this surface quality program are prepared at the same time as the rest of the Runoff Block. Thus, when an inlet drainage basin is selected it may be subdivided into areas containing a single type of land use. Five land uses which may be modeled are: single family residential, multi-family residential, commercial, industrial, and undeveloped or parklands.

The start time, number of time steps, and length of integration period for the quality portion of the Runoff Block are identical to those in the quantity portion, where they are specified only once for the entire Runoff Block. The number of dry days prior to the storm event being modeled must be specified. This number may be obtained from rainfall records and includes all days, prior to the storm events, in which cumulative rainfall is less than 1 inch. The street cleaning frequency is determined by specifying the number of days between cleanings. The number of passes per cleaning made by the street sweeper is also specified. The accumulation of dust and dirt on city streets is a function of the street cleaning frequency. If the interval between storms is long and the cleaning frequency is low, a shock loading of suspended and settleable solids is imposed on the sewer system. These solids also generate an organic demand (BOD, COD). Pollutant loading rates in the SWMM are based on the studies made by APWA in Chicago (1). Industrial areas tended to provide maximum street litter. Commercial areas tended to generate a somewhat lesser quantity of dust and dirt than industrial areas, but higher than residential areas. The residential areas tended to show increasing amounts of dust and dirt as the population density increased, reflecting the increased usage made of the streets by pedestrians and vehicles.

From estimates of factors such as average daily traffic and average daily litter production, APWA developed dust and dirt accumulation factors for each type of land use, as listed in Table 5-2. The program generates the initial mass of dust and dirt (DD) as a function of total curb length, dry days, and the APWA factors for pounds of DD per day per 100 feet of curb (parameter DDFACT). The mass of each pollutant (including the organic demand parameters BOD and COD) is in turn generated as a fraction of the DD present. These factors (QFACT) are expressed as milligram of pollutant per gram of DD (or MPN/g for coliforms). In addition to BOD, COD, and coliforms, the Runoff Block quality portion simulates suspended solids (SS), erosion and its sediment contribution, settleable solids, nitrogen, phosphate (PO_4), and grease. The pollutant loading factors used are listed in Table 5-3, except for erosion. The calculations for erosion and its SS contribution are handled separately and are discussed later in this section. The catchbasin storage volume in card group 9 refers to the volume of water stored or trapped in the catchbasin prior to the storm event. The concentration of BOD (mg/l) of the stored water in each catchbasin should be verified by the SWMM user; otherwise, a value of 100 is recommended. If an initial concentration of 100 mg/l is chosen, the program automatically assigns a value of 300 mg/l for catchbasin COD (DATA CBFACT statement in BLOCK DATA). An average ratio of COD:BOD of 3.0 has been found in catchbasins from Chicago field tests (1).

Although not routinely required as card input data, all of the above loading and pollutant generation factors may be easily changed by altering appropriate DATA statements in subroutine BLOCK DATA. This is encouraged if the user has better values based upon local data.

Two different methods are included for suspended solids generation. If ISS = 0 (Card 9, Table 5-7), the exponential washoff described in Volume I (4) will be used. If ISS = 1, a special method included in the original SWMM Release 1 (see statement SFQU215 of

SFQUAL in Volume IV (4)) will be used. The latter method (ISS = 1) is based on calibrations in San Francisco and will produce concentrations early in the storm that are one or two orders of magnitude higher than the former method (ISS = 0). Later in the storm, the former method (ISS = 0) will still produce some suspended solids while the latter is likely to have already removed the entire surface load. No clear recommendation can be given to either method due to the lack of surface quality data measured at a catchbasin or other inlet point.

Urban Erosion

An erosion modeling capability has been added to the SWMM by application of the Universal Soil Loss Equation. The user specifies IROS = 1 in card group 2 (see Table 5-7) and the highest average 30-minute rainfall intensity (RAINIT), inches per hour. This latter value may be obtained from the input hyetograph.

The Universal Soil Loss Equation was derived from statistical analyses of soil loss and associated data obtained in 40 years of research by the Agricultural Research Service (ARS) and assembled

Table 5-2. DUST AND DIRT ACCUMULATION[a]

Type	Land use	Pounds DD/dry day/100 ft-curb
1.	Single family residential	0.7
2.	Multi-family residential	2.3
3.	Commercial	3.3
4.	Industrial	4.6
5.	Undeveloped or park	1.5

[a]Based on 1969 APWA report for Chicago (1).

Table 5-3. MG POLLUTANT PER GRAM OF DUST AND DIRT[a] FOR EACH LAND USE TYPE

Parameter	Land Use Type (Table 5-2) 1	2	3	4	5[b]
SS	1000.0	1000.0	1000.0	1000.0	1000.0
BOD	5.0	3.6	7.7	3.0	5.0
COD	40.0	40.0	39.0	40.0	20.0
Coliforms[c]	1.3×10^6	2.7×10^6	1.7×10^6	1.0×10^6	0.0
Settleable solids	100.0	100.0	100.0	100.0	100.0
N	0.48	0.61	0.41	0.43	0.05
PO_4	0.05	0.05	0.07	0.03	0.01
Grease[d]	1.00	1.00	1.00	1.00	1.00

[a] Most values are based on 1969 APWA report (1).

[b] Values for undeveloped and park lands are assumed.

[c] Units for coliforms are MPN/gram.

[d] All values are assumed.

at the ARS runoff and soil loss data center at Purdue University. The data include more than 250,000 runoff events at 48 research stations in 26 states, representing about 10,000 plot-years of erosion studies under natural rain. It was developed by Wischmeier and Smith (12) as an estimate of the average annual soil erosion from rainstorms for a given upland area, expressed as the average annual soil loss per unit area, A (tons per acre):

$$A = (R)(K)(LS)(C)(P) \tag{5-4}$$

where R = the rainfall factor

K = the soil erodibility factor

LS = the slope length gradient ratio

C = the cropping management factor or cover index factor

P = the erosion control practice factor

This equation represents the most comprehensive attempt at relating the major factors in soil erosion. It is used in the SWMM to predict the average soil loss for a given storm or time period. It is recognized that the Universal Soil Loss Equation was not developed for making predictions based on specific rainfall events. There are many random variables which tend to cancel out when computing annual time averages which would not cancel out when predicting individual storm yields: for example, the initial soil-moisture condition, or antecedent moisture condition (AMC), is a parameter which cannot be determined directly and used reliably. It should be understood by the SWMM user that Equation 5-4 enables land management planners to estimate gross erosion rates for a wide range of rainfall, soil, slope, crop, and management conditions.

The user supplies:

1) The area of each subcatchment subject to erosion

2) The flow distance in feet from the point of origin of overland flow over the erodible area to the point at which runoff enters the gutter or manhole

3) the soil factor K

4) The cropping management factor C

5) The control practice factor, P.

The program obtains the ground slope from the information supplied on each subcatchment in card group 7. Note, however, that the subcatchment numbers in card group 10 must be read in the same order as the subcatchment numbers in card group 7.

The rainfall factor, R, is equal to the sum of the rainfall erosion indexes for all storms during the period of prediction, $\sum EI$. For a single storm, R would simply equal EI for that storm. If we sum over all the time intervals, then the total storm's rainfall energy is given by:

$$R = EI = \sum_i [(9.16 + 3.31 \log X_i) D_i] I \qquad (5\text{-}5)$$

where E = storm's rainfall energy (hundreds of foot-tons/acre)

$= \sum_i Y_i D_i = \sum_i (9.16 + 3.31 \log X_i) D_i$

i = rainfall hyetograph time intervals

Y_i = kinetic energy in hundreds of foot-tons/acre-inch

X_i = rainfall intensity during time interval i, inches/hour

D_i = inches of rainfall during time interval i

I = maximum average 30-minute intensity of rainfall

It is important to note that the R factor does not account for soil losses due to snowmelt and wind erosion.

The soil factor, K, is a measure of the potential erodibility of a soil and has units of tons per unit of erosion index, EI. The soil erodibility nomograph shown in Figure 5-7 (10) is used to find the value of the soil factor once five soil parameters have been estimated. These parameters are: percent silt plus

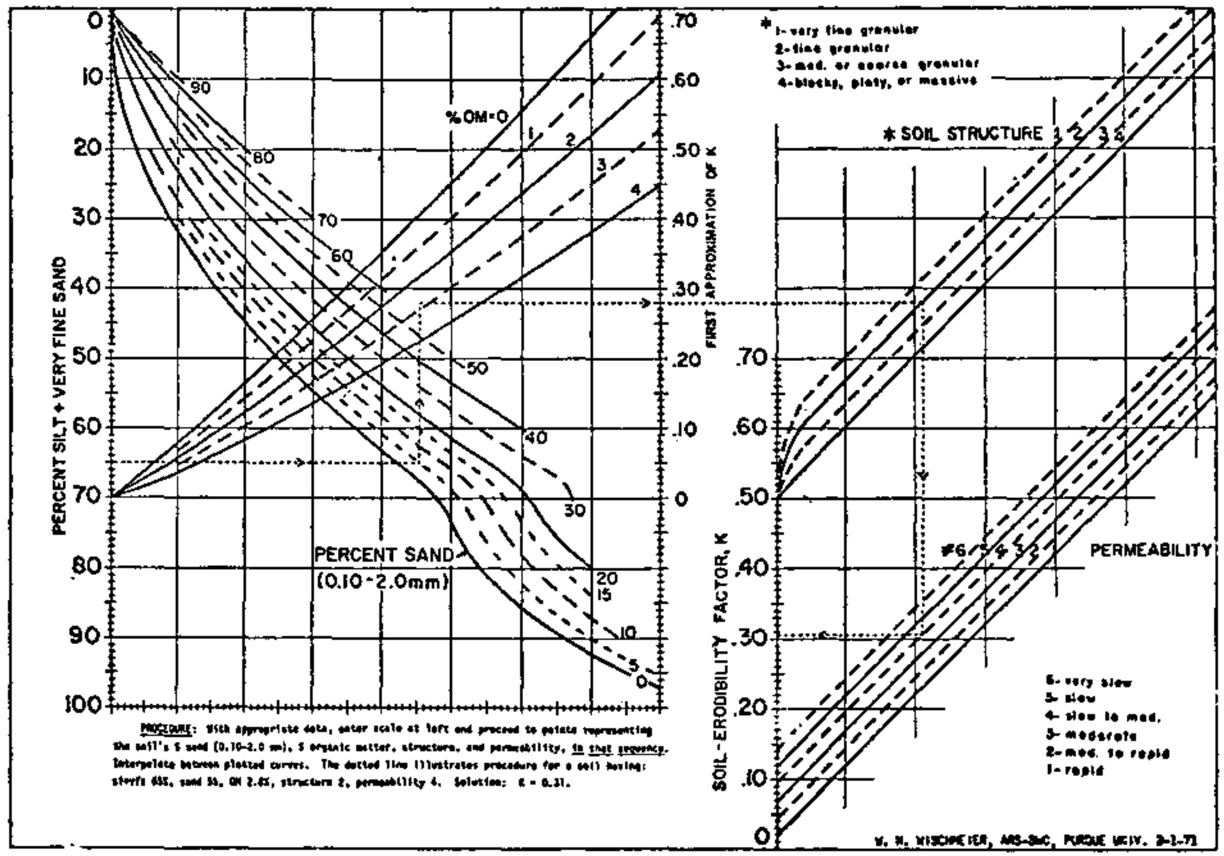

Figure 5-7. Soil Erodibility Nomograph (10)

very fine sand (0.05-0.10 mm), percent sand greater than 0.10 mm, organic matter content, structure, and permeability. To use the nomograph, enter on the left vertical scale with the appropriate percent silt plus very fine sand. Proceed horizontally to the correct percent sand curve, then move vertically to the correct organic matter curve. Moving horizontally to the right from this point, the first approximation of K is given on the vertical scale. For soils of fine granular structure and moderate permeability, this first approximation value corresponds to the final K value and the procedure is terminated. If the soil structure and permeability is different than this, it is necessary to continue the horizontal path to interact the correct structure curve, proceed vertically downward to the correct permeability curve, and move left to the soil erodibility scale to find K. This procedure is illustrated by the dotted line on the nomograph. For a more complete discussion on this topic, see Wischmeier, Johnson and Cross (10).

Table 5-4 (6) lists soil factor values for soil types found in Maryland. The user should request assistance from local Soil Conservation Service or Agricultural Research Service experts to obtain similar information.

The slope length-gradient ratio is a function of runoff length and slope and is given by:

$$LS = L^{1/2}(0.0076 + 0.0053S + 0.00076S^2) \qquad (5\text{-}6)$$

where L = the length in feet from the point of origin of overland flow to the point where the slope decreases to the extent that deposition begins or to the point at which runoff enters a defined channel

S = the average percent slope over the given runoff length.

In using the average percent slope in calculating the LS factor, the predicted erosion will be different from the actual erosion when the slope is not uniform. Meyer and Kramer (7) show that when the actual slope is convex, the average slope prediction will underestimate the total erosion whereas for a concave slope, the

Table 5-4. SOIL ERODIBILITY INDEX K VALUES FOR MARYLAND SOIL SERIES (6)

Soil series	Horizon	Texture range	K Value
Adelphia	A	Sl,fsl,l	0.32
	B	L,scl,fsl	0.40
	C	Sl,ls	0.20
Athol	A	Sil	0.37
		Gsil,gl	0.32
	B	Sicl,cl	0.30
		G,cl	0.30
	C	Sicl,cl	0.30
		Gsl,gl	0.30
Aura	A	Sl,l	0.43
		Gl,gsl	0.30
		Ls	0.20
	B	Scl	0.40
		Gscl,gsl	0.30
	C	Scl,sl	0.40
		Gsl,gcl	0.30
		Ls	0.20
Bertie	A	Sil,l	0.37
	B	Sil,sicl,l	0.40
	C	Stratified	0.30
		Sl,l,ls	
		Gsl	0.20
Berks	A	Shsil,chsil	0.24
	B	Sh to vshsil	0.20
	C	Vshsil	0.20
		Shattered shale	0.20
Bermudian	A	Sil,l	0.43
		Fsl	0.40
	B	Stratified silt	0.50
		S	0.30
		G	0.20
Bibb	A	Sl to sicl	0.32
	B	Highly variable	0.20

Table 5-4 (continued). SOIL ERODIBILITY INDEX K VALUES FOR MARYLAND SOIL SERIES

Soil series	Horizon	Texture range	K Value
Birdsboro	A	Sil,l	0.28
	B	Sicl,cl	0.30
	C	Sl,s,g	0.20
		Sicl,l	0.30
Bucks	A	Sil	0.32
	B	Sicl,sil	0.40
	C	Shsil,vshsil	0.20
Chalfont	A	Sil,vstl	0.43
	B	Sil,sicl	0.60
	C	Shsil,shl	0.60
Chillum	A	Sil,sicl	0.32
		Gl	0.30
	B	Gscl,gl	0.30
		Gsl	0.20
Colemantown	A	L,sl	0.43
	B	Sc,scl	0.40
	C	Sl,cl,scl	0.40
Collington	A	Sl,fsl,l	0.28
		Ls	0.20
	B	Scl,cl,sl,l	0.40
	C	Sl,ls	0.20
Colts Neck	A	Sl	0.28
		Ls	0.20
	B	Scl,sl,l	0.40
	C	Sl	0.30
Croton	A	Sil	0.43
	B	Sil,sicl	0.50
	C	Shsil,shsicl	0.40
Donlonton	A	Fsl,ls,sil	0.43
	B	Sc,cl,sic	0.40
	C	Sc,sicl,cl,ls	0.30

Table 5-4 (continued). SOIL ERODIBILITY INDEX K VALUES FOR MARYLAND SOIL SERIES

Soil series	Horizon	Texture range	K Value
Duffield	A	Sil	0.32
	B	Sicl	0.30
	C	Sicl	0.40
		Shsil	0.30
Edgemont	A	Chl	0.24
	B	Chl,chscl	0.30
	C	Chl,shsl	0.20
Elkton	A	Sil,fsl,sl,l	0.43
	B	Sic,c	0.40
	C	Sic,sicl,scl	0.40
Evesboro	A	Ls,s	0.17
Fallsington	A	Sl,fsl,l	0.28
	B	Scl,sl	0.30
	C	S,ls,sl	0.20
Fort Mott	A	S,ls	0.20
	B	Sl	0.30
	C	S	0.20
Freneau	A	Sl,l	0.28
Galestown	A	Ls,s	0.17
Howell	A	Fsl,sil,l	0.43
	B	Cl,sicl	0.40
	C	C,sic,sicl	0.30
Keansburg	A	Sl,l	0.28
	B	Sl,l	0.30
Keyport	A	Sil,l,fsl	0.43
	B	C,sic,cl	0.40
	C	Sicl,sic	0.40
	Sandy substratum	Scl,sl	0.30
Klej	A	Ls,fs,lfs	0.17
	B	Ls,fs,lfs,sl	0.20

Table 5-4 (continued). SOIL ERODIBILITY INDEX K VALUES FOR MARYLAND SOIL SERIES

Soil series	Horizon	Texture range	K Value
Lakeland	A	Ls,lfs	0.17
Lansdale	A	L,sl	0.28
	B	Scl,sl	0.30
		L	0.40
	C	Chsil,gsl	0.30
		Chsl,gsl	0.20
Legore	A	Sil,sicl	0.24
		Gl	0.20
	B	Cl	0.30
		Gcl,gl,gsicl	0.20
	C	L,sil,sicl	0.30
		Gl,vgl,gcl	0.20
Lehigh	A	Sil	0.43
		Chsil	0.37
	B	Chsicl	0.40
	C	Chsicl,vchsil	0.30
Matapeake	A	Sil,fsl,l	0.32
	B	Sil,sicl	0.40
	C	S,ls,sl,l,gs	0.30
Matawan	A	Sl,ls,fsl	0.32
	B	Cl,scl,sc,sl	0.40
Mattapex	A	Sil,l,fsl	0.37
	B	Sicl,sil,cl	0.40
	C	Sl,ls,s,l,gs	0.20
Monmouth	A	Fsl,l,lfs	0.43
	B	Sc,scl	0.40
	C	Sl,scl,sc	0.30
Neshaminy	A	Sil	0.32
		Vstsil	0.28
	B	Sicl,cl,scl,sl	0.30
	C	Diabase bedrock	

Table 5-4 (continued). SOIL ERODIBILITY INDEX K VALUES FOR MARYLAND SOIL SERIES

Soil series	Horizon	Texture range	K Value
Norton	A	Sil,l	0.32
	B	Sicl	0.40
	C	Sil	0.40
		Vgl,shl	0.30
Othello	A	Sil,l,fsl,sicl	0.37
	B	Sicl,sil	0.40
	C	Sl,ls,scl	0.30
Penn	A	L	0.32
		Shsil	0.28
	B	Sil	0.40
		Shsil,sicl	0.30
Pocomoke	A	Sl,l,fsl,ls,lfs	0.28
	B	Ls,s	0.20
Raritan	A	Sil	0.43
	B	Cl,sicl	0.30
	C	Stratified silt,fsl	0.20
		C,sil,l,g	0.30
Readington	A	Sil	0.43
	B	Sil,sicl	0.40
	C	Sil	0.40
		Vshsil	0.30
Rowland	A	Sil,l	0.43
		Sicl	0.40
	B	Stratified silt and gravel	0.30
		Sil	0.40
Rutlege	A	Ls,lfs	0.17
	B	S,fs,ls,lfs	0.20
Sassafras	A	Fsl,l,sl,lfs	0.28
		Ls	0.20
		Gfsl,gsl	0.24
	B	Scl,sl,l	0.30
	C	Sl,ls,fsl,gsl,gls	0.20

Table 5-4 (continued). SOIL ERODIBILITY INDEX K VALUES FOR MARYLAND SOIL SERIES

Soil series	Horizon	Texture range	K Value
Shrewsbury	A	Sl,fsl,l	0.28
	B	Scl,sl	0.30
	C	S,ls,sl	0.20
Steinsburg	A	Sl	0.28
		Gsl,vgsl	0.24
	B	Gsl	0.20
	C	Sandstone	
Watchung	A	Sil	0.43
	B	C,cl,sicl	0.40
	C	Sil,sicl,l	0.40
Westphalia	A	Fsl,lfs	0.49
	B	Fsl,lfs,vfsl	0.40
	C	Fs,lfs,fsl	0.30
Woodstown	A	Sl,fsl,l	0.28
		Ls	0.20
	B	Scl,l,sl	0.40
	C	S,ls,sl,gsl,gls	0.20

USDA SOIL TEXTURE ABBREVIATIONS USED IN TABLE 5-4

C	Clay
Ch	Channery
Cl	Clay loam
Co	Coarse
Fs	Fine sand
Fsl	Fine sandy loam
G	Gravelly
Gcl	Gravelly clay loam
Gl	Gravelly loam
Gscl	Gravelly sandy clay loam
Gsl	Gravelly sandy loam
L	Loam
Lfs	Loamy fine sand
Ls	Loamy sand
S	Sand
Scl	Sandy clay loam
Sh	Shaly
Sic	Silty clay
Sicl	Silty clay loam
Sil	Silt loam
Sl	Sandy loam
St	Stony
Vfs	Very fine sand
Vfsl	Very fine sandy loam

prediction equation will overestimate the actual erosion. If possible, to minimize these errors, large eroding sites should be broken up into areas of fairly uniform slope.

The cropping management factor, C, is dependent upon the type of ground cover, the general management practice and the condition of the soil over the area of concern. The C factor is set equal to one for continuous fallow ground which is defined as land that has been tilled and kept free of vegetation and surface crusting. Values for the cropping management factor are given in Table 5-5 (6). Again consultation with local soils experts is recommended.

The control practice factor is similar to the C factor except that P accounts for the erosion-control effectiveness of superimposed practices such as contouring, terracing, compacting, sediment basins and control structures. Values for the control practice factor for construction sites are given in Table 5-6 (8). Agricultural land use P factor values can be found in Agriculture Handbook 282 (11).

The C and P factors are the subject of much controversy among erosion and sedimentation experts of the US Department of Agriculture (USDA) and the Soil Conservation Service (SCS). These factors are estimates and many have no theoretical or experimental justification. It has been suggested that upper and lower limits be placed on these factors by local experts to increase flexibility of Universal Soil Loss Equation for local conditions.

The P factors in the upper portion of Table 5-6 were designated as estimates when they were originally published. SCS scientists have found no theoretical or experimental justification for factors significantly greater than 1.0. Surface conditions 4, 6, 7 and 8 ($P \leq 1.0$), Table 5-6 also are estimates with no experimental verification.

After the erosion calculations are made, the program computes the suspended solids contribution from erosion and adds the value to the suspended solids from other sources. When erosion is modeled, the program prints out, for each subcatchment the total suspended solids and the suspended solids without erosion, as shown in Table 5-9. Following the erosion cards, the subcatchment surface quality cards are prepared. These pertain to land use information which can be obtained from city maps (see card group 11, Table 5-7). The last two card groups refer to print control information. Figure 5-8 shows the sequencing of the data deck for the Runoff Block.

Table 5-5. CROPPING MANAGEMENT FACTOR C
(6)

Type of cover	C Value	Mulch	Rate of application (tons/acre)	C Value	Maximum allowable slope length
None (fallow)	1.00	Hay or straw	0.5	0.35	20 feet
			1.0	0.20	30
Temporary seedings:			1.5	0.10	40
First sixty days	0.40		2.0	0.05	50
After sixty days	0.05				
		Stone or gravel	15.0	0.80	15
Permanent seedings:			60.0	0.20	80
First sixty days	0.40		135.0	0.10	175
After sixty days	0.05		240.0	0.05	200
After one year	0.01				
		Chemical mulches			
Sod (laid immediately)	0.01	First ninety days	a	0.50	50
		After ninety days	a	1.00	50
		Woodchips	2.0	0.80	25
			4.0	0.30	50
			7.0	0.20	75
			12.0	0.10	100
			20.0	0.06	150
			25.0	0.05	200

[a] As recommended by manufacturer

Table 5-6. EROSION CONTROL PRACTICE FACTOR P FOR CONSTRUCTION SITES (8)

Surface condition with no cover	Factor P
1. Compact, smooth, scraped with bulldozer or scraper up and down hill	1.30
2. Same as above, except raked with bulldozer root raked up and down hill	1.20
3. Compact, smooth, scraped with bulldozer or scraper across the slope	1.20
4. Same as above, except raked with bulldozer root raked across slope	0.90
5. Loose as a disced plow layer	1.00
6. Rough irregular surface, equipment tracks in all directions	0.90
7. Loose with rough surface greater than 12" depth	0.80
8. Loose with smooth surface greater than 12" depth	0.90
<u>Structures</u>	
1. Small sediment basins:	
0.04 basin/acre	0.50
0.06 basin/acre	0.30
2. Downstream sediment basins:	
with chemical flocculants	0.10
without chemical flocculants	0.20
3. Erosion control structures:	
normal rate usage	0.50
high rate usage	0.40
4. Strip building	0.75

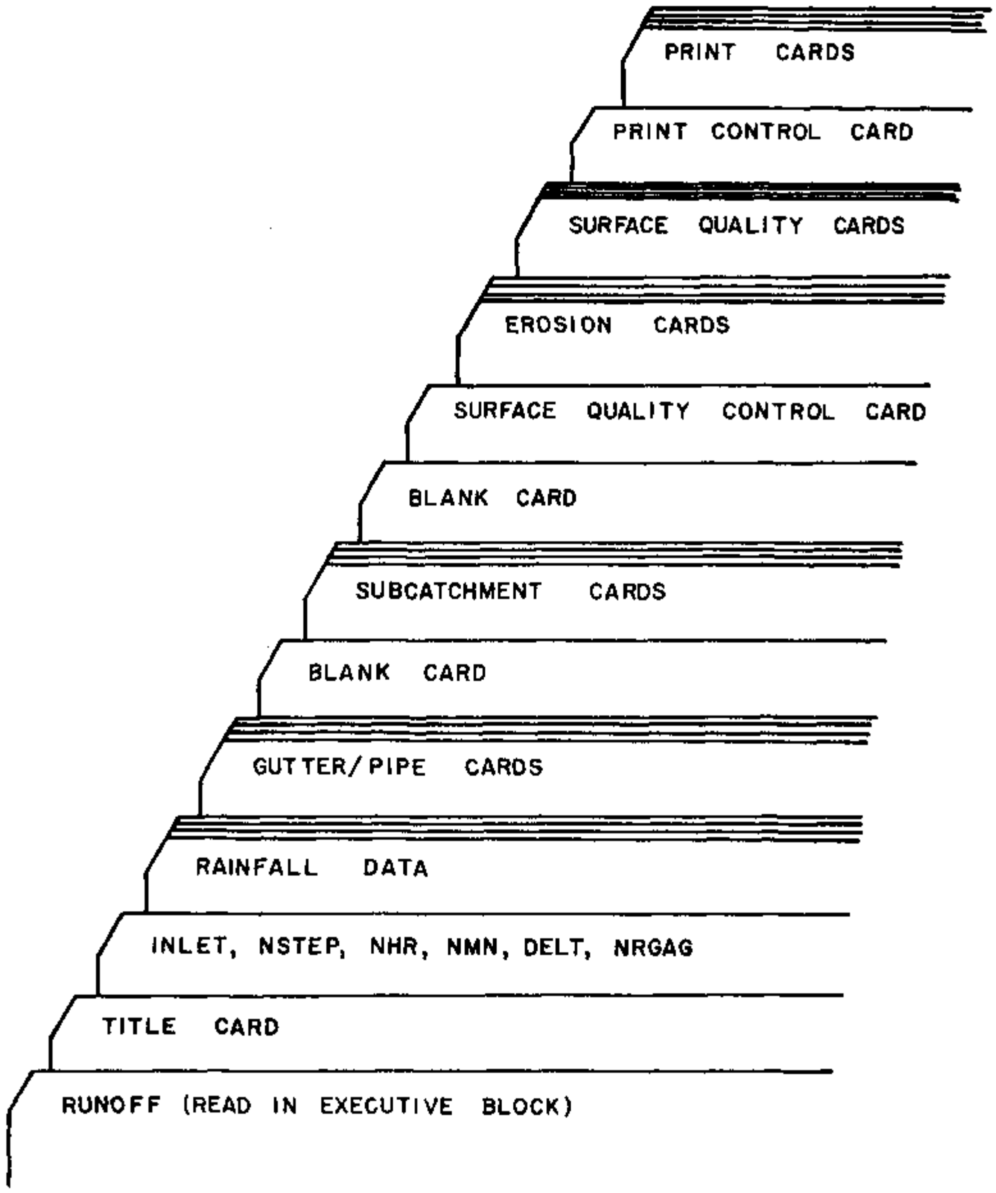

Figure 5-8. Data Deck for the Runoff Block

Table 5-7. RUNOFF BLOCK CARD DATA

Card group	Format	Card columns	Description	Variable name	Default value
1	20A4		Title cards: two cards with heading to be printed on output.	TITLE	Blanks
2			Control card: one card.		
	2I5	1-5	Basin identification number.	BASIN	0
		6-10	Number of time-steps to be calculated (maximum = 150).	NSTEP	None
	I3	11-13	Hour of start of storm (24-hour clock).	NHR	0
	I2	14-15	Minutes of start of storm.	NMN	0
	F5.0	16-20	Integration period (time step), min.	DELT	None
	I5	21-25	Number of hyetographs (rain gages) (maximum = 10).	NRGAG	None
	F5.0	26-30	Percent of impervious area with zero detention (immediate runoff).	PCTZER	25.0
	I5	31-35	IROS = 1, Erosion for subcatchment is to be modeled.	IROS	0
	F5.0	36-40	If IROS = 1, Highest average 30-minute rainfall intensity, in/hr.	RAINIT	0.0
3			Rainfall control card.		
	I5	1-5	Number of data points for each hyetograph (maximum = 200).	NHISTO	None
	F5.0	6-10	Time interval between values, min.	THISTO	None

NOTE: The Runoff block requires only one scratch data-set.
All non-decimal numbers must be right-justified.

Table 5-7 (continued). RUNOFF BLOCK CARD DATA

Card group	Format	Card columns	Description	Variable name	Default value
			REPEAT CARD GROUP 4 FOR EACH HYETOGRAPH.		
4			Rainfall hyetograph cards: 10 intervals per card" (maximum number of values = 200).[a]		
	10F5.0	1-5	Rainfall intensity, first interval, in/hr.	RAIN(1)	None
		6-10	Rainfall intensity, second interval, in/hr.	RAIN(2)	None
		11-15	Rainfall intensity, third interval, in/hr.	RAIN(3)	None
		16-20	Rainfall intensity, fourth interval, in/hr.	RAIN(4)	None
		.		.	
		.		.	
		.		.	
		.		.	
		.		.	
			REPEAT CARD 5 FOR EACH GUTTER/PIPE.		
5			Gutter/pipe cards: one card per gutter/ pipe (if none, leave out) (maximum number = 200).		
	I10	1-10	Gutter/pipe number.[b]	NAMEG	None
	2I5	11-15	Gutter or inlet number for drainage.[b]	NGTO	None
		16-20	= 1 for gutter, = 2 for pipe.	NP	None
	7F8.0	21-28	Bottom width of gutter or pipe diameter, ft.	GWIDTH=G1	None

[a]Problems may occur when zero rainfall occurs several time-steps before the actual start of the rainfall (the computer underflows).

[b]Numbers may be arbitrarily chosen. However, if inlet number is to correspond to inlet manhole for Transport Block, it must be ≤ 1000. The maximum total number of inlets must be ≤ 50 for input to Receiving or ≤ 70 for input to Transport.

Table 5-7 (continued). RUNOFF BLOCK CARD DATA

Card group	Format	Card columns	Description	Variable name	Default value
		29-36	Length of gutter, ft.	GLEN =G2	None
		37-44	Invert slope, ft/ft.	GSLOPE=G3	None
		45-52	Left-hand side slope, ft/ft.	GS1 =G4	None
		53-60	Right-hand side slope, ft/ft.	GS2 =G5	None
		61-68	Manning's coefficient.	GN =G6	0.018
		69-76	Depth of gutter when full, in.	DFULL =G7	10.0
6			Blank card to terminate gutter cards: one card (must always be included).		
			REPEAT CARD 7 FOR EACH SUBCATCHMENT.		
7	3I5	1-5	Hyetograph number (based on the order in which they are read in).	JK	1
		6-10	Subcatchment number.[a]	NAMEW	None
		11-15	Gutter or manhole number for drainage.[a,b]	NGTO	None
	10F5.0	16-20	Width of subcatchment, ft.	WWIDTH=W1	None
			This term actually refers to the physical width of overland flow in the subcatchment and may be obtained as illustrated under Instructions for Data Preparation.[c]		
		21-25	Area of subcatchment, acres.	WAREA =W2	None
		26-30	Percent imperviousness of subcatchment.	PCIMP =W3	0.001
		31-35	Ground slope, ft/ft.	WSLOPE=W4	0.030

[a]Numbers may be arbitraily chosen. However, if inlet number is to correspond to inlet manhole for Transport Block, it must be $\leq$ 1000. The maximum total number of inlets must be $\leq$ 70 for input to Transport or $\leq$ 50 for input to Receiving.

[b]Need one inlet or gutter/pipe for each subcatchment basin.

[c]As an approximation, twice the length of the principal drainage couduit through the subcatchment may be used.

Table 5-7 (continued). RUNOFF BLOCK CARD DATA

Card group	Format	Card columns	Description	Variable name	Default value
		36-40	Impervious area. Resistance factor. (Manning's n)	W5 =W5	0.013
		41-45	Pervious area. Resistance factor. (Manning's n)	W6 =W6	0.250
		46-50	Impervious area. Retention storage, in.	WSTORE=W7	0.062
		51-55	Pervious area. Retention storage, in.	WSTORE=W8	0.184
		56-60	Maximum infiltration rate, in/hr.	WLMAX =W9	3.00
		61-65	Minimum infiltration rate, in/hr.	WLMIN =W10	0.52
	F10.5	66-75	Decay rate of infiltration in Horton's equation, 1/sec.	DECAY =W11	0.00115
8			Blank card to terminate subcatchment cards: one card.		
9			SURFACE QUALITY CONTROL CARD		
	I10	1-10	Surface Quality NQS = 0, no quality modeled NQS = 1, quality to be modeled	NQS	0
		******	THE FOLLOWING PARAMETERS ARE NEEDED ONLY ****** IF NQS = 1:		
	2F10.0	11-20	Number of dry days prior to this storm in which the accumulative rainfall is less than 1.0 inch.	DRYDAY	0.0
		21-30	Street cleaning frequency, days.	CLFREQ	0.0
	I10	31-40	Number of street sweeper passes.	NPASS	0
	2F10.0	41-50	Catchbasin storage volume, ft^3.	CBVOL	0.0
		51-60	Concentration of BOD (mg/l), of the stored water in each catchbasin (100 recommended)	CBFACT(4)	0.0
	I5	61-65	Method for calculating suspended solids	ISS	0

Table 5-7 (continued). RUNOFF BLOCK CARD DATA

Card group	Format	Card columns	Description	Variable name	Default value
			ISS = 0, same as for all other pollutants (Vol. I).		
			ISS = 1, special technique. Same as in original Release 1 of the SWMM.		
10			Erosion card.		
			If IROS = 0 on Card 2, SKIP TO CARD 11.		
			REPEAT CARD 10 FOR EACH SUBCATCHMENT.		
	I5	1-5	Subcatchment number (must be read in same order as Card Group 7).	N	None
	5F5.0	6-10	Area of subcatchment subject to erosion, acres.	ERODAR(N)	0.0
		11-15	Flow distance in feet from point of origin of overland flow over erodible area to point at which runoff enters gutter or manhole.	ERLEN(N)	0.0
		16-20	Soil factor 'K'.[a]	SOILF(N)	0.0
		21-25	Cropping management factor 'C'.[b]	CROPMF(N)	0.0
		26-30	Control practice factor 'P'.[b]	CONTPF(N)	0.0
11			SUBCATCHMENT SURFACE QUALITY DATA CARDS (one card per subcatchment and must be read in the same order as Card Group 7). If NQS = 0, skip to Card 12.		
	5X	1-5	Not used.		
	2I5	6-10	Subcatchment number	N	None

[a] See instructions for data preparation

[b] See instructions for data preparation and consult with local Soil Conservation Service or Agricultural Research Service experts.

Table 5-7 (continued). RUNOFF BLOCK CARD DATA

Card group	Format	Card columns	Description	Variable name	Default value
		11-15	Land use classification.	KL	5
			= 1, For single family residential,		
			= 2, For multiple family residential,		
			= 3, For commercial,		
			= 4, For industrial,		
			= 5, For undeveloped or park lands.		
	2F10.0	16-25	Number of catchbasins in subcatchment.	BA	None
		26-35	Total length of all gutters within subcatchment, hundreds of feet.	GQ	None
12			GUTTER/INLET PRINT CONTROL: ONE CARD		
	2I5	1-5	Number of gutters/inlets for which flows are to be printed (maximum = 200).	NPRNT	0
		6-10	Number of time-steps between printings.	INTERV	None
13			IF NPRNT = 0, SKIP CARD 13.		
			GUTTER/INLET PRINT CARDS: 16 VALUES/CARD.		
	16I5	1-5	Gutter/inlet numbers for which flows and/or pollutants are to be printed.	IPRNT(1)	None
		6-10		IPRNT(2)	None
		11-15		IPRNT(3)	None
		.		.	
		.		.	
		.		.	
		.		.	
		.		IPRNT(NPRNT)	None

Table 5-8. RUNOFF BLOCK VARIABLES[a]

Variable Name	C*	Description	Units	Variable Name	C*	Description	Units
A		SS removing coefficient		CBSUM	C	Sum of the drainage to catchbasin in each time-step	gal.
ASUB	C	Area of subarea	acre	CBVOL		Volume of liquid remaining in a catchbasin	gal.
ATOT	C	Total area of subarea draining to all inlets	acre	CCOLI	C	Concentration of coliform bacteria of a subarea during one time-step	MPN/100 ml
AVAIL		Fraction of total dust and dirt available at start of time-step		CLEAN		Number of cleanings since last storm	
AVGFLO	C	Average runoff within a time-step	cfs	CLFREQ		Frequency of street sweepings	
AXO		Trapezoidal cross-sectional area, starting	sq ft	CONBOD		Average concentration of BOD during each time-step	mg/L
AX1		Trapezoidal cross-sectional area, final	sq ft	CONCSS		Average concentration of SS during each time-step	mg/L
				CONVER		Factor for converting lb/DT/cfs to mg/L	
B		SS removing coefficient		CONV2		Integer that converts flow unit from cfs to 100 ml/min	
BOD	C	BOD removed at each time-step to the inlet	lb/DT				
BODNS		Non-soluble BOD from dust and dirt removed during each time-step	lb/DT	CURVE		Name of subroutine	
				D		Computational variable, internal	
C	C	Removing coefficient		DAX1		Change in trapezoidal cross-sectional area	sq ft
CBASTM	C	BOD removed during one time-step including both catchbasin and surface area	lb/DT	DCORR		Time-step water depth	ft
CBBOD		Concentration of BOD in each catchbasin	mg/L	DD		Dust and dirt accumulation rate for each subarea	
CBCENT		Pollution removed from the catchbasin	%	DDELV		Rate of change in volume change	
CBDEN		Density of catchbasins	No./acre	DECAY	C	Exponential decay rate for infiltration	1/sec
CBINC	C	BOD removed from catchbasins during one time-step	lb/DT	DEL		Time-step change in depth of watershed flow	
				DELD	C	Instantaneous pipe diameter in radians	radian
CBLBS	C	BOD remaining after each time-step	lb	DELR		Newton-Raphson change in depth for correction	
CBNUM		Number of catchbasins within a subarea		DELT	C	Integration time interval	sec, min
				DELT2	C	One half of a time-step	min
				DELV		Average volume change	

[a] Does not include variables added during updating.

*C = Variable names shared in common blocks.

Table 5-8 (continued). RUNOFF BLOCK VARIABLES

Variable Name	C*	Description	Units
DF		Sum of volume change plus flow change times time	
DFLOW1		Change in flow	
DFULL		Gutter's maximum depth (for pipes DFULL = 2.62)	in.
DO		Instantaneous depth	ft
DRAIN		Runoff to each catchbasin during each time-step	gal.
DRYDAY		Number of dry days prior to storm	days
DT		Time-step interval	min
DUMMY	C	Dummy common block	
DWP1		Change in wetted perimeter	
D1		Estimated final depth	in.
E		Hundred times average runoff	
ENDTIM		Time of simulation, 24 hour clock	hr
ERROR		Name of error statement	
ERT		Computational variable	
EXPON		Computational variable	
F		Newton-Raphson volume correction (WSHED)	
F		SS removed during one time-step (SFQUAL)	lb/DT
FLOW		Average flow	cfs
FLOWO		Starting flow	cfs
FLOW1		Final flow	cfs
GCON	C	Manning's equation less hydraulic radius	
GDEPTH	C	Instantaneous gutter depth	in.

Variable Name	C*	Description	Units
GFLOW	C	Gutter flow	cfs
GLEN	C	Length of gutter/pipe	ft
GN	C	Manning's roughness coefficient	
GRAPH	XF	Name of subroutine	
GS		Factor in a geometric series	
GSLOPE	C	Slope of gutter/pipe	ft/ft
GS1	C	Gutter side slope, left	ft/ft
GS2	C	Gutter side slope, right	ft/ft
GUTTER	C	Length of gutter in subarea	100-ft
GWIDTH	C	Pipe diameter or gutter width	ft
G1		Read in value of bottom width of gutter or pipe diameter	ft
G2		Read in value of length of gutter	ft
G3		Read in value of invert slope	ft/ft
G4		Read in value of left-hand side slope	ft/ft
G5		Read in value of right-hand side slope	ft/ft
G6		Read in value of Manning's coefficient	
G7		Read in value of depth of gutter when full	in.
HCURVE		Name of subroutine	
HGRAPH	C	Magnitude of variable to be printed in vertical coordinate of the curve	
HISTOG	C	Length of histogram expressed in time	sec
HORIZ	C	Horizontal title unit of hydrograph in time	hr

Table 5-8 (continued). RUNOFF BLOCK VARIABLES

Variable Name	C*	Description	Units
HTIME	C	Time interval to be printed in the horizontal coordinate of the curve	
HYDRO		Name of subroutine	
I		Bookkeeping integer	
IA		Do loop counter	
IFLG		Surcharge indicator	
IFPRNT		Name of scratch tape	
IHOUR		Hour of start of storm, 24-hour clock	hr
II		Bookkeeping integer	
IJ		Bookkeeping integer	
IK		Bookkeeping integer	
IKOUNT	C		
IMIN		Minute of start of storm	min
INCNT	C	Name of the tape	
IND		Bookkeeping integer, time interval	
INLET		Inlet number	
INPT		Variable which transfer program from tape to compiler	
INPUT	C	Inlet number	
INTCNT		Printing counter	
INTERV	C	Interval integrization cycles for printed hydrographs	
IOUTCT	C	Name of the tape	
IPOINT	C	Internal pointer	
IPRNT	C	Points for which hydrograph will be printed	
ISAVE	C	Points for which hydrograph will be saved	
ISKIP		Number of inlets minus one	
ISUB		Bookkeeping integer	
J		Bookkeeping integer	
JIN	C	Name of input tape	
JJ		Bookkeeping integer	
JK		Bookkeeping integer	
JKL		Do loop counter	
JN	C	Number of input manholes	
JOUT	C	Name of output tape	
JT		Bookkeeping integer	
K		Bookkeeping integer	
KHOUR		Hour of start of storm, 24-hour clock	
KK		Bookkeeping integer	
KL		Do loop counter	
KLAND	C	Land use	
KMIN		Minute of start of storm	min
KNUM	C	Temporary subarea number reset to inlet number	
KOUNT		Computational counter	
KSKIP		Do loop counter for SKIPN	
KSPOT		Bookkeeping integer	
KTNUM		Number of subarea	
KTSTEP		Time-step counter	

Table 5-8 (continued). RUNOFF BLOCK VARIABLES

Variable Name	C*	Description	Units
L		Bookkeeping integer	
LL		Bookkeeping integer	
M		Bookkeeping integer	
MKOUNT		Computational counter	
MM		Bookkeeping integer	
N		Bookkeeping integer	
NAMEW	C	External subcatchment number	
NCLEAN		*Number of cleanings since last storm*	
NEW		Bookkeeping integer	
NEXDAY		Number of days after start of storm simulation ends	day
NG	C	Number of gutters	
NGAGP		Number of graphic point	
NGOTO		Gutter number to which watershed drains	
NGTOG	C	Gutter connections	
NGTOI	C	Inlet connections	
NGUT	C	Bookkeeping integer	
NHISTO	C	Number of rainfall time interval	
NHR		Hour of the start of storm	hr
NHYET	C	Number of hyetograph	
NIN	C	Maximum number of gutters draining to gutter, and watersheds draining to gutter	

Variable Name	C*	Description	Units
NING	C	Do loop counter	
NINLTS		Total number of inlets	
NMN		Minutes of the start of storm	min
NOG	C	Total number of gutters/pipes	
NOLD		Bookkeeping integer	
NOPASS		Number of street sweeper passes	
NOUT		Output file variable	
NP		Read in value of NPG	
NPG	C	Control switch for type of gutter, 1=regular, 2=pipe, 3=dummy connected directly to inlet	
NPRINT		Number of time-steps between printing	
NPRNT	C	Number of points where hydrographs are printed	
NPT	C	Number of points to be plotted	
NQUAL		Number of quality constituents used as zero in Runoff quantity	
NRAIN	C	Number of rainfall	
NRANVL		Rain data points limiter	
NRGAG	C	Number of hyetographs	
NSAVE	C	Number of points where hydrographs are saved	
NSCRAT	C	Name of the tape	
NSHED	C	Number of the watershed	
NSPOT		Bookkeeping integer	
NSTEP	C	Number of time-steps	
NSTOP		Error switch	
NTIMEH		Hour of day of simulation (24-hour clock)	hr

Table 5-8 (continued). RUNOFF BLOCK VARIABLES

Variable Name	C*	Description	Units
NTQUAL		Scratch output file indentifier	
NTSTEP		Number of time-steps modeled	
NTYPE		Number of types	
NUSTEP		Number of printed hydrograph points	
NW	C	Number of watershed	
NWTOG	C	Gutter connection	
NWTOI		Inlet connection	
NX		Bookkeeping integer	cfs
ORIZ		Horizontal title unit for hydrograph in time	hr
OUTFLW	C	Flow out of the gutter	cfs
P			
PCIMP	C	Percent imperviousness of watershed	%
PCNTCB		Percent removal of BOD by catchbasin of one subarea	%
PCNTSS		Percent removal of SS from total dust and dirt of one subarea	%
PCTBOD		Percent removal of BOD from available surface BOD of one subarea	%
PCTZER	C	Percent of impervious area with zero detention depth	%
PO	C	Soluble BOD in dust and dirt	lb
POCB		Total BOD available from catchbasins	lb
POOCB		BOD available in each catchbasin at start	lb

Variable Name	C*	Description	Units
POP	C	BOD removed from dust and dirt during one time-step	lb/DT
POPSS	C	SS removed during one time-step	lb/DT
QIN	C	Input from upstream gutter	cfs
QSUR	C	Surcharge	cf
RADO		Starting hydraulic radius	ft
RAD1		Final hydraulic radius	ft
RAIN	C	Rainfall	in./hr
REFF		Street sweeper removal efficiency	percent, decimal
REMDD	C	Remaining dust and dirt after each time-step	lb
RHYDRO		Name of subroutine	
RI	C	Instantaneous rainfall rate	in./hr
RLOSS	C	Infiltration loss, instantaneous	in./hr
RUNCFS	C	Instantaneous runoff for each inlet	cfs
RUNOFF		Average runoff over a time-step	in./hr
RUNTMP	C	Flow entering input manholes	cfs
SFCOLI	C	Total coliform in runoff	MPN/min
SFQUAL		Name of subroutine	
SKIP1		Scratch tape variable, unformatted	
SKIP2		Scratch tape variable, unformatted	
SKIP3		Scratch tape variable, unformatted	

Table 5-8 (continued). RUNOFF BLOCK VARIABLES

Variable Name	C*	Description	Units
SKIP4		Scratch tape variable, unformatted	
SKIP5		Scratch tape variable, unformatted	
SKIP6		Scratch tape variable, unformatted	
SKIP7		Scratch tape variable, unformatted	
SS	C	Suspended solids	lb
SUMBOD		Sum of total surface BOD in each area	lb
SUMCB		Sum of total BOD in catchbasins	lb
SUMDD		Sum of the dust and dirt	lb
SUMI	C	Total infiltration into ground	cf
SUMOFF	C	Total gutter flow @ inlet manhole	cf
SUMQW	C	Total flow for each subcatchment	cf
SUMR	C	Total rainfall	cf
SUMST	C	Total surface storage	cf
T		Time-step interval	hr
TAREA		Total area	acres
TBOD		Total BOD in surface runoff	lb
TCBAST	C	Total BOD removed for each inlet	lb
TCBINC	C	Total BOD removed from catchbasins for each inlet	lb
TCCOLI	C	Total concentration of coliform during one time-step	MPN/ 100 ml
TGS		Sum of the geometric series plus 1.0	
THISTO		Time of rainfall time intervals	min
TIME	C	Time	sec
TIMEM		Time of simulation (24-hour clock)	min
TIMES		Time of simulation (SFQUAL)	sec
TIME2	C	Time minus half-step	sec
TITEL		Description of curve in horizontal coordinates	
TITL		Description of curve in vertical coordinate	
TITLE	C	Description of problem	
TMAX		Maximum time to be printed in curve	hr
TMINS		Time-step interval	min
TOTDD	C	Total dust and dirt on ground at start of storm for each inlet	lb
TPCBOD		Percent of total BOD removed from each area	%
TPCTBD		Total percent removal of BOD from catchbasin of all areas	%
TPCTCB		Total percent removal of BOD from catchbasin and surface of all areas	%
TPCTSS		Total percent removal of SS from surface of all areas	%
TPOP	C	Total BOD removed from dust and dirt for each inlet	lb
TPOPSS	C	Total SS removed for each inlet	lb
TPTBOD		Total percent removal of BOD from surface of all areas	%
TRAIN	C	Time when rainfall ends	min, sec
TSEC		Time-step interval	sec
TSMBD		Sum of total BOD for the study area	lb

Table 5-8 (continued). RUNOFF BLOCK VARIABLES

Variable Name	C*	Description	Units
TSUMCB		Sum of the original dust and dirt available in the catchbasin	lb
TSUMDD		Sum of the original dust and dirt available on surface drainage area	lb
TTCBNC		Total removal of BOD from all of catchbasin and surface area	lb
TTCBST		Total removal of BOD of all catchbasins	lb
TTPOP		Total removal of BOD from all surface area	lb
TTPPSS		Total removal of SS of all areas	lb
TZERO		Starting time of the hydrograph	sec
VER		Vertical title unit for hydrograph	in./hr
VERT	C	Vertical title unit for hydrograph	in./hr
WAR		Impervious area of watershed with immediate runoff	sq ft
WAREA	C	Area of watershed	acres, sq ft
WCON	C	Modified Manning's equations, impervious and pervious portions of watershed	
WDEPTH	C	Instantaneous depth on watershed	ft
WFLO		Average watershed flow during time interval	cfs
WFLOW	C	Instantaneous flow from watershed	cfs
WLMAX	C	Maximum infiltration rate	in./hr
WLMIN	C	Minimum infiltration rates	in./hr
WN	C	Dummy variable	
WPO		Wetted perimeter, starting	ft
WP1		Wetted perimeter, final	ft

Variable Name	C*	Description	Units
WSHED		Name of subroutine	
WSLOPE	C	Average slope of watershed	ft/ft
WSTORE	C	Minimum and maximum storage depth on surface of watershed	ft
WWIDTH	C	Average width of watershed	ft
W1		Read in value of the average width of watershed	ft
W2		Read in value of the area of watershed	acre
W3		Read in value of the percent of imperviousness	%
W4		Read in value of slope of watershed	ft/ft
W5		Resistance factor for impervious area	
W6		Resistance factor for pervious area	
W7		Retention storage for impervious area	in.
W8		Retention storage for pervious area	in.
W9		Read in value of maximum infiltration rate	in./hr
W10		Read in value of minimum infiltration rate	in./hr
W11		Read in value of decay rate of infiltration	1/sec
X	C	Number of time interval used in the horizontal coordinate	
XLAB	C	Minimum point in the horizontal scale	
Y		Number of point used in the vertical coordinate	
YLAB	C	Minimum point in the vertical scale	

Table 5-9. SAMPLE OF EROSION PRINTOUT

LANCASTER PENNSYLVANIA STEVENS AVE DISTRICT **** RELEASE II ****
STORM OF SEPTEMBER 14, 1973 DURATION 9 HOURS

SUMMARY OF QUANTITY AND QUALITY RESULTS AT LOCATION 31

FLOW IN CFS AND QUALITY IN (MG/L)

TIME	FLOW	BOD	SUS-S	COLIF	COD	SET-S	NIT	PO4	GREASE	SUS-S WITHOUT EROSION
6 25.0	0.27	38.39	1013.93	.130E 06	117.54	0.03	0.08	0.01	0.10	.782883E 00
6 50.0	1.12	4.24	244.82	.140E 06	15.17	0.05	0.13	0.01	0.11	.170686E 01
7 15.0	1.39	0.61	198.68	.125E 06	3.94	0.06	0.14	0.01	0.10	.207176E 01
7 40.0	0.88	0.53	102.36	.115E 06	3.55	0.05	0.12	0.01	0.09	.149623E 01
8 5.0	0.51	0.45	173.49	.101E 06	3.12	0.04	0.09	0.01	0.08	.121371E 01
8 30.0	0.70	0.41	210.57	.888E 05	2.73	0.04	0.09	0.01	0.07	.126962E 01
8 55.0	0.83	0.39	178.32	.830E 05	2.56	0.04	0.10	0.01	0.06	.143401E 01
9 20.0	1.48	0.34	425.87	.663E 05	2.04	0.05	0.10	0.01	0.05	.171272E 01
9 45.0	3.58	0.38	263.58	.524E 05	1.61	0.12	0.18	0.02	0.04	.358665E 01
10 10.0	1.84	0.27	150.49	.408E 05	1.26	0.07	0.12	0.01	0.03	.225552E 01
10 35.0	1.57	0.22	95.01	.323E 05	0.99	0.06	0.10	0.01	0.02	.187092E 01
11 0.0	0.84	0.17	106.74	.280E 05	0.86	0.04	0.07	0.01	0.02	.123880E 01
11 25.0	0.37	0.15	0.93	.275E 05	0.85	0.04	0.05	0.01	0.02	.929881E 00
11 50.0	0.63	0.12	329.56	.212E 05	0.65	0.03	0.05	0.00	0.02	.854406E 00
12 15.0	0.89	0.14	166.49	.210E 05	0.65	0.04	0.06	0.01	0.02	.115358E 01
12 40.0	0.98	0.14	150.44	.189E 05	0.58	0.04	0.06	0.01	0.01	.124167E 01
13 5.0	1.09	0.11	442.20	.150E 05	0.46	0.04	0.05	0.01	0.01	.108614E 01
13 30.0	1.09	0.13	82.44	.150E 05	0.46	0.05	0.07	0.01	0.01	.142452E 01
13 55.0	2.23	0.13	250.13	.107E 05	0.33	0.06	0.09	0.01	0.01	.181339E 01
14 20.0	3.65	0.16	279.06	.762E 04	0.23	0.11	0.12	0.01	0.01	.254702E 01
14 45.0	2.43	0.12	142.05	.545E 04	0.17	0.09	0.09	0.01	0.00	.192927E 01
15 10.0	1.73	0.07	279.04	.365E 04	0.11	0.05	0.05	0.00	0.00	.104022E 01
15 35.0	1.61	0.08	56.20	.336E 04	0.10	0.06	0.06	0.01	0.00	.122568E 01
16 0.0	1.79	0.05	270.14	.245E 04	0.08	0.05	0.05	0.00	0.00	.100727E 01

SAMPLE APPLICATION

An example of an application of the Runoff Block, SWMM, to the North Lancaster Drainage District, Lancaster, Pennsylvania, is presented in this section. Both surface quantity and quality are modeled. The study area is marked by a dotted ellipse in Figure 5-9. Some of the subcatchments, their boundaries, and inlet manholes are shown in Figure 5-10. A coarse discretization of the physical drainage system was followed. The storm event of March 22, 1972, with an approximate duration of 4 hours, was selected because an accurate rainfall history was available. Input data are shown in Table 5-10.

The rainfall history, in 5 minute intervals, is shown in Table 5-11. Included are the number of time steps, percent impervious area with zero detention depth (immediate runoff), and the integration time interval. For simulation purposes, the time of start of storm is 1100 hours, with actual rainfall first observed at 1125 hours. The information displayed in Table 5-12 may be obtained by the user from city sewer maps, topographic maps, or zoning maps. The values shown for the resistance factors, surface storage, and infiltration rate are default values. If values more appropriate than these are available, then they should be specified by the user (see the following section on calibration of the Runoff Block). Note that the subcatchments are numbered for identification purposes only, i.e., they are not used in the execution of the program. No gutter/pipes are used. Figure 5-11 shows the total basin inlet hydrograph computed from the input rainfall hyetograph and subcatchment data. Table 5-13 lists the inlets for which hydrographs will be listed (specified by user). It also shows the computed total rainfall, infiltration, gutter flow, surface storage, and the error in continuity (numerical solution technique). In Table 5-14, the program prints the inlets for which hydrographs will be stored (for transfer to Transport), and the quality input parameters. Table 5-15 identifies land use types for each subcatchment, the number of catchbasins in each subcatchment, and the total gutter length within each subcatchment. The catchbasin density for Lancaster is approximately one per acre. These parameters are important elements of the quality simulation.

The final quantity and quality results for each subcatchment are summarized in Tables 5-16 and 5-17. Table 5-16 is essentially a heading printed by the program to advise the user of the summary that follows (Table 5-17). The inlets for which quantity and quality results are to be printed are specified by the user in the print control cards.

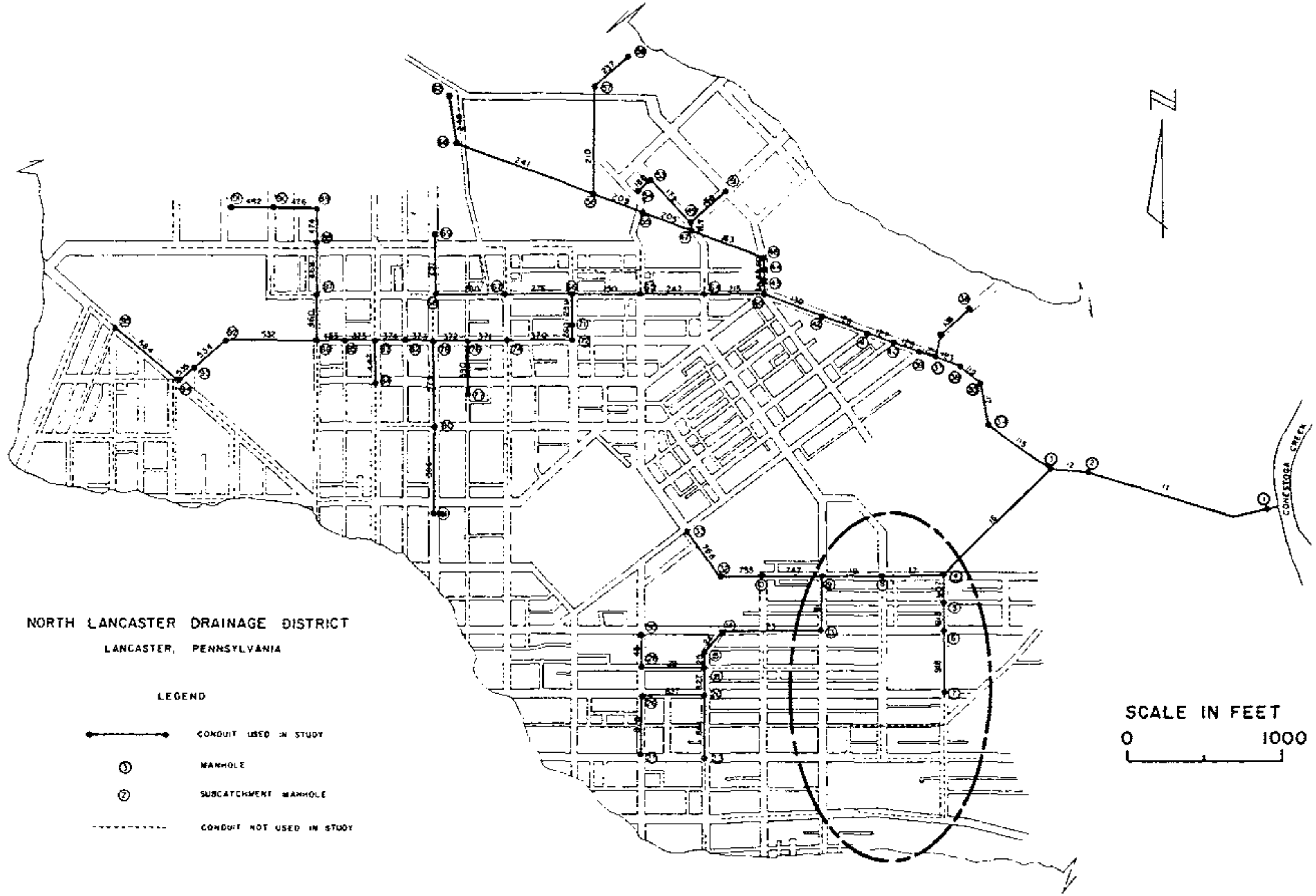

Figure 5-9. Sample Application Study Area

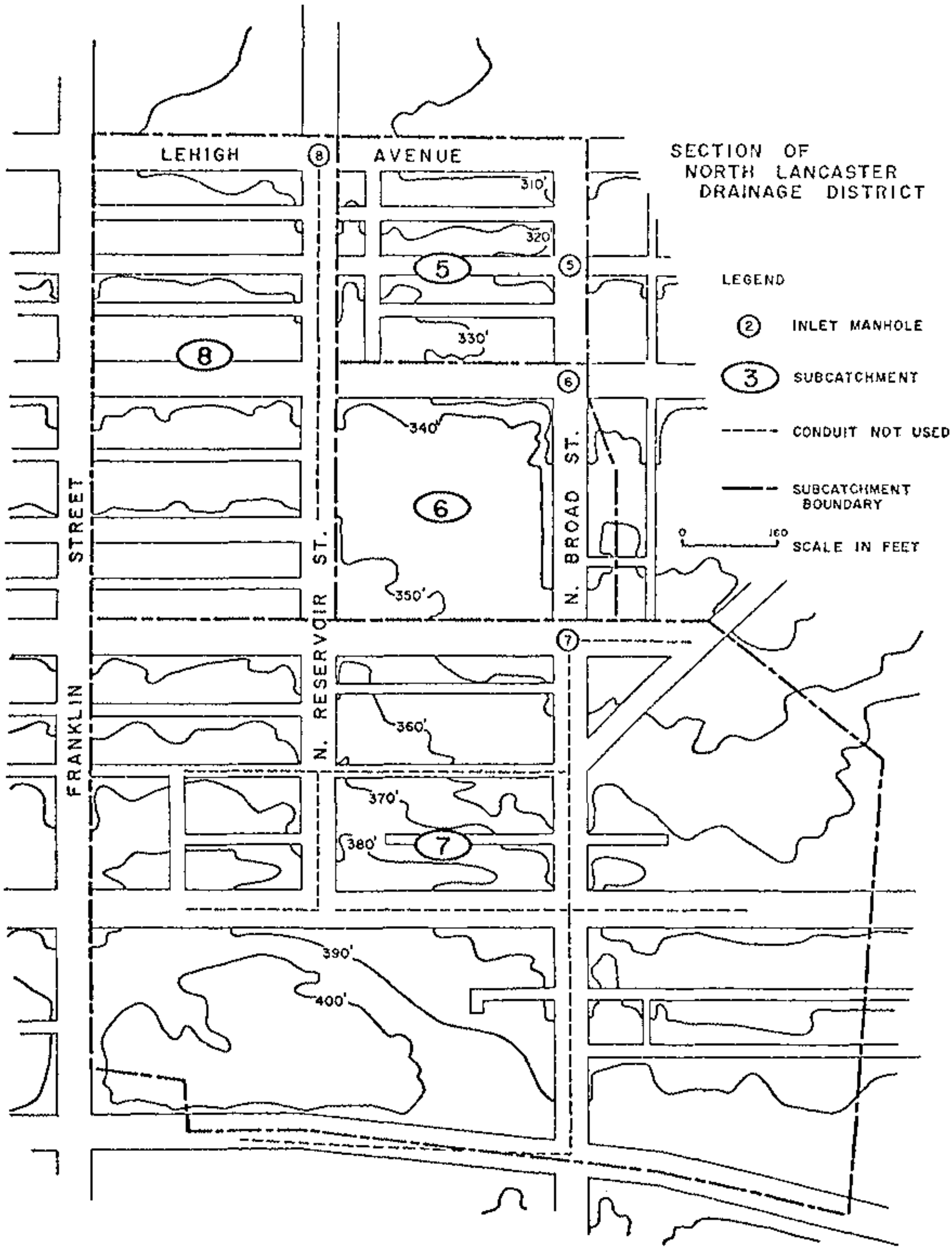

Figure 5-10. Sample Application Subcatchment Boundaries

Table 5-10. INPUT DATA NORTH LANCASTER, PENNSYLVANIA, DRAINAGE DISTRICT

DATA	CARD GROUP NUMBER

```
                                                        (READ IN EXECUTIVE BLOCK)
RUNOFF
    LANCASTER  PENNSYLVANIA  NORTH  DRAINAGE  DISTRICT                               } 1
    STORM OF MARCH 22, 1972 DURATION 4 HRS. STUDY 3  (STORM #7)                    } 2
   66  100 11 0   5.    1  25.                                                       3
   48  .5.0
0.0   0.0   0.0   0.0   .12   .36   .48   .36   .12   .12
.06   .06   .12   .12   .24   0.0   0.0   0.0   0.0   .12
.06   .06   .06   .06   .12   0.0   0.0   0.0   0.0   0.0                            4
0.0   0.0   0.0   0.0   0.0   0.0   .12   .48   .24   .36
.06   .06   .06   .06   .06   .06   0.0   0.0
                                                        (Blank Card)                  5,6
      5      5   1  800.    7.   31.0.028
      6      6   1  672.    9.   20.0.031
      7      7   18108.    46.   32.0.044
      8      8   11700.    16.   46.0.035
      9      9   11010.     8.   17.0.020
     10     10   1  730.   12.   10.0.025
     13     13   1  684.    9.   46.0.025
     14     14   1  684.    5.   37.0.025
     15     15   1    6.   31.    0.0.030
     18     18   1  928.    3.   47.0.025
     20     20   12684.    12.   58.0.025
     22     22   13536.    21.   58.0.025
     26     26   12354.    12.   54.0.032
     27     27   11180.    22.   58.0.035
     28     28   12370.     9.   47.0.019
     30     30   17032.    34.   42.0.019
     32     32   1  420.    4.   24.0.025
     33     33   16358.    47.   28.0.022
     38     38   113664    78.   43.0.018
     39     39   13100.     5.   51.0.019
     40     40   12465.    19.   57.0.019
     41     41   15554.    25.   59.0.016
     42     42   11608.     9.   59.0.018
     43     43   1  130.   0.4   51.0.008
     44     44   1  120.   0.3   51.0.007
     46     46   1  120.   0.3   51.0.012
     47     47   1  360.    3.   45.0.005
     49     49   1  290.    2.   45.0.007
     51     51   11653.    17.   38.0.012
     53     53   1  598.   18.   38.0.010
     54     54   1  780.   14.   23.0.008
     55     55   1  210.    1.   38.0.017                                               7
     56     56   1  210.    1.   38.0.009
     57     57   11600.    48.   23.0.012
     58     58   11200.    32.   23.0.008
     60     60   11600.    30.   23.0.006
     62     62   1  690.   18.   23.0.006
     63     63   11100.     6.   58.0.021
     64     64   12558.     8.   58.0.014
     65     65   1  780.    9.   49.0.009
     66     66   1  800.    6.   54.0.010
     67     67   1  400.   13.   51.0.018
     68     68   1  630.    9.   45.0.010
     69     69   1  960.   21.   43.0.008
     71     71   11020.     2.   51.0.005
     72     72   17830.    35.   57.0.014
     74     74   12250.    14.   51.0.023
     76     76   1  290.    2.   51.0.015
     77     77   13700.    21.   51.0.021
     78     78   1  880.    7.   61.0.012
     80     80   1  560.   19.   56.0.024
     81     81   1  700.   11.   58.0.018
     82     82   1  400.    6.   63.0.007
     83     83   11680.     8.   52.0.017
     84     84   11370.     9.   56.0.020
     85     85   11400.    11.   52.0.021
     86     86   11200.    12.   24.0.015
     87     87   1  360.    3.   38.0.003
     88     88   11810.    29.   22.0.004
     89     89   1  290.    2.   45.0.004
     90     90   11080.     6.   40.0.004
     91     91   11150.    30.   17.0.004
     92     92   1  360.    3.   10.0.019
     93     93   12920.     8.   23.0.011
     94     94   14160.    20.   32.0.021
     95     95   15110.    56.   22.0.021
                                                        (Blank Card)                  8
```

Table 5-10 (continued). INPUT DATA NORTH LANCASTER, PENNSYLVANIA, DRAINAGE DISTRICT

	1		5.		7.		1	16.044		1	9
	5		3		23.10		1.				
	6		3		29.70		1.				
	7		3		152.00		1.				
	8		1		52.80		1.				
	10		1		39.60		1.				
	13		1		29.70		1.				
	14		1		16.50		1.				
	15		4		19.80		1.				
	18		1		9.90		1.				
	20		1		39.60		1.				
	22		2		69.30		1.				
	26		2		39.60		1.				
	27		2		72.60		1.				
	28		1		29.70		1.				
	30		1		112.20		1.				
	32		1		13.20		1.				
	33		1		155.00		1.				
	38		1		258.00		1.				
	39		1		16.50		1.				
	40		1		62.70		1.				
	41		1		82.50		1.				
	42		1		29.70		1.				
	43		2		1.30		1.				
	44		2		1.00		1.				
	46		4		1.00		1.				
	47		2		9.90		1.				
	49		2		6.60		1.				
	51		1		56.10		1.				
	53		3		59.40		1.				
	54		2		46.20		1.				
	55		3		3.30		1.				
	56		4		3.30		1.				11
	57		5		32.80		1.				
	58		5		35.20		1.				
	60		3		99.00		1.				
	62		3		59.40		1.				
	63		1		19.80		1.				
	64		1		26.40		1.				
	65		1		29.70		1.				
	66		1		19.80		1.				
	67		1		42.80		1.				
	68		1		29.70		1.				
	69		1		69.30		1.				
	71		1		6.60		1.				
	72		1		115.50		1.				
	74		1		46.20		1.				
	76		1		6.60		1.				
	77		1		69.30		1.				
	78		1		23.10		1.				
	80		1		62.70		1.				
	81		1		36.30		1.				
	82		4		19.80		1.				
	83		1		26.40		1.				
	84		1		29.70		1.				
	85		4		36.30		1.				
	86		3		39.60		1.				
	87		1		9.90		1.				
	88		1		95.70		1.				
	89		1		6.60		1.				
	90		1		19.80		1.				
	91		1		99.00		1.				
	92		4		3.30		1.				
	93		1		26.40		1.				
	94		1		66.00		1.				
	95		1		185.00		1.				
10	1										12
7	8	27	33	38	62	91	93	94	95		13

Table 5-11. RAINFALL HISTORY

LANCASTER PENNSYLVANIA NORTH DRAINAGE DISTRICT

STORM OF MARCH 22, 1972 DURATION 4 HRS, STUDY 3 (STORM #7)

BASIN NUMBER 66

NUMBER OF TIME STEPS 100

INTEGRATION TIME INTERVAL (MINUTES), 5.00

25.0 PERCENT OF IMPERVIOUS AREA HAS ZERO DETENTION DEPTH

FOR 47 RAINFALL STEPS, THE TIME INTERVAL IS 5.00 MINUTES

FOR RAINGAGE NUMBER 1, RAINFALL HISTORY IS

0.0	0.0	0.0	0.0	0.12	0.36	0.48	0.36	0.12	0.12
0.06	0.06	0.12	0.12	0.24	0.0	0.0	0.0	0.0	0.12
0.06	0.06	0.06	0.06	0.12	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0	0.12	0.48	0.24	0.36
0.06	0.06	0.06	0.06	0.06	0.06	0.0			

Table 5-12. SUBCATCHMENT DATA

* * * * * S U B C A T C H M E N T D A T A * * * * *

SUBCATCH- MENT NO.	GUTTER OR INLET	WIDTH (FT)	AREA (AC)	PERCENT IMPERV.	SLOPE (FT/FT)	RESISTANCE FACTOR IMPERV.	RESISTANCE FACTOR PERV.	SURFACE STORAGE(IN) IMPERV.	SURFACE STORAGE(IN) PERV.	INFILTRATION RATE(IN/HR) MAXIMUM	INFILTRATION RATE(IN/HR) MINIMUM	INFILTRATION RATE(IN/HR) DECAY RATE	GAGE NO
1	5	5	900.0	7.	31.0	0.028	0.013	0.250	0.062	0.184	3.00	0.52	0.00115	1
2	6	6	672.0	9.	20.0	0.031	0.013	0.250	0.062	0.184	3.00	0.52	0.00115	1
3	7	7	8109.0	46.	32.0	0.044	0.013	0.250	0.062	0.184	3.00	0.52	0.00115	1
4	8	8	1700.0	16.	46.0	0.035	0.013	0.250	0.062	0.184	3.00	0.52	0.00115	1
5	9	9	1010.0	8.	17.0	0.020	0.013	0.250	0.062	0.184	3.00	0.52	0.00115	1
6	10	10	730.0	12.	10.0	0.025	0.013	0.250	0.062	0.184	3.00	0.52	0.00115	1
7	13	13	684.0	9.	46.0	0.025	0.013	0.250	0.062	0.184	3.00	0.52	0.00115	1
8	14	14	684.0	5.	37.0	0.025	0.013	0.250	0.062	0.184	3.00	0.52	0.00115	1
9	15	15	6.0	31.	0.0	0.030	0.013	0.250	0.062	0.184	3.00	0.52	0.00115	1
10	19	18	929.0	3.	47.0	0.025	0.013	0.250	0.062	0.184	3.00	0.52	0.00115	1
11	20	20	2583.0	12.	59.0	0.025	0.013	0.250	0.062	0.184	3.00	0.52	0.00115	1
12	22	22	3535.0	21.	58.0	0.025	0.013	0.250	0.062	0.184	3.00	0.52	0.00115	1
13	26	26	2364.0	12.	54.0	0.032	0.013	0.250	0.062	0.184	3.00	0.52	0.00115	1
14	27	27	1190.0	22.	58.0	0.035	0.013	0.250	0.062	0.184	3.00	0.52	0.00115	1
15	28	28	2370.0	9.	47.0	0.019	0.013	0.250	0.062	0.184	3.00	0.52	0.00115	1
16	30	30	7032.0	34.	42.0	0.019	0.013	0.250	0.062	0.184	3.00	0.52	0.00115	1
17	32	32	420.0	4.	24.0	0.025	0.013	0.250	0.062	0.184	3.00	0.52	0.00115	1
18	33	33	6359.0	47.	28.0	0.022	0.013	0.250	0.062	0.184	3.00	0.52	0.00115	1
19	38	38	13644.0	78.	43.0	0.018	0.013	0.250	0.062	0.184	3.00	0.52	0.00115	1
20	39	39	3100.0	5.	51.0	0.019	0.013	0.250	0.062	0.184	3.00	0.52	0.00115	1
21	40	40	2465.0	19.	57.0	0.019	0.013	0.250	0.062	0.184	3.00	0.52	0.00115	1
22	41	41	5554.0	25.	59.0	0.016	0.013	0.250	0.062	0.184	3.00	0.52	0.00115	1
23	42	42	1609.0	9.	59.0	0.018	0.013	0.250	0.062	0.184	3.00	0.52	0.00115	1
24	43	43	130.0	0.	51.0	0.008	0.013	0.250	0.062	0.184	3.00	0.52	0.00115	1
25	44	44	120.0	0.	51.0	0.007	0.013	0.250	0.062	0.184	3.00	0.52	0.00115	1
26	46	46	120.0	0.	51.0	0.012	0.013	0.250	0.062	0.184	3.00	0.52	0.00115	1
27	47	47	360.0	3.	45.0	0.005	0.013	0.250	0.062	0.184	3.00	0.52	0.00115	1
28	49	49	290.0	2.	45.0	0.007	0.013	0.250	0.062	0.184	3.00	0.52	0.00115	1
29	51	51	1633.0	17.	38.0	0.012	0.013	0.250	0.062	0.184	3.00	0.52	0.00115	1
30	53	53	598.0	18.	38.0	0.010	0.013	0.250	0.062	0.184	3.00	0.52	0.00115	1
31	54	54	780.0	14.	23.0	0.008	0.013	0.250	0.062	0.184	3.00	0.52	0.00115	1
32	55	55	210.0	1.	38.0	0.017	0.013	0.250	0.062	0.184	3.00	0.52	0.00115	1
33	56	56	210.0	1.	38.0	0.009	0.013	0.250	0.062	0.184	3.00	0.52	0.00115	1
34	57	57	1600.0	48.	23.0	0.012	0.013	0.250	0.062	0.184	3.00	0.52	0.00115	1
35	59	59	1200.0	32.	23.0	0.008	0.013	0.250	0.062	0.184	3.00	0.52	0.00115	1
36	60	60	1400.0	30.	23.0	0.006	0.013	0.250	0.062	0.184	3.00	0.52	0.00115	1
37	62	62	890.0	19.	23.0	0.006	0.013	0.250	0.062	0.184	3.00	0.52	0.00115	1
38	63	63	1100.0	6.	58.0	0.021	0.013	0.250	0.062	0.184	3.00	0.52	0.00115	1
39	64	64	2559.0	8.	58.0	0.014	0.013	0.250	0.062	0.184	3.00	0.52	0.00115	1
40	65	65	780.0	9.	49.0	0.009	0.013	0.250	0.062	0.184	3.00	0.52	0.00115	1
41	66	66	830.0	6.	54.0	0.010	0.013	0.250	0.062	0.184	3.00	0.52	0.00115	1
42	67	67	400.0	13.	51.0	0.018	0.013	0.250	0.062	0.184	3.00	0.52	0.00115	1
43	68	68	630.0	9.	45.0	0.010	0.013	0.250	0.062	0.184	3.00	0.52	0.00115	1
44	69	69	940.0	21.	43.0	0.008	0.013	0.250	0.062	0.184	3.00	0.52	0.00115	1
45	71	71	1020.0	2.	51.0	0.005	0.013	0.250	0.062	0.184	3.00	0.52	0.00115	1
46	72	72	7830.0	35.	57.0	0.014	0.013	0.250	0.062	0.184	3.00	0.52	0.00115	1
47	74	74	2250.0	14.	51.0	0.023	0.013	0.250	0.062	0.184	3.00	0.52	0.00115	1
48	76	76	290.0	2.	51.0	0.015	0.013	0.250	0.062	0.184	3.00	0.52	0.00115	1
49	77	77	3700.0	21.	51.0	0.021	0.013	0.250	0.062	0.184	3.00	0.52	0.00115	1
50	78	78	890.0	7.	61.0	0.012	0.013	0.250	0.062	0.184	3.00	0.52	0.00115	1
51	80	80	560.0	19.	56.0	0.024	0.013	0.250	0.062	0.184	3.00	0.52	0.00115	1
52	81	81	700.0	11.	58.0	0.018	0.013	0.250	0.062	0.184	3.00	0.52	0.00115	1
53	82	82	400.0	6.	63.0	0.007	0.013	0.250	0.062	0.184	3.00	0.52	0.00115	1
54	83	83	1690.0	8.	52.0	0.017	0.013	0.250	0.062	0.184	3.00	0.52	0.00115	1
55	84	84	1370.0	9.	56.0	0.020	0.013	0.250	0.062	0.184	3.00	0.52	0.00115	1
56	85	85	1400.0	11.	52.0	0.021	0.013	0.250	0.062	0.184	3.00	0.52	0.00115	1
57	86	86	1200.0	12.	24.0	0.015	0.013	0.250	0.062	0.184	3.00	0.52	0.00115	1
58	87	87	360.0	3.	39.0	0.003	0.013	0.250	0.062	0.184	3.00	0.52	0.00115	1
59	88	88	1810.0	29.	22.0	0.004	0.013	0.250	0.062	0.184	3.00	0.52	0.00115	1
60	89	89	290.0	2.	45.0	0.004	0.013	0.250	0.062	0.184	3.00	0.52	0.00115	1
61	90	90	1080.0	6.	40.0	0.004	0.013	0.250	0.062	0.184	3.00	0.52	0.00115	1
62	91	91	1150.0	30.	17.0	0.004	0.013	0.250	0.062	0.184	3.00	0.52	0.00115	1
63	92	92	340.0	3.	10.0	0.019	0.013	0.250	0.062	0.184	3.00	0.52	0.00115	1
64	93	93	2920.0	8.	23.0	0.011	0.013	0.250	0.062	0.184	3.00	0.52	0.00115	1
65	94	94	4160.0	20.	32.0	0.021	0.013	0.250	0.062	0.184	3.00	0.52	0.00115	1
66	95	95	5110.0	56.	22.0	0.021	0.013	0.250	0.062	0.184	3.00	0.52	0.00115	1

