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IMPLEMENTATION AND TESTING OF THE STORM WATER MANAGEMENT MODEL (SWMM) SOFTWARE

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CHAPTER 1

INTRODUCTION

The EPA's Storm Water Management Model (SWMM) is a large, complex model capable of simulating the movement of precipitation and pollutants from the ground surface through pipe and continuous simulation may be performed on catchments having storm sewers, combined sewers, and natural drainage, for prediction of flows, stages, and pollutant concentrations.

The model may be used for both planning and design. The planning model is used for an overall assessment of the urban runoff problem and proposed abatement options. This model is typified by continuous simulation for several years using long-term precipitation data. Catchment schematization is usually "coarse" in keeping with the planning level of analysis. A design-level, event simulation also may be run using a detailed catchment schematization and shorter time steps for precipitation input.

The SWMM Windows interface was developed to assist the user in data input and model execution and to make a complex model user-friendly. The Windows interface was developed for the Office of Science and Technology, Standards and Applied Sciences Division of the U.S. Environmental Protection Agency to assist them with the Total Maximum Daily Load (TMDL) program. The Windows interface integrates the SWMM model and data handling needs to make the model implementation user friendly. A brief description of the SWMM model structure is presented in order to facilitate subsequent discussions.

This report is divided into nine sections. Section 2 gives a technical summary of the SWMM model, as well as the model structure, the interaction between the various blocks of SWMM, the input requirements, and the output. Section 3 describes the Windows Implementation of the blocks, including descriptions of the screens sequences, the corresponding blocks, changes made for ease of use, and limitations of the implementation. Section 4 provides minimum hardware requirements and installation information for the Windows SWMM. Section 5 provides the information necessary to use the SWMM interface, including:

- Accessing an Existing File or Opening a New File
- File-Naming Conventions
- Saving Input Files
- Setting Up a Default Editor for Viewing Output Files
- SWMM Windows Interface Commands and Function Keys
- Submitting an Input File to the Model
- Import File Option in SWMM
- Export Function

- Array Screen Capabilities
- Using the Manual Run Option

Section 6 contains four example runs that highlight user entry and model output. Section 7 describes the SWMM post-processor capabilities, which allows the user to display tabulated summary information and graphical representations of the modeling results. Section 8 contains some real time applications of the SWMM model in various fields taken from an extensive literature review. Finally, section 9 concludes the report. Appendices provide the screen structure and variable descriptions for the Windows interface blocks.

CHAPTER 2

THE SWMM 4.3 MODEL

2.1 General

SWMM simulates most quantity and quality processes in the urban hydrologic cycle on the basis of rainfall (hyetograph) and other meteorological inputs and system characterization (catchment, conveyance, storage/treatment). Storm sewers, combined sewers, and natural drainage systems can be simulated as well.

2.2 Model Structure and Description of Blocks

SWMM is constructed in the form of "blocks" as follows:

Computational Blocks:	Runoff, Transport, Extran, Storage/Treatment
Services Blocks:	Executive, Rain, Temp, Graph, Statistics, Combine

Each block has a specific function, and the results of each block are entered on working