TOTAL NUMBER OF SUBCATCHMENTS, 66

TOTAL TRIBUTARY AREA (ACRES), 1014.00

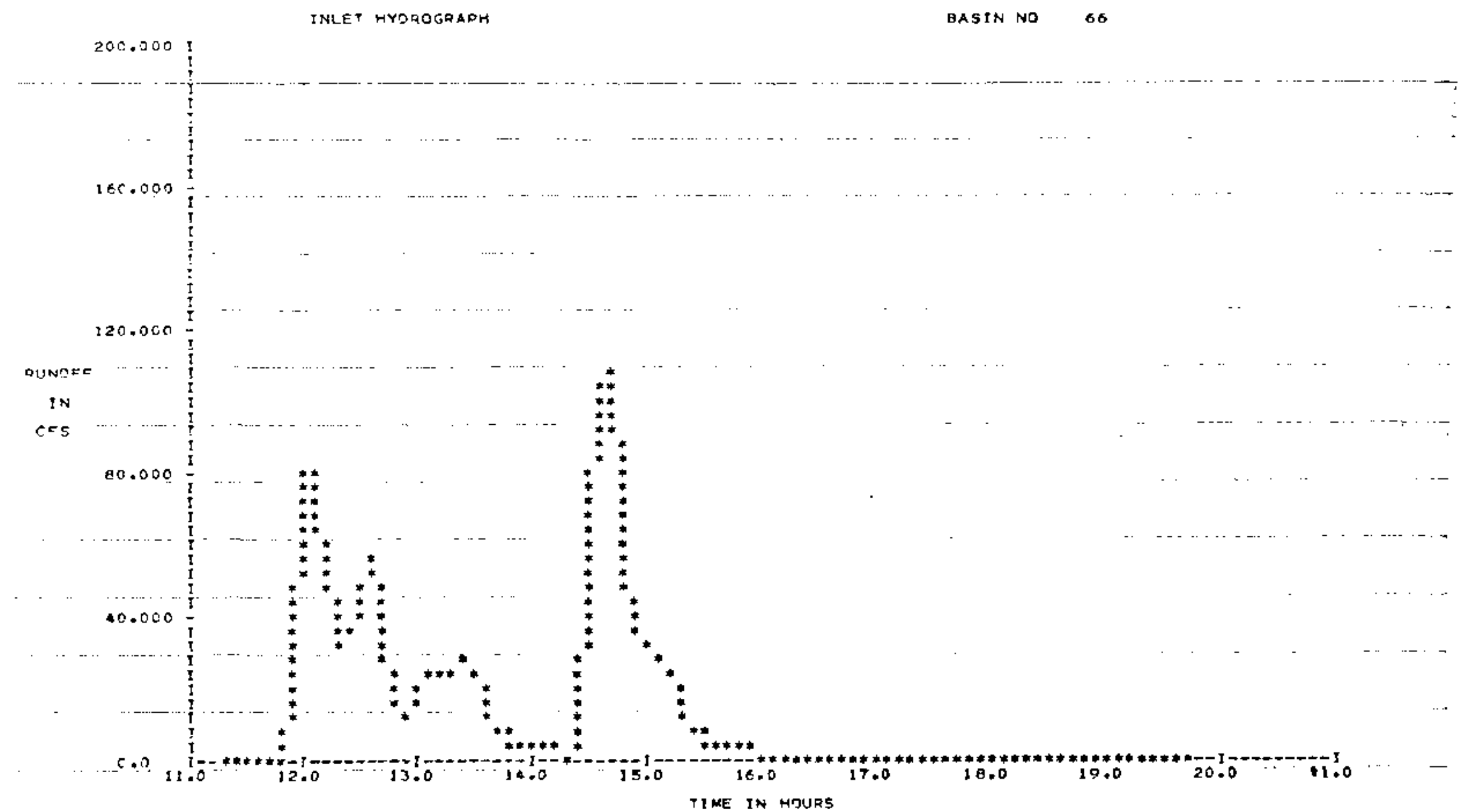

Figure 5-1.1. Inlet Hydrograph

Table 5-13. HYDROGRAPHS LISTED AND TOTAL FLOW COMPUTATIONS

HYDROGRAPHS WILL BE LISTED FOR THE FOLLOWING 10 GUTTERS OR INLETS

7	8	27	33	38	62	91	93	94	95

TOTAL RAINFALL (CU FT)	0.128749E 07
TOTAL INFILTRATION (CU FT)	0.807409E 06
TOTAL GUTTER FLOW AT INLET (CU FT)	0.416127E 06
TOTAL SURFACE STORAGE AT END OF STORM (CU FT)	0.644884E 05
ERROR IN CONTINUITY, PERCENTAGE OF RAINFALL.	-0.04155

Table 5-14. HYDROGRAPHS STORED AND QUALITY INPUT PARAMETERS

```
HYDROGRAPHS WILL BE STORED FOR THE FOLLOWING 66 INLETS

          5    6    7    8    9   10   13   14   15   18
         20   22   26   27   28   30   32   33   38   39
         40   41   42   43   44   46   47   49   51   53
         54   55   56   57   58   60   62   63   64   65
         66   67   68   69   71   72   74   76   77   78
         80   81   82   83   84   85   86   87   88   89
         90   91   92   93   94   95


     .....QUALITY SIMULATION INCLUDED IN THIS RUN.....


     INPUT PARAMETERS AS FOLLOWS

     NUMBER OF CONSTITUENTS          8

     NUMBER OF DRY DAYS            5.0

     STREET CLEANING FREQ          7.0 DAYS

     PASSES PER CLEANING             1

     STD CATCHBASIN VOLUME       16.04 FT3

     CATCHBASIN CONTENTS BOD     100.0 MG/L

     METHOD FOR CALCULATING SS:
       SPECIAL TECHNIQUE.
       SAME AS IN ORIGINAL
       RELEASE I OF THE SWMM.
       ISS = 1
```

Table 5-15. SUBCATCHMENT QUALITY DEFINITIONS

WATERSHED QUALITY DEFINITIONS

SUBAREA NUMBER		LAND USE CLASS.	TOTAL GUTTER LENGTH*10**2 FT.	NUMBER OF CATCHBASINS
1	5	3	23.10	7.00
2	6	3	29.70	9.00
3	7	3	152.00	46.00
4	8	1	52.80	16.00
5	9	1	26.40	8.00
6	10	1	39.60	12.00
7	13	1	29.70	9.00
8	14	1	16.50	5.00
9	15	4	19.80	6.00
10	18	1	9.90	3.00
11	20	1	39.60	12.00
12	22	2	69.30	21.00
13	26	2	39.60	12.00
14	27	2	72.60	22.00
15	28	1	29.70	9.00
16	30	1	112.20	34.00
17	32	1	13.20	4.00
18	33	1	155.00	47.00
19	38	1	258.00	78.00
20	39	1	16.50	5.00
21	40	1	52.70	19.00
22	41	1	82.50	25.00
23	42	1	29.70	9.00
24	43	2	1.30	0.40
25	44	2	1.00	0.30
25	46	4	1.00	0.30
27	47	2	9.90	3.00
28	49	2	6.60	2.00
29	51	1	56.10	17.00
30	53	2	59.40	18.00
31	54	2	46.20	14.00
32	55	3	3.30	1.00
33	56	4	3.30	1.00
34	57	5	32.80	48.00
35	58	5	35.20	32.00
36	60	3	99.00	30.00
37	62	3	59.40	18.00
38	63	1	19.80	6.00
39	64	1	26.40	8.00
40	65	1	29.70	9.00
41	66	1	19.80	6.00
42	67	1	42.80	13.00
43	68	1	29.70	9.00
44	69	1	69.30	21.00
45	71	1	6.60	2.00
46	72	1	115.50	35.00
47	74	1	46.20	14.00
48	76	1	6.60	2.00
49	77	1	69.30	21.00
50	78	1	23.10	7.00
51	80	1	62.70	19.00
52	81	1	36.30	11.00
53	82	4	19.80	6.00
54	83	1	26.40	8.00
55	84	1	29.70	9.00
56	85	4	36.30	11.00
57	86	3	39.60	12.00
58	87	1	9.90	3.00
59	88	1	95.70	29.00
60	89	1	6.60	2.00
61	90	1	19.80	6.00
62	91	1	99.00	30.00
63	92	4	3.30	3.00
64	93	1	26.40	8.00
65	94	1	66.00	20.00
66	95	1	185.00	56.00

Table 5-16. SUMMARY OF QUANTITY AND QUALITY RESULTS

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THIS IS A SUMMARY OF THE QUANTITY AND QUALITY RESULTS

     LANCASTER  PENNSYLVANIA  NORTH  DRAINAGE  DISTRICT
     STORM OF MARCH 22, 1972 DURATION 4 HRS. STUDY 3  (STORM #7)

NSTEP  NPTS  NQS  DELT      TZERO      TAREA
  100    10    8  300.    40800.0    1014.0

THE FOLLOWING INLET/GUTTER NUMBERS WILL BE PRINTED FOR SELECTED TIME STEPS
       7    8   27   33   38   62   91   93   94   95

*****  NOTE:  ONLY THE FIRST THREE POLLUTANTS ARE TRANSFERED TO OTHER BLOCKS.
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Table 5-17. QUANTITY AND QUALITY RESULTS AT A SPECIFIC LOCATION

LANCASTER PENNSYLVANIA NORTH DRAINAGE DISTRICT
STORM OF MARCH 22, 1972 DURATION 4 HRS, STUDY 3 (STORM #7)

SUMMARY OF QUANTITY AND QUALITY RESULTS AT LOCATION 62

FLOW IN CFS AND QUALITY IN MG/L (AND COLIF IN MPN/L)

TIME	FLOW	BOD	SUS-S	COLIF	COD	SET-S	NIT	PO4	GREASE
11 25.0	0.0	0.0	0.0	.0	0.0	0.0	0.0	0.0	0.0
11 30.0	0.0	0.0	0.0	.0	0.0	0.0	0.0	0.0	0.0
11 35.0	0.0	0.0	0.0	.0	0.0	0.0	0.0	0.0	0.0
11 40.0	0.0	0.0	0.0	.0	0.0	0.0	0.0	0.0	0.0
11 45.0	0.00	0.0	0.0	.0	0.0	0.0	0.0	0.0	0.0
11 50.0	0.06	38.22	6.52	.101E 07	23.21	1.67	0.55	0.07	0.60
11 55.0	0.19	44.58	25.40	.121E 07	27.68	2.00	1.45	0.17	0.71
12 0.0	0.57	44.57	108.09	.125E 07	28.69	2.14	5.19	0.54	0.74
12 5.0	0.72	53.31	271.39	.165E 07	37.95	3.00	12.64	1.29	0.97
12 10.0	0.62	53.93	335.10	.196E 07	44.97	3.62	15.59	1.59	1.15
12 15.0	0.53	39.85	276.68	.196E 07	45.07	3.60	12.96	1.33	1.16
12 20.0	0.42	32.43	219.46	.199E 07	45.61	3.62	10.39	1.07	1.17
12 25.0	0.41	24.96	166.13	.190E 07	41.22	3.27	7.94	0.82	1.06
12 30.0	0.44	21.60	157.40	.168E 07	38.50	3.08	7.52	0.78	0.99
12 35.0	0.56	20.06	176.12	.155E 07	35.49	2.90	8.33	0.86	0.91
12 40.0	0.53	22.35	219.79	.174E 07	39.95	3.33	10.34	1.06	1.02
12 45.0	0.34	23.25	206.30	.216E 07	49.48	4.09	9.84	1.02	1.27
12 50.0	0.24	17.43	114.33	.205E 07	47.13	3.85	5.68	0.60	1.21
12 55.0	0.17	14.45	69.11	.199E 07	45.55	3.70	3.63	0.40	1.17
13 0.0	0.19	10.86	46.50	.157E 07	36.07	2.94	2.50	0.28	0.92
13 5.0	0.24	10.60	54.36	.148E 07	33.96	2.79	2.83	0.31	0.87
13 10.0	0.25	12.01	68.89	.164E 07	37.64	3.11	3.53	0.38	0.97
13 15.0	0.25	11.79	69.10	.163E 07	37.48	3.11	3.49	0.38	0.96
13 20.0	0.25	11.57	67.11	.163E 07	37.32	3.12	3.44	0.37	0.96
13 25.0	0.29	10.92	67.81	.151E 07	34.69	2.92	3.45	0.37	0.89
13 30.0	0.28	11.95	77.40	.164E 07	37.72	3.20	3.91	0.42	0.97
13 35.0	0.20	12.92	71.00	.193E 07	44.24	3.75	3.70	0.40	1.13
13 40.0	0.15	11.28	44.73	.187E 07	42.97	3.64	2.50	0.28	1.10
13 45.0	0.11	10.32	30.21	.183E 07	42.07	3.56	1.84	0.22	1.08
13 50.0	0.09	9.71	21.69	.180E 07	41.35	3.51	1.45	0.18	1.06
13 55.0	0.07	9.31	16.42	.178E 07	40.79	3.46	1.20	0.15	1.05
14 0.0	0.06	9.03	13.03	.176E 07	40.33	3.43	1.04	0.13	1.03
14 5.0	0.05	8.82	10.74	.174E 07	39.94	3.40	0.94	0.12	1.02
14 10.0	0.04	8.67	9.15	.173E 07	39.62	3.37	0.86	0.12	1.02
14 15.0	0.03	8.54	8.00	.172E 07	39.35	3.35	0.81	0.11	1.01
14 20.0	0.03	8.44	7.14	.170E 07	39.11	3.33	0.77	0.11	1.00
14 25.0	0.06	5.71	5.86	.114E 07	26.20	2.23	0.56	0.08	0.67
14 30.0	0.39	5.56	24.61	.917E 06	21.03	1.82	1.35	0.15	0.54
14 35.0	0.82	10.63	105.24	.114E 07	26.22	2.42	5.04	0.52	0.57
14 40.0	1.02	16.56	202.20	.139E 07	31.79	3.22	9.47	0.97	0.82
14 45.0	0.95	19.14	239.36	.155E 07	35.60	3.74	11.18	1.14	0.91
14 50.0	0.65	17.35	219.84	.182E 07	41.66	4.25	10.37	1.07	1.07
14 55.0	0.49	14.41	134.14	.168E 07	38.51	3.78	6.48	0.68	0.99
15 0.0	0.41	11.91	92.27	.159E 07	36.49	3.54	4.57	0.48	0.94
15 5.0	0.35	10.49	69.53	.153E 07	35.10	3.40	3.53	0.38	0.90
15 10.0	0.32	9.61	56.06	.149E 07	34.11	3.31	2.91	0.32	0.87
15 15.0	0.26	9.52	47.02	.157E 07	35.93	3.49	2.53	0.28	0.92
15 20.0	0.19	9.37	34.41	.167E 07	38.34	3.71	1.99	0.23	0.98
15 25.0	0.14	8.52	21.51	.163E 07	37.32	3.61	1.40	0.17	0.96
15 30.0	0.11	8.01	14.38	.159E 07	36.55	3.54	1.07	0.13	0.94
15 35.0	0.08	7.68	10.18	.157E 07	35.95	3.48	0.87	0.11	0.92
15 40.0	0.07	7.46	7.59	.155E 07	35.47	3.44	0.75	0.10	0.91
15 45.0	0.06	7.31	6.21	.153E 07	35.08	3.41	0.68	0.09	0.90
15 50.0	0.05	7.20	5.28	.152E 07	34.76	3.39	0.64	0.09	0.89
15 55.0	0.04	7.11	4.64	.150E 07	34.49	3.35	0.60	0.09	0.88
16 0.0	0.03	7.04	4.18	.149E 07	34.25	3.33	0.58	0.08	0.88
16 5.0	0.03	6.99	3.85	.148E 07	34.05	3.32	0.56	0.08	0.87
16 10.0	0.02	6.94	3.60	.148E 07	33.88	3.30	0.55	0.08	0.87
16 15.0	0.02	6.90	3.42	.147E 07	33.72	3.29	0.54	0.08	0.86
16 20.0	0.02	6.86	3.27	.146E 07	33.58	3.27	0.53	0.08	0.86
16 25.0	0.02	6.83	3.16	.145E 07	33.45	3.26	0.53	0.08	0.86
16 30.0	0.02	6.81	3.07	.145E 07	33.34	3.25	0.52	0.08	0.85
16 35.0	0.01	6.78	3.00	.145E 07	33.24	3.24	0.52	0.08	0.85
16 40.0	0.01	6.76	2.94	.144E 07	33.15	3.24	0.51	0.08	0.85
16 45.0	0.01	6.74	2.90	.144E 07	33.07	3.23	0.51	0.08	0.85
16 50.0	0.01	6.72	2.86	.144E 07	32.99	3.22	0.51	0.08	0.85
16 55.0	0.01	6.71	2.82	.144E 07	32.92	3.22	0.51	0.08	0.84
17 0.0	0.01	6.69	2.80	.143E 07	32.86	3.21	0.50	0.07	0.84
17 5.0	0.01	6.68	2.77	.143E 07	32.80	3.21	0.50	0.07	0.84
17 10.0	0.01	6.67	2.75	.143E 07	32.74	3.20	0.50	0.07	0.84
17 15.0	0.01	6.66	2.74	.142E 07	32.69	3.20	0.50	0.07	0.84

RUNOFF CALIBRATION AND SENSITIVITY

In an overall urban runoff simulation, the origin of all flows and pollutants, aside from contributions by DWF or infiltration, occurs in the Runoff Block. Hence, an accurate representation of hydrographs and pollutographs at all points within the system depends heavily upon the Runoff results. For this reason, a special section is devoted to its calibration and sensitivity.

Calibration

A model that requires a large amount of input data, such as Runoff, generally needs calibration and verification because, in most cases, the user is unable to supply accurate values for every input parameter. Hence, default values are often used by the program. Default values represent values considered acceptable, in most cases, in lieu of better substitute information locally obtained. For example, infiltration rates, surface storage, and resistance factors are seldom measured in the field. Yet, the default values written into the program may not accurately represent the study area. When good flow measurements at selected inlets are available, input parameters may be adjusted until a good fit exists between the computed hydrographs and the measured transient flows. These measurements pertain only to a specific storm event. However, once the calibration efforts are completed for one storm event, little adjustment is needed for others. After adequate calibration and verification, any storm event occurring over the study area may be modeled by inserting the appropriate input hyetograph.

Sensitivity

In an application of the Runoff Model to the Washington, DC, metropolitan area, Graham, Costello, and Mallon (5) performed a sensitivity analysis to show the relative importance of model input parameters and identify the significant effects of imperviousness and specific curb length on the watershed BOD_5 washoff per storm.

Their report contains much useful information for the Runoff user and should be examined. They found that the greatest effect on both quantity and quality results was due to the interrelated parameters representing land use and characteristics of the impervious areas. Infiltration rates had a smaller effect, primarily on the total runoff volume.

It should be noted that an awareness of the sensitivity of the Model to input parameters is an invaluable aid towards a successful application, but it is not implied that a modification of all of these parameters is appropriate or valid in a calibration attempt. Modification of physical watershed parameters for which "accurate" measurements are available or obtainable from existing maps, would constitute a misrepresentation of the drainage basin. Comparison of computed quantity and quality with measured quantity and quality for a specific storm event may reveal the need for: (1) a more refined discretization of the physical system, (2) a more accurate evaluation of such factors as percent imperviousness and width of overland flow, and/or (3) a revision of the pollutant loading rates, catchbasin pollutant concentrations, and land use classifications.

Quantity Examples

The storm event of January 21, 1974, over the Stevens Avenue District, Lancaster, Pennsylvania, was chosen for these runs. One parameter at a time was varied, while all other input data remained constant. Assuming that a careful and thorough evaluation of physical data (such as area, ground slope, percent imperviousness) has been made, the user has flexibility to adjust seven quantity input parameters:

1) Resistance factor for impervious areas
2) Resistance factor for pervious areas
3) Surface storage on impervious areas
4) Surface storage on pervious areas
5) Maximum rate of infiltration
6) Minimum rate of infiltration
7) Decay rate of infiltration.

The resistance factor for impervious areas had little effect. A 100 fold increase in magnitude resulted in an 18 percent increase in surface storage, but resulted in only a 1.5 percent reduction of the total gutter flow (runoff volume). A 50 fold increase in the resistance factor for pervious areas had no effect. Impervious area surface storage (or detention depth) was more important: increasing its magnitude from 0.001 inch to 0.200 inch resulted in a 100 percent increase in surface storage, and an 18 percent decrease in the total gutter flow. The Model was totally insensitive to a 50 fold increase in the magnitude of the pervious area surface storage parameter. Variation of the maximum rate of infiltration from 1.50 inches per hour to 6.00 inches per hour produced no effects on runoff volume. Variation of the minimum rate of infiltration from 1.50 inches per hour to 0.01 inches per hour (holding the maximum rate and the decay rate constant) resulted in a net decrease of 8 percent in the total volume of infiltration. The runoff volume increased by 75 percent as a result of the decreased infiltration.

The relative effect of the maximum versus minimum infiltration rates is affected by the decay rate (DECAY). As DECAY is increased, the infiltration curve (Figure 5-4) moves rapidly towards its minimum value. As DECAY is decreased, the infiltration curve remains near its maximum value longer. These examples illustrate that the default value for DECAY leads to the former situation.

The results presented above pertain to a specific drainage basin (41 subcatchments, 134.59 acres) subjected to a specific storm event. Results will vary somewhat depending on the rainfall and the geomorphology of the drainage basin. However, the same parameters should remain sensitive on a relative basis. In summary, the Model is considered sensitive to the following quantity input parameters for calibration purposes:

1) Surface roughness for impervious areas

2) Detention depth for impervious areas

3) Maximum or minimum values of infiltration, the former only for values of the decay rate less than the default value.

<u>Quality Examples</u>

If the user has measured values that indicate different pollutant loadings from those given in Table 5-3, the new factors may be supplied through the BLOCK DATA subroutine (see Program Operation). An accurate computation of suspended solids requires erosion data. The most significant parameter in the quality simulation is land use classification, since the APWA loading rates are a function of land use types. Other important factors include: (1) the number of dry days preceding the storm event, (2) the street cleaning frequency and number of passes, (3) the volume of water trapped in the catchbasin between storm events, and (4) the BOD (COD) demand exerted by the trapped fluid in the catchbasin.

The number of dry days can be determined from rainfall records and should not be varied for calibration. The volume of trapped water in the catchbasins can usually be determined from sewer plans obtainable from the municipality. In the event of several catchbasin types, an average value may be used. If this estimate is not accurate, this paramèter may have to be adjusted during calibration. Few municipalities measure the catchbasin organic demand, thus the user should assume the default value and adjust this parameter according to the results. The street cleaning frequency and number of passes may also be obtained from the municipality.

Table 5-18 illustrates the effect of catchbasin volume and initial concentration on resulting concentrations for a sample run. Neither has a dramatic effect, and all catchbasin effects decay as the runoff continues, and disappear entirely after about the first hour of the storm, depending on its magnitude.

Table 5-18. EFFECT ON BOD CONCENTRATIONS (mg/l) OF DIFFERENT CATCHBASIN PARAMETERS

Volume (ft^3)	20	25	30	20	20	20
Initial concentration (mg/l)	150	150	150	50	100	200
Elapsed time (min)						
10	81.2	84.9	87.7	61.0	71.1	91.3
15	119.7	125.5	130.7	109.4	114.5	124.8
20	131.7	135.1	139.0	129.0	130.4	133.0
25	116.6	118.0	120.0	116.0	116.3	116.9
30	99.1	99.6	100.5	99.0	99.0	99.2
35	92.6	92.8	93.2	92.5	92.6	92.6
40	89.3	89.3	89.6	89.2	89.2	89.3
45	87.0	87.0	87.2	87.0	87.0	87.0
50	89.2	89.2	89.2	89.1	89.2	89.2

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SECTION 6

TRANSPORT BLOCK

BLOCK DESCRIPTION

Introduction

Flow routing through the sewer system is controlled in the Storm Water Management Model (SWMM) by subroutine TRANS which is called from the Executive Block program. TRANS has the responsibility of coordinating not only routing of sewage quantities but also such functions as routing of quality parameters (subroutine QUAL), estimating dry-weather flow (DWF) (subroutine FILTH), estimating infiltration (subroutine INFIL), and calling internal storage (subroutine TSTRDT). The relationships among the subroutines which make up the Transport Block are shown in Figure 6-1. The FORTRAN program is about 4,100 cards long, consisting of 25 subroutines and functions.

This section describes the Transport Block, provides instructions on data preparation, and furnishes examples of program usage.

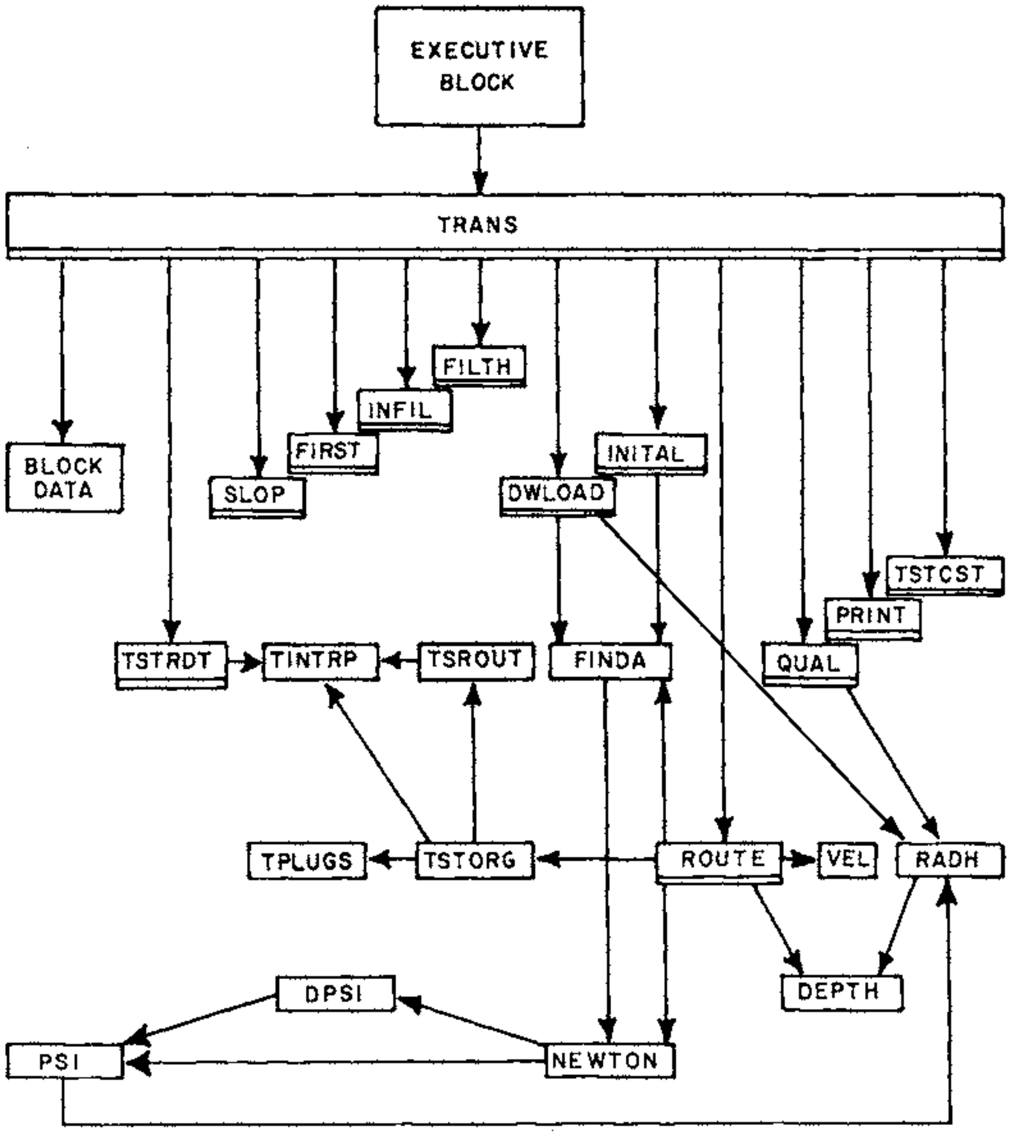
A description of each subroutine or function is contained in comment cards at the beginning of the subroutine in the program listing.

Instructions are provided for these subroutines requiring card input data, namely: transport, internal storage, infiltration, and DWF.

Examples, with sample I/O data, are given for transport, infiltration and DWF computations. Internal storage procedures are similar to those described in Section 7; hence, they are not presented here.

Broad Description of Flow Routing

To categorize a sewer system conveniently prior to flow routing, each component of the system is classified as a certain type of "element." All elements in combination form a conceptual representation of the system in a manner similar to that of links and nodes. Elements may be conduits, manholes, lift stations, overflow struc-



Note: Arrows point from the calling program to the called program. Boxes with double underline represent major subroutines.

Figure 6-1. Transport Block

tures, or any other component of a real system. Conduits themselves may be of different element types depending upon their geometrical cross-section (e.g., circular, rectangular, horseshoe). A sequencing is first performed (in subroutine SLOP) to order the numbered elements for computations. Flow routing then proceeds downstream through all elements during each increment in time until the storm hydrographs have been passed through the system.

The solution procedure basically follows a kinematic wave approach in which disturbances are allowed to propagate only in the downstream direction. As a consequence, backwater effects are not modeled beyond the realm of a single conduit, and downstream conditions (e.g., tide gates, diversion structures) will not affect upstream computations. Systems that branch in the downstream direction can be modeled using "flow divider" elements to the extent that overflows, etc., are not affected by backwater conditions. Surcharging is modeled simply by storing excess flows (over and above the full-flow conduit capacity) at the upstream manhole until capacity exists to accept the stored volume. Pressure-flow conditions are not explicitly modeled and no attempt is made to determine if ground surface flooding exists. However, a message is printed at each time step for each location at which surcharging occurs. The Transport routine has proven its ability to model accurately flows in most sewer systems, within the limitations discussed above, and as such it should be more than adequate for most applications. However, it will not accurately simulate systems with extensive interconnections or loops, systems that exhibit flow reversals or significant backwater effects, or systems in which surcharging must be treated as a pressure-flow phenomenon.

An option in the program is the use of the internal storage model which acts as a transport element. The model provides the possibility of storage-routing of the storm at one or two separate points within the sewer system (restricted by computer core capacity). The program routes the flow through the storage unit for each time-step based on the continuity equation in a manner analogous to flood routing through a reservoir. Extensive backwater conditions may thus be modeled by treating portions of the sewer system as a storage unit with a horizontal water surface. Entry to the internal storage subroutines is through TSTRDT (for data), TSTORG (for computations), and TSTCST (for cost).

Broad Description of Quality Routing

Contaminants are also handled by the Transport Block. Pollutants may be introduced to the sewer system by three means:

1) Storm-generated pollutographs computed by the Runoff Block[a] are transferred on tape/disk devices to enter the system at designated inlet manholes.

2) Residual bottom sediment in the pipes may be resuspended due to the flushing action of the storm flows (subroutine DWLOAD).

3) For combined systems, DWF pollutographs (subroutine FILTH) are also entered at designated inlet manholes.

The routing of the pollutants is then done for each time step by subroutine QUAL. The maximum number of contaminants that can be routed is four, although suspended solids, BOD and coliforms are the only ones commonly input from Runoff.

Program Operation

Most of the input to TRANS is related to data needed to describe the particular sewer system being modeled (e.g., dimensions, slopes, roughnesses, etc.) and parameters needed to solve the governing flow routing equations.

Following input of these data, the sewer elements are sequenced for computations in subroutine SLOP. Certain geometric and flow parameters are then initialized in subroutine FIRST while others are initialized in TRANS. The various program parameters and initialized variables describing the elements are then printed.

Element numbers at which storm hydrographs and pollutographs will enter the system are read from a tape/disk in the order in which hydrograph and pollutograph ordinates will be read at each time step from tape/disks. Parameters relating to the amount of data to be stored and printed out are also read (from cards).

If indicated, infiltration values will be calculated in subroutine INFIL and DWF quantity and quality parameters will be calculated in subroutine FILTH. Subroutine DWLOAD then initializes suspended solids deposition and subroutine INITIAL initializes flows and pollutant concentrations in each element to values corresponding to a condition of dry-weather flow and infiltration only.

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[a]Although only the Runoff Block will be mentioned in the text, the Transport Block can receive inputs from the Runoff, Storage/Treatment and Transport Block itself.

The main iterations of the program consist of an outer loop on time steps and an inner loop on element numbers in order to calculate flows and concentrations in all elements at each time step. Inlet hydrographs and pollutograph ordinates are read from a tape at each time step prior to entering the loop on element numbers.

When in the loop on element numbers (with index I), the current sewer element through which flows are to be routed, indicated by the variable M, is determined from the vector JR(I). This array is calculated in subroutine SLOP in a manner to insure that prior to flow routing in a given element, all flows upstream will have been calculated.

When calculating flows in each element, the upstream flows are summed and added to surface runoff, DWF, and infiltration entering at that element. These latter three quantities are allowed to enter the system only at non-conduits (e.g., manholes, flow dividers). If the element is a conduit, a check for surcharging is made. If the inflow exceeds the conduit capacity, excess flow is stored at the element just upstream (usually a manhole) and the conduit is assumed to operate at full-flow capacity until the excess flow can be transmitted. A message indicating surcharging is printed.

A simple hydraulic design routine is available at this point. If desired (NDESN = 1), when a surcharge condition is encountered, the conduit will be increased in size in standard increments (for circular pipes) or in six-inch width increments for rectangular conduits until capacity exists to accept the flow. (Conduits that are neither circular nor rectangular will be converted to circular if they need to be resized.) A message is printed indicating the resizing, and a table of final conduit dimensions is printed at the end of the simulation. This design operation will effectively eliminate surcharging but will also minimize in-system storage within manholes, etc. The net effect is to increase hydrograph peaks at the downstream end of the system. An obvious conflict can thus exist between controls aimed at curing in-system hydraulic problems and controls intended for pollution abatement procedures at the outfall.

Flows are routed through each element in subroutine ROUTE and quality parameters are routed in subroutine QUAL. When routing flows in conduits, ROUTE may be entered more than once depending upon the value of ITER, the number of iterations. It is necessary to iterate upon the solution in certain cases because of the implicit nature of calculating the energy grade line in ROUTE.

Upon completion of flow and quality routing at all time steps for all elements, TRANS then performs the task of outputting the various data. Hydrograph and pollutograph ordinates for the outfall point(s) are written onto tape for further use by the Executive Block, and subroutine PRINT is then called for printing outflows for any other desired elements.

INSTRUCTIONS FOR DATA PREPARATION

Instructions for data preparation for the Transport Block have been divided along the lines of the major components for clarity of the presentation. These components are: (1) Transport, (2) Internal Storage, (3) Infiltration and (4) Dry-Weather Flow. All data input card and tape/disk sources enter the Transport Block through one of these components. The typical data deck setup for the complete Transport Block is shown in Figure 6-2. Transport data describe the physical characteristics of the conveyance system. Internal Storage data describe a particular type of Transport element. Infiltration and DWF data describe the necessary drainage area characteristics to permit the computation of the respective inflow quantities and qualities.

(Data card preparation and sequencing instructions for the complete Transport Block are given at the end of these instructions in Table 6-6.)

Transport Block

Use of the Transport program involves three primary steps:

1) Preparation of theoretical data for use by subroutines engaged in hydraulic calculations in the program.

2) Preparation of physical data describing the combined sewer system.

3) Generation of inlet hydrographs and pollutographs required as input to the Transport Model and computational controls.

Data for Step 1 are supplied with the Storm Water Management program for 13 different conduit shapes, and it will only be necessary for the user to generate supplemental data in special instances. These instances will occur only when conduit sections of very unusual geometry are incorporated into the sewer system. Generation of such data will be discussed below.

The primary data requirements for the user are for Step 2, the physical description of the combined sewer system, i.e., the tabulation

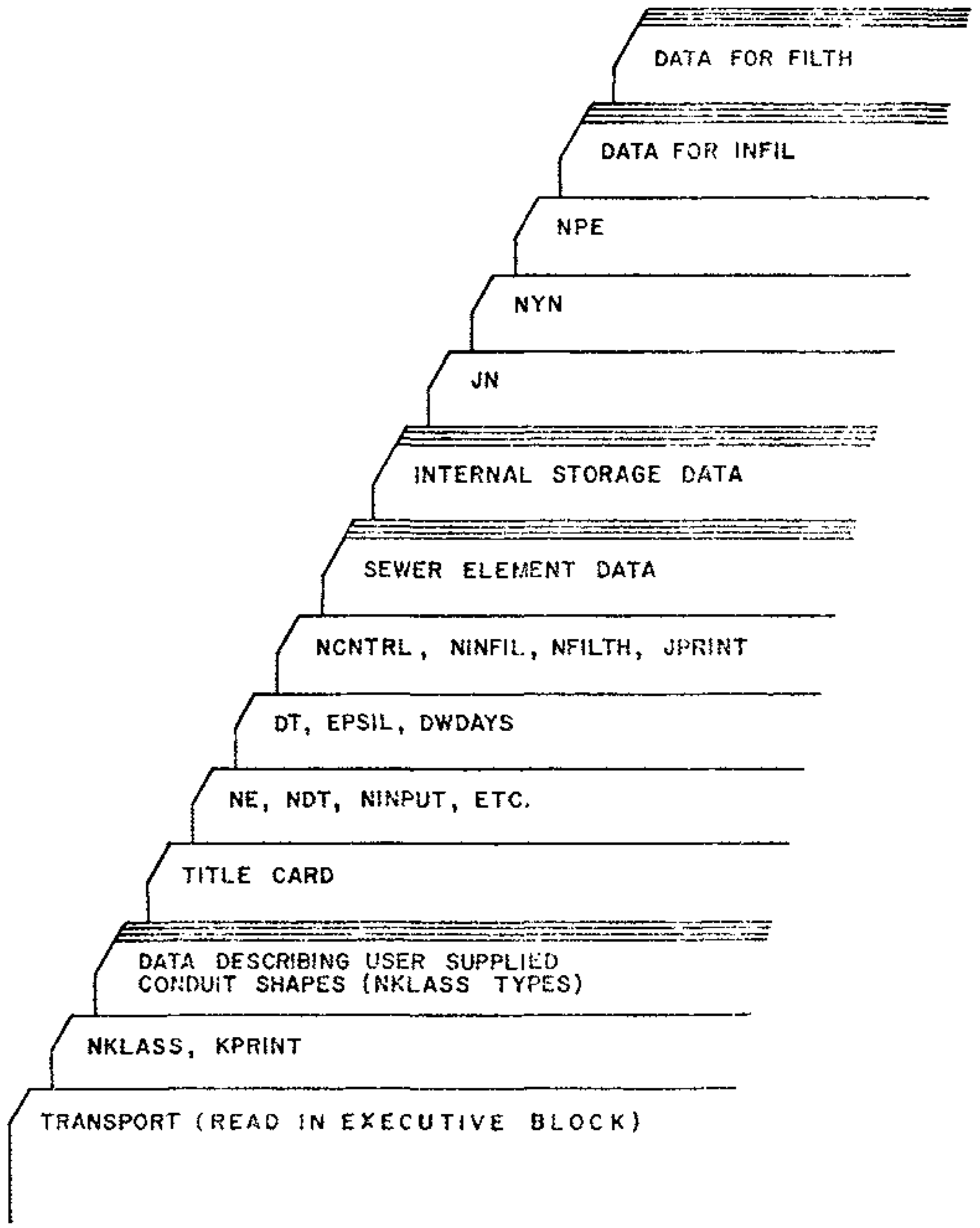


Figure 6-2. Data Deck for the Transport Block

of seven shapes, dimensions, slopes, roughness, etc., which will be discussed in detail below.

The data for Step 3 will be generated by the Runoff Block, described in Section 5 of this manual and by subroutine INFIL and FILTH.

Step 1. Theoretical Data --

The first data read by TRANS describe the number and types of different conduit shapes found in the system. Only in the case of a very unusual shape should it become necessary to generate theoretical data to supplement the data supplied by the program. The required data describe flow-area relationships of conduits, as shown in Figure 6-3 through the parameters ANORM and QNORM described below. A similar depth-area relationship is also required using the parameter DNORM.

The flow-area data are generated from Manning's equation, normalized by dividing by the corresponding equation for the conduit flowing full, denoted by the subscript f. Thus,

$$Q/Q_f = A*R**0.667/(A_f*R_f**0.667) = f(A/A_f) \qquad (6-1)$$

where Q = flow

A = flow area

R = hydraulic radius

For a given conduit shape (e.g., circular, rectangular, horseshoe), the hydraulic radius is a unique function of the area of flow; hence, Q/Q_f (interpolated between values of QNORM) is a function only of A/A_f (interpolated between values of ANORM). This function is tabulated for circular conduits in Appendix I of Reference 3, for example, and on page 443 of Reference 4 for a Boston horseshoe section. It is shown in graphical form for several conduit shapes in Chapter XI, Reference 8, from which some data supplied with this program have been generated. A list of the conduit shapes supplied with the Storm Water Management program as well as all other element types is given in Table 6-1. The conduits are illustrated in Figure 6-4. If y = depth of flow, values of y/y_f corresponding to A/A_f (ANORM) are tabulated as the variable DNORM.

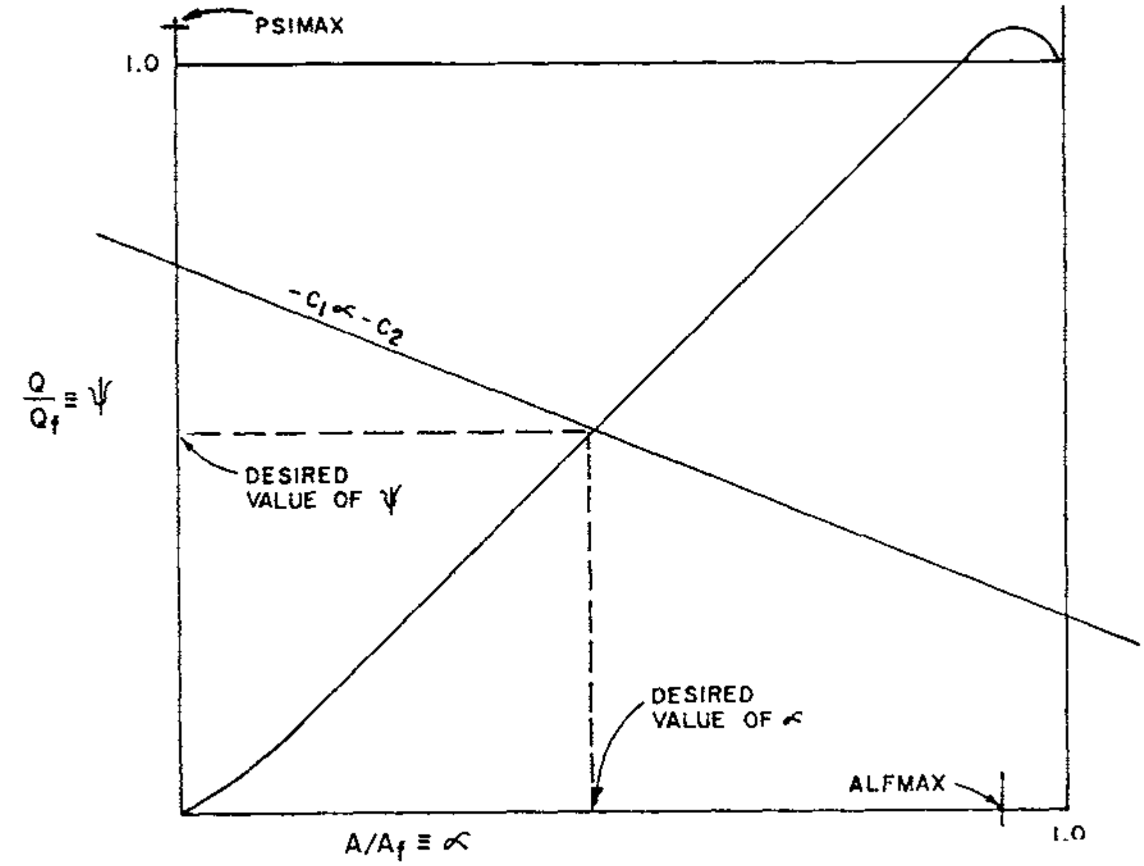


Figure 6-3. The Intersection of the Straight Line and the Normalized Flow-Area Curve as Determined in Route. The ψ-α Curve is Formed by Straight Line Segments Delineated by the Variables ANORM and QNORM, for Conduits with a Tabular Q-A Relationship. Q Denotes Flow, A Denotes Area, and the Subscript f Denotes Values at Full-Flow. The Line $-C_1 \alpha - C_2$ is Formed by the Program from the Continuity Equation.

It will often be satisfactory to represent a shape not included in Table 6-1 by one of similar geometry. This use of "equivalent" sewer sections will avoid the problem of generating flow-area and depth-area data. An equivalent section is defined as a conduit shape from Table 6-1 whose dimensions are such that its cross-sectional area and the area of the actual conduit are equal. Only very small errors should result from the flow routing when this is done.

If it is desired to have the exact flow-area and depth-area relationships, then the product $AR^{2/3}$ must be found as a function of area. In general, the mathematical description of the shape will be complex and the task is most easily carried out graphically. Areas may be planimetered, and the wetted perimeter measured to determine R. In addition, the depth may be measured with a scale. The required flow-area relationship of Equation 6-1 may then be tabulated as can the depth-area relationship. The number of points on the flow-area and depth-area curves required to describe the curves is an input variable (MM and NN, respectively). Note that the normalized flows (QNORM) and depths (DNORM) must be tabulated at points corresponding to MM-1 and NN-1, respectively, <u>equal</u> divisions of the normalized area axis (ANORM).

<u>Step 2. The Physical Representation of the Sewer System</u> --

These data are the different element types of the sewer system and their physical descriptions. The system must first be identified as a system of conduit lengths, joined at manholes (or other non-conduits). In addition, either real or hypothetical manholes should delineate significant changes in conduit geometry, dimensions, slope, or roughness. Finally, inflows to the system (i.e., stormwater, wastewater, and infiltration) are allowed to enter only at manholes (or other non-conduits). Thus, manholes must be located at points corresponding to inlet points for hydrographs generated by the Runoff Block and input points specified in subroutines FILTH and INFIL.

In general, the task of identifying elements of the sewer system will be done most conveniently in conjunction with the preparation of data for these other subroutines.

Each element (conduit or non-conduit) must be identified with a number which may range from 1 to 1000. They need not be sequential or continuous. Experience has shown that a schematic map showing

Table 6-1. DIFFERENT ELEMENT TYPES SUPPLIED WITH THE STORM WATER MANAGEMENT MODEL

NTYPE	
	Conduits
1	Circular
2	Rectangular
3	Phillips standard egg shape
4	Boston horseshoe
5	Gothic
6	Catenary
7	Louisville semielliptic
8	Basket-handle
9	Semi-circular
10	Modified basket-handle
11	Rectangular, triangular bottom
12	Rectangular, round bottom
13	Trapezoid
14, 15	User supplied
	Non-conduits
16	Manhole
17	Lift station
18	Flow divider
19	Storage unit
20	Flow divider
21	Flow divider
22	Backwater element

the complete sewer network and the numbering system will be very useful for debugging and identification purposes. It is difficult to rely upon detailed (and often cluttered) sewer plans alone.

Description of Conduits -- The 13 conduit shapes supplied with the *SWMM are shown in Figure 6-4.* For each shape, the required dimensions are illustrated in the figure and specified in Table 6-2. In addition, Table 6-2 gives the formula for calculating the total cross-sectional area of the conduit.

Usually, the shape and dimensions of the conduit will be indicated on plans. It is then a simple matter to refer to Figure 6-4 for the proper conduit type and dimensions. If the shape does not correspond to any supplied by the program, it will ordinarily suffice to choose a shape corresponding most nearly to the one in question. For example, an inverted egg can be reasonably approximated by a catenary section. The dimensions of the substitute shape should be chosen so that the area of the substitute conduit and that of the actual conduit are the same. This is facilitated by Table 6-2, in which the area is given as a function of the conduit dimensions. If desired, the flow-depth area parameters for up to three additional conduit shapes may be read in at the beginning of the program as discussed previously. (See also Card Group 2-10, Table 6-6.)

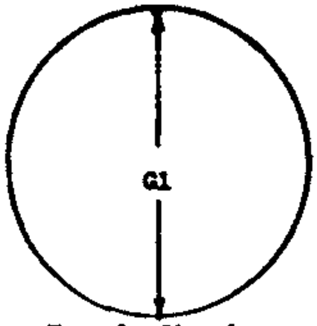
Occasionally, the conduit dimensions and area may be given, but the shape not specified. It will sometimes be possible to deduce the shape from the given information. For example, a conduit may have an area of 4.58 feet^2 (0.425 meters^2) and dimensions of 2 feet by 3 feet. First, assume that the 2 foot dimension is the width and the 3 foot dimension is the depth of the conduit. Second, note from Figure 6-4 that the ratio of depth to width for an egg-shaped conduit is 1.5:1. Finally, the area of an egg-shaped conduit of 3 foot depth is 0.5105 x 9 = 4.59 feet^2 (0.426 meters^2). It is concluded that the conduit should be type 3 with GEOM1 = 3 feet.

Because of the limits on the size of the computer program, it will usually not be possible to model every conduit in the drainage basin. Consequently, aggregation of individual conduits into longer ones will usually be the rule. Average slopes and sizes may be used provided that the flow capacity of the aggregate conduit is not significantly less than that of any portion of the real system. This is to avoid simulated surcharge conditions that would not occur in reality. In general, flow calculations are relatively insensitive to conduit

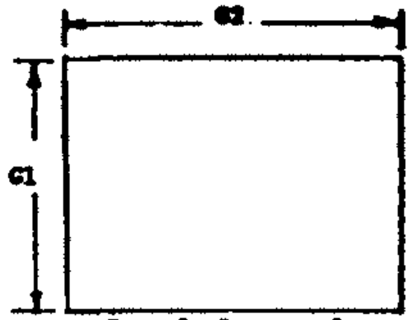
Table 6-2. SUMMARY OF AREA RELATIONSHIPS AND REQUIRED CONDUIT DIMENSIONS[a]

NTYPE	Shape	Area	Required dimensions (ft)
1	Circular	$(\pi/4)(G1)**2$	GEOM1 = Diameter
2	Rectangular	G1*G2	GEOM1 = Height GEOM2 = Width
3	Egg-shaped	$0.5105*(G1)^2$	GEOM1 = Height
4	Horseshoe	$0.829*(G1)^2$	GEOM1 = Height
5	Gothic	$0.655*(G1)^2$	GEOM1 = Height
6	Catenary	$0.703*(G1)^2$	GEOM1 = Height
7	Semielliptic	$0.785*(G1)^2$	GEOM1 = Height
8	Basket-handle	$0.786*(G1)^2$	GEOM1 = Height
9	Semi-circular	$1.27*(G1)^2$	GEOM1 = Height
10	Modified basket-handle	$G2(G1+(\pi/8)G2)$	GEOM1 = Side height GEOM2 = Width
11	Rectangular, triangular bottom	G2(G1-G3/2)	GEOM1 = Height GEOM2 = Width GEOM3 = Invert height
12	Rectangular, round bottom	Θ = 2*ARSIN *(G2/(2G3)) Area = G1*G2 + (G3)**2/2 *(Θ-SIN(Θ))	GEOM1 = Side height GEOM2 = Width GEOM3 = Invert radius
13	Trapezoidal channel	G1(G2+G1/G3)	GEOM1 = Depth GEOM2 = Bottom width GEOM3 = Side slope (vertical/horizontal)

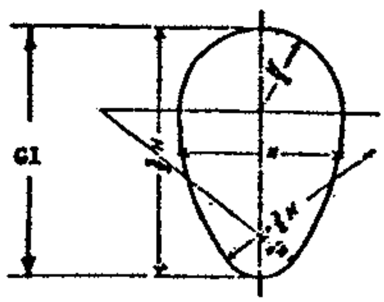
[a]Refer to Figure 6-4 for definition of dimensions, G2, and G3. Note that G1 ≡ GEOM1, G2 ≡ GEOM2, G3 ≡ GEOM3.



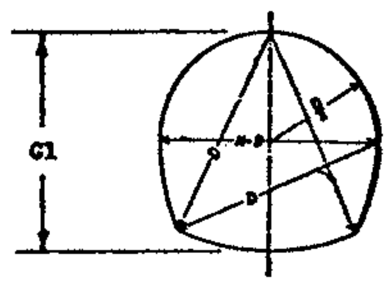
Type 1: Circular



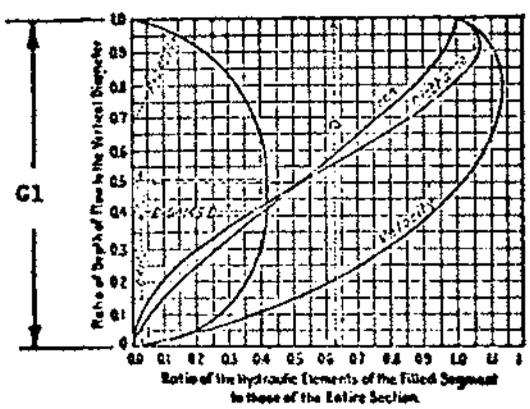
Type 2: Rectangular



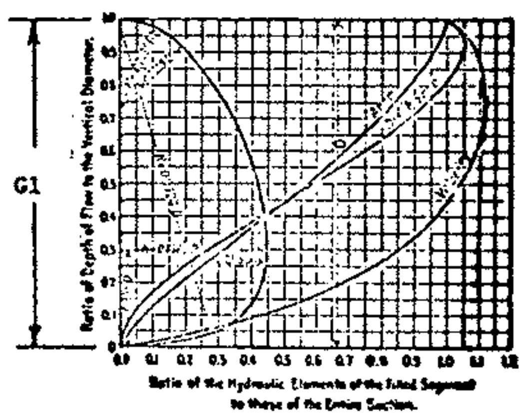
Type 3: Phillips Standard Egg Shape



Type 4: Boston Horseshoe

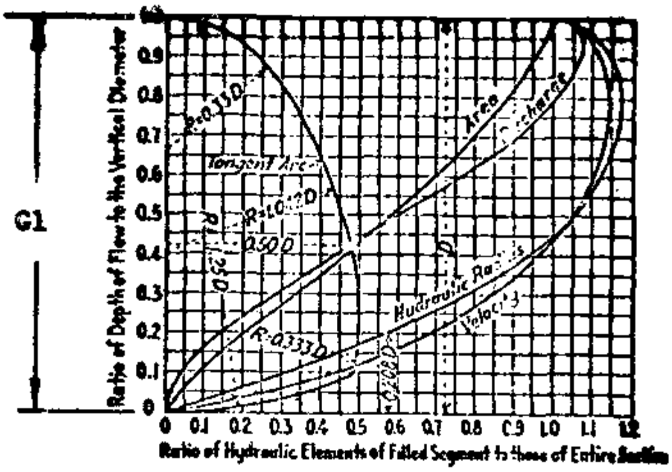


Type 5: Gothic

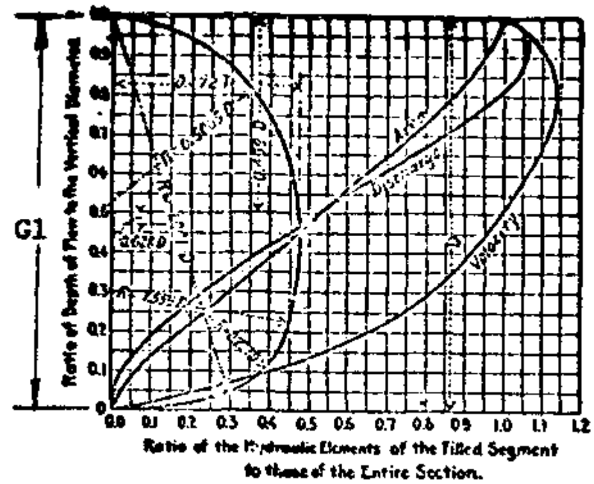


Type 6: Catenary

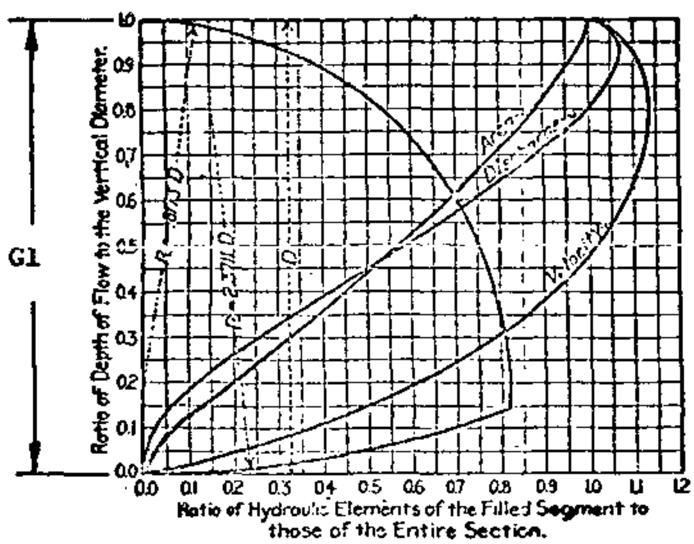
Figure 6-4. Sewer Cross-Sections



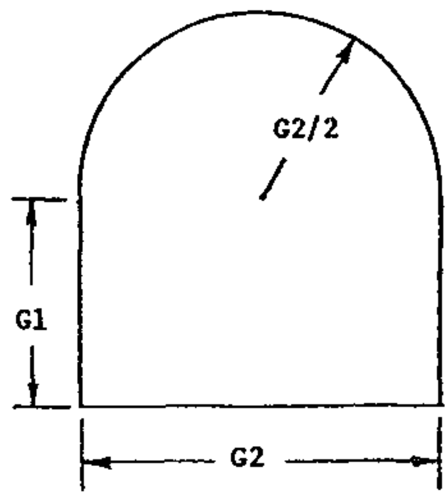
Type 7: Louisville Semielliptic



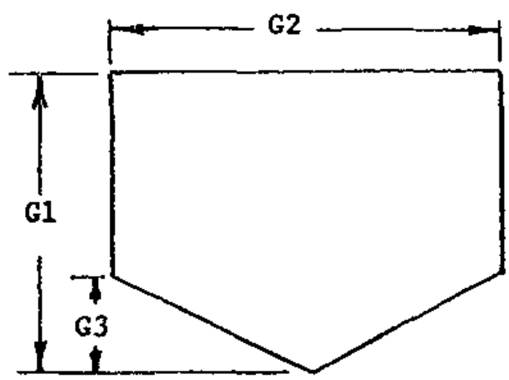
Type 8: Basket-handle



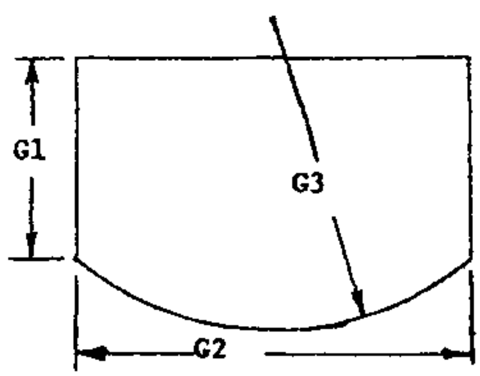
Type 9: Semi-circular



Type 10: Modified Basket-handle



Type 11: Rectangular, Triangular Bottom



Type 12: Rectangular, Round Bottom

Figure 6-4 (continued). Sewer Cross-Sections

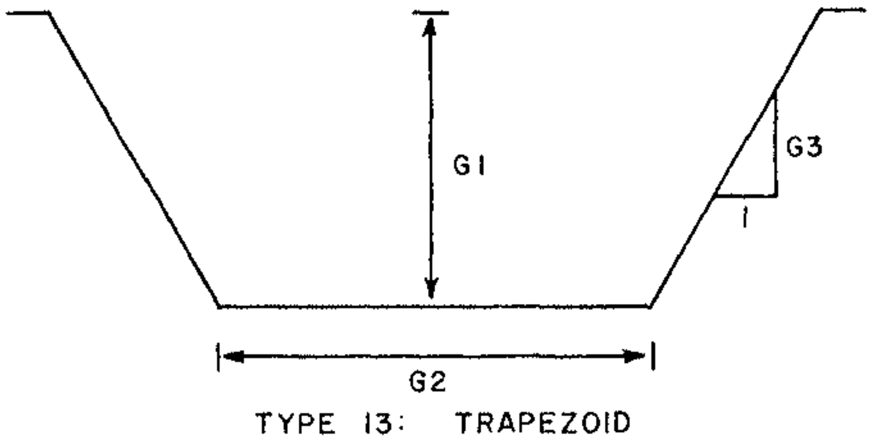


Figure 6-4 (continued). Sewer Cross-Section lengths although with conduits over 4000 to 5000 feet (1200 meters and 1500 meters) long some loss of routing accuracy will result. Conduit lengths should always be separated by manholes (or other non-conduit type elements). The conduit length should be measured from the center of the adjacent manholes. A further means of simulating large systems lies in simulating different portions with separate Transport runs and combining the results using the Combine Block (see Section 4).

Values of Manning's roughness may be known by engineers familiar with the sewer system. Otherwise, they may be estimated from tables in many engineering references (e.g., References 1, 3, 4, 6) as a function of the construction material and sewer conditions. The value may be adjusted to account for losses not considered in the routing procedure (e.g., head losses in manholes or other structures, roots, obstructions). However, the flow routing is relatively insensitive to small changes in Manning's n.

Description of Non-Conduits -- The sewer system consists of many different structures, each with its own hydraulic properties. Elements 16 through 22 are designed to simulate such structures. Data requirements for these elements are given in Table 6-3. Brief descriptions of these elements follow.

Manholes (NTYPE = 15) -- No data are required for manholes except their numbers and upstream element numbers. Note that the number of upstream elements is limited to three. If more than three branches of the system should join at a point, two manholes could be placed in series, allowing a total of five branches to joint at that point, etc. Flow routing is accomplished in manholes by specifying that the outflow equals the sum of the inflows.

Lift Stations (NTYPE = 17) -- The data requirements for lift stations are given in Table 6-3. It is assumed that the force main will remain full when the pump is not operating, resulting in no time delay in the flow routing (i.e., no time is required to fill the force main when the pump starts). When the volume of sewage in the wet well reaches its specified capacity, the pumps begin to operate at a constant rate. This continues until the wet well volume equals zero.

Flow Dividers (NTYPE = 18 and 21) -- The routing procedure through these elements is explained in the discussion below. Typical uses are given.

Table 6-3. PARAMETERS REQUIRED FOR NON-CONDUITS

NTYPE	Description	Dist	GEOM1	Slope	Rough	GEOM2	Barrel	GEOM3
16	Manhole	N.R.[a]	N.R.	N.R.	N.R.	N.R.	N.R.	N.R.
17	Lift station	Pumping rate, assumed constant (cfs).	Volume in wet well at which pumps will start (cfs).	N.R.	N.R.	N.R.	N.R.	N.R.
18	Flow divider	N.R.	Maximum undiverted flow. Inflow in excess of this value is diverted (cfs).	N.R.	N.R.	N.R.	N.R.	Number of element into which flows the undiverted flow (include decimal point).
19	Storage unit[b]	N.R.	N.R.	N.R.	N.R.	N.R.	N.R.	If parameter ISTOUT = 9 for storage unit, GEOM3 = number of element into which flows the outflow from the orifice outlet. Other wise, N.R.
20	Flow divider	Maximum inflow without flow over the weir (cfs).	Weir height, above zero flow depth (ft).	Maximum inflow through whole structure (cfs).	Weir constant times weir length (ft).	Depth in structure at time of maximum inflow (ft).	N.R.	Number of element into which flows the undiverted flow (weir flow is the diverted flow).
21	Flow divider	N.R.	N.R. (assigned in program)	N.R.	N.R.	N.R.	N.R.	Number of element into which flows the undiverted flow.
22	Backwater element	N.R.	N.R.	N.R.	N.R.	N.R.	N.R.	Element number of downstream storage unit.

[a]N.R. = Not Required.

[b]Additional parameters are read in subsequently.

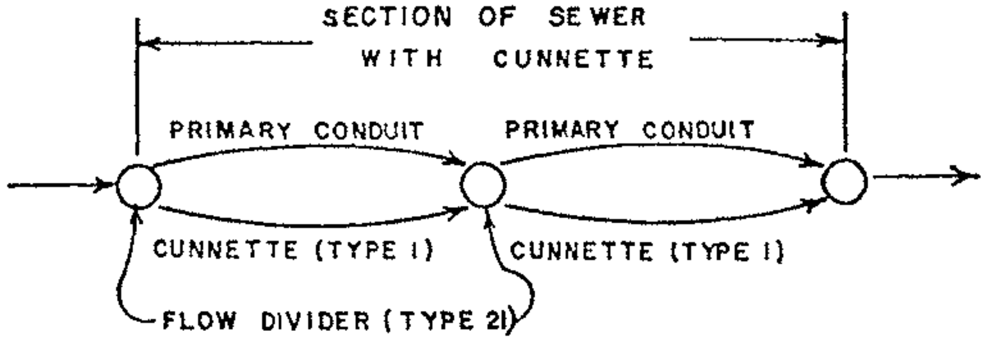
NOTE: All elements require an element under (NOE), three upstream element numbers (NUE), and type (NTYPE). Parameters for conduits are defined in Table 6-2.

1) Simple diversion structure -- A type 18 flow divider may be used to model a diversion structure in which none of the flow is diverted until it reaches a specified value (GEOM1). When the inflow is above this value, the non-diverted flow (QO1) remains constant at its capacity, GEOM1, and the surplus flow (QO2) is diverted.

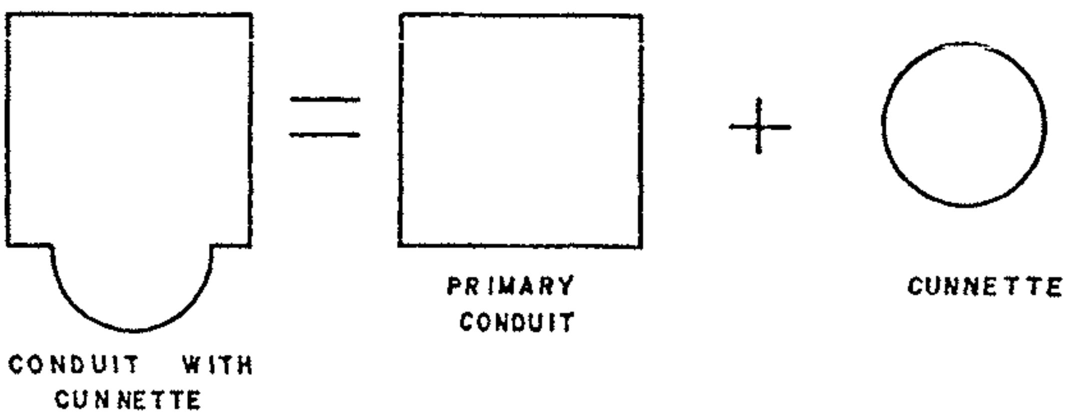
2) Cunnette section -- A type 21 flow divider may be used to model a downstream cunnette section. The cunnette section is considered as a separate circular conduit to be placed parallel to the primary conduit as shown in Figure 6-5. In order to model the cunnette as a semi-circle, the separate circular conduit is given a diameter (GEOM1) so that its area will be twice that of the actual total cunnette flow area. (The distance, slope and roughness will be the same as for the primary conduit.) A type 21 flow divider is then the upstream element common to both conduits, as shown in Figure 6-5. (The program assigns a value of GEOM1 of the flow divider equal to half the full flow capacity of the circular pipe simulating the cunnette so that it has the hydraulic characteristics of a semi-circle.) Any flow higher than GEOM1 will be diverted to the primary conduit. Note that the parameter GEOM3 of the flow divider will be the element number assigned to the cunnette section. Note further that the element downstream from the two parallel conduits must list them both as upstream elements.

Routing at Flow Dividers (NTYPE = 18 and 21) -- Both types will divide the inflow, QI, into two outflows, QO1 and QO2. The divider then acts as follows:

$$\begin{array}{lll} \text{For } 0 \le QI \le GEOM1, & QO1 = QI & \\ & QO2 = 0.0 & \\ & & (6\text{-}2) \\ \text{For } GEOM1 \le QI, & QO1 = GEOM1 & \\ & QO2 = QI - GEOM1 & \end{array}$$



a. SCHEMATIC OF HYPOTHETICAL FLOW DIVISION



b. SPLIT OF CONDUIT INTO PRIMARY CONDUIT AND CUNNETTE

Figure 6-5. Cunnette Section

The undiverted outflow, QO1, will flow into the downstream element denoted by GEOM3. (The element into which QO2 flows does not need to be specified.)

Flow Divider (NTYPE = 20) -- This element is used to model a weir-type diversion structure in which a linear relationship can adequately relate the flow rate and the depth of flow into the weir structure. Input parameters are defined in Table 6-3. The weir constant, incorporated into the variable ROUGH, can be varied to account for the type of weir. Typical values of the weir constant are 3.3 for a broad crested weir and 4.1 for a side weir .

The flow divider behaves as a function of the inflow, QI, as follows:

For Q ≤ QI ≤ DIST, QO1 = QI
QO2 = 0.0

For DIST ≤ Q1, QO1 and QO2 are computed as follows:

1) Compute depth of flow above the weir, assuming a linear flow-depth relationship:

   DH = (QI-DIST)*(GEOM2-GEOM1)/(SLOPE-DIST)

2) Compute the diverted flow from the weir formula:

   QO2 = ROUGH*DH**1.5

3) Compute the undiverted flow:

   QO1 = QI - QO2

Storage Unit (NTYPE 19) -- This element is specified only when internal storage computations are required. The supporting data must have been fed previously into the program (subroutine TSTRDT). The inflowing pollutant concentrations are determined first. Then quantity and quality routing are accomplished in subroutine TSTORG, and its subroutines: TSROUT and TPLUGS. Subroutine TSTORG is called from ROUTE each time step to compute movements within the storage unit. TSROUT provides the hydraulic routing computation and

TPLUGS traces and identifies the plug elements when the plug flow-through option is selected. If the alternate option, complete mixing, is selected, necessary computations are completed within TSTORG. A more comprehensive description of the storage routine is presented in Section 7 of this manual.

A storage unit may be placed anywhere in the sewer system where appreciable storage may exist, such as at an outflow or diversion structure. The required data inputs are described later. It should be noted that the storage area or "reservoir" now consists of a portion of the sewer system itself, and area-depth relationships must be worked out accordingly.

Backwater Element (NTYPE = 22) -- This element may be used to model backwater conditions in a series of conduits due to a flow control structure downstream. The situation is modeled in a manner analogous to reservoir flood routing as follows:

1) A storage element (NTYPE 19) is placed at the location of the control structure. The type of storage element will depend upon the structure (i.e., weir, orifice, or combination of weir and orifice). One inflow to this storage element is then from the conduit just upstream.

2) If the water surface is extended horizontally upstream from the flow control structure at the time of maximum depth at the structure, it will intersect the invert slope of the sewer at a point corresponding to the assumed maximum length of backwater. The reach between this point and the structure may encompass several conduit lengths. A backwater element (NTYPE 22) is placed at this point of maximum backwater, in place of a manhole, for instance.

3) The backwater element then diverts flow directly into the storage element depending upon the volume of water (and hence, the length of backwater) in the storage element. If the backwater extends all the way to the backwater element, the total flow is diverted to the storage element; none is diverted to the conduits.

4) The amount of diverted flow (QO1) is assumed directly proportional to the length of the backwater. The storage area in reality consists of the conduits. Since most conduits can be assumed to have a constant width, on the average, the backwater length is assumed proportional to the square root of the current storage volume, obtained from the storage routine.

5) The parameter GEOM3 of the backwater element must contain the element number of the downstream storage unit.

6) Parameters for the storage element are read in as usual. Note that the depth-area values will correspond to the storage area of the upstream conduits. Note also that the storage unit must list the backwater element as one of its upstream elements, as well as the conduit immediately upstream.

7) At each time step, the backwater element computes the ratio of current to maximum storage volume in the downstream storage element. Call this ratio r. Then

QO1 = QI*r**0.5

and (6-4)

QO2 = QI - QO1

where QO1 = flow directly into storage unit

QO2 = flow into intermediate conduits

QI = inflow to backwater element

Step. 3. Input data and Computational Controls --

The basic input data, hydrographs and pollutographs are generated outside of the Transport Model. However, certain operational controls are available within Transport.

Choice of Time Step (DT) -- The size of the time step must be chosen to coincide with the spacing of the ordinates of the inflow hydrographs and pollutographs. In tests of sensitivity, it was found that except for very small values of DT (10 seconds), the output from Transport is insensitive to the length of the time step. Between values of two minutes and 30 minutes, hydrograph ordinates varied by less than one percent. For extremely short time step values, the peak flow moved downstream faster and never attained the maximum value that it had with a DT of two minutes and longer. Within the range commonly needed by SWMM users (two minutes to 30 minutes), the choice of time step will not significantly affect results.

Choice of Number of Time Steps (NDT) -- The total number of time steps should not be less than the number used in the Runoff Block nor greater than 150.

Choice of Number of Iterations (NITER) -- The purpose of iterations in the computations is to eliminate flow oscillations in the output. The flatter pipe slopes (less than 0.001 ft/ft) require iterations of the flow routing portion of the Transport Model to help dampen these oscillations. Four iterations have proven to be sufficient in most cases.

Choice of Allowable Convergence Error (EPSIL) -- Convergence of the flow routing procedure should not be any problem, and the default value for EPSIL, 0.0001, may be used. It will provide sufficient accuracy and result in only a very minimal increase in computer time over larger values. The only convergence problems that may exist can occur when flow enters a dry conduit. For instance, this could occur at the beginning of a storm in a storm-sewered area with no infiltration. Messages to this effect will be printed if parameter NPRINT $\neq$ 0. These may almost always be ignored since the default options in subroutine ROUTE will continue program execution and only result in a very small error in continuity (a fraction of a percent).

Alternate Hydrograph and Pollutograph Inputs -- Hydrograph and pollutographs may be entered from a tape/disk file (e.g., as generated in the Runoff Block) or, alternatively, entered from cards, using card groups 28, 46 and 47 in Table 6-6. Parameter NCNTRL on card 14 is set accordingly. Note that input from both cards and tape/disk may not be performed simultaneously. If, for some reason, input from cards is not desired, a tape/disk file containing the specified input values could be created and specified as an input file to Transport in place of, say, a file generated by the Runoff Block. These data and their sequence can be determined from the tape/disk read statements in subroutine TRANS.

Internal Storage Model

Use of the internal storage routine involves five basic steps. A somewhat more detailed data description may be found in Section 7.

Step 1. Call --

The internal storage routine is called by subroutine TRANS when element NTYPE 19 is specified. No more than two locations may be specified in a single run.

Step 2. Storage Description: Part 1 --

Describe the storage unit node (inline); construction (natural, manmade and covered, manmade and uncovered); and type of outlet device (orifice, weir, or pumped). A manmade unit is assumed to have the shape of an (inverted) truncated right circular cone.

Step 3. Output --

Select output and computational options according to the following:

1) Flow routing by plug flow or complete mixing;

2) Complete printout or suppressed; and

3) Costs estimated or cost suppressed.

Step 4. Description: Part 2 --

Describe the basin flood depth and geometry. Describe design parameters of outlet control. Describe initial conditions in basin.

Step 5. Unit Costs --

Specify unit costs to be used if cost output is desired. The sequence of cards and choices (Steps 2-5) are repeated for each storage basin location.

Infiltration Model

The infiltration program, INFIL, has been developed to estimate infiltration into a given sewer system based upon existing information about the sewer, its surrounding soil and groundwater, and precipitation. It should be bourne in mind throughout that the accuracy of infiltration prediction is dependent upon the accuracy and extent of data descriptive of infiltration in the system being modeled.

Using these data, INFIL has been structured to estimate average daily infiltration inflows at discrete locations along the trunk sewers of a given sewer system. A typical urban drainage basin in which infiltration might be estimated is shown in Figure 6-6.

Since the Storm Water Management Model's principal use will be to simulate individual storms which cover a time period of less than a day, average daily estimates from INFIL are calculated only once prior to sewer flow routing. INFIL is called from subroutine TRANS by setting the variable, NINFIL, equal to 1, thus signaling the computer to estimate infiltration.

For the purposes of analysis, infiltration is classified into four categories, i.e., miscellaneous sources causing a base dry weather inflow, frozen residual moisture, antecedent precipitation, and high groundwater. The cumulative effects of the first three sources can be seen in Figure 6-7 which excludes surface runoff. Figure 6-7 shows total infiltration QINF as the sum of dry weather infiltration DINFIL, wet weather infiltration RINFIL, and melting residual ice and frost infiltration SINFIL. However, in cases where the groundwater table rises above the sewer invert, it is assumed that groundwater inflow GINFIL alone will be the dominant source of infiltration. Thus, infiltration is defined as:

$$\text{QINF} = \begin{cases} \text{DINFIL} + \text{RINFIL} + \text{SINFIL} \\ \text{or} \\ \text{GINFIL for high groundwater table} \end{cases} \qquad (6\text{-}5)$$

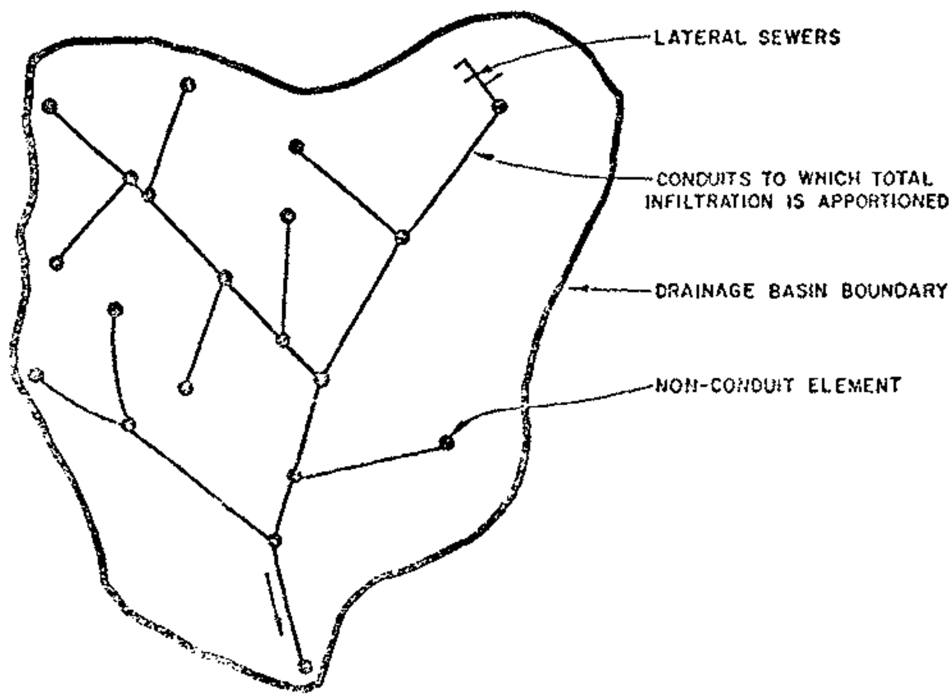
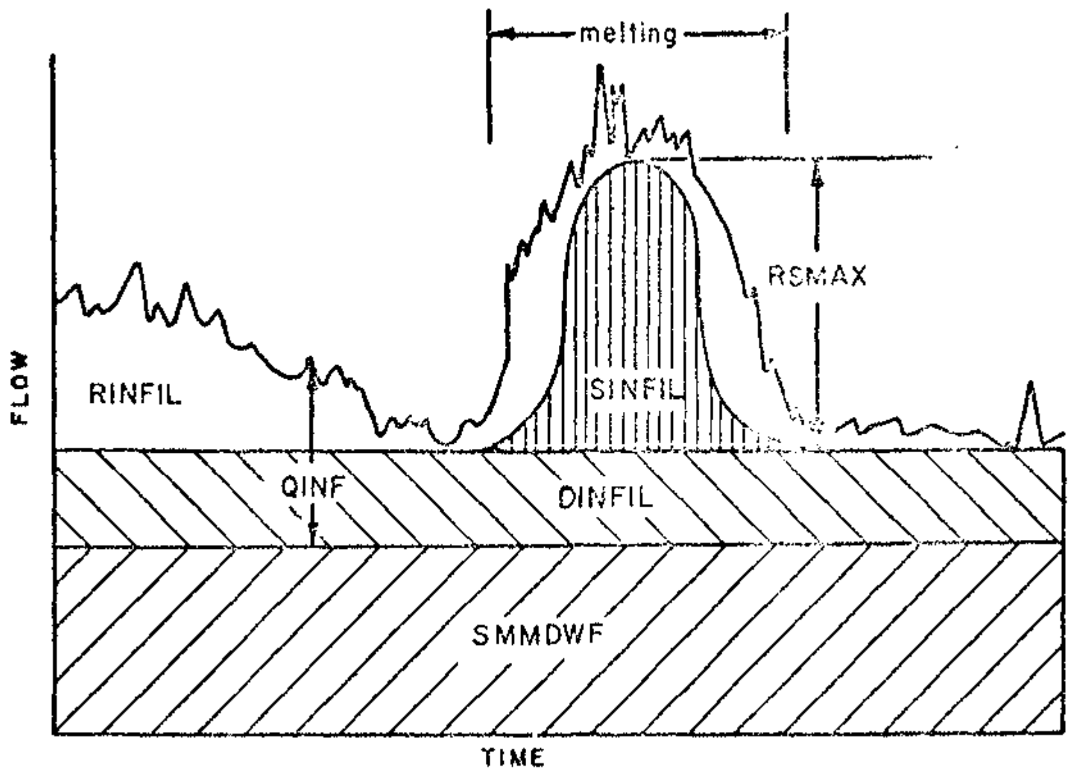


Figure 6-6. Typical Drainage Basin in which Infiltration is to be Estimated



QINF = Total infiltration
DINFIL = Dry weather infiltration
RINFIL = Wet weather infiltration
SINFIL = Melting residual ice and snow infiltration
RSMAX = Residual moisture peak contribution
SMMDWF = Accounted for sewage flow

Figure 6-7. Components of Infiltration

Throughout subroutine INFIL, observations and estimates based upon local data are given preference over generalized estimates for infiltration. Thus, the hierarchy for basing estimates is:

1) Use historical data for the study area under consideration;

2) Use historical data for a nearby study area and adjust results accordingly;

3) Use estimates of local professionals; and

4) Use generalized estimates based upon country-wide observations.

Dry Weather Infiltration (DINFIL) --

If the study area under consideration has been gaged, base dry weather infiltration can be taken by inspection from the flow data. In the absence of flow data, an estimate of the unit infiltration rate XLOCAL (gpm/inch - diameter/mile) for dry weather must be obtained from local professionals. From data in the form of calculated values of DIAM and PLEN, Equation 6-6 can then be used to determine DINFIL:

$$\text{DINFIL} = \text{XLOCAL*DIAM*PLEN} \qquad (6\text{-}6)$$

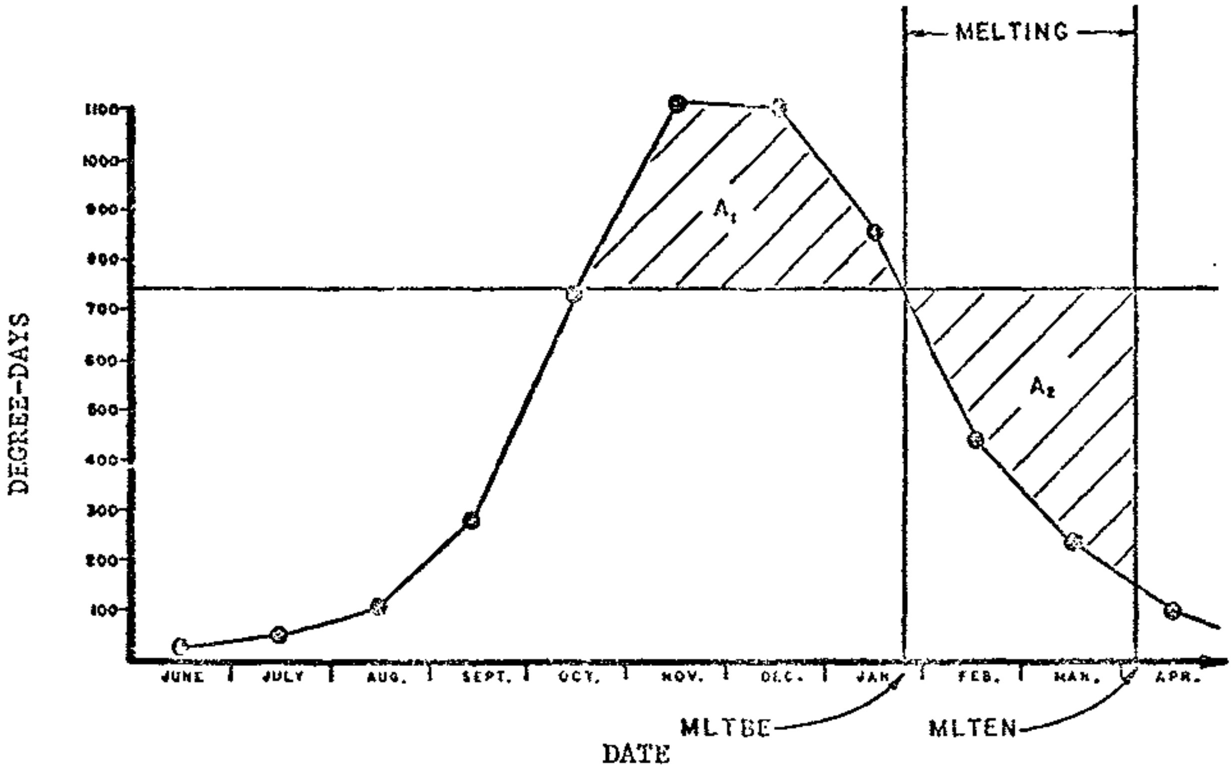
where DIAM = average sewer diameter, inches

PLEN = pipe length, miles

Residual Melting Ice and Frost Infiltration (SINFIL) --

SINFIL arises from residual precipitation such as snow as it melts following cold periods. Published data (1) in the form of monthly degree days (below 65°F) provide an excellent index as to the significance of SINFIL. Average monthly degree-days for cities in the United States are reproduced in Appendix A. The onset and duration of melting can be estimated by noting the degree days NDD above and immediately below a value of 750. Refer to Figure 6-8 for the following description.

Within subroutine INFIL, the beginning of melting MLTBE is taken as the day on which NDD drops below 750. Next, MLTEN is determined so that A_1 equals A_2. In the absence of evidence to the contrary, it is



MLTBE = Day on which melting period begins
MLTEN = Day on which melting period ends

Figure 6-8. Prescribed Melting Period

assumed that the melting rate is sinusoidal. The maximum contribution RSMAX from residual moisture can be determined from previous gaging of the study area or local estimates. In either case, SINFIL is determined within the program by the following equation:

$$\text{SINFIL} = \begin{cases} \text{RSMAX*sin[180*(NDYUD-MLTBE)/(MLTEN-MLTBE)]} \\ \text{0.0 if NDYUD is not in melting period or if} \\ \text{NDD never exceeds 750.} \end{cases} \qquad (6\text{-}7)$$

where NDYUD = day on which infiltration estimate is desired

RSMAX = residual moisture peak contribution, gpm

MLTBE = beginning of melting period, day

MLTEN = end of melting period, day

<u>Antecedent Precipitation (RINFIL)</u> --

RINFIL depends upon antecedent precipitation occurring within nine days prior to an estimate. If antecedent rainfall is unavailable or less than 0.25 inch (6.4 mm), the RINFIL contribution to QINFIL is set equal to 0.0. From analyses on reported sewer flow data not affected by melting, RINFIL was found to satisfy the following linear relationship:

$$\text{RINFIL = ALF + ALFO*RNO + ALF1*RN1 + ... + ALF9*RN9} \qquad (6\text{-}8)$$

where RINFIL = SWFLOW - DINFIL - SMMDWF

ALFN = coefficient to rainfall for N days prior to estimate

RNN = precipitation on N days prior to estimate, inches

SWFLOW = daily average sewer flow excluding surface runoff, gpm

SMMDWF = accounted for sewage flow, gpm

To determine the coefficients in Equation 6-8, a linear regression should be run on existing flow and rainfall data. For comparative purposes, the results of regression analyses for study areas (7) in three selected cities are given in Table 6-4.

Table 6-4. RINFIL EQUATIONS FOR THREE STUDY AREAS

Study Area	Equation
Bradenton, Florida	RINFIL = 4.1 + 2.9RN0 + 17.5RN1 + 15.0RN2 + 12.8RN3 + 13.0RN4 + 10.4RN5 + 13.2RN6 + 10.1RN7 + 11.8RN8 + 9.5N9
Baltimore, Maryland	RINFIL = 2.4 + 11.3RN0 + 11.6RN1 + 5.5RN2 + 6.4RN3 + 4.8RN4 + 3.6RN5 + 1.0RN6 + 1.5RN7 + 1.4RN8 + 1.8RN9
Springfield, Missouri	RINFIL = 2.0 + 18.3RN0 + 13.9RN1 + 8.9RN2 + 5.5RN3 + 6.7RN4 + 16.RN5 + 5.2RN6 + 4.6RN7 + 4.4RN8 + 1.3RN9

High Groundwater Table (GINFIL) --

For locations and times of the year that cause the groundwater table to be above the sewer invert, groundwater infiltration GINFIL supersedes contributions from DINFIL, RINFIL, and SINFIL. GINFIL can be determined from historical sewer flow data by inspection or regression analysis. Regression analysis would involve determination of the BETA coefficients in Equation 6-9:

$$GINFIL = BETA + BETA1*GWHD + BETA2*GWHD**2 + BETA3*GWHD**0.5 \quad (6\text{-}9)$$

where GWHD = groundwater table elevation above sewer invert, feet

BETAN = coefficient for term N

Apportionment of Infiltration --

Once an estimate of local infiltration QINF has been obtained, this flow must be apportioned throughout the designated study area. The criterion chosen for apportionment is an opportunity factor OPINF which represents the relative number and length of openings susceptible to infiltration. Pipe joints constitute the primary avenue for entry of infiltration (5). OPINF for an entire study area is determined using Equation 6-10:

$$OPINF = \sum_{\text{conduits}} (\pi*DIAM*DIST/ULEN) \quad (6\text{-}10)$$

where π*DIAM = pipe circumference, feet

DIST/ULEN = number of joints in each conduit

ULEN = average distance between joints, feet

Hydrologic Data --

Concurrent historical rainfall, water table, and sewer flow data of several weeks' duration are needed to completely describe infiltration. In addition, rainfall for the nine days prior to the flow estimate is required to satisfy the regression equation for RINFIL.

Ideally, the rainfall record would be from a rain gage which is located near the center of the study area and which records daily rainfall in inches. If more than one rain gage is located within the study area, daily measurements from all gages should be averaged. Missing data (e.g., from a malfunctioning gage) or a total absence of measurements due to no gaging within the study area can be overcome with measurements taken from a rain gage located within a few miles. If Weather Bureau Climatological Data recorded at the nearest airport or federal installation are not available, contact the National Weather Records Center for assistance (11).

Should some other form of precipitation, e.g., snowfall, be encountered, it will be necessary to convert this to equivalent rainfall. If estimates are unavailable from the Weather Bureau, the ratio of 10 inches of snow to one inch of rain may be used.

Water table data should also be obtained from gaging within the study area. However, shallow-well data from the US Geological Survey or state geological office can be used to supplement missing data. Water table elevations are not required if they are below the sewer inverts for the day on which QINF is to be estimated.

Sewer Data --

Sewer flow data for regression analysis should be taken from a gage located at the downstream point within the study area. Upstream gaging may be used to estimate flows at the downstream point by simply adjusting flows based upon respective surface area.

Physical sewer data (e.g., lengths, diameters, shapes) are taken from information used within TRANS to route sewer flow. To assist in determining the number of joints in the trunk sewer, an estimate of the average pipe section length ULEN should be supplied.

Summary of Infiltration Data

Effective use of the Infiltration Model requires estimates of its component flows, namely:

DINFIL = dry weather infiltration

RINFIL = wet weather infiltration

SINFIL = melting residual ice and snow

GINFIL = groundwater infiltration.

Step 1. Determine Groundwater Condition --

If the groundwater table is predominantly above the sewer invert, all infiltration is attributed to this source (GINFIL). In this case, an estimate of the total infiltration is made directly (in cfs for the total drainage basin) and read in on a data card. This card followed by two blank cards would complete the infiltration data input. If the groundwater table is not predominantly above the sewer invert, proceed to Step 2.

Step 2. Build-Up Infiltration from Base Estimates --

From measurements, historical data, or judgment, provide estimates of DINFIL and RINFIL. In this case, GINFIL must be set equal to 0.0. Next, provide the control parameters: the day the storm occurs (a number from 1 to 365 starting with July 15 as day 1), the peak residual moisture (see example 2 below), and the average pipe length (in feet). Finally, read in the 12 monthly degree-day totals taken from Appendix A or a local source.

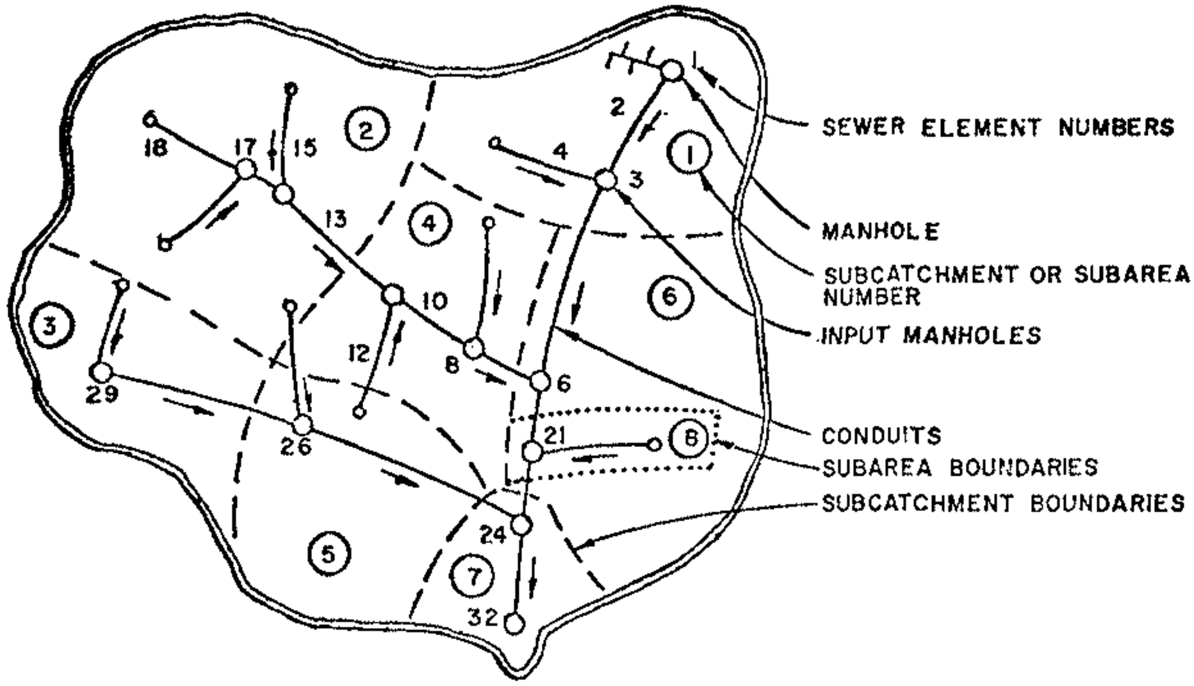
Dry Weather Flow Model

Subroutine FILTH has been developed to estimate average sewage flow and quality from residential, commercial, and industrial urban areas. FILTH estimates sewage inputs at discrete locations along the trunk sewers of any specified urban drainage basin. These estimates are calculated from data describing drainage basin subsections (subcatchments and subareas) under which the trunk sewer passes. An example of a hypothetical sewer system and input situation is given in Figure 6-9.

To save repetition all drainage basin subdivisions will be referred to as subareas in the following discussion. As shown in the figure, an input manhole near the center of each subarea is assumed to accept all sewage flow from that subarea. Criteria for establishing subarea boundaries and input locations are discussed later in the text.

In the context of the Storm Water Management Model, FILTH calculates daily sewage flow (cfs) and characteristics (BOD, SS, and total coliforms) averaged over the entire year for each subarea. FILTH is called from the program TRANS by setting the parameter NFILTH equal to one. Flow and characteristic estimates and corresponding manhole input numbers are then returned to TRANS where the estimates undergo adjustment depending upon the day of the week and hour of the day during which simulation is proceeding.

The subroutine is omitted when modeling separate storm sewers.



Sewer and Subcatchment Data

1. Manhole 32 is the most downstream point.
2. Subcatchments 1,2,3, and 4 are single-family residential areas, each 100 acres in size and each with water metering.
3. Subcatchments 5 and 7 are 220-acre industrial areas.
4. Subarea 6 is a 250-acre park.
5. Subarea 8 is a 50-acre commercial area.

Subareas 6 and 8 constitute a subcatchment draining to input manhole number 21.

Resulting Data

8 sewage estimates
KTNUM, total subcatchments and subareas in drainage basin = 8.
TOTA, total acres in drainage basin = 1,140.

KNUM, subcatchment or subarea	INPUT, input manhole number	KLAND, land use category	ASUB, acres in subcatchment or subarea
1	3	1	100
2	17	1	100
3	29	1	100
4	8	1	100
5	26	4	220
6	21	5	250
7	24	4	220
8	21	3	50

Figure 6-9. Determination of Subcatchment and Identification to Estimate Sewage at 8 Points

FILTH is designed to handle an unrestricted number of inlet areas and individual process flow contributors. As a safeguard against faulty data, however, a program interrupt is provided if the combined number exceeds 160, which is a limit set by the Transport Model.

Quantity Estimates --

Three data categories are used to estimate sewage flow: (1) drainage basin data, (2) subarea data, and (3) decision and adjustment parameters.

Study area data are TOTA, KTNUM and ADWF. KTNUM denotes the number of subareas into which a drainage basin, having a surface area TOTA (acres), is being divided. ADWF, which is optional depending upon its availability, gives the average sewage flow (cfs) originating from the entire drainage basin (e.g., average flow data from a treatment plant serving the study area).

Subarea data requirements consist of several options depending upon availability and choice of input. Discussion later in the text will assist in data tabulation by noting the order of preference where options exist. Subarea data can be broken into three categories as follows: (1) identification parameters, (2) flow data, and (3) estimating data.

1) Identification parameters -- Identification parameters are KNUM, INPUT, and KLAND. KNUM identifies each subarea by a number less than or equal to KTNUM. For each of the KTNUM subareas, INPUT indicates the number of the manhole into which DWF is assumed to enter. Land use within each subarea which approximately corresponds to zoning classification, is categorized according to Table 6-5. KLAND serves as an important factor in deciding subarea locations and sizes. Figure 6-9 will assist in describing how the above data are determined and tabulated.

2) Flow data -- Flow data are optional inputs that eliminate the need for using predictive equations. Two possible types of flow data are average sewage flow measurements, SEWAGE, and metered water use, WATER. Commercial or

Table 6-5. LAND USE CLASSIFICATION

KLAND	
1	Single-family residential
2	Multi-family residential
3	Commercial
4	Industrial
5	Park and open area

industrial sewage flow or water use measurements should be input using the variable SAWPF. Flows from commercial and industrial establishments located in residential subareas may be included using SAQPF, also.

Metering at lift stations and other flow control structures within the study area is occasionally available and should be used whenever possible. Metered water use offers a more available source of subarea flow data. Unfortunately, considerable effort in locating, tabulating, and averaging these data is often required.

3) Estimating data -- For each subarea where SEWAGE and WATER measurements are not available estimated water use must be used as an estimate of sewage flow. In the case of a factory or commercial establishment, estimates can be made by multiplying the number of employees by an established coefficient (gpd per employee). In the case of a large factory or commercial establishment, one subarea may be established with estimated water use tabulated as SAQPF for that subarea. On the other hand, estimates of water use for established non-residential areas (e.g., industrial parks or shopping centers) may be summed and tabulated as SAWPF for one large subarea. A list of the above mentioned coefficients is given in Appendix A.

   In the case of residential areas, estimating data for each subarea are METHOD, PRICE, ASUB, POPDEN, DWLINGS, FAMILY, and VALUE. Default values and definitions of each of these are given in the description of input data.

Decision and adjustment parameters consist of DVDWF, HVDWF, KDAY, KHOUR, KMINS, CPI, and CCCI. DVDWF and HVDWF are daily and hourly correction factors, respectively, for DWF. DVDWF is comprised of seven numbers that are ratios of daily average sewage flows to weekly average flow. Likewise, HVDWF is comprised of 24 numbers that are ratios of hourly average sewage flows to daily average flow. Both groups of numbers have been derived from observed flow variation patterns throughout the country (9,10). Their use is to correct measured or estimated average sewage flow to more accurate estimates depending upon the day and hour. Typical sewage flow variations are shown in Figures 6-10 and 6-11. Even though these flow patterns are suggested, locally observed patterns more accurately describe local variations and should be used when available.

KDAY, KHOUR, and KMINS denote the day, hour, and minute at which simulation is to begin. As simulation proceeds, these values are continually updated to their correct values. By noting the current day and hour, the appropriate values of DVDWF and HVDWF can be multiplied by average flow to determine the correct value. KDAY ranges from 1 to 7 with Sunday being day number 1. KHOUR ranges from 1 to 24 with midnight to 1 am being hour number 1. Likewise, KMINS ranges from 1 to 60 with minute 1 being the first minute after the hour.

Two cost indices are employed to adjust current house valuations and water prices to appropriate 1960 values and 1963 prices, respectively. This is done because estimating equations within FILTH are based upon 1960 values and 1963 prices. CPI, consumer price index, has been chosen to adjust water price by multiplying water price by 1960 CPI divided by the current CPI. CCCI, composite construction cost index, has been chosen to adjust house valuations similarly. Both indices can be found in most libraries in journals on economic affairs (12,13).

Quality Estimates --

The purpose of the DWF quality computation is to apportion waste characteristics (such as would be measured at a sewage treatment plant before treatment) among the various subareas in the drainage basin under study, or in the event no measured data are available, to estimate and apportion usable average values. The apportionment is based upon the flow distribution, land use, measured or estimated industrial flows, average family income, the use or absence of garbage grinders, and infiltration.

When called, subroutine FILTH first reads in an array of daily and hourly flow and characteristic variations. All are expressed as ratios of their respective yearly or daily averages and they are stored in real time sequence (one set of values for each day starting with Sunday or each hour starting at 1:00 am).

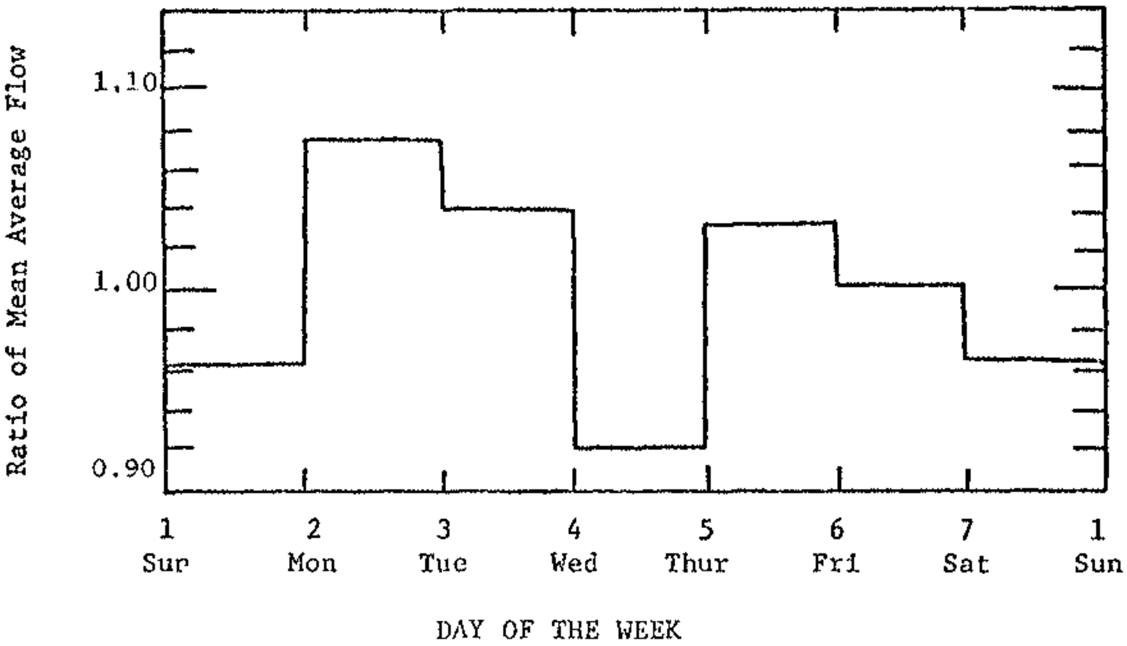


Figure 6-10. Representative Daily Flow Variation

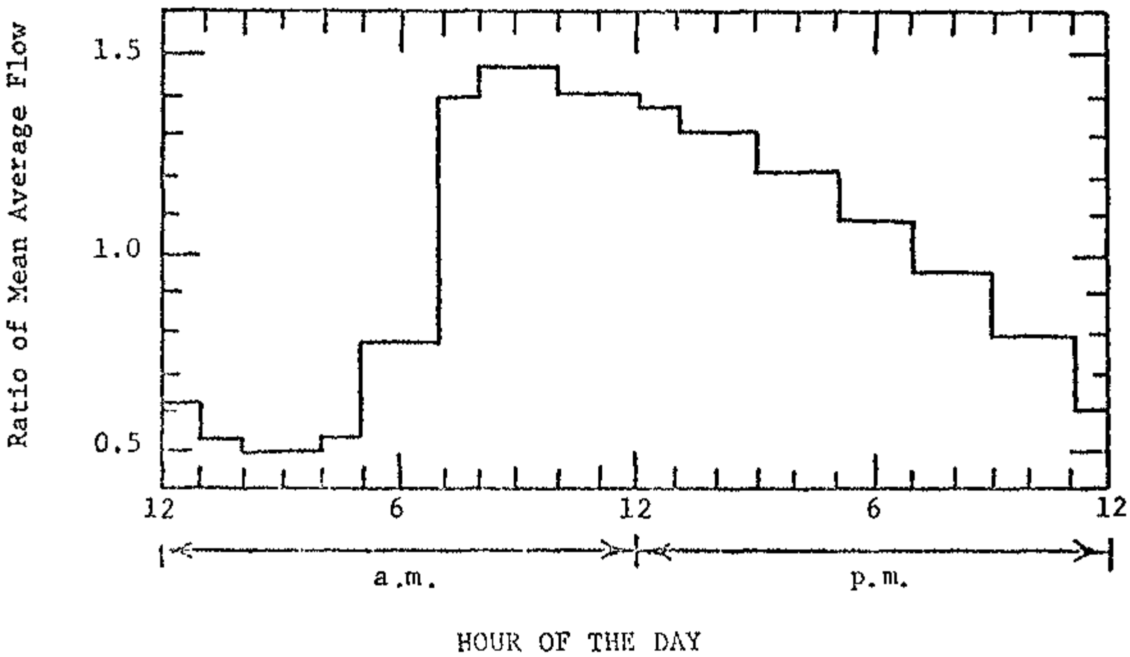


Figure 6-11. Representative Hourly Flow Variation

The next card read gives the total number of subareas and process flow sources to be processed: the type case--that is, whether the total DWF characteristics are known or to be estimated, the number of process flow contributors, the starting time of the storm event, the cost indices, and the total drainage basin population.

The next series of computations sets values for A1BOD, A1SS, and A1COLI, which are the average weighted DWF characteristics in pound/day/cfs for BOD and SS and in MPN/day/capita for total coliforms. Depending upon the instructions given, computations proceed along Case 1 or Case 2 channel.

Case 1 -- In this instance, the total DWF quality characteristics are known at a point well downstream in the system. These characteristics may be obtained from treatment plant operating records (raw sewage) or by a direct sampling program. The average daily values are read into the program for flow, BOD, SS, and coliforms. The total pounds per day of BOD and SS and the total MPN per day of coliforms are then calculated. Then, infiltration is subtracted from the average daily flow. (NOTE that infiltration is computed by a separate subroutine of the Transport Model and must be executed prior to subroutine FILTH or a default will be assumed.)

Next, the known process flow contributions are summed and deducted from the daily totals, yielding a further corrected flow, C2DWF, and characteristics, C1BOD and C1SS.

Finally, corrections are made for personal income variations, degree of commercial use, and garbage grinder status. The DWF quantity does not change but the characteristics obtain new, weighted values, C2BOD and C2SS.

A1BOD and A1SS are then computed directly. A1COLI is computed by dividing the total MPN per day by the total population.

Case 2 -- Here no direct measurements are available; thus, estimates must be made or default values will be assumed. A typical application of Case 2 would be in a situation where several catchments are to be modeled, yet funds will permit monitoring the DWF only in a single area. A1BOD, A1SS, and A1COLI would be computed via the Case 1 subroutine for the known area and the results would be transferred as Case 2 for the remaining catchments.

The default values for A1BOD, A1SS, and A1COLI are 1300, 1420 and 200 billion, respectively. These values assume 85 gal/capita/day (322 l/capita/day), 0.20 lbs/capita/day BOD (0.091 kg/capita/day), 0.22 lbs/capita/day SS (0.1 kg/capita/day), and 200 billion MPN/capita/day for average income families.

A loop is next formed to compute and design average daily quality values for all inlets and individual process flow sources. This loop also computes the DWF quantities as described earlier.

Two data cards are required to read in all the flow and quality parameters for each subarea and each individual process flow source. After computation of the DWF quantity for the subarea, the population is computed and totalized. Next, the quality characteristics are computed on the basis of land use, family income, and garbage grinder status, and the results are tabulated (printed) and totalized (printed only on call - subtotals - or completion).

The computational sequence is complete when all areas and process flow sources have been executed (i.e., number of iterations equals KTNUM) and totals have been printed. Upon completion, control returns to TRANS.

Following execution of FILTH, the initial sediment load settled in the sewer system is estimated in subroutine DWLOAD. For an assumed particle size distribution, the daily sediment accumulation is calculated using Shield's erosion criteria and suspended solids concentrations in the dry weather flow. A constant daily buildup occurs during consecutive dry weather days, DWDAYS, prior to the storm. This sediment may subsequently be eroded (in subroutine QUAL) during the storm, providing a "first flush" phenomenon.

Subroutine FILTH will initialize all flows, areas and concentrations to their dry weather flow values. This is accomplished simply by adding flows together and computing weighted average concentrations at manholes. Infiltration is assumed to contain no pollutants.

Summary of Dry Weather Flow Requirements

Step 1. Establishing Subareas --

Establishment of the subareas constitutes the initial step in applying subroutine FILTH. Both detail of input data and assumptions made in developing FILTH impose constraints on the type, size, and number of subareas. However, most important in subarea establishment is the type of estimating data available. An upper limit of 200 acres (81 ha) per subarea is assumed in the following discussion. This is a somewhat arbitrary limit based in part on previous verification results from FILTH.

Subareas should be located and sized to utilize existing sewer flow measurements taken within the drainage basin. These measurements should be recent and of sufficient duration to provide a current average sewage flow value for the period of time during which simulation is to proceed. Daily and hourly flow variation should be compared to assumed values as described earlier in the text. A gaging site with less than 200 acres (81 ha) contributing flow provides a very convenient data input situation. A subarea should be established upstream from the gage with average sewage flow tabulated as SEWAGE for that subarea. It is convenient, though not necessary, for the subareas to correspond to subcatchments in Runoff.

If metered water use is to be used to estimate sewage flow, subareas should be located to coincide with meter reading zones or other zones used by the water department that simplify data takeoff. Since water use would be used to estimate sewage flow, average winter readings should be used to minimize the effects of lawn sprinkling and other summer uses.

If neither gaging nor metered water use are input, sewage estimates must be made. Subareas should then be established to yield appropriate input data for the residential estimating equations in FILTH. Zero sewage flow is assumed from commercial, industrial, and parkland subareas for which estimates or measurements of SAQPF are not given. Since KLAND and VALUE are the significant variables in estimating subarea sewage flow, subareas should be located and sized to include land with uniform land use and property valuation. To utilize existing census data, subarea boundaries should be made to coincide with census tract boundaries.

Criteria for establishing subareas are listed in the following summary:

1) Subareas in general should:

   a. Be less than or equal to 200 acres (81 ha) in size;

   b. Be less than or equal to 160 in number; and

   c. Conform to the branched pipe network.

2) Subareas should be established to employ any existing sewer flow measurements.

3) Subareas for which metered water use is used to estimate sewage flow should be compatible with meter reading zones.

4) Residential subareas for which estimated water use is used to estimate sewage flow should:

   a. Be uniform with respect to land use;

   b. Be uniform with respect to dwelling unit valuation; and

   c. Coincide with census tracts.

Step 2. Collection of Data --

Other than the establishment of measured data described earlier, the primary data source is the US Bureau of Census for census tract information. This source provides readily available data on population distribution, family income, and the number and relative age of dwelling units. City records, aerial photographs, and on-site inspection may be necessary to define land use activities, process flows, and dwelling density variations within tracts.

Step 3. Data Tabulation --

Once subareas have been established, several alternatives exist regarding data tabulation. An identification number KNUM should be given to each subarea prior to data takeoff. However, once KNUM's have been established, corresponding INPUT manhole numbers are selected from a previously numbered schematic diagram of the trunk sewer. This numbered schematic serves as the mechanism to coordinate runoff, infiltration, and sewage inputs. Refer to the subroutine TRANS discussion for additional information about the numbered schematic. If water use estimates are necessary, land use should be determined from city zoning maps and the previously tabulated values for KLAND.

ADWF should be tabulated as average drainage basin sewage flow. As with ADWF, SEWAGE should be averaged from flow data for the appropriate month, season, or year. ADWF, SAQPF, or SEWAGE may be obtained from routine or specific gaging programs done by the city, consulting engineers, or other agencies. SAQPF may be estimated for commercial and industrial areas using water use coefficients. Also, SAQPF and WATER may be determined for all land use categories from water meter records.

Table 6-6. TRANSPORT BLOCK CARD DATA

Card group	Format	Card columns	Description	Variable name	Default value
1	16I5	5	Number of sewer cross-sectional shapes, in addition to the 12 program-supplied for which element routing parameters are to follow (maximum value = 3).	NKLASS	0
		10	Control parameter for printing out flow routing parameters for all shapes, *i.e.*	KPRINT	0
			KPRINT = 0 to suppress printing,		
			KPRINT = 1 to allow printing (for all shapes, program-supplied and additional)		
			DELETE CARD GROUPS 2 TO 10 IF NKLASS = 0.		
2			Name of user-supplied shapes.	NAME	
	204A	1-16	16-letter name of shape 1.	NAME(I,14)	None
		17-32	16-letter name of shape 2.	NAME(I,15)	None
3			Number of values of DNORM to be supplied (maximum value = 51, minimum value = 2).	NN	
	16I5	4-5	Number of values for shape 1.	NN(14)	None
		9-10	Number of values for shape 2.	NN(15)	None

NOTE: All non-decimal numbers must be right-justified.
NOTE: Must always specify output tape or disk, two scratch data sets needed.

Table 6-6 (continued). TRANSPORT BLOCK CARD DATA

Card group	Format	Card columns	Description	Variable name	Default value
4			Number of values of QNORM to be read (maximum value = 51, minimum value = 2).	MM	
	16I5	4-5	Number of values for shape 1.	MM(14)	None
		9-10	Number of values for shape 2.	MM(15)	None
5			Value of A/A_f[a] corresponding to the maximum Q/Q_f[b] value for each shape.	ALFMAX	
	8F10.5	1-10	A/A_f value for shape 1.	ALFMAX(14)	None
		11-20	A/A_f value for shape 2.	ALFMAX(15)	None
6			Maximum Q/Q_f value for each shape.	PSIMAX	
	8F10.5	1-10	Maximum Q/Q_f value for shape 1.	PSIMAX(14)	None
		11-20	Maximum Q/Q_f value for shape 2.	PSIMAX(15)	None
7			Factor used to determine full flow area for each shape, *i.e.*, for use in AFULL = AFACT(GEOM1)^2.	AFACT	

[a] A/A_f = ANORM is the cross-sectional flow area divided by the cross-sectional flow area of the pipe running full. Tabular values of ANORM are generated in the program by dividing the ANORM axis (0.0 - 1.0) into NN-1 or MM-1 equal divisions.

[b] Q/Q_f = QNORM is the flow rate divided by the flow rate of the conduit flowing full.

Table 6-6 (continued). TRANSPORT BLOCK CARD DATA

Card group	Format	Card columns	Description	Variable name	Default value
	8F10.5	1-10	Factor for shape 1.	AFACT(14)	None
		11-20	Factor for shape 2.	AFACT(15)	None
8			Factor used to determine full flow hydraulic radius for each shape, *i.e.*, for use in equation RADH = RFACT(GEOM1).	RFACT	
	8F10.5	1-10	Factor for shape 1.	RFACT(14)	None
		11-20	Factor for shape 2.	RFACT(15)	None
			REPEAT CARD GROUP 9 FOR EACH ADDED SHAPE.		
9			Input of tabular data (depth of flow, y, divided by total depth of conduit, y_f (y/y_f)) for each added shape corresponding to the NN-1 equal divisions of A/A_f of the conduit as given by NN on card group 3.[a]	DNORM	
	8F10.5	1-10	First value for y/y_f for shape 1.	DNORM(I,1)	None
		11-20	Second value for y/y_f for shape .	DNORM(I,2)	None
		.	.	.	
		.	.	.	
		.	.	.	
		.	Last value of y/y_f for shape 1.	DNORM(I,NN(I))	None
			(Total of NN(14)/8 + NN(15)/8 data cards)		

[a] y/y_f = DNORM is the depth of flow, y, divided by the maximum flow depth, y_f (*e.g.*, diameter of a circular conduit).

Table 6-6 (continued). TRANSPORT BLOCK CARD DATA

Card group	Format	Card columns	Description	Variable name	Default value
			REPEAT CARD GROUP 10 FOR EACH ADDED SHAPE.		
10			Input of tabular data (flow rate, Q, divided by the flow rate of the conduit running full, Q_f (Q/Q_f)). for each added shape corresponding to the MM-1 equal divisions of A/A_f of the conduit as given by MM on card group 4.	QNORM	
	8F10.5 .	1-10	First value of Q/Q_f for shape 1.	QNORM(I,1)	None
		11-20	Second value of Q/Q_f for shape 1.	QNORM(I,2)	None
		.	.	.	
		.	.	.	
		.	.	.	
		.	Last value for Q/Q_f for shape 1.	QNORM(I,MM(I))	None
			(Total of MM(14)/8 + MM(15)/8 data cards)		
11	20A4		Title card containing a one-line heading to be printed above output.	TITLE	Blanks
12			Execution control data.		
	16I5	3-5	Total number of sewer elements (maximum = 160).	NE	None
		8-10	Total number of time-steps (maximum = 150).[a]	NDT	None
		14-15	Total number of non-conduit elements into which there will be input hydrographs and pollutographs (maximum = 70, minimum = 1).[a]	NINPUT	None

[a]Not required if input is from tape or disk.

Table 6-6 (continued). TRANSPORT BLOCK CARD DATA

Card group	Format	Card columns	Description	Variable name	Default value
		19-20	Total number of non-conduit elements at which input hydrographs and pollutographs are to be printed out (maximum = 20, minimum = 1).	NNYN	None
		24-25	Total number of non-conduit elements at which routed hydrographs and pollutographs are to be printed out (maximum = 20, minimum = 1).	NNPE	None
		30	Total number of non-conduit elements at which flow is to be transferred to a subsequent block by tape or disk (maximum = 5, minimum = 1).[a]	NOUTS	None
		35	Control parameter for program-generated error messages occurring in the execution of the flow routing scheme. These errors do not normally affect the program execution. NPRINT = 0 to suppress messages (recommended), NPRINT = 1 to print messages from ROUTE, NPRINT = 2 to print messages from ROUTE and TRANS.	NPRINT	0
		40	Total number of pollutants being routed (maximum = 4 , minimum = 0)[b]. When NPOLL = 0, program will route flows only and all quality operations will be bypassed.	NPOLL	0
		45	Total number of iterations to be used in routing subroutine (4 recommended).	NITER	4

[a]These are the only points that can be plotted by subroutine GRAPH after being routed by TRANSPORT.

[b]The three pollutants ordinarily routed are BOD, SS and coliforms. A fourth conservative pollutant may be routed if provided for on input tapes, but internal storage should not be used in this case. Not required if input is from tape or disk.

Table 6-6 (continued). TRANSPORT BLOCK CARD DATA

Card group	Format	Card columns	Description	Variable name	Default value
13			Execution control data.		
	8F10.5	1-10	Size of time-step for computation, sec.[a]	DT	None
		11-20	Allowable error for convergence of iterative methods in routing routine (0.0001 recommended).	EPSIL	0.0001
		21-30	Total number of days (dry weather days) prior to simulation during which solids were not flushed from the sewers.	DWDAYS	0
14			Execution control data.		
	16I5	5	Control parameter specifying means to be used in transferring inlet hydrographs, *i.e.*, NCNTRL = 0, normal transfer by tape or disk, NCNTRL = 1, input from cards, utilizing card groups 28, 46 and 47.	NCNTRL	0
		10	Control parameter in estimating groundwater infiltration inflows, *i.e.*, NINFIL = 0, infiltration not estimated (INFIL not called and corresponding data omitted), NINFIL = 1, infiltration to be estimated (subroutine INFIL called).	NINFIL	0
		15	Control parameter in estimating sanitary sewage inflow, *i.e.*, NFILTH = 0, sewage inflows not estimated (FILTH not called and corresponding data omitted),	NFILTH	0

[a] Not required if input is from tape or disk.

Table 6-6 (continued). TRANSPORT BLOCK CARD DATA

Card group	Format	Card columns	Description	Variable name	Default value
			NFILTH = 1, sewage inflows to be estimated (subroutine FILTH called).		
		20	Control parameter concerning printed output, *i.e.*,	JPRINT	0
			JPRINT = 0, flows and concentration not printed,		
			JPRINT = 1, flows and concentrations printed out in tabular form.		
		25	Control parameter concerning plotting of output,	JPLOT	0
			JPLOT = 0, plotting routine *not* called from within TRANSPORT,		
			JPLOT = 1, plotting routine *is* called from within TRANSPORT.[a]		
		30	Control parameter for hydraulic design routine, *i.e.*,	NDESN	0
			NDESN = 0, hydraulic design routine is not called,		
			NDESN = 1, hydraulic design routine is to be called.		
			REPEAT CARD GROUP 15 FOR EACH NUMBERED SEWER ELEMENT (maximum number of cards = 160). THESE CARDS MAY BE READ IN ANY ORDER.		
15			Sewer element data.		
	5I4	1-4	External element number.[b] No element may be labeled with a number greater than 1000, and it must be a positive numeral.	NOE	None

[a]Not operational.

[b]"External" numbers are those assigned by the user to the various sewer system components. "Internal" numbers are assigned within the program. All input to the Transport Model is in terms of external numbers.

Table 6-6 (continued). TRANSPORT BLOCK CARD DATA

Card group	Format	Card columns	Description	Variable name	Default value
			However, numbering need not be consecutive or continuous.		
		******	EXTERNAL NUMBER(S) OF UPSTREAM ELEMENT(S). UP TO THREE ARE ALLOWED. A ZERO DENOTES NO UPSTREAM ELEMENT (maximum value = 1000). ******		
		5-8	First of three possible upstream elements.	NUE(1)	None
		9-12	Second of three possible upstream elements.	NUE(2)	None
		13-16	Third of three possible elements.	NUE(3)	None
		17-20	Classification of element type. Obtain value from Table 6-1.	NTYPE	16
		******	THE FOLLOWING VARIABLES ARE DEFINED BELOW FOR CONDUITS ONLY. REFER TO TABLE 6-1 FOR REQUIRED INPUT FOR NON-CONDUITS. ******		
	7F8.3	21-28	Element length for conduit, ft.	DIST	None
		29-36	First characteristic dimension of conduit, ft. See Figure 6-4 and Table 6-2 for definition.	GEOM1	None
		37-44	Invert slope of conduit, ft/100 ft.	SLOPE	0.1
		45-52	Manning's roughness of conduit.	ROUGH	0.013
		53-60	Second characteristic dimension of conduit, ft. See Figure 6-4 and Table 6-2 for definition. (Not required for some conduit shapes.)	GEOM2	None
		61-68	Number of barrels[a] for this element. The barrels are assumed to be identical in shape and flow characteristics. (Must be integer $\geq$ 1.)	BARREL	1.0

[a]Example: A two barrelled conduit would consist of two identical parallel conduits adjacent to each other.

Table 6-6 (continued). TRANSPORT BLOCK CARD DATA

Card group	Format	Card columns	Description	Variable name	Default value
		69-76	Third characteristic dimension of conduit, ft. See Figure 6-4 and Table 6-2 for definition. (Not required for some conduit shapes.)	GEOM3	None
			CARDS 16 THROUGH 26 ARE DATA INPUT FOR INTERNAL STORAGE. (NTYPE = 19). OMIT THESE DATA CARDS IF INTERNAL IS NOT DESIRED.		
			REPEAT STORAGE MODEL DATA FOR EACH STORAGE ELEMENT (maximum = 2).		
16			Storage unit data card.		
	10I5	1-5	Storage mode parameter.[a]	ISTMOD	1
			= 1 in-line storage.		
		6-10	Storage type parameter.	ISTTYP	1
			= 1 irregular (natural) reservoir,		
			= 3 geometric (regular) uncovered reservoir.		
		11-15	Storage outlet control parameter.	ISTOUT	1
			= 1 gravity with orifice center line at zero storage tank depth,		
			= 2 gravity with fixed weir,		
			= 6 existing fixed-rate pumps,		
			= 9 gravity with both weir and orifice.		

[a]Must be set equal to one since other storage mode parameters are not programmed.

Table 6-6 (continued). TRANSPORT BLOCK CARD DATA

Card group	Format	Card columns	Description	Variable name	Default value
17			Computation/print control card.		
	3I10	1-10	Pollutant parameter.	IPOL	0
			= 0 no pollutants (hydraulics only),		
			= 1 perfect plug flow through basin,		
			= 2 perfect mixing in basin.		
		11-20	Print control parameter.	IPRINT	0
			= 0 no print each time-step,		
			= 1 print each time-step in storage.		
		21-30	Cost computation parameter.	ICOST	0
			= 0 no cost computations,		
			= 1 costs to be computed.		
18			Reservoir flood depth data card.		
	F10.2	1-10	Maximum (flooding) reservoir depth, ft.	DEPMAX	None
			INCLUDE EITHER CARD GROUP 19 OR 20, NOT BOTH.		
			INCLUDE CARD GROUP 19 ONLY IF ISTTYP ON CARD 16 HAS THE VALUE 1.		
19			Reservoir depth-area data card.		
	F10.2	1-10	A reservoir water depth, ft.	ADEPTH(1)	None
	F10.0	11-20	Reservoir surface area corresponding to above depth, ft^2.	AASURF(2)	None
	.	.	.	.	
	.	.	.	.	
	.	.	.	.	
	F10.2	61-70	A reservoir water depth, ft.	ADEPTH(4)	None

Table 6-6 (continued). TRANSPORT BLOCK CARD DATA

Card group	Format	Card columns	Description	Variable name	Default value
	F10.0	71-80	Reservoir surface area corresponding to above depth, ft^2.	AASURF(4)	None
			(NOTE: The above pair of variables is repeated 11 times, 4 pairs per card.)		
			INCLUDE CARD 20 ONLY IF ISTTYP ON CARD 16 HAS THE VALUE 3.		
20			Reservoir dimensions data card. Reservoir has shape of inverted truncated cone.		
	2F10.0	1-10	Reservoir base area, ft^2.	BASEA	None
		11-20	Reservoir base circumference, ft.	BASEC	None
	F10.5	21-30	Cotan of sideslope (horizontal/vertical).	COTSLO	None
			INCLUDE ONLY ONE OF THE OUTLET DATA CARDS 21, 22, 23 or 24.		
			INCLUDE CARD 21 ONLY IF ISTOUT ON CARD 16 HAS THE VALUE 1.		
21			Orifice outlet data card.		
	F10.3	1-10	Orifice outlet area x discharge coefficient, ft^2.	CDAOUT	None
			INCLUDE CARD 22 ONLY IF ISTOUT ON CARD 16 HAS THE VALUE 2.		
22			Weir outlet data card.		
	2F10.3	1-10	Weir height (ft) above depth = 0.	WEIRHT	None
		11-20	Weir length, ft.	WEIRL	None

Table 6-6 (continued). TRANSPORT BLOCK CARD DATA

Card group	Format	Card columns	Description	Variable name	Default value
			INCLUDE CARD 23 ONLY IF ISTOUT ON CARD 16 HAS THE VALUE 6.		
23			Pump outlet data card.		
	3F10.3	1-10	Outflow pumping rate, cfs.	QPUMP	None
		11-20	Depth (ft) at pump startup.	DSTART	None
		21-30	Depth (ft) at pump shutdown (DSTOP > 0.0).[a]	DSTOP	None
			INCLUDE CARD 24 ONLY IF ISTOUT HAS THE VALUE 9.		
24			Weir and orifice outlet data card.		
	8F10.5	1-10	Weir height above depth = 0, ft.	WEIRHT	None
		11-20	Weir length, ft.	WEIRL	None.
		21-30	Orifice outlet area x discharge coefficient, ft^2.	CDAOUT	None
		31-40	Orifice centerline elevation above zero depth, ft.	ORIFHT	None
25			Initial conditions data card.		
	2F10.2	1-10	Storage (ft^3) at time zero.	STORO	None
		11-20	Outflow rate (cfs) at time zero.	QOUTO	None
			CARD 26 MUST BE INCLUDED: IT MAY BE BLANK IF ICOST ON CARD 17 HAS THE VALUE 0.		
26			Cost data card.		

[a]DSTOP must equal or be greater than the level in storage that contains enough volume to handle the pumping rate, QPUMP, for one time-step.

Table 6-6 (continued). TRANSPORT BLOCK CARD DATA

Card group	Format	Card columns	Description	Variable name	Default value
	F10.2	1-10	$/yard^3 for storage excavation.	CPCUYD	None
	2F10.0	11-20	$/acre for storage land.	CPACRE	None
		21-30	$/pump station with related structures.	CPS	None
27			List of external non-conduit element numbers at which outflows are to be transferred to subsequent blocks for a total of NOUTS (card 12) non-conduit elements.	JN	
	16I5	1-5	First element number.[a]	JN(1)	None
		6-10	Second element number.[a]	JN(2)	None
		. . . . .	Last element number.[a]	JN(NOUTS)	None
			IF NCNTRL = 0 ON CARD 14, SKIP TO CARD GROUP 29.		
28			Non-conduit element numbers into which hydrographs and pollutographs (from card input) enter the sewer system. These must be in the order in which hydrograph and pollutograph ordinates appear at each time step.		
	16I5	1-5	First element number.	NORDER(1)	None
		6-10	Second element number.	NORDER(2)	None
		. . . . .	Last element number.	NORDER(NINPUT)	None

[a]Element numbers transferred to subsequent blocks must be numbered less than or equal to 100.

Table 6-6 (continued). TRANSPORT BLOCK CARD DATA

Card group	Format	Card columns	Description	Variable name	Default value
29			List of external non-conduit element numbers at which input hydrographs and pollutographs are to be stored and printed out for a total of NNYN (card 12) non-conduit elements.	NYN	
	16I5	1-5	First input location number.	NYN(1)	None
		6-10	Second input location number.	NYN(2)	None
		.		.	
		.		.	
		.		.	
		.	Last input location number.	NYN(NNYN)	None
30			List of external non-conduit element numbers at which output hydrographs and pollutographs are to be stored and printed out for a total of NNPE (card 12) non-conduit elements.	NPE	
	16I5	1-5	First output location number.	NPE(1)	None
		6-10	Second output location number.	NPE(2)	None
		.		.	
		.		.	
		.	Last output location number.	NPE(NNPE)	None
			IF SUBROUTINE INFIL IS TO BE CALLED (NINFIL = 1), INSERT CARDS 31 THROUGH 33 OTHERWISE OMIT.		
31			Estimated infiltration.		
	10F8.1	1-8	Base dry weather infiltration, gal/min.	DINFIL	0.0
		9-16	Groundwater infiltration, gal/min.	GINFIL	0.0
		17-24	Rainwater infiltration, gal/min.	RINFIL	0.0

Table 6-6 (continued). TRANSPORT BLOCK CARD DATA

Card group	Format	Card columns	Description	Variable name	Default value
32			Control parameters.		
	I5	3-5	Day of year of estimate.[a]	NDYUD	None
	6F8.1	6-13	Peak residual moisture, gal/min.	RSMAX	0.0
		14-21	Average distance between joints, ft.	ULEN	6.0
33			Monthly degree-days.[b]	NDD	
	16I5	1-5	July degree-days.	NDD(1)	None
		6-10	August degree-days.	NDD(2)	None
		.		.	.
		.		.	.
		.		.	.
		56-60	June degree-days.	NDD(12)	None
			IF SUBROUTINE FILTH IS TO BE CALLED (INFILTH = 1), INSERT CARD GROUPS 34 THROUGH 45, OTHERWISE OMIT.		
34			Factors to correct yearly average sewage flows to daily average by accounting for daily variations throughout a typical week.		
	7F10.0	1-10	Flow correction for Sunday.	DVDWF(1)	1.0
		11-20	Flow correction for Monday.	DVDWF(2)	1.0
		.		.	
		.		.	
		.		.	
		.		.	
		61-70	Flow correction for Saturday.	DVDWF(7)	1.0

[a]Day one is July 15.
[b]See Table A-1 for values at selected locations.

Table 6-6 (continued). TRANSPORT BLOCK CARD DATA

Card group	Format	Card columns	Description	Variable name	Default value
			IF NPOLL = 0 SKIP TO CARD GROUP 37		
35			Factors to correct BOD yearly averages to daily averages.		
	7F10.0	1-10	BOD correction for Sunday.	DVBOD(1)	1.0
		.			.
		.			.
		.			.
		.			.
		61-70	BOD correction for Saturday.	DVBOD(7)	1.0
36			Factors for correction of yearly SS averages to daily averages.		
	7F10.0	1-10	SS correction for Sunday.	DVSS(1)	1.0
		.			.
		.			.
		.			.
		.			.
		61-70	SS correction for Saturday.	DVSS(7)	1.0
37			Factors to correct daily average sewage flow to hourly averages by accounting for hourly variations throughout a typical day (3 cards needed).		
	8F10.0	1-10	Midnight to 1 a.m. factor (first card).	HVDWF(1)	1.0
		.			.
		.			.
		.			.
		.			.
		1-10	8 a.m. to 9 a.m. factor (second card).	HVDWF(9)	1.0
		.			.
		.			.
		.			.
		.			.
		1-10	4 p.m. to 5 p.m. factor (third card).	HVDWF(17)	1.0

Table 6-6 (continued). TRANSPORT BLOCK CARD DATA

Card group	Format	Card columns	Description	Variable name	Default value
			IF NPOLL = 0 SKIP TO CARD GROUP 41		
38			Factors for BOD hourly corrections (3 cards needed).		
	8F10.0	1-10	Midnight to 1 a.m. factor (first card).	HVBOD(1)	1.0
		.			.
		.			.
		.			.
		.			.
		71-80	11 a.m. to midnight factor (third card).	HVBOD(24)	1.0
39			Factors for SS hourly corrections (3 cards needed).		
	8F10.0	1-10	Midnight to 1 a.m. factor (first card).	HVSS(1)	1.0
		.			.
		.			.
		.			.
		.			.
		71-80	11 a.m. to midnight factor (third card).	HVSS(24)	1.0
			INCLUDE ONLY WHEN 3 POLLUTANTS ARE SPECIFIED.		
40			Factors for E. coli hourly corrections (3 cards needed).		
	8F10.0	1-10	Midnight to 1 a.m. factor (first card).	HVCOLI(1)	1.0
		.			.
		.			.
		.			.
		.			.
		71-80	11 a.m. to midnight factor (third card).	HVCOLI(24)	1.0
41			Study area data.		
	6I5	1-5	Total number of subareas within a given study area in which sewage flow and quality are to estimated.	KTNUM	None
		6-10	Indicator as to whether study area data, such as treatment plant records, are to be used to estimate sewage quality, *i.e.*,	KASE	1

Table 6-6 (continued). TRANSPORT BLOCK CARD DATA

Card group	Format	Card columns	Description	Variable name	Default value
			KASE = 1, yes,		
			KASE = 2, no.		
		11-15	Total number of process flows within the study area for which data are included in one of the following card groups.	NPF	0
		16-20	Number indicating the day of the week during which simulation begins (Sunday = 1).	KDAY	1
		21-25	Number indicating the hour of the day during which simulation begins (1 a.m. = 1).	KHOUR	0
		26-30	Number indicating the minute of the hour during which simulation begins.	KMINS	0
	2F5.1	31-35	Consumer Price Index.	CPI	109.5
		36-40	Composite Construction Cost Index.	CCCI	103.0
	F10.3	41-50	Total population in all areas, thousands.	POPULA	None
			IF KASE = 1, INCLUDE CARD GROUPS 42, 43 and 44.		
42			Average study area data.		
	3F10.0	1-10	Total study area average sewage flow, *i.e.*, from treatment plant records, cfs.[a]	ADWF	0.0
		11-20	Total study area average BOD, mg/l.	ABOD	0.0
		21-30	Total study area average SS, mg/l.	ASUSO	0.0
	E10.2	31-40	Total coliforms, MPN/100 ml.	ACOCI	0.0

[a]If ADWF = 0.0, then total BOD, SS, and COLI will = 0.0. Predicted DWF out downstream end of system will be adjusted to this value.

Table 6-6 (continued). TRANSPORT BLOCK CARD DATA

Card group	Format	Card columns	Description	Variable name	Default value
43			Categorized study area data.		
	8F8.0	1-8	Total study area from which ABOD and ASUSO were taken, acres.	TOTA	None
		9-16	Total contributing industrial area, acres.	TINA	None
		17-24	Total contributing commercial area, acres.	TCA	None
		25-32	Total contributing high income (above $15,000) residential area, acres.	TRHA	None
		33-40	Total contributing average income (above $7,000 but below $15,000) residential area, acres.	TRAA	None
		41-48	Total contributing low income (below $4,000) residential area, acres.	TRLA	None
		49-56	Total area from the above three residential areas that contribute additional waste from garbage grinders, acres.	TRGGA	None
		57-64	Total park and open area within the study area, acres.	TPOA	None
			IF PROCESS FLOW DATA ARE AVAILABLE (NPF NOT EQUAL 0 AND KASE = 1), REPEAT CARD GROUP 44 FOR EACH PROCESS FLOW. OTHERWISE, SKIP TO CARD GROUP 45.		
44			Process flow characteristics.		
	I5	1-5	External manhole number into which flow is assumed to enter (maximum value = 1000, minimum value = 1).	INPUT	None
	6F10.3	6-15	Average daily process flow entering the study area system, cfs.	QPF	None
		16-25	Average daily BOD of process flow, mg/l.	BODPF	0.0
		26-35	Average daily SS of process flow, mg/l.	SUSPF	0.0

Table 6-6 (continued). TRANSPORT BLOCK CARD DATA

Card group	Format	Card columns	Description	Variable name	Default value
			REPEAT CARD GROUP 45 FOR EACH OF THE KTNUM SUBAREAS. THESE SUBAREAS DO NOT NECESSARILY HAVE TO CORRESPOND TO RUNOFF SUBCATCHMENTS.		
45			Subarea data.		
	2I3	1-3	Subarea number.	KNUM	None
		4-6	External number of the manhole into which flow is assumed to enter for subarea KNUM (maximum value = 1000, minimum value = 1).	INPUT	None
	3I1	7	Predominant land use within subarea, *i.e.*,	KLAND	5
			KLAND = 1, Single-family residential,		
			KLAND = 2, Multi-family residential,		
			KLAND = 3, Commercial,		
			KLAND = 4, Industrial,		
			KLAND = 5, Undeveloped or park lands.		
		8	Parameter indicating whether or not water usage within subarea KNUM is metered.	METHOD	2
			METHOD = 1, metered water use,		
			METHOD = 2, incomplete or no metering.		
		9	Parameter indicating units in which water usage estimates (WATER) are tabulated.	KUNIT	0
			KUNIT = 0, thousand gal/mo,		
			KUNIT = 1, thousand ft^3/mo.		

Table 6-6 (continued). TRANSPORT BLOCK CARD DATA

Card group	Format	Card columns	Description	Variable name	Default value
	13F5.1	10-14	Measured winter water use for subarea KNUM in the unts specified by KUNIT (not required).	WATER	None
		15-19	Cost of the last thousand gal. of water per billing period for an average consumer within subarea KNUM, cents/1,000 gal. (not required).	PRICE	None
		20-24	Measured average sewage flow from the entire subarea KNUM, cfs (not required).	SEWAGE	None
		25-29	Total area within subarea KNUM, acres (maximum = 200).	ASUB	None
		30-34	[a]Population density within subarea KNUM, population/acres.	POPDEN	None
		35-39	[a]Total number of dwelling units within subarea KNUM.	DWLINGS	10.0/ac.
		40-44	[a]Number of people living in average dwelling unit within subarea KNUM.	FAMILY	3.0
		45-49	[a]Market value of average dwelling unit within subarea KNUM, thousands of dollars.	VALUE	20.0
		50-54	[a]Percentage of dwelling units possessing garbage grinders within subarea KNUM.	PCGG	None
		55-59	Total industrial process flow originating within subarea KNUM, cfs.[b]	SAQPF	0.0
		60-64	BOD contributed from industrial process flow originating within subarea KNUM, mg/l.	SABPF	0.0
		65-69	SS contributed from industrial process flow originating within subarea KNUM, mg/l.	SASPF	0.0
		70-74	Income of average family living within subarea KNUM.	XINCOM	VALUE/2.5

[a]Not required if KLAND greater than 2.

[b]If SAQPF = 0.0, then DWBOD and DWSS will be zero for land use 4 (i.e., for industrial flow to be considered KLAND must equal 4).

Table 6-6 (continued). TRANSPORT BLOCK CARD DATA

Card group	Format	Card columns	Description	Variable name	Default value
	12	75-76	MSUBT = 0, subtotals not made,	MSUBT	0
			MSUBT = 1, subtotal made.		
			END OF FILTH DATA CARDS.		
			IF NCNTRL = 0 ON CARD 14, SKIP CARDS 46 and 47.		
46			Time for start of storm.		
	F10.0	1-10	Time of day of start of storm, sec.	TZERO	0.0
			REPEAT CARD 47 FOR EACH INLET FOR FIRST TIME STEP AND THEN REPEAT CARD 47 FOR EACH INLET FOR SECOND TIME STEP, ETC. REPEAT THIS COMBINATION UNTIL ALL TIME STEPS HAVE BEEN READ.[a]		
47			Hydrograph and pollutograph input cards.		
	4F10.0	1-10	Input flow for this time step at first inlet, cfs.	RNOFF(1)	0.0
		11-20	Input BOD for this time step at first inlet, lbs/min.	PLUTO(1,1)	0.0
		21-30	Input SS for this time step at first inlet, lbs/min.	PLUTO(1,2)	0.0
		31-40	Input coliform for this time step at first inlet, MPN/min.	PLUTO(1,3)	0.0
		41-80	Not used.		
			FOR GRAPHING TRANSPORT OUTPUT, CALL GRAPH SUBROUTINE THROUGH THE EXECUTIVE BLOCK.		
			END OF TRANSPORT BLOCK DATA CARDS.		

[a]Note: Order of inlets must be the same as indicated in card group 28.

Table 6-7. TRANSPORT BLOCK VARIABLES[a]

Variable Name	C*	Description	Units
A	C	Cross-sectional areas of flow	sq ft
AA		Cross-sectional areas of flow	sq ft
AAA	C	Flow depth computational variable	
AASURF		Surface area (data array member)	sq ft
AB		Area computational variable	
ABOD		Average BOD concentration measured in sewer or at treatment facility	mg/L
ACOLI		Total coliforms	MPN/100 ml
ADEPTH		Depth (data array member)	ft
ADWF		Average measured DWF	cfs
AF		Cross-sectional area of conduit	sq ft
AFACT	C	Factor to calculate AFULL	
AFULL	C	Full flow area for conduits	sq ft
AINFIL		Total infiltration within drainage basin	cfs
ALF	C	Value of A/A_f corresponding to Q/Q_f value	
ALFMAX	C	Value of A/A_f corresponding to maximum Q/Q_f value	
ALM		Computational variable associated with conduit area	
ALPHA		Normalized area flow, A/A_f	
ANORM	C	Normalized depths, D/D_f, corresponding to A/A_f	
AO2DT2		Routing parameter (data array member)	
APLAN	C	Land area requirement	sq ft
AQQ		Average computed infiltration	cfs
AREAF		Flow area of given flow rate in conduit	sq ft
ARG		Cotangent of angle which is formed from radius and wetted surface	
ASUB		Total area within subarea KNUM	acres
ASUSO		Average SS concentration measured in sewer or at treatment facility	mg/L
ATERM	C	Variable used to calculate area of a conduit, area flow/area full	
A1		Normalized depth of conduit upstream, A/A_f	ft
A1BOD		Average weighted BOD	lb/day/cfs
A1COLI		Average number of coliform bacteria	MPN/day/cfs
A1SS		Average weighted SS	lb/day/cfs
A2		Normalized depth of conduit downstream, A/A_f	ft
BARREL	C	Total number of barrels in each conduit	
BASEA		Base area (geometric basin)	sq ft
BASEC		Base circumference (geometric basin)	ft
BDEPTH	C	Depth (array member)	ft
BLANK	C	Supercritical flow indicator	
BODCON		Computed BOD concentration	mg/L
BODCOT		BOD outflow concentration	mg/L
BODIN	C	BOD input to storage element	lb/DT
BODOUT	C	BOD output from storage element	lb/DT
BODPF		Average BOD of a process flow	mg/L
BSTOR	C	Maximum storage capacity of storage element	cf

[a]Does not include variables added during updating.

C* = Variable names shared in common blocks.

Table 6-7 (continued). TRANSPORT BLOCK VARIABLES

Variable Name	C*	Description	Units
CATH	C	Flow depth computation variable	
CATHY		Flow depth variable used in computing the hydraulic radius	
CCCI		Composite construction cost index	
CDAOUT		Orifice area x discharge coefficient	sq ft
CF		Correction factor to weight sewage strength	
CF2		Correction factor for DWF	
CLAND	C	Cost of land	$
COSTSLO		Basin sideslopes cotangent	ft/ft
CPACRE	C	Unit cost of land	$/acre
CPCUYD	C	Unit cost of excavation	$/cy
CPI		Consumer Price Index	
CPOLL	C	Pollutant concentrations	lb/cf
CPS	C	Pumping station and structure cost	$/ps
CRITD		Critical settling diameter of particles undergoing deposition in conduits	mm
CSTOR	C	Cost of excavation for storage	$
CTOTAL	C	Total cost	$
CUMIN		Cumulative water inflow	cf
CUMOUT	C	Cumulative water outflow	cf
C1	C	Flow routing variable	variable
C1BOD		Computed BOD total after deducting process flows	lb/day
C1DT		Time-step	days
C1DWF		Total DWF less infiltration	cfs
C11		Normalized flow-area computational variable	
C2		Negative value of normalized flow rate	
C2BOD		Computed BOD total further corrected for weighting effects	lb/day
C2DWF		C1DWF less process flows	cfs
C2SS		Weighted SS strengths according to subarea	lb/day
D		Computational variable used in subroutine NEWTON	
DALPHA		Increment for normalized area data	
DD		Wetted depth of the modified element cross-section area, i.e., basket-handle conduit and rectangular with triangular bottom	
DDEPTH		Depth increment	ft
DDWF		Daily adjusted sewage inflows, ADWF	cfs
DELQ		Incremental difference of the flows between each time-step	cfs
DEPMAX	C	Maximum flooding depth of reservoir	ft
DEPTH		Water depth of reservoir	ft
DEPTHL		Depth of reservoir for the previous time-step	ft
DETENT	C	Reservoir plug flow detention time	sec
DH		Computation variable used in determining the flow over a flow divider	
DIAM		Diameter of circular pipe	ft

Table 6-7 (continued). TRANSPORT BLOCK VARIABLES

Variable Name	C*	Description	Units
DINFIL		Dry weather infiltration	gpm
DIST	C	Conduit length	ft
DNORM	C	Normalized depths of flow	
DPSI		Derivative of Q/Q_f with respect to A/A_f	
DPSI		Name of subroutine	
DSTART	C	Depth at the pump startup	ft
DSTOP	C	Depth at pump shutdown	ft
DT	C	Size of time-step	sec
DTIM		Time on input tape from RUNOFF	sec
DTMORE	C	Extra time-step needed to pump dry	
DTON	C	Number of time-steps pumped	
DTPUMP	C	Total time-steps to pump dry	
DUMDEP	C	Dummy depth used in internal storage reservoir calculations	ft
DUMSTR	C	Dummy storage volume used in internal storage reservoir calculations	cf
DUMY1		Corrected hourly DWF	cfs
DUMY2		Corrected hourly BOD concentration	lb/sec
DUMY3		Corrected hourly SS concentration	lb/sec
DUMY4		Corrected hourly concentration of fourth pollutant	(not yet programmed)
DUMY5		Corrected hourly coliform concentration	MPN/sec
DV		The change in flow velocity between two succeeding flow routing iterations	
DVBOD	C	Daily BOD variation factor	
DVDWF	C	Daily sewage flow variation factor	
DVSS	C	Daily SS variation factor	
DWBOD		BOD of DWF of each subarea	lb/sec/DT
DWCOLI		Coliform load of DWF in each subarea	MPN/100 mL
DWDAYS		Total number of antecedent dry days	days
DWF		Dry weather flow	cfs
DWLNGS		Total number of dwelling units within subarea KNUM	
DWLOAD		Name of subroutine	
DWSS		SS of DWF in each subarea	lb/sec/DT
DW1BOD		DWF BOD in each subarea for each time-step	lb/DT
DW1SS		DWF SS in each subarea for each time-step	lb/DT
DXDT	C	Length of conduit divided by time-step interval in seconds	ft/sec
D1	C	Perimeter of rectangular, round bottom conduit	ft
D1		Rate constant for decay	1/day
D2	C	Wetted perimeter of rectangular, round bottom conduit	ft
D2		Rate constant for reaeration	1/day
D2COLI		Total DWF coliform per subarea	MPN/sec
EPSIL	C	Allowable error for convergence in routing routine	
FAMILY		Number of people living in average dwelling unit within subarea KNUM	
FILTH		Name of subroutine	
FINDA		Name of subroutine	

Table 6-7 (continued). TRANSPORT BLOCK VARIABLES

Variable Name	C*	Description	Units
FIRST		Name of subroutine	
FON		Fraction of time-step pumped	
FRAC	C	Fraction of an inflow plug	
GEOM1	C	Conduit vertical dimension	ft
GEOM2	C	Conduit horizontal dimension	ft
GEOM3	C	Conduit dimension	ft
GINFIL		Groundwater infiltration	gpm
GNO	C	Supercritical flow indicator, flow not supercritical	
H		Head over weir	ft
HELP		Normalized area flow (= ALPHA)	
HVBOD	C	Hourly BOD variation factor	
HVCOLI	C	Hourly coliform variation factor in DWF	
HVDWF	C	Hourly sewage flow variation factor	
HVSS	C	Hourly SS variation factor	
I		Dimension and do loop counter	
I		Ratio of A/ΔA for linear interpolation counter (DPSI, PSI)	
ICHK		Newton-Raphson iteration check	
ICOST	C	Cost output control parameter	

Variable Name	C*	Description	Units
IFLOOD	C	Flood Indicator	
II		Do loop counters	
III		Do loop counters	
IK		Do loop counter for element number	
INCNT	C	Counting parameter for I/O input files	
INFIL		Name of subroutine	
INITAL	XF	Name of subroutine	
INPUT		External element number for flow and quality inputs to the sewer	
INUE	C	Internal upstream element numbers	
IOLD	C	Routing solution indicator	
IOUTCT	C	Counting parameter for I/O output files	
IP		Pollutant number	
IPOL	C	Pollution control parameter	
IPRINT	C	Print control parameter	
IR	C	Element number sequencing array	
ISTMOD	C	Storage mode parameter	
ISTOUT	C	Storage outlet type parameter	
ISTTYP	C	Storage reservoir type parameter	
ITER	C	Iteration number for routing	
J		Do loop counter	
JIN	C	Input file reference numbers	

Table 6-7 (continued). TRANSPORT BLOCK VARIABLES

Variable Name	C*	Description	Units
JJ		Do loop counter	
JN		External element numbers at which flow enters receiving water	
JOUT	C	Output file reference numbers	
JP		Number of first inlet plug in outflow	
JPLOT		Control parameter for plotting routed hydrographs and pollutographs	
JR	C	Element number sequencing array	
K		Interpolation warning flag	
KASE		Study area indicator	
KDAY		Number for the day of the week (Sunday = 1)	
KDEPTH	C	Parameter indicating form of input for D-A data	
KDT		Time-step number	
KFLAG		Interpolation warning flag	
KFULL	C	Parameter indicating surcharging	
KHOUR	C	Number for the hour of a day	hr
KJ		Do loop counter for time	
KLAND		Predominant land use within subarea	
KLASS	C	Parameter indicating form of input for Q-A data	
KMINS	C	Number for the minute of an hour	min
KNUM		Total number of subareas within a given study area in which sewage flow and quality are to be estimated	
KP		Inlet plug number	
KPRINT		Control parameter for printing sewer cross-section data	
KSTOR	C	Storage unit number	
KSTORE	C	Storage element array	
KTNUM	C	Total number of subareas	
KTSTEP	C	Total Number of time-steps	
KUNIT	C	Parameter indicating units in which water usages are tabulated	
KVAL		Shields K as criterion for deposition and resuspension	
L		Size of data array	
L		GEOM3	
LABEL	C	Flag to label last increment of flow in plug flow	
LP	C	Number of last inlet plug in outflow	
LPREV	C	LP for previous time-step	
L1		Half width of the wetted surface in the element cross-sectional area	
M	C	Current internal element number	
METHOD		Parameter indicating whether or not water usage is metered	
MLTBE		Day on which melting period begins	
MLTEN		Day on which melting period ends	
MM	C	Total number of values of ANORM and QNORM	
MMM	C	Total number of values of ANORM and QNORM	

Table 6-7 (continued). TRANSPORT BLOCK VARIABLES

Variable Name	C	Description	Units
MSUBT		Subtotaling indicator for DWF output	
N	C	Current time-step number	
NAME	C	Name given to each user-supplied sewer cross-section	
NAREA1		Dummy variables used to calculate length of melting in INFIL	
NCNTRL		Control parameter for type of I/O interfacing mechanism	
ND		Do loop counter for converting unit	
NDD		Monthly degree/day values	degree-day
NDDAY		Subscript variable	
NDT	C	Total number of time-steps	
NDUM1		Total number of time-steps in runoff	
NDUM2		Size of time-step in RUNOFF, read off input file	sec
NDXDAY		Assigned daily degree/day values	degree-day
NDYUD		Day on which infiltration estimate is desired	
NE	C	Total number of sewer elements	
NEE		NE + 1	
NEP1		NE + 1	
NEWTON		Name of subroutine	
NFILTH		Control parameter for calling subroutine FILTH	
NGOTO		Element type number minus fifteen	
NIN	C	Internal element sequencing number	
NINFIL		Control parameter for calling subroutine INFIL	

Variable Name	C*	Description	Units
NINPUT		Total number of rainfall input locations to the sewer	
NITER		Maximum number of iterations to be made in flow routing	
NJ		Do loop counter for converting units	
NKLAS		NKLASS + 12	
NKLASS	C	Total number of user-supplied sewer cross-sections	
NN	C	Total number of values of DNORM	
NNEED		Dummy variable for sequencing elements	
NNN		Total number of values of DNORM	
NNPE		Total number of routed sewer hydrographs to be printed out	
NNYN		Total number of input hydrographs to be printed out	
NOE	C	External number of an element	
NORDER	C	External non-conduit element numbers at which runoff enters sewer	
NOS		Dummy variable	
NOUTS		Total number of hydrographs to the receiving water	
NPE	C	External element numbers at which routed outflow is printed	
NPF		Number of process flow	
NPOLL	C	Total number pollutants being routed	
NPOLS		NPOLL + 1	
NPRINT	C	Control parameter for printing sewer routing error messages	
NSCRAT	C	Data set reference numbers for temporary storage of data	

Table 6-7 (continued). TRANSPORT BLOCK VARIABLES

Variable Name	C*	Description	Units
NSCRAT	C	Scratch tape number	
NSTOR	C	Total number of storage units	
NT		Element type	
NTOT		Total number of degree days above 750	degree-day
NTRIN		Data set reference numbers for I/O file	
NTROUT		Data set reference numbers for I/O file	
NTU		Element type	
NTX		Scratch file	
NTYPE	C	Element type	
NUE	C	External upstream element numbers	
NX		Day numbers used in assigning daily degree/day values	
NX1		Day numbers used in assigning daily degree/day values	
NX2		Day numbers used in assigning daily degree/day values	
NY		Assigned daily degree/day values	
NYN	C	External element number at which inflow to sewer is printed	
NY1		Assigned daily degree/day values	degree-day
NY2		Assigned daily degree/day values	degree-day
OP		The preparation of total infiltration for each conduit	
OPINF		Opportunity factor representing length of openings susceptible to infiltration for total areas	ft
OPNFIL		Opportunity factor representing susceptibility of each conduit to infiltration for individual areas	ft
OUT	C	Overflow hydrograph and pollutograph storage array	variable
OUTIN	C	Inflow hydrograph and pollutograph storage array	variable
OUT1	C	Printed outflows	cfs
OUT2	C	Printed pollutants	lb/min, MPN/min
O2DT2		Interpolated storage volume	cf
PCGG		Percent of dwelling units possessing garbage grinders within subarea KNUM	%
PCT1		Fraction of sediment on bottom of sewer with diameter greater than or equal to CRITD	
PCT2		Fraction of sediment in suspension with diameter greater than or equal to CRITD	
PER		Wetted perimeter of modified cross-section area	ft
PLUTO	C	Pollutant ordinates from surface runoff	lb/min
POP		Total population in each subarea	
POPDEN		Population density per acre	
POPULA		Total population in all areas	thousands
PP		Same as OUT2	
PRICE		Cost of last thousand gallons of water per billing period	¢/1,000 gal.
PRINT		Name of subroutine	

Table 6-7 (continued). TRANSPORT BLOCK VARIABLES

Variable Name	C*	Description	Units
PS		Normalized flows	
PSI		Name of function	
PSI		Normalized flow, same as PS	
PSIMAX	C	Maximum Q/Q_f value	
PUMP	C	Constant pumping rate of pumps	cfs
P1	C	Conduit dimensional variable for computation purposes (FIRST)	
P2	C	Conduit dimensional variable for computation purposes (FIRST)	
P4	C	Conduit dimensional variable for computation purposes (FIRST)	
P5	C	Conduit dimensional variable for computation purposes (FIRST)	
P6	C	Conduit dimensional variable for computation purposes (FIRST)	
P7	C	Conduit dimensional variable for computation purposes (FIRST)	
Q	C	Sewer flows	cfs
QDWF	C	Sewage inflows	cfs
QFULL	C	Full flow capacity for conduits	cfs
QI	C	Sewer element inflow	cfs
QINF		Total infiltration	gpm
QINFIL	C	Groundwater infiltration inflows	cfs

Variable Name	C*	Description	Units
QINST	C	Water inflow rate to storage unit	cfs
QINSTL	C	Inflow rate previous time-step	cfs
QMAX	C	Maximum flow capacity for conduits	cfs
QNORM	C	Normalized flows	Q/Q_f
QO	C	Sewer element outflow	cfs
QOLD		Flow rate for previous time-step	cfs
QOUST	C	Outflow rate from storage unit	cfs
QOUSTL	C	Outflow rate previous time-step	cfs
QOUT		Outflow rate	cfs
QOUTO	C	Initial outflow rate	cfs
QO1	C	Undiverted flow in a flow divider or the flow going to the element number given in GEOM3	cfs
QO2	C	Diverted flow in a flow divider	cfs
QPF		Average daily process flow entering study system	cfs
QPUMP	C	Pumped outflow rate	cfs
QQ		Infiltration flow rate	cfs
QQDWF		Sum of DWF and infiltration flow	cfs
QQF		Ratio of total infiltration flow to DWF flow	
QUAL		Name of subroutine	
R	C	Same as P5, conduit dimensional variable for depth calculations	
RADH		Name of function	
RECEIV		Name of subroutine	

Table 6-7 (continued). TRANSPORT BLOCK VARIABLES

Variable Name	C*	Description	Units
RFACT	C	Factor to calculate full-flow hydraulic radius	
RH		Computation variable associated with conduit flow area	
RHYD		Hydraulic radius	ft
RINFIL		Average infiltration due to rain water infiltrating into pipes from the ground	gpm
RNOFF	C	Flow ordinates from surface runoff	cfs
ROUGH	C	Conduit roughness (Manning's n)	
ROUTE		Name of subroutine	
RR		Radius of the element (circular pipe)	
RSMAX		Peak infiltration caused by residual melting ice	gpm
S		Wetted perimeter (RADH)	ft
S		Saturation value for DO (QUAL)	mg/L
SABPF		BOD contributed from industrial process flow	mg/L
SAQPF		Total industrial process flow originating within subarea KNUM	cfs
SASPF		SS contributed by industrial process flows	mg/L
SBOD	C	BOD in storage unit	lb
SBODC		BOD concentration in storage unit	mg/L
SCF	C	Supercritical flow indicator	
SCOL		Coliform concentration in storage unit	lb
SCOLC		Coliform concentration in storage unit	MPN/ml
SCOUR	C	Sediment removed from conduits	lb
SEWAGE		Measured average sewage flow	cfs
SINFIL		Infiltration due to melting residual ice	gpm

Variable Name	C*	Description	Units
SLOP		Name of subroutine	
SLOPE	C	Conduit invert slope	ft/ft ft/100 ft
SLUPE		Slope of line $-C_1\alpha - C_2$ on Figure 6-3	
SMMBOD		Summation of BOD in system	lb/sec/DT
SMMDWF		Summation of DWF in system	cfs
SMMQQ		Summation of infiltration flow rate in system	cfs
SMMSS		Summation of SS in system	lb/sec/DT
SMTDWF		Sum total of DWF and infiltration	cfs
SPG		Specific gravity of sediment	
SSCONC		Total and subtotal SS concentration of DWF	mg/L
SSCOUT		SS concentration in outflow	mg/L
SSIN	C	SS inflow rate	lb/DT
SSOUT	C	SS outflow rate	lb/DT
SSS	C	SS in storage unit	lb
SSSC		SS concentration in storage unit	mg/L
STOR	C	Water in storage	cf
STORF	C	Storage at end of storm	cf
STORL	C	Stored water previous time-step	cf
STORMX	C	Maximum storage during storm	cf
STORO	C	Initial storage	cf
SUMBOD		Sum of BOD from all process flow	lb/sec
SUMINF		Sum of DINFIL and RINFIL	gpm
SUMQPF		Sum of the process flows from all locations	cfs

Table 6-7 (continued). TRANSPORT BLOCK VARIABLES

Variable Name	C*	Description	Units
SUMSS		Sum of SS from all process flow	lb/sec
SUM1		Sum for sewer flows	cfs
SUM2		Sum for concentration of pollution, SS	lb/sec
SUM3		The amount of solids held in suspension due to velocity of flow	lb/sec
SURGE1	C	Surcharged flow volume, last time-step	cf
SURGE2	C	Surcharged flow volume, this time-step	cf
SUSPP		Average daily SS of process flow	
TBODOT		Total BOD discharged from outfall	lb
TCA		Total contributing commercial area	acres
TCOLI		Total coliform in DWF per day	MPN/day
TDTR		Total contributing area except industrial and park and open space area	acres
TDWFA		Total computed residential and commercial area which contributed to DWF	acres
TERM		Term in routing equation	
THETA		The angle which is drawn from center of cross-section area to the wetted surface	radian
TIME	C	Time from start of simulation	sec
TIME2M		Time since start of inflow	min
TINA		Total contributing industrial area	acres
TITLE	C	Title associated with I/O	
TOTA		Total study area from which ABOD and ASUSO were taken	acres
TOTAL		Sum of all incoming sewer flow	cfs
TOTAL1		Sum of all pollutant flow rates from sewer element immediately upstream	lb/sec
TOTAL2		Pollutant flow rate of incoming DWF	variable
TOTAL3		Pollutant flow rate of incoming runoff	lb/sec
TOTAL4		Pollutant flow rate of all flow and scouring effect	lb/sec
TOTBOD		Total of BOD	lb/day
TOTPOP		Total population	
TOTSS		Total SS	lb/day
TPOA		Total park and open space area	acres
TRAA		Total contributing average income below $15,000 but above $7,000 residential area	acres
TRANS		Name of subroutine	
TRGGA		Total area from TRHA, TRAA, TRIA that contributes additional waste from garbage grinders	acres
TRHA		Total contributing high income above $15,000 residential area	acres
TRLA		Total contributing low income below $7,000 residential area	acres
TSSOUT		Total SS discharged from outfall	lb
TSTCST		Name of subroutine	
TSTORG		Name of subroutine	
TSTRDT		Name of subroutine	
TZERO		Time storm started	sec
ULEN		Average distance between joints in study area sewers	ft
ULIMIT		Upper limit of bed load of solids	lb

Table 6-7 (continued). TRANSPORT BLOCK VARIABLES

Variable Name	C*	Description	Units
VALUE		Market value of average dwelling unit within subarea KNUM	$1000's
VEL		Name of a function	
VOLIN	C	Water inflow per time-step	cf
VOLOUT	C	Water outflow per time-step	cf
VOL1		Previous volume of wastewater within each element	cf
VOL2		Current volume of wastewater within each element	cf
WATER		Winter water use for KNUM (units of KNUM)	variable
WD		Weight on spatial derivative in routing flows	
WDWF	C	Sewage pollutant concentrations	lb/sec
WTDWFA		Weight strength of DWF contributing area (not including industrial and park and open area)	acres
WDWF1		Daily adjusted sewage BOD concentration	lb/sec
WDWF2		Daily adjusted sewage SS concentration	lb/sec
WDWF3		Daily adjusted sewage coliform concentration	MPN/sec
WEIRHT		Weir height	ft
WEIRL		Weir length	ft
WELL1	C	Wet well volume for lift stations	cf
WELL2	C	Wet well volume for lift stations	cf
WSLOPE		Slope of water surface	ft/ft
WT		Weight on time derivative in routing flows	
X		Data array member	
XX		Input to interpolation routine	
XINCOM		Income of average family living	$1000's
XL		Width of rectangular pipe	ft
XMLTBE		Floating point number MLTBE	
XMLTEN		Floating point number MLTEN	
XNDYUD		Floating point number NDYUD	
XXARG		Dummy variable used to calculate SINFIL	
Y		Data array member	
YE		Output value from interpolation routine	
YES	C	Supercritical flow indicator, flow is supercritical	

SAMPLE RUNS

Three examples of the use of the Transport Block or its subroutines are given:

Example 1	The complete Transport Block but with Internal Storage not called
Example 2	Subroutine INFIL
Example 3	Subroutine FILTH

Actual I/O information are used in part to illustrate these examples.

Example 1. Transport Block

The sewer system shown in Figure 6-12 will be used to illustrate I/O sections of the Transport program. The system is in the North Lancaster Drainage District, Lancaster, Pennsylvania, composed of 147 elements. The system outfall is at element 1.

Description of Sample Data --

Table 6-8 shows a listing of actual data presented to the program for execution. The data have been broken up into four sections; a verbal description of the implications of each section follows.

Section A -- Section A lists the following example I/O specifications:

- No new conduit shapes are to be added
- It is not desired to print flow-area relationships
- Title card
- There are 147 total elements in the system
- Simulation will occur over 100 time steps
- There are 66 inflows to the system; 10 of these inputs are to be printed out

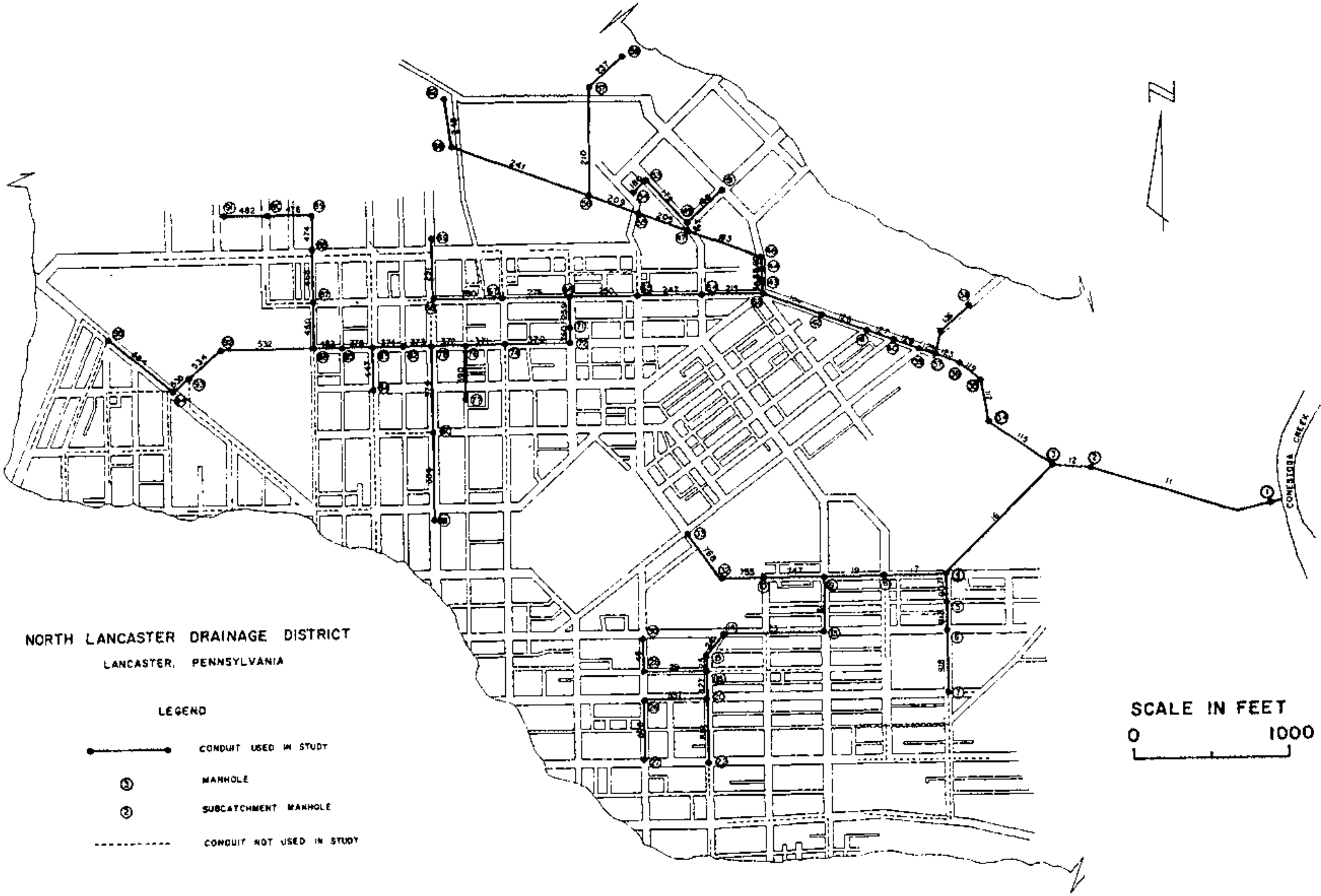


Figure 6-12. North Lancaster, Pennsylvania, Drainage District

Table 6-8. INPUT DATA NORTH LANCASTER, PENNSYLVANIA, DRAINAGE DISTRICT

	DATA						CARD GROUP NUMBER
	TRANSPORT					(READ IN EXECUTIVE BLOCK)	
A	0 0						1
A	STORM OF MARCH 22, 1972 DURATION 4 HRS, STUDY 3 (STORM #7)						2
A	147 100 66 10 10 1 0 3 2						3
A	300. 0 1 .0001 1 1 5.						4
B	1 11		16				5
B	2 12		16				5
B	3 16	115	16				5
B	4 17	907	16				5
B	5 913		16				5
B	6 918		16				5
B	7 0		16				5
B	8 19		16				5
B	9 747	21	16				5
B	10 755		16				5
B	11 2		1	1745.	10.00	1.40	5
B	12 3		1	400.	10.00	0.90	5
B	13 23		16				5
B	14 24		16				5
B	15 25		16				5
B	16 4		1	1520.	6.00	1.32	5
B	17 8		1	600.	6.00	1.10	5
B	18 827	29	16				5
B	19 9		1	515.	6.00	1.40	5
B	20 861	837	16				5
B	21 13		1	430.	5.00	3.41	5
B	22 0		16				5
B	23 14		1	589.	5.00	0.79	5
B	24 15		1	623.	5.00	0.66	5
B	25 18		1	145.	5.00	0.77	5
B	26 878		16				5
B	27 0		16				5
B	28 45		16				5
B	29 28		1	563.	3.50	0.76	5
B	30 0		16				5
B	32 768		16				5
B	33 0		16				5
B	34 117		16				5
B	35 119		16				5
B	36 123		16				5
B	37 136	125	16				5
B	38 0		16				5
B	39 126		16				5
B	40 127		16				5
B	41 128		16				5
B	42 130		16				5
B	43 159		16				5
B	44 160		16				5
B	45 30		1	369.	3.50	0.36	5
B	46 163		16				5
B	47 167	205	16				5
B	49 168	172	16				5
B	51 0		16				5
B	53 180		16				5
B	54 0		16				5
B	55 209		16				5
B	56 210	211	16				5
B	57 237		16				5
B	58 0		16				5
B	60 245		16				5
B	62 0		16				5
B	63 215	158	16				5
B	64 247		16				5
B	65 250		16				5
B	66 276	259	16				5
B	67 280		16				5
B	68 291		16				5
B	69 0		16				5
B	71 260		16				5
B	72 370		16				5
B	74 371		16				5
B	76 390	372	16				5
B	77 0		16				5
B	78 379	373	16				5
B	80 386		16				5
B	81 0		16				5
B	82 374		16				5
B	83 447	375	16				5
B	84 0		16				5
B	85 451		16				5
B	86 460	532	16				5
B	87 468		16				5

Table 6-8 (continued). INPUT DATA NORTH LANCASTER, PENNSYLVANIA, DRAINAGE DISTRICT

Card							Card type
B	88	474	16				15
	89	476	16				
	90	482	16				
	91	0	16				
	92	530	16				
	93	535	16				
	94	564	16				
	95	0	16				
	115	34	1	600.	8.00	1.29	
	116	35	1	400.	8.00	0.60	
	118	36	1	250.	8.00	0.86	
	119	37	1	300.	8.00	1.01	
	123	39	1	125.	8.00	0.71	
	125	40	1	250.	8.00	0.71	
	126	41	1	256.	8.00	1.02	
	127	42	1	507.	8.00	0.84	
	128	63	1	552.	8.00	0.64	
	130	38	1	350.	8.00	0.73	
	136	43	1	169.	4.00	1.58	
	158	44	1	60.	4.00	0.80	
	159	46	1	87.	4.00	0.66	
	160	47	1	541.	4.00	1.48	
	163	49	1	118.	4.00	0.36	
	167	51	1	431.	4.00	0.56	
	168	53	1	509.	4.00	0.87	
	172	54	1	205.	3.00	0.51	
	180	55	1	600.	4.50	1.18	
	205	56	1	500.	4.50	1.74	
	209	57	1	900.	4.50	0.46	
	210	60	1	1200.	4.50	0.92	
	211	64	1	535.	3.00	1.77	
	214	58	1	800.	3.00	0.92	
	237	62	1	700.	7.00	1.19	
	245	65	1	564.	7.00	0.98	
	247	66	1	380.	7.00	0.89	
	250	71	1	390.	7.00	0.72	
	259	72	1	114.	5.00	0.49	
	260	67	1	630.	3.50	0.87	
	276	68	1	650.	3.00	0.44	
	280	69	1	400.	4.00	1.08	
	281	74	1	541.	4.00	0.50	
	370	76	1	365.	4.00	0.67	
	371	78	1	295.	4.00	0.88	
	372	82	1	316.	4.00	0.41	
	373	83	1	344.	6.00	0.58	
	374	85	1	617.	4.00	0.65	
	375	80	1	753.	4.00	1.46	
	376	81	1	710.	3.00	2.50	
	386	77	1	375.	4.00	1.68	
	390	84	1	395.	4.00	2.34	
	447	86	1	276.	4.50	1.22	
	453	87	1	400.	4.50	0.25	
	460	88	1	440.	3.50	0.13	
	468	89	1	310.	3.50	0.27	
	474	90	1	430.	3.50	0.30	
	476	91	1	500.	4.00	0.54	
	482	92	1	845.	4.00	1.35	
	532	93	1	470.	4.00	1.94	
	534	94	1	450.	4.00	1.17	
	535	95	1	400.	4.00	0.72	
	564	3	1	540.	3.50	0.71	
	747	2	1	410.	4.00	0.76	
	753	23	1	520.	4.00	4.47	
	760	20	1	418.	4.00	0.70	
	827	26	1	560.	4.00	1.57	
	837	22	1	555.	4.00	4.53	
	861	27	1	540.	4.00	3.52	
	878	5	1	260.	4.00	3.87	
	907	6	1	280.	4.00	3.11	
	913	7	1	554.	4.00	3.37	
	918		1				

C												Card type
	1											27
	5 86	27 78	39 66	44 63	46 56	63 37	66 9	78 4	91 3	95 1		28

D										Card type
	35	251	1300.0	0.0						30
		0	35	6.0						31
		.908	7	460	750	890 1198	891 831	458 188	14	32
	.829		33		1.042	1.018	1.032	1.012	.970	33
	.739		1.018		.964	1.030	.953	1.089	.807	34
	.906		1.128		1.009	1.044	1.053	1.054	1.005	35
	1.092		1.042		.732	.718	.689	.701	.792	36
	1.181		.819		1.198	1.174	1.158	1.144	1.124	.950
			1.148		1.078	1.074	1.115	1.070	1.057	1.098
			1.072							1.015	37
	1.0		1.0		1.0	1.0	1.0	1.0	1.0	1.0	38
	1.0		1.0		1.0	1.0	1.0	1.0	1.0	1.0	

Table 6-8 (continued). INPUT DATA NORTH LANCASTER, PENNSYLVANIA, DRAINAGE DISTRICT

```
1.0      1.0      1.0      1.0      1.0      1.0      1.0      1.0      36
1.0      1.0      1.0      1.0      1.0      1.0      1.0      1.0
1.0      1.0      1.0      1.0      1.0      1.0      1.0      1.0      38
1.0      1.0      1.0      1.0      1.0      1.0      1.0      1.0
1.0      1.0      1.0      1.0      1.0      1.0      1.0      1.0
1.0      1.0      1.0      1.0      1.0      1.0      1.0      1.0
1.0      1.0      1.0      1.0      1.0      1.0      1.0      1.0      40
1.0      1.0      1.0      1.0      1.0      1.0      1.0      1.0
   66       1     0      2     11    20121.4165.750.0                   41
8.5          200.           200.    0.0   10000.                       42
952.      90.        140.               572.      0.0     132.    190.  43
   5   5310        40.       7.   14.   35.  2.7  14.   0.              7.
   6   6310        40.       9.   22.   75.  2.7  14.   0.              7.
   7   7310        40.      46.   25.  375.  2.7  14.   0.              7.
   8   8110        40.      16.   13.   75.  2.7  14.   0.              7.
   9   9110        40.       8.    0.
  10  10110        40.      12.    0.
  13  13110        40.       9.   22.   75.  2.7  14.   0.              7.
  14  14110        40.       5.   40.   75.  2.7  14.   0.              7.
  15  15410        40.       6.    0.                   1.01000. 820.
  18  18110        40.       3.   31.   35.  2.7  14.   0.              7.
  20  20110        40.      12.   65.  120.  2.5  14.   0.              7.
  22  22210        40.      21.   33.  280.  2.5  14.   0.              7.
  26  26210        40.      15.   33.  160.  2.5  14.   0.              7.
  27  27210        40.      22.   32.  280.  2.5  14.   0.              7.
  28  28110        40.       9.   22.   75.  2.7  14.   0.              7.
  30  30110        40.      34.   21.  260.  2.7  14.   0.              7.
  32  32110        40.       4.    0.
  33  33110        40.      47.   17.  300.  2.7  14.   0.              7.
  38  38110        40.      78.   13.  380.  2.7  24.  20.             14.
  39  39110        40.       5.   40.   75.  2.7  14.   0.              7.
  40  40110        40.      19.   37.  260.  2.7  14.   0.              7.
  41  41110        40.      25.   36.  340.  2.7  14.   0.              7.
  42  42110        40.       9.   56.  190.  2.7  14.   0.              7.
  43  43210        40.     0.4     0.
  44  44210        40.     0.3     0.
  46  46410        40.     0.3     0.                   2.01000. 820.
  47  47210        40.       1.   33.   35.  2.7  24.  20.             14.
  49  49210        40.      26.    0.
  51  51110        40.      17.   18.  115.  2.7  24.  20.             14.
  53  53210        40.      18.   11.   75.  2.7  24.  20.             14.
  54  54210        40.      14.   14.   75.  2.7  24.  20.             14.
  55  55310        40.       1.    0.
  56  56410        40.             0.                   0.71000. 820.
  57  57510        40.      48.    4.   70.  2.7  24.  20.             14.
  58  58510        40.      32.    4.   55.  2.7  24.  20.             14.
  60  60310        40.      30.    5.   35.  2.7  24.  20.             14.
  62  62310        40.      18.    5.   20.  2.7  24.  20.             14.
  63  63110        40.       6.   33.   75.  2.7  14.   0.              7.
  64  64110        40.       8.   50.  150.  2.7  14.   0.              7.
  65  65110        40.       9.   22.   75.  2.7  14.   0.              7.
  66  66110        40.       6.   50.  110.  2.7  14.   0.              7.
  67  67110        40.      13.   23.  100.  3.0  14.   0.              7.
  68  68110        40.       9.   22.   65.  3.0  14.   0.              7.
  69  69110        40.      21.   19.  130.  3.0  14.   0.              7.
  71  71110        40.       2.    0.
  72  72110        40.      35.   34.  400.  2.7  14.   0.              7.
  74  74110        40.      14.   21.  120.  2.4  14.   0.              7.
  76  76110        40.       2.    0.
  77  77110        40.      21.   14.  120.  2.4  14.   0.              7.
  78  78110        40.       7.   14.   40.  2.4  14.   0.              7.
  80  80110        40.      19.   16.  130.  2.4  14.   0.              7.
  81  81110        40.      11.    9.   40.  2.4  14.   0.              7.
  82  82410        40.       6.   33.   85.  2.4  14.   0.   1.01000. 820.   7.
  83  83110        40.       8.   25.   85.  2.4  14.   0.              7.
  84  84110        40.       9.   33.  120.  2.4  14.   0.              7.
  85  85410        40.      11.   18.   85.  2.4  14.   0.   0.71000. 820.   7.
  86  86310        40.      12.    8.   40.  2.4  14.   0.              7.
  87  87110        40.       3.   33.   35.  3.0  14.   0.              7.
  88  88110        40.      29.   10.   95.  3.0  14.   0.              7.
  89  89110        40.       2.   50.   35.  3.0  14.   0.              7.
  90  90110        40.       6.   17.   35.  3.0  14.   0.              7.
  91  91110        40.      30.    3.   30.  3.0  14.   0.              7.
  92  92410        40.       3.    0.                   1.51000. 820.
  93  93110        40.       8.   13.   45.  2.4  14.   0.              7.
  94  94110        40.      20.   45.  280.  3.2  14.   0.              7.
  95  95110        40       56.   20.  350.  3.2  14.   0.              7.
```

0 45

- Ten outflows are to be printed out
- Outflow for one element is to be written on tape or disk
- No tracing messages are to be generated
- Three pollutants (BOD, SS, and coliform) are to be routed
- Four iterations will be used in the routing routine
- Time step interval is 300 seconds
- The iteration convergence criterion is 0.0001
- Five days of dry weather occurred prior to the storm
- Transfer between Model blocks is by either tape or disk
- Infiltration into the sewer is not estimated
- Combined sewer will be modeled by estimating sanitary flows
- The output will be printed in tabular form.

Section B -- This section physically describes the sewer system in terms of its geometry and dimensions. Refer to Table 6-3 for data requirements of each type of conduit shape.

Section C -- These input records specify that the outflow hydrograph and pollutograph for element 1 will be provided on tape or disk for subsequent use by other programs of the Storm Water Management Model, that input hydrographs and pollutographs will be printed out for elements 5, 27, 39, 44, 46, 63, 66, 78, 91 and 95, and that the ten elements for which outflow hydrographs and pollutographs to be printed out are elements 86, 78, 66, 63, 56, 37, 9, 4, 3, 1.

The next three input records are inserted because subroutine INFIL is to be called. The first establishes the infiltration from dry weather flow groundwater and rainwater. The last two determine which day of the year the storm occurs on and read in the monthly degree days. A further example of INFIL data is shown in Example 2.

Section D -- These data satisfy the requirements of subroutine FILTH as applied to this particular system. Waste water enters the system at the 66 nodes listed. The description of FILTH data for a simplified system is covered in Example 3.

Description of Sample Output --

Many options are available to the user for output retrieval from the Transport program. In this example, only the most illustrative ones have been selected and these are shown in the following tables.

Table 6-9 shows the external and internal numbering system used by the program in sequencing the sewer elements.

The most important part of the output is shown in Table 6-10, which describes the sewer system in terms of element types, dimensions, slopes, areas, and flow capacities. This information is strictly based upon the data provided by the user. Careful inspection of this output will detect any errors made using data preparation.

The output from subroutines INFIL and FILTH follow and is shown in Tables 6-11, 6-12 and 6-13. Tables 6-14 and 6-15 contain the sections of output describing the initial conditions prior to the storm to be simulated.

After the storm has passed through the system, the total pounds of solids left deposited within the sewer elements are printed out. This is shown in Table 6-16.

Table 6-17 shows the results of Transport's Pollutant Monitoring Routine.

The final section of the output relates to input and output hydrographs and pollutographs which were specified by the user to be printed out. Tables 6-18 and 6-19 show some of the described inflows. Table 6-20 shows the desired outflow hydrographs. The

Table 6-9. SEQUENCE NUMBERING FOR TRANS EXAMPLE PARTIAL LISTING

STORM OF MARCH 22, 1972 DURATION 6 HRS. STUDY 3 (STORM #7)

ELEMENT LINKAGES AND COMPUTATION SEQUENCE. ELEMENT NO. ZERO IS GIVEN INTERNAL NO. = NO. ELEMENTS + 1 = 148

EXTERNAL ELEMENT NUMBER	INTERNAL ELEMENT NUMBER	TYPE	DESCRIPTION	UPSTREAM ELEMENTS (EXTERNAL NOS.) 1	2	3	ORDER OF COMPUTATIONS AT EACH TIME STEP (PROCEEDING DOWNSTREAM) COMPUTATION SEQUENCE	EXTERNAL NUMBER	INTERNAL NUMBER	INTERNAL UPSTREAM ELEMENT NUMBERS		
1	1	16	MANHOLE	11	0	0	1	7	7	148	148	148
2	2	16	MANHOLE	12	0	0	2	22	22	148	148	148
3	3	16	MANHOLE	16	115	0	3	27	27	148	148	148
4	4	16	MANHOLE	17	907	0	4	30	30	148	148	148
5	5	16	MANHOLE	913	0	0	5	33	32	148	148	148
6	6	16	MANHOLE	918	0	0	6	38	37	148	148	148
7	7	16	MANHOLE	0	0	0	7	45	44	30	148	148
8	8	16	MANHOLE	19	0	0	8	28	28	44	148	148
9	9	16	MANHOLE	747	21	0	9	29	29	28	148	148
10	10	16	MANHOLE	795	0	0	10	51	48	148	148	148
11	11	1	CIRCULAR	2	0	0	11	54	50	148	148	148
12	12	1	CIRCULAR	3	0	0	12	58	54	148	148	148
13	13	16	MANHOLE	23	0	0	13	62	56	148	148	148
14	14	16	MANHOLE	24	0	0	14	69	63	148	148	148
15	15	16	MANHOLE	25	0	0	15	77	68	148	148	148
16	16	1	CIRCULAR	4	0	0	16	81	71	148	148	148
17	17	1	CIRCULAR	8	0	0	17	84	74	148	148	148
18	18	16	MANHOLE	827	29	0	18	91	81	148	148	148
19	19	1	CIRCULAR	9	0	0	19	95	85	148	148	148
20	20	16	MANHOLE	861	837	0	20	136	95	37	148	148
21	21	1	CIRCULAR	13	0	0	21	168	101	48	148	148
22	22	16	MANHOLE	0	0	0	22	180	103	50	148	148
23	23	1	CIRCULAR	14	0	0	23	53	49	103	148	148
24	24	1	CIRCULAR	15	0	0	24	172	102	49	148	148
25	25	1	CIRCULAR	18	0	0	25	49	47	101	102	148
26	26	16	MANHOLE	878	0	0	26	167	100	47	148	148
27	27	16	MANHOLE	0	0	0	27	237	109	54	148	148
28	28	16	MANHOLE	45	0	0	28	57	53	109	148	148
29	29	1	CIRCULAR	26	0	0	29	210	106	53	148	148
30	30	16	MANHOLE	0	0	0	30	245	110	56	148	148
32	31	16	MANHOLE	768	0	0	31	60	55	110	148	148
33	32	16	MANHOLE	0	0	0	32	211	107	55	148	148
34	33	16	MANHOLE	117	0	0	33	56	52	106	107	148
35	34	16	MANHOLE	119	0	0	34	209	105	52	148	148
36	35	16	MANHOLE	123	0	0	35	55	51	105	148	148
37	36	16	MANHOLE	136	125	0	36	205	104	51	148	148
38	37	16	MANHOLE	0	0	0	37	47	46	100	104	148
39	38	16	MANHOLE	126	0	0	38	163	99	46	148	148
40	39	16	MANHOLE	127	0	0	39	46	45	99	148	148
41	40	16	MANHOLE	128	0	0	40	160	98	45	148	148
42	41	16	MANHOLE	130	0	0	41	44	43	98	148	148
43	42	16	MANHOLE	159	0	0	42	159	97	43	148	148
44	43	16	MANHOLE	160	0	0	43	43	42	97	148	148
45	44	1	CIRCULAR	30	0	0	44	156	96	42	148	148
46	45	16	MANHOLE	163	0	0	45	291	117	63	148	148
47	46	16	MANHOLE	167	205	0	46	68	62	117	148	148
49	47	16	MANHOLE	168	172	0	47	280	116	62	148	148
51	48	16	MANHOLE	0	0	0	48	67	61	116	148	148
53	49	16	MANHOLE	180	0	0	49	276	115	61	148	148
54	50	16	MANHOLE	0	0	0	50	386	125	71	148	148
55	51	16	MANHOLE	209	0	0	51	83	70	125	148	148
56	52	16	MANHOLE	210	211	0	52	379	124	70	148	148
57	53	16	MANHOLE	237	0	0	53	390	126	68	148	148
58	54	16	MANHOLE	0	0	0	54	447	127	74	148	148
60	55	16	MANHOLE	245	0	0	55	482	133	81	148	148
62	56	16	MANHOLE	0	0	0	56	90	80	133	148	148
63	57	16	MANHOLE	215	156	0	57	476	132	80	148	148
64	58	16	MANHOLE	247	0	0	58	89	79	132	148	148
65	59	16	MANHOLE	250	0	0	59	474	131	79	148	148
66	60	16	MANHOLE	276	259	0	60	88	78	131	148	148
67	61	16	MANHOLE	283	0	0	61	468	130	78	148	148
68	62	16	MANHOLE	291	0	0	62	87	77	130	148	148
69	63	16	MANHOLE	0	0	0	63	460	129	77	148	148
71	64	16	MANHOLE	260	0	0	64	584	137	85	148	148
72	65	16	MANHOLE	370	0	0	65	94	84	137	148	148

Table 6-10. ELEMENT DATA FOR TRANS EXAMPLE PARTIAL LISTING

STORM OF MARCH 22, 1972 DURATION 4 HRS. STUDY 3 (STORM #7)

NUMBER OF ELEMENTS= 147
NUMBER OF TIME INT= 100
TIME INTERVAL= 300.0 SECONDS.

ELEMENT PARAMETERS

EXT. ELE. NUM.	TYPE	DESCRIPTION	SLOPE (FT/FT)	DISTANCE (FT)	MANNING ROUGHNESS	GEOM1 (FT)	GEOM2 (FT)	GEOM3 (FT)	NUMBER OF BARRELS	AFULL (SQ.FT)	QFULL (CFS)	QMAX (CFS)	SUPER-CRITICAL FLOW WHEN LESS THAN 95% FULL?
1	16	MANHOLE	0.0	0.0	0.0	0.0	0.0	0.0	1.0	0.0	0.0	0.0	
2	16	MANHOLE	0.0	0.0	0.0	0.0	0.0	0.0	1.0	0.0	0.0	0.0	
3	16	MANHOLE	0.0	0.0	0.0	0.0	0.0	0.0	1.0	0.0	0.0	0.0	
4	16	MANHOLE	0.0	0.0	0.0	0.0	0.0	0.0	1.0	0.0	0.0	0.0	
5	16	MANHOLE	0.0	0.0	0.0	0.0	0.0	0.0	1.0	0.0	0.0	0.0	
6	16	MANHOLE	0.0	0.0	0.0	0.0	0.0	0.0	1.0	0.0	0.0	0.0	
7	16	MANHOLE	0.0	0.0	0.0	0.0	0.0	0.0	1.0	0.0	0.0	0.0	
8	16	MANHOLE	0.0	0.0	0.0	0.0	0.0	0.0	1.0	0.0	0.0	0.0	
9	16	MANHOLE	0.0	0.0	0.0	0.0	0.0	0.0	1.0	0.0	0.0	0.0	
10	16	MANHOLE	0.0	0.0	0.0	0.0	0.0	0.0	1.0	0.0	0.0	0.0	
11	1	CIRCULAR	0.01400	1745.00	0.0130	10.000	0.0	0.0	1.0	78.540	1961.958	2118.915	YES
12	1	CIRCULAR	0.00900	400.00	0.0130	10.000	0.0	0.0	1.0	78.540	1573.066	1698.911	NO
13	16	MANHOLE	0.0	0.0	0.0	0.0	0.0	0.0	1.0	0.0	0.0	0.0	
14	16	MANHOLE	0.0	0.0	0.0	0.0	0.0	0.0	1.0	0.0	0.0	0.0	
15	16	MANHOLE	0.0	0.0	0.0	0.0	0.0	0.0	1.0	0.0	0.0	0.0	
16	1	CIRCULAR	0.01320	1520.00	0.0130	6.000	0.0	0.0	1.0	28.274	487.883	526.914	NO
17	1	CIRCULAR	0.01100	600.00	0.0130	6.000	0.0	0.0	1.0	28.274	445.374	481.004	NO
18	16	MANHOLE	0.0	0.0	0.0	0.0	0.0	0.0	1.0	0.0	0.0	0.0	
19	1	CIRCULAR	0.01460	515.00	0.0130	6.000	0.0	0.0	1.0	28.274	513.104	554.152	NO
20	16	MANHOLE	0.0	0.0	0.0	0.0	0.0	0.0	1.0	0.0	0.0	0.0	
21	1	CIRCULAR	0.03410	430.00	0.0130	5.000	0.0	0.0	1.0	19.635	482.232	520.811	YES
22	16	MANHOLE	0.0	0.0	0.0	0.0	0.0	0.0	1.0	0.0	0.0	0.0	
23	1	CIRCULAR	0.00790	585.00	0.0130	5.000	0.0	0.0	1.0	19.635	232.109	250.678	NO
24	1	CIRCULAR	0.00660	623.00	0.0130	5.000	0.0	0.0	1.0	19.635	212.154	229.126	NO
25	1	CIRCULAR	0.00770	143.00	0.0130	5.000	0.0	0.0	1.0	19.635	229.152	247.485	NO
26	16	MANHOLE	0.0	0.0	0.0	0.0	0.0	0.0	1.0	0.0	0.0	0.0	
27	16	MANHOLE	0.0	0.0	0.0	0.0	0.0	0.0	1.0	0.0	0.0	0.0	
28	16	MANHOLE	0.0	0.0	0.0	0.0	0.0	0.0	1.0	0.0	0.0	0.0	
29	1	CIRCULAR	0.00760	503.00	0.0130	3.500	0.0	0.0	1.0	9.621	87.946	94.981	NO
30	16	MANHOLE	0.0	0.0	0.0	0.0	0.0	0.0	1.0	0.0	0.0	0.0	
32	16	MANHOLE	0.0	0.0	0.0	0.0	0.0	0.0	1.0	0.0	0.0	0.0	
33	16	MANHOLE	0.0	0.0	0.0	0.0	0.0	0.0	1.0	0.0	0.0	0.0	
34	16	MANHOLE	0.0	0.0	0.0	0.0	0.0	0.0	1.0	0.0	0.0	0.0	
35	16	MANHOLE	0.0	0.0	0.0	0.0	0.0	0.0	1.0	0.0	0.0	0.0	
36	16	MANHOLE	0.0	0.0	0.0	0.0	0.0	0.0	1.0	0.0	0.0	0.0	
37	16	MANHOLE	0.0	0.0	0.0	0.0	0.0	0.0	1.0	0.0	0.0	0.0	
38	16	MANHOLE	0.0	0.0	0.0	0.0	0.0	0.0	1.0	0.0	0.0	0.0	
39	16	MANHOLE	0.0	0.0	0.0	0.0	0.0	0.0	1.0	0.0	0.0	0.0	
40	16	MANHOLE	0.0	0.0	0.0	0.0	0.0	0.0	1.0	0.0	0.0	0.0	
41	16	MANHOLE	0.0	0.0	0.0	0.0	0.0	0.0	1.0	0.0	0.0	0.0	
42	16	MANHOLE	0.0	0.0	0.0	0.0	0.0	0.0	1.0	0.0	0.0	0.0	
43	16	MANHOLE	0.0	0.0	0.0	0.0	0.0	0.0	1.0	0.0	0.0	0.0	
44	16	MANHOLE	0.0	0.0	0.0	0.0	0.0	0.0	1.0	0.0	0.0	0.0	
45	1	CIRCULAR	0.00360	369.00	0.0130	3.500	0.0	0.0	1.0	9.621	60.528	65.371	NO
46	16	MANHOLE	0.0	0.0	0.0	0.0	0.0	0.0	1.0	0.0	0.0	0.0	
47	16	MANHOLE	0.0	0.0	0.0	0.0	0.0	0.0	1.0	0.0	0.0	0.0	
49	16	MANHOLE	0.0	0.0	0.0	0.0	0.0	0.0	1.0	0.0	0.0	0.0	
51	16	MANHOLE	0.0	0.0	0.0	0.0	0.0	0.0	1.0	0.0	0.0	0.0	
53	16	MANHOLE	0.0	0.0	0.0	0.0	0.0	0.0	1.0	0.0	0.0	0.0	
54	16	MANHOLE	0.0	0.0	0.0	0.0	0.0	0.0	1.0	0.0	0.0	0.0	
55	16	MANHOLE	0.0	0.0	0.0	0.0	0.0	0.0	1.0	0.0	0.0	0.0	
56	16	MANHOLE	0.0	0.0	0.0	0.0	0.0	0.0	1.0	0.0	0.0	0.0	
57	16	MANHOLE	0.0	0.0	0.0	0.0	0.0	0.0	1.0	0.0	0.0	0.0	
58	16	MANHOLE	0.0	0.0	0.0	0.0	0.0	0.0	1.0	0.0	0.0	0.0	
60	16	MANHOLE	0.0	0.0	0.0	0.0	0.0	0.0	1.0	0.0	0.0	0.0	
62	16	MANHOLE	0.0	0.0	0.0	0.0	0.0	0.0	1.0	0.0	0.0	0.0	
63	16	MANHOLE	0.0	0.0	0.0	0.0	0.0	0.0	1.0	0.0	0.0	0.0	
64	16	MANHOLE	0.0	0.0	0.0	0.0	0.0	0.0	1.0	0.0	0.0	0.0	
65	16	MANHOLE	0.0	0.0	0.0	0.0	0.0	0.0	1.0	0.0	0.0	0.0	
66	16	MANHOLE	0.0	0.0	0.0	0.0	0.0	0.0	1.0	0.0	0.0	0.0	
67	16	MANHOLE	0.0	0.0	0.0	0.0	0.0	0.0	1.0	0.0	0.0	0.0	
68	16	MANHOLE	0.0	0.0	0.0	0.0	0.0	0.0	1.0	0.0	0.0	0.0	
69	16	MANHOLE	0.0	0.0	0.0	0.0	0.0	0.0	1.0	0.0	0.0	0.0	
71	16	MANHOLE	0.0	0.0	0.0	0.0	0.0	0.0	1.0	0.0	0.0	0.0	
72	16	MANHOLE	0.0	0.0	0.0	0.0	0.0	0.0	1.0	0.0	0.0	0.0	

Table 6-11. INFILTRATION

TOTAL AREA INFILTRATICN(IN GPM) DUE TO:

BASE FLOW	GROUND WATER	MELT	RAIN
35.0000	35.0000	0.0	0.0

APPORTIONED INFILTRATION

ELEMENT NO.	QINFIL(CFS)	PROP. TOT. INFIL.	INFIL. INPUT AT UPSTREAM ELE. NO.
45	0.001	0.0071	30
29	0.001	0.0108	28
136	0.001	0.0135	38
168	0.001	0.0071	51
180	0.000	0.0034	54
172	0.001	0.0112	53
167	0.000	0.0026	49
237	0.001	0.0132	58
210	0.002	0.0223	57
245	0.001	0.0116	62
211	0.002	0.0231	60
209	0.001	0.0124	56
205	0.001	0.0149	55
163	0.001	0.0119	47
160	0.000	0.0019	46
159	0.000	0.0013	44
158	0.000	0.0037	43
291	0.001	0.0066	69
260	0.001	0.0161	68
276	0.001	0.0173	67
386	0.001	0.0117	81
379	0.001	0.0124	80
390	0.000	0.0062	77
447	0.001	0.0065	84
482	0.001	0.0096	91
476	0.001	0.0083	90
474	0.000	0.0060	89
468	0.001	0.0109	88
460	0.001	0.0099	87
584	0.001	0.0154	95
535	0.000	0.0028	94
534	0.001	0.0103	93
532	0.002	0.0279	92
453	0.001	0.0091	86
375	0.001	0.0072	85
374	0.001	0.0105	83
373	0.001	0.0122	82
372	0.001	0.0114	78
371	0.001	0.0141	76
370	0.002	0.0208	74
260	0.000	0.0044	72
259	0.001	0.0150	71
250	0.002	0.0223	66
247	0.002	0.0217	65
215	0.002	0.0206	64
130	0.002	0.0243	63
128	0.002	0.0223	42
127	0.001	0.0113	41
126	0.001	0.0110	40
125	0.000	0.0055	39
123	0.001	0.0132	37
119	0.001	0.0110	36
117	0.001	0.0176	35
115	0.002	0.0264	34
768	0.001	0.0101	33
755	0.000	0.0069	32
747	0.001	0.0121	10
861	0.001	0.0092	22
878	0.001	0.0089	27
837	0.001	0.0092	26
827	0.000	0.0048	20
25	0.000	0.0040	18
24	0.001	0.0171	15
23	0.001	0.0162	14
21	0.001	0.0118	13
19	0.001	0.0170	9
17	0.002	0.0198	8
518	0.001	0.0122	7
913	0.000	0.0062	6
507	0.000	0.0057	5
16	0.004	0.0502	4

Table 6-12. DRY WEATHER FLOW

QUANTITY AND QUALITY OF D W F FOR EACH SUBAREA

A1BOD = 890.12LBSPERDAY/CFS
A1SS = 890.12 LBSPERDAY/CFS
A1COLI = 4.65E 07 MPN/DAY PER CAPITA
ADWF = 9.50 CFS

KNUM	INPUT	DWF CFS	+	INFIL CFS	=	QQCWF CFS	KLAND	DWBOD LBS/MIN	DWSS LBS/MIN	TOTPOP PERSONS	BODCONC MG/L	SSCONC MG/L	COLIFORMS MPN/100ML
5	5	0.0		0.0		0.0	3	0.0	0.0				
6	6	0.0		0.0		0.0	3	0.0	0.0				
7	7	0.0		0.0		0.0	3	0.0	0.0				
8	8	0.022		0.000		0.022	1	0.01	0.01				
9	9	0.025		0.000		0.025	1	0.01	0.01				
10	10	0.038		0.000		0.038	1	0.02	0.02				
13	13	0.022		0.000		0.022	1	0.01	0.01				
14	14	0.022		0.000		0.022	1	0.01	0.01				
15	15	1.000		0.0		1.000	4	3.74	3.07				
18	18	0.010		0.000		0.010	1	0.01	0.01				
20	20	0.035		0.000		0.036	1	0.02	0.02				
22	22	0.066		0.001		0.066	2	0.04	0.04				
26	26	0.037		0.000		0.038	2	0.02	0.02				
27	27	0.066		0.001		0.066	2	0.04	0.04				
28	28	0.022		0.000		0.022	1	0.01	0.01				
30	30	0.076		0.001		0.077	1	0.05	0.05				
32	32	0.013		0.000		0.013	1	0.01	0.01				
33	33	0.088		0.001		0.089	1	0.05	0.05				
38	38	0.124		0.001		0.125	1	0.08	0.08				
39	39	0.022		0.000		0.022	1	0.01	0.01				
40	40	0.076		0.001		0.077	1	0.05	0.05				
41	41	0.100		0.001		0.101	1	0.06	0.06				
42	42	0.056		0.000		0.056	1	0.03	0.03				
43	43	0.001		0.000		0.001	2	0.00	0.00				
44	44	0.001		0.000		0.001	2	0.00	0.00				
46	46	2.000		0.0		2.000	4	7.49	6.14				
47	47	0.010		0.000		0.010	2	0.01	0.01				
49	49	0.006		0.000		0.006	2	0.00	0.00				
51	51	0.035		0.000		0.036	1	0.02	0.02				
53	53	0.022		0.000		0.022	2	0.01	0.01				
54	54	0.022		0.000		0.022	2	0.01	0.01				
55	55	0.0		0.0		0.0	3	0.0	0.0				
56	56	0.700		0.0		0.700	4	2.62	2.15				
57	57	0.0		0.0		0.0	5	0.0	0.0				
58	58	0.0		0.0		0.0	5	0.0	0.0				
60	60	0.0		0.0		0.0	3	0.0	0.0				
62	62	0.0		0.0		0.0	3	0.0	0.0				
63	63	0.022		0.000		0.022	1	0.01	0.01				
64	64	0.044		0.000		0.044	1	0.03	0.03				
65	65	0.022		0.000		0.022	1	0.01	0.01				
66	66	0.032		0.000		0.033	1	0.02	0.02				
67	67	0.029		0.000		0.030	1	0.02	0.02				
68	68	0.019		0.000		0.019	1	0.01	0.01				
69	69	0.038		0.000		0.038	1	0.02	0.02				
71	71	0.006		0.000		0.006	1	0.00	0.00				
72	72	0.129		0.001		0.130	1	0.08	0.08				
74	74	0.035		0.000		0.036	1	0.02	0.02				
76	76	0.005		0.000		0.006	1	0.00	0.00				
77	77	0.035		0.000		0.036	1	0.02	0.02				
78	78	0.012		0.000		0.012	1	0.01	0.01				
80	80	0.038		0.000		0.038	1	0.02	0.02				
81	81	0.012		0.000		0.012	1	0.01	0.01				
82	82	1.000		0.0		1.000	4	3.74	3.07				
83	83	0.025		0.000		0.025	1	0.02	0.02				
84	84	0.035		0.000		0.036	1	0.02	0.02				
85	85	0.700		0.0		0.700	4	2.62	2.15				
86	86	0.0		0.0		0.0	3	0.0	0.0				
87	87	0.010		0.000		0.010	1	0.01	0.01				
88	88	0.028		0.000		0.028	1	0.02	0.02				
89	89	0.010		0.000		0.010	1	0.01	0.01				
90	90	0.010		0.000		0.010	1	0.01	0.01				
91	91	0.009		0.000		0.009	1	0.01	0.01				
92	92	1.300		0.0		1.300	4	4.67	3.99				
93	93	0.013		0.000		0.013	1	0.01	0.01				
94	94	0.062		0.001		0.063	1	0.05	0.05				
95	95	0.103		0.001		0.104	1	0.06	0.06				
TOTALS		8.52		0.01		8.54		131.04 LBS	108.46 LBS	18434.	820.	479.	4.10E 03

Table 6-13. DAILY AND HOURLY CORRECTION FACTORS FOR SEWAGE DATA

DAILY AND HOURLY CORRECTION FACTORS FOR SEWAGE DATA

DAY	DVDWF	CVdCD	DVSS	DVCOLI
1	0.908	0.929	0.739	
2	1.018	1.128	1.042	
3	1.042	C.964	1.009	
4	1.018	1.030	1.044	
5	1.032	C.953	1.053	
6	1.012	1.089	1.054	
7	0.970	0.907	1.005	
HOUR				
1	0.906	1.000	1.000	1.000
2	0.819	1.000	1.000	1.000
3	0.732	1.000	1.000	1.000
4	0.718	1.000	1.000	1.000
5	0.689	1.000	1.000	1.000
6	0.701	1.000	1.000	1.000
7	0.792	1.000	1.000	1.000
8	0.950	1.000	1.000	1.000
9	1.092	1.000	1.000	1.000
10	1.148	1.000	1.000	1.000
11	1.196	1.000	1.000	1.000
12	1.174	1.000	1.000	1.000
13	1.158	1.000	1.000	1.000
14	1.144	1.000	1.000	1.000
15	1.124	1.000	1.000	1.000
16	1.096	1.000	1.000	1.000
17	1.101	1.000	1.000	1.000
18	1.072	1.000	1.000	1.000
19	1.078	1.000	1.000	1.000
20	1.074	1.000	1.000	1.000
21	1.115	1.000	1.000	1.000
22	1.070	1.000	1.000	1.000
23	1.057	1.000	1.000	1.000
24	1.015	1.000	1.000	1.000

Table 6-14. INITIAL CONCENTRATIONS PRIOR TO STORM

INITIAL BED CF SOLIDS (LBS) IN SEWER DUE TO
5.0 DAYS OF DRY WEATHER PRICR TO STORM

ELEMENT NUMBER	SOLIDS IN BOTTOM (LBS)
45	1.27562
29	0.45083
136	0.91770
168	0.64334
180	0.86132
172	0.48229
167	1.46624
237	0.0
210	0.0
245	0.0
211	0.0
209	0.39018
205	29.40700
163	0.43152
160	4.80974
159	3.54350
158	0.00423
291	0.27413
280	1.02050
276	0.49451
386	0.07072
379	0.08509
390	0.09352
447	0.02091
482	1.40712
476	3.52432
474	3.87139
468	15.47214
460	3.65693
564	0.57519
535	0.09626
534	0.06865
532	0.50324
453	0.64968
375	2.45520
374	2.95066
373	5.20603
372	1.06216
371	2.40260
370	4.01223
260	4.03845
259	1.89322
250	0.81072
247	0.44261
215	0.0
130	1.75247
128	0.16582
127	0.0
126	0.87986
125	0.86845
123	0.0
119	0.04625
117	2.02105
115	0.0
768	0.05067
765	0.43326
747	0.44284
861	0.01721
878	0.02302
837	0.05265
827	0.00951
25	0.17666
24	1.75903
23	1.39705
21	0.0
19	0.28073
17	0.72798
918	0.0
913	0.0
907	0.0
16	0.41280
12	0.0
11	0.0

Table 6-15. FLOWS AND CONCENTRATION INITIALIZED TO DRY WEATHER FLOW

ELEMENT FLOWS, AREAS, AND CONCENTRATIONS ARE INITIALIZED TO DRY WEATHER FLOW AND INFILTRATION VALUES.

ELE. NO.	TYPE	FLOW (CFS)	AREA (SQ. FT.)	INIT. VEL. (FPS)	BOD (LBS/CF)	S.S. (LBS/CF)	ECOLI. (MPN/ML)	CPOLL NO.4
45	1	0.104	0.063	1.6546	0.0116	0.0107	5.01E 06	
29	1	0.135	0.055	2.4041	0.0115	0.0106	4.94E 06	
136	1	0.169	0.045	3.7401	0.0122	0.0113	4.37E 06	
108	1	0.051	0.023	1.8621	0.0122	0.0113	4.33E 06	
160	1	0.029	0.017	1.7770	0.0122	0.0113	4.65E 06	
172	1	0.059	0.021	2.8116	0.0121	0.0112	4.83E 06	
167	1	0.119	0.066	1.8066	0.0119	0.0110	4.29E 06	
237	1	0.001	0.000	2.3667	0.0	0.0	6.80E 07	
210	1	0.003	0.001	2.2115	0.0	0.0	7.59E 07	
245	1	0.001	0.001	1.0846	0.0	0.0	4.37E 07	
211	1	0.003	0.001	2.6450	0.0	0.0	3.88E 07	
209	1	0.955	0.222	4.3010	0.0659	0.0530	3.30E 05	
205	1	0.956	0.539	1.7735	0.0698	0.0529	3.29E 05	
163	1	1.069	0.273	3.9124	0.0627	0.0473	8.24E 05	
160	1	3.758	0.887	4.2519	0.0652	0.0517	2.36E 05	
159	1	3.799	0.830	4.5772	0.0682	0.0517	2.36E 05	
158	1	3.801	0.654	5.8128	0.0681	0.0517	2.36E 05	
291	1	0.052	0.020	2.5659	0.0115	0.0106	5.57E 06	
260	1	0.079	0.037	2.1629	0.0114	0.0105	5.49E 06	
276	1	0.120	0.037	3.2026	0.0113	0.0105	5.43E 06	
366	1	0.017	0.004	3.9344	0.0110	0.0102	4.29E 06	
379	1	0.069	0.023	3.0066	0.0113	0.0104	4.23E 06	
390	1	0.048	0.015	3.2252	0.0115	0.0106	4.45E 06	
447	1	0.048	0.013	3.6064	0.0115	0.0106	4.49E 06	
482	1	0.013	0.006	2.0264	0.0109	0.0101	5.16E 06	
476	1	0.027	0.018	1.5164	0.0110	0.0102	5.14E 06	
474	1	0.042	0.029	1.4329	0.0111	0.0103	5.12E 06	
463	1	0.060	0.068	1.1756	0.0112	0.0104	5.29E 06	
460	1	0.095	0.058	1.6303	0.0112	0.0103	5.23E 06	
564	1	0.140	0.055	2.5578	0.0115	0.0106	5.62E 06	
535	1	0.252	0.077	3.2606	0.0116	0.0107	5.85E 06	
534	1	0.271	0.064	4.1986	0.0115	0.0106	5.72E 06	
532	1	2.033	0.443	4.5894	0.0625	0.0476	7.61E 05	
453	1	2.129	0.488	4.3629	0.0602	0.0459	9.93E 05	
375	1	3.078	0.603	3.8328	0.0633	0.0462	7.34E 05	
374	1	3.161	0.675	3.6107	0.0619	0.0472	8.29E 05	
373	1	4.516	1.288	3.5612	0.0645	0.0490	6.12E 05	
372	1	4.602	0.978	4.7075	0.0635	0.0483	6.80E 05	
371	1	4.660	1.084	4.2963	0.0626	0.0478	7.16E 05	
370	1	4.709	1.215	3.8761	0.0623	0.0474	7.56E 05	
260	1	4.665	1.258	3.6828	0.0605	0.0461	9.06E 05	
259	1	4.394	1.034	4.4726	0.0604	0.0460	9.04E 05	
250	1	5.060	1.040	4.8675	0.0587	0.0449	1.05E 06	
247	1	5.092	1.010	5.0425	0.0565	0.0447	1.07E 06	
215	1	5.153	0.833	6.1499	0.0579	0.0442	1.11E 06	
130	1	8.566	1.600	4.9914	0.0621	0.0473	7.54E 05	
128	1	9.063	1.634	5.5468	0.0616	0.0470	7.88E 05	
127	1	9.199	1.537	5.9837	0.0609	0.0464	8.46E 05	
126	1	9.303	1.777	5.2366	0.0603	0.0460	8.93E 05	
125	1	9.333	1.781	5.2405	0.0602	0.0459	9.06E 05	
123	1	9.504	1.580	6.0133	0.0593	0.0453	9.68E 05	
119	1	9.505	1.674	5.6624	0.0593	0.0453	9.68E 05	
117	1	9.506	1.929	4.9279	0.0593	0.0453	9.67E 05	
115	1	9.508	1.446	6.5749	0.0593	0.0453	9.67E 05	
768	1	0.120	0.036	3.3435	0.0115	0.0107	4.65E 06	
755	1	0.137	0.057	2.4041	0.0112	0.0104	4.24E 06	
747	1	0.185	0.075	2.5400	0.0107	0.0098	3.03E 06	
861	1	0.090	0.017	5.2961	0.0115	0.0106	5.64E 06	
878	1	0.090	0.019	4.0685	0.0115	0.0107	5.73E 06	
837	1	0.141	0.045	3.1179	0.0115	0.0106	5.66E 06	
827	1	0.279	0.043	6.5350	0.0115	0.0105	5.47E 06	
25	1	0.428	0.139	3.0694	0.0115	0.0106	5.29E 06	
24	1	1.733	0.532	3.3533	0.0562	0.0430	1.27E 06	
23	1	1.814	0.506	3.5873	0.0554	0.0425	1.33E 06	
21	1	1.845	0.286	6.4553	0.0547	0.0419	1.36E 06	
19	1	2.070	0.434	4.7728	0.0499	0.0384	1.51E 06	
17	1	2.101	0.507	4.1427	0.0493	0.0380	1.56E 06	
918	1	0.001	0.000	5.5337	0.0	0.0	7.76E 08	
913	1	0.001	0.000	5.3159	0.0	0.0	6.16E 08	
907	1	0.002	0.000	6.6522	0.0	0.0	5.08E 08	
16	1	2.107	0.404	4.5362	0.0492	0.0379	2.01E 06	
12	1	11.617	1.947	5.9675	0.0574	0.0439	1.16E 06	
11	1	11.624	1.663	6.8848	0.0574	0.0439	1.16E 06	

Table 6-16. CONCENTRATIONS AFTER STORM

BED OF SOLIDS IN SEWER AT END OF STORM

ELEMENT NUMBER	SOLIDS IN BOTTOM (LBS)
45	0.02279
29	0.00732
136	0.01537
168	0.01138
180	0.01276
172	0.00775
167	0.02555
237	0.00000
210	0.00004
245	0.00252
211	0.00021
209	0.00614
205	0.50449
163	0.00697
160	0.09092
159	0.06728
158	0.00034
291	0.00403
280	0.01758
276	0.00694
380	0.00095
379	0.00060
390	0.00138
447	0.00038
482	0.01946
476	0.05392
474	0.05964
468	0.25048
460	0.05229
584	0.00956
535	0.00175
534	0.00122
532	0.00768
453	0.01021
375	0.04285
374	0.05237
373	0.09282
372	0.01629
371	0.04034
370	0.07011
260	0.07051
259	0.03096
250	0.01169
247	0.00559
215	0.0
130	0.02557
128	0.00089
127	0.0
126	0.01100
125	0.01081
123	0.0
119	0.00000
117	0.03004
115	0.0
768	0.00093
755	0.00704
747	0.00702
861	0.00030
d78	0.00040
837	0.00095
627	0.00012
25	0.00322
24	0.03136
23	0.02450
21	0.0
19	0.00396
17	0.01187
918	0.00000
913	0.00000
907	0.00000
16	0.00623
12	0.0
11	0.0

Table 6-17. POLLUTANT MONITORING RESULTS

RESULTS OF POLLUTANT MONITORING ROUTINE

POLLUTANTS ASSOCIATED WITH MANHOLES (INLET POINTS) RANKED IN ORDER OF SIGNIFICANCE OF SUSPENDED SOLIDS.

		SUSPENDED SOLIDS (LB)				5 - DAY BOD (LB)			TOTAL
RANK	INLET	RUNOFF	D.W.F.	P.SCOUR	TOTAL SS	RUNOFF	D.W.F.	TOTAL BOD	INFLOW (CF)
1	46	.735E 00	.342E 04	0.42	.342E 04	0.63	.416E 04	.417E 04	.258E 03
2	92	.645E 00	.222E 04	0.07	.222E 04	1.28	.271E 04	.271E 04	.169E 03
3	82	.175E 02	.171E 04	2.90	.173E 04	16.12	.208E 04	.210E 04	.142E 03
4	15	.0	.171E 04	0.17	.171E 04	0.0	.208E 04	.208E 04	.129E 03
5	85	.284E 02	.120E 04	0.04	.122E 04	24.82	.140E 04	.140E 04	.111E 03
6	56	.202E 01	.120E 04	-0.00	.120E 04	1.04	.146E 04	.146E 04	.915E 02
7	7	.152E 03	.0	0.0	.152E 03	68.55	.0	.686E 02	.541E 02
8	38	.446E 02	.453E 02	0.0	.899E 02	141.42	.453E 02	.187E 03	.139E 03
9	60	.755E 02	.0	-0.00	.755E 02	32.41	.0	.324E 02	.254E 02
10	72	.242E 02	.444E 02	3.94	.725E 02	83.13	.444E 02	.128E 03	.698E 02
11	27	.305E 02	.226E 02	0.0	.551E 02	53.98	.226E 02	.765E 02	.552E 02
12	22	.347E 02	.226E 02	0.0	.573E 02	51.59	.226E 02	.741E 02	.532E 02
13	95	.188E 02	.353E 02	0.0	.542E 02	52.82	.353E 02	.881E 02	.585E 02
14	41	.177E 02	.343E 02	0.16	.521E 02	61.34	.343E 02	.956E 02	.670E 02
15	33	.193E 02	.303E 02	0.0	.496E 02	50.15	.303E 02	.804E 02	.597E 02
16	30	.191E 02	.262E 02	0.0	.453E 02	60.23	.262E 02	.865E 02	.623E 02
17	62	.452E 02	.0	0.0	.452E 02	19.40	.0	.194E 02	.152E 02
18	40	.131E 02	.262E 02	0.0	.394E 02	45.08	.262E 02	.713E 02	.496E 02
19	47	.416E 01	.366E 01	30.34	.382E 02	5.72	.366E 01	.938E 01	.633E 01
20	94	.912E 01	.282E 02	0.57	.379E 02	27.20	.282E 02	.555E 02	.341E 02
21	86	.313E 02	.0	4.10	.354E 02	13.52	.0	.135E 02	.106E 02
22	26	.169E 02	.129E 02	0.02	.318E 02	27.53	.129E 02	.404E 02	.267E 02
23	53	.222E 02	.785E 01	0.85	.309E 02	29.35	.785E 01	.372E 02	.278E 02
24	42	.833E 01	.192E 02	1.73	.272E 02	22.04	.192E 02	.412E 02	.268E 02
25	80	.130E 02	.131E 02	0.07	.262E 02	44.10	.131E 02	.572E 02	.437E 02
26	77	.135E 02	.121E 02	0.0	.256E 02	44.81	.121E 02	.559E 02	.439E 02
27	69	.120E 02	.131E 02	0.0	.251E 02	37.67	.131E 02	.510E 02	.379E 02
28	74	.899E 01	.121E 02	2.36	.235E 02	29.86	.121E 02	.420E 02	.309E 02
29	88	.974E 01	.958E 01	3.81	.231E 02	27.26	.958E 01	.368E 02	.270E 02
30	51	.860E 01	.137E 02	0.0	.222E 02	27.27	.137E 02	.410E 02	.286E 02
31	5	.224E 02	.0	-0.30	.224E 02	10.07	.0	.101E 02	.801E 01
32	64	.558E 01	.151E 02	0.44	.211E 02	19.29	.151E 02	.344E 02	.227E 02
33	20	.837E 01	.121E 02	0.07	.205E 02	28.95	.121E 02	.411E 02	.301E 02
34	87	.155E 01	.353E 01	15.22	.203E 02	4.76	.353E 01	.829E 01	.567E 01
35	8	.200E 02	.0	-0.00	.200E 02	8.47	.0	.847E 01	.666E 01
36	67	.834E 01	.101E 02	1.00	.194E 02	27.58	.101E 02	.377E 02	.280E 02
37	54	.115E 02	.786E 01	0.0	.194E 02	14.01	.786E 01	.219E 02	.146E 02
38	84	.614E 01	.121E 02	0.0	.183E 02	20.97	.121E 02	.331E 02	.231E 02
39	66	.430E 01	.111E 02	2.35	.174E 02	13.46	.111E 02	.246E 02	.162E 02
40	8	.957E 01	.757E 01	0.28	.174E 02	30.90	.757E 01	.365E 02	.300E 02
41	83	.520E 01	.803E 01	2.43	.162E 02	17.37	.838E 01	.234E 02	.180E 02
42	13	.538E 01	.757E 01	1.37	.143E 02	17.34	.757E 01	.249E 02	.181E 02
43	78	.505E 01	.404E 01	5.20	.143E 02	17.66	.404E 01	.217E 02	.172E 02
44	28	.549E 01	.757E 01	1.25	.143E 02	17.74	.757E 01	.253E 02	.184E 02
45	65	.562E 01	.757E 01	0.90	.140E 02	18.40	.757E 01	.260E 02	.191E 02
46	10	.195E 01	.103E 02	0.43	.126E 02	5.16	.103E 02	.155E 02	.934E 01
47	68	.533E 01	.656E 01	0.27	.121E 02	16.54	.656E 01	.235E 02	.174E 02
48	14	.254E 01	.757E 01	1.73	.118E 02	7.79	.757E 01	.154E 02	.975E 01
49	63	.419E 01	.757E 01	0.00	.118E 02	14.45	.757E 01	.220E 02	.158E 02
50	81	.770E 01	.404E 01	0.00	.117E 02	20.46	.404E 01	.305E 02	.249E 02
51	39	.519E 01	.757E 01	0.07	.116E 02	10.04	.757E 01	.182E 02	.122E 02
52	91	.808E 01	.303E 01	0.0	.111E 02	21.64	.303E 01	.249E 02	.159E 02
53	9	.214E 01	.690E 01	0.44	.947E 01	5.82	.690E 01	.127E 02	.835E 01
54	89	.117E 01	.353E 01	3.47	.817E 01	3.73	.353E 01	.726E 01	.405E 01
55	90	.324E 01	.353E 01	1.39	.816E 01	10.08	.353E 01	.136E 02	.102E 02
56	58	.797E 01	.0	0.0	.797E 01	31.27	.0	.313E 02	.270E 02
57	57	.743E 01	.0	-0.00	.743E 01	46.77	.0	.468E 02	.406E 02
58	93	.272E 01	.454E 01	0.09	.742E 01	7.86	.454E 01	.124E 02	.994E 01
59	71	.127E 01	.172E 01	3.97	.690E 01	4.23	.172E 01	.595E 01	.467E 01
60	18	.161E 01	.353E 01	0.45	.579E 01	5.88	.353E 01	.942E 01	.653E 01
61	49	.270E 01	.157E 01	1.11	.544E 01	3.80	.157E 01	.537E 01	.403E 01
62	44	.355E 00	.236E 00	4.72	.531E 01	0.61	.236E 00	.845E 00	.682E 00
63	32	.143E 01	.345E 01	0.05	.493E 01	4.07	.345E 01	.752E 01	.518E 01
64	43	.575E 00	.314E 00	3.46	.437E 01	0.83	.314E 00	.115E 01	.925E 00
65	76	.127E 01	.172E 01	1.14	.414E 01	4.22	.172E 01	.594E 01	.466E 01
66	55	.369E 01	.0	0.38	.406E 01	1.72	.0	.172E 01	.151E 01
67	34	.0	.0	1.99	.199E 01	0.0	.0	.0	.206E 00
68	37	.0	.0	1.76	.176E 01	0.0	.0	.0	.103E 00
69	4	.0	.0	0.72	.716E 00	0.0	.0	.0	.391E 00
70	3	.0	.0	0.41	.407E 00	0.0	.0	.0	.172E 00
71	35	.0	.0	0.05	.462E-01	0.0	.0	.0	.137E 00
72	1	.0	.0	0.0	.0	0.0	.0	.0	.0
73	2	.0	.0	0.0	.0	0.0	.0	.0	.748E 00
74	36	.0	.0	0.0	.0	0.0	.0	.0	.658E-01

Table 6-18. INFLOWS FROM RUNOFF BLOCK PARTIAL LISTING

LANCASTER PENNSYLVANIA NORTH DRAINAGE DISTRICT

TOTAL SIMULATION TIME = 30000.0 SECONDS. TIME STEP = 300.0 SECONDS.

INFLOW POLLUTOGRAPHS AND HYDROGRAPHS AT THE FOLLOWING EXTERNAL ELEMENT NUMBERS:

5	6	7	8	9	10	13	14	15	18	20	22	26	27	28	30	32	33	38	39
40	41	42	43	44	46	47	49	51	53	54	55	56	57	58	60	62	63	64	65
66	67	68	69	71	72	74	76	77	78	80	81	82	83	84	85	86	87	88	89
90	91	92	93	94	95														

SELECTED INLET HYDROGRAPHS - CFS

EXTERNAL ELEMENT NUMBER	TIME STEP 1	2	3	4	5	6	7	8	9	10
5	0.0	0.0	0.0	0.0	0.007	0.076	0.198	0.587	0.531	0.328
	0.239	0.172	0.187	0.235	0.344	0.287	0.111	0.058	0.035	0.075
	0.138	0.134	0.133	0.132	0.169	0.147	0.071	0.041	0.026	0.018
	0.013	0.010	0.008	0.006	0.005	0.004	0.041	0.414	0.716	0.665
	0.497	0.233	0.173	0.147	0.138	0.134	0.098	0.052	0.032	0.021
	0.015	0.011	0.008	0.007	0.005	0.004	0.004	0.003	0.003	0.002
	0.002	0.002	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001
	0.001	0.001	0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
27	0.0	0.0	0.0	0.0	0.014	0.178	0.615	1.805	2.260	1.941
	1.624	1.504	1.251	1.356	1.719	1.651	1.053	0.721	0.520	0.588
	0.751	0.757	0.762	0.765	0.880	0.850	0.600	0.442	0.337	0.264
	0.211	0.172	0.143	0.120	0.102	0.087	0.199	1.216	2.589	3.176
	2.553	1.994	1.511	1.241	1.079	0.977	0.791	0.563	0.418	0.321
	0.252	0.203	0.166	0.138	0.116	0.079	0.085	0.073	0.064	0.056
	0.050	0.045	0.040	0.036	0.032	0.029	0.027	0.024	0.022	0.021
	0.019	0.017	0.016	0.015	0.014	0.013	0.012	0.011	0.011	0.010
	0.009	0.009	0.006	0.008	0.007	0.007	0.007	0.006	0.006	0.006
	0.005	0.005	0.005	0.005	0.005	0.004	0.004	0.004	0.004	0.004
39	0.0	0.0	0.0	0.0	0.018	0.145	0.290	0.971	0.569	0.303
	0.237	0.165	0.222	0.302	0.462	0.309	0.055	0.024	0.013	0.098
	0.206	0.162	0.136	0.155	0.220	0.163	0.045	0.021	0.012	0.007
	0.005	0.004	0.003	0.002	0.002	0.001	0.079	0.753	0.953	0.743
	0.520	0.168	0.157	0.158	0.154	0.154	0.094	0.034	0.017	0.010
	0.006	0.004	0.003	0.002	0.002	0.002	0.001	0.001	0.001	0.001
	0.001	0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
44	0.0	0.0	0.0	0.0	0.001	0.006	0.014	0.042	0.038	0.023
	0.017	0.012	0.013	0.017	0.024	0.020	0.008	0.004	0.002	0.005
	0.010	0.010	0.009	0.009	0.012	0.010	0.005	0.003	0.002	0.001
	0.001	0.001	0.000	0.000	0.000	0.000	0.003	0.030	0.051	0.047
	0.035	0.016	0.012	0.010	0.010	0.009	0.007	0.004	0.002	0.001
	0.001	0.001	0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
46	0.0	0.0	0.0	0.0	0.001	0.006	0.015	0.047	0.038	0.021
	0.016	0.011	0.013	0.017	0.025	0.020	0.006	0.003	0.002	0.005
	0.010	0.010	0.009	0.009	0.012	0.010	0.004	0.002	0.001	0.001
	0.001	0.000	0.000	0.000	0.000	0.000	0.003	0.034	0.054	0.047
	0.034	0.014	0.011	0.010	0.039	0.039	0.006	0.003	0.002	0.001
	0.001	0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
63	0.0	0.0	0.0	0.0	0.009	0.101	0.285	0.829	0.025	0.551
	0.407	0.297	0.307	0.370	0.327	0.462	0.208	0.116	0.073	0.125
	0.210	0.211	0.211	0.211	0.263	0.236	0.128	0.079	0.053	0.037
	0.027	0.021	0.016	0.013	0.011	0.039	0.060	0.567	1.056	1.054
	0.822	0.422	0.302	0.254	0.232	0.221	0.167	0.097	0.063	0.043
	0.032	0.024	0.016	0.015	0.012	0.010	0.008	0.007	0.006	0.005
	0.004	0.004	0.003	0.003	0.003	0.002	0.002	0.002	0.002	0.002
	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001

Table 6-19. INPUT POLLUTOGRAPHS FROM RUNOFF BLOCK PARTIAL LISTING

SELECTED INLET POLLUTOGRAPHS

EXTERNAL ELEMENT NUMBER	TIME STEP 1	2	3	4	5	6	7	8	9	10
	*** BOD IN LBS/MIN ***									
5	0.0	0.0	0.0	0.0	0.002	0.020	0.053	0.154	0.139	0.085
	0.062	0.045	0.048	0.061	0.068	0.074	0.029	0.015	0.009	0.019
	0.035	0.034	0.034	0.034	0.043	0.037	0.018	0.010	0.007	0.005
	0.003	0.002	0.002	0.002	0.0	0.0	0.010	0.104	0.179	0.165
	0.123	0.057	0.042	0.036	0.034	0.033	0.024	0.013	0.008	0.005
	0.304	0.003	0.002	0.002	0.001	0.0	0.0	0.0	0.0	0.0
	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	** SUSPENDED SOLIDS IN LBS/MIN **									
5	0.0	0.0	0.0	0.0	0.005	0.053	0.137	0.394	0.346	0.210
	0.151	0.108	0.116	0.144	0.207	0.170	0.065	0.034	0.020	0.044
	0.060	0.077	0.076	0.075	0.095	0.082	0.039	0.023	0.014	0.010
	0.007	0.005	0.004	0.003	0.0	0.0	0.023	0.222	0.370	0.332
	0.241	0.112	0.081	0.069	0.065	0.062	0.045	0.024	0.015	0.010
	0.007	0.005	0.004	0.003	0.002	0.0	0.0	0.0	0.0	0.0
	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	*** COLIFORM IN MPN/MIN ***									
5	0.0	0.0	0.0	0.0	3.19E 09	3.18E 09	3.14E 09	3.04E 09	2.96E 09	2.90E 09
	2.87E 09	2.64E 09	2.81E 09	2.78E 09	2.73E 09	2.68E 09	2.67E 09	2.66E 09	2.65E 09	2.64E 09
	2.62E 09	2.60E 09	2.59E 09	2.57E 09	2.54E 09	2.52E 09	2.51E 09	2.51E 09	2.50E 09	2.50E 09
	2.50E 09	2.50E 09	2.50E 09	2.50E 09	0.0	0.0	2.49E 09	2.43E 09	2.34E 09	2.26E 09
	2.20E 09	2.17E 09	2.15E 09	2.13E 09	2.12E 09	2.10E 09	2.09E 09	2.09E 09	2.08E 09	2.08E 09
	2.08E 09	2.08E 09	2.08E 09	2.07E 09	2.07E 09	0.0	0.0	0.0	0.0	0.0
	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	*** BOD IN LBS/MIN ***									
27	0.0	0.0	0.0	0.0	0.003	0.043	0.150	0.438	0.546	0.467
	0.389	0.311	0.298	0.322	0.406	0.369	0.247	0.169	0.122	0.137
	0.175	0.177	0.177	0.178	0.205	0.197	0.139	0.102	0.078	0.061
	0.049	0.040	0.033	0.028	0.023	0.020	0.046	0.279	0.591	0.719
	0.665	0.447	0.338	0.277	0.240	0.217	0.175	0.125	0.092	0.071
	0.056	0.045	0.037	0.030	0.026	0.022	0.019	0.016	0.014	0.012
	0.011	0.010	0.009	0.008	0.007	0.006	0.006	0.005	0.005	0.005
	0.004	0.004	0.004	0.003	0.003	0.003	0.003	0.003	0.002	0.002
	0.002	0.002	0.002	0.002	0.002	0.002	0.001	0.001	0.001	0.001
	0.001	0.001	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	** SUSPENDED SOLIDS IN LBS/MIN **									
27	0.0	0.0	0.0	0.0	0.003	0.041	0.140	0.396	0.480	0.393
	0.324	0.264	0.239	0.253	0.311	0.290	0.182	0.123	0.086	0.048
	0.124	0.124	0.123	0.121	0.139	0.131	0.092	0.067	0.051	0.040
	0.032	0.026	0.021	0.018	0.015	0.013	0.029	0.175	0.357	0.414
	0.366	0.239	0.176	0.142	0.121	0.108	0.066	0.061	0.045	0.034
	0.027	0.021	0.017	0.014	0.012	0.010	0.009	0.008	0.007	0.006
	0.005	0.005	0.004	0.004	0.003	0.003	0.003	0.003	0.002	0.002
	0.002	0.002	0.002	0.002	0.001	0.001	0.001	0.001	0.001	0.001
	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001
	0.001	0.001	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	*** COLIFORM IN MPN/MIN ***									
27	0.0	0.0	0.0	0.0	3.53E 09	3.52E 09	3.46E 09	3.38E 09	3.25E 09	3.14E 09
	3.05E 09	2.98E 09	2.92E 09	2.85E 09	2.77E 09	2.69E 09	2.64E 09	2.61E 09	2.59E 09	2.56E 09
	2.53E 09	2.50E 09	2.40E 09	2.43E 09	2.39E 09	2.36E 09	2.33E 09	2.32E 09	2.30E 09	2.29E 09
	2.28E 09	2.26E 09	2.27E 09	2.27E 09	2.26E 09	2.26E 09	2.25E 09	2.20E 09	2.11E 09	2.00E 09
	1.93E 09	1.83E 09	1.76E 09	1.75E 09	1.71E 09	1.69E 09	1.66E 09	1.65E 09	1.64E 09	1.63E 09
	1.62E 09	1.61E 09	1.61E 09	1.61E 09	1.60E 09	1.60E 09	1.60E 09	1.59E 09	1.59E 09	1.59E 09
	1.59E 09	1.59E 09	1.59E 09	1.59E 09	1.59E 09	1.59E 09	1.58E 09	1.58E 09	1.58E 09	1.58E 09
	1.58E 09	1.58E 09	1.58E 09	1.58E 09	1.58E 09	1.58E 09	1.58E 09	1.58E 09	1.58E 09	1.58E 09
	1.58E 09	1.58E 09	1.58E 09	1.58E 09	1.58E 09	1.58E 09	1.58E 09	1.58E 09	1.58E 09	1.58E 09
	[illegible]	[illegible]	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Table 6-20. OUTFLOWS FROM SELECTED MANHOLES

SELECTED OUTFLOW HYDROGRAPHS - CFS

EXTERNAL ELEMENT NUMBER	TIME STEP 1	2	3	4	5	6	7	8	9	10
80	2.129	2.129	2.129	2.129	2.145	2.322	3.054	5.940	9.690	9.743
	7.053	6.587	5.927	5.820	6.095	7.495	6.729	4.959	3.883	3.552
	3.035	4.248	4.515	4.410	4.565	4.794	4.518	3.827	3.343	2.976
	2.736	2.589	2.492	2.394	2.331	2.276	2.316	3.607	8.301	12.646
	11.880	9.955	7.436	5.007	5.396	4.905	4.626	4.120	3.579	3.174
	2.316	2.611	2.503	2.416	2.342	2.279	2.217	2.144	2.114	2.069
	2.070	2.054	2.041	2.031	2.022	2.014	2.008	2.002	2.037	2.139
	2.134	2.136	2.133	2.131	2.129	2.127	2.125	2.124	2.122	2.121
	2.063	1.932	1.932	1.924	1.924	1.922	1.921	1.921	1.920	1.919
	1.919	1.918	1.921	1.925	1.927	1.927	1.927	1.927	1.926	1.926
78	4.602	4.602	4.602	4.602	4.629	4.968	6.258	10.954	17.200	18.765
	16.254	13.493	12.369	12.266	13.540	14.865	13.692	10.876	8.711	7.785
	8.084	8.747	9.194	9.350	9.500	9.637	9.357	8.232	7.184	6.510
	6.037	5.558	5.464	5.279	5.122	5.010	5.106	7.468	14.979	22.623
	24.760	19.772	15.932	12.771	11.243	10.515	9.967	8.773	7.634	6.669
	6.319	5.617	5.515	5.348	5.109	5.041	4.896	4.748	4.666	4.596
	4.556	4.513	4.430	4.453	4.427	4.408	4.359	4.374	4.466	4.609
	4.653	4.651	4.645	4.640	4.632	4.625	4.621	4.615	4.611	4.607
	4.408	4.209	4.193	4.167	4.151	4.169	4.167	4.167	4.162	4.162
	4.150	4.156	4.165	4.173	4.177	4.176	4.175	4.174	4.173	4.172
66	5.060	5.060	5.060	5.060	5.115	5.760	8.078	15.946	25.328	29.438
	26.712	21.639	19.280	18.807	21.018	22.920	21.209	16.972	13.168	11.210
	11.435	12.474	13.184	13.486	14.081	14.432	13.604	11.933	10.131	8.776
	7.902	7.261	6.860	6.425	6.135	5.949	6.121	10.482	22.242	34.602
	29.746	34.440	20.136	20.257	17.361	16.054	14.793	13.210	11.061	9.628
	5.479	7.656	7.063	6.606	6.330	6.071	5.854	5.649	5.481	5.331
	5.253	5.174	5.116	5.004	5.018	4.983	4.948	4.921	4.927	5.008
	5.129	5.192	5.181	5.164	5.152	5.143	5.134	5.123	5.117	5.108
	5.001	4.925	4.738	4.626	4.617	4.619	4.613	4.608	4.603	4.602
	4.597	4.595	4.595	4.599	4.607	4.610	4.609	4.606	4.604	4.603
63	8.986	8.986	8.986	8.986	9.028	9.542	11.422	18.547	31.300	40.485
	41.479	35.698	30.793	29.208	30.349	33.534	33.212	29.055	23.186	18.677
	18.257	16.928	20.225	20.879	21.407	22.066	21.673	19.961	17.538	15.363
	13.836	12.867	11.994	11.317	10.846	10.477	10.443	13.524	25.217	42.959
	55.448	54.212	43.795	34.155	28.721	26.359	23.925	21.603	19.276	16.632
	14.708	13.573	12.411	11.691	11.059	10.036	10.260	9.912	9.653	9.413
	9.247	9.115	9.020	8.926	8.455	8.791	8.736	8.690	8.314	8.927
	9.008	9.141	9.103	9.146	9.118	9.132	9.069	9.073	9.060	9.047
	8.625	8.527	8.476	8.252	8.185	8.172	8.177	8.170	8.159	8.157
	8.150	8.147	8.153	8.161	8.104	8.173	8.173	8.170	8.167	8.164
56	0.955	0.955	0.955	0.955	0.955	0.966	1.138	2.044	4.479	5.701
	5.297	4.634	4.108	3.935	4.241	4.751	4.547	3.625	2.616	2.362
	2.336	2.300	2.693	2.705	2.751	2.906	2.840	2.460	2.141	1.933
	1.736	1.578	1.443	1.348	1.274	1.216	1.166	1.370	3.577	6.598
	7.066	7.198	5.594	4.480	3.924	3.538	3.234	2.635	2.363	2.089
	1.673	1.697	1.533	1.413	1.321	1.249	1.171	1.127	1.091	1.063
	1.039	1.019	1.003	0.989	0.977	0.967	0.958	0.950	1.011	1.005
	1.000	0.995	0.991	0.987	0.984	0.981	0.978	0.976	0.974	0.972
	0.884	0.852	0.830	0.879	0.878	0.876	0.875	0.874	0.873	0.873
	0.872	0.871	0.875	0.874	0.874	0.873	0.873	0.872	0.872	0.871
37	9.504	9.504	9.504	9.504	9.631	11.018	15.084	28.525	41.205	47.957
	53.664	45.633	39.347	36.799	39.735	41.767	39.240	34.566	28.195	23.708
	22.478	23.156	23.989	25.085	26.407	27.053	25.471	23.098	20.693	17.928
	15.304	14.323	13.365	12.519	11.363	11.470	11.819	20.187	38.244	54.143
	67.574	66.230	55.109	44.618	35.560	31.929	29.463	25.400	22.291	19.638
	17.032	15.130	14.036	12.957	12.157	11.036	11.135	10.804	10.456	10.167
	9.947	9.763	9.637	9.533	9.440	9.363	9.297	9.240	9.252	9.368
	9.489	9.670	9.668	9.707	9.670	9.645	9.630	9.612	9.599	9.582
	9.493	9.279	9.065	8.901	8.732	8.636	8.651	8.650	8.639	8.634
	8.525	8.624	8.621	8.626	8.636	8.640	8.645	8.546	8.642	8.638
1	11.624	11.624	11.624	11.624	11.636	11.854	13.308	19.768	39.918	65.583
	74.494	63.822	58.812	51.117	49.117	53.976	57.459	53.751	44.820	35.324
	29.203	27.937	30.071	32.452	33.954	35.102	35.978	34.426	30.519	26.513
	22.905	19.778	17.819	16.517	15.464	14.664	14.131	15.398	26.186	57.824
	90.469	59.328	87.663	69.001	54.316	46.067	40.295	37.871	33.272	28.440
	24.977	21.512	16.834	17.196	16.082	15.055	14.279	13.732	13.253	12.833
	12.476	12.170	11.954	11.790	11.646	11.543	11.443	11.359	11.298	11.274
	11.348	11.501	11.604	11.777	11.835	11.830	11.790	11.762	11.749	11.730
	11.705	11.640	11.469	11.200	10.928	10.722	10.695	10.614	10.645	10.641
	10.619	10.613	10.607	10.602	10.606	10.619	10.633	10.640	10.642	10.640

outflow pollutographs are shown in Tables 6-21 and 6-22 in pounds per minute and milligrams per liter, respectively.

Example 2. Subroutine INFIL

The Pine Valley area of Baltimore, Maryland, is used in the following example to demonstrate the application of INFIL. In this case, the groundwater table was taken as being below the sewer. Historical climatological and flow data are available for estimating infiltration on April 15.

1) INFIL

   Historical flow data from the previous year indicate that minimum average flow was approximately 50 gpm. Since only 30 gpm can be attributed to sewage, DINFIL is taken as 20 gpm.

2) SINFIL

   From a heating and air conditioning handbook (2), degree-days are found to be well above 750 prior to April. Since frost and other residual moisture will contribute if melting occurs during April 15, degree-days NDD were input to subroutine INFIL. Based upon these data, INFIL computed that thawing begins on March 10 (i.e., 238 days from beginning of degree day data or MLTBE = 238 and ends on May 1 (i.e., MLTEN = 289) with April 15 (i.e., NDYUD = 274) occurring during this period. From historical flow data, the maximum incremental flow due to spring thaw appears to be nearly 65 gpm. It follows that SINFIL is:

$$\text{SINFIL} = \text{RSMAX*SIN}(360°/2*(\text{NDYUD} - \text{MLTBE})/(\text{MLTEN} - \text{MLTBE})) \quad (6\text{-}11)$$

$$= 65*\text{SIN}(172°)$$

$$= 52 \text{ gpm.}$$

3) RINFIL

   Total precipitation on April 15 and the previous 9 days was 1.81 inches for this example. RINFIL could then be estimated from a regression equation based upon previous flow data.

Table 6-21. OUTFLOW POLLUTOGRAPHS FROM SELECTED MANHOLES

SELECTED OUTFLOW POLLUTOGRAPHS

EXTERNAL ELEMENT NUMBER	TIME STEP 1	2	3	4	5	6	7	8	9	10
				*** BOD IN LBS/MIN ***						
86	7.684	7.683	7.683	7.683	7.608	7.565	7.844	9.231	10.223	9.566
	8.491	8.362	8.338	8.326	8.706	9.046	8.728	7.788	7.552	7.761
	7.729	8.277	8.233	7.908	8.049	8.167	8.051	7.606	7.646	7.596
	7.569	7.527	7.507	7.413	7.414	7.399	7.334	7.490	9.840	10.596
	9.482	9.082	8.296	7.747	8.029	7.844	7.777	7.621	7.471	7.465
	7.352	7.319	7.322	7.299	7.295	7.277	7.222	7.065	7.076	7.067
	7.064	7.050	7.058	7.055	7.053	7.052	7.051	7.049	7.195	7.640
	7.585	7.596	7.590	7.591	7.591	7.590	7.590	7.590	7.590	7.589
	7.402	6.829	6.846	6.862	6.889	6.887	6.867	6.687	6.866	6.687
	6.867	6.887	6.897	6.928	6.925	6.925	6.925	6.925	6.925	6.925
				** SUSPENDED SOLIDS IN LBS/MIN **						
86	6.220	6.000	6.743	6.691	6.556	6.336	6.424	7.571	8.136	7.155
	6.229	6.136	6.155	6.184	6.510	6.607	6.306	5.707	5.614	5.851
	5.840	6.210	6.146	5.899	6.011	6.070	5.956	5.655	5.727	5.719
	5.719	5.699	5.692	5.627	5.633	5.625	5.589	5.800	7.366	7.443
	6.523	6.250	5.605	5.630	5.661	5.765	5.719	5.624	5.554	5.603
	5.533	5.527	5.540	5.531	5.535	5.526	5.489	5.373	5.382	5.378
	5.376	5.376	5.376	5.375	5.375	5.374	5.374	5.374	5.464	5.824
	5.785	5.793	5.789	5.790	5.790	5.790	5.793	5.790	5.790	5.790
	5.043	5.212	5.202	5.252	5.257	5.255	5.255	5.255	5.255	5.255
	5.255	5.256	5.263	5.287	5.286	5.285	5.285	5.285	5.285	5.285
				*** COLIFORM IN MPN/MIN ***						
86	1.27E 08	1.27E 08	1.27E 08	1.27E 08	3.64E 09	4.49E 09	5.30E 09	6.27E 09	7.90E 09	7.85E 09
	7.15E 09	6.66E 09	6.61E 09	6.49E 09	6.60E 09	6.75E 09	6.64E 09	6.25E 09	6.06E 09	6.01E 09
	5.93E 09	6.27E 09	6.41E 09	6.29E 09	6.28E 09	6.27E 09	6.23E 09	6.07E 09	5.98E 09	5.87E 09
	5.66E 09	5.53E 09	5.53E 09	5.58E 09	5.59E 09	5.56E 09	5.53E 09	5.23E 09	6.78E 09	7.61E 09
	6.23E 09	5.76E 09	5.33E 09	4.88E 09	5.15E 09	5.02E 09	5.10E 09	5.09E 09	5.06E 09	5.05E 09
	4.65E 09	4.65E 09	4.66E 09	4.74E 09	4.76E 09	4.77E 09	4.77E 09	4.75E 09	2.35E 09	2.11E 09
	1.63E 09	1.64E 09	1.57E 09	1.50E 09	1.43E 09	1.36E 09	1.33E 09	1.28E 09	1.16E 09	1.02E 09
	9.46E 08	9.25E 08	9.20E 08	9.16E 08	9.16E 08	9.15E 08	9.15E 08	9.14E 08	9.14E 08	8.73E 08
	7.65E 08	6.34E 08	5.18E 08	4.10E 08	3.10E 08	2.31E 08	1.79E 08	1.48E 08	1.30E 08	1.22E 08
	1.17E 08	1.15E 08	1.14E 08	1.14E 08	1.14E 08	1.14E 08	1.14E 08	1.14E 08	1.14E 08	1.14E 08
				*** BOD IN LBS/MIN ***						
1	40.012	39.985	39.961	39.940	39.918	39.984	41.367	47.386	64.632	75.413
	73.274	60.494	50.353	44.435	43.605	48.311	51.390	49.985	45.391	39.732
	35.160	36.890	40.873	44.397	45.925	46.210	46.030	44.427	41.526	39.098
	37.011	35.185	34.933	35.445	35.843	36.283	36.538	37.698	47.376	69.720
	78.617	72.509	60.236	48.381	41.365	39.516	38.274	40.061	38.956	36.849
	36.341	34.931	33.883	34.084	34.776	35.022	35.357	35.849	36.009	36.101
	36.059	35.957	35.990	36.073	36.113	36.226	36.270	36.306	36.373	36.489
	36.910	37.621	38.382	38.944	39.305	39.433	39.384	39.348	39.366	39.362
	39.347	39.222	38.732	37.837	36.663	36.174	35.677	35.555	35.689	35.734
	35.708	35.728	35.742	35.745	35.784	35.833	35.890	35.929	35.948	35.957
				** SUSPENDED SOLIDS IN LBS/MIN **						
1	30.723	31.177	32.047	33.126	33.591	34.222	34.765	38.687	51.522	58.776
	53.269	45.082	37.513	33.192	32.632	35.765	37.833	36.640	33.302	29.330
	26.650	27.592	30.572	33.186	34.248	34.370	34.170	32.942	30.807	29.103
	27.092	26.463	26.381	26.651	27.221	27.611	27.845	28.687	35.943	51.935
	56.345	49.957	40.965	33.200	28.909	27.897	27.319	28.621	28.215	26.902
	26.749	25.918	25.319	25.607	26.234	26.508	26.831	27.257	27.466	27.522
	27.516	27.457	27.498	27.574	27.616	27.713	27.756	27.792	27.850	27.947
	28.275	28.625	29.412	29.847	30.127	30.229	30.194	30.168	30.185	30.184
	30.173	30.079	29.704	29.020	28.290	27.747	27.519	27.273	27.376	27.411
	27.392	27.408	27.419	27.422	27.453	27.490	27.535	27.564	27.580	27.587
				*** COLIFORM IN MPN/MIN ***						
1	8.06E 08	8.06E 08	8.06E 08	8.06E 08	1.37E 09	4.03E 09	1.03E 10	2.37E 10	5.35E 10	8.49E 10
	8.89E 10	7.83E 10	6.80E 10	6.20E 10	6.25E 10	6.69E 10	6.81E 10	6.47E 10	5.86E 10	5.13E 10
	4.70E 10	4.94E 10	5.70E 10	6.25E 10	6.26E 10	6.15E 10	6.07E 10	5.64E 10	5.40E 10	4.57E 10
	4.63E 10	4.36E 10	4.31E 10	4.31E 10	4.25E 10	4.13E 10	3.99E 10	4.06E 10	5.13E 10	7.62E 10
	8.20E 10	6.41E 10	5.55E 10	4.69E 10	4.25E 10	4.11E 10	4.04E 10	4.26E 10	4.14E 10	3.89E 10
	3.77E 10	3.58E 10	3.46E 10	3.44E 10	3.45E 10	3.38E 10	3.26E 10	3.15E 10	3.05E 10	2.97E 10
	2.92E 10	2.88E 10	2.82E 10	2.69E 10	2.49E 10	2.29E 10	2.14E 10	2.04E 10	1.97E 10	1.90E 10
	1.82E 10	1.74E 10	1.64E 10	1.55E 10	1.47E 10	1.36E 10	1.30E 10	1.24E 10	1.19E 10	1.14E 10
	1.10E 10	1.04E 10	9.85E 09	9.19E 09	8.54E 09	7.90E 09	7.32E 09	6.75E 09	6.34E 09	5.95E 09
	5.69E 09	5.49E 09	5.35E 09	5.20E 09	5.17E 09	5.03E 09	4.78E 09	4.45E 09	4.12E 09	3.87E 09

Table 6-22. OUTFLOW POLLUTOGRAPHS FROM SELECTED MANHOLES

EXTERNAL ELEMENT NUMBER	SELECTED OUTFLOW POLLUTOGRAPHS									
	TIME STEP 1	2	3	4	5	6	7	8	9	10
	*** BOD IN MG/L ****									
80	965.384	965.336	965.327	965.325	950.469	673.779	687.021	415.722	282.219	262.628
	296.766	340.409	376.285	382.681	350.258	322.855	346.933	420.141	520.288	586.050
	568.791	521.139	467.771	479.035	467.492	455.657	476.629	531.614	611.882	682.739
	740.133	777.726	805.828	823.177	850.953	859.465	846.986	555.396	317.113	224.136
	213.516	243.068	298.416	369.606	398.074	427.755	449.684	494.790	556.377	630.866
	653.227	749.727	782.609	806.136	833.134	854.164	871.268	881.679	895.244	905.020
	912.945	919.415	924.840	929.393	933.253	936.554	939.402	941.865	944.617	955.591
	950.935	951.131	951.790	952.703	953.634	954.483	955.271	955.971	956.609	957.170
	957.255	945.353	954.002	956.708	957.876	958.479	958.870	959.208	959.499	959.784
	960.042	960.257	960.532	961.411	961.121	961.213	961.340	961.468	961.636	961.776
	*** SUSPENDED SOLIDS IN MG/L ***									
66	781.523	836.711	847.230	840.716	817.608	729.941	562.579	340.931	224.588	196.452
	217.715	249.200	277.783	284.203	260.109	235.813	250.683	307.878	386.769	440.659
	429.746	391.026	364.143	357.769	349.118	338.684	352.621	355.296	458.289	514.073
	559.241	598.844	610.498	675.656	660.511	601.012	645.503	430.092	237.375	157.445
	145.375	167.252	213.965	266.623	290.502	314.392	330.724	305.138	415.075	472.268
	525.450	566.148	592.202	612.372	632.163	646.699	662.230	670.472	660.939	688.705
	695.328	700.173	704.403	708.071	711.137	713.765	716.030	717.992	720.071	728.464
	723.102	725.353	725.910	726.649	727.394	728.077	728.703	729.263	729.775	730.235
	730.502	721.604	728.469	730.028	730.930	731.400	731.712	731.984	732.217	732.444
	732.647	732.541	733.025	733.694	733.490	733.509	733.672	733.791	733.907	734.018
	***COLIFORM IN MPN/100ML ***									
86	3.50E 03	3.50E 03	3.50E 03	3.50E 03	9.95E 04	1.14E 05	1.02E 05	6.19E 04	4.78E 04	4.73E 04
	5.48E 04	6.11E 04	6.54E 04	6.54E 04	5.78E 04	5.29E 04	5.79E 04	7.40E 04	9.16E 04	9.52E 04
	9.55E 04	8.60E 04	8.34E 04	8.37E 04	8.00E 04	7.67E 04	8.09E 04	9.32E 04	1.05E 05	1.16E 05
	1.22E 05	1.25E 05	1.30E 05	1.37E 05	1.41E 05	1.44E 05	1.40E 05	8.51E 04	4.80E 04	3.53E 04
	3.03E 04	3.38E 04	4.21E 04	5.11E 04	5.60E 04	6.00E 04	6.47E 04	7.25E 04	8.30E 04	9.34E 04
	1.01E 05	1.05E 05	1.09E 05	1.13E 05	1.19E 05	1.23E 05	1.26E 05	1.30E 05	6.51E 04	5.92E 04
	5.15E 04	4.64E 04	4.51E 04	4.33E 04	4.14E 04	3.96E 04	3.85E 04	3.74E 04	3.33E 04	2.81E 04
	2.60E 04	2.54E 04	2.53E 04	2.53E 04	2.53E 04	2.52E 04	2.53E 04	2.53E 04	2.53E 04	2.41E 04
	2.17E 04	1.93E 04	1.57E 04	1.25E 04	9.45E 03	7.06E 03	5.46E 03	4.51E 03	3.99E 03	3.72E 03
	3.59E 03	3.53E 03	3.50E 03	3.43E 03	3.48E 03	3.48E 03	3.48E 03	3.48E 03	3.48E 03	3.48E 03
	*** BOD IN MG/L ****									
1	920.785	920.106	919.855	919.123	917.717	902.304	831.507	641.220	433.110	307.597
	252.383	255.129	229.026	232.529	255.568	239.426	239.247	248.759	270.912	300.865
	331.227	353.258	363.556	355.514	361.510	351.351	342.240	345.211	363.976	394.479
	432.231	479.373	524.423	574.033	626.036	660.979	621.649	656.387	483.975	322.532
	232.457	175.273	193.810	187.559	204.702	229.401	254.078	282.970	313.195	340.602
	364.216	434.354	481.238	530.217	578.437	622.268	602.369	698.341	728.050	752.490
	773.169	790.347	805.390	818.481	829.495	839.507	847.900	855.016	861.153	865.798
	870.066	875.018	880.277	884.576	888.432	891.650	893.585	894.844	896.308	897.671
	891.262	901.375	903.362	903.574	902.847	902.472	897.322	896.104	896.824	898.295
	899.516	900.539	901.354	901.901	902.336	902.646	902.940	903.239	903.505	903.584
	*** SUSPENDED SOLIDS IN MG/L ***									
1	707.015	717.457	737.463	762.319	781.445	772.290	698.802	523.513	345.258	239.733
	191.360	175.225	170.622	173.695	177.720	177.348	176.128	182.343	198.761	222.112
	246.217	263.610	271.963	273.228	269.819	261.327	254.059	255.963	270.023	293.630
	323.406	357.911	376.045	434.560	470.671	502.992	527.102	501.846	367.179	240.255
	155.632	134.535	125.003	128.707	142.009	161.992	181.355	203.574	226.841	253.042
	280.435	322.286	359.601	398.339	430.354	470.984	502.640	530.973	554.391	573.675
	589.978	603.522	615.348	625.649	634.322	642.214	648.653	654.504	659.384	663.110
	666.523	670.430	674.549	677.938	680.958	683.546	685.007	686.093	687.265	688.358
	683.505	671.260	682.805	693.093	692.502	692.230	688.263	687.370	687.939	689.082
	690.027	690.825	691.462	691.899	692.242	692.491	692.729	692.968	693.228	693.500
	***COLIFORM IN MPN/100ML ***									
1	4.07E 03	4.07E 03	4.07E 03	4.07E 03	6.93E 03	1.99E 04	4.56E 04	7.03E 04	7.86E 04	7.60E 04
	7.00E 04	6.68E 04	6.78E 04	7.19E 04	7.45E 04	7.27E 04	6.95E 04	7.06E 04	7.67E 04	8.52E 04
	9.44E 04	1.04E 05	1.11E 05	1.13E 05	1.09E 05	1.03E 05	9.90E 04	9.96E 04	1.04E 05	1.10E 05
	1.19E 05	1.27E 05	1.42E 05	1.53E 05	1.61E 05	1.65E 05	1.66E 05	1.55E 05	1.15E 05	7.73E 04
	5.32E 04	4.06E 04	3.72E 04	3.99E 04	4.59E 04	5.24E 04	5.88E 04	6.60E 04	7.30E 04	8.02E 04
	8.87E 04	9.77E 04	1.04E 05	1.17E 05	1.26E 05	1.32E 05	1.34E 05	1.34E 05	1.35E 05	1.36E 05
	1.37E 05	1.39E 05	1.39E 05	1.34E 05	1.28E 05	1.17E 05	1.10E 05	1.05E 05	1.02E 05	9.88E 04
	9.43E 04	8.87E 04	8.27E 04	7.73E 04	7.27E 04	6.85E 04	6.47E 04	6.18E 04	5.95E 04	5.72E 04
	5.49E 04	5.27E 04	5.04E 04	4.82E 04	4.59E 04	4.33E 04	4.02E 04	3.73E 04	3.50E 04	3.30E 04
	3.15E 04	3.04E 04	2.90E 04	2.91E 04	2.80E 04	2.78E 04	2.64E 04	2.45E 04	2.27E 04	2.13E 04

For Pine Valley, sewer flow data not affected by spring thaw were correlated with antecedent rainfall in the following manner. These sanitary sewage flows were first adjusted to remove accounted for sewage and dry weather infiltration for each day.

$$RINFIL(I) = SWFLOW(I) - SMMDWF - DINFIL \qquad (6\text{-}12)$$

where SWFLOW(I) = Average sewer flow on day I

Linear regression was then performed on the following data yielding Equation

Date	RINFIL, gpm	X_1	X_2	X_3	X_4	X_5	X_6	X_7	X_8	X_9	X_{10}
		in./day									
June											
1	28.87	0.12	0.02	0.00	0.06	0.00	0.00	0.36	0.00	0.00	0.00
2	24.64	0.00	0.12	0.02	0.00	0.06	0.00	0.00	0.36	0.00	0.00
3	19.68	0.11	0.00	0.12	0.02	0.00	0.06	0.00	0.00	0.36	0.00
etc.	dependent	etc. independent variables									

$$\begin{aligned} RINFIL = {} & 2.40 + 11.3X_1 + 11.6X_2 + 5.5X_3 \\ & + 6.4X_4 + 4.8X_5 + 3.6X_6 + 1.0X_7 \\ & + 1.5X_8 + 1.4X_9 + 1.8X_{10} \end{aligned} \qquad (6\text{-}13)$$

For April 15, RINFIL was then calculated to be 10.2 gpm. Therefore,

$$QINFIL = 20.0 + 52.0 + 10.2 = 82.2 \text{ gpm.}$$

Example 3. Subroutine FILTH

A hypothetical test area, Smithville, total population 15,000, is used as an example to demonstrate the application of subroutine FILTH. The test area is made up of six subcatchment basins and nine land use areas as shown in Figure 6-13. It was assumed that flow records and water metering records were unavailable. The industrial and commercial flows, however, were known for subareas 3, 4, and 5.

A Case 2 procedure was followed using the default values for A1BOD, A1SS and A1Coli. The areas, population density, cost of the dwellings, percentage of houses having garbage disposal units, and the average income of the families within each subarea are given in Table 6-23. The start of the storm simulation is on a Monday at 1:30 pm.

The data deck for FILTH is shown in Table 6-24. The first three data cards are the average daily variations for DWF, BOD, and SS. No daily variation for coliforms is modeled. The following 12 cards, in groups of threes, define the changes from daily averages to hourly flow rates and concentrations for flow, BOD, SS, and coliforms, respectively. The starting value of each group represents the 1 am condition. These factors are reproduced in the computer output as a check (shown in Table 6-25). The remaining card groups represent the information about each subarea. Card group 40 is a control card. It should be noted that for subareas 3, 4, and 5, dummy subareas (31, 41, and 51) were introduced giving a total of 12 subareas to account for the multiple land uses.

The output from FILTH (Table 6-26) is in two parts. The first group of values expresses the default concentrations of BOD, SS, and coliforms along with the yearly average daily flow. The second block gives the calculated values for each subarea taking into account the time and the day of the week the simulation occurred. Subtotals were requested for each inlet manhole.

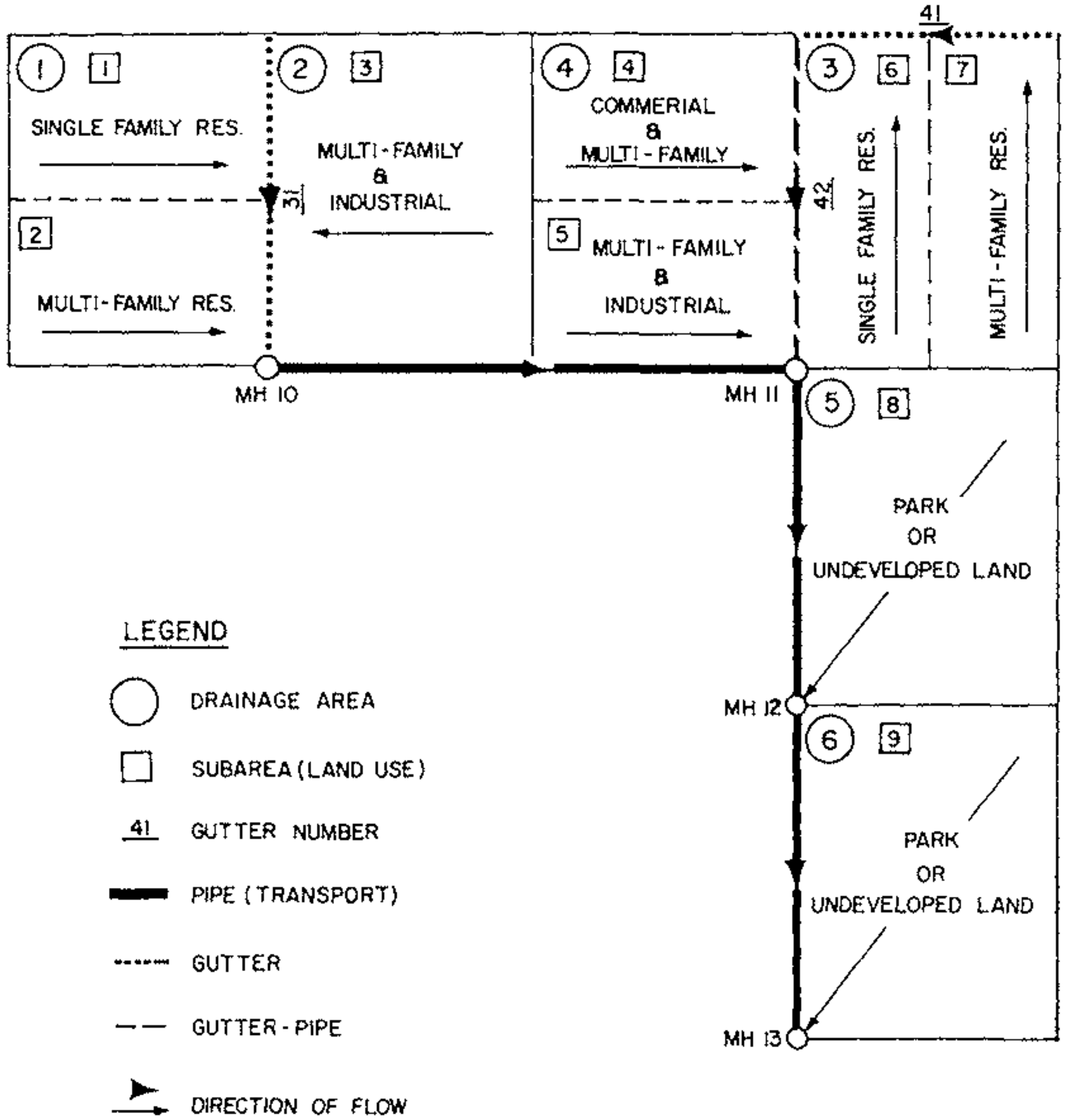


Figure 6-13. Schematic of Smithville Test Area

Table 6-23. LAND USE DATA FOR SMITHVILLE TEST AREA

Subarea	Area, acres	Population Density per acre	Average Cost of Dwellings	Percentage of Garbage Disposals	Average Family Yearly Income
1	10.0	10.0	$50,000	25.0%	$15,000
2	10.7	50.0	10,000	10.0	7,000
3	140.1	30.0	10,000	0.0	5,000
4	60.0	50.0	10,000	10.0	7,000
5	38.1	50.0	10,000	10.0	7,000
6	50.0	10.0	50,000	25.0	15,000
7	44.1	50.0	10,000	10.0	7,000
8	73.5	0.0	N.A.	N.A.	N.A.
9	73.5	0.0	N.A.	N.A.	N.A.

Table 6-24. DATA DECK FOR SMITHVILLE TEST AREA

```
                                  DATA                                              CARD GROUP
                                                                                       NO.
    0.96    1.08    1.05    0.90    1.04    1.00    0.97
    1.00    1.00    1.00    1.00    1.00    1.00    1.00                             33-35
    1.00    1.00    1.00    1.00    1.00    1.00    1.00
    0.74    0.67    0.63    0.59    0.54    0.56    0.67    0.96
    1.42    1.19    1.20    1.15    1.17    1.11    1.09    1.15                      36
    1.21    1.23    1.25    1.71    1.17    1.15    0.89    1.07
    0.85    0.71    0.60    0.41    0.46    0.49    0.72    0.87
    0.77    1.57    1.02    0.87    0.91    0.94    1.07    1.07                      37
    1.14    0.99    1.45    1.16    1.55    1.29    0.99    1.60
    1.05    1.05    1.10    0.50    0.66    1.33    1.10    0.89
    1.03    0.91    0.66    0.63    0.94    0.94    1.05    1.05                      38
    1.16    0.94    1.33    1.22    1.44    1.19    0.89    1.05
    1.10    0.64    0.45    0.87    0.54    0.48    1.29    1.18
    1.37    1.49    1.30    1.12    0.89    0.55    0.45    0.47                      39
    0.96    1.18    0.94    1.01    2.82    1.77    0.84    0.71
  12   2   3   2  13  30           15.000                                             40
 1 101          10.0 10.0          50.0 25.0                15.0
 2 102          10.7 50.0          10.0 10.0                 7.0
 3 102         140.1 30.0          10.0  0.0                 5.0
31 104                                       5.00 200. 200.       1
 4 112          60.0 50.0          10.0 10.0                 7.0
41 113                                       0.80 190. 220.                           44
 5 112          38.1 50.0          10.0 10.0                 7.0
51 114                                       3.00 200. 200.
 6 111          50.0 10.0          50.0 25.0                15.0
 7 112          44.1 50.0          10.0 10.0                 7.0 1
 8 125          73.5                                             1
 9 135          73.5                                             1
```

Table 6-25. ASSUMED HOURLY AND DAILY VARIATION IN SEWAGE FLOW FOR SMITHVILLE TEST AREA

DAILY AND HOURLY CORRECTION FACTORS
FOR SEWAGE DATA

DAY	DVDWF	DVBOD	DVSS	DVCOLI
1	0.960	1.000	1.000	
2	1.090	1.000	1.000	
3	1.050	1.000	1.000	
4	0.900	1.000	1.000	
5	1.040	1.000	1.000	
6	1.000	1.000	1.000	
7	0.970	1.000	1.000	
HOUR				
1	0.740	0.850	1.050	1.100
2	0.670	0.710	1.050	0.640
3	0.630	0.600	1.100	0.450
4	0.590	0.410	0.500	0.870
5	0.540	0.460	0.660	0.540
6	0.560	0.490	1.330	0.440
7	0.670	0.720	1.100	1.270
8	0.960	0.970	0.880	1.150
9	1.420	0.770	1.030	1.370
10	1.190	1.570	0.910	1.470
11	1.200	1.020	0.660	1.300
12	1.150	0.870	0.630	1.120
13	1.170	0.910	0.940	0.870
14	1.110	0.940	0.940	0.580
15	1.080	1.070	1.050	0.450
16	1.150	1.070	1.050	0.670
17	1.210	1.140	1.160	0.960
18	1.230	0.990	0.940	1.180
19	1.250	1.450	1.330	0.840
20	1.210	1.160	1.220	1.010
21	1.170	1.550	1.440	2.820
22	1.150	1.290	1.100	1.770
23	0.880	0.990	0.880	0.840
24	1.070	1.600	1.050	0.710

Table 6-26. DATA OUTPUT FOR SMITHVILLE TEST AREA

QUANTITY AND QUALITY OF D W F FOR EACH SUBAREA

A1BOD = 1300.00LBSPERDAY/CFS
A1SS = 1420.00 LBSPERDAY/CFS
A1COLI = 2.00E 11 MPN/DAY PER CAPITA
ADWF = 2.32 CFS

KNUM	INPUT	DWF CFS	+ INFIL CFS	= QQDWF CFS	KLAND	DWBOD LBS/MIN	DWSS LBS/MIN	TOTPOP PERSONS	BODCONC MG/L	SSCONC MG/L	COLIFORMS MPN/100ML
1	10	0.02	0.01	0.03	1	0.02	0.02				
2	10	0.05	0.02	0.07	2	0.04	0.05				
3	10	0.38	0.17	0.55	2	0.27	0.30				
31	10	5.00	2.27	7.27	4	3.74	3.74				
SUBTOTALS											
		5.44	2.47	7.91		20.39 LBS	20.55 LBS	4838.	138.	139.	6.14E 07
4	11	0.27	0.12	0.39	2	0.25	0.27				
41	11	0.80	0.36	1.16	3	0.65	0.71				
5	11	0.17	0.08	0.25	2	0.16	0.17				
51	11	3.00	1.36	4.36	4	2.25	2.25				
6	11	0.09	0.04	0.13	1	0.09	0.10				
7	11	0.20	0.09	0.29	2	0.18	0.20				
SUBTOTALS											
		9.97	4.52	14.49		38.28 LBS	39.05 LBS	12448.	141.	144.	7.16E 06
8	12	0.0	0.0	0.0	5	0.0	0.0				
SUBTOTALS											
		9.97	4.52	14.49		38.28 LBS	39.05 LBS	12448.	141.	144.	7.02E 06
9	13	0.0	0.0	0.0	5	0.0	0.0				
SUBTOTALS											
		9.97	4.52	14.49		38.28 LBS	39.05 LBS	12448.	141.	144.	7.02E 06
TOTALS											
		9.97	4.52	14.49		38.28 LBS	39.05 LBS	12448.	141.	144.	7.02E 06

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SECTION 7

STORAGE/TREATMENT BLOCK

BLOCK DESCRIPTION

The routing of flow through the storage/treatment package is controlled by subroutine STORAG which is called from the Executive Block program. STORAG coordinates the sewage quantities and qualities, the specifications of storage and treatment facilities to be modeled, and the estimation of their costs. The FORTRAN program is about 3,700 lines in length, comprising 16 subroutines. The relationships among the subroutines which comprise the Storage Block are shown in Figure 7-1.

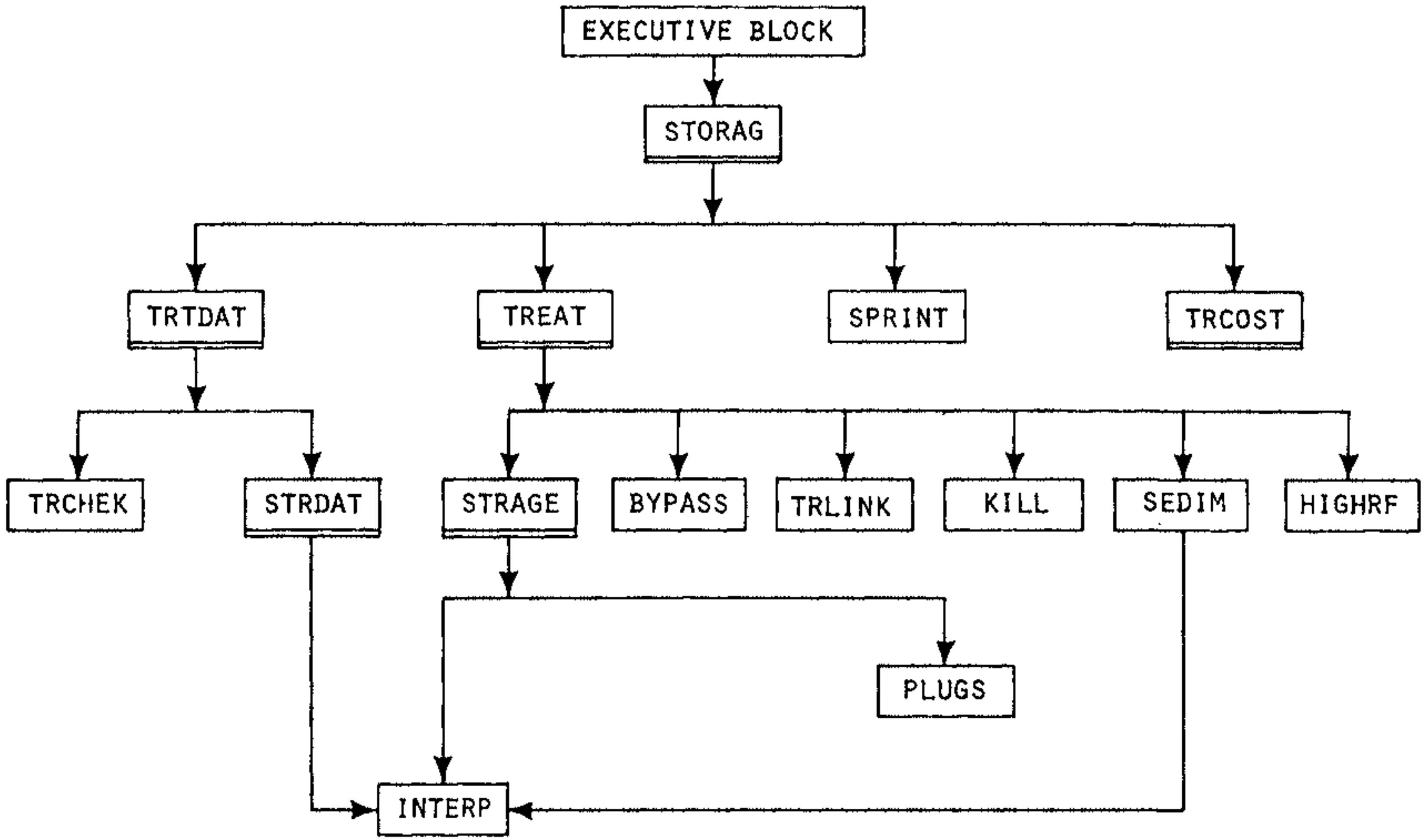
This section describes the Storage/Treatment Block, provides instructions on data preparation, and furnishes examples of program usage. A description of each subroutine is contained in comment cards at the beginning of the subroutine in the program listing.

Instructions are given for those subroutines requiring card input data, namely, the coordinating subroutine STORAG, the subroutines specifying the treatment and storage facilities, and the cost estimation subroutine.

Examples, with sample I/O data, are given for treatment, storage and cost computations.

Broad Description of Storage

With the Storage Model, holding or routing functions may be modeled in irregular or geometric shaped storage units, and with alternative inlet and outlet controls such as by weir, orifice, or pumping. The characteristics of the storage unit are first specified in subroutine STRDAT, and the flow of water and pollutants are then simulated each time step, by subroutine STRAGE. With gravity outflows, routing is performed by subroutine SROUTE. Two optional types of through-flow are suitable, i.e., plug flow (subroutine PLUGS) and complete mixing.



NOTE: BOXES WITH DOUBLE UNDERLINE REPRESENT MAJOR SUBROUTINES.

Figure 7-1. Storage Block

This external version of storage, as opposed to the internal version incorporated within the Transport Model, cannot be used without including specifications for sedimentation within the storage basin. The resuspension of solids settled in storage is not modeled.

Broad Description of Treatment

The quality of the storm or combined sewer overflow may be improved by passing the sewage through a treatment package made up by the user. The treatment package is composed by selecting treatment processes from the options indicated in Figure 7-2, thus forming a computational string. The characteristics of the treatment package are first specified in subroutine TRTDAT, and the sewage flows and treatment are then simulated each time step by subroutine TREAT, aided by a number of minor subroutines (see Figure 7-1) as needed.

Treatment packages not including storage may be modeled by specifying the appropriate bypass, Option 01.

Broad Description of Cost Estimation

Subroutine TRCOST handles the estimation of all storage and treatment costs after the storm simulation has been completed. Capital costs for the supply, installation, and required land for each process included in the string are computed, from which annual costs are derived. Storm event costs, such as those for chemicals consumed and operation and maintenance, are also computed.

Programming Limitations

The following programming limitations apply to the Storage/Treatment Block:

1) Maximum number of time steps = 150.

2) Maximum number of pollutants = 3 and these must be BOD, SS, and coliforms.

3) Maximum number of Transport Model outfalls (Transport Block output files) = 5, any one of which may be called for Storage Block operations.

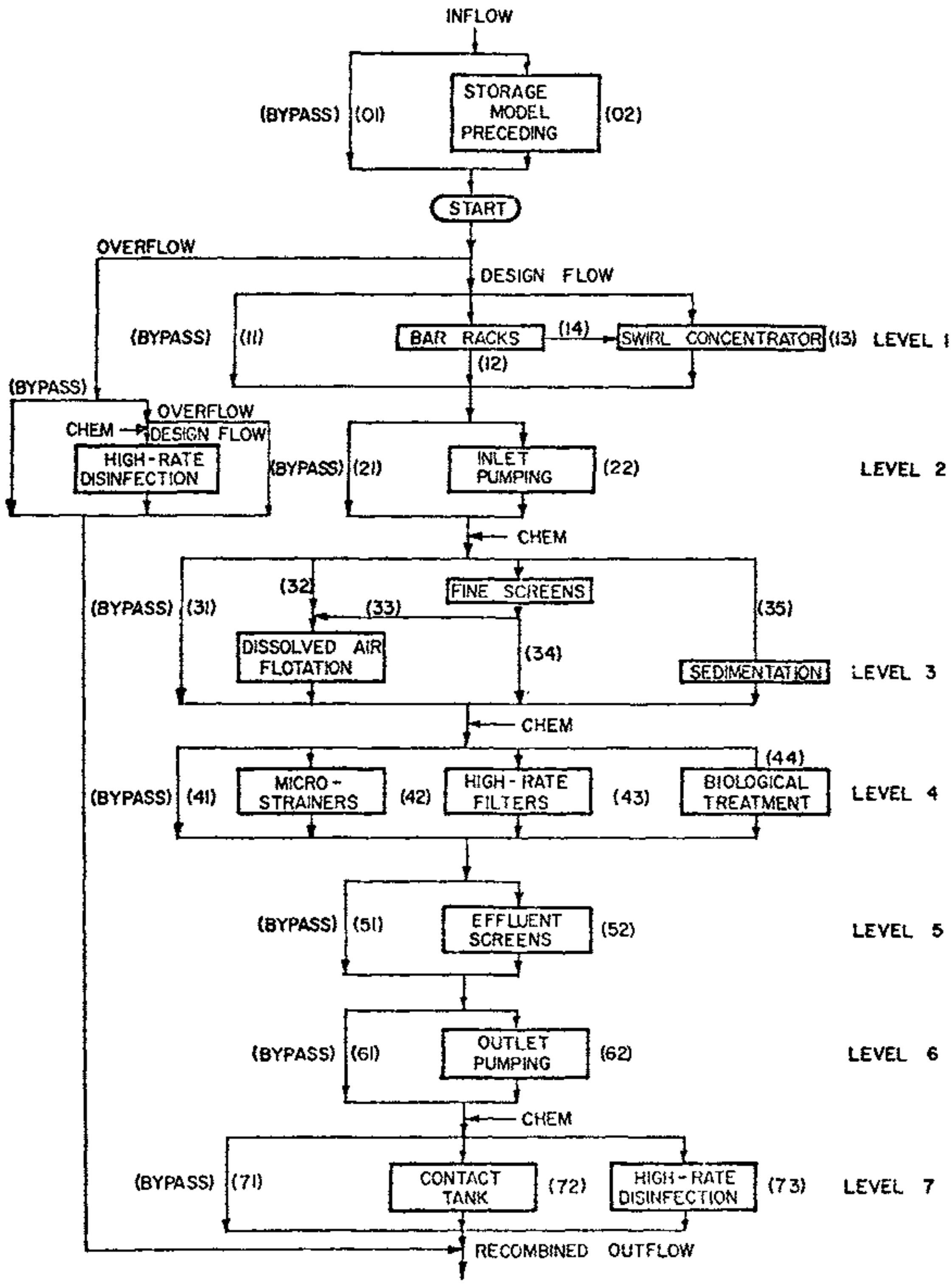


Figure 7-2. Options Available in Revised Treatment Model

4) Maximum number of Transport Model outfalls to be treated in a single run = 1.

5) Maximum number of points of chlorine application in Treatment = 1.

6) When treatment by high rate filters is included the only permissible time step size = 0.5,1.0, 2.0, 2.5, 5.0, or 10.0 minutes.

INSTRUCTIONS FOR DATA PREPARATION

Instructions for data preparation for the Storage Block have been divided along the lines of the major components for clarity of the presentation. These components are: Storage, Treatment, and Cost. Programming options permit the deletion of the cost and/or storage routines; however, some form of treatment must be specified once the Block is called. The typical data deck setup for the complete Storage Block is shown in Figure 7-3. Storage data describe the physical characteristics of the storage system and controls. Treatment data specify the treatment string sequence and provide supplemental data based upon the processes selected. Cost estimation data describe locations and years to be simulated and provide unit costs.

Data card preparation and sequencing instructions for the complete Storage Block are given at the end of these instructions in Table 7-2 followed by an alphabetical listing of the variable names and descriptions in Table 7-3.

Storage Model

Use of the External Storage Model involves seven basic steps.

Step 1. Flow and Quality Input --

Rewind and read the Transport output file. Specify the external element number of the outfall to be treated, the number of complete runs through treatment desired (generally one), and the design flow. When it is desired to run different treatment options, the number of such runs and the treatment options for each run must be specified. In addition to the hydrographs and pollutographs, data read from the tape listing are the number and size of time steps, time zero, and the total tributary area.

Step 2. Storage/Treatment String --

Set ISTOR = 02 and specify treatment string (see instructions under Treatment Model below for option selection). Option 35 = sedimentation must be used if an external storage unit is to be modeled.

Step 3. Output --

Select output and computational options according to the following:

```
IPRINT = 0 = NO PRINTOUT EACH TIME STEP
             (SUMMARY POSSIBLE)
       = 1 = PRINTOUT SOLUTION EACH TIME STEP
             (QUANTITY)
       = 2 = PRINTOUT SOLUTION EACH TIME STEP
             (QUALITY)
ICOST  = 0 = NO COST COMPUTATIONS AND SUMMARY
       = 1 = COMPUTE COSTS AND SUMMARIZE
IRANGE = 0 = QUANTITY RANGES (MAX,AV,MIN) NOT
             SUMMARIZED
       = 1 = QUANTITY RANGES (MAX,AV,MIN)
             SUMMARIZED
ITABLE = 0 = INFLOWS,OUTFLOWS NOT SUMMARIZED IN
             FINAL TABLES
       = 1 = INFLOWS AND OUTFLOWS SUMMARIZED IN
             FINAL TABLES
```

Step 4. Storage Unit --

Describe the storage unit mode (in-line), construction (natural, manmade and covered, manmade and uncovered), type of outlet device (orifice, weir or pumped), routing (plug flow or complete mixing), and basin parameters.

Step 5. Unit Cost --

Specify the storage basin unit cost ($ per cubic yard of maximum storage capacity) to be used to represent excavation, lining, cover, and appurtenances.

Step 6. Treatment and Treatment Cost Data --

Furnish supplemental data based upon the treatment options selected (see instructions under Treatment Model and Cost Model).

Step 7. Starting Time --

Furnish the clock time of the start of the simulation. This may be different from the time of start of storm.

Treatment Model

The steps in data preparation for use in the Treatment Model follow the same sequence as that listed for the Storage Model. Steps 1, 3, 6 and 7 are identical to the Storage Model. If external storage is omitted (by setting ISTOR = 01 in Step 2), Steps 4 and 5 are deleted. An extension of the discussion of Steps 2 and 6 follows.

Step 2. Storage/Treatment String --

In setting up a treatment string, all seven levels (see Figure 7-1) must be specified. The first digit in each option identified represents the computation level, and the second digit represents the path on that level. If the bypass of certain levels is requested (i.e., no treatment on that computational level), this condition is specified by setting the path indicator equal to 1. Similarly, if the path indicator is other than 1, some treatment will be performed. For example, if a treatment string is to represent a plant providing bar racks, microstrainers, and chlorination, and nothing else, the appropriate specification would be:

01-12-21-31-42-51-61-72.

Step 6. Treatment and Treatment Cost Data --

Only certain treatment options require supplemental data input. These options are:

1) Inlet and/or outlet pumping.

2) Swirl concentrator.

3) High rate disinfection for overflow.

4) Dissolved air flotation.

5) Sedimentation.

6) High rate filters.

The pumping options require that the total pumping head be given (for computation of operating costs). The swirl concentrator option requires specifications regarding unit size, design flow, particle size and specific gravity. The high rate disinfection option requires specification of the design flow. The dissolved air flotation units require specifications regarding polymer use, chlorine use, design overflow rate, recirculation flow, and tank depth. Similarly, sedimentation tanks require overflow rates, tank depths, and chlorine use. High rate filters require that the maximum operating rate, chemical addition, maximum design head loss, and maximum solids holding capacity (at maximum head and maximum flow rate) be specified. Detailed instructions are given in Table 7-2.

Cost Estimation Model

The cost model is called by setting ICOST = 1 in Step 3. The cost data cards follow the supplemental treatment data cards in Step 6.

The first card sets the interest rate, the useful life expectancy of the equipment, the year to be modeled, and the city to which costs are to be adjusted. The city cost factor is the ratio of that city's ENR (Engineering News Record Construction Cost Index) average to the national average.

Next, ENR Cost Indexes expected to prevail in each of the next 10 years are read in. Finally, the general unit costs for land, power, chlorine, polymers and alum are read. A summary of these cost parameters and their units follows (default values are listed in Table 7-1).

```
UCLAND = UNIT COST OF LAND,      $/ACRE
UCPOWR = UNIT COST OF POWER,     $/KWH
UCCL2  = UNIT COST OF CHLORINE, $/LB
UCPOLY = UNIT COST OF POLYMERS, $/LB
UCALUM = UNIT COST OF ALUM,      $/LB
RATEPC = INTEREST RATE FOR AMORTIZATION,
         PERCENT
NYRS   = AMORTIZATION PERIOD, YEARS
MODYR  = YEAR OF MODEL, FOR COSTS
SITEF  = AN ENR FACTOR FOR GEOGRAPHIC LOCATION
         OF SITE
```

Table 7-1. DEFAULT VALUES USED IN SUBROUTINE TRCOST

Item	Default value
Interest rate	7 percent
Amortization period	25 year
Site factors	1.0
Unit cost land	$20,000.00/acre
Unit cost power	.02/kwh
Unit cost chlorine	.20/lb
Unit cost polymers	1.25/lb
Unit cost alum	.03/lb
Storage construction unit cost (excavation, lining, etc.)	3.00/cy

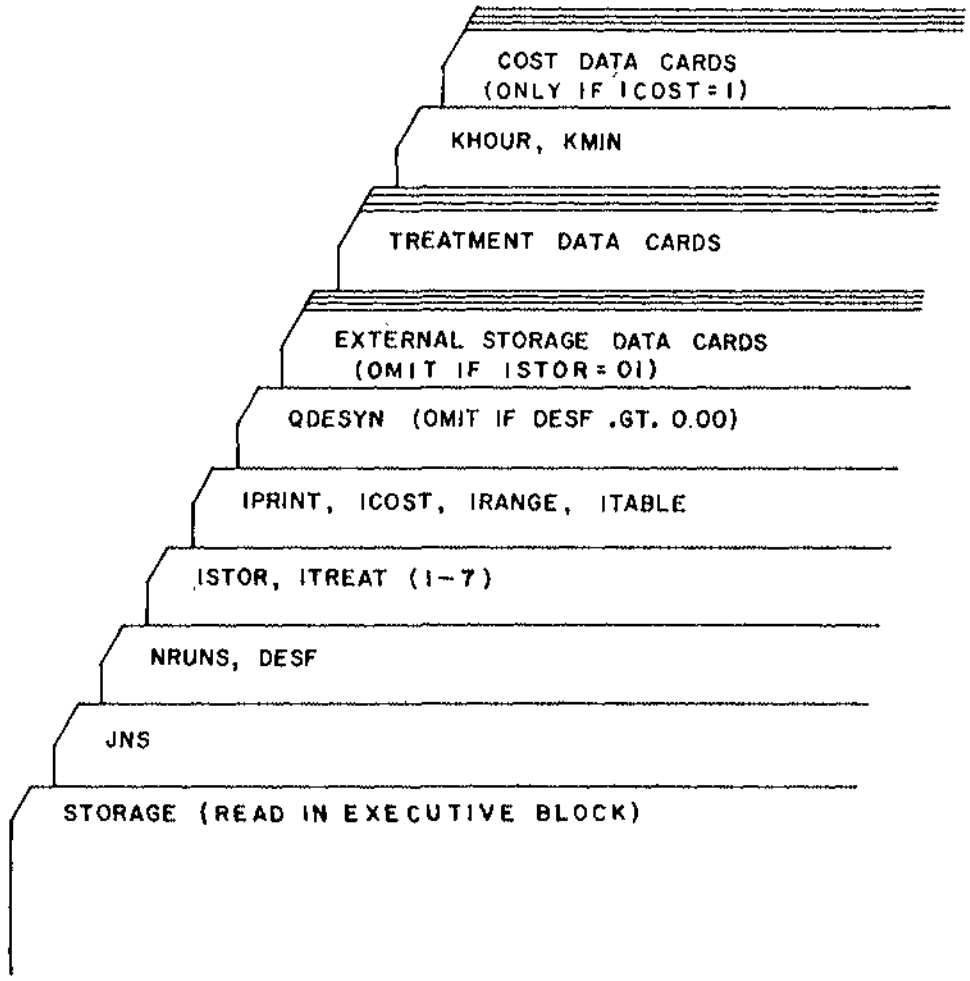


Figure 7-3. Data Deck for Storage Block

Table 7-2. STORAGE BLOCK CARD DATA

Card group	Format	Card column	Description	Variable name	Default value
1	I10	1-10	External element numbers from the Transport Block (NOUTS) which route the flow to the Storage Block (maximum = 1 for each run).	JNS	None
2			Execution control data.		
	I10	1-10	Number of different treatment executions to be made on the output from the Transport Block, element JNS	NRUNS	None
	F10.2	11-20	The ratio of the maximum flow to be treated to the maximum flow arriving (if unknown leave blank and include Card Group 5).	DESF	QDESYN.
	F10.2	21-30	Design flow for high-rate disinfection for overflows, cfs.	QDHIGH	0.0
	I10	31-40	High-rate disinfection for overflow. = 0, No, = 1, Yes.	IQDHO	0
3			Treatment control data.		
	I615	1-5	Parameter indicating if external storage is to be called. ISTOR = 1, External storage not called, ISTOR = 2, External storage called. Inflow, (up to treatment capacity) bypasses storage directly to treatment. ISTOR = 3, External storage called. All inflow is routed to storage prior to treatment.	ISTOR	1
		6-10	Bar racks and swirl concentrator (level 1).	ITREAT(1)	11

Table 7-2 (continued). STORAGE BLOCK CARD DATA

Card group	Format	Card column	Description	Variable name	Default value
			= 11, Bar racks and swirl concentrator bypassed,		
			= 12, Bar racks are in waste stream,		
			= 13, Swirl concentrator is in waste stream,		
			= 14, Bar racks followed by swirl concentrator are in waste stream.		
		11-15	Inlet pumping parameter (level 2).	ITREAT(2)	21
			= 21, No pump station,		
			= 22, Pump station exists.		
		16-20	Primary treatment parameter (level 3).	ITREAT(3)	31
			= 31, No primary treatment (flow bypassed),		
			= 32, Dissolved air flotation,		
			= 33, Fine screens and dissolved air flotation,		
			= 34, Fine screens only,		
			= 35, Sedimentation.		
		21-25	Secondary treatment parameter (level 4).	ITREAT(4)	41
			= 41, No secondary treatment (flow bypassed),		
			= 42, Microstrainers,		
			= 43, High rate filter,		
			= 44, Biological treatment.		
		26-30	Effluent screens (level 5).	ITREAT(5)	51
			= 51, No screens,		
			= 52, Effluent screens.		

Table 7-2 (continued). STORAGE BLOCK CARD DATA

Card group	Format	Card column	Description	Variable name	Default value
		31-35	Outlet pumping parameter (level 6).	ITREAT(6)	61
			= 61, No pumping,		
			= 62, pumping required.		
		36-40	Chlorine contact tank or high-rate disinfection (level 7).	ITREAT(7)	71
			= 71, No chlorine contact tank or high-rate disinfection (flow bypassed),		
			= 72, Chlorine contact tank,		
			= 73, High-rate disinfection.		
4			Computation print control card.		
	4I10	1-10	Printout of treatment results for each time step.	IPRINT	0
			= 0, Printout for each time step suppressed,		
			= 1, Printout quantity results for each time step,		
			= 2, Printout quality results for each time step.		
		11-20	Cost control data.	ICOST	0
			= 0, Cost calculations and the resulting printout are suppressed,		
			= 1, Compute costs and print cost summary.		
		21-30	Flow quantities summarization control parameter.	IRANGE	0
			= 0, Flow quantity range not summarized,		
			= 1, Quantity ranges summarized.		

Table 7-2 (continued). STORAGE BLOCK CARD DATA

Card group	Format	Card column	Description	Variable name	Default value
		31-40	Control of tabular output of the inlet and outlet flows from the treatment model.	ITABLE	0
			= 0, Flows not summarized in tabular form,		
			= 1, Flows summarized in tabular form.		
			IF DESF IN CARD GROUP 2 IS ZERO INCLUDE CARD GROUP 5, OTHERWISE OMIT.		
5	F10.2	1-10	Design flow rate of treatment facilities, cfs.	QDESYN	None
			IF TREAT(1) ≠ 13 OR 14, SKIP CARDS 6 AND 7.		
6			Swirl concentrator data.		
	I10	1-10	Number of particles sizes (maximum number = 9).	NOPART	None
	2F10.0	11-20	Swirl concentrator diameter, ft.	DIAMSP	None
		21-30	Specific gravity of particles.	SPGRAV	None
7			Swirl concentrator particle size data card.		
	16F5.0	1-5	Particle size, cm.	PSIZE(1)	None
		6-10	Fraction of total particles.[a]	PCENT(1)	None
		11-15	Particle size, cm.	PSIZE(2)	None

[a]All values of PCENT are entered as fractions.

Table 7-2 (continued). STORAGE BLOCK CARD DATA

Card group	Format	Card column	Description	Variable name	Default value
			Fraction of total particles	PCENT(2)	None
			.	.	
			.	.	
			.	.	
			Particle size, cm.	PSIZE(NOPART)	None
				.	
			Fraction of total particles	PCENT(NOPART)	None
			CARDS 8 THROUGH 17 ARE DATA INPUT FOR EXTERNAL STORAGE. (ISTOR = 2 ON CARD 3). OMIT THESE DATA CARDS IF EXTERNAL STORAGE IS NOT DESIRED.		
8			Storage unit data card.		
	10I5	1-5	Storage mode parameter.	ISTMOD	1
			= 1, In-line storage.		
		6-10	Storage type parameter.	ISTTYP	1
			= 1, Irregular (natural) reservoir,		
			= 2, Geometric (regular) covered reservoir,		
			= 3, Geometric (regular) uncovered reservoir.		
		11-15	Storage outlet control parameter.	ISTOUT	1
			= 1, Gravity with orifice center line at zero storage tank depth,		
			= 2, Gravity with fixed weir,		
			= 5, Dual rate pumps[a],		
			= 6, Existing fixed-rate pumps,		
			= 9, Gravity with both weir and orifice.[b]		

[a]Second pump starts if first pump does not lower water level.

[b]This type of storage outlet is not presently programmed, if modelling is desired, use internal storage from Transport Block.

Table 7-2 (continued). STORAGE BLOCK CARD DATA

Card group	Format	Card columns	Description	Variable name	Default value
9			Computation/print control card.		
	3I10	1-10	Basin flow parameter. = 0, No pollutants, (hydraulics only), = 1, Perfect plug flow through basin, = 2, Perfect mixing in basin.	IPOL	0
		11-20	Print control parameter. = 0, No print each time step, = 1, Print each time step in storage.	ISPRIN	0
10			Reservoir flood depth data card.		
	F10.2	1-10	Maximum (flooding) reservoir depth, ft.	DEPMAX	None
	I10	11-20	Chlorination option.[a]	ICL2	None
			INCLUDE EITHER CARD GROUP 11 OR 12, NOT BOTH.		
			INCLUDE CARD GROUP 11 IF ISTTYP ON CARD 8 HAS THE VALUE 1.		
11			Reservoir depth-area data card.		
	F10.2	1-10	A reservoir water depth, ft.	ADEPTH(1)	None
	F10.0	11-20 . . .	Reservoir surface area corresponding to above depth, ft^2.	AASURF(2) . . .	None
	F10.2	61-70	A reservoir water depth, ft.	ADEPTH(4)	None

[a]Not presently programmed, leave blank.

Table 7-2 (continued). STORAGE BLOCK CARD DATA

Card group	Format	Card columns	Description	Variable name	Default value
	F10.0	71-80	Reservoir surface area corresponding to above depth, ft^2.	AASURF(4)	None
			(NOTE: The above pair of variables is repeated 11 times, 4 pairs per card.)		
			INCLUDE CARD 12 ONLY IF ISTTYP ON CARD 8 HAS THE VALUE 2 OR 3.		
12			Reservoir dimensions data card.		
	2F10.0	1-10	Reservoir base area, ft^2.	BASEA	None
		11-20	Reservoir base circumference, ft.	BASEC	None
	F10.5	21-30	Cotan of sideslope (horizontal/vertical).	COTSLO	None
			INCLUDE ONLY ONE OF THE OUTLET DATA CARDS 13, 14 OR 15.		
			INCLUDE CARD 13 ONLY IF ISTOUT ON CARD 8 HAS THE VALUE 1.		
13			Orifice outlet data card.		
	F10.3	1-10	Orifice outlet area x discharge coefficient, ft^2.	CDAOUT	None
			INCLUDE CARD 14 ONLY IF ISTOUT ON CARD 8 HAS THE VALUE 2.		
14			Weir outlet data card.		
	2F10.3	1-10	Weir height above depth = 0, ft.	WEIRHT	None
		11-20	Weir length, ft.	WEIRL	None

Table 7-2 (continued). STORAGE BLOCK CARD DATA

Card group	Format	Card columns	Description	Variable name	Default value
			INCLUDE CARD 15 ONLY IF ISTOUT ON CARD 8 HAS THE VALUE 5 OR 6.		
15			Pump outlet data card.		
	3F10.3	1-10	Outflow pumping rate,[a] cfs.	QPUMP	None
		11-20	Depth at pump startup, ft.	DSTART	None
		21-30	Depth at pump shutdown, ft. (DSTOP > 0.0)[b]	DSTOP	None
16			Initial conditions data card.		
	2F10.2	1-10	Storage at time zero, ft^3.	STORO	0.0
		11-20	Outflow rate at time zero, cfs.	QUOTO	0.0
17			Cost data card.		
	F10.2	1-10	$/$yard^3$ for storage excavation.	CPCUYD	0.0
			END OF EXTERNAL STORAGE CARDS.		
			IF ITREAT(2) = 22 ON CARD 3, INCLUDE CARD 18.		
18	F10.2	1-10	Pump head for inlet lift station of the treatment facilities, ft.	HEAD1	None
			INCLUDE ONLY ONE OF THE LEVEL 3 TREATMENT CARDS 19 OR 20 IF ITREAT(3) IS NOT EQUAL TO 31 OR 34 ON CARD 3.		
			INCLUDE CARD 19 ONLY IF ITREAT(3) ON CARD 3 HAS THE VALUE OF 32 OR 33.		

[a]Pumping rate is for a single pump. Dual pumping (ISTOUT = 5) doubles this rate when second pump is on.

[b]DSTOP must equal or be greater than the level in storage that contains enough volume to handle the pumping rate, QPUMP, for one time step.

Table 7-2 (continued). STORAGE BLOCK CARD DATA

Card group	Format	columns	Description	Variable name	Default value
19			Dissolved air flotation data cards.		
	2I5	1-5	Chemical addition to the unit.	ICHEM	0
			= 0, No chemical addition,		
			= 1, Chemical addition.		
		6-10	Chlorine addition to the unit.	ICL2	0
			= 0, No chlorine addition,		
			= 1, Chlorine addition.		
	3F10.2	11-20	Design overflow rate, gal/day/ft^2. (5,000.0 suggested).	OVRDAF	None
		21-30	Amount of flow recirculation, percent (15% suggested).	RECIRC	None
		31-40	Depth of dissolved air flotation tank, ft.	DEEP	None
			INCLUDE CARD 20 IF ITREAT(3) = 35 AND ISTOR = 1 ON CARD 3.		
20			Primary sedimentation tank cards.		
	2F10.2	1-10	Primary sedimentation tank overflow rate, gal/day/ft^2 (1,000.0 suggested).	OVRSED	None
		11-20	Depth of sedimentation tank, ft (8.0 suggested).	SEDEP	None
	I10	21-30	Chlorine addition to unit.	ICL2	0
			= 0, No chlorine addition,		
			= 1, Chlorine addition.		
			INCLUDE CARD 21 ONLY IF ITREAT(4) = 43 ON CARD 3.		
21			High rate filter data cards.		

Table 7-2 (continued). STORAGE BLOCK CARD DATA

Card group	Format	Card columns	Description	Variable name	Default value
	F10.2	1-10	Maximum operating rate of the filter, gal/min/ft^2.	OPRAMA	None
	I10	11-20	Addition of chemicals.	ICHEMH	0
			= 0, No chemicals added,		
			= 1, Chemicals added.		
	2F10.2	21-30	Maximum design head loss of filter, ft.	HM	None
		31-40	Maximum solids holding capacity at maximum head and maximum flow rate, lb/ft^2.	SQM	None
			INCLUDE CARD 22 ONLY IF ITREAT(6) = 62 ON CARD 3.		
22	F10.2	1-10	Pump head for outflow lift station from treatment facilities, ft.	HEAD2	None
			END OF TREATMENT CARDS.		
23			Time for start of treatment-storage simulation.		
	2I5	1-5	Hour of start, 24 hour clock.	KHOUR	0
		6-10	Minute of start, min.	KMIN	0
			INCLUDE CARDS 24 THROUGH 26 ONLY IF ICOST = 1 ON CARD 4.		
24			ENR cost data.		
	F10.2	1-10	Amortization interest rate for construction of treatment facilities, percent.	RATEPC	7.0
	2I10	11-20	Amortization period, yr.	NYRS	25

Table 7-2 (continued). STORAGE BLOCK CARD DATA

Card group	Format	Card columns	Description	Variable name	Default value
		21-30	Year of computer simulation (minimum = 1970, maximum = 1980).	MMDDYR	None
	F10.4	31-40	ENR factor for the geographic location of treatment facilities.	SITEF	1.0
25			ENR cost index for year and location.	IENR	
	8I10	1-10	ENR for 1970.	IENR(1)	None
		11-20	ENR for 1971.	IENR(2)	None
		. . .		. . .	
		71-80	ENR for 1977.	IENR(8)	None
		. . .		. . .	
		21-30	ENR for 1980.	IENR(11)	None
26			Unit cost data card.		
	F10.0	1-10	Unit cost of land, $/acre.	UCLAND	20000.0
	F10.5	11-20	Unit cost of power, $/KWH.	UCPOWR	0.02
	3F10.2	21-30	Unit cost of chlorine, $/lb.	UCCL2	0.20
		31-40	Unit cost of polymers, $/lb.	UCPOLY	1.25
		41-50	Unit cost of alum, $/lb.	UCALUM	0.03
			END OF STORAGE BLOCK CARDS.		

Table 7-3. STORAGE/TREATMENT VARIABLES[a]

Variable Name	C*	Description	Unit
AASURF	C	Surface area of natural reservoir	sq ft
ADEPTH	C	Depth of reservoir	ft
ADJ		Dummy variable	
ALACST		Amortized cost of land required	$/yr
ALAND		Area of land required for this equipment	acres
ALANDT		Total area of land required for the equipment	acres
ALASC		Amortized cost of land required for screens	$/yr
ALCSTT		Total amortized cost of land required	$/yr
ALSC		Area of land required for screens	acres
ALUMUH		Alum used for high rate filter	lb
ALUMUT	C	Total alum used	lb
ANCSTT		Total amortized cost of installed equipment	$/yr
ANNSC		Amortized cost of screens	$/yr
ANNTOT		Total amortization cost including land and equipment	$
AO2DT2	C	Volume of outflow per half time-step	cf
APLAN	C	Land area requirement	sq ft
AREA		Surface area of man-made storage unit	sq ft
AREA1		Surface area for preceding time-step	sq ft
AREA2		Surface area for present time-step	sq ft

Variable Name	C*	Description	Unit
AREAMS	C	Submerged screen area	sq ft/unit
ATERM	C	Volume in storage plus outflow	cf
BACK		Back flow volume	cf
BASEA		Base area of reservoir	sq ft
BASEC		Base circumference of reservoir	ft
BASICM		Cost of minimum maintenance (no storm)	$/yr
BCIF		BOD concentration of inflow	mg/L
BCIFMN		Minimum BOD concentration of the inflow	mg/L
BCIFMX		Maximum concentration of BOD of inflow to the whole model	mg/L
BCIFT		Accumulative total or arithmetic average of BOD concentration of the inflow to the whole model	mg/L
BCIN	C	BOD inflow rate to one treatment unit	lb/DT
BCINMN		Minimum BOD concentration of the inflow	mg/L
BCINMX		Maximum BOD concentration of the inflow	mg/L
BCINT		Accumulative total or arithmetic average of BOD concentration of inflow to one treatment unit	mg/L
BCOF		BOD concentration in the bypass (overflow)	mg/L
BCOFMN		Minimum BOD concentration of the bypass (overflow)	mg/L
BCOFMX		Maximum BOD concentration of overflow	mg/L
BCOFT		Accumulative total or average of BOD concentration of the overflow	mg/L
BCOU	C	BOD concentration of outflow from one treatment unit per time-step	mg/L

[a]Does not include variables added during updating.
*Variable names shared in common blocks.

Table 7-3 (continued). STORAGE/TREATMENT VARIABLES

Variable Name	C*	Description	Unit
BCOUFT		BOD concentration of outflow	mg/L
BCOUMN	C	Minimum BOD concentration of the outflow	mg/L
BCOUMX	C	Maximum concentration of BOD of outflow	mg/L
BCOUS		BOD concentration in the outflow from screens	mg/L
BCOUT	C	Accumulative total or arithmetic average of BOD concentration of outflow from one treatment level	mg/L
BCREDU		BOD concentration reduced	mg/L
BCRL		BOD concentration of the released flow per time-step	mg/L
BCRLMN		Minimum BOD concentration of the released flow	mg/L
BCRLMX		Maximum BOD concentration of the released flow	mg/L
BCRLT		Accumulated total or arithmetic average at BOD concentration of the released flow	mg/L
BCRM	C	BOD concentration of the waste flows from individual treatment unit	mg/L
BCRMMN	C	Minimum BOD concentration removed	mg/L
BCRMMX	C	Maximum BOD concentration removed	mg/L
BCRMT	C	Accumulative total for arithmetic average of BOD concentration of the wasted flows from one treatment unit	mg/L
BCRM1		BOD concentration of the waste flows from individual treatment unit	mg/L
BDARR	C	Outfall BOD	lb
BDCIF		BOD concentration of inflow (= BCIF)	mg/L

Variable Name	C*	Description	Unit
BDCRL		BOD concentration of released flow = BCRL	mg/L
BDEPTH	C	Water depth	ft
BDIF	C	Total BOD in the inflow to the whole model	lb
BDIFRF		Fraction of BOD removed to BOD flowing into whole model	
BDIFT		Accumulative total BOD of the inflow	lb
BDIN	C	BOD inflow rate to one treatment unit	lb/DT
BDINRF		Fraction of BOD removed to BOD flowing into each treatment unit	
BDINT	C	Accumulative total BOD flow into one treatment unit	lb
BDOF		BOD rate in bypassed waste flows	lb/DT
BDOFT		Accumulative total BOD in the overflows	lb
BDOU	C	BOD outflow rate	lb/DT
BDOUS		BOD outflow rate from screens	lb/DT
BDOUT	C	Accumulative total BOD flow out of one treatment unit	lb
BDRD		BOD reduction, percentage	%
BDRL	C	BOD released per time-step	lb/DT
BDRLT		Accumulative total BOD released from the whole model	lb
BDRM	C	BOD removal per time-step	lb/DT
BDRMT	C	Accumulative total BOD removal by one treatment unit	lb
BDRMIT		Accumulative total BOD removed by the whole model	lb

Table 7-3 (continued). STORAGE/TREATMENT VARIABLES

Variable Name	C*	Description	Unit
BDRS		BOD removed by screens per time-step	lb/DT
BDRST		Total BOD removed by screens	lb
BIG	C	Initializing number, (10^{12})	
BMSC		Basic maintenance cost of fine screens	$/storm
BODCOT		BOD outflow concentration	mg/L
BODIN	C	BOD inflow rate (pollutograph)	lb/DT
BODOUT	C	BOD outflow	lb
BREFF		BOD removal efficiency	
BREFFH	C	BOD removal efficiency of high rate filter	
BREFF2		BOD removal efficiency	
BSICMT		Total minimum maintenance cost	$
BSTOR	C	Storage	cf
BYPASS		Name of subroutine	
CAPCST		Capital cost of installed equipment	$
CAPMS		Capacity per microstrainer unit	mgd
CAPSC		Capital cost of screens	$
CAPST		Capital cost for five screens	$
CAPTOT		Total capital costs including land and equipment	$
CAPUCL		Dosing rate per trickling filter unit	lb/day
CCIF		Coliform concentration of inflow to whole model	MPN/100 ml
CCIFMN		Minimum coliform concentration of the inflow	MPN/100 ml
CCIFMX		Maximum coliform concentration of inflow	MPN/100 ml
CCIFT		Accumulative total for arithmetic average of coliform concentration of inflow	MPN/100 ml
CCIN		Coliform concentration of the inflow to one treatment unit	MPN/100 ml
CCINMN		Minimum coliform concentration of the inflow to one unit	MPN/100 ml
CCINMX		Maximum coliform concentration of the inflow to one unit	MPN/100 ml
CCINT		Accumulative total or arithmetic average of coliform concentration of the inflow to one treatment level	MPN/100 ml
CCOF		Coliform concentration in the overflow	MPN/100 ml
CCOFMN		Minimum coliform concentration of the overflow	MPN/100 ml
CCOFMX		Maximum coliform concentration of overflow	MPN/100 ml
CCOFT		Accumulative total for arithmetic average of coliform concentration of the overflow	MPN/100 ml
CCOU		Coliform concentration of the outflow during one time-step	MPN/100 ml
CCOUMN		Minimum coliform concentration of the outflows	MPN/100 ml
CCOUMX		Maximum coliform concentration of the outflow	MPN/100 ml
CCOUT		Accumulative total for arithmetic average of the outflow coliform concentration	MPN/100 ml
CCRL		Coliform concentration of the released flow per time-step	MPN/100 ml
CCRLMN		Minimum coliform concentration of the released flow	MPN/100 ml

Table 7-3 (continued). STORAGE/TREATMENT VARIABLES

Variable Name	C*	Description	Unit
CCRLMX		Maximum coliform concentration of the released flow	MPN/100 ml
CCRLT		Accumulative total or arithmetic average of coliform concentration of the released flow	MPN/100 ml
CDAOUT		Outlet orifice area times discharge coefficient	sq ft
CFSOF		Overflow rate for microstrainer	cfs
CFSTR		Internal bypass flow treated by microstrainer	cfs
CFSTR2		Effluent flow from microstrainer	cfs
CHCOST		Chemical cost, per process	$/storm
CHCSTT		Total chemical costs	$/storm
CHEMU		Chemical use per time-step and process	lb
CHEMUH		Chemical used for high rate filter	lb
CHEMUT	C	Total chemicals use per unit	lb
CLACST		Capital cost of land required	$
CLAND	C	Cost of lands	$
CLASC		Cost of land for screens	$
CLCSTT		Total capital cost of land requirement	$
CL2CST	C	Cost of chlorine used	$/storm
CL2DEM		Chlorine demand	mg/L
CL2U		Chlorine used per time-step	lb
CL2UC		Chlorine used	lb/day
CL2UT	C	Total chlorine used	lb/day

Variable Name	C*	Description	Unit
CL2UTT		Total chlorine used for whole model	lb
COARR	C	Outfall coliform	MPN
COCIF		Coliform concentration of inflow (= CCIF)	MPN/100 ml
COCRL		Coliform concentration of released flow (= CCRL)	MPN/100 ml
COIF	C	Coliform inflow rate for Storage Model	MPN/DT
COIFRF		Fraction of coliform removed to coliform flowing into the whole model	
COIFT		Accumulative total coliform inflow	MPN
COIN		Coliform inflow rate to one treatment unit	MPN/DT
COINRF		Fraction of coliform removed to coliform flowing into each treatment unit	
COINT		Accumulative total coliform flowing into one treatment unit	MPN
COLCOT		Coliform outflow	MPN/100 ml
COLIFT		Total coliform flowing into whole model	MPN
COLIN	C	Coliform inflow rate (pollutograph)	MPN/DT
COLOUT	C	Coliform outflow	MPN/DT
CONVER	C	Conversion factor 10^6/DT sec lbs/cf	mg/L/lb/cfs
CONVOL		Volume of contact tank	cf
COOF		Number of coliform per time-step in the overflow	MPN/DT
COOFT		Accumulative total coliform in the overflow	MPN
COOU		Coliform outflow from one treatment unit per time-step	MPN/DT

Table 7-3 (continued). STORAGE/TREATMENT VARIABLES

Variable Name	C*	Description	Unit
COOUT		Accumulative total coliform flowing out of one treatment unit	MPN
CORD		Coliform reduction, percentage	%
CORL	C	Coliform released per time-step	MPN/DT
CORLT		Accumulative total coliform released	MPN
CORM		Coliform removed from treatment	MPN/DT
CORMT		Accumulative total coliform removed by one treatment unit	MPN
COTSLO		Contangent of side slope angle	
CPACRE	C	Cost per acre of land	$/acre
CPCSTT		Total capital cost of installed equipment	$
CPCUYD	C	Unit cost of excavation	$/cy
CPS	C	Capital cost of pump station for storage	$
CRC		Computational variable for CRF	
CRF		Capital recovery factor	
CSTOR	C	Cost of storage	$
CTOTAL	C	Total cost	$
CUMIN	C	Cumulative inflow since start of simulation	cf
CUMOUT	C	Cumulative outflow since start of simulation	cf
C2CSTT		Total chlorine cost	$/storm
DBOD		Dissolved BOD	lb
DDEPTH		Depth increment of storage reservoirs	ft
DEEP		Depth of air flotation tank	ft
DEPMAX	C	Maximum allowable depth in reservoir	ft
DEPTH	C	Water depth	ft
DEPTHL		Depth for previous time-step	ft
DEPTH2		Depth of storage unit	ft
DESF	C	Design flow fraction of maximum flow	
DETENT	C	Detention time	sec
DETMIN		Detention time	min
DS		Suspended solids removed in the filter	lb/DT
DSTART	C	Reservoir depth at start of pumping	ft
DSTOP	C	Reservoir depth at end of pumping	ft
DSTP		Depth at which pumps start up	ft
DSTRT		Depth at which pumps start up	ft
DS1		Suspended solids stored in the filter	lb/DT
DT	C	Time-step interval	min, sec
DTMORE	C	Additional time-step required to pump wet well down	
DTON	C	Number of time-steps pumping occurred	
DTPUMP	C	Dummy variable	
DT2		Half time-step interval	min
DUM		Increment of arriving flow rate	
DUMDEP	C	Storage depth	ft
DUMSTR	C	Storage capacity	cf
DUMTRM		Routing parameter (= ATERM)	cf
DUMAO2		Term in Routing parameter (= $O_2\Delta t/2$)	cf

Table 7-3 (continued). STORAGE/TREATMENT VARIABLES

Variable Name	C*	Description	Unit
DVR		Parameter indicating unreliable storage unit	
ENR		ENR cost index for year and location	
F		Fraction of chemical dosing flow rate to total flow rate of treatment unit	
FACTOR		Integer for unit conversion	
FAREAB	C	Face area of bar screens	sq ft
FMS		Factor for microstrainer	
FON		Fraction of time-step pumped	
FRAC	C	Fraction of an inflow plug	
FRONT		Computational variable for plug flow	
FR2ST		Fraction of totals entering storage unit	
GPMSF		Flow rate through microstrainer	gpm/ft^2
H		Head over weir	ft
H		Head loss through filter (HIGH)	ft
HCL		Head loss thru filter due to solids load	ft
HEAD1	C	Pump head for inlet lift station	ft
HEAD2	C	Pump head for outlet lift station	ft
HIGHRF		Name of subroutine	
HM	C	Maximum design head loss	
HO		Operation head loss through sand of filters	ft
HRFD	C	Multiplier for number of backwash iterations for high rate filters	
H1		Head over weir	ft
I		Bookkeeping integer	
IA		Bookkeeping integer	
ICHEM	C	Indicator noting if chemicals are added	
ICHEMH	C	Indicator noting if chemicals are added to the high rate filter(s)	
ICL2	C	Indicator for chlorine addition	
ICOST	C	Indicator for cost compilation and summary	
IENR		ENR Index	
INTERP		Name of subroutine	
IPOL	C	Pollution control parameter	
IPRINT	C	Print control parameter	
IRANGE	C	Parameter indicating if quantity ranges are summarized	
ISPRIN	C	Print control parameter	
ISTBUP		Indicator of back up effect	
ISTEXS		Indicator for excess flow handling	
ISTINF		Indicator for nonmodel inflow devices	
ISTMOD	C	Indicator for storage mode	
ISTOR	C	Indicator for separate storage modeling	
ISTOUT	C	Indicator for outlet type	
ISTTYP	C	Indicator for type storage structure	
ITABLE	C	Indicator parameter for summarizing inflows and outflows in table form	
ITR		Indicator of illegal combination of treatment	
ITREAT	C	Treatment parameter	
ITR100		ITREAT x 100	

Table 7-3 (continued). STORAGE/TREATMENT VARIABLES

Variable Name	C*	Description	Unit
J		Title parameter	
JM	C	Same as J	
JN	C	Outfall element numbers transferred by file	
JN5	C	Print control counter	
JP	C	Number of first inlet plugs in outflow	
JS	C	Outfall array pointer designating JNS Element	
J1		Variable indicating if bar racks are used, level 1	
J2		Variable indicating if pumping is used, level 2	
J3		Type of primary treatment, level 3	
J4		Type of secondary treatment, level 4	
J5		Variable indicating if there are effluent screens, level 5	
J6		Variable indicating if there is an effluent pump station, level 6	
J7		Variable indicating if there are chlorine contact tanks, level 7	
K		Bookeeping integer for level of treatment	
KDT	C	Time-step number	
KDTBW		Backwash time-step number	
KENR		Number of years from 1969 to the desired year of the ENR cost index	
KFLAG		Interpolation warning flag	
KHOUR	C	Hour of day during simulation	hr

Variable Name	C*	Description	Unit
KILL		Name of subroutine	
KK		Do loop counter	
KMIN	C	Minute during simulation	min
KMOD	C	Bookkeeping integer for module size	
KNCOMB		Number of illegal treatment combinations	
KNECON		Parameter indicating inadvisable treatment combinations	
KNTOF	C	Number of times there is storage overflow	
KP		Inlet plug number	
KPASS		Parameter indicating design flow too large	
KRUN		Do loop variable denoting run number	
KYEAR		Calendar year	
L	C	Do loop counter for level of treatment	
LABEL	C	A label number	
LP	C	Number of last inlet plug in outflot	
LPREV	C	LP for previous time-step	
LR		Variable which indicates type and level of treatment	
M		Do loop counter	
MHOUR		Selected hour of simulation when contaminants removals are computed	
MM		Do loop counter	
MMIN		Selected minute of simulation when contaminants removals are computed	
MMM		Do loop counter	

Table 7-3 (continued). STORAGE/TREATMENT VARIABLES

Variable Name	C*	Description	Unit
MODCST	C	Cost of module	$
MODSIZ	C	Treatment module size	mgd
MODYR		Year of desired ENR	
N		Do loop counter	
NAME	C	Name of the treatment option	
ND		Time-step computation variable	
NDT	C	Number of time-steps	
NDTBW		Number of time-steps for backwash	
NEVEN		Number of high rate filter units in even numbers	
NFLAG	C	Indicator of inadmissible treatment combination or time-step length	
NM	C	Time-step when pollution reduction calculations will be made	
NMS	C	Number of microstrainer units	
NN		Counter for plug flow	
NNCOMB		Number of illegal combinations	
NNECON		Number of inadvisable combinations	
NOCOMB		An illegal combination pair	
NOE		Number of elements	
NOESUN		Number of effluent screens	
NOUNIT		Number of treatment module unit	
NOUTS		Number of outfalls from transport Black	
NPOLL	C	Number of pollutants	
NRUNS		Number of different treatment runs	
NSCRN	C	Number of screens	
NSED	C	Number of sedimentation tanks used	
NSTIN		Input file number	
NSTOUT		Output file number	
NUE		Number of the upstream element	
NUNITC		Number of dosing units	
NUNITH	C	Number of high rate filter units	
NYEAR		Dummy variable	
NYRS		Amortization periods	years
OFACT		Fraction of overflow rate to total inflow	
OPRA		Operating flow rate of high rate filter	gpm/sq ft
OPRAMA	C	Maximum operating rate for high rate filter	gpm/sq ft
OTCSTT		Total miscellaneous cost for the storm	$/storm
OTHCST		Storm costs excluding chemical cost	$/storm
OTHSC		Non-chemical storm costs for fine screens	$/storm
OVFRA		Overflow rate	gpd/sq ft
OVRDAF	C	Design overflow rate	gpd/sq ft
OVRSED	C	Design overflow rate of sedimentation tank	gpd/sq ft
PBDOF		Pounds of BOD overflowing out of microstrainer	lb
PBDTR		Pounds of BOD treated by microstrainer	lb
PCL2DM		Chlorine demand rate	lb/day

Table 7-3 (continued). STORAGE/TREATMENT VARIABLES

Variable Name	C*	Description	Unit
PCL2MX		Chlorinator capacity required	lb/day
PLUGS		Name of subroutine	
POLL	C	Pollutants	
PSSOF		Pounds of SS overflowing out of micro-strainer	lb
PSSTR		Pounds of SS treated by microstrainer	lb
PUMPDV		Volume pumped per time-step	cf
Q		Water flowrate	mgd
QAV		Average flow rate of inflow and outflow $\left(\frac{QQIF + QQRL}{2}\right)$	cfs
QDESYN	C	Design through flow rate for treatment package	cfs
QDSMGD		Design through flow rate for treatment package	mgd
QIN	C	Water inflow rate (hydrograph)	cfs
QINSTL	C	Inflow rate to storage for previous time-step	cfs
QKILL		Disinfectant dosage flow rate	cfs
QMOD	C	Design capacity for treatment module	mgd
QO	C	Outfall flows from TRANS	cfs
QOMAX	C	Maximum outflow from storage unit	cfs
QOUS		Effluent flow rate from screens	cfs
QOUST	C	Outflow rate from storage unit	cfs
QOUSTL	C	Outflow rate for previous time-step	cfs
QOUT		Outflow rate from storage unit	cfs

Variable Name	C*	Description	Unit
QOUTO	C	Initial outflow rate	cfs
QPUMP	C	Constant pump at outflow rate	cfs
QQARR	C	Arrival flow rate	cfs
QQESUN		Module capacity of effluent screens	mgd/unit
QQIF	C	Water arrival rate to model	cfs
QQIFT		Total inflow rate to whole model	cfs
QQIFMN		Minimum inflow rate	cfs
QQIFMX	C	Maximum arrival rate of flow from TRANS	cfs
QQIN	C	Inflow rate of one treatment unit	cfs
QQINMN		Minimum inflow rate for a treatment unit	cfs
QQINMX		Maximum inflow rate for a treatment unit	cfs
QQINT		Total inflow rate to one unit	cfs
QQOF		Overflow rate	cfs
QQOFMN		Minimum overflow rate	cfs
QQOFMX		Maximum overflow rate	cfs
QQOFR		Amount of overflow from storage unit	cfs
QQOFT		Total overflow rate	cfs
QQOU	C	Outflow rate	cfs
QQOUMN	C	Minimum outflow rate	cfs
QQOUMX	C	Maximum outflow rate	cfs
QQOUS		Effluent flow rate from screens	cfs

Table 7-3 (continued). STORAGE/TREATMENT VARIABLES

Variable Name	C*	Description	Unit	Variable Name	C*	Description	Unit
QQOUT	C	Accumulative total outflow rate for arithmetic average	cfs	S	C	SS held in high rate filters	lb/sq ft
QQRL	C	Effluent from treatment plus bypass flow rate	cfs	SBOD	C	BOD in storage unit	lb
QQRLMN		Minimum flow rate from treatment units and bypass line	cfs	SBODC		Average BOD concentration in the storage unit	mg/L
QQRLMX		Maximum flow rate released from treatment and bypass line	cf	SCIF		SS concentration of the influent	mg/L
QQRLT		Accumulative flow rate from treatment units and bypass line	cfs	SCIFMN		Minimum SS concentration in the influent	mg/L
QQRM	C	Removal flow rate	cfs	SCIFMX		Maximum SS concentraton of the influent	mg/L
QQRMMN	C	Minimum removal flow rate	cfs	SCIFT		Accumulative total or arithmetic average of SS concentration of the influent	mg/L
QQRMT	C	Accumulative removal flow rate by one treatment step	cfs	SCIN	C	SS concentration of the inflow to one treatment unit	mg/L
QQRS		Flow removed by screens	cfs	SCINMN		Minimum SS concentration of the inflow	mg/L
QRAT		Ratio of design flow to max. flow from from storage unit		SCINMX		Maximum SS concentration of the inflow	mg/L
QU		Capacity of high rate filter per unit	mgd	SCINT		Accumulative total for arithmetic average of SS concentration of the inflow to one treatment level	mg/L
RATEPC		Interest rate for amortization	%	SCOF		SS concentration in the overflow	mg/L
RIJP		Time-step number		SCOFMN		Minimum SS concentration in the overflow	mg/L
RIL		Time-step		SCOFMX		Maximum SS concentration of overflow	mg/L
RILP		Time-step number		SCOFT		Accumulative total for arithmetic average of SS concentration of overflow	mg/L
RECIRC	C	Recirculation flow	%	SCOL	C	Coliform in storage unit	MPN
RKTSTP		Number of time-step (= KDT)		SCOLC		Coliform concentration in storage unit	MPN/100 ml
RL		Number time-steps minus one		SCOU	C	Outflow SS concentration	mg/L
				SCOUMN	C	Minimum SS concentration of the outflow	mg/L

Table 7-3 (continued). STORAGE/TREATMENT VARIABLES

Variable Name	C*	Description	Unit	Variable Name	C*	Description	Unit
SCOUMX	C	Maximum concentration of SS of outflow	mg/L	SLOAD		Solids loading on screens	lb/min/sq ft
SCOUS		SS concentration in the outflow from screens	mg/L	SOUT		Volume out of plug flow	cf
				SPRINT		Name of subroutine	
SCOUT	C	Accumulative total for arithmetic average of SS concentration in outflow of one treatment level	mg/L	SQM	C	Maximum solids holding capacity at maximum head and maximum flow rate	lb/sq ft
SCRCAP	C	Capacity per screen	cfs	SREFF		SS removal efficiency	
SCREEN	C	Area of fine screen	sq ft	SREFFH	C	SS removal efficiency of high rate filter	
SCRL		SS concentration of the released flow per time-step	mg/L	SREFF1		Same as SREFFH	
SCRLMN		Minimum SS concentration of the released flow	mg/L	SREFF2		Same as SREFFH	
				SROUTE		Name of subroutine	
SCRLMX		Maximum SS concentration in the released flow	mg/L	SSARR	C	SS arrival rate	lb/DT
SCRLT		Accumulative total for arithmetic average of SS concentration of the released flow	mg/L	SSCIF		SS concentration of inflow to the whole model (= SSIF)	mg/L
SCRM	C	SS concentration of the waste flow from a treatment unit	mg/L	SSCOUT		SS outflow concentration	mg/L
				SSCRL		SS concentration of released flow (= SSRL)	
SCRMMN	C	Minimum SS concentration in removal flow	mg/L				
SCRMMX	C	Maximum SS concentration removal flow	mg/L	SSIF	C	SS inflow rate (storage)	lb/DT
SCRMT	C	Accumulative total for arithmetic average of SS concentration of the removal flow by one treatment level	mg/L	SSIFRF		Fraction of SS removed to SS flowing into the whole model	
				SSIFT		Accumulative total SS in the inflow to the whole model	lb
SCRM1		SS removed by microstrainer	mg/L				
SEDA	C	Surface area of sedimentation tank	sq ft	SSIN	C	SS in flow rate of one treatment level	lb/DT
SEDEP		Sedimentation tank depth	ft	SSINRF		Fraction of SS removed to SS flowing into each treatment level	
SEDIM		Name of subroutine					
SEDNUM		Number of sedimentation tanks required		SSINT	C	Accumulative total SS flow into treatment level	lb
SITEF		An ENR factor for geographic location of site		SSOF		SS flow rate in overflow	lb/DT

Table 7-3 (continued). STORAGE/TREATMENT VARIABLES

Variable Name	C*	Description	Unit
SSOFT		Accumulative total SS in the outflow from the whole model	lb
SSOU	C	SS outflow rate	lb/DT
SSOUS		SS outflow rate from screens	lb/DT
SSOUT	C	Accumulative total SS outflow from one treatment level	lb
SSRD		SS reduction, percentage	%
SSRL	C	SS released per time-step	lb/DT
SSRLT		Total SS released to the whole model	lb
SSRM	C	SS removed per time-step	lb/DT
SSRMT	C	Accumulative total SS removed from each unit	lb
SSRMTT		Total SS removal from the whole model	lb
SSRS		SS removed by screens	lb/DT
SSRST		Accumulative total SS removed by screens	lb
SSS	C	SS in the storage unit	lb
SSSC		Average SS concentration in the storage unit	mg/L
STMTOT		Total storm costs including chemical and others	$
STOR	C	Water in storage	cf
STORAG		Name of subroutine	cf
STORDV		Buffer volume of storage for pumping	
STORHI		Storage volume at pump starting level	cf
STORL	C	Water in storage at previous time-step	cf
STORLO	C	Storage volume at pump stop level	cf
STORMX	C	Maximum storage capacity	cf
STORZ		Water stored per time-step	cf
STORO	C	Initial storage	cf
STOT		Total volume of outflow plugs	cf
STRAGE		Name of subroutine	
STRDAT		Name of subroutine	
SUAREA	C	Submerged area	sq ft
SUM		Sum of the inflow volume	cf
SUSIN	C	SS inflow rate (pollutograph)	lb/DT
SUSOUT	C	SS outflow	lb/DT
S1		SS held in high rate filters	lb/sq ft
TCHEM		Total chemical used	lb
TERM		Term in routing equation, $S_2 + O_2\frac{\Delta t}{2}$	cf
TIME		Time of time-step	sec
TIME2M		Time since start of inflow	min
TITLE		Title on input file	
TOTCST	C	Dummy variable	
TRCHEK		Name of subroutine	
TRCOST		Name of subroutine	
TREAT		Name of subroutine	
TRIBA	C	Total area of basin	acres
TRLINK		Name of subroutine	
TRTDAT		Name of subroutine	
TSSOUT		Total output of SS	

Table 7-3 (continued). STORAGE/TREATMENT VARIABLES

Variable Name	C*	Description	Unit
TSURFA	C	Total surface area	sq ft
TZERO		Time of start of storm	sec
UAREAH	C	High rate filter area per unit	sq ft
UCCL2		Unit cost of chlorine	$/lb
UCLAND		Unit cost of land	$/acre
UCLIME		Unit cost of alum	$/lb
UCPOLY		Unit cost of polymers	$/lb
UCPOWR		Unit cost of power	$/KWH
UNESN		Design flow/100	cfs/100
UNESNO		Design flow for effluent screens	cfs
VIKK		Inflow volume per time-step (= VOLIN)	cf
VOKK		Outflow volume per time-step (= VOLOUT)	cf
VOLCON	C	Volume of contact tank	cf
VOLDAF	C	Volume of dissolved air flotation tank	cf
VOLIN	C	Inflow water volume per time-step	cf
VOLOUT	C	Outflow water volume per time-step	cf
VOLOUZ		Water outflow per time-step	cf
VOLSED	C	Volume of sedimentation tank	cf
WAIF		Total water inflow per time-step	cf/DT
WAIFRF		Fraction of water removed to water inflow of the whole model	
WAIFT		Accumulative total inflow volume to the whole model	cf
WAIN	C	Water inflow to one treatment level	cf/DT
WAINRF		Fraction of water removed to water flowing into each treatment level	
WAINT	C	Accumulative total inflow volume to one treatment level	cf
WAOF		Volume of overflow per time-step	cf/DT
WAOFT		Total outflow volume from the whole model	cf
WAOU	C	Water volume from one treatment unit	cf/DT
WAOUT	C	Accumulative total water flowing out one treatment level	cf
WARL		Volume of water released per time-step	cf
WARLT		Total water released	cf
WARM	C	Water removed	cf
WARMT	C	Total water removed by one treatment level	cf
WARS		Water removed by fine screens	cf/DT
WARST		Total water removed by screen	cf
WARMTT	C	Total volume of water removed from the whole model	cf
WEIRHT		Reservoir depth when surface at weir elevation	ft
WEIRL		Weir length	ft
WEIRQ		Outflow through fixed weir by gravity	cfs/ft
Y		Data array number	
YE		Output value	
X		Data array number	
XE		Input value	

SAMPLE RUNS

Two examples illustrating the use of the Storage/Treatment Block are included herein. Example 1 incorporates external storage and sedimentation due to storage. All other treatment options are bypassed. Example 2 bypasses external storage and provides treatment by bar racks, sedimentation, biological treatment unit, and chlorination. High rate disinfection of the overflow is also included in this example.

Example 1. Storage Only

This example receives most of its data from the Transport Block output file created for Stevens Avenue District of the City of Lancaster, Pennsylvania.

Description of Input Data --

Table 7-4 shows a listing of the card data presented to the program for execution. The first two cards identify the outfall (7), and the number of complete runs through the program desired (1). The ratio of the maximum flow to be treated to the maximum flow arriving is set equal to zero on card 2, thereby necessitating the use of card 5. High rate disinfection of the overflow is not included for this example. The third and fourth cards identify the treatment string and print control options. The treatment string includes only the sedimentation due to storage. All other treatment options have been bypassed. The fifth card specifies the design flow rate of treatment facilities. The next six cards describe the geometry and design parameters of the storage unit. The next card is the cost data card for storage exectuion. The value of CPCUYD on this card has been set equal to zero. The last card specifies the clock time of start of storm.

Description of the Sample Output --

The output for Example 1 is shown, somewhat abbreviated, in Tables 7-5 through 7-8 inclusive. Table 7-5 shows the control information read from the Transport Block output file. Table 7-6 shows the input data and design computations accomplished in subroutine TRTDAT and STRDAT. Note that the storage unit and all treatment units are fully described. Table 7-7 shows the performance in each level for each time step. This table has been abbreviated to show output only for the first 13 time steps. Table 7-8 shows a summary of the treatment performance at each level and at representation time periods (all levels combined).

Table 7-4. EXAMPLE 1. CARD INPUT DATA LIST

Data	Card Group Number
STORAGE	
7	1
1 0.0	2
1 11 21 35 41 51 61 71	3
2 0 0 0	4
400.0	5
1 2 1	6
1 1	7
100.0	8
1950.0 165.0 0.0	10
3.0	11
0.0 0.0	13
0.0	14
11 00	21
ENDPROGRAM	

Table 7-5. EXAMPLE 1. CONTROL INFORMATION PASSED FROM TRANSPORT BLOCK

```
STORAGE  BLOCK CALLED

ENTRY MADE TO STORAGE/TREATMENT MODEL

STORAGE/TREATMENT MODEL UPDATED BY UNIVERSITY OF FLORIDA JAN, 1974

LANCASTER  PENNSYLVANIA  STEVENS  AVE  DISTRICT ****  RELEASE II  ****
OUTPUT FROM EXTERNAL STORAGE/TREATMENT MODELS

INPUT DATA-SET OUTFALLS AT THE FOLLOWING ELEMENT NUMBERS:
  7
INPUT TO STORAGE/TREATMENT MODEL SUPPLIED FROM EXTERNAL ELEMENT NUMBER   7

NUMBER OF RUNS             =        1
TIME-STEP SIZE             =     5.00 MIN.
NO. TIME-STEPS MODELED     =      100
TRIBUTARY AREA             =   134.59 ACRES
NO. TRANSP. MOD. OUTFALLS  =        1
NO. OF POLLUTANTS          =        3
TIME ZERO                  =  40800.0 SEC
```

Table 7-6. EXAMPLE 1. OUTPUT OF SUBROUTINES TRTDAT AND STRDAT

```
******* RUN NO. 1 *******
INPUT DATA FOR TREATMENT PACKAGE FOLLOWS

                    CHARACTISTICS OF THE TREATMENT PACKAGE ARE
                          LEVEL    MODE         PROCESS

                            0       02      STORAGE ROUTED
                            1       11                        (BYPASS)
                            2       21                        (BYPASS)
                            3       35         STORAGE
                            4       41                        (BYPASS)
                            5       51                        (BYPASS)
                            6       61                        (BYPASS)
                            7       71                        (BYPASS)
                                                              IPRINT = 2, ICOST = 0, IRANGE = 0, ITABLE = 0

  SPECIFIED TREATMENT CAPACITY USED.

         DESIGN FLOWRATE =    400.00 CFS.
         TREATMENT SYSTEM INCLUDES MODULE UNITS
            DESIGN FLOW IS THEREFORE INCREASED TO NEXT LARGEST MODULE SIZE
            ADJUSTED DESIGN FLOWRATE =    464.10 CFS., =    300.00 MGD.
            (KMOD = 15)
            CHARACTERISTICS OF STORAGE UNIT ARE
                 OUTLET TYPE  =  1
                 STORAGE MODE =  1
                 STORAGE TYPE =  2

            IPOL = 1, PRINT CONTROL (ISPRIN) = 1

         MAN-MADE RESERVOIR, WITH MAX. DEPTH = 100.00 FT.,  AND CHARACTERISTICS
                  BASE AREA =      1950. SQ.FT.,        BASE CIRCUMF. =       165. FT.,      COT(SIDESLOPE) =   0.0
            RESERVOIR OUTLET CONTROL BY GRAVITY WITH FIXED ORIFICE
            ORIFICE AREA*CD =      3.000 SQ.FT.  DT =    300.00 SEC. (FROM INPUT HYDROGRAPH)
         - NOTE
              ORIFICE CENTERLINE ASSUMED AT TANK DEPTH = 0. WHEN STORAGE = 0
            DEPTH(FT) STOR(CU.FT)    DEPTH(FT) STOR(CU.FT)    DEPTH(FT) STOR(CU.FT)    DEPTH(FT) STOR(CU.FT)
              0.0         0.          10.00      19500.          20.00     39000.          30.00     58500.
             40.00     78000.         50.00      97500.          60.00    117000.          70.00    136500.
             80.00    156000.         90.00     175500.         100.00    195000.
            THE TWO SETS OF 11 STORAGE PARAMETERS, FOR DT =   300.000 SEC., ARE
    ATERM.,        0.     30920.    55150.    78260.   100839.   123055.   144972.   166714.   188300.   209759.   231112.
    AO2DT2.,       0.     11620.    16150.    19760.    22839.    25535.    27972.    30214.    32300.    34259.    36112.
            ASSUMED UNIT COST (EXCAVATION, LINING, ETC.) = 0.0  $/CU.YD.

  DESIGN FLOW INPUT TO TREATMENT WILL BE 'CONSIDERABLY RESTRICTED BY MAXIMUM POSSIBLE OUTFLOW FROM STORAGE =   240.75 CFS
            THEREFORE REDUCE TREATMENT DESIGN FLOW

  SPECIFIED TREATMENT CAPACITY USED.

         DESIGN FLOWRATE =    240.75 CFS.
         TREATMENT SYSTEM INCLUDES MODULE UNITS
            DESIGN FLOW IS THEREFORE INCREASED TO NEXT LARGEST MODULE SIZE
            ADJUSTED DESIGN FLOWRATE =    309.40 CFS., =    200.00 MGD.
            (KMOD = 13)

         BAR RACKS AND/OR SWIRL CONCENTRATOR NOT INCLUDED  (LEVEL 1)

         INFLOW BY GRAVITY (NO PUMPING)  (LEVEL 2)

         TREATMENT BY SEDIMENTATION IN ASSOCIATED STORAGE - SEE LEVEL 0 ABOVE
            NO CHLORINE ADDED

         NO SECONDARY TREATMENT INCLUDED  (LEVEL 4)

         NO EFFLUENT SCREENS  (LEVEL 5)

         OUTFLOW BY GRAVITY (NO PUMPING)  (LEVEL 6)

         NO CHLORINE CONTACT TANK FOR OUTFLOW  (LEVEL 7)
```

Table 7-7. EXAMPLE 1. OUTPUT OF PERFORMANCE PER TIME STEP

```
PERFORMANCE PER TIME STEP

        NOTE:  NO BOD OR SS ARE REMOVED IN LEVELS 2, 5, & 6, REGARDLESS OF THE OPTIONS SELECTED
               NO SS REMOVALS IN LEVEL 7 (CHLORINE CONTACT TANK)
               LEVEL 1 & 5 REMOVALS (AT BAR RACKS AND EFFLUENT SCREENS) ARE REPORTED IN SUMMARY ONLY

 --- TIME ---------------INFLOWS-----------------      STORAGE          BYPASS LEVEL 4       NO CONTACT TANK           OUTFLOWS
              ************************           *****************   *****************   **********************   ***************************
 HR:MIN        WATER   BOD      SS COLIFORMS      TOTAL   BOD    SS    TOTAL   BOD    SS    TOTAL   BOD COLIFORMS   TOTAL   BOD     SS COLIFORMS
                CFS   MG/L   MG/L MPN/100ML        CFS   MG/L  MG/L     CFS  MG/L  MG/L     CFS  MG/L MPN/100ML     CFS   MG/L  MG/L MPN/100ML
 U STP TIME INFLOW OUTFLOW  STORAGE DEPTH   IN: BOD     SS STOR: BOD        SS    BOD        SS OUT: BOD       SS    BOD     SS    J  L
 N NO (MIN)  (CFS)  (CFS)   (CU.FT) (FT.)      (LB)   (LB)      (LB)      (LB) (MG/L)  (MG/L)       (LB)     (LB) (MG/L) (MG/L)  P  P

   0   0.0   0.0   0.0         0.   0.0

   1   5.0   1.1   0.4       103.   0.05     7.6      4.7           7.6     4.7 1187.2  732.1           0.0       0.0        0.0    0.0   0  0
                                       COLIN= 2.21E 09SCUL(MPN)= 2.21E 09CONC= 7.56E 04COLOUT= 0.0   0.0   CONC= 0.0
 11: 5 ARR  0.30    0.     0.   0.0     OUT  0.30   0.    0.    0.30    0.     0.    0.30    0.   0.0         0.30    0.     0.   0.0
       OVF  0.0     0.     0.   0.0     REM  0.10   0.    0.    0.0     0.     0.    0.0     0.

   2  10.0   1.1   0.9       234.   0.12     7.6      5.0           6.7     4.4  460.7  301.6           8.6       5.3  503.0  312.2   1  2
                                       COLIN= 2.21E 09SCUL(MPN)= 1.94E 09CONC= 2.93E 04COLOUT= 2.88E 09CONC= 3.20E 04
 11:10 ARR  0.91  503.   312.   0.32E 05 OUT 0.81  335.   92.   0.81  335.    92.   0.81  335.  0.94E 04     0.81  335.    92.  0.94E 04
       OVF  0.0     0.     0.   0.0     REM  0.10 1856. 2095.   0.0     0.     0.    0.0     0.

   3  15.0   1.1   1.0       268.   0.14     7.6      5.3           7.0     4.9  421.7  290.8           7.3       4.8  374.2  247.0   2  3
                                       COLIN= 2.21E 09SCUL(MPN)= 2.04E 09CONC= 2.69E 04COLOUT= 2.12E 09CONC= 2.38E 04
 11:15 ARR  1.05  374.   247.   0.24E 05 OUT 0.95  248.   75.   0.95  248.    75.   0.95  248.  0.72E 04     0.95  248.    75.  0.72E 04
       OVF  0.0     0.     0.   0.0     REM  0.10 1557. 1870.   0.0     0.     0.    0.0     0.

   4  20.0   1.1   1.1       277.   0.14     7.6      5.2           7.1     4.9  413.1  282.0           7.6       5.2  376.1  258.5   3  4
                                       COLIN= 2.21E 09SCUL(MPN)= 2.06E 09CONC= 2.63E 04COLOUT= 2.19E 09CONC= 2.38E 04
 11:20 ARR  1.08  374.   258.   0.24E 05 OUT 0.98  248.   79.   0.98  248.    79.   0.98  248.  0.73E 04     0.98  248.    79.  0.73E 04
       OVF  0.0     0.     0.   0.0     REM  0.10 1602. 2013.   0.0     0.     0.    0.0     0.

   5  25.0   1.1   1.1       279.   0.14     7.6      5.0           7.1     4.7  409.6  267.8           7.6       5.2  373.8  254.1   4  5
                                       COLIN= 3.31E 09SCUL(MPN)= 3.00E 09CONC= 3.80E 04COLOUT= 2.37E 09CONC= 2.55E 04
 11:25 ARR  1.09  374.   254.   0.26E 05 OUT 0.99  248.   78.   0.99  248.    78.   0.99  248.  0.78E 04     0.99  248.    78.  0.78E 04
       OVF  0.0     0.     0.   0.0     REM  0.10 1614. 1995.   0.0     0.     0.    0.0     0.

   6  30.0   1.1   1.1       285.   0.15     7.5      4.8           7.0     4.4  393.6  250.0           7.7       5.0  369.5  240.2   5  6
                                       COLIN= 1.89E 10SCUL(MPN)= 1.63E 10CONC= 2.02E 05COLOUT= 5.55E 09CONC= 5.87E 04
 11:30 ARR  1.11  370.   240.   0.59E 05 OUT 1.01  245.   74.   1.01  245.    74.   1.01  245.  0.18E 05     1.01  245.    74.  0.18E 05
       OVF  0.0     0.     0.   0.0     REM  0.10 1623. 1919.   0.0     0.     0.    0.0     0.

   7  35.0   1.5   1.3       321.   0.16     7.7      4.8           6.6     4.2  330.9  209.3           8.0       5.1  341.7  216.1   6  7
                                       COLIN= 8.34E 10SCOL(MPN)= 7.16E 10CONC= 7.87E 05COLOUT= 2.81E 10CONC= 2.63E 05
 11:35 ARR  1.25  342.   216.   0.26E 06 OUT 1.15  226.   69.   1.15  226.    69.   1.15  226.  0.84E 05     1.15  226.    69.  0.83E 05
       OVF  0.0     0.     0.   0.0     REM  0.10 1665. 1915.   0.0     0.     0.    0.0     0.

   8  40.0   3.5   2.2       554.   0.28    11.4      7.6           7.3     5.0  212.0  145.4          10.7       6.8  263.9  167.3   7  8
                                       COLIN= 2.75E 11SCUL(MPN)= 2.16E 11CONC= 1.30E 06COLOUT= 1.30E 11CONC= 7.06E 05
 11:40 ARR  2.16  264.   167.   0.71E 06 OUT 2.06  180.   64.   2.06  180.    64.   2.06  180.  0.27E 06     2.06  180.    64.  0.27E 06
       OVF  0.0     0.     0.   0.0     REM  0.10 1991. 2294.   0.0     0.     0.    0.0     0.

   9  45.0   9.4   5.3      1367.   0.70    21.2     15.5          12.0     9.3  190.9  109.8          16.5      11.2  165.8  111.9   8  9
                                       COLIN= 5.79E 11SCUL(MPN)= 3.90E 11CONC= 1.01E 06COLOUT= 4.05E 11CONC= 8.93E 05
 11:45 ARR  5.34  166.   112.   0.89E 06 OUT 5.24  128.   64.   5.24  128.    64.   5.24  128.  0.51E 06     5.24  128.    64.  0.51E 06
       OVF  0.0     0.     0.   0.0     REM  0.10 2112. 2591.   0.0     0.     0.    0.0     0.

  10  50.0  13.4   9.8      2510.   1.29    24.5     18.9          15.0    12.4   96.0   79.5          21.5      15.8  117.4   86.2   9 10
                                       COLIN= 5.38E 11SCUL(MPN)= 3.56E 11CONC= 5.01E 05COLOUT= 5.72E 11CONC= 6.87E 05
 11:50 ARR  9.80  117.    86.   0.69E 06 OUT 9.70  102.   65.   9.70  102.    65.   9.70  102.  0.52E 06     9.70  102.    65.  0.52E 06
```

Table 7-8. EXAMPLE 1. OUTPUT OF SUMMARY OF TREATMENT EFFECTIVENESS

SUMMARY OF TREATMENT EFFECTIVENESS

TOTALS	FLOW (M.G.)	BOD (LB)	SS (LB)	COLIF (MPN)
INPUT	0.758	1003.8	620.2	1.39E 13
OVERFLOW (BYPASS)	0.0	0.0	0.0	0.0
TREATED	0.758	1003.8	620.2	1.39E 13
REMOVED	0.022	283.4	315.5	6.00E 12
RELEASED	0.736	720.4	304.6	7.87E 12

REMOVALS	FLOW(M.G.)	BOD (LB)	SS (LB)
LEVEL 1	0.0	0.0	0.0
LEVEL 3 (TOTAL)	0.022	283.4	315.5
LEVEL 4	0.0	0.0	0.0
LEVEL 5	0.0	0.0	0.0
LEVEL 7	0.0	0.0	0.0
TRASH:			
BAR RACKS	0.0	CU.FT (AT 50 LB/CU.FT.)	
EFFLUENT SCREENS	0.0	CU.FT (AT 50 LB/CU.FT.)	

= NO B.R. OR SW.C.
\# STORAGE
= BYPASS LEVEL 4
* NO EFFL. SCREENS
* NO CONTACT TANK

REMOVAL PERCENTAGES	FLOW (VOL)	BOD (LB)	SS (LB)	COLIF (MPN)
OF OVERALL INPUTS	2.96	28.23	50.88	43.28
OF TREATED FRACTIONS	2.96	28.23	50.88	43.28

CONSUMPTIONS (LB)	CHLORINE	POLYMERS
LEVEL 3	0.0	0.0
LEVEL 4	0.0	0.0
LEVEL 7	0.0	0.0
TOTAL	0.0	0.0

\# STORAGE
* BYPASS LEVEL 4
* NO CONTACT TANK

REPRESENTATIVE VARIATION OF TREATMENT PERFORMANCE WITH TIME (OVERALL).

TIME	11: 5	11:50	12:35	13:20	14: 5	14:50	15:35	16:20	17: 5	17:50	18:35
WATER											
AV. FLOW (CFS)	0.35	9.75	6.57	4.97	1.56	7.03	1.91	1.20	1.12	1.08	0.97
BOD											
ARRIVING (MG/L)	0.0	117.35	108.74	127.07	263.91	103.60	221.66	309.26	345.15	357.52	359.60
RELEASED (MG/L)	0.0	101.74	87.61	97.30	176.14	84.54	149.80	264.95	225.70	236.95	238.77
% REDUCTION (LB)	0.0	14.06	20.52	24.64	37.32	19.43	35.77	38.95	39.29	39.52	40.02
S. SOLIDS											
ARRIVING (MG/L)	0.0	86.22	70.76	78.76	158.43	56.51	129.03	185.20	208.37	216.31	217.82
RELEASED (MG/L)	0.0	64.74	44.97	44.01	54.23	37.01	47.47	56.67	64.96	66.72	65.68
% REDUCTION (LB)	0.0	25.56	37.31	45.16	67.85	35.33	65.03	70.81	71.44	71.85	72.76
COLIFORMS											
ARR (MPN/100ML)	0.0	6.87E 05	5.14E 05	6.90E 05	1.03E 06	3.72E 05	7.46E 05	4.70E 05	1.82E 05	1.04E 05	3.89E 04
REL (MPN/100ML)	0.0	5.16E 05	3.26E 05	3.65E 05	3.54E 05	2.44E 05	2.74E 05	1.49E 05	5.65E 04	3.22E 04	1.17E 04
% REDUCTION (LB)	0.0	25.76	37.49	45.31	67.94	35.50	65.13	70.89	71.52	71.93	72.84

Example 2. Treatment and Cost Only

This example receives most of its data from the Transport Block output file created for the North Drainage District of the City of Lancaster, Pennsylvania.

Description of the Input Data --

Table 7-9 shows the listing of the card data presented to the program for execution. Note that the high rate disinfection is specified, and cards relating to the storage unit have been deleted. Cards were inserted to describe the design parameters of the sedimentation unit. Cost cards are also included.

Description of Sample Output --

The output for Example 2 is shown in Tables 7-10 through 7-14, inclusive. Figure 7-4 illustrates the input flow, BOD and SS as well as the output flow, BOD and SS.

CALIBRATION OF STORAGE/TREATMENT BLOCK

Computer runs were made to test the sensitivity of the Storage/ Treatment Block to various input design parameters.

Table 7-15 shows the effect of varying the design overflow rate of the sedimentation unit on the treatment efficiency. Variation of the depth of the unit has no effect on the treatment efficiency. Table 7-16 shows the effect of varying the design overflow rate and the recirculation flow on the efficiency of dissolved air flotation unit. The depth variation has no effect on the efficiency of the unit. As shown in Table 7-15, variation in the recirculation flow also has no effect on the removal efficiency. Table 7-17 shows the effect of varying the maximum operating rate, maximum design head loss and the maximum solids holding capacity of the high rate filters. This table illustrates that variation in the design head loss has no effect on the efficiency of the high rate filters.

Table 7-9. EXAMPLE 2. CARD INPUT DATA LIST

```
                                Data                                                                  Card Group
                                                                                                        Number

STORACE                                                                                                    1
      1                                                                                                    2
      1       0.0       150.      1                                                                        3
   1  12   21  35   44   51   61  72                                                                       4
      2         0         0       0                                                                        5
15.47                                                                                                     18
1240.0   10.0                                                                                             21
  11  00                                                                                                  22
7.0            25       1974  1.1                                                                         23
    1314      1346      1378       1410       1442       1474      1506      1538
    1570      1602      1634
20000.0  0.02      0.20      1.25      0.03                                                               24
ENDPROGRAM
```

Table 7-10. EXAMPLE 2. CONTROL INFORMATION PASSED FROM TRANSPORT BLOCK

```
STORAGE  BLOCK CALLED

ENTRY MADE TO STORAGE/TREATMENT MODEL

STORAGE/TREATMENT MODEL UPDATED BY UNIVERSITY OF FLORIDA JAN. 1974

    LANCASTER  PENNSYLVANIA  NORTH  DRAINAGE  DISTRICT
OUTPUT FROM EXTERNAL STORAGE/TREATMENT MODELS

INPUT DATA-SET OUTFALLS AT THE FOLLOWING ELEMENT NUMBERS:
  1
INPUT TO STORAGE/TREATMENT MODEL SUPPLIED FROM EXTERNAL ELEMENT NUMBER   1

NUMBER OF RUNS          =        1
TIME-STEP SIZE          =     5.00 MIN.
NO. TIME-STEPS MODELED  =      100
TRIBUTARY AREA          =  1014.00 ACRES
NO. TRANSP. MOD. OUTFALLS =      1
NO. OF POLLUTANTS       =        3
TIME ZERO               =  40800.0 SEC

HIGH RATE DISINFECTION DEVICE FOR OVERFLOW USED.
DESIGN FLOW    150.00 CFS
```

Table 7-11. EXAMPLE 2. OUTPUT OF SUBROUTINE TRTDAT

```
******* RUN NO. 1 *******
INPUT DATA FOR TREATMENT PACKAGE FOLLOWS

              CHARACTISTICS OF THE TREATMENT PACKAGE ARE
                 LEVEL    MODE         PROCESS

                   0       01      NO SEP. STORAGE
                   1       12       BAR RACKS
                   2       21                          (BYPASS)
                   3       35      SEDIMENTATION
                   4       44     BIOLOGICAL TREAT
                   5       51                          (BYPASS)
                   6       61                          (BYPASS)
                   7       72       CONTACT TANK
**** WARNING ****
     THE FOLLOWING COMBINATIONS OF TREATMENT OPTIONS ARE CONSIDERED ECONOMICALLY INADVISEABLE - SIMULATION CONTINUES
     ITREAT    WITH    ITREAT
       72      WITH      35
                                                        IPRINT = 2,  ICOST = 1,  IRANGE = 0,  ITABLE = 0
     SPECIFIED TREATMENT CAPACITY USED.
             DESIGN FLOWRATE =      15.47 CFS.
             TREATMENT SYSTEM INCLUDES MODULE UNITS
                 DESIGN FLOW IS THEREFORE INCREASED TO NEXT LARGEST MODULE SIZE
                 ADJUSTED DESIGN FLOWRATE =     15.47 CFS., =      10.00 MGD.
                 (KMOD =  2)
             NO STORAGE FROM A SEPARATE STORAGE MODEL IS ASSOCIATED WITH THIS TREATMENT MODEL
             PRELIMINARY TREATMENT BY MECHANICALLY CLEANED BAR RACKS  (LEVEL 1)
                 NUMBER OF SCREENS     =      2
                 CAPACITY PER SCREEN   =      7.73 CFS
                 SUBMERGED AREA        =      2.58 SQ.FT. (PERPENDICULAR TO THE FLOW)
                 FACE AREA OF BARS     =      3.61 SQ.FT.
             INFLOW BY GRAVITY (NO PUMPING)  (LEVEL 2)
             TREATMENT BY SEDIMENTATION (LEVEL 3) - (NO ASSOCIATED STORAGE)
                 DESIGN OVERFLOW RATE =   1240.00 GPD/SQ.FT.  (1600 SUGGESTED)
                 SED TANK DEPTH       =     10.00 FEET      (8 FEET SUGGESTED)
                 NUMBER OF SED TANKS  =      1
                 SURFACE AREA         =   8064.51 SQ.FT./TANK
                 NO CHLORINE ADDED
             BIOLOGICAL TREATMENT  (LEVEL 4)
             NO EFFLUENT SCREENS  (LEVEL 5)
             OUTFLOW BY GRAVITY (NO PUMPING)  (LEVEL 6)
             TREATMENT BY CHLORINE CONTACT TANK (LEVEL 7)
                 NUMBER OF DOSING UNITS =     2
                 DOSING RATE PER UNIT   =   2000.00 LB/DAY
                 MAXIMUM DEMAND RATE    =   2086.17 LB/DAY
                 VOLUME OF CONTACT TANK =    13923. CU.FT. AT 15 MIN. DETENTION TIME
```

Table 7-12. EXAMPLE 2. OUTPUT OF PERFORMANCE PER TIME STEP

PERFORMANCE PER TIME STEP

NOTE: NO BOD OR SS ARE REMOVED IN LEVELS 2, 5, & 6, REGARDLESS OF THE OPTIONS SELECTED
NO SS REMOVALS IN LEVEL 7 (CHLORINE CONTACT TANK)
LEVEL 1 & 5 REMOVALS (AT BAR RACKS AND EFFLUENT SCREENS) ARE REPORTED IN SUMMARY ONLY

TIME		INFLOWS					SEDIMENTATION			BIOLOGICAL TREAT			CONTACT TANK			OUTFLOWS			
HR:MIN		WATER CFS	BOD MG/L	SS MG/L	COLIFORMS MPN/100ML		TOTAL CFS	BOD MG/L	SS MG/L	TOTAL CFS	BOD MG/L	SS MG/L	TOTAL CFS	BOD MG/L	COLIFORMS MPN/100ML	TOTAL CFS	BOD MG/L	SS MG/L	COLIFORMS MPN/100ML
11:25	ARR	11.62	921.	707.	0.41E 04	OUT	11.52	628.	292.	11.47	126.	59.	11.47	101.	0.34E 00	11.47	101.	59.	0.34E 00
	OVF	0.0	0.	0.	0.0	REM	0.10	34471.	47770.	0.05	5785.	2690.	0.0	0.					
11:30	ARR	11.62	920.	757.	0.41E 04	OUT	11.52	627.	296.	11.47	126.	60.	11.47	101.	0.34E 00	11.47	101.	60.	0.34E 00
	OVF	0.0	0.	0.	0.0	REM	0.10	34449.	48481.	0.05	5781.	2730.	0.0	0.					
11:35	ARR	11.62	920.	737.	0.41E 04	OUT	11.52	627.	304.	11.47	126.	61.	11.47	101.	0.34E 00	11.47	101.	61.	0.34E 00
	OVF	0.0	0.	0.	0.0	REM	0.10	34426.	49844.	0.06	5778.	2807.	0.0	0.					
11:40	ARR	11.62	919.	762.	0.41E 04	OUT	11.52	627.	315.	11.46	126.	63.	11.46	101.	0.34E 00	11.46	101.	63.	0.34E 00
	OVF	0.0	0.	0.	0.0	REM	0.10	33412.	50043.	0.06	5775.	2902.	0.0	0.					
11:45	ARR	11.64	918.	761.	0.55E 04	OUT	11.53	626.	323.	11.47	126.	65.	11.47	101.	0.46E 00	11.47	100.	65.	0.46E 00
	OVF	0.0	0.	0.	0.0	REM	0.11	32540.	50043.	0.06	5772.	2979.	0.0	0.					
11:50	ARR	11.85	902.	772.	0.12E 05	OUT	11.75	617.	322.	11.69	124.	65.	11.69	99.	0.10E 01	11.69	99.	65.	0.10E 01
	OVF	0.0	0.	0.	0.0	REM	0.11	32382.	50043.	0.06	5796.	3024.	0.0	0.					
11:55	ARR	13.31	829.	709.	0.27E 05	OUT	13.20	577.	308.	13.14	116.	62.	13.14	93.	0.24E 01	13.14	93.	62.	0.24E 01
	OVF	0.0	0.	0.	0.0	REM	0.10	32869.	50043.	0.06	6099.	3251.	0.0	0.					
12: 0	ARR	19.77	634.	564.	0.44E 05	OUT	15.37	453.	266.	15.30	91.	53.	15.30	73.	0.42E 01	19.60	191.	165.	0.19E 03
	OVF	4.30	615.	564.	0.97E 03	REM	0.10	28266.	45299.	0.07	5569.	3274.	0.0	0.					
12: 5	ARR	39.92	422.	506.	0.54E 05	OUT	15.37	301.	239.	15.31	60.	48.	15.31	48.	0.51E 01	39.76	265.	324.	0.13E 04
	OVF	24.45	402.	506.	0.21E 04	REM	0.10	15796.	40628.	0.06	3700.	2937.	0.0	0.					
12:10	ARR	65.58	294.	553.	0.59E 05	OUT	15.37	210.	261.	15.31	42.	52.	15.31	30.	0.56E 01	65.42	217.	435.	0.30E 04
	OVF	50.11	274.	553.	0.39E 04	REM	0.10	13106.	44426.	0.06	2580.	3211.	0.0	0.					
12:15	ARR	74.48	239.	612.	0.45E 05	OUT	15.37	170.	289.	15.30	34.	58.	15.30	22.	0.62E 01	74.31	178.	497.	0.38E 04
	OVF	59.11	218.	612.	0.08E 04	REM	0.10	10613.	49225.	0.07	2089.	3558.	0.0	0.					
12:20	ARR	68.42	219.	608.	0.74E 05	OUT	15.37	156.	287.	15.30	31.	58.	15.30	19.	0.70E 01	68.65	159.	485.	0.39E 04
	OVF	53.35	199.	608.	0.51E 04	REM	0.10	9751.	48865.	0.07	1920.	3537.	0.0	0.					
12:25	ARR	58.51	209.	557.	0.83E 05	OUT	15.37	149.	263.	15.30	30.	53.	15.30	18.	0.78E 01	58.65	144.	425.	0.36E 04
	OVF	43.34	189.	557.	0.49E 04	REM	0.10	9317.	44719.	0.06	1834.	3232.	0.0	0.					
12:30	ARR	51.12	209.	496.	0.90E 05	OUT	15.37	149.	234.	15.31	30.	47.	15.31	18.	0.85E 01	50.96	137.	360.	0.32E 04
	OVF	35.65	189.	496.	0.46E 04	REM	0.10	9305.	39778.	0.06	1832.	2875.	0.0	0.					
12:35	ARR	49.12	210.	424.	0.91E 05	OUT	15.37	150.	200.	15.32	30.	40.	15.32	18.	0.86E 01	48.97	136.	304.	0.31E 04
	OVF	33.65	191.	424.	0.45E 04	REM	0.10	9369.	33990.	0.05	1844.	2457.	0.0	0.					
12:40	ARR	53.98	207.	377.	0.95E 05	OUT	15.37	147.	177.	15.33	30.	36.	15.33	18.	0.80E 01	53.83	138.	280.	0.33E 04
	OVF	38.51	187.	377.	0.46E 04	REM	0.10	9206.	30175.	0.04	1812.	2181.	0.0	0.					
12:45	ARR	57.46	204.	364.	0.81E 05	OUT	15.37	145.	171.	15.33	29.	34.	15.33	17.	0.76E 01	57.32	139.	275.	0.34E 04
	OVF	41.99	184.	364.	0.47E 04	REM	0.10	9082.	29086.	0.04	1788.	2102.	0.0	0.					
12:50	ARR	53.75	213.	371.	0.95E 05	OUT	15.37	152.	174.	15.33	30.	35.	15.33	18.	0.83E 01	53.61	143.	278.	0.34E 04
	OVF	38.26	193.	371.	0.47E 04	REM	0.10	9480.	29621.	0.04	1566.	2141.	0.0	0.					
12:55	ARR	44.82	236.	381.	0.11E 06	OUT	15.37	168.	179.	15.33	34.	36.	15.33	22.	0.10E 02	44.67	149.	263.	0.31E 04
	OVF	29.35	216.	381.	0.48E 04	REM	0.10	10599.	30500.	0.04	2069.	2205.	0.0	0.					
13: 0	ARR	35.32	267.	386.	0.12E 06	OUT	15.37	191.	181.	15.32	38.	36.	15.32	26.	0.12E 02	35.18	151.	233.	0.25E 04
	OVF	19.85	248.	386.	0.44E 04	REM	0.10	11911.	30869.	0.04	2345.	2231.	0.0	0.					
13: 5	ARR	29.20	299.	379.	0.13E 06	OUT	15.37	213.	178.	15.33	43.	36.	15.33	31.	0.12E 02	29.06	148.	198.	0.18E 04
	OVF	13.73	279.	379.	0.59E 04	REM	0.10	13321.	30285.	0.04	2623.	2189.	0.0	0.					
13:10	ARR	27.99	321.	354.	0.13E 06	OUT	15.37	229.	168.	15.33	46.	34.	15.33	34.	0.13E 02	27.79	156.	179.	0.17E 04
	OVF	12.07	302.	354.	0.38E 04	REM	0.10	14313.	28609.	0.04	2818.	2068.	0.0	0.					
13:15	ARR	30.07	330.	335.	0.14E 06	OUT	15.37	236.	157.	15.33	47.	32.	15.33	35.	0.13E 02	29.93	169.	179.	0.20E 04
	OVF	14.60	311.	335.	0.01E 04	REM	0.10	14715.	26729.	0.04	2897.	1932.	0.0	0.					
13:20	ARR	32.09	331.	319.	0.13E 06	OUT	15.37	236.	150.	15.33	47.	30.	15.33	35.	0.12E 02	32.35	180.	182.	0.23E 04
	OVF	17.02	311.	319.	0.43E 04	REM	0.10	14741.	25457.	0.04	2902.	1840.	0.0	0.					
13:25	ARR	33.95	326.	310.	0.12E 06	OUT	15.37	233.	145.	15.33	47.	29.	15.33	35.	0.12E 02	33.82	183.	182.	0.23E 04

Table 7-13. EXAMPLE 2. OUTPUT OF SUMMARY OF TREATMENT EFFECTIVENESS

SUMMARY OF TREATMENT EFFECTIVENESS

TOTALS	FLOW (M.G.)	BOD (LB)	SS (LB)	COLIF (MPN)
INPUT	5.606	19474.1	20777.8	1.90E 13
OVERFLOW (BYPASS)	2.592	4710.8	8029.5	4.02E 11
TREATED	3.014	14337.5	12748.3	1.11E 13
REMOVED	0.033	12808.6	11644.2	1.86E 13
RELEASED	5.573	6239.6	9133.4	4.03E 11

REMOVALS	FLOW(M.G.)	BOD (LB)	SS (LB)	
LEVEL 1	0.000	6.8	135.6	= BAR RACKS
LEVEL 3 (TOTAL)	0.022	4474.7	7092.5	= SEDIMENTATION
LEVEL 4	0.011	7884.7	4416.2	= BIOLOGICAL TREAT
LEVEL 5	0.0	0.0	0.0	= NO EFFL. SCREENS
LEVEL 7	0.0	442.4	0.0	= CONTACT TANK

TRASH:

BAR RACKS	18.077	CU.FT (AT 50 LB/CU.FT.)
EFFLUENT SCREENS	0.0	CU.FT (AT 50 LB/CU.FT.)

REMOVAL PERCENTAGES	FLOW (VOL)	BOD (LB)	SS (LB)	COLIF (MPN)
OF OVERALL INPUTS	0.59	65.77	56.04	97.88
OF TREATED FRACTIONS	1.10	89.34	91.34	167.18

CONSUMPTIONS (LB)	CHLORINE	POLYMERS	
LEVEL 3	0.0	0.0	= SEDIMENTATION
LEVEL 4	0.0	0.0	= BIOLOGICAL TREAT
LEVEL 7	219.6	0.0	= CONTACT TANK
TOTAL	435.9	0.0	

REPRESENTATIVE VARIATION OF TREATMENT PERFORMANCE WITH TIME (OVERALL).

TIME	11:25	12:10	12:55	13:40	14:25	15:10	15:55	16:40	17:25	18:10	18:55
WATER											
AV. FLOW (CFS)	11.55	65.50	44.75	34.36	14.05	46.00	16.01	11.72	11.59	11.56	10.55
BOD											
ARRIVING (MG/L)	920.78	294.06	235.85	307.76	676.84	188.87	556.32	812.02	878.12	900.52	899.09
RELEASED (MG/L)	100.72	216.93	149.22	173.33	76.31	117.45	81.82	88.96	96.08	98.52	97.02
% REDUCTION (LB)	89.19	26.30	36.84	43.82	88.83	37.90	85.41	89.17	89.18	89.19	89.34
S. SOLIDS											
ARRIVING (MG/L)	707.02	553.14	381.45	299.55	525.71	268.27	436.51	623.23	673.67	690.88	689.88
RELEASED (MG/L)	58.66	435.36	262.56	177.92	47.69	186.81	56.43	51.97	55.94	57.34	54.86
% REDUCTION (LB)	91.80	21.37	31.29	40.75	91.01	30.46	87.17	91.75	91.79	91.80	92.15
COLIFORMS:											
ARR (MPN/100ML)	4.08E 03	5.89E 04	1.06E 05	1.19E 05	2.03E 05	6.89E 04	1.60E 05	1.58E 05	9.59E 04	6.03E 04	3.61E 04
REL (MPN/100ML)	3.38E-01	2.96E 03	3.13E 03	2.26E 03	1.84E 01	2.12E 03	1.13E 02	1.31E 01	7.96E 00	5.00E 00	2.87E 00
% REDUCTION (LB)	99.99	94.99	97.06	98.10	99.99	96.94	99.93	99.99	99.99	99.99	99.99

Table 7-14. EXAMPLE 2. OUTPUT OF SUMMARY OF TREATMENT COSTS

```
SUMMARY OF TREATMENT COSTS

        ASSUMED FUTURE ENGINEERING NEWS RECORD INDICES
        CONSTRUCTION  =  20 CITY AVERAGE

              YEAR      ENR INDEX

              1970        1314
              1971        1346
              1972        1378
              1973        1410
              1974        1442
              1975        1474
              1976        1506
              1977        1538
              1978        1570
              1979        1602
              1980        1634

        COST PARAMETERS . .
             INTEREST RATE            =      7.00 PERCENT
             AMORTIZATION PERIOD      =        25 YEARS
             CAP. RECOVERY FACTOR     =    0.0858
             YEAR OF SIMULATION       =      1974
             SITE LOCATION FACTOR     =    1.1000

        UNIT COSTS . .
             LAND      =  20000.00  $/ACRE
             POWER     =      0.020 $/KWH
             CHLORINE  =      0.200 $/LB
             POLYMERS  =      1.250 $/LB
             ALUM      =      0.03  $/LB
```

TREATMENT	LEVEL	CAPITAL COSTS INSTAL	CAPITAL COSTS LAND	ANNUAL COSTS INSTAL	ANNUAL COSTS LAND	ANNUAL COSTS MIN MAINT	STORM EVENT COSTS CHLORINE	STORM EVENT COSTS CHEM	STORM EVENT COSTS OTHER
BAR RACKS	1	99586.	1384.	8546.	97.	996.	0.	0.	27.
NO INLET PUMPING	2	0.	0.	0.	0.	0.	0.	0.	0.
SEDIMENTATION	3	329497.	9752.	28274.	683.	3295.	0.	0.	27.
BIOLOGICAL TREAT	4	623109.	0.	0.	0.	0.	0.	0.	0.
NO EFFL. SCREENS	5	0.	0.	0.	0.	0.	0.	0.	0.
NO OUTLET PUMPS	6	0.	0.	0.	0.	0.	0.	0.	0.
HIGH RATE DISINF	7	234247.	807.	10606.	56.	2472.	44.	0.	15.
LEVEL 7 INCLUDES HIGHRATE DISINFECTION FOR OVERFLOW									
	SUBTOTAL	$ 1286478.	$ 11943.	$ 47426.	$ 836.	$ 6763.	$ 44.	$ 0.	$ 69.
	TOTAL	$ 1298420.		$ 55024.			$ 113.		
	TOTAL PER TRIB ACRE	$ 1280.		$ 54.			$ 0.		

TOTAL LAND REQUIREMENT = 0.54 ACRES.

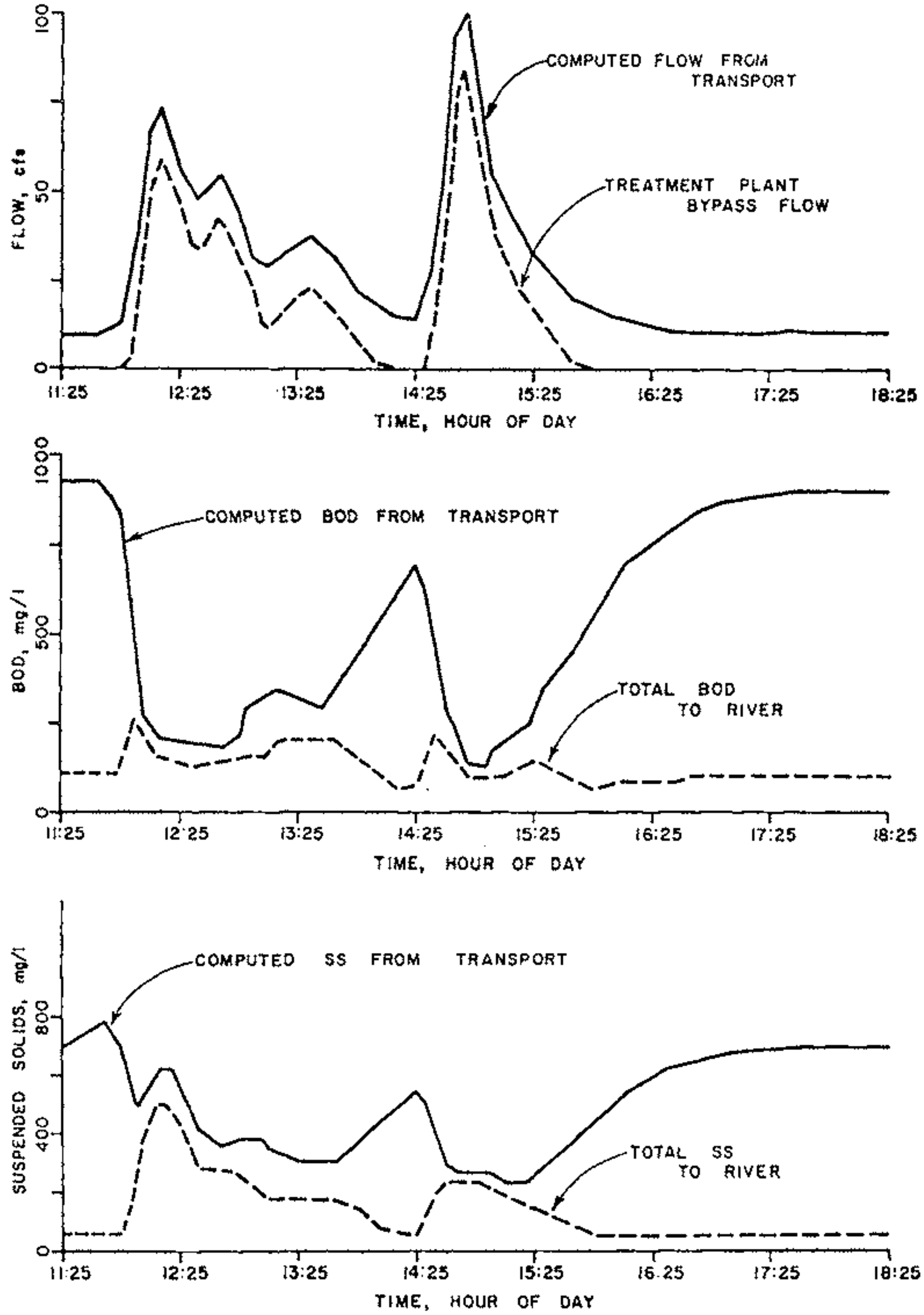


Figure 7-4. Example 2. Input and Output Quantity and Quality

Table 7-15. SENSITIVITY OF SEDIMENTATION UNIT

	Run I	Run II	Run III
Input parameters			
Design overflow rate - gpd/sft	400.0	1000.0	2000.0
Depth of unit - ft	10.0	10.0	10.0
Output			
BOD removal - percent	43.2	40.5	36.7
SS removal - percent	78.5	73.6	66.7

Table 7-16. SENSITIVITY OF DISSOLVED AIR FLOTATION UNIT

	Run I	Run II	Run III	Run IV	Run V
Input parameters					
Design overflow rate - gpd/sft	1000.0	5000.0	10,000.0	5,000.0	5000.0
Recirculation flow - percent	15.0	15.0	15.0	15.0	100.0
Unit of Depth - ft	8.0	8.0	8.0	8.0	8.0
Output removal efficiency					
BOD removal - percent	71.23	66.66	59.31	66.66	66.66
SS removal - percent	69.57	66.96	61.04	66.96	66.96

Table 7-17. SENSITIVITY OF HIGH RATE FILTERATION

	Run I	Run II	Run III	Run IV	Run V
Input parameters					
Maximum operating rate - gpm/sft	5.0	20.0	50.0	20.0	20.0
Maximum design head loss - ft	10.0	10.0	10.0	10.0	1.0
Maximum solids handling capacity - lbs/sft	1.0	1.0	1.0	3.0	1.0
Output removal efficiency					
BOD removal - percent	76.3	79.9	79.9	77.4	79.9
SS removal - percent	58.4	61.4	60.6	59.0	61.4

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SECTION 8

RECEIVING WATER BLOCK

BLOCK DESCRIPTION

Introduction

The Receiving Water Model simulates the behavior of estuaries, reservoirs, lakes, and rivers. The program has two distinct phases which may be simulated together or separately. In Phase A, the time history of stage, velocity, and flow is generated for various points in the system. In Phase B, the hydrodynamics are utilized to model the behavior of conservative and nonconservative quality constituents.

The receiving water is simulated by cutting the continuous system into a series of discrete one- and two-dimensional elements which connect node points. For the purpose of this analysis, the velocity of flow is assumed constant with depth, one-dimensional elements represent rivers and specific channels, and two-dimensional elements represent areas of continuous water surface. For each time-step, the equations of motion and continuity are applied to all nodal points to derive the hydrodynamics for the system. The hydrodynamics are used with equations for conservation of mass to determine the concentration of quality constituents.

Subroutine RECEIV, which is called by the Executive Block Program, drives the quantity (Phase A) and quality (Phase B) sections of the model which act independently, linked only by data transmitted through a peripheral file. Figure 8-1 shows the linkages among subprograms which make up the Receiving Water Block.

Program Operation

There are three primary subroutines in the Receiving Water Block: subroutine RECEIV, which provides liaison with the Executive Block of the Storm Water Management Program; subroutine SWFLOW, which

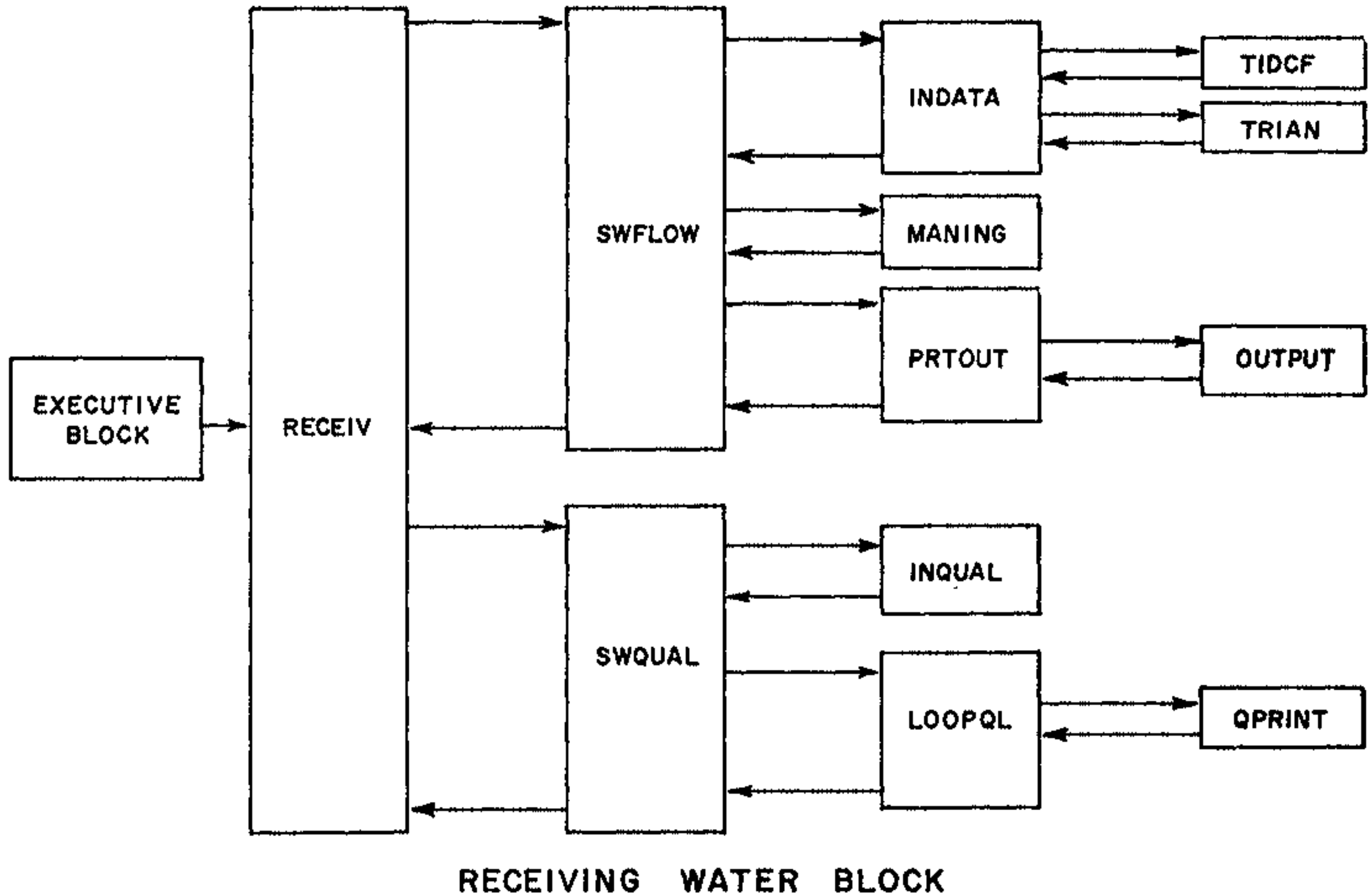

Figure 8-1. Programs of the Receiving Water Block

coordinates the hydraulic computations; and subroutine SWQUAL, which coordinates the quality computations.

Subroutine RECEIV reads information to decide if quantity and/or quality are to be simulated and calls SWFLOW and SWQUAL as may be appropriate. The output files generated by either the Transport Block or the Storage Block, as selected by the user when declaring I/O tape/disk identifiers, are used in the computations.

The quantity model consists of seven subroutines: SWFLOW, INDATA, TIDCF, MANING, TRIAN, PRTOUT, and OUTPUT.

Subroutine SWFLOW is the driving quantity routine and operates in four steps:

1) Calls INDATA for input.

2) Carries out hydraulic computations, including calculation of possible variable Manning's n values in MANING.

3) Calls PRTOUT for output of results.

4) Saves all geometric and flow information on a peripheral file.

Upon its completion, the program returns with a set of hydrodynamic information required for later calculation of water quality.

Subroutine INDATA reads all the input data for receiving water quality computations. If necessary, it calls TIDCF to generate tidal stage coefficients and TRIAN to calculate necessary geometric data for the system. Subroutine TIDCF uses a least square procedure to calculate the coefficients of the tidal function H(T) = A1 + A2 SIN(T) + A3 SIN(2T) + A4 SIN(3T) + A5 COS(T) + A6 COS(2T) + A7 COS(3T) from input values of H and T. Subroutine TRIAN reduces triangular areas to three one-dimensional channel systems with appropriate values for length and width. Subroutine PRTOUT prints the stored information concerning stage, velocity, and flow and then calls subroutine OUTPUT. Subroutine OUTPUT calls the execution plot routines to draw graphs of the time history of stage.

The quality section consists of four subroutines: SWQUAL, INQUAL, LOOPQL and QPRINT. Subroutine SWQUAL is the driving quality routine which operates in three stages:

1) Calls INQUAL to read input data.

2) Calls LOOPQL for each day of simulation.

3) Prints daily average, maximum, and minimum concentrations of water quality constituents.

Mass lost to the system through outflows is a normal part of the computations. A special case is the mass lost through tidal exchange. This calculation is performed at the completion of each day's cycle, and is based on the volume difference between flood and ebb tides.

Subroutine INQUAL reads control information from cards and geometric data that was previously used in the quantity modeling.

The three types and sources of basic information to this subroutine are:

1) The basic hydrodynamics from SWFLOW.

2) Time-quality information from models preceding SWFLOW and transferred through it.

3) Initial quality constituent concentrations and controlling parameters.

Subroutine LOOPQL reads one quality cycle of hydraulic information right after its entry. It then reads a new set of values from the appropriate pollutographs or interpolates as necessary. If inputs occur from both tape/disks and cards for the same junction, the card inputs override the tape/disk inputs. Boundary conditions are computed for conservative and nonconservative quality constituents.

Advective flow concentration changes are computed next, and all nodal quality constituent concentrations are updated, with checks for depletion. The program next computes nodal quality constituent concentration changes due to mass input. Finally, for nonconservative constituents, the effects of reaeration and decay are computed. If desired, reaeration coefficients and/or oxygen saturation values will be calculated by the program at each time step for each junction.

The average, maximum, and minimum concentrations are stored for later printout by SWQUAL. This program also allows the calling of

QPRINT, to print all concentrations for this quality cycle. Return is made to SWQUAL. Subroutine QPRINT prints the instantaneous concentration levels for the system.

INSTRUCTIONS FOR DATA PREPARATION

Introduction

Use of the Receiving Water Model involves three basic steps:

Step 1 - Idealization of the physical system

Step 2 - Quantity decisions

Step 3 - Quality decisions.

These steps are discussed below. The representation of the data for program input is shown schematically in Figure 8-2. Data card preparation and sequencing instructions for the complete Receiving Water Block are given at the end of these instructions in Table 8-1 followed by an alphabetical listing of the variable names and descriptions in Table 8-2.

The program uses up to four scratch files:

Scratch File 1	is used to transmit hydrodynamics from quantity to quality model
Scratch File 2	is used as a scratch file by the quantity and quality model separately
Scratch File 3	is an input restart file for the quality model (see below)
Scratch File 4	is the output restart file for the quality model.

Scratch files 1 and 2 must be defined. However, if the restart facilities of the quality model are not used, 3 and 4 need not be defined.

The restart option allows quality calculations to continue from the point at which the program stopped on a prior run. For

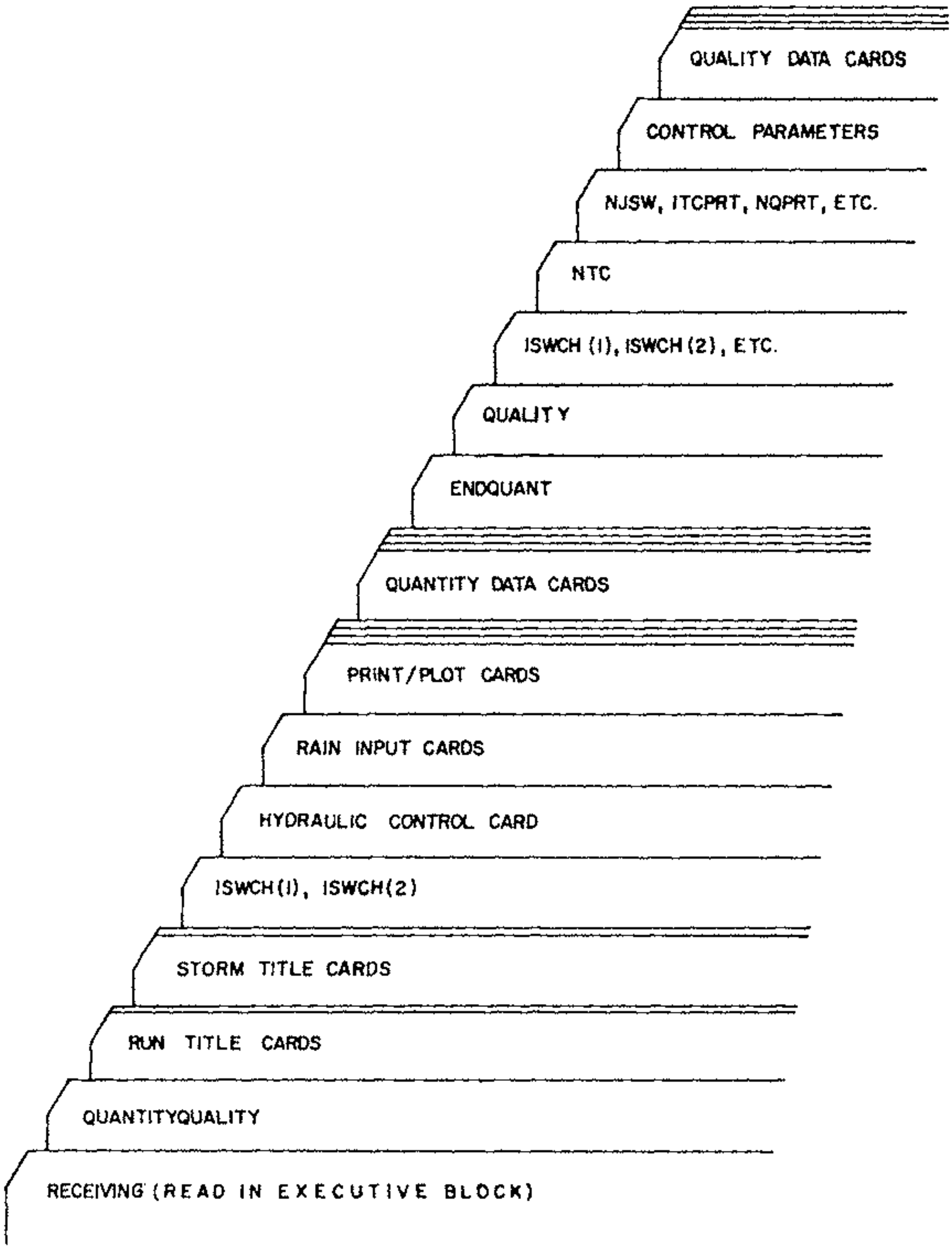

Figure 8-2. Data Deck for Receiving Water Block

example, the quality model may be run and a restart tape written on the data set corresponding to scratch file 4. On a subsequent entry to the quality model the same data set is specified as scratch file 3 (see Section 2, Initial Job Set-Up, for a description of data set assignments), ISWCH(1) = 1 and all input data and concentrations, etc., will be assigned the values they had at the end of the prior run. Thus, a much longer quality simulation can be accomplished in this manner. Note that the number of daily cycles, NTC, must be read as the total number of cycles desired, including the prior run, although all other time parameters (e.g., input times of pollutograph ordinates) are treated as if the restart run begins at time TZERO.

Step 1. Idealization of the Physical System

The first step in use of the Receiving Water Model is idealization of the physical system into one- (channel) and two-dimensional (area) discrete elements of an appropriate size to describe the system in the detail required. This areal schematization of the receiving waters is accomplished through a combination of user-supplied data and calculations within the program. The area may be subdivided into one-dimensional channels, two-dimensional triangular area elements, or two-dimensional quadrilateral area elements. Any combination of these spatial subdivisions may be used as illustrated in Figure 8-3. The program usually relies on user input for geometrical data, e.g., junction areas and depths, channel lengths, widths, depths and roughnesses. These data are generated from accurate maps of the area, typically those of the US Geological Survey or US Coast and Geodetic Survey. However, for triangular area elements, at the user's option, the program will generate appropriate junction areas and channel lengths and widths in subroutine TRIAN.

Areas are assigned to each of the three junctions of the triangle on the basis of the Thiessen polygon method in which the perpendicular bisectors of the three sides form the areal boundaries. See Figure 8-4. The three perpendicular bisectors of a triangle join at the circumcenter (point A). The perpendicular distance from the circumcenter to a side (channel) is assigned to be the width of that channel. For instance, channel 13-15 in Figure 8-4 will be assigned width A-B. In order for each channel to have a width, the circumcenter must lie inside the triangle; hence, the triangle must be acute. (Note that for a right triangle, TRIAN will assign zero width to the hypotenuse.)

TRIAN only computes areas internal to the triangle. Thus, area A-B-13-G-A is assigned to junction 13 by the program. If the

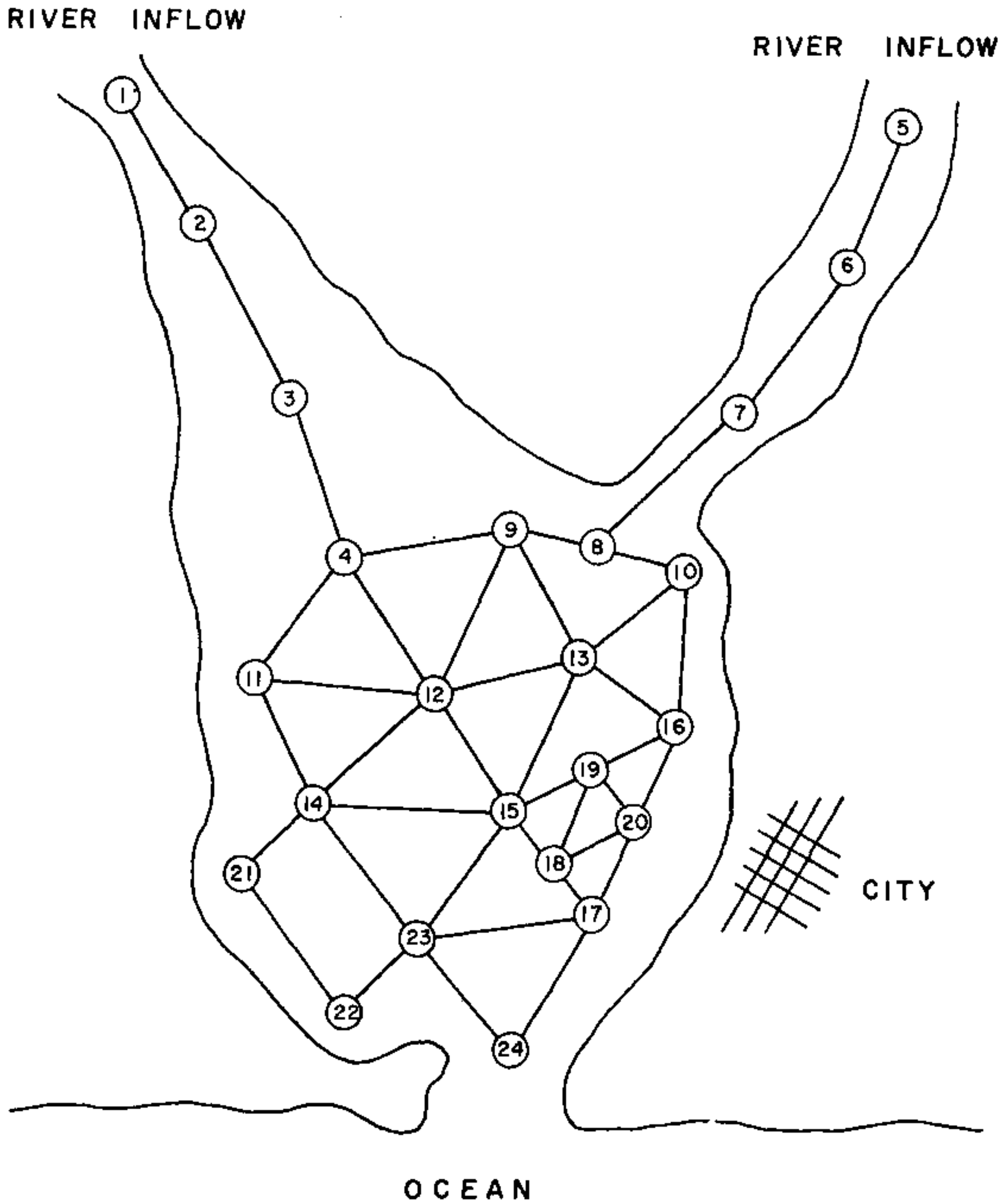

Figure 8-3. Hypothetical Receiving Water Illustrating Various Forms of Schematization: One-Dimensional Channels, Two-Dimensional Triangular Elements, and Quadrilaterals or Higher Order Polygons Constructed of One-Dimensional Channels. At the User's Option, the Program (Subroutine TRIAN) will Compute Geometrical Data (Areas, Lengths, Widths) for the Interior of Triangles.

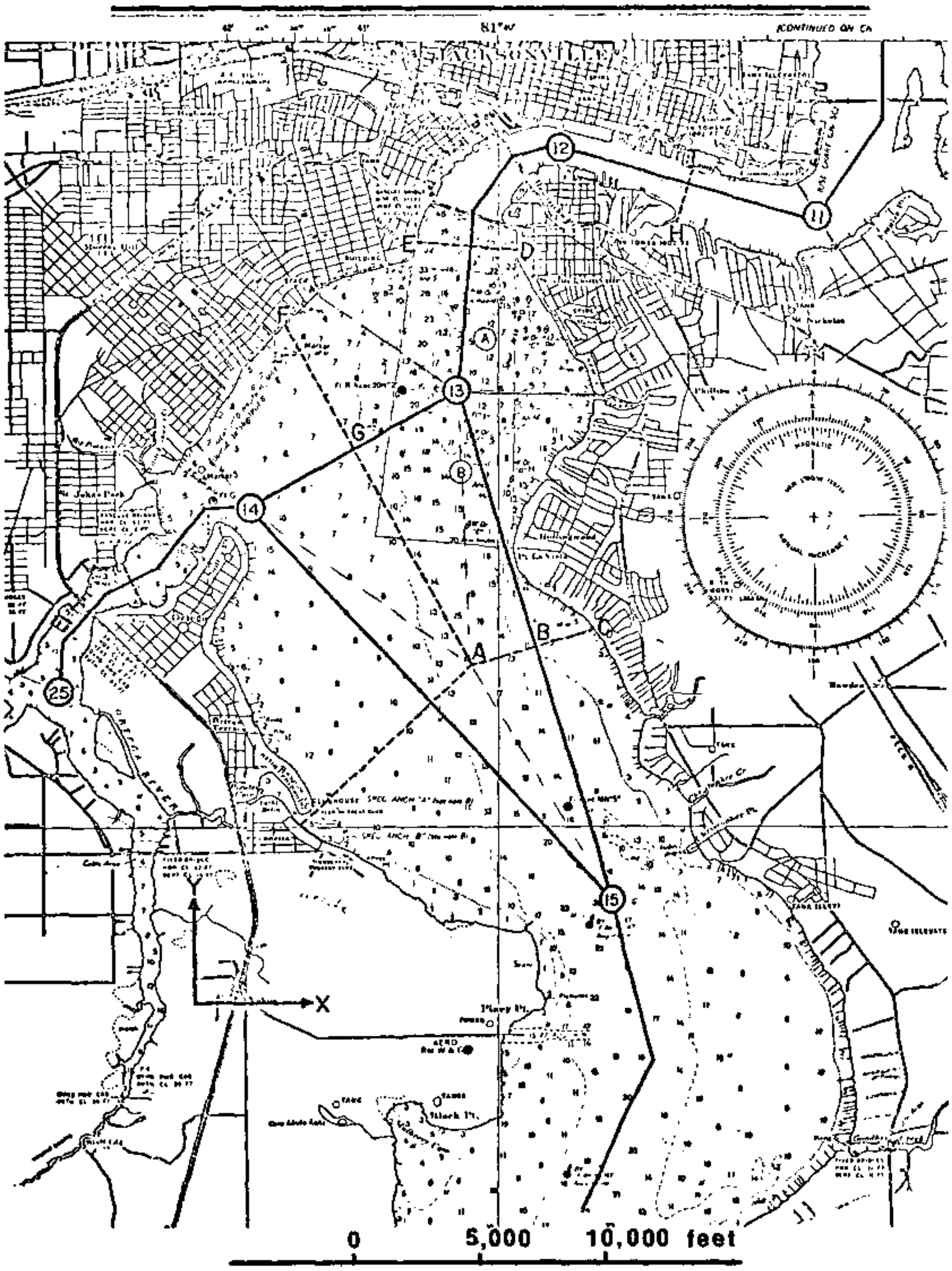

Figure 8-4. Schematization of Portion of St. Johns River at Jacksonville, Florida. Base Map is U.S.C. and G.S. No. 685.

triangle is adjacent to a boundary, as in Figure 8-4, the additional area is accounted for by assigning it to junction 13 on card group 15. (This is in spite of the admonition to leave parameter SURF blank if TRIAN is to be used.) The area 13-B-C-D-E-F-G-13 will then be added to the area A-B-13-G-A computed by TRIAN for junction 13.

An alternative to adding additional junction area to that calculated by TRIAN is to input the total junction area, for example, area A-C-D-E-F-A for junction 13. In this case, ISWCH(6) = 1 and all areas calculated in TRIAN are ignored. In order to account for the area between the channel and the boundary, a separate channel card for channel 13-15 should be read in using length B-C as the width. This width will then be added to the width computed in TRIAN, length A-B. This additional channel card should be read in prior to the triangle card that contains this same channel. If read in after the triangle card (and hence, the geometrical calculations) the width on the channel card will supersede that calculated in TRIAN.

If TRIAN is used to compute geometrical parameters, the x and y coordinates of each triangle junction are required. Otherwise, they are not needed, unless there is a wind (WIND $\neq$ 0), in which case they are needed for wind stress calculations.

If a situation is to be modeled in which real channels (e.g., canals) are present in a low lying marsh or flood plain, use of the "parallel channel" option (ISWCH(5)) may be useful. In this case, a first channel between two junctions models the flood plain or marsh characteristics, typically high roughness, shallow depths, and large widths. A second channel (numbered higher than parameter NCGT) is then used to model the characteristics of the real canal between the two junctions, typically low roughness, larger depths and narrow width. The program routes water through both channels or only the latter depending upon the water surface elevation.

The decision on detail must be based upon the size limitation of the program and the desired time interval of integration. The time interval for quantity integration, DELT, is restricted by wave celerity considerations (the Courant condition). For the numerical scheme to remain stable, there must be for all channels

$$\text{DELT} \leq \frac{0.75\ L}{\sqrt{gd}} \tag{8-1}$$

where L = length, feet

g = gravity = 32.2 feet/second^2

d = expected maximum channel depth, feet

DELT = quantity time step, seconds

The quantity 0.75 is a "safety factor." DELT will usually lie between 30 and 300 seconds. When channel data are printed out, the last column notes if Equation 8-1 is likely to be violated.

Step 2. *Quantity Decisions*

To prepare a run, the parameters described in the data input instructions, Table 8-1, are required. The following discussion expands upon descriptions provided in that table. The preceeding discussion has already covered some points.

Card 4. Control Switches -- Three downstream boundary conditions are available: weir or dam, tidal or specified outflow. Specified outflows are not calculated by the program but must be provided by the user, either in card group 26 or 28. Multiple boundary-condition junctions are also allowed.

Spatial variations in rainfall may be important when modeling a flood plain or marsh. This is allowed if ISWCH(3) = 1, and the relevant parameters are read in using card groups 22 to 26.

When triangular area elements are used, channel roughnesses will be given a value equal to the average of the two end junctions. If this is not desired, set ISWCH(4) = 1 and read in the desired roughnesses on card group 17.

If ISWCH(6) = 0, any areas entered for a particular junction on card group 15 will be added to areas subsequently calculated for that junction in subroutine TRIAN.

If ISWCH(6) = 1, the area entered for a junction on card group 14 will be the total area for that junction, and subsequent areas calculated in TRIAN will be ignored.

When flood plains or marshes are modeled, the variation in roughness with flow depth may be important. For instance, at very low depths, Manning's n may become very large. Such a variation may be input on card 14 if ISWCH(7) = 1.

Card 5. Hydraulic Control Card -- Control decisions are required on:

a. Number of daily cycles.

b. Number of hours in a daily cycle, typically 24 or 25, the latter for the case of a tidal boundary condition subject to a semi-diurnal tide. Note that this is also the period (PERIOD) used in calculating the tidal head function in subroutine TIDCF.

c. Number of hours in a quality cycle. Flows, stages and volumes will be averaged over this time interval for input to the quality model. Quantity output occurs after each quality cycle and quality output can occur no more frequently than this time. If quality calculations are not being performed, QINT may be adjusted to suit the overall simulation period and desired printing frequency. For example, if the hydraulic time step, DELT, is not too small, a simulation for a month of real time could use NTC = 1, PERIOD = 30 x 24 = 720 hours and QINT = 24 hours.

d. Length of hydraulic (fundamental) time step. This should be as large as possible, but will usually be limited by Equation 8-1 to DELT $\leq$ 300 seconds.

e. Clock time of start of simulation. All subsequent time inputs (e.g., card groups 6, 24, 28, 39) are clock times and should be greater than or equal to TZERO.

f. Number of junctions and channels for which output is to be printed and plotted.

g. Evaporation, taken as uniform and constant over the area.

h. Wind speed and direction, taken as uniform and constant over the area.

i. Day cycle at which printed output will start. If NWSWRT = 1, printed output will include the first "warm-up" cycle during which card or tape inputs (storm inputs) do not occur.

j. Number of junctions with stormwater input from cards.

k. Number of rainfall input times, if needed.

l. Downstream junction number. This junction will be subject to the tidal or weir boundary condition. If ISWCH(1)=3, this parameter is, instead, the total number of boundary-condition (downstream) junctions, and actual junction numbers are read in card group 10.

m. Channel number delineating higher numbered channels that are parallel to lower numbered channels.

Card Group 6. Rain Input -- If rainfall is spatially constant, it is input here. Unless the receiving waters are especially shallow or have low flows (e.g., a marsh, flood plain or very small stream) rainfall is likely to have little effect on the simulation.

Card Group 10. Multiple Boundary Junctions -- The junction number and type of boundary condition (e.g. tidal, weir) is given for each boundary-condition junction. Any mixture of types may be used. This option is used, for example, to simulate a bay with multiple outlets to the ocean.

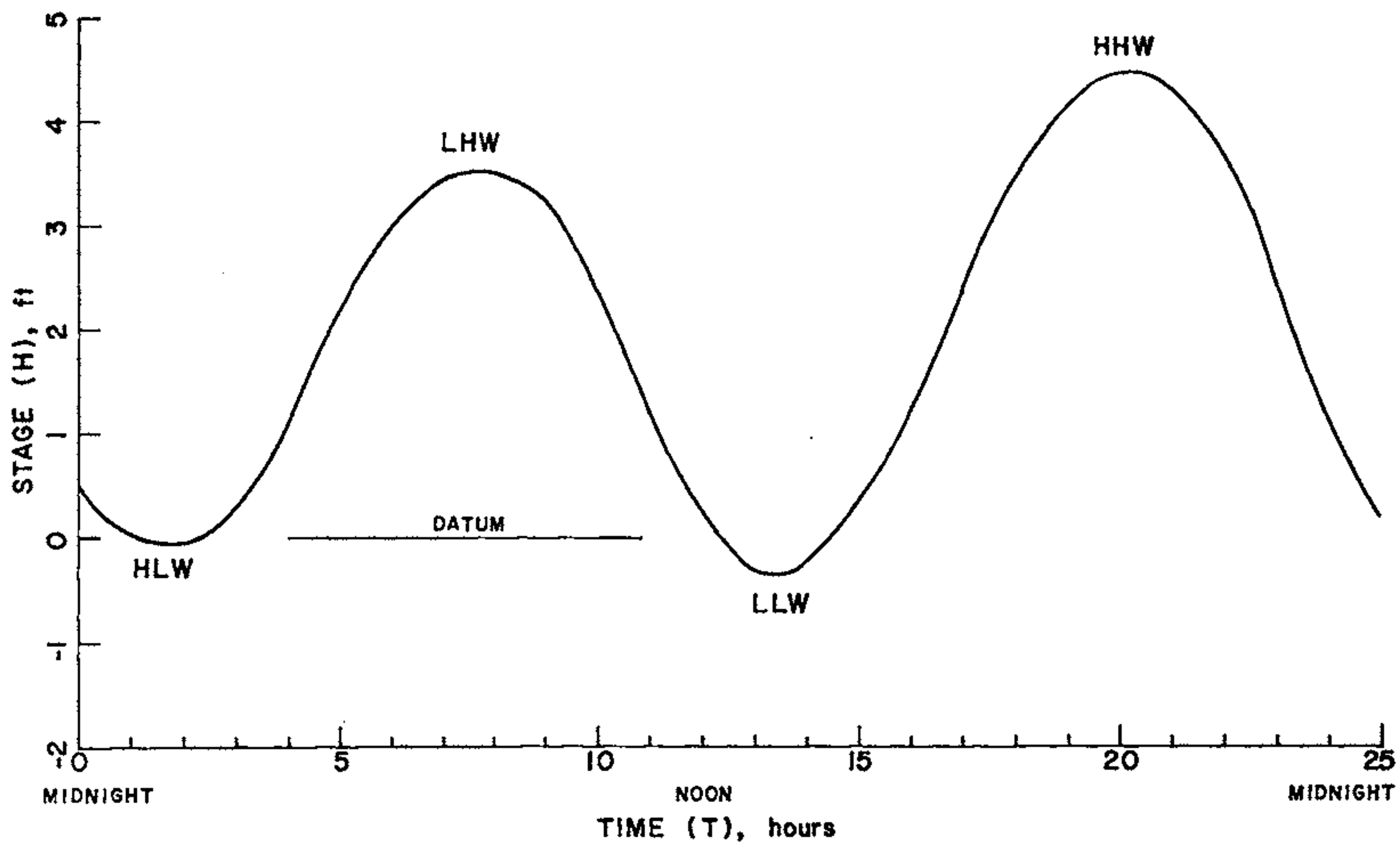

Figure 8-5. Semi-Diurnal Tide at Mouth of St. Johns River at Mayport, Florida August 1, 1970. Datum is Mean Low Water.

Card Groups 11, 12. Tidal Information -- The input values are assembled from a typical tidal record, such as that shown in Figure 8-5. The period (PERIOD) should correspond as nearly as possible to the length of a day since it is used as such in the program. Thus, a period of 25 hours is frequently used for a semi-diurnal tide. A user option allows development of the tidal function H(T) from only four tidal stages, low low water (LLW) high high water (HHW), high low water (HLW), and low high water (LHW). If used, these should be input in their appropriate time sequence, as illustrated in Figure 8-5. The computed tidal function, H(T), generally gives a very accurate fit to the data, and is repeated for all days of the simulation.

Card 13. Weir Data -- A downstream stage-discharge relationship will be utilized where Q = WEIR1*(H-WEIR2)**WEIR3.

Card 14. Variable Manning's Roughness -- These data must be developed from measurements or hydraulic calculations. As an example, Figure 8-6 illustrates values found by the Corps of Engineers (2) for sawgrass in Conservation Area 2 of the Florida Everglades.

Card Groups 15, 16. Junction Data -- These have been discussed in the section on Idealization of the Physical System. Accurate initial values of the water surface elevation will establish initial conditions (prior to the storm) much faster, especially where an estuary is being modeled. Areas and depths are commonly taken from US Geological Survey or US Coast and Geodetic Survey maps. Areas must be planimetered unless TRIAN is used. Depths should represent an average over the junction area.

Card Groups 17, 18. Channel Data -- Comments in the above paragraph apply regarding previous discussion, initial conditions, and data sources. If NTEMP(4) $\neq$ 0, it refers to a fourth junction lying midway between two previous junctions NTEMP(1) and NTEMP(3) This may be used conveniently to reduce the scale of the triangles and provide more definition of a selected area (e.g., near a city) as sketched in Figure 8-3. As an example from that figure, element 16-13-15 would list NTEMP(4) = 19. NTEMP(2) must equal 13. The small triangles near the city are read in on four separate cards. Channel widths are usually averages (e.g. area/length).

Card Group 22. Stormwater Input Junctions -- The junctions listed will receive inflows from cards. If ISWCH(3) = 1 and variable rainfall is input in card groups 23 to 27, all junctions that receive rainfall and/or inflows must be listed in this card group.

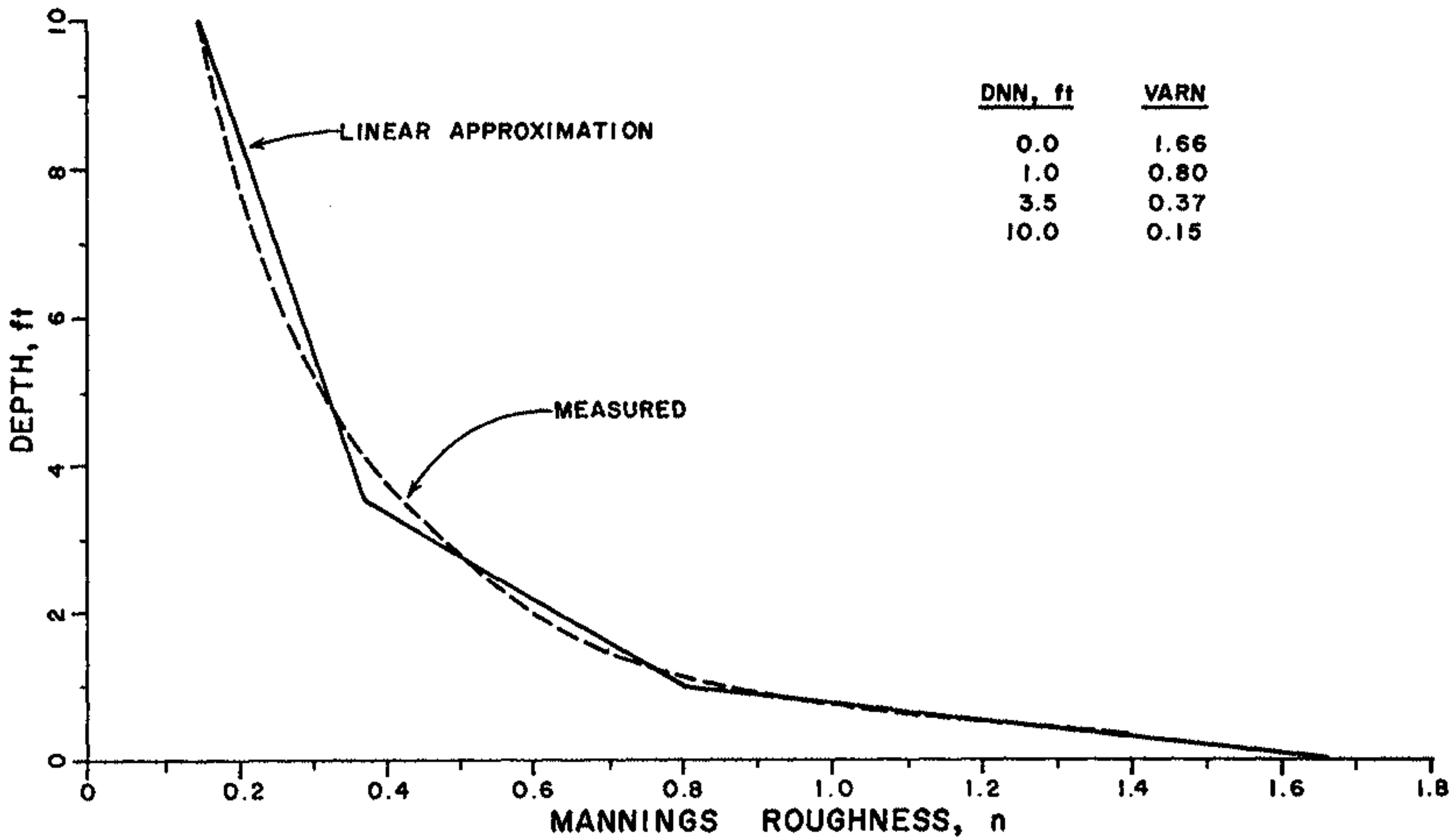

Figure 8-6. Variation of Manning's Roughness with Depth of Flow Over Sawgrass in the Florida Everglades. Data are from the Corps of Engineers (2).

Card Groups 23 to 27. Input Flows with Variable Rainfall -- For this case, rainfall volumes at each stormwater input junction are computed first and added to external inflows that may occur. Input times (card group 24) need not be evenly spaced, but the spacing must be equal to or greater than the quantity time step, DELT. Rainfall from NGAGE rain gages is distributed over NJSW "stormwater input" junctions. For each junction, the fraction of rainfall assigned to it from each rain gage must be determined and entered on card group 25. This is done by overlaying the Thiessen network formed by the rain gages onto the Thiessen network of the junction areas. The fraction of junction area occupied by the Thiessen polygon of a given rain gage is then the fraction assigned to that gage on card group 25 for that junction. Note that the fractions (weights) entered for a given junction should sum to one.

When this option is used, all inflows to the system will be entered on card group 26 followed by all rainfalls on card group 27. Variable outflows at a junction may be included as negative inflows. (Outflows and inflows that are constant with time should have been included in card group 15.) If inflows occur from both tape/disk and cards for a given junction, the card input will supersede the tape input.

Card Group 28. Input Flows with Constant Rainfall -- Inflow hydrograph ordinates are entered for each of the NJSW junctions at the indicated time. Input times need not be evenly spaced, but the spacing must be equal to or greater than the quantity time step, DELT. Variable outflows at a junction may be included as negative inflows. (Outflows and inflows that are constant with time should have been included in card group 15.) If inflows occur from both tape/disk and cards for a given junction, the card input will supersede the tape/disk input.

Of course, inflows are not limited to stormwater sources. Variable river inflow into the upstream end of a receiving water would commonly be entered on these cards.

Step 3. Quality Decisions

The quality model may be run separately from the quantity model, provided the latter has been run at least once to provide the required hydrodynamic information. (This information is stored on the data set assigned to scratch file 1.) If quality is to be run alone, only QUALITY would have been entered on card 1.

Card 31. Control Switches -- These are reset upon entry to the quality model. For switches ISWCH(1) and ISWCH(3), refer to the previous discussion of the restart option.

Occasionally, it is useful to input variable pollutant loadings on the "warm-up" day of the simulation. This is allowed if ISWCH(6) = 1, otherwise input of card group 39 will not occur until the second day of the simulation.

In estuaries, a considerable spatial variation in oxygen saturation concentrations may exist because of salinity differences, as indicated by chloride concentrations. This variation may be approximated by entering different constant (with time) values at each junction (by setting ISWCH(7) = 1). This can also be used to account for temperature effects. Alternatively, the program will compute saturation values using linear relationships developed from Table 7-9, page 263 of Clark, Viessman and Hammer (1). Naturally, the accuracy of the saturation values will depend upon the accuracy of the chloride simulation. However, chlorides are a common verification parameter for estuarine water quality models.

Spatially variable reaeration coefficients may also be entered manually or computed by the program using the O'Connor and Dobbins formula (3), depending upon the setting of ISWCH(8).

Any single quantity day cycle may be used for all quality day cycles depending upon the setting of ISWCH(10).

Card 32. Daily Cycles -- If the restart option is used, the number of daily cycles, NTC, refers to the total time of simulation, including the prior quality run. However, other time inputs assume time TZERO occurs on the day of the restart.

Card 33. Stormwater and Print Data -- NJSW refers to the number of junctions with variable pollutant loadings, input in card group 39.

Should the length of the quality simulation be limited by the number of quality cycle printouts available, LQCPRT, the restart option may be used to extend the simulation period.

Card 34. Control Parameters -- Remember that the length of a daily cycle is established in the quantity model as parameter PERIOD or card 5. Hence, if the system is tidally influenced, the length of a "day" may be 25 hours.

The number of quality constituents KCON will be augmented in the program to include one additonal pollutant for each nonconservative pollutant (as indicated by DECAY > 0 on card group 35). The principal example of this is the addition of DO when BOD is simulated. This additional pollutant will have no physical meaning for other than the BOD-DO simulation. However, this characteristic must be remembered in checking the total number of water quality constituents to be modeled. KCON should not include these additional constituents.

A fraction of the flow that leaves the tidal boundary junction, JGW (e.g., the mouth of an estuary) on ebb tide may return on the following flood tide. If so, the entering flow will carry a pollutant load back into the receiving water. This fraction is entered as parameter XRQD. Ideally, it could be determined from dye studies. More commonly, it may serve as a calibration parameter, typically being adjusted until, say, the predicted chloride distribution matches measured values. The stronger and more directionally consistent is the longshore current at the estuary mouth, the closer to zero will be the parameter XRQD. (If multiple tidal boundary junctions are used, XRQD is the same for all.)

The water temperature is treated as constant over the whole receiving water body. It is required only when the program is used to compute oxygen saturation values or reaeration coefficients, although it is generally useful information about the system.

When oxygen saturation values are computed by the program, it must know which constituent corresponds to chlorides. Parameter ICL is used for this purpose.

When coliforms are simulated, different conversion factors are required in the program than for other constituents. If, by accident, coliforms are simulated and KOLIF = 0, the resulting concentrations will be off by a constant factor that may be determined by studying subroutines INQUAL and LOOPQL.

Card Group 35. Quality Boundary and Decay Data -- The junction JGW is the one at which the tidal or weir boundary conditions apply.

The boundary concentration, CS, only affects tidally influenced simulations, and represents the constituent concentration in the portion of flood tide that consists of ocean water.

If the dissolved oxygen saturation concentration is to be constant, it is input here as CSAT. This parameter need be input only on the BOD-DO card. CSAT also serves as the DO saturation of the ocean water at JGW and as a default value for parameter STT on card group 36.

The reaeration coefficient for DO (often called K_2 in the literature) is input here if it is to be constant over the receiving water. Again, this parameter need be input only on the BOD-DO card. REAER also serves as a default value for parameter ATT on card 36.

Nonconservative water quality constituents are often described by a first-order decay process. DECAY is the rate constant in this exponential process, typified by the relationship dC/dt = DECAY * C. For BOD, DECAY is often called K_1 in the literature and usually ranges between 0.1 and 0.6 day^{-1}. If a quality constituent is treated as nonconservative (i.e., DECAY > 0) an additional pollutant will be added by the program and simulated, analogous to adding DO when BOD is modeled. This will not affect simulation of the nonconservative pollutant but must be remembered in the total number of pollutants allowed by the program.

<u>Card Group 36. Junction Quality Data</u> -- Accurate values of initial concentrations will help the program to "warm up" and establish initial conditions prior to stormwater runoff. If allowed to run long enough, however, the program should eventually establish these values itself.

Constant mass loadings usually correspond to the pollutant loads carried by the constant inflows described in the quantity portion on card group 15. These inputs are used to describe loadings from a waste treatment plant, for example, or from an inflowing river, if the flows are constant.

The DO concentration of inflows refers to any flows entering this junction, constant or variable.

<u>Card Group 38. Stormwater Input Junctions</u> -- The junctions listed will receive pollutant loadings from cards.

<u>Card Group 39. Pollutant Loadings</u> -- Variable pollutant inputs are entered here and/or from tape/disks generated by other programs. If inputs occur from both tape/disks and cards for a junction, the card input will supersede the tape/disk input. Input times need not be evenly spaced, but the spacing must be equal to or greater than the quality time step, QINT.

Table 8-1. RECEIVING WATER BLOCK CARD DATA

Card group	Format	Card columns	Description	Variable name	Default value
1			Control Card.[a]		
	4A4	1-8	If hydraulic calculations are to be carried out, write QUANTITY.		Blanks
		9-16	If quality modeling is to be accomplished, write QUALITY.		Blanks
			IF QUANTITY ANALYSIS IS NOT SELECTED, SKIP TO CARD GROUP 31.		
			QUANTITY MODEL DATA.		
2			Run title card, 2 cards.		
	15A4	1-60	Two card title for run.	ALPHA	Blanks
3			Storm title card, 2 cards.		
	15A4	1-60	Two card title for storm.	TITLE	Blanks
4			Control switches.		
	10I5	1-5	= 0, System is influenced by downstream head relationship (dam),	ISWCH(1)	0
			= 1, System is tidally influenced,[b]		
			= 2, System has specified outflow, as read in card groups 26 or 28.		
			= 3, System has multiple boundary-condition junctions. Type is specified in card group 10.		
		6-10	= 0, Print input channel and junction data,	ISWCH(2)	0
			= 1, Skip printing of input channel and junction data.		
		11-15	= 1, Spatially variable rainfall allowed. Junction inflows computed using card groups 23 to 27.	ISWCH(3)	0

[a] If both QUANTITY and QUALITY are punched, the program first carries out quantity, then quality analysis.

[b] A "tidal" boundary condition can include specification of a constant head (e.g. entering a lake).

Table 8-1 (continued). RECEIVING WATER BLOCK CARD DATA

Card group	Format	Card columns	Description	Variable name	Default value
		16-20	= 1, Triangles are used in card group 17 and specified roughness values are desired for each leg of the triangle.	ISWCH(4)	0
		21-25	= 1, Parallel channels are used between same two junctions to model different hydraulic characteristics.	ISWCH(5)	0
		26-30	= 0, Junction surface area must be left out of input data card group 15 when triangles are used in card group 17,	ISWCH(6)	0
			= 1, Junction surface area must be furnished to card group 15 when triangles are used in card group 17.		
		31-35	= 1, Manning's coefficients for channels are computed at each time step on basis of empirical relationship of n *vs* depth.	ISWCH(7)	0
		36-40	Not used.	ISWCH(8)	0
		41-45	Not used.	ISWCH(9)	0
		46-50	Not used.	ISWCH(10)	0
5			Hydraulic control card.		
	I5	1-5	Number of day cycles desired.	NTCYC	None
	4F5.0	6-10	Number of hr/day cycle. This is also the period (or multiple of the period) of the tidal cycle.	PERIOD	None
		11-15	Length of quality time-step, hr. (Maximum of 30 quality time-steps per day cycle).	QINT	None
		16-20	Length of hydraulic time-step, sec.	DELT	None
		21-25	Initial time for start of hydrograph input from cards, hr.	TZERO	None

Table 8-1 (continued). RECEIVING WATER BLOCK CARD DATA

Card group	Format	Card columns	Description	Variable name	Default value
	3I5	26-30	Number of junctions for time-history printout.	NHPRT	None
		31-35	Number of channels for time-history printout.	NQPRT	None
		36-40	Number of plots desired.	NPLT	0
	3F5.0	41-45	Evaporation, in/mo.	EVAP	0
		46-50	Wind velocity, mph.	WIND	0
		51-55	Wind direction, clockwise, degrees from North.	WDIR	0
	5I5	56-60	Day cycle where printed output will start. TZERO occurs on this day.	NQSWRT	None
		61-65	Number of junctions of stormwater input from cards.	NJSW	0
		66-70	Number of input times of rain information.	INRAIN	0
		71-75	Junction number where a head relationship is specified. JGW can be zero if ISWCH(1) = 2. If ISWCH(1) = 3, NJGW = total number of boundary condition junctions (maximum = 20). Actual junction numbers are read in card group 10.	JGW or NJGW	None
		76-80	If ISWCH(5) = 1 on card 4, then channel numbers greater than this number (NCGT) are parallel to other lower numbered channels. If ISWCH(7) = 1 on card 4, Manning's coefficients for channel numbers greater than NCGT are not calculated at each time-step but are constant as read in.	NCGT	0
			IF INRAIN = 0 ON CARD 5, SKIP RAIN INPUT CARD 6.		
6			Rain input cards, INRAIN pairs of values, 8 per card (Maximum number pairs = 100).		
	8F10.0	1-10	Rate of precipitation, in/hr.	RAIN(1)	None
		11-20	Time from start of storm, min.	INTIME(1)	None

Table 8-1 (continued). RECEIVING WATER BLOCK CARD DATA

Card group	Format	Card columns	Description	Variable name	Default value
		21-30	Etc., up to INRAIN points.	RAIN(2)	None
		31-40		INTIME(2)	
7			Junctions selected for stage-history printout, NHPRT (card 5) values, 8 per card (maximum = 50).		
	8I10	1-10	First junction number.	JPRT(1)	None
		11-20	Second junction number.	JPRT(2)	None
		.	.	.	
		.	.	.	
		.	.	.	
		.	.	.	
		.	Last junction number	JPRT(NHPRT)	None
8			Channels selected for flow print, NQPRT (card 5) values, 8 per card (maximum = 50).		
	8I10	1-7	Lower junction n. (numerically lower) at end of first desired channel.[a]	CPRT(1)	None
		8-10	Higher junction no. (numerically higher) at end of first desired channel.[a]		
		11-17	.	CPRT(2)	None
		18-20	.		
		.	.	.	
		.	.	.	
		.	Lower junction no. (numerically lower) at end of last desired channel.	CPRT(NQPRT)	None
		.	Higher junction no. (numerically higher) at end of last desired channel.		

[a]Right adjust all numbers.

Table 8-1 (continued). RECEIVING WATER BLOCK CARD DATA

Card group	Format	Card columns	Description	Variable name	Default value
			IF NPLT = 0 ON CARD 5, SKIP CARD GROUP 9.		
9			Junctions selected for head plot, NPLT (card 5) values (maximum = 50).		
	8I10	1-10	First junction to be plotted.	JPLT(1)	None
		11-20	Second junction to be plotted.	JPLT(2)	None
		.	.	.	
		.	.	.	
		.	.	.	
		.	Last junction to be plotted.	JPLT(NPLT)	None
			IF ISWCH(1) ≠ 3 ON CARD 4, SKIP DIRECTLY TO CARD 11 OR 13. IF ISWCH(1) = 3, REPEAT CARD GROUPS 10 AND 11/12 OR 13 NJGW (CARD 5) NUMBER OF TIMES (Maximum = 20).		
10			Multiple boundary condition card.		
	2I5	1-5	Junction number of boundary condition junction.	JGW	None
		6-10	Type of boundary condition.	IIBC	1
			= 1, Tidal (include card groups 11, 12),		
			= 2, Weir (include card 13)		
			IF ISWCH(1) = 2 ON CARD 4, SKIP TO CARD 14. IF ISWCH(1) = 0, SKIP TO CARD 13. INCLUDE CARDS 11, 12 IF ISWCH(1) = 1 OR IF IIBC = 1 ON CARD 10.		
11			Tide input control card.		
	4I5	1-5	If = 1 will expand from only four tidal stages (HHW, LLW, LHW, HLW over one daily cycle of length = PERIOD) for tidal coefficients.	KO	0
		6-10	Number of tidal stage data points, maximum = 50. (NOTE: Set NI = 4 if KO = 1).	NI	None

Table 8-1 (continued). RECEIVING WATER BLOCK CARD DATA

Card group	Format	Card columns	Description	Variable name	Default value
		11-15	Maximum number of iterations for curve fit, usually 50.	MAXIT	50
		16-20	= 0, Skip tidal I/O print,	NCHTID	0
			= 1, Print all parameters used.		
12			Tidal stage card, NI pairs of values, 4 pairs/card.[a] NOTE: If KO = 1 only four stages (HHW, LLW, LHW, HLW) are read, in appropriate time sequence.		
	8F10.0	1-10	Time in hours of tidal stage, first point.[b]	TT(1)	None
		11-20	Tidal stage (ft), first point.[c]	YY(1)	None
		21-30	Time in hours of tidal stage, second point.	TT(2)	None
		31-40	Tidal stage (ft), second point.	YY(2)	None
		. . .	. . .	. . .	
		.	Tidal stage (ft), last point.	YY(NI)	None
			SKIP TO CARD 14 IF ISWCH(1) ≠ 0 ON CARD 4 OR IIBC ≠ 2 ON CARD 10.		
13			Downstream head stage card.		
	3F10.0	1-10	WEIR factor.	WEIR1=A1	None
		11-20	Elevation of top of WEIR, ft (referenced to datum plane).[d]	WEIR2=A2	None
		21-30	Power law for WEIR.	WEIR3=A3	None

[a]Tidal stage is for the first day of simulation.

[b]Time range TT(1) to TT(NI) may exceed PERIOD of card 5.

[c]Tidal stage is for the first day of simulation. This will be repeated on subsequent days.

[d]Datum plane usually mean low low water.

Table 8-1 (continued). RECEIVING WATER BLOCK CARD DATA

Card group	Format	Card columns	Description	Variable name	Default value
			SKIP TO CARD 15 IF ISWCH(7) ≠ 1 ON CARD 4.		
14			Variable Manning's roughness card. Four pairs of depth *vs* n values are required.		
	8F10.0	1-10	Lowest depth, ft (should be zero).	DNN(1)	0
		11-20	Manning's *n corresponding to lowest* depth.	VARN(1)	None
		21-30	Next depth, ft.	DNN(2)	0
		31-40	Corresponding Manning's n.	VARN(2)	None
		41-50	Next depth, ft.	DNN(3)	0
		51-60	Corresponding Manning's n.	VARN(3)	None
		61-70	Highest depth, ft.	DNN(4)	0
		71-80	Corresponding Manning's n.	VARN(4)	None
			REPEAT CARD 15 FOR EACH JUNCTION (maximum = *100*).		
15			Junction cards.		
	I5	1-5	Junction number.	J	None
	F5.0	6-10	Water surface-elevation, ft (referenced to datum plane).[a]	HEAD(J)[b]	None
			IF NTEMP(3) ON CARD 17 IS SUPPLIED ****** *LEAVE SURFACE AREA BLANK* UNLESS ****** ISWCH(6) = 1 ON CARD 4.[c]		
	F10.0	11-20	Surface area of junction, millions of sq ft.[d]	AS(J)=*SURF*	None

[a] Datum plane usually mean low low water.

[b] Head is negative when below datum plane.

[c] However, if the junction area is to be added to junction area computed for triangle, include surface area and set ISWCH(6) = 0. See discussion of Figure 8-3.

[d] Half of the surface area of the previous channel plus half of the surface area of succeeding channel.

Table 8-1 (continued). RECEIVING WATER BLOCK CARD DATA

Card group	Format	Card columns	Description	Variable name	Default value
	2F5.0	21-25	Constant junction flow into receiving waters, cfs.	QIN(J)=QF1	None
		26-30	Constant junction flow out of receiving waters, cfs.	QOU(J)=QF2	None
	2F10.0	31-40	Junction depth, ft.[a]	DEP(J)=DT	None
		41-50	Junction Manning's coefficient. (Include Manning's coefficient if program develops geometric data. Channel roughness will be average of two end junctions unless ISWCH(4) = 1 on card 4.)	COF(J)=CF	None
	20X	51-70	Leave columns blank.		
		******	X AND Y COORDINATES REQUIRED ONLY IF WIND ≠ 0 ON CARD 5 OR NTEMP(3) ≠ 0 ****** ON CARD GROUP 17.		
	2F5.0	71-75	X-coordinate (easterly), thousands of ft.	X(J)=X1	None
		76-80	Y-coordinate (northerly), thousands of ft.	Y(J)=Y1	None
16	I5	1-5	To terminate junction cards, write 99999.		None
			REPEAT CARD 17 FOR EACH CHANNEL OR TRIANGLE (maximum number of channels = 225).		
17			Channel or triangle cards.		
	5I5	1-5	Channel or triangle number.[b]	N	None
		6-10	Junction at lower end of channel (numerically lower).	NTEMP(1)	None
		11-15	Junction at upper end of channel (numerically higher).	NTEMP(2)	None
		16-20	Blank unless program is used to develop geometric data through the use of triangles. Then NTEMP(1), NTEMP(2), NTEMP(3) are the vertices of an *acute triangle*. Program will develop channel characteristics.	NTEMP(3)	0

[a] Depth is distance to bottom from datum plane (downward is positive).

[b] These numbers may be changed by program.

Table 8-1 (continued). RECEIVING WATER BLOCK CARD DATA

Card group	Format	Card columns	Description	Variable name	Default value
		21-25	Blank unless it is the number of a fourth junction which lies midway between NTEMP(1) and NTEMP(3). Program will develop geometric data.	NTEMP(4)	0
		******	IF NTEMP(3) IS SUPPLIED THEN LEAVE COLUMNS 26-75 BLANK. *BUT* IF ISWCH(4) = 1 ON CARD 4, ALEN = MANNING'S ROUGHNESS FOR CHANNEL NTEMP(1) TO NTEMP(2), WIDTH = MANNING'S ROUGHNESS FOR CHANNEL NTEMP(2) TO NTEMP(3), RAD = MANNING'S ROUGHNESS FOR CHANNEL NTEMP(1) TO NTEMP(3). ******		
	5F10.0	26-35	Length of channel, ft.	ALEN	None
		36-45	Average width of channel, ft.	WIDTH	None
		46-55	Average depth of channel, ft.[a]	RAD	None
		56-65	Manning's coefficient, n.	COEF	0.018
		66-75	Initial velocity, ft/sec.	VEL	0
18	I5	1-5	To terminate channel cards, write 99999.		None
			IF NPLT = 0 ON CARD 5, SKIP TO CARD 22.		
19			Plot title card.		
	18A4	1-72	Title for plot output.	TITL	None
20			Plot horizontal label card.		
	20A4	1-80	Label below the x axis.	HORIZ	None

[a]Depth is distance to bottom from datum plane (downward is positive).

Table 8-1 (continued). RECEIVING WATER BLOCK CARD DATA

Card group	Format	Card columns	Description	Variable name	Default value
21			Plot vertical label card.		
	6A4	1-8	Line 1 of the vertical label.	VERT(1) VERT(2)	None
		9-16	Line 2 of the vertical label.	VERT(3) VERT(4)	None
		17-24	Line 3 of the vertical label.	VERT(5) VERT(6)	None
			IF NJSW = 0 ON CARD 5, SKIP TO CARD GROUP 30.[a]		
22			Stormwater input control card, NJSW (card 5) values (maximum = 50).		
	16I5	1-5	Number of first junction receiving stormwater input.	JSW(1)	None
		6-10	Number of second junction receiving stormwater input.	JSW(2)	None
		. . .	. . .	. . .	
		.	Number of last junction receiving stormwater input.	JSW(NJSW)	None
			IF ISWCH(3) ≠ 1 ON CARD 4, SKIP TO CARD GROUP 28; OTHERWISE INCLUDE CARDS 23 THROUGH 27.		
23	3I5	1-5	Total number of time inputs of rainfall and stormwater flows (maximum = 100).	NTIMST	None
		6-10	Total number of rain gages (maximum = 50).	NGAGE	None

[a]NOTE: If stormwater input is provided to the same junction(s) from both tape/disk and cards, the card input will override the tape/disk input.

Table 8-1 (continued). RECEIVING WATER BLOCK CARD DATA

Card group	Format	columns	Description	Variable name	Default value
		11-15	Units for time inputs (card group 24): 0 = seconds 2 = hours 1 = minutes 3 = days	NTCC	0
			INPUT TIMES FOR RAINFALL INTENSITIES AND STORMWATER HYDROGRAPHS. UNITS CORRESPOND TO THOSE GIVEN ON CARD 23.		
24	8F10.0	1-10	Time of first inflow (time of day).[a]	TEEM(1)	None
		11-20	Time of second inflow.	TEEM(2)	None
		.	.	.	
		.	.	.	
		.	.	.	
		.	Time of last inflow (should be larger than expected time of analysis).	TEEM(NTIMST)	None
			REPEAT CARD 25 FOR EACH JUNCTION LISTED IN CARD GROUP 20 (maximum = 50).		
25	16F5.0	1-5	Fraction of rainfall from first gage allocated to junction.	RCENT (NJSW,NGAGE)	None
		6-10	.	.	
			.	.	
		11-15	.	.	
		.	.	.	
		.	Fraction of rainfall from last gage allocated to junction.		
			REPEAT CARD 26 FOR EACH INPUT TIME.		
26			Stormwater hydrograph input cards.[b]		

[a] This is cumulative time if more than one day is simulated.

[b] **NOTE:** Variable outflows may be read as negative inflow values.

Table 8-1 (continued). RECEIVING WATER BLOCK CARD DATA

Card group	Format	Card columns	Description	Variable name	Default value
	8F10.0	1-10	Flow volume for first junction, cfs.	EXXT (NTIMST,NJSW)	None
		11-20	.		
		.	.		
		.	.		
		.	Flow volume for last junction, cfs.		
			REPEAT CARD 27 FOR EACH INPUT TIME.		
27	16F5.0	1-5	Rainfall intensity for first rain gage, in/hr.	DRAIN(1)	None
		6-10	.	.	
			.	.	
		11-15	.	.	
		.	.	.	
		.	.	.	
		.	Rainfall intensity for last rain gage, in/hr.	DRAIN(NGAGE)	None
			IF ISWCH(3) = 1 ON CARD 4, SKIP TO CARD 30. REPEAT CARD 28 FOR EACH INPUT TIME (maximum = 50 junctions).		
28			Input hydrograph.[a]		
	8F10.0	1-10	Time of day, sec.[b]	TE(1)	None
		11-20	Flow volume for first junction, cfs.	QE(1,1)	None
		21-30	Flow volume for second junction, cfs.	QE(1,2)	None
		.	.	.	
		.	.	.	
		.	.	.	
		.	Flow volume for last junction, cfs.	QE(1, NJSW)	None
29	F10.0	1-10	Terminate input hydrograph cards with TE(1) beyond expected time of analysis.		None

[a]NOTE: Variable outflows may be read as negative inflow values.

[b]This is cumulative time if more than one day is simulated.

Table 8-1 (continued). RECEIVING WATER BLOCK CARD DATA

Card group	Format	Card columns	Description	Variable name	Default value
30			Final data card.		
	2A4	1-8	Write ENDQUANT.		None
			END OF QUANTITY DATA CARDS.		
			QUALITY MODEL DATA.		
31			Control switches (1 is yes, 0 is no).		
	10I5	1-5	Restart from scratch file 3.	ISWCH(1)	0
		6-10	Skip printing of maximum and minimum concentrations.	ISWCH(2)	0
		11-15	Write restart data on scratch file 4.	ISWCH(3)	0
		16-20	BOD/DO is at least one of constituents.	ISWCH(4)	0
		21-25	Tidally influenced receiving water.	ISWCH(5)	0
		26-30	Input from cards (or tape/disk) on first day of quality simulations.[a]	ISWCH(6)	0
		31-35	Variable oxygen saturation coefficients.	ISWCH(7)	0
			= 0, Same constant value at all junctions,		
			= 1, Different constant value at each junction,		
			= 2, Computed at each time step as function of temperature and chloride concentration. (NOTE: Chlorides must be one of the constituents when this option is used.)		
		36-40	Variable reaeration coefficients.	ISWCH(8)	0
			= 0, Same constant value at all junctions.		
			= 1, Different constant value at each junction.		

[a]TZERO occurs on first day of input from cards or tape/disk.

Table 8-1 (continued). RECEIVING WATER BLOCK CARD DATA

Card group	Format	Card columns	Description	Variable name	Default value
			= 2, Computed at each time step as function of depth and velocity using O'Connor-Dobbins formula.		
		41-45	Not used.	ISWCH(9)	0
		46-50	Use only the daily quantity cycle on input file indicated by value of ISWCH(10). Value of zero indicates use of all days.	ISWCH(10)	0
			IF ISWCH(1) = 0 ON CARD 31, SKIP TO CARD 33. RESTARTING FROM SCRATCH FILE 3.		
32			Daily cycle card.		
	I5	1-5	Number of daily cycles desired.[a]	NTC	None
			THIS WOULD BE LAST CARD OF DATA DECK IF ISWCH(1) = 1 ON CARD 31, EXCEPT FOR CARD GROUP 39.		
33			Storm water and print card.		
	10I5	1-5	Number of junctions with stormwater input from cards (maximum = 20).[b]	NJSW	None
		6-10	Initial daily cycle at which detailed quality information will print.	ITCPRT	None
		11-15	Number of quality time steps between printing out of quality results.[c]	NQPRT	None
		16-20	Total number of quality cycles printed (maximum = 50).	LQCPRT	None
34			Control parameters.		
	3I5	1-5	Number of daily cycles desired.	NTC	None

[a]This is the total number of cycles, including those used previously in generating the restart tape.

[b]NOTE: If stormwater input is provided to the same junction(s) from both tape/disk and cards, the card input will override the tape/disk input.

[c]Quality time step is read on card 5.

Table 8-1 (continued). RECEIVING WATER BLOCK CARD DATA

Card group	Format	Card columns	Description	Variable name	Default value
		6-10	Number of constituents (*maximum* total number = 6).[a]	KCON	None
		11-15	Print interval, days.	NPRT	None
	2F5.0	16-20	Ocean exchange ratio at tidal point (JGW). This is fraction of inflowing flood tide that consists of returning outflow from prior ebb tide (*e.g.*, if XRQD = 0.20, 80% of inflow or flood tide consists of fresh ocean water).	XRQD[b]	0
		21-25	Water temperature, °C (range $0 \leq$ TEMP ≤ 30). Required only if ISWCH(7) or ISWCH(8) = 2.	TEMP	0
	2I5	26-30	Constituent number corresponding to chlorides. Determined from sequence of 35, 36 cards. Required only if ISWCH(7) = 2.	ICL	0
		31-35	Constituent number corresponding to coliforms. Determined from sequence of 35 , 36 cards. KOLIF = 0 means coliforms are not simulated.	KOLIF	0
			FOR EACH QUALITY CONSTITUENT READ A SET OF 35 AND 36 CARDS.		
35			Quality boundary and decay data.		
	I5	1-5	Head-stage control node.[b]	JGW	None
	F10.0	6-15	Boundary concentration at JGW (*e.g.*, in ocean water) of constituent, mg/ℓ (or MPN/100 mℓ for coliforms).	CS	0

[a]NOTE: If BOD is modeled, DO will be added automatically as the extra constituent (number KCON+1) and should not be included in KCON.

[b]If multiple boundary junctions are used, JGW is not required, and the program automatically assigns parameters XRQD, CS and CSAT to all tidal boundary junctions.

Table 8-1 (continued). RECEIVING WATER BLOCK CARD DATA

Card group	Format	Card columns	Description	Variable name	Default value
	3E5.0	16-20	Boundary dissolved oxygen at JGW (*e.g.*, in ocean water) and constant saturation value for receiving water if ISWCH(7) = 0, mg/ℓ.	CSAT	0
		21-25	Reaeration coefficient, day^{-1}.	REAER	0
		26-30	First order decay exponent for non-conservative constituent, day^{-1}.[a]	DECAY	0
	5X	31-35	Leave columns blank.		
	6A4	36-59	Constituent name.	TITLE	Blanks
			FOR EACH NODE WITH A NON-ZERO INITIAL VALUE, INCLUDE CARD 36.		
36			Junction quality data.		
	I5	1-5	Node number.	JTT	None
	7F10.0	6-15	Initial concentration of node, mg/ℓ (or MPN/100 mℓ for coliforms).	CTT	0
		16-25	Constant mass loading, lbs/day (or MPN/min for coliforms).	CPP	0
		******	THE FOLLOWING FOUR VALUES REQUIRED ONLY ON CARDS FOR BOD. ******		
		26-35	Initial nodal dissolved oxygen concentration, mg/ℓ.	CTTOX	0
		36-45	Dissolved oxygen concentration of inflow, mg/ℓ.	CPPOX	0
		******	THE FOLLOWING VALUE REQUIRED IF ISWCH(7) = 1 ON CARD 31. **********		

[a]NOTE: With present programming, any non-conservative constituent (DECAY > 0) will be treated similarly to BOD-DO, that is, an extra constituent analagous to DO will be added and simulated. It will not affect simulation of the non-conservative constituent, but must be remembered in total number of constituents.

Table 8-1 (continued). RECEIVING WATER BLOCK CARD DATA

Card group	Format	Card columns	Description	Variable name	Default value
		46-55	DO saturation concentration at node, mg/ℓ.	STT	CSAT
			THE FOLLOWING VALUE REQUIRED IF ISWCH(8) = 1 ON CARD 31.		
		56-65	Reaeration coefficient at node, day^{-1}.	ATT	REAER
37	I5	1-5	Terminate card group 36 by writing 99999.		None
			IF NJSW $\geq$ 1 ON CARD 33 INCLUDE CARD GROUPS 38 AND 39.		
38			Stormwater input, NJSW (card 33) values (maximum = 20).		
	16I5	1-5	First junction for stormwater input.	JSW(1)	None
		6-10	Second junction for stormwater input.	JSW(2)	None
		.	.	.	
		.	.	.	
		.	.	.	
		.	Last junction for stormwater input.	JSW(NJSW)	None
			CARD GROUP 39 MUST BE READ IN GROUPS, EACH GROUP CONSISTING OF KCON NUMBER OF CARDS.		
39			Time and load rate (repeated sets of cards, each set consisting of KCON time groups).		
	8F10.0	1-10	Time of day, sec.[a]	TE	None
		11-20	Load rate of constituent for JSW(1), lbs/day (or MPN/min for coliforms).	CE(1)	None
		21-30	Load rate of constituent for JSW(2).	CE(2)	None
		.	.	.	
		.	.	.	
		.	.	.	
		.	Load rate of constituent for JSW(NJSW) lbs/day.	CE(NJSW)	None

[a]This is cumulative time if more than one day is simulated.

Table 8-2. RECEIVING BLOCK VARIABLES[a]

Variable Name	C*	Description	Unit
A(I) **	C	Channel cross-section area at start of time-step	sq ft
AA(10)	C	Tidal curve fit coefficients during least square process	
AK(I)	C	Modified friction factor	
ALPHA (30)	C	Title for printing	
ALEN		Channel length	
ANAME		Input variable use for branching to either Quantity or Quality Block	
AREA		Computed nodal area to find initial nodal volume	
AS(J)	C	Node surface area	sq ft
AT(I)	C	Channel cross-section at midpoint of time-step	
		WEIR1 = Weir coefficient	
		WEIR2 = Elevation of weir crest	ft
		WEIR3 = Exponent in the expression Q = WEIR1(H-WEIR2)$^{\text{WEIR3}}$ where H is the water surface elevation and Q is the flow.	
ASTERK		Variable containing asterisk	
ATOT		Total surface area of receiving water	sq ft
AX(100,50)	C	Array containing X coordinates of plots	
AY(100,50)	C	Array containing Y coordinates of plots	
A1, A2, A3, A4, A5, A6, A7	C	Coefficients of the expression H = A1 + A2COS(WT) + A3COS(2WT) + A4COS(3WT) + A5SIN(WT) + A6SIN (2WT) + A7SIN(3WT) for tidal input	
B(I)	C	Channel width	ft
BLANK		Variable containing blank	
C(J,6)	C	Constituent nodal concentrations	J=1,NJ K-1,KCON
CARD		Variable for reading second half of final card	
CE(6,20,2)	C	Storm water node input values of loading rate	lb/day
CF		Manning's coefficient for junction	
CLOSS		Constituent concentration lost to decay	
CMAX(J,6)	C	Daily maximum constituent concentration	mg/L
CMIN(J,6)	C	Daily minimum constituent concentration	mg/L
COEF		Manning's coefficient for channel	
COF(J)	C	Junction friction factor	
CPP		Steady state load rate for load node JTT	lb/day
CPPOX		Steady state DO inflow concentration	mg/L
CPRT(K)	C	Channel print array	
CS(6)	C	Conservative constituent concentration at controlled state-time node (JGW)	mg/L
CSAT(6)	C	DO constituent concentration at JGW	mg/L
CSPIN(J,6)	C	Initial constituent mass input levels	
CT(6,20,2)	C	Constituent loading rate from storm water input	lb/day
CTT		Initial node JTT constituents concentrations	mg/L
CTTOX		Initial node JTT DO concentrations	mg/L
C2(6)	C	Concentration at controlled stage-time node (JGW)	mg/L

[a]Does not include variables added during updating.
*Variable names shared in common blocks.
**In variable dimensions I is for number of channels, J is for number of junctions, and K is for number of point junctions, channels, and plots.

Table 8-2 (continued). RECEIVING BLOCK VARIABLES

Variable Name	C	Description	Unit
CURVE		Name of subroutine	
D		Dummy read variable	
DCDT(J,6)	C	Change of nodal concentration with time	
DECAY(6)	C	First order delay coefficient for non-conservative constituents	1/day
DELH		Increment of head of a junction for a time-step	ft
DELMAX		Maximum difference between the calculated and tidal stage input	ft
DELT	C	Time-step increment	
DELTA		Maximum allowable difference between the calculated and input tidal stage	ft
DELTQ	C	Length of quality time-step (usually an hour)	sec
DELT2		1/2 time-step increment	sec
DELV1, DELV2		Component of velocity change during a time-step	ft/sec
DEP(J)	C	Depth of water of a junction at zero datum	ft
DEPTH		Computed depth of node at a junction for initial volume	
DIFF		Difference between the calculated and input tidal stage	ft
DISOXY		Part of label for nonconservative constituents	mg/L
DT		Junction depth	ft
DUMMY		Dummy write variable to indicate end of data	
DVOL		Volume change in a time-step	cf

Variable Name	C*	Description	Unit
EBB		Total flow leaving system at tidal junction	cf
ENDER(2)		Array containing ENDQUANT to terminate model	
EVAP	C	Evaporation rate for whole system converted from ft/mo	cfs
FINAL		Variable for reading first half of final card	
FJ1		Internal variable	
FJ3		Internal variable	
FLOOD		Total flow entering system at tidal junction	cf
FWIND(I)	C	Drag force due to wind	
G		Channel length determined from X & Y coordinates	ft
H(J)	C	Head at junction at beginning of time-step	ft
HAVE(J)	C	Junction average head during a daily cycle	ft
HBAR(J)	C	Junction average head during a quality cycle	ft
HEAD		Distance water surface is from datum plane	ft
HN(J)	C	Junction head at end of time-step	ft
HORIZ	C	Graph horizontal axis title	
HOUR		Time-hours	hr
HPLT(K)	C	Array saved on scratch for later plotting	ft

Table 8-2 (continued). RECEIVING BLOCK VARIABLES

Variable Name	C*	Description	Unit
HT(J)	C	Junction head at end of 1/2 time-step	ft
IABS		Name of function	
IC		Internal variable	
ICOL	C	Printing column header	
ICON(6)		Bookkeeping integer for nonconservative constituents	
IDELT		Length of hydraulic cycle (integration step)	sec
IDUM	C	Column heading for channel printout	
II		Channel number	
INDATA		Name of subroutine	
INQUAL		Name of subroutine	
INRAIN		Number of rainfall inputs	
INSTH	C	Switch to cause reading of pollutograph from hydrograph file after one daily cycle	
INTIME(100)	C	Time of rainfall inputs	
IPERID		Length of tidal cycle	hrs
IPOINT(J,8)	C	Pointer array containing node to node connections	
IQINT		Length of quality cycle	sec
ISKIP	C	Printing counter	
ISW(20)	C	Storm water input junctions from hydrograph file	
ISWCH(10)	C	Control switches	
ITCPRT	C	Day cycle chosen for start of detailed quality printing	

Variable Name	C*	Description	Unit
JBOUND(20)	C	Junction with specified boundary conditions	
JGW	C	Junction with specified head flow or head relationships	
JH		Highest numbered junction at the end of a channel	
JJ		Lowest numbered junction at the end of the channel	
JJBOUN	C	Number of junctions with specified boundary conditions	
JPLT(K)	C	Array of junctions to be plotted	
JPRT(K)	C	Array of junctions for stage printout	
JSW(20)	C	Storm water input node numbers from cards	
JTT		Node number for special start conditions	
KCON	C	Number of constituents, including DO for nonconservative	
KCONO	C	Number of constituents	
KO		Switch to cause generation of a full tide from HHW, LLW, HLW, LHW	
KPRT	C	Counter for printing, standard output	
KRAIN		Counter for interpolation of rainfall input	
KSTART		Do loop start point for DO loop	
LEN(I)	C	Channel length	ft
LOOPQL		Name of subroutine	
LQCPRT	C	Desired total number of detailed quality print cycles	

Table 8-2 (continued). RECEIVING BLOCK VARIABLES

Variable Name	C*	Description	Unit
LTIME	C	Printing counter	
MADD(J,6)	C	Mass of nodal constituent	
MAXIT		Maximum number of iterations in tidal curve fit, usually 50	
MCOUNT		Card read counter at end of SWFLOW	
MCPRJ		Channel numbers for which flow and velocity are to be printed	
MINO		Name of function	
MJSW		Number of storm water input nodes from hydrograph file	
MJPRT		Junction numbers for which stage is to be printed	
MSTPRT	C	Printing counter for quality cycle, used in QPRINT	
MTOTAL		Printing counter, total hours printed	
NC	C	Number of channels	
NCHAN(J,8)	C	Channels associated with nodes	
NCHTID		Print control for tide generation	
NCLOS(I)	C	If equal to 1 channel dry, otherwise no effect	
NCON		Number of quality constituents on hydrograph input file	
NCURVE		Number of points on plotted curves	
NDC		Total number of curves	
NDRY		Number of dry junctions	
NEBB		Number of cycle with outflow at tide junction	
NEXIT	C	Set equal to 1 when error condition exists	
NFLD		Number of cycles with inflow at tide junction	
NH		Node at channel end	
NHCYC	C	Number of time-steps per quality cycle	
NHPRT	C	Number of junctions at which head will be printed	
NI		Number of tidal input values	
NINREC		Counter for tape storm water input	
NINT		Number of hydraulic cycles per tidal cycle	
NJ	C	Number of junctions	
NJSW	C	Number of storm water input junctions for cards	
NJUNC(I,2)	C	Nodes at channel ends	
NL		Node at channel end	
NPDEL	C	Number of time-steps per plot point	
NPLT	C	Number of points to be plotted	
NPRT	C	Standard output print interval, in days	
NPT	C	Number of parts on card curve	
NPTOT		Counter of time-steps for plotting	
NQ		Quality cycle counter	
NQCTOT	C	Printing counter	
NQCYC	C	Number of quality cycles per day	hr

Table 8-2 (continued). RECEIVING BLOCK VARIABLES

Variable Name	C*	Description	Unit
NQPRT	C	Quality cycle interval increments between detailed quality cycle prints (SWQUAL)	hr
NQSWRT	C	Number of daily cycles at which printing will start	
NSTEPS		Number of input records on input hydrograph file	
NSTART	C	Day DO loop start cycle	
NSTPRT	C	Printing counter, day cycle	
NT	C	Daily cycle number	
NTAG		Day, DO loop counter	
NTC	C	Number of day cycles	
NTCYC	C	Number of daily cycles to be simulated	
NTEMP(8)	C	Temporary array of channels entering a node	
NTIMS		Number of times through drying up connection	
NTINT	C	20 for first call to output 21 for subsequent calls	
NUNCH(I)	C	Array containing compacted form of junction connections	
NX		Number of curves to be plotted on one plot	
N5	C	Card reader	
N6	C	Printer	
N10	C	Scratch file number	
N20	C	SWFLOW-SWQUAL interfacing file	
N21	C	Input file containing hydrographs	
N22		Scratch file containing plot information	
N30	C	Restart input file	
N40	C	Output file	

Variable Name	C*	Description	Unit
OGAIN		Dissolved oxygen gained from reaeration	
PERIOD	C	Period in hours of daily cycle	hr
PREC		Instantaneous rainfall rate	ft/sec
PRTH(30,K)	C	Array for printing heads	ft
PRTOUT		Name of subroutine	
PRTQ(30,K)	C	Array for printing flows	cfs
PRTV(30,K)	C	Array for printing velocities	ft/sec
Q(I)	C	Channel flow	cfs
QAVE(I)	C	Daily cycle average flow	cfs
QBAR(I)	C	Quality cycle average flow	cfs
QE(20,2)	C	Inflows on input cards (subroutine SWFLOW)	cfs
QF	C	Total inflow to system through control node, 1-day cycle	cfs
QIN(J)	C	Inflows to junctions	cfs
QINBAR(J)	C	Quality cycle average junction inflow	cfs
QINST		Initial inflow to junction	cfs
QINT		Quality time-step interval	hr
QOU(J)	C	Outflow from junction	cfs
QOUBAR(J)	C	Quality cycle average junction outflow	cfs
QT(20,2)	C	Inflows from hydrograph input file	cfs
QUIN(J)		Flow into system at nodes	cfs
QUINST(J)		Instantaneous inflow rate	cfs
R(I)	C	Hydraulic radius	ft

Table 8-2 (continued). RECEIVING BLOCK VARIABLES

Variable Name	C*	Description	Unit
RAD		Channel depth measured from datum	ft
RAIN(100)	C	Rainfall hyetograph values	in/ft
REAER(6)	C	Reaeration coefficient	1/day
RES		Accumulative difference between the calculated and input tidal stage	ft
RNT		Temporary hydraulic radius at 1/2 time-step	ft
SIGN		Library function	
SLOPE	C	Instantaneous rate of change of inflow	ft/sec^2
SUM		Computed tidal stage	ft
SUMC(J,6)		Average daily nodal concentration	
SUMQ		Total flow leaving junction	cfs
SWFLOW		Name of subroutine	
SWQUAL		Name of subroutine	
SXX(10,10)	C	Matrix used for least square tidal fit	
SXY(10)	C	Vector used for least square tidal fit	
T	C	Time counter for whole analysis	sec
TDELT		Time-step of hydrograph input file	sec
TE	C	Time of inflow for card input	sec
TEMP		Simplifying variable used during solution of velocities	
TEO	C	Previous value of TE	sec
TEP	C	Time of inflow in hours	hr
TF		Estimate maximum time-step for channel	sec
TIME		Time counter for storm input	sec
TITEL2		Input hydrograph title	
TITLE(40)		Title array read from input hydrograph file	
TITLE(30)	C	Title array read from cards	
TITLESW(30)	C	Description of run	
TMAX		Dummy write variable to indicate end of data	
TOLD		Time of previous input rainfall	sec
TT(50)	C	Time from start of storm of input for tidal condition and from hydrograph file	sec
TTP		Times of previous input from hydrograph file	sec
TZ		Time of start of storm	hr
TZERO	C	Zero time for the analysis	sec
T2		Time at end of half hydraulic time-step	sec
U(225)	C	Channel velocity	
V	C	Channel velocity at start of time-step	ft/sec
VBAR	C	Average nodal volume during quality cycle	cf
VOL(J)	C	Nodal volume	cf
VOLO(J)	C	Volume of JGW	
VOLUME		Initial nodal volume	cf
VT	C	Channel velocity at 1/2 time-step	ft/sec
V2		Velocity during a half hydraulic time-step	ft/sec
W		Fundamental frequency of daily tidal variation	rad/sec

Table 8-2 (continued). RECEIVING WATER BLOCK VARIABLES

Variable Name	C*	Description	Unit
WDIR	C	Wind direction in degrees from north	deg
WEIR1		Weir coefficient	
WEIR2		Elevation of weir crest	ft
WEIR3		Exponent in the expression Q = WEIR1 $(H-WEIR2)^{WEIR3}$ where H is the water surface elevation and Q is the flow	
WIDTH		Width of channel	ft
WIND	C	Wind force	mph
X(J)	C	X coordinate of junctions	ft
XMX		Blank or asterisk depending on whether estimated maximum time-step is satisfied	
XRQD	C	Mass exchange ratio of JGW	
XX(10)	C	Vector used in least square tidal fit	
Y(J)	C	Y coordinate of junctions	ft
YY(50)	C	Stage level of tidal input	ft

SAMPLE RUN

The St. Johns River, from Palatka, Florida to its mouth at Mayport, a distance of about 75 miles (120 km) is presented as an example application of the Receiving Water Block. Figure 8-7 illustrates the layout of the 37 junctions and 40 channels used in the simulation. In addition, Figure 8-4 is a detailed diagram of the area of junctions 13, 14 and 15. All physical data were reduced from US Coast and Geodetic Survey nautical charts 685 and 636-SC and US Geological Survey quadrangal maps for Mayport and Eastport, Florida. Note that channels represent meandering river segments and need not be straight lines. Lengths are scaled off the maps. Since there is only one true triangle in the system (13-14-15) subroutine TRIAN was not used. Junction areas entered represent the totals for those junctions, as illustrated on Figure 8-4.

Measured tides at junction 1 were input from the National Oceanographic and Atmospheric Administration tide gage at Mayport. Although the tide of July 19, 1973 is used in the run, Figure 8-5 illustrates the type of semi-diurnal tide experienced there.

Table 8-3 lists all input data for the run. These data reflect the base dry weather loads entering the system at several junctions. The purpose of the run was to determine the effect of these loads rather than to simulate a specific stormwater runoff event. Thus, the only "stormwater" input is the river inflow at Palatka and is read in from cards. The BOD loading at Palatka is obtained through a known concentration measured there. This is then multiplied by the flow and converted to pounds per day.

Quantity output is illustrated on Tables 8-4 to 8-10 and Figure 8-8. Initial values of velocities and stages for channels and junctions were obtained by using the final values from a previous run. Although Table 8-5 indicates possible problems with the time step for channel 31, none were experienced.

Quality output is illustrated on Tables 8-11 to 8-19. The value of the exchange coefficient (XRQD) of 0.1 was determined from the best match of the predicted and measured chloride distribution.

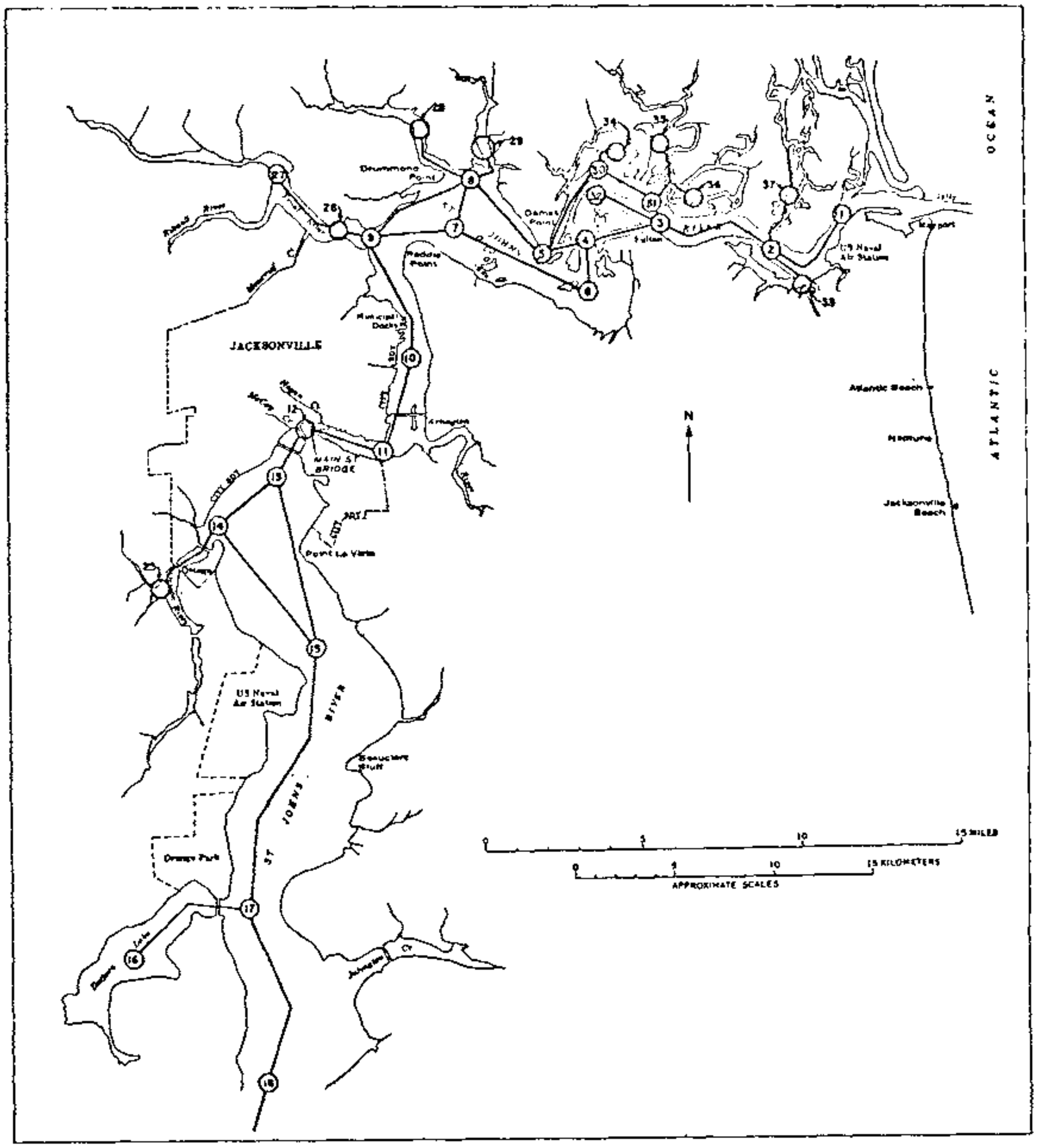

Figure 8-7. Schematization of the St. Johns River for Receiving Simulation. Junctions 19-24 Progress Upstream to Junction 24 at Palatka. Junctions 34-37 are Used to Simulate Storage Available in Tidal Marshes. The Interaction of Junctions 33 and 37 with the Intracoastal Waterway, on Which They are Located is not Simulated.

Table 8-3. INPUT DATA FOR RECEIVING EXAMPLE

```
                                   DATA                                                  CARD GROUP
                                                                                           NUMBER
RECEIVING                                                         (READ IN EXECUTIVE  BLOCK)
QUANTITYQUALITY                                                                              1
THIS IS A SAMPLE RUN OF QUANTITY AND QUALITY                                       }
LOWER ST. JOHNS RIVER. JULY 1972 VERIFICATION DATA.                                }         2
JULY 19, 1972 TIDE AT MAYPORT.                                                     }
USE MEASURED FLOW AT PALATKA, JULY 17-20, 1973.                                    }         3
    1     0     0     0     1     0     0     0     0     0                                  4
    3   25     1.  180.   0.0   37    40     6   0.0   0.0   0.0    1     1     0     1        5
         1         2         3         4         5         6         7         8
         9        10        11        12        13        14        15        16
        17        18        19        20        21        22        23        24             7
        25        26        27        28        29        30        31        32
        33        34        35        36        37
     23024     22023     21022     20021     19020     18019     17018     16017
     15017     14015     13015     13014     14025     12013     11012     10011
      9010      9026     26027      8009      7009      7008      8028      8029             8
      5008      6007      4006      4005      5030     30031      3031      3004
      3032      2003      2033      1002     30034     31035     31036      2037
         1         5        12        14        17        24                                 9
    0   26   50    1                                                                        11
0.0       2.94      1.0       3.45      2.0       3.91      3.0       3.88
4.0       3.5       5.0       2.68      6.0       1.7       7.0       1.03
8.0       0.61      9.0       0.93      10.0      1.35      11.0      1.94
12.0      2.77      13.0      3.63      14.0      4.26      15.0      4.51                  12
16.0      4.34      17.0      3.87      18.0      3.1       19.0      2.19
20.0      1.4       21.0      1.0       22.0      1.04      23.0      1.61
24.0      2.22      25.0      2.91
    1 2.94  12.13    1.12      25.0
    2 2.81  36.22              33.0
    3 2.68  26.94              30.0
    4 2.58  15.73              20.0
    5 2.53  28.4     .003      25.0
    6 2.33  91.8     1.245      4.0
    7 2.31  85.09    1.795      4.0
    8 2.42  43.34    2.073     26.0
    9 2.39  49.21    0.75      12.0
   10 2.41  48.25    34.7      27.0
   11 2.40  65.26    10.08     20.0
   12 2.41  23.14    10.05     25.0
   13 2.43 116.5     3.36       9.0
   14 2.45 114.0     0.92       7.0
   15 2.53 364.3     6.37      14.0
   16 2.56 154.4               12.0
   17 2.55 453.3     0.18      17.0                                                         15
   18 2.57 430.1     1.377     13.0
   19 2.59 459.2               12.0
   20 2.59 430.1               14.0
   21 2.56 486.1               10.0
   22 2.54 206.8               10.0
   23 2.53 130.6               10.0
   24 2.53  48.1               11.0
   25 2.45  94.6     12.4       5.0
   26 2.37  27.48    10.84      8.0
   27 2.36  32.5     2.487      6.0
   28 2.38  19.73    33.97      4.0
   29 2.42  16.73    0.226      4.0
   30 2.61  27.09    0.152     23.0
   31 2.66  10.32              23.0
   32 2.68   9.93               9.0
   33 2.80  26.0     7.94       4.0
   34 2.40  29.0                2.0
   35 2.56  42.0                4.0
   36 2.58  25.0                4.0
   37 2.65  63.7                4.0
99999                                                                                       16
    1    23   24          19500.     5950.     10.        0.025     -0.08
    2    22   23          20840.     5740.     10.        0.025     -0.17
    3    21   22          34100.     9380.     10.        0.025     -0.18
    4    20   21          52800.    11730.     12.        0.025     -0.27
    5    19   20          28700.    11070.     13.        0.025     -0.36
    6    18   19          40500.    12600.     13.        0.025     -0.40
    7    17   18          32680.    13140.     14.        0.025     -0.42
    8    16   17          17670.     4000.     12.        0.025      0.03
    9    15   17          37220.    13100.     15.        0.025     -0.44                     17
   10    14   15          22900.     6050.     10.        0.025     -0.75
   11    13   15          26850.     5920.     11.        0.025     -0.49
   12    13   14           9430.     9110.      9.        0.025     -0.55
   13    14   25          11570.     2020.      6.        0.025      0.13
   14    12   13          11900.     4510.     20.        0.025     -0.96
   15    11   12          10520.     2230.     29.        0.025     -1.37
   16    10   11          18640.     3850.     25.        0.025     -0.87
   17     9   10           9770.     3550.     17.        0.025     -1.27
   18     9   26           7260.     2700.     10.        0.025      0.21
```

Table 8-3 (continued). INPUT DATA FOR RECEIVING EXAMPLE

```
19  26  27      13960.   2820.    7.   0.025   0.14
20   8   9      14060.   2250.   22.   0.025  -1.16
21   7   9       8350.   1936.    5.   0.025  -0.79
22   7   8       6470.   1224.    6.   0.025  -0.85
23   8  28      10090.   1732.    4.   0.025   0.31
24   8  29       4390.   2540.    4.   0.025   0.14
25   5   8      14660.   2110.   26.   0.025  -0.68
26   6   7      21900.   5300.    4.   0.025  -0.20
27   4   6       7040.    927.    5.   0.025   1.21
28   4   5       7200.   1740.   24.   0.025  -0.39
29   5  30      15250.   1464.   21.   0.025   0.48
30  30  31       8220.   1516.   23.   0.025   0.12      17
31   3  31       4390.   1634.   26.   0.025   0.27
32   3   4       9110.   1148.   27.   0.025  -0.18
33   3  32       7890.    935.   15.   0.025   0.14
34   2   3      16440.   2400.   31.   0.025   0.18
35   2  33       5540.    963.   10.   0.025   0.46
36   1   2      12480.   1992.   29.   0.025   0.67
37  30  34       5980.    800.    4.   0.025   1.17
38  31  35      12500.    900.   10.   0.025   0.82
39  31  36       6800.    700.    7.   0.025   0.84
40   2  37       8300.    800.   10.   0.025   1.43
99999                                                   18
STAGES AT MAYPORT, DAME PT, MAIN ST, ORTEGA RIVER, ORANGE PK, PALATKA.   19
ELAPSED TIME IN HOURS.                                  20
STAGE INFEET,   MLW                                     21
   24                                                   22
0.0         6990.
86300.      6990.
86400.      4570.
172700.     4570.
172800.     2740.                                       23
259100.     2740.
259200.     4270.
432000.     4270.
ENDQUANT                                                29
     0     0      0     1     1        2    2           30
     1     1      3    36                               31
     1     2      1   0.1  29.0   2                     32
     1   0.0    7.0   0.1   0.4      BOD           2    33
     1         1.0  162.0      5.0    7.0   6.67    .3
     2         1.0   22.0      5.0    7.0   6.76  0.087
     3         1.0             5.0    7.0   7.28    .08
     4         1.0             5.0    7.0   7.28    .10
     5         1.0             5.0    7.0   7.28  0.112
     6         1.0  345.0      5.0    7.0   7.31  0.87
     7         1.0  531.0      5.0    7.0   7.31  0.87
     8         1.0 16755.0     5.0    7.0   7.38  0.112
     9         1.0  6544.0     5.0    7.0   7.46  0.112
    10         1.0 63414.0     5.0    7.0   7.57    .05
    11         1.0 14570.0     5.0    7.0   7.58    .01
    12         1.0 38406.0     5.0    7.0   7.64    .03
    13         1.0 11436.0     5.0    7.0   7.69  0.161
    14         1.0  4546.0     5.0    7.0   7.74    .40
    15         1.0  1252.0     5.0    7.0   7.74  0.186
    16         1.0             5.0    7.0   7.74  0.211
    17         1.0    69.0     5.0    7.0   7.76  0.161
    18         1.0   234.0     5.0    7.0   7.76  0.198
    19         1.0             5.0    7.0   7.75  0.211
    20         1.0             5.0    7.0   7.76  0.186
    21         1.0             5.0    7.0   7.75  0.235   38
    22         1.0             5.0    7.0   7.76  0.235
    23         1.0             5.0    7.0   7.76  0.235
    24         1.0    69.0     5.0    7.0   7.76  0.223
    25         1.0 14595.0     5.0    7.0   7.72  0.62
    26         1.0 18666.0     5.0    7.0   7.54  0.322
    27         1.0  1023.0     5.0    7.0   7.54  0.46
    28         1.0 24333.0     5.0    7.0   7.37  0.87
    29         1.0   365.0     5.0    7.0   7.39  0.87
    30         1.0  1518.0     5.0    7.0   7.12  0.112
    31         1.0             5.0    7.0   7.16  0.112
    32         1.0             5.0    7.0   7.31  0.273
    33         1.0  3567.0     5.0    7.0   6.72  0.161
    34         1.0             5.0    7.0   7.54  2.48
    35         1.0             5.0    7.0   7.54  0.57
    36         1.0             5.0    7.0   7.54  0.57
    37         1.0             5.0    7.0   7.54  0.87     37
99999.                                                    35
     1    18000.         CHLORIDES (MGL)            2
     1    14255.
     2    13142.                                          36
     3     6371.
     4     6400.
     5     6428.
```

Table 8-3 (continued). INPUT DATA FOR RECEIVING EXAMPLE

```
    6      6000.
    7      6000.
    8      5114.
    9      4000.
   10      2600.
   11      2367.
   12      1667.
   13      1090.
   14       462.
   15       395.
   16       370.
   17       161.
   18       191.
   19       237.
   20       232.
   21       236.                                   36
   22       185.
   23       182.
   24       223.
   25       738.
   26      3000.
   27      2000.
   28      5214.
   29      5010.
   30      8485.
   31      8000.
   32      6000.
   33     13677.
   34      3000.
   35      3000.
   36      3000.
   37      3000.
99999.                                            37
   24                                             38
0.0        97900.
0.0
86300.     97900.
86300.
86400.     64000.
86400.
172700.    64000.
172700.
172800.    38400.
172800.
259100.    38400.                                 39
259100.
259200.    59800.
259200.
432000.    59800.
432000.
600000.    59800.
600000.
ENDPROGRAM                    (READ IN EXECUTIVE BLOCK)
```

Table 8-4. SUMMARY OF QUANTITY CONTROL INFORMATION AND TIDAL DATA

```
THIS IS A SAMPLE RUN OF QUANTITY AND QUALITY                                E.P.A.
LOWER ST. JOHNS RIVER, JULY 1972 VERIFICATION DATA.                         RECEIVING WATER HYDRODYNAMICS

DAYS SIMULATED   3
WATER QUALITY CYCLES PER DAY  25
INTEGRATION CYCLES PER WATER QUALITY CYCLE  20
LENGTH OF INTEGRATION STEP IS  180. SECONDS
INITIAL TIME  0.0  HOURS
EVAPORATION RATE,  0.0 INCHES PER MONTH
WIND VELOCITY,   0. MPH   WIND DIRECTION,   0. DEGREES FROM NORTH
ESTUARIAL SYSTEM
WRITE CYCLE STARTS AT THE   1 TIME CYCLE

NO PRECIPITATION INPUT

PRINTED OUTPUT AT THE FOLLOWING 37 JUNCTIONS
      1   2   3   4   5   6   7   8   9  10  11  12  13  14  15  16  17  18  19  20
     21  22  23  24  25  26  27  28  29  30  31  32  33  34  35  36  37

PRINTED OUTPUT FOR THE FOLLOWING 40 CHANNELS
      23024    22023    21022    20021    19020    18019    17018    16017    15017    14015
      13015    13014    14025    12013    11012    10011     9010     9026    26027     8009
       7005     7008     8028     8029     5008     6007     4006     4505     5030    30031
       3031     3004     3032     2003     2033     1002    30034    31035    31036     2037
KD IS  0 NUMBER OF TERMS IS  26 MAXIMUM NUMBER OF ITERATIONS IS  50 TIDE CHECK SWITCH IS 1
```

NO.	TIME	VALUE
1	0.0	2.940
2	1.000	3.450
3	2.000	3.910
4	3.000	3.480
5	4.000	3.5[illegible]0
6	5.000	2.[illegible]0
7	6.000	1.700
8	7.000	1.030
9	8.000	0.610
10	9.000	0.930
11	10.000	1.350
12	11.000	1.940
13	12.000	2.770
14	13.000	3.630
15	14.000	4.260
16	15.000	4.510
17	16.000	4.340
18	17.000	3.870
19	18.000	3.100
20	19.000	2.190
21	20.000	1.400
22	21.000	1.000
23	22.000	1.040
24	23.000	1.610
25	24.000	2.220
26	25.000	2.910

TIME	OBSERVED	COMPUTED	DIFF
0.0	2.9400	2.9[illegible]9	0.[illegible]49
1.0000	3.4500	3.6[illegible]30	0.15[illegible]
2.0000	3.9100	3.93[illegible]5	0.0[illegible]
3.0000	3.[illegible]00	3.[illegible]	-0.0[illegible]
4.0000	3.5[illegible]00	3.[illegible]0	-0.[illegible]
5.0000	2.[illegible]00	2.[illegible]1	-0.[illegible]04
6.0000	1.7000	1.7835	0.0934
7.0000	1.0300	1.1049	0.0749
8.0000	0.6100	0.7443	0.1343
9.0000	0.9300	0.7898	-0.1402
10.0000	1.3500	1.2309	-0.1191
11.0000	1.9400	1.9677	0.0277
12.0000	2.7700	2.8389	0.0689
13.0000	3.6300	3.6590	0.0290
14.0000	4.2600	4.2555	-0.0045
15.0000	4.5100	4.5034	-0.0066
16.0000	4.3400	4.3495	0.0095
17.0000	3.8700	3.8265	-0.0435
18.0000	3.1000	3.0501	-0.0499
19.0000	2.1900	2.1991	0.0091
20.0000	1.4000	1.4767	0.0767
21.0000	1.0000	1.0609	0.0609
22.0000	1.0400	1.0559	0.0159
23.0000	1.6100	1.4586	-0.1514
24.0000	2.2200	2.1543	-0.0657
25.0000	2.9100	2.9447	0.0347
TOTAL			1.6246

COEFFICIENTS FOR TIDAL INPUT WAVE AT JUNCTION 1

A1	A2	A3	A4	A5	A6	A7	PERIOD(HRS)
2.553	-0.339	1.580	0.069	-0.173	0.553	0.012	25.00

WHERE THE WAVEFORM IS GIVEN BY

H(J) = A1 + A2.SIN(WT) + A3.SIN(2WT) + A4.SIN(3WT) + A5.COS(WT) + A6.COS(2WT) + A7.COS(3WT)

Table 8-5. CHANNEL DATA

* * * * * C H A N N E L   D A T A * * * * *

CHANNEL NUMBER	LENGTH (FT)	WIDTH (FT)	AREA (SQ FT)	MANNING COEF.	VELOCITY (FPS)	HYD RADIUS (FT)	JUNCTIONS AT ENDS		MAX TIME STEP (SEC)	EXCEEDED BY STEP OF 180
1	19500.	5950.00	74553.	0.025	-0.08	12.5	23	24	952.	
2	20840.	5740.00	71951.	0.025	-0.17	12.5	22	23	1017.	
3	34100.	9380.00	117719.	0.025	-0.18	12.5	21	22	1653.	
4	52800.	11700.00	170527.	0.025	-0.27	14.6	20	21	2396.	
5	28700.	11070.00	172581.	0.025	-0.36	15.6	19	20	1261.	
6	40500.	12600.00	196308.	0.025	-0.40	15.6	18	19	1780.	
7	32680.	13180.00	217930.	0.025	-0.42	16.6	17	18	1394.	
8	17670.	4000.00	58220.	0.025	0.03	14.6	16	17	803.	
9	37200.	13100.00	229774.	0.025	-0.44	17.5	15	16	1543.	
10	20900.	6050.00	75564.	0.025	-0.75	12.5	14	15	1022.	
11	20950.	3920.00	52842.	0.025	-0.89	13.5	13	15	983.	
12	9430.	9110.00	95108.	0.025	-0.55	10.4	13	14	502.	
13	11570.	2020.00	17069.	0.025	0.13	8.4	14	25	632.	
14	11900.	4510.00	101114.	0.025	-0.96	22.4	12	13	438.	
15	12500.	2210.00	70033.	0.025	-1.37	31.4	11	12	328.	
16	18640.	3850.00	105509.	0.025	-0.87	27.4	10	11	632.	
17	9770.	3550.00	68970.	0.025	-1.27	19.4	9	10	386.	
18	7260.	2700.00	33426.	0.025	0.21	12.4	9	26	356.	
19	13950.	2820.00	26409.	0.025	0.14	9.4	26	27	753.	
20	14060.	2250.00	54911.	0.025	-1.16	24.4	8	9	496.	
21	8350.	1936.00	14230.	0.025	-0.79	7.3	7	9	525.	
22	6470.	1224.00	10239.	0.025	-0.85	8.4	7	8	353.	
23	10090.	1732.00	11085.	0.025	0.31	6.4	8	28	677.	
24	4390.	2540.00	16397.	0.025	0.19	6.4	8	29	294.	
25	14680.	2110.00	60082.	0.025	-0.68	28.5	5	8	480.	
26	21900.	5300.00	33496.	0.025	-0.20	6.3	6	7	1478.	
27	7040.	927.00	6911.	0.025	1.21	7.5	4	6	440.	
28	7220.	1740.00	46206.	0.025	-0.39	26.6	4	5	244.	
29	15250.	1464.00	34596.	0.025	0.48	23.6	5	30	548.	
30	8220.	1516.00	38863.	0.025	0.12	25.6	30	31	283.	
31	4390.	1634.00	46847.	0.025	0.27	28.7	3	31	143.	YES
32	9110.	1148.00	34015.	0.025	-0.18	29.6	3	4	292.	
33	7890.	935.00	16531.	0.025	0.14	17.7	3	32	326.	
34	16400.	2400.00	80988.	0.025	0.18	33.7	2	3	495.	
35	5540.	963.00	12331.	0.025	0.46	12.8	2	33	268.	
36	12480.	1992.00	63495.	0.025	0.67	31.9	1	2	387.	
37	5980.	800.00	5204.	0.025	1.17	6.5	30	34	398.	
38	12500.	900.00	11349.	0.025	0.82	12.6	31	35	608.	
39	6800.	700.00	6734.	0.025	0.84	9.6	31	36	377.	
40	8300.	800.00	10189.	0.025	1.43	12.7	2	37	402.	

Table 8-6. JUNCTION DATA

* * * * * J U N C T I O N D A T A * * * * *

JUNCTION NUMBER	INITIAL HEAD (FT)	DEPTH (FT)	SURFACE AREA (10**6 SQ FT)	INPUT (CFS)	OUTPUT (CFS)	CHANNELS ENTERING JUNCTION												COORDINATES X	Y
1	2.90	25.0	12.13	1.	0.	36	0	0	0	0	0	0	0	0	0	0	0	0.0	0.0
2	2.81	33.0	36.22	0.	0.	34	[illegible]	[illegible]	36	0	0	0	0	0	0	0	0	0.0	0.0
3	2.68	30.0	26.94	0.	0.	[illegible]	[illegible]	[illegible]	34	0	0	0	0	0	0	0	0	0.0	0.0
4	2.58	30.0	16.73	0.	0.	[illegible]	[illegible]	[illegible]	0	0	0	0	0	0	0	0	0	0.0	0.0
5	2.53	25.0	28.40	0.	0.	[illegible]	[illegible]	[illegible]	0	0	0	0	0	0	0	0	0	0.0	0.0
6	2.33	8.0	91.60	0.	0.	[illegible]	[illegible]	[illegible]	0	0	0	0	0	0	0	0	0	0.0	0.0
7	2.31	8.0	85.09	[illegible]	0.	[illegible]	[illegible]	[illegible]	0	0	0	0	0	0	0	0	0	0.0	0.0
8	2.42	26.0	93.36	5.	0.	[illegible]	[illegible]	[illegible]	22	25	0	0	0	0	0	0	0	0.0	0.0
9	2.39	12.0	49.21	5.	0.	17	[illegible]	[illegible]	21	0	0	0	0	0	0	0	0	0.0	0.0
10	2.41	17.0	48.25	[illegible]	0.	16	[illegible]	0	0	0	0	0	0	0	0	0	0	0.0	0.0
11	2.40	20.0	65.26	[illegible]	0.	15	[illegible]	0	0	0	0	0	0	0	0	0	0	0.0	0.0
12	2.41	25.0	23.14	0.	0.	14	[illegible]	0	0	0	0	0	0	0	0	0	0	0.0	0.0
13	2.43	9.0	16.50	5.	0.	11	12	14	0	0	0	0	0	0	0	0	0	0.0	0.0
14	2.45	7.0	14.00	1.	0.	10	13	12	0	0	0	0	0	0	0	0	0	0.0	0.0
15	2.53	14.0	164.30	6.	0.	9	10	1	0	0	0	0	0	0	0	0	0	0.0	0.0
16	2.56	12.0	154.90	0.	0.	8	0	0	0	0	0	0	0	0	0	0	0	0.0	0.0
17	2.57	[illegible]	453.20	0.	0.	7	8	0	0	0	0	0	0	0	0	0	0	0.0	0.0
18	2.59	13.0	430.10	0.	0.	6	7	0	0	0	0	0	0	0	0	0	0	0.0	0.0
19	2.59	12.0	459.20	0.	0.	5	6	0	0	0	0	0	0	0	0	0	0	0.0	0.0
20	2.56	14.0	430.10	0.	0.	4	5	0	0	0	0	0	0	0	0	0	0	0.0	0.0
21	2.54	10.0	406.10	0.	0.	3	4	0	0	0	0	0	0	0	0	0	0	0.0	0.0
22	2.53	10.0	206.60	0.	0.	2	3	0	0	0	0	0	0	0	0	0	0	0.0	0.0
23	2.53	10.0	130.60	0.	0.	1	2	0	0	0	0	0	0	0	0	0	0	0.0	0.0
24	[illegible]	11.0	48.10	0.	0.	1	0	0	0	0	0	0	0	0	0	0	0	0.0	0.0
25	2.45	5.0	94.60	12.	0.	13	0	0	0	0	0	0	0	0	0	0	0	0.0	0.0
26	2.37	8.0	27.48	1.	0.	19	18	0	0	0	0	0	0	0	0	0	0	0.0	0.0
27	2.36	6.0	32.60	1.	0.	19	0	0	0	0	0	0	0	0	0	0	0	0.0	0.0
28	2.38	4.0	19.73	34.	0.	23	0	0	0	0	0	0	0	0	0	0	0	0.0	0.0
29	2.42	4.0	16.73	0.	0.	24	0	0	0	0	0	0	0	0	0	0	0	0.0	0.0
30	2.61	23.0	27.09	0.	0.	30	37	29	0	0	0	0	0	0	0	0	0	0.0	0.0
31	2.66	25.0	10.32	0.	0.	[illegible]	39	30	31	0	0	0	0	0	0	0	0	0.0	0.0
32	2.68	9.0	9.93	0.	0.	33	0	0	0	0	0	0	0	0	0	0	0	0.0	0.0
33	2.60	4.0	26.00	0.	0.	35	0	0	0	0	0	0	0	0	0	0	0	0.0	0.0
34	2.40	2.0	29.00	0.	0.	37	0	0	0	0	0	0	0	0	0	0	0	0.0	0.0
35	2.56	4.0	42.00	0.	0.	38	0	0	0	0	0	0	0	0	0	0	0	0.0	0.0
36	2.58	4.0	25.00	0.	0.	39	0	0	0	0	0	0	0	0	0	0	0	0.0	0.0
37	2.65	4.0	63.70	0.	0.	40	0	0	0	0	0	0	0	0	0	0	0	0.0	0.0

TOTAL AREA FOR THE SYSTEM 4344.09 * 10**6 SQ FT OR 155.82 SQ MILES

JULY 19, 1972 TIDE AT MAYPORT. USE MEASURED FLOW AT PALATKA, JULY 17-20, 1973.

Table 8-7. SAMPLE JUNCTION OUTPUT, DAY 1

THIS IS A SAMPLE RUN OF QUANTITY AND QUALITY
LOWER ST. JOHNS RIVER, JULY 1972 VERIFICATION DATA.

E.P.A.
RECEIVING WATER HYDRODYNAMICS

JULY 19, 1972 TIDE AT MAYPORT.

USE MEASURED FLOW AT PALATKA, JULY 17-20, 1973.

DAY IS 1

* T I M E H I S T O R Y O F S T A G E *

HOUR	JUNCTION 13 HEAD(FEET)	JUNCTION 14 HEAD(FEET)	JUNCTION 15 HEAD(FEET)	JUNCTION 16 HEAD(FEET)	JUNCTION 17 HEAD(FEET)	JUNCTION 18 HEAD(FEET)
0.0	2.4300	2.4500	2.5300	2.5600	2.5500	2.5700
1.00	2.6026	2.5759	2.5491	2.4912	2.5045	2.4874
2.00	2.8817	2.8390	2.6936	2.5216	2.5447	2.4548
3.00	3.0239	2.9779	2.8219	2.7338	2.7205	2.6127
4.00	3.0430	3.0033	2.8815	2.8320	2.8286	2.7585
5.00	2.9799	2.9611	2.8825	2.8634	2.8613	2.8391
6.00	2.8222	2.8344	2.8429	2.8749	2.8641	2.8615
7.00	2.5209	2.5678	2.6871	2.8046	2.7939	2.8668
8.00	2.3159	2.3666	2.5051	2.6355	2.6318	2.7603
9.00	2.2405	2.3000	2.4670	2.5266	2.5484	2.6428
10.00	2.2054	2.2749	2.4365	2.5282	2.5054	2.5433
11.00	2.2061	2.2571	2.3968	2.4166	2.4352	2.4719
12.00	2.2346	2.2564	2.3380	2.3751	2.3589	2.3667
13.00	2.4204	2.3863	2.3501	2.2766	2.2961	2.2705
14.00	2.7157	2.6606	2.5075	2.3130	2.3397	2.2435
15.00	2.8919	2.8382	2.6431	2.5560	2.5403	2.4410
16.00	2.9999	2.9316	2.7584	2.6813	2.6830	2.5982
17.00	3.0665	3.0062	2.8334	2.7621	2.7646	2.7120
18.00	3.0644	3.0267	2.8930	2.8558	2.8467	2.8002
19.00	2.9560	2.9510	2.9014	2.9033	2.9041	2.9054
20.00	2.7150	2.7550	2.8362	2.9375	2.9243	2.9790
21.00	2.4961	2.5436	2.6767	2.8562	2.8338	2.9479
22.00	2.4023	2.4576	2.6159	2.6612	2.6903	2.7696
23.00	2.3518	2.4108	2.5443	2.6211	2.6096	2.6094
24.00	2.3403	2.3890	2.5179	2.5574	2.5620	2.5998
25.00	2.3878	2.4055	2.4858	2.5897	2.5014	2.5157

Table 8-7 (continued). SAMPLE JUNCTION OUTPUT, DAY 1

THIS IS A SAMPLE RUN OF QUANTITY AND QUALITY
LOWER ST. JOHNS RIVER, JULY 1972 VERIFICATION DATA.

E.P.A.
RECEIVING WATER HYDRODYNAMICS

JULY 19, 1972 TIDE AT MAYPORT.

USE MEASURED FLOW AT PALATKA, JULY 17-20, 1973.

DAY IS 1

* T I M E H I S T O R Y O F S T A G E *

HOUR	JUNCTION 1 HEAD(FEET)	JUNCTION 2 HEAD(FEET)	JUNCTION 3 HEAD(FEET)	JUNCTION 4 HEAD(FEET)	JUNCTION 5 HEAD(FEET)	JUNCTION 6 HEAD(FEET)
0.0	2.9400	2.8100	2.6800	2.5800	2.5300	2.3300
1.00	3.6030	3.4928	3.3848	3.2843	3.2361	2.9516
2.00	3.9386	3.8709	3.8029	3.7081	3.6657	3.5366
3.00	3.8528	3.9423	3.8231	3.7490	3.7185	3.6417
4.00	3.3660	3.4226	3.4715	3.4716	3.4684	3.4940
5.00	2.6091	2.7294	2.8591	2.9471	2.9806	3.1029
6.00	1.7837	1.9543	2.0959	2.2138	2.2706	2.5752
7.00	1.1049	1.3245	1.4831	1.6412	1.7097	2.0223
8.00	0.7442	0.9555	1.1101	1.3001	1.3772	1.6728
9.00	0.7898	0.9030	1.0022	1.1754	1.2405	1.5378
10.00	1.2309	1.2215	1.2179	1.3065	1.3442	1.4751
11.00	1.9677	1.8673	1.7678	1.7308	1.7249	1.6164
12.00	2.8390	2.7048	2.5648	2.4533	2.3976	2.1449
13.00	3.6590	3.4897	3.3442	3.2114	3.1524	2.8136
14.00	4.2556	4.0701	3.9207	3.7581	3.6925	3.4714
15.00	4.5034	4.3422	4.2068	4.0204	3.9529	3.6929
16.00	4.3495	4.2630	4.1907	4.0467	3.9950	3.7875
17.00	3.8264	3.8505	3.8735	3.8212	3.8007	3.7502
18.00	3.0501	3.1620	3.2802	3.3442	3.3597	3.4602
19.00	2.1991	2.3406	2.4750	2.5818	2.6372	2.8876
20.00	1.4766	1.6474	1.7790	1.9051	1.9631	2.2922
21.00	1.0609	1.2297	1.3594	1.5154	1.5830	1.8112
22.00	1.0559	1.1548	1.2477	1.4052	1.4689	1.6950
23.00	1.4587	1.4540	1.4540	1.5355	1.5697	1.6821
24.00	2.1544	2.0598	1.9660	1.9302	1.9230	1.8290
25.00	2.9448	2.8260	2.6976	2.5941	2.5432	2.3253

Table 8-8. SAMPLE CHANNEL OUTPUT, DAY 1

THIS IS A SAMPLE RUN OF QUANTITY AND QUALITY
LOWER ST. JOHNS RIVER, JULY 1972 VERIFICATION DATA.

E.P.A.
RECEIVING WATER HYDRODYNAMICS

JULY 19, 1972 TIDE AT MAYPORT.

USE MEASURED FLOW AT PALATKA, JULY 17-20, 1973.

DAY IS 1

* * * * * * * * * * * * * * * T I M E H I S T O R Y O F F L O W A N D V E L O C I T Y * * * * * * * * * * * * * * *

HOUR	CHANNEL 3 31 FLOW (CFS)	VEL (FPS)	CHANNEL 3 4 FLOW (CFS)	VEL (FPS)	CHANNEL 3 32 FLOW (CFS)	VEL (FPS)	CHANNEL 2 3 FLOW (CFS)	VEL (FPS)	CHANNEL 2 33 FLOW (CFS)	VEL (FPS)	CHANNEL 1 2 FLOW (CFS)	VEL (FPS)
0.0	0.	0.27	0.	-0.18	**********	0.16	0.	0.18	0.	0.46	0.	0.67
1.00	33610.	0.70	35628.	1.04	1624.	0.09	75199.	0.92	3772.	0.29	96778.	1.50
2.00	39073.	0.80	57932.	1.64	708.	0.04	99521.	1.19	1274.	0.09	106982.	1.63
3.00	33485.	0.66	61533.	1.74	-489.	-0.03	93205.	1.11	-1737.	-0.13	84770.	1.29
4.00	18990.	0.39	48146.	1.37	-1310.	-0.08	62263.	0.75	-3962.	-0.31	43716.	0.66
5.00	-4670.	-0.11	15177.	0.43	-2013.	-0.12	3022.	0.03	-5620.	-0.46	-23061.	-0.38
6.00	-31313.	-0.69	-27311.	-0.83	-2021.	-0.13	-66056.	-0.84	-5430.	-0.47	-92346.	-1.51
7.00	-46845.	-1.05	-58804.	-1.80	-1364.	-0.09	-110766.	-1.43	-3844.	-0.35	-130644.	-2.18
8.00	-53894.	-1.22	-74898.	-2.32	-667.	-0.05	-131332.	-1.71	-1483.	-0.16	-141272.	-2.38
9.00	-50346.	-1.14	-78590.	-2.44	57.	0.00	-128704.	-1.68	730.	0.07	-125148.	-2.18
10.00	-35610.	-0.80	-69072.	-2.12	1104.	0.07	-100618.	-1.30	3590.	0.34	-80436.	-1.39
11.00	-13497.	-0.29	-44481.	-1.33	1855.	0.12	-51084.	-0.64	5552.	0.49	-25522.	-0.40
12.00	16998.	0.37	-2107.	-0.04	2441.	0.15	23843.	0.31	6297.	0.52	54722.	0.48
13.00	40826.	0.86	44305.	1.29	1886.	0.11	92282.	1.13	5094.	0.39	119004.	1.45
14.00	55706.	1.18	74304.	2.11	1273.	0.07	134745.	1.61	3204.	0.23	151698.	2.30
15.00	60380.	1.27	89731.	2.52	368.	0.02	151506.	1.79	706.	0.05	155413.	2.33
16.00	54103.	1.09	89381.	2.50	-442.	-0.03	141830.	1.67	-1805.	-0.13	133274.	2.00
17.00	36521.	0.74	71432.	2.01	-1240.	-0.07	103348.	1.23	-3944.	-0.30	85104.	1.29
18.00	9562.	0.19	37692.	1.07	-1960.	-0.11	39991.	0.48	-5688.	-0.45	13472.	0.19
19.00	-21122.	-0.46	-7905.	-0.25	-2236.	-0.14	-37356.	-0.46	-5863.	-0.49	-65500.	-1.07
20.00	-38970.	-0.85	-44963.	-1.37	-1608.	-0.10	-93349.	-1.14	-4249.	-0.38	-111522.	-1.84
21.00	-46759.	-1.05	-64998.	-2.00	-767.	-0.05	-118551.	-1.48	-1933.	-0.18	-125999.	-2.10
22.00	-45731.	-1.03	-73369.	-2.26	74.	0.01	-118640.	-1.54	673.	0.07	-115823.	-1.93
23.00	-34360.	-0.76	-66790.	-2.04	1046.	0.07	-97315.	-1.24	3466.	0.32	-81616.	-1.34
24.00	-13835.	-0.30	-43839.	-1.39	1133.	0.11	-50858.	-0.63	5185.	0.43	-26869.	-0.62
25.00	14757.	0.32	-2746.	-0.07	2240.	0.13	20143.	0.26	5591.	0.45	48121.	0.77

Table 8-8 (continued). SAMPLE CHANNEL OUTPUT, DAY 1

THIS IS A SAMPLE RUN OF QUANTITY AND QUALITY
LOWER ST. JOHNS RIVER, JULY 1972 VERIFICATION DATA.

E.P.A.
RECEIVING WATER HYDRODYNAMICS

JULY 19, 1972 TIDE AT MAYPORT.

USE MEASURED FLOW AT PALATKA, JULY 17-20, 1973.

DAY IS 1

* * * * * * * * * * * * * * * T I M E   H I S T O R Y   O F   F L O W   A N D   V E L O C I T Y * * * * * * * * * * * * * * *

HOUR	CHANNEL 17 18 FLOW (CFS)	CHANNEL 17 18 VEL (FPS)	CHANNEL 16 17 FLOW (CFS)	CHANNEL 16 17 VEL (FPS)	CHANNEL 15 17 FLOW (CFS)	CHANNEL 15 17 VEL (FPS)	CHANNEL 14 15 FLOW (CFS)	CHANNEL 14 15 VEL (FPS)	CHANNEL 13 15 FLOW (CFS)	CHANNEL 13 15 VEL (FPS)	CHANNEL 13 14 FLOW (CFS)	CHANNEL 13 14 VEL (FPS)
0.0	0.	-0.42	0.	0.03	0.	-0.48	0.	-0.75	0.	-0.89	0.	-0.55
1.00	-65899.	-0.30	2436.	0.09	-71963.	-0.31	-37078.	-0.48	-28361.	-0.53	-27452.	-0.28
2.00	-19612.	-0.09	-5159.	-0.09	1363.	0.01	8596.	0.12	15866.	0.30	20585.	0.25
3.00	65234.	0.30	-10557.	-0.18	94063.	0.41	51422.	0.68	48207.	0.89	56017.	0.58
4.00	104824.	0.48	602.	0.01	113147.	0.48	63463.	0.81	54856.	0.99	61553.	0.61
5.00	100522.	0.45	-3035.	-0.05	106569.	0.45	55137.	0.72	47129.	0.86	53576.	0.56
6.00	84602.	0.38	2415.	0.04	79152.	0.34	40760.	0.52	31406.	0.57	29667.	0.30
7.00	44658.	0.20	3398.	0.06	25892.	0.11	4590.	0.05	-3108.	-0.07	-13078.	-0.18
8.00	-42263.	-0.20	10436.	0.18	-70634.	-0.31	-37908.	-0.51	-38543.	-0.70	-47316.	-0.50
9.00	-106115.	-0.49	-2340.	-0.04	-111306.	-0.49	-61054.	-0.82	-54006.	-1.03	-61303.	-0.68
10.00	-110147.	-0.51	5019.	0.09	-121379.	-0.53	-65771.	-0.88	-57387.	-1.10	-67656.	-0.73
11.00	-100222.	-0.46	1950.	0.03	-111912.	-0.49	-63634.	-0.86	-55222.	-1.06	-65030.	-0.70
12.00	-85865.	-0.40	1973.	0.07	-98665.	-0.43	-55015.	-0.74	-46548.	-0.89	-53004.	-0.57
13.00	-59831.	-0.28	2091.	0.03	-66925.	-0.29	-35209.	-0.47	-26043.	-0.50	-23797.	-0.28
14.00	-10932.	-0.05	-4947.	-0.09	13825.	0.07	16462.	0.23	22495.	0.43	32276.	0.34
15.00	71099.	0.33	-12685.	-0.22	104460.	0.46	58930.	0.77	54700.	1.02	65552.	0.67
16.00	110033.	0.50	-403.	-0.01	123560.	0.53	72164.	0.93	63205.	1.16	76638.	0.77
17.00	114098.	0.52	-6020.	-0.10	131283.	0.56	73082.	0.90	63338.	1.16	77690.	0.77
18.00	113030.	0.51	-1368.	-0.02	123735.	0.53	70032.	0.89	58896.	1.07	67897.	0.67
19.00	95232.	0.43	-3428.	-0.06	103791.	0.44	55488.	0.71	45177.	0.82	49281.	0.49
20.00	55437.	0.25	1206.	0.02	52525.	0.22	25402.	0.32	16475.	0.30	10923.	0.11
21.00	-16682.	-0.08	4032.	0.10	-43326.	-0.19	-26998.	-0.36	-30270.	-0.56	-37167.	-0.34
22.00	-82885.	-0.38	6814.	0.11	-103308.	-0.45	-57792.	-0.76	-52018.	-0.98	-58782.	-0.62
23.00	-105327.	-0.48	147.	0.00	-111478.	-0.48	-62239.	-0.82	-54588.	-1.04	-65186.	-0.69
24.00	-100651.	-0.46	3780.	0.06	-111615.	-0.49	-61404.	-0.81	-53153.	-1.01	-62795.	-0.66
25.00	-84674.	-0.41	1466.	0.03	-96878.	-0.43	-55147.	-0.73	-46072.	-0.87	-50755.	-0.53

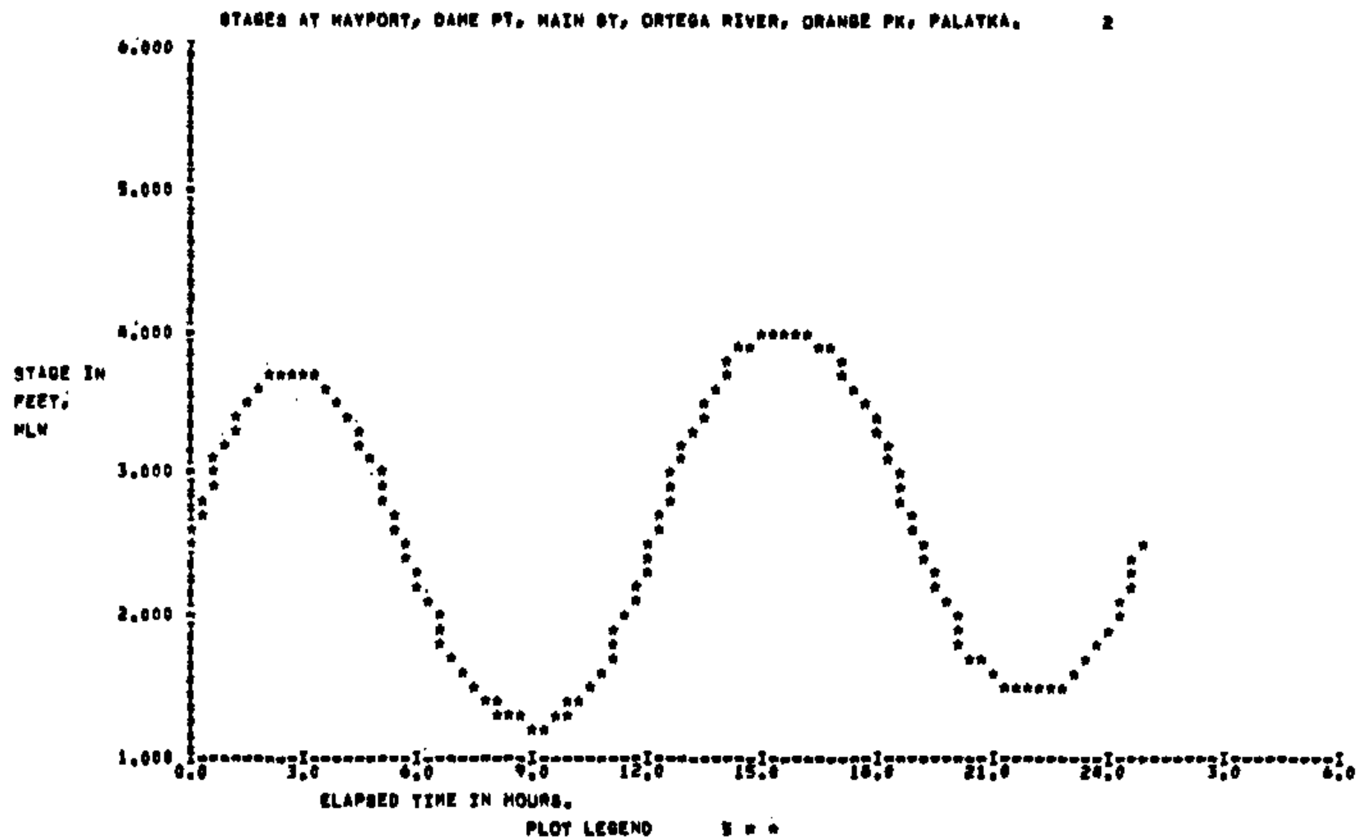

Figure 8-8. Stages at Junction 5 (Dame Pt.), Day 1

Table 8-9. SAMPLE JUNCTION OUTPUT, DAY 2

THIS IS A SAMPLE RUN OF QUANTITY AND QUALITY
LOWER ST. JOHNS RIVER, JULY 1972 VERIFICATION DATA.

E.P.A.
RECEIVING WATER HYDRODYNAMICS

JULY 19, 1972 TIDE AT MAYPORT.

USE MEASURED FLOW AT PALATKA, JULY 17-20, 1973.

DAY IS 2

* T I M E H I S T O R Y O F S T A G E *

HOUR	JUNCTION 13 HEAD(FEET)	JUNCTION 14 HEAD(FEET)	JUNCTION 15 HEAD(FEET)	JUNCTION 16 HEAD(FEET)	JUNCTION 17 HEAD(FEET)	JUNCTION 18 HEAD(FEET)
0.0	2.3870	2.4055	2.4838	2.5057	2.5014	2.5157
1.00	2.5760	2.5451	2.5070	2.4459	2.4565	2.4276
2.00	2.8500	2.8021	2.6619	2.4759	2.5040	2.4099
3.00	2.9800	2.9325	2.7755	2.7060	2.6870	2.6008
4.00	3.0152	2.9744	2.8634	2.8169	2.8156	2.7842
5.00	2.9758	2.9574	2.8760	2.8574	2.8538	2.8247
6.00	2.8279	2.8038	2.8438	2.8678	2.8609	2.8613
7.00	2.5274	2.5710	2.6881	2.8187	2.8032	2.8759
8.00	2.3371	2.3788	2.5193	2.6479	2.6498	2.7911
9.00	2.2593	2.3199	2.4935	2.5626	2.5777	2.6708
10.00	2.2356	2.3032	2.4678	2.5541	2.5358	2.5732
11.00	2.2334	2.2852	2.4259	2.4487	2.4638	2.5057
12.00	2.2613	2.2846	2.3708	2.4181	2.3943	2.4047
13.00	2.4469	2.4150	2.3847	2.3154	2.3356	2.3162
14.00	2.7506	2.6975	2.5463	2.3598	2.3850	2.2908
15.00	2.9404	2.8792	2.7002	2.6109	2.5972	2.4962
16.00	3.0506	2.9857	2.8194	2.7489	2.7469	2.6621
17.00	3.1193	3.0610	2.8964	2.8251	2.8297	2.7806
18.00	3.1139	3.0792	2.9536	2.9206	2.9112	2.8668
19.00	3.0036	3.0016	2.9604	2.9639	2.9666	2.9772
20.00	2.7577	2.7997	2.8903	3.0007	2.9873	3.0521
21.00	2.5531	2.6039	2.7437	2.9245	2.9044	3.0253
22.00	2.4701	2.5365	2.7014	2.7489	2.7747	2.8550
23.00	2.4331	2.4945	2.6362	2.7074	2.6983	2.7571
24.00	2.4174	2.4640	2.6026	2.6457	2.6486	2.6868
25.00	2.4563	2.4780	2.5826	2.5874	2.5833	2.6002

Table 8-10. SAMPLE CHANNEL OUTPUT, DAY 2

THIS IS A SAMPLE RUN OF QUANTITY AND QUALITY
LOWER ST. JOHNS RIVER, JULY 1972 VERIFICATION DATA.

E.P.A.
RECEIVING WATER HYDRODYNAMICS

JULY 19, 1972 TIDE AT MAYPORT.

USE MEASURED FLOW AT PALATKA, JULY 17-20, 1973.

DAY IS 2

* * * * * * * * * * * * * * * T I M E H I S T O R Y O F F L O W A N D V E L O C I T Y * * * * * * * * * * * * * * *

HOUR	CHANNEL 17 18 FLOW (CFS)	VEL. (FPS)	CHANNEL 16 17 FLOW (CFS)	VEL. (FPS)	CHANNEL 15 17 FLOW (CFS)	VEL. (FPS)	CHANNEL 14 15 FLOW (CFS)	VEL. (FPS)	CHANNEL 13 15 FLOW (CFS)	VEL. (FPS)	CHANNEL 13 14 FLOW (CFS)	VEL. (FPS)
0.0	-89679.	-0.41	1448.	0.03	-98874.	-0.43	-55147.	-0.73	-46073.	-0.87	-50755.	-0.33
1.00	-62744.	-0.29	2576.	0.04	-68050.	-0.29	-34445.	-0.45	-25872.	-0.48	-23718.	-0.24
2.00	-12442.	-0.05	-5707.	-0.10	10990.	0.05	13238.	0.18	19316.	0.37	28070.	0.29
3.00	66004.	0.30	-10622.	-0.18	96649.	0.42	53843.	0.70	49795.	0.92	57519.	0.58
4.00	97772.	0.44	-1163.	-0.02	108359.	0.46	62315.	0.80	[illegible]	0.95	62529.	0.62
5.00	98683.	0.44	-1908.	-0.03	104434.	0.45	55320.	0.71	[illegible]	0.85	54162.	0.54
6.00	83155.	0.37	1157.	0.02	80346.	0.34	41431.	0.53	[illegible]	0.58	29978.	0.30
7.00	43522.	0.19	3406.	0.06	25908.	0.11	5150.	0.06	[illegible]	[illegible]	-12253.	-0.13
8.00	-46285.	-0.22	9892.	0.17	-72550.	-0.33	-38489.	-0.52	[illegible]	[illegible]	-47464.	-0.51
9.00	-110905.	-0.51	-3026.	-0.05	-114867.	-0.50	-62442.	-0.83	-55028.	-1.05	-61980.	-0.66
10.00	-111318.	-0.51	5637.	0.10	-123407.	-0.54	-66957.	-0.89	-58296.	-1.11	-68548.	-0.73
11.00	-102510.	-0.47	1355.	0.02	-112947.	-0.49	-64349.	-0.86	-55724	-1.07	-65859.	-0.70
12.00	-88237.	-0.41	4140.	0.07	-100800.	-0.44	-55957.	-0.75	-47327.	-0.90	-53805.	-0.57
13.00	-63788.	-0.30	1619.	0.03	-70098.	-0.31	-36803.	-0.49	-27848.	-0.52	-25276.	-0.26
14.00	-18027.	-0.08	-5087.	-0.09	6894.	0.04	13516.	0.19	20039.	0.39	30049.	0.31
15.00	64243.	0.30	-13506.	-0.23	99831.	0.43	56565.	0.74	53056.	0.96	64141.	0.65
16.00	106640.	0.49	-376.	-0.01	120882.	0.52	70896.	0.91	62166.	1.14	75362.	0.75
17.00	112007.	0.51	-6111.	-0.10	129259.	0.55	71881.	0.92	62278.	1.13	76451.	0.76
18.00	110936.	0.50	-1274.	-0.02	121340.	0.52	68728.	0.87	57726.	1.04	66514.	0.66
19.00	92776.	0.41	-3335.	-0.06	100955.	0.43	53806.	0.68	43632.	0.79	47346.	0.47
20.00	49501.	0.22	1085.	0.02	47234.	0.20	22505.	0.28	13754.	0.24	7728.	0.07
21.00	-30173.	-0.14	5601.	0.10	-54564.	-0.24	-31166.	-0.41	-33544.	-0.63	-40224.	-0.42
22.00	-90876.	-0.41	5955.	0.10	-109774.	-0.47	-61414.	-0.81	-54575.	-1.03	-61051.	-0.64
23.00	-108929.	-0.50	653.	0.01	-115376.	-0.50	-66167.	-0.84	-56230.	-1.06	-67721.	-0.71
24.00	-103139.	-0.47	3528.	0.06	-114135.	-0.49	-63269.	-0.83	-54710.	-1.03	-64784.	-0.68
25.00	-91722.	-0.42	2111.	0.04	-102187.	-0.44	-57094.	-0.75	-47610.	-0.90	-53167.	-0.56

Table 8-11. QUALITY CONTROL INFORMATION

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JULY 19, 1972 TIDE AT MAYPORT.                                   USE MEASURED FLOW AT PALATKA, JULY 17-20, 1973.
THIS IS A SAMPLE RUN OF QUANTITY AND QUALITY                                                            F.P.A.
LOWER ST. JOHNS RIVER, JULY 1972 VERIFICATION DATA.                                     DYNAMIC STORM WATER QUALITY

MAXIMUM JUNCTION NUMBER   37
MAXIMUM CHANNEL NUMBER   40
NUMBER OF QUALITY CYCLES PER DAY   25
NUMBER OF DAYS    3
NUMBER OF CONSTITUENTS   2
** CHLORIDES MUST BE CONSTITUENT NUMBER  2
LENGTH OF QUALITY INTEGRATION STEP (SECONDS)  3600.
PRINT INTERVAL.   1 DAYS
EXCHANGE REQUIREMENT AT OCEAN = RATIO OF ESTUARINE FLOW RETURNED TO AMOUNT THAT FLOWS OUT, PER TIDAL CYCLE   0.10
AVERAGE WATER TEMPERATURE (DEGREES CENTIGRADE)  29.00
THERE ARE  1 STORMWATER INPUT JUNCTIONS
QUALITY CYCLE CONCENTRATIONS, PRINTOUT STARTS IN TIME CYCLE  1 .
   PRINTED EVERY  3  HOUR(S), FOR A TOTAL OF 108 HOURS.

                 * * * * *  SWITCH  SETTINGS  * * * * *
SWITCH NUMBER     1    2    3    4    5    6    7    8    9   10
SWITCH SETTING    0    0    0    1    1    0    2    2    0    0
```

Table 8-12. BOD INPUT DATA

CONSTITUENT NUMBER 1 BOD

SINK CONCENTRATION, MGL (OR MPN/L) 0.0

OXYGEN SATURATION (MGL) 7.00

REAERATION COEFFICIENT (1/DAY) 0.100

DECAY COEFFICIENT (1/DAY) 0.40

DISSOLVED OXYGEN FOR THIS CONSTITUENT IS CONSTITUENT 3

INITIAL CONCENTRATIONS, MGL (OR MPN/L), BY JUNCTION

JUNCTION	1	2	3	4	5	6	7	8	9	10
1 TO 10	0.100E 01	0.100E 01	0.100E 01	0.100E 01	0.100E 01	0.100E 01	0.100E 01	0.100E 01	0.100E 01	0.100E 01
11 TO 20	0.100E 01	0.100E 01	0.100E 01	0.100E 01	0.100E 01	0.100E 01	0.100E 01	0.100E 01	0.100E 01	0.100E 01
21 TO 30	0.100E 01	0.100E 01	0.100E 01	0.100E 01	0.100E 01	0.100E 01	0.100E 01	0.100E 01	0.100E 01	0.100E 01
31 TO 37	0.100E 01	0.100E 01	0.100E 01	0.100E 01	0.100E 01	0.100E 01	0.100E 01			

MASS LOADINGS, THOUSANDS OF LBS/DAY (OR OF MPN/MIN), BY JUNCTION

JUNCTION	1	2	3	4	5	6	7	8	9	10
1 TO 10	0.162	0.022	0.0	0.0	0.0	0.345	0.331	16.755	6.544	63.614
11 TO 20	14.570	38.408	11.836	4.544	[illegible]	0.0	[illegible]	[illegible]	0.0	0.0
21 TO 30	0.0	0.0	0.0	0.049	14.595	10.868	1.023	24.333	0.545	1.518
31 TO 37	0.0	0.0	5.567	0.0	0.0	0.0	0.0			

Table 8-13. DO INPUT DATA

INITIAL DISSOLVED OXYGEN CONCENTRATIONS (MGL), BY JUNCTION

JUNCTION	1	2	3	4	5	6	7	8	9	10
1 TO 10	0.500E 01	0.500E 01	0.500E 01	0.500E 01	0.500E 01	0.500E 01	0.500E 01	0.500E 01	0.500E 01	0.500E 01
11 TO 20	0.500E 01	0.500E 01	0.500E 01	0.500E 01	0.500E 01	0.500E 01	0.500E 01	0.500E 01	0.500E 01	0.500E 01
21 TO 30	0.500E 01	0.500E 01	0.500E 01	0.500E 01	0.500E 01	0.500E 01	0.500E 01	0.500E 01	0.500E 01	0.500E 01
31 TO 37	0.500E 01	0.500E 01	0.500E 01	0.500E 01	0.500E 01	0.500E 01	0.500E 01			

DISSOLVED OXYGEN CONCENTRATION OF INFLOW (MGL), JUNCTION

JUNCTION	1	2	3	4	5	6	7	8	9	10
1 TO 10	0.700E 01	0.700E 01	0.700E 01	0.700E 01	0.700E 01	0.700E 01	0.700E 01	0.700E 01	0.700E 01	0.700E 01
11 TO 20	0.700E 01	0.700E 01	0.700E 01	0.700E 01	0.700E 01	0.700E 01	0.700E 01	0.700E 01	0.700E 01	0.700E 01
21 TO 30	0.700E 01	0.700E 01	0.700E 01	0.700E 01	0.700E 01	0.700E 01	0.700E 01	0.700E 01	0.700E 01	0.700E 01
31 TO 37	0.700E 01	0.700E 01	0.700E 01	0.700E 01	0.700E 01	0.700E 01	0.700E 01			

DO SATURATIONS ARE COMPUTED AT EACH JUNCTION AT EACH TIME STEP AS FUNCTION OF CHLORIDE CONC (CONSTITUENT 2) BY FORMULA:
CSAT (MGL) = 7.77 - 0.7600E-04 * CHLORIDES (MGL) FOR TEMPERATURE OF 29.0 DEG. CENT.

REAERATION COEFFICIENTS ARE COMPUTED AT EACH JUNCTION AT EACH TIME STEP USING OCONNOR AND DOBBINS FORMULA:
REAR COEF(1/SEC) = SQRT(D*U)/H**1.5 WHERE U=AVE VELOCITY, H=DEPTH AND
D=MOLECULAR DIFFUSIVITY OF OXYGEN IN WATER = 0.3045E-07 SQ FT/SEC AT 29.0 DEG. CENT.
A MINIMUM VALUE OF 2 FT/DAY/DEPTH WILL BE USED

Table 8-14. CHLORIDES INPUT DATA

CONSTITUENT NUMBER 2 CHLORIDES (MGL)

SINK CONCENTRATION, MGL (OR MPN/L)18000.00

INITIAL CONCENTRATIONS, MGL (OR MPN/L), BY JUNCTION

JUNCTION	1	2	3	4	5	6	7	8	9	10
1 TO 10	0.193E 05	0.131E 05	0.637E 04	0.640E 04	0.643E 04	0.600E 04	0.600E 04	0.311E 04	0.400E 04	0.260E 04
11 TO 20	0.237E 04	0.167E 04	0.109E 04	0.462E 03	0.395E 03	0.370E 03	0.161E 03	0.191E 05	0.237E 05	0.232E 05
21 TO 30	0.336E 03	0.185E 03	0.182E 03	0.223E 03	0.738E 03	0.300E 04	0.200E 04	0.521E 04	0.500E 04	0.849E 04
31 TO 37	0.600E 04	0.600E 04	0.137E 05	0.300E 04	0.300E 04	0.500E 04	0.500E 04			

MASS LOADINGS, THOUSANDS OF LBS/DAY (OR OF MPN/MIN), BY JUNCTION

JUNCTION	1	2	3	4	5	6	7	8	9	10
1 TO 10	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
11 TO 20	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
21 TO 30	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
31 TO 37	0.0	0.0	0.0	0.0	0.0	0.0	0.0			

CONSTITUENT NUMBER 1 AT 0.0 HOURS OR 0.0 DAYS FROM START

JUNCTION	LBS/DAY
24	0.979E 05

CONSTITUENT NUMBER 2 AT 0.0 HOURS OR 0.0 DAYS FROM START

JUNCTION	LBS/DAY
24	0.0

Table 8-15. QUALITY OUTPUT DURING DAY 1. SINCE THIS IS THE "WARM-UP" DAY, TZERO BEGINS ON DAY 2 AND THE CUMULATIVE TIME IS LISTED AS ZERO.

THIS IS A SAMPLE RUN OF QUANTITY AND QUALITY.
LOWER ST. JOHNS RIVER, JULY 1972 VERIFICATION DATA.

EPA STORMWATER MODEL
RECEIVING WATER QUALITY

JULY 19, 1972 TIDE AT MAYPORT. USE MEASURED FLOW AT PALATKA, JULY 17-20, 1972.
JUNCTION CONCENTRATIONS, MGL (OR MPN/L), DURING TIME CYCLE (DAY) 1, QUALITY CYCLE 3, TIME (SEC) 0.

CONSTITUENT NUMBER 1, BOD

JUNCTION	1	2	3	4	5	6	7	8	9	10
1 TO 10	0.00	0.37	0.87	0.95	0.95	0.95	0.96	0.78	0.97	1.02
11 TO 20	0.97	1.04	0.96	0.96	0.95	0.95	0.98	0.92	0.95	0.95
21 TO 30	0.95	0.95	0.95	0.95	0.98	1.05	0.97	1.26	0.96	0.95
31 TO 37	0.95	0.95	0.97	0.95	0.95	0.95	0.95			

CONSTITUENT NUMBER 2, CHLORIDES (MGL)

JUNCTION	1	2	3	4	5	6	7	8	9	10
1 TO 10	17995.16	16309.45	10390.55	8163.00	6768.95	6634.55	5204.86	5671.07	4252.91	3138.08
11 TO 20	2208.29	1786.07	1122.35	342.64	420.33	342.41	168.14	[illegible]	[illegible]	[illegible]
21 TO 30	234.72	184.91	182.57	225.00	460.74	3189.30	2684.49	5178.71	5015.66	7764.46
31 TO 37	8202.15	6059.66	13534.15	7644.43	4583.49	5580.05	10424.85			

CONSTITUENT NUMBER 3, BOD (DO)

JUNCTION	1	2	3	4	5	6	7	8	9	10
1 TO 10	6.39	4.61	4.56	4.98	4.98	5.06	5.07	4.98	4.99	4.98
11 TO 20	4.98	4.98	5.01	5.02	5.00	5.00	4.99	5.00	5.00	5.00
21 TO 30	5.00	5.01	5.01	5.01	5.05	5.01	5.02	5.04	5.03	4.96
31 TO 37	4.97	4.98	4.98	5.07	5.01	5.03	5.01			

COMPUTED OXYGEN SATURATION VALUES(MGL) AT THIS TIME STEP

JUNCTION	1	2	3	4	5	6	7	8	9	10
1 TO 10	6.40	6.53	6.90	7.15	7.26	7.26	7.37	7.34	7.45	7.93
11 TO 20	7.60	7.63	7.66	[illegible]	7.74	7.74	7.79	7.76	7.75	7.75
21 TO 30	7.75	7.76	7.76	7.75	7.72	7.53	7.81	7.38	7.39	7.18
31 TO 37	7.15	7.31	6.74	7.14	7.42	7.35	6.98			

COMPUTED REAERATION COEFFICIENTS (1/DAY) AT THIS TIME STEP

JUNCTION	1	2	3	4	5	6	7	8	9	10
1 TO 10	0.10	0.07	0.08	0.14	0.11	0.58	0.51	0.16	0.17	0.12
11 TO 20	0.15	0.12	0.21	0.24	0.15	0.15	0.14	0.12	0.15	0.16
21 TO 30	0.15	0.16	0.16	0.16	0.26	0.17	0.19	0.26	0.26	0.11
31 TO 37	0.10	0.11	0.14	0.25	0.14	0.16	0.14			

Table 8-16. SUMMARY BOD OUTPUT, DAY 1

JULY 19, 1972 TIDE AT MAYPORT. USE MEASURED FLOW AT PALATKA, JULY 17-20, 1973.

THIS IS A SAMPLE RUN OF QUANTITY AND QUALITY
LOWER ST. JOHNS RIVER, JULY 1972 VERIFICATION DATA.

E.P.A.
DYNAMIC STORM WATER QUALITY

AVERAGE JUNCTION CONCENTRATIONS, MGL (OR MPN/L), DURING TIDAL OR TIME CYCLE 1, CONSTITUENT NUMBER 1 BOD

JUNCTION	1	2	3	4	5	6	7	8	9	10
1 TO 10	0.244E 00	0.468E 00	0.663E 00	0.735E 00	0.820E 00	0.763E 00	0.909E 00	0.916E 00	0.950E 00	0.101E 01
11 TO 20	0.987E 00	0.104E 01	0.941E 00	0.865E 00	0.849E 00	0.817E 00	0.820E 00	0.817E 00	0.817E 00	0.817E 00
21 TO 30	0.817E 00	0.817E 00	0.817E 00	0.817E 00	0.929E 00	0.120E 01	0.867E 00	0.195E 01	0.870E 00	0.800E 00
31 TO 37	0.746E 00	0.817E 00	0.803E 00	0.835E 00	0.819E 00	0.820E 00	0.726E 00			

MAXIMUMS

JUNCTION	1	2	3	4	5	6	7	8	9	10
1 TO 10	0.662E 00	0.983E 00	0.983E 00	0.983E 00	0.983E 00	0.984E 00	0.984E 00	0.997E 00	0.103E 01	0.109E 01
11 TO 20	0.103E 01	0.107E 01	0.991E 00	0.984E 00	0.983E 00	0.983E 00	0.983E 00	0.983E 00	0.983E 00	0.983E 00
21 TO 30	0.983E 00	0.983E 00	0.983E 00	0.983E 00	0.995E 00	0.134E 01	0.985E 00	0.269E 01	0.985E 00	0.985E 00
31 TO 37	0.983E 00	0.983E 00	0.990E 00	0.983E 00	0.983E 00	0.983E 00	0.983E 00			

MINIMUMS

JUNCTION	1	2	3	4	5	6	7	8	9	10
1 TO 10	0.459E-03	0.617E-01	0.239E 00	0.323E 00	0.334E 00	0.320E 00	0.808E 00	0.787E 00	0.828E 00	0.917E 00
11 TO 20	0.987E 00	0.965E 00	0.839E 00	0.787E 00	0.729E 00	0.657E 00	0.645E 00	0.696E 00	0.657E 00	0.642E 00
21 TO 30	0.657E 00	0.657E 00	0.657E 00	0.658E 00	0.860E 00	0.100E 01	0.784E 00	0.100E 01	0.784E 00	0.575E 00
31 TO 37	0.413E 00	0.646E 00	0.525E 00	0.650E 00	0.635E 00	0.618E 00	0.421E 00			

Table 8-17. SUMMARY CHLORIDES OUTPUT, DAY 1

JULY 19, 1972 TIDE AT MAYPORT. USE MEASURED FLOW AT PALATKA, JULY 17-20, 1972.

THIS IS A SAMPLE RUN OF QUANTITY AND QUALITY
LOWER ST. JOHNS RIVER, JULY 1972 VERIFICATION DATA.

E.P.A.
DYNAMIC STORM WATER QUALITY

AVERAGE JUNCTION CONCENTRATIONS, MGL (OR MPN/L), DURING TIDAL OR TIME CYCLE 1, CONSTITUENT NUMBER 2 CHLORIDES (MGL)

JUNCTION	1	2	3	4	5	6	7	8	9	10
1 TO 10	0.157E 05	0.135E 05	0.101E 05	0.876E 04	0.723E 04	0.804E 04	0.508E 04	0.565E 04	0.465E 04	0.396E 04
11 TO 20	0.253E 04	0.207E 04	0.148E 04	0.922E 03	0.685E 03	0.355E 03	0.243E 03	0.201E 03	0.230E 03	0.232E 03
21 TO 30	0.232E 03	0.189E 03	0.184E 03	0.222E 03	0.691E 03	0.315E 04	0.217E 04	0.502E 04	0.640E 04	0.792E 04
31 TO 37	0.859E 04	0.621E 04	0.120E 05	0.704E 04	0.553E 04	0.638E 04	0.103E 05			

MAXIMUMS

JUNCTION	1	2	3	4	5	6	7	8	9	10
1 TO 10	0.180E 05	0.174E 05	0.149E 05	0.137E 05	0.104E 05	0.105E 05	0.551E 04	0.758E 04	0.596E 04	0.535E 04
11 TO 20	0.354E 04	0.294E 04	0.210E 04	0.138E 04	0.101E 04	0.370E 03	0.341E 03	0.218E 03	0.237E 03	0.232E 03
21 TO 30	0.235E 03	0.192E 03	0.186E 03	0.223E 03	0.727E 03	0.330E 04	0.226E 04	0.520E 04	0.502E 04	0.100E 05
31 TO 37	0.124E 05	0.667E 04	0.135E 05	0.783E 04	0.724E 04	0.807E 04	0.117E 05			

MINIMUMS

JUNCTION	1	2	3	4	5	6	7	8	9	10
1 TO 10	0.111E 05	0.909E 04	0.637E 04	0.593E 04	0.525E 04	0.600E 04	0.424E 04	0.423E 04	0.303E 04	0.257E 04
11 TO 20	0.170E 04	0.131E 04	0.962E 03	0.452E 03	0.383E 03	0.347E 03	0.161E 03	0.191E 03	0.226E 03	0.231E 03
21 TO 30	0.220E 03	0.185E 03	0.182E 03	0.220E 03	0.669E 03	0.300E 04	0.200E 04	0.466E 04	0.470E 04	0.646E 04
31 TO 37	0.701E 04	0.600E 04	0.105E 05	0.300E 04	0.300E 04	0.300E 04	0.300E 04			

Table 8-18. SUMMARY DO OUTPUT, DAY 1

JULY 19, 1972 TIDE AT MAYPORT. USE MEASURED FLOW AT PALATKA, JULY 17-20, 1973.

THIS IS A SAMPLE RUN OF QUANTITY AND QUALITY
LOWER ST. JOHNS RIVER, JULY 1972 VERIFICATION DATA.

E.P.A.
DYNAMIC STORM WATER QUALITY

AVERAGE JUNCTION CONCENTRATIONS, MGL (OR MPN/L), DURING TIDAL OR TIME CYCLE 1, CONSTITUENT NUMBER 3 BOD (DO)

JUNCTION	1	2	3	4	5	6	7	8	9	10
1 TO 10	0.569E 01	0.530E 01	0.517E 01	0.515E 01	0.506E 01	0.528E 01	0.516E 01	0.502E 01	0.500E 01	0.498E 01
11 TO 20	0.497E 01	0.499E 01	0.504E 01	0.509E 01	0.509E 01	0.501E 01	0.500E 01	0.499E 01	0.502E 01	0.502E 01
21 TO 30	0.503E 01	0.504E 01	0.504E 01	0.504E 01	0.517E 01	0.501E 01	0.505E 01	0.509E 01	0.519E 01	0.504E 01
31 TO 37	0.512E 01	0.496E 01	0.503E 01	0.522E 01	0.507E 01	0.511E 01	0.514E 01			

MAXIMUMS

JUNCTION	1	2	3	4	5	6	7	8	9	10
1 TO 10	0.649E 01	0.626E 01	0.593E 01	0.577E 01	0.535E 01	0.563E 01	0.531E 01	0.514E 01	0.504E 01	0.501E 01
11 TO 20	0.500E 01	0.505E 01	0.513E 01	0.517E 01	0.512E 01	0.500E 01	0.504E 01	0.506E 01	0.507E 01	0.507E 01
21 TO 30	0.508E 01	0.511E 01	0.510E 01	0.510E 01	0.531E 01	0.502E 01	0.510E 01	0.513E 01	0.526E 01	0.530E 01
31 TO 37	0.561E 01	0.499E 01	0.535E 01	0.544E 01	0.521E 01	0.529E 01	0.552E 01			

MINIMUMS

JUNCTION	1	2	3	4	5	6	7	8	9	10
1 TO 10	0.150E 01	0.336E 01	0.456E 01	0.465E 01	0.490E 01	0.500E 01	0.500E 01	0.498E 01	0.496E 01	0.495E 01
11 TO 20	0.495E 01	0.495E 01	0.500E 01	0.500E 01	0.500E 01	0.500E 01	0.499E 01	0.500E 01	0.500E 01	0.500E 01
21 TO 30	0.500E 01	0.500E 01	0.500E 01	0.500E 01	0.500E 01	0.499E 01	0.500E 01	0.500E 01	0.500E 01	0.495E 01
31 TO 37	0.482E 01	0.494E 01	0.495E 01	0.500E 01	0.500E 01	0.500E 01	0.496E 01			

INPUT, POUNDS PER DAY, CONSTITUENT NUMBER 1 AT 23.97 HOURS OR 1.00 DAYS FROM START

JUNCTION	LBS/DAY
24	0.979E 05

INPUT, POUNDS PER DAY, CONSTITUENT NUMBER 2 AT 23.97 HOURS OR 1.00 DAYS FROM START

JUNCTION	LBS/DAY.
24	0.0

Table 8-19. QUALITY OUTPUT DURING DAY 2. QUALITY OUTPUT WAS REQUESTED EVERY THREE HOURS. SINCE A "DAY" IS 25 HOURS, THIS WILL OCCUR ON DIFFERENT CYCLES ON DIFFERENT DAYS.

THIS IS A SAMPLE RUN OF QUANTITY AND QUALITY
LOWER ST. JOHNS RIVER, JULY 1972 VERIFICATION DATA.

EPA STORMWATER MODEL
RECEIVING WATER QUALITY

JULY 19, 1972 TIDE AT MAYPORT. USE MEASURED FLOW AT PALATKA, JULY 17-20, 1973.
JUNCTION CONCENTRATIONS, MGL (OR MPN/L), DURING TIME CYCLE (DAY) 2, QUALITY CYCLE 2, TIME (SEC) 7200.

CONSTITUENT NUMBER 1 BOD

JUNCTION	1	2	3	4	5	6	7	8	9	10
1 TO 10	0.02	0.23	0.51	0.60	0.73	0.64	0.89	0.88	0.96	1.06
11 TO 20	0.98	1.02	0.81	0.76	0.70	0.88	0.95	0.99	0.98	0.84
21 TO 30	0.64	0.64	0.64	0.79	0.85	1.29	0.79	2.46	0.78	0.63
31 TO 37	0.56	0.62	0.48	0.64	0.60	0.59	0.59			

CONSTITUENT NUMBER 2 CHLORIDES (MGL)

JUNCTION	1	2	3	4	5	6	7	8	9	10
1 TO 10	17732.35	14450.17	9961.09	8534.69	6707.11	7892.46	5075.64	5342.50	4382.59	3751.88
11 TO 20	2288.86	1915.75	1461.57	1130.53	873.19	347.08	315.04	218.02	226.50	231.20
21 TO 30	226.76	191.51	166.86	202.22	793.53	3530.09	2372.01	4959.41	4968.31	8076.95
31 TO 37	8960.00	6850.09	11611.25	7791.27	7662.71	8537.59	11875.26			

CONSTITUENT NUMBER 3 BOD (DO)

JUNCTION	1	2	3	4	5	6	7	8	9	10
1 TO 10	6.42	6.01	5.38	5.27	5.13	5.32	5.10	5.03	4.98	4.95
11 TO 20	4.99	5.04	5.14	5.16	5.15	5.05	5.04	5.07	5.08	5.08
21 TO 30	5.09	5.12	5.11	4.70	5.32	5.00	5.18	5.06	5.24	5.23
31 TO 37	5.30	5.01	5.43	5.30	5.24	5.31	5.57			

COMPUTED OXYGEN SATURATION VALUES(MGL) AT THIS TIME STEP

JUNCTION	1	2	3	4	5	6	7	8	9	10
1 TO 10	6.42	6.67	7.01	7.12	7.26	7.17	7.38	7.36	7.44	7.48
11 TO 20	7.60	7.62	7.66	7.65	7.70	7.74	7.75	7.75	7.75	7.75
21 TO 30	7.75	7.76	7.76	7.75	7.71	7.50	7.59	7.59	7.59	7.16
31 TO 37	7.09	7.25	6.89	7.18	7.19	7.14	6.87			

COMPUTED REAERATION COEFFICIENTS (1/DAY) AT THIS TIME STEP

JUNCTION	1	2	3	4	5	6	7	8	9	10
1 TO 10	0.10	0.08	0.08	0.14	0.09	0.45	0.46	0.13	0.11	0.08
11 TO 20	0.07	0.06	0.13	0.17	0.12	0.14	0.12	0.13	0.13	0.14
21 TO 30	0.15	0.14	0.18	0.16	0.57	0.18	0.19	0.31	0.27	0.11
31 TO 37	0.12	0.11	0.14	0.57	0.19	0.27	0.25			

REFERENCES

1. Clark, J. W., Viessman, W., Jr., and M. J. Hammer, Water Supply and Pollution Control, Second Edition, International Textbook Company, Scranton, PA (1971).

2. Corps of Engineers, "Everglades Gaging Program, Progress Report, Everglades Area, Florida," Report No. 6, US Army Engineer District, Jacksonville, FL (December 31, 1956).

3. O'Connor, D. J., and W. E. Dobbins, "Mechanism of Reaeration in Natural Streams," Transactions, ASCE, 123:641 (1956).

SECTION 9

GLOSSARY

WATERSHED - The area which is drained by a river system.

DRAINAGE BASIN (STUDY AREA) - The area which contributes runoff to a stream at a given point (an individual section of a watershed).

SUBCATCHMENT - A subdivision of a drainage basin (generally determined by topography and pipe network configuration).

SUBAREA - A subdivision of a subcatchment (generally based upon a single land use but may be identical to a subcatchment).

ABBREVIATIONS

APWA	- American Public Works Association
ASCE	- American Society of Civil Engineers
EPA	- Environmental Protection Agency
M&E	- Metcalf & Eddy, Inc.
UF	- University of Florida
USPH	- U.S. Public Health Service
WRE	- Water Resources Engineers, Inc.

BOD	- biochemical oxygen demand (5-day)
cf	- cubic feet
cfs	- cubic feet per second
COD	- chemical oxygen demand
DO	- dissolved oxygen
DWF	- dry weather flow
fpm	- feet per minute

fps - feet per second

ft - feet

gal. - gallons

gal./capita/day - gallons per capita per day

gpd - gallons per day

gph - gallons per hour

gpm - gallons per minute

gpm/sq ft - gallons per minute per square foot

gpsf - gallons per square foot

hr - hour

in. - inches

in./hr - inches per hour

JCL - job control language

lb - pounds

lb/acre/day - pounds per acre per day

lb/acre/yr - pounds per acre per year

lb/capita/day - pounds per capita per day

lb/cf - pounds per cubic foot

lb/day/cfs - pounds per day per cubic feet per second

lb/ft - pounds per foot

lb/sec - pounds per second

mgd - million gallons per day

mg/gram - milligrams per gram

mg/L - milligrams per liter

min - minutes

mm - millimeters

MPN	- most probable number
ppm	- parts per million
psf	- pounds per square foot
psi	- pounds per square inch
rpm	- revolutions per minute
sec	- second
sq ft	- square feet
sq ft/min	- square feet per minute
SS	- suspended solids
tons/mo	- tons per month
tons/sq mi/mo	- tons per square mile per month
VSS	- volatile suspended solids
yr	- year

SYMBOLS

Δ	delta
α	alpha
Σ	sigma
$<$	less than
$>$	greater than
∂	partial differentiation
ρ	rho
Ψ	psi
Π	pi
θ	theta

SECTION 10
APPENDIX A

Table A-1. AVERAGE MONTHLY DEGREE-DAYS FOR CITIES IN THE UNITED STATES (BASE 65F) (1)

State	Station	July	Aug	Sept	Oct	Nov	Dec	Jan	Feb	Mar	April	May	June
Ala.	Anniston	0	0	17	118	438	614	614	485	381	128	25	0
	Birmingham	0	0	13	123	396	598	623	491	378	128	30	0
	Mobile	0	0	0	23	198	357	412	290	209	40	0	0
	Montgomery	0	0	0	55	267	458	483	360	265	66	0	0
Ariz.	Flagstaff	49	78	243	586	876	1135	1231	1014	949	687	465	212
	Phoenix	0	0	0	13	182	360	425	275	175	62	0	0
	Yuma	0	0	0	0	105	259	318	167	88	14	0	0
Ark.	Bentonville	1	1	38	216	516	810	879	716	519	247	86	7
	Fort Smith	0	0	9	131	435	698	775	571	418	127	24	0
	Little Rock	0	0	10	110	405	654	719	543	401	122	18	0
Calif.	Eureka	267	248	264	335	411	508	552	465	493	432	375	282
	Fresno	0	0	0	86	345	580	629	400	304	145	43	0
	Independence	0	0	28	216	512	778	799	619	477	267	120	18
	Los Angeles	0	0	17	41	140	253	328	244	212	129	68	19
	Needles	0	0	0	19	217	416	447	243	124	26	3	0
	Point Reyes	350	336	263	282	317	425	467	406	437	413	415	363
	Red Bluff	0	0	0	59	319	564	617	423	336	117	51	0
	Sacramento	0	0	17	75	321	567	614	403	317	196	85	5
	San Diego	11	7	24	52	147	255	317	247	223	151	97	43
	San Francisco	189	177	110	128	237	406	462	336	317	279	248	180
	San Jose	7	11	26	97	270	450	487	342	308	229	137	46
Colo.	Denver	0	5	103	385	711	958	1042	854	797	492	266	60
	Durango	25	37	201	535	861	1204	1271	1002	859	615	394	139
	Grand Junction	0	0	36	333	792	1132	1271	924	738	402	145	23
	Leadville	280	332	509	841	1139	1413	1470	1285	1245	990	740	434
	Pueblo	0	0	74	383	771	1051	1104	865	775	456	203	27
Conn.	Hartford	0	14	101	384	699	1082	1178	1050	871	528	201	31
	New Haven	0	18	93	363	663	1026	1113	1005	865	567	261	52
D. C.	Washington	0	0	32	231	510	831	884	770	606	314	80	0
Fla.	Apalachicola	0	0	0	17	154	304	352	263	184	33	0	0
	Jacksonville	0	0	0	11	129	276	303	226	154	14	0	0
	Key West	0	0	0	0	0	18	28	24	7	0	0	0
	Miami	0	0	0	0	5	48	57	48	15	0	0	0
	Pensacola	0	0	0	18	177	334	383	275	203	45	0	0
	Tampa	0	0	0	0	60	163	201	148	102	0	0	0
Ga.	Atlanta	0	0	8	107	387	611	632	515	392	135	24	0
	Augusta	0	0	0	59	282	494	521	412	308	62	0	0
	Macon	0	0	0	63	280	481	497	391	275	62	0	0
	Savannah	0	0	0	38	225	412	424	330	238	43	0	0
	Thomasville	0	0	2	48	208	361	359	299	178	52	5	1
Idaho	Boise	0	0	135	389	762	1054	1169	868	719	453	249	92
	Lewiston	0	0	133	406	747	961	1060	815	663	408	222	68
	Pocatello	0	0	183	487	873	1184	1333	1022	880	561	317	136
Ill.	Cairo	0	0	28	161	492	784	856	683	523	182	47	0
	Chicago	0	0	90	350	765	1147	1243	1053	868	507	229	58
	Peoria	0	11	86	339	759	1128	1240	1028	828	435	192	41
	Springfield	0	0	56	259	666	1017	1116	907	713	350	127	14
Ind.	Evansville	0	0	59	215	570	871	939	770	589	251	90	6
	Fort Wayne	0	17	107	377	759	1122	1260	1036	874	516	226	53
	Indianapolis	0	0	59	247	642	986	1051	893	725	375	140	16
	Royal Center	11	19	116	373	740	1104	1239	976	860	502	245	54
	Terre Haute	0	5	77	295	681	1023	1107	913	715	371	145	24

Table A-1 (continued). AVERAGE MONTHLY DEGREE-DAYS FOR CITIES IN THE UNITED STATES (BASE 65F) (1)

State	Station	July	Aug.	Sept	Oct	Nov	Dec	Jan	Feb	Mar	April	May	June
Iowa	Charles City	17	30	151	444	912	1352	1494	1240	1001	537	256	70
	Davenport	0	7	79	320	756	1147	1262	1044	834	432	175	35
	Des Moines	0	6	89	346	777	1178	1308	1072	849	425	183	41
	Dubuque	8	28	149	444	882	1290	1414	1187	983	543	267	76
	Keokuk	1	3	71	303	680	1077	1191	1025	761	397	136	18
	Sioux City	8	17	128	405	885	1290	1423	1170	930	474	228	54
Kan.	Concordia	0	0	55	277	687	1029	1144	899	725	341	146	20
	Dodge City	0	0	40	262	669	980	1076	840	694	347	135	15
	Iola	0	1	40	236	579	930	1026	817	599	282	98	8
	Topeka	0	0	42	242	630	977	1088	851	669	295	112	13
	Wichita	0	0	32	219	597	915	1023	778	619	280	101	7
Ky.	Louisville	0	0	41	206	549	849	911	762	605	270	86	0
	Lexington	0	0	56	259	636	933	1008	854	710	368	140	15
La.	New Orleans	0	0	0	5	141	283	341	223	163	19	0	0
	Shreveport	0	0	0	53	305	490	550	386	272	61	0	0
Me.	Eastport	141	136	261	521	798	1206	1333	1201	1063	774	524	288
	Greenville	69	113	315	642	1012	1464	1625	1443	1251	842	468	194
	Portland	15	56	199	515	825	1238	1373	1218	1039	693	394	117
Md.	Baltimore	0	0	29	207	489	812	880	776	611	326	73	0
Mass.	Boston	0	7	77	315	618	998	1113	1002	849	534	236	42
	Fitchburg	12	29	144	432	774	1139	1240	1137	940	572	254	70
	Nantucket	22	34	111	372	615	924	1020	949	880	642	394	139
Mich.	Alpena	50	85	215	530	864	1218	1358	1263	1156	762	437	135
	Detroit-Willow Run	0	10	96	393	759	1125	1231	1089	915	552	244	55
	Detroit City	0	8	96	381	747	1101	1203	1972	927	558	251	60
	Escanaba	62	95	247	555	933	1321	1473	1327	1203	804	471	166
	Grand Rapids	0	20	105	394	756	1107	1215	1086	939	546	248	58
	Houghton	70	94	268	582	965	1355	1535	1421	1251	820	474	195
	Lansing	13	33	140	455	813	1175	1277	1142	986	591	287	70
	Ludington	41	55	182	472	794	1135	1271	1183	1056	698	418	153
	Marquette	69	87	236	543	933	1299	1435	1291	1181	789	477	189
	Sault Ste. Marie	109	126	298	639	1005	1398	1587	1442	1302	846	499	224
Minn.	Duluth	66	91	277	614	1092	1550	1696	1448	1252	801	487	200
	Minneapolis	8	17	157	459	960	1414	1562	1310	1057	570	259	80
	Moorhead	20	47	240	607	1105	1609	1815	1555	1225	679	327	98
	St. Paul	12	21	154	459	951	1401	1553	1305	1051	564	256	77
Miss.	Corinth	0	1	13	142	418	669	696	570	396	149	32	1
	Meridian	0	0	0	90	338	528	561	413	309	85	9	0
	Vicksburg	0	0	0	51	268	456	507	374	273	71	0	0
Mo.	Columbia	0	6	62	262	654	989	1091	876	698	326	135	14
	Hannibal	1	3	66	288	652	1037	1139	980	710	374	128	15
	Kansas City	0	0	44	240	621	970	1085	851	666	292	111	8
	St. Louis	0	0	38	202	570	893	983	792	620	270	94	7
	Springfield	0	8	61	249	615	908	1001	790	632	295	118	16
Mont.	Billings	8	20	194	497	876	1172	1305	1089	958	564	304	119
	Harve	20	38	270	564	1023	1383	1513	1291	1076	597	313	125
	Helena	51	78	359	598	969	1215	1438	1114	992	660	427	225
	Kalispell	47	83	326	639	990	1249	1386	1120	970	639	391	215
	Miles City	6	11	187	525	966	1373	1516	1257	1048	570	285	106
	Missoula	22	57	292	623	993	1283	1414	1100	939	609	365	176
Neb.	Drexel	4	6	95	405	788	1271	1353	1096	843	493	219	38
	Lincoln	0	7	79	310	741	1113	1240	1000	794	377	172	32
	North Platte	7	11	120	425	846	1172	1271	1016	887	489	243	59
	Omaha	0	5	88	331	783	1166	1302	1058	831	389	175	32
	Valentine	11	10	145	461	891	1212	1361	1100	970	543	288	83

Table A-1 (continued). AVERAGE MONTHLY DEGREE-DAYS FOR CITIES IN THE UNITED STATES (BASE 65F (1)

State	Station	July	Aug	Sept	Oct	Nov	Dec	Jan	Feb	Mar	April	May	June
Nev.	Reno	27	61	165	443	744	986	1048	804	756	519	318	165
	Tonopah	0	5	96	422	723	995	1082	860	763	504	272	91
	Winnemucca	0	17	180	508	822	1085	1153	854	794	546	299	111
N.H.	Concord	11	57	192	527	849	1271	1392	1226	1029	660	316	82
N.J.	Atlantic City	0	0	29	230	507	831	905	829	729	468	189	24
	Cape May	1	2	38	221	527	852	936	876	737	459	188	33
	Newark	0	0	47	301	603	961	1039	932	760	450	148	11
	Sandy Hook	1	2	40	268	579	921	1016	973	833	499	206	31
	Trenton	0	0	55	285	582	930	1004	904	735	429	133	11
N.M.	Albuquerque	0	0	10	218	630	899	970	714	589	289	70	0
	Roswell	0	0	8	156	501	750	787	566	443	185	28	0
	Santa Fe	12	15	129	451	772	1071	1094	892	786	544	297	60
N.Y.	Albany	0	6	98	388	708	1113	1234	1103	905	531	202	31
	Binghamton	0	36	141	428	735	1113	1218	1100	927	570	240	48
	Buffalo	16	30	122	433	753	1116	1225	1128	992	636	315	72
	Canton	27	61	219	550	898	1368	1516	1385	1139	695	340	107
	Ithaca	17	40	156	451	770	1129	1236	1156	978	606	292	83
	New York	0	0	31	250	552	902	1001	910	747	435	130	7
	Oswego	20	39	139	430	738	1132	1249	1134	995	654	355	90
	Rochester	9	34	133	440	759	1141	1249	1148	992	615	289	54
	Syracuse	0	29	117	396	714	1113	1225	1117	955	570	247	37
N.C.	Asheville	0	0	50	262	552	769	794	678	572	285	105	5
	Charlotte	0	0	7	147	438	682	704	577	449	172	29	0
	Hatteras	0	0	0	63	244	481	527	487	394	171	25	0
	Manteo	0	0	7	113	358	595	642	594	469	249	75	7
	Raleigh	0	0	10	118	387	651	691	577	440	172	29	0
	Wilmington	0	0	0	73	288	508	533	463	347	104	7	0
N.D.	Bismarck	29	37	227	598	1098	1535	1730	1464	1187	657	355	116
	Devils Lake	47	61	276	654	1197	1558	1866	1576	1314	750	394	137
	Grand Forks	32	60	274	663	1160	1681	1895	1608	1298	718	359	123
	Williston	29	42	261	605	1101	1528	1705	1442	1194	663	360	138
Ohio	Cincinnati	0	0	42	222	567	880	942	812	645	314	108	0
	Cleveland	0	9	60	311	636	995	1101	977	846	510	223	49
	Columbus	0	0	59	299	554	983	1051	907	741	408	153	22
	Dayton	0	5	74	324	693	1032	1094	941	781	435	179	39
	Sandusky	0	0	66	327	684	1039	1122	997	853	513	217	41
	Toledo	0	12	102	387	756	1119	1197	1056	905	555	245	60
Okla.	Broken Arrow	0	0	28	169	513	805	881	646	506	212	61	5
	Oklahoma City	0	0	12	149	459	747	843	630	472	169	38	0
Ore.	Baker	25	47	255	518	852	1138	1268	972	837	591	384	200
	Medford	0	0	77	326	624	822	862	627	552	381	207	69
	Portland	13	14	85	280	534	701	791	594	515	347	199	70
	Roseburg	14	10	98	288	531	694	744	563	508	366	223	83
Pa.	Erie	0	17	76	352	672	1020	1128	1039	911	573	273	55
	Harrisburg	0	0	69	308	630	964	1051	921	750	423	128	14
	Philadelphia	0	0	33	219	516	856	933	837	667	369	93	0
	Pittsburgh	0	0	56	298	612	924	992	879	735	402	137	13
	Reading	0	5	57	285	588	936	1017	902	725	411	123	11
	Scranton	0	18	115	389	693	1057	1141	1028	849	516	196	35
R.I.	Block Island	6	21	88	330	591	927	1026	955	865	603	335	96
	Narragansett Pier	1	26	121	366	691	1012	1113	1074	916	622	342	113
	Providence	0	7	68	330	624	986	1076	972	809	507	197	31
S.C.	Charleston	0	0	0	34	214	410	445	363	260	43	0	0
	Columbia	0	0	0	76	308	524	538	443	318	77	0	0
	Due West	0	0	9	142	393	594	651	491	411	158	39	2
	Greenville	0	0	10	131	411	648	673	552	442	161	32	0

Table A-1 (continued). AVERAGE MONTHLY DEGREE-DAYS FOR CITIES IN THE UNITED STATES (BASE 65F) (1)

State	Station	July	Aug	Sept	Oct	Nov	Dec	Jan	Feb	Mar	April	May	June
S.D.	Huron	10	16	149	472	975	1407	1597	1327	1032	558	279	80
	Pierre	4	11	136	438	887	1317	1460	1253	971	516	233	52
	Rapid City	32	24	193	500	891	1218	1361	1151	1045	615	357	148
Tenn.	Chattanooga	0	0	24	169	477	710	725	588	467	179	45	0
	Knoxville	0	0	33	179	498	744	760	630	500	196	50	0
	Memphis	0	0	13	98	392	639	716	574	423	131	20	0
	Nashville	0	0	22	154	471	725	778	636	498	186	43	0
Texas	Abilene	0	0	5	98	350	595	673	479	344	113	0	0
	Amarillo	0	0	37	240	594	859	921	711	586	298	99	0
	Austin	0	0	0	30	214	402	484	322	211	50	0	0
	Brownsville	0	0	0	0	59	159	219	106	74	0	0	0
	Corpus Christi	0	0	0	0	113	252	330	192	118	6	0	0
	Dallas	0	0	0	53	299	518	607	432	288	75	0	0
	Del Rio	0	0	0	26	188	371	419	235	147	21	0	0
	El Paso	0	0	0	70	390	626	670	445	330	110	0	0
	Fort Worth	0	0	0	58	299	533	622	446	308	90	5	0
	Galveston	0	0	0	0	131	271	356	247	176	30	0	0
	Houston	0	0	0	0	162	303	378	240	166	27	0	0
	Palestine	0	0	0	45	260	440	531	368	265	71	0	0
	Port Arthur	0	0	0	8	170	315	381	258	181	27	0	0
	San Antonio	0	0	0	25	201	374	462	293	190	34	0	0
	Taylor	0	0	2	56	234	462	494	375	214	64	8	0
Utah	Modena	6	11	156	499	832	1142	1190	944	816	567	338	97
	Salt Lake City	0	0	61	330	714	995	1119	857	701	414	208	64
Vt.	Burlington	19	47	172	521	858	1308	1460	1313	1107	681	307	72
	Northfield	62	112	283	602	947	1389	1524	1384	1176	754	405	166
Va.	Cape Henry	0	0	0	120	366	648	698	636	512	267	60	0
	Lynchburg	0	0	49	236	531	809	846	722	584	289	82	5
	Norfolk	0	0	5	118	354	636	679	602	464	220	41	0
	Richmond	0	0	31	181	456	750	787	695	529	254	57	0
	Wytheville	7	13	82	352	662	916	945	836	677	410	168	35
Wash.	North Head L.H. Reservation	239	205	234	341	486	636	704	585	598	492	406	285
	Seattle	49	45	134	329	540	679	753	602	558	396	246	107
	Spokane	17	28	205	508	879	1113	1243	988	834	561	330	146
	Tacoma	66	62	177	375	579	719	797	636	595	435	282	143
	Tatoosh Island	295	288	315	406	528	648	713	610	629	525	437	330
	Walla Walla	0	0	93	308	675	890	1023	748	564	338	171	38
	Yakima	0	7	150	446	807	1066	1181	862	660	408	205	53
W.Va.	Elkins	9	31	122	412	726	995	1017	910	797	477	224	53
	Parkersburg	0	0	56	272	600	896	949	826	672	347	119	13
Wis.	Green Bay	32	58	183	515	945	1392	1516	1336	1132	696	347	107
	La Crosse	11	20	152	447	921	1380	1528	1280	1035	552	250	74
	Madison	10	30	137	419	864	1287	1417	1207	1011	573	266	79
	Milwaukee	11	24	112	397	795	1184	1302	1117	961	606	335	100
	Wausau	26	58	216	568	982	1427	1594	1381	1147	680	315	100
Wyo.	Cheyenne	33	39	241	577	897	1125	1225	1044	1029	717	315	100
	Lander	7	23	244	632	1050	1383	1494	1179	1045	687	396	163
	Yellowstone Park	125	173	424	759	1079	1386	1464	1252	1165	841	603	334

Source: American Society of Heating and Air Conditioning Engineers, "Heating, Ventilating, Air Conditioning Guide," Annual Publication (Ref. 1).

Table A-2. GUIDE FOR ESTABLISHING WATER USAGE IN COMMERCIAL SUBAREAS

Commercial category	Parameter	Coefficients, mean annual water use, gpd/unit of parameter
Barber Shops	Barber Chair	97.5
Beauty Shops	Station	532.0
Bus-Rail Depots	Sq ft	5.0
Car Washes	Inside Sq ft	4.78
Churches	Member	0.14
Golf-Swim Clubs	Member	33.3-100.0
Bowling Alleys	Alley	200.0
Colleges Resid.	Student	179.0
Hospitals	Bed	150.0-559.0
Hotels	Sq ft	0.256
Laundromats	Sq ft	6.39
Laundries	Sq ft	0.64
Medical Offices	Sq ft	0.62
Motels	Sq ft unit	0.33
Drive-In Movies	Car Stall	8.0
Nursing Homes	Bed	75.0-209.0
New Office Bldgs.	Sq ft	0.16
Old Office Bldgs.	Sq ft	0.27
Jails and Prisons	Occupant	10.0-15.0
	Person	200.0
Restaurants	Seat	10.0-90.0
Drive-In Restaurants	Car Stalls	109.0

Table A-2 (continued). GUIDE FOR ESTABLISHING WATER USAGE IN COMMERCIAL SUBAREAS (2)

Commercial category	Parameter	Coefficients, mean annual water use, gpd/unit of parameter
Night Clubs	Person Served	2.0
Retail Space	Sale Sq ft	0.16
Schools, Elementary	Student	6.0-15.0
Schools, High	Student	10.0-19.9
YMCA-YWCA	Person	50.0
Service Stations	Inside Sq ft	0.49
Theaters	Employee	30.0
	Seat	5.0
Apartments	Dwelling Unit	50.0-195.0
Shopping Centers	Sq ft	0.20

Sources: Hittman Associates, Inc., "A System for Calculating and Evaluating Municipal Water Requirements" (Ref. 2); and F. P. Linaweaver and J. C. Geyer, "Commercial Water Use Project," Johns Hopkins University, Baltimore, Maryland.

Table A-3. GUIDE FOR ESTABLISHING WATER USAGE IN INDUSTRIAL SUBAREAS (2)

Industrial category	Standard Industrial Classification Number	Mean Annual Usage Coefficients gpd/employee
Meat Products	201	903.890
Dairies	202	791.350
Can, Frozen Food	203	784.739
Grain Mills	204	488.249
Bakery Products	205	220.608
Sugar	206	1433.611
Candy	207	244.306
Beverages	208	1144.868
Miscellaneous Foods	209	1077.360
Cigarettes	211	193.613
Weaving, Cotton	221	171.434
Weaving, Synthetics	222	344.259
Weaving, Wool	223	464.439
Knitting Mills	225	273.429
Textile Finish	226	810.741
Floor Covering	227	297.392
Yarn-Thread Mill	228	63.558
Miscellaneous Textile	229	346.976
Whl. Apparel Industry	230	20.000
Saw-Planning Mill	242	223.822
Millwork	243	316.420
Wood Containers	244	238.000
Miscellaneous Wood	249	144.745
Home Furniture	251	122.178
Furniture Fixture	259	122.178
Pulp Mills	261	13494.110
Paper Mills	262	2433.856
Paperboard Mills	263	2464.478
Paper Products	264	435.790
Paperboard Boxes	265	154.804
Building Paper Mills	266	583.355
Whl. Print Industry	270	15.000
Basic Chemicals	281	2744.401
Fibers, Plastic	282	864.892
Drugs	283	457.356
Soap-Toilet Goods	284	672.043
Paint Allied Products	285	845.725
Gum-Wood Chemicals	286	332.895
Agricultural Chem.	287	449.836
Miscellaneous Chemicals	289	984.415

Table A-3 (continued). GUIDE FOR ESTABLISHING WATER USAGE IN INDUSTRIAL SUBAREAS (2)

Industrial category	Standard Industrial Classification Number	Mean Annual Usage Coefficients gpd/employee
Petroleum Refining	291	3141.100
Paving-Roofing	295	829.592
Tires, Tubes	301	375.211
Rubber Footware	302	82.592
Reclaimed Rubber	303	1031.523
Rubber Products	306	371.956
Plastic Products	307	527.784
Leather Tanning	311	899.500
Flat Glass	321	590.140
Pressed, Blown Glassware	322	340.753
Products of Purchased Glass	323	872.246
Cement, Hydraulic	324	279.469
Structural Clay	325	698.197
Pottery Products	326	326.975
Cement, Plaster	327	353.787
Cut Stone Products	328	534.789
Non-Metallic Mineral	329	439.561
Steel-Rolling	331	494.356
Iron, Steel Foundries	332	411.052
Prime Non-Ferrous	333	716.626
Secondary Non-Ferrous	334	1016.596
Non-Ferrous Rolling	335	675.475
Non-Ferrous Foundries	336	969.586
Prime Metal Industries	339	498.331
Metal Cans	341	162.547
Cutlery, Hardware	342	459.300
Plumbing, Heating	343	411.576
Structure, Metal	344	319.875
Screw Machine	345	433.193
Metal Stamping	346	463.209
Metal Service	347	1806.611
Fabricated Wire	348	343.367
Fabricated Metal	349	271.186
Engines, Turbines	351	197.418
Farm Machinery	352	320.704
Construction Equipment	353	218.365

Table A-3 (continued). GUIDE FOR ESTABLISHING WATER USAGE IN INDUSTRIAL SUBAREAS (2)

Industrial category	Standard Industrial Classification Number	Mean Annual Usage Coefficients gpd/employee
Metalwork, Machinery	354	196.255
Special Industry Machinery	355	290.494
General Industrial Machinery	356	246.689
Office Machines	357	138.025
Service Industrial Machine	358	334.203
Miscellaneous Machines	359	238.839
Electric Distribution Products	361	272.001
Electric Industrial Apparatus	362	336.016
Home Appliances	363	411.914
Light-Wiring Fixtures	364	369.592
Radio TV Receiving	365	235.763
Communication Equipment	366	86.270
Electronic Comp.	367	203.289
Electric Product	369	393.272
Motor Vehicles	371	318.233
Aircraft and Parts	372	154.769
Ship and Boat Building	373	166.074
Railroad Equipment	374	238.798
Motorcycle, Bike	375	414.858
Scientific Instruments	381	181.007
Mechanical Measure	383	237.021
Medical Instrument	384	506.325
Photo Equipment	386	120.253
Watches, Clocks	387	164.815
Jewelry, Silver	391	306.491
Toys, Sport Goods	394	213.907
Costume Jewelry	396	423.124
Miscellaneous Manufacturing	398	258.270
Miscellaneous Manufacturing	399	258.270

Source: Hittman Associates, Inc., "A System for Calculating and Evaluating Municipal Water Requirements" (Ref. 2).

REFERENCES

1. American Society of Heating and Air Conditioning Engineers, "Heating, Ventilating, Air Conditioning Guide," Annual Publication.

2. Hittman Associates, Inc., "A System for Calculating and Evaluating Municipal Water Requirements."

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(Please read Instructions on the reverse before completing)

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16. ABSTRACT

A comprehensive mathematical model (the EPA Storm Water Management Model, SWMM) capable of representing urban stormwater runoff and combined sewer overflow phenomena was developed. SWMM portrays correctional devices in the form of user-selected options for storage and/or treatment with associated estimates of cost. Effectiveness is portrayed by computed treatment efficiencies and modeled changes in receiving water quality. The original project report published in 1971 is divided into four volumes: Volume I, "Final Report"; Volume II, "Verification and Testing"; Volume III, "User's Manual"; and Volume IV, "Program Listing" (EPA Report Nos. 11024DOC07/71, 11024DOC08/71, 11024DOC09/71, and 11024DOC10/71, respectively).

Effort on modification and improvement of the SWMM has been, and is being continued since its release. As a result, this official "Release 2" of the SWMM includes additional program components, i.e., new runoff routine, urban erosion prediction, new treatment process performance and cost functions, and new receiving water quality. This report provides a revised and improved User's Manual to accompany "Release 2" as in the original User's Manual, Volume III.

This report was submitted in partial fulfillment of Project R-802411 by the University of Florida under the sponsorship of the Environmental Protection Agency. Work was completed as of August 1974.

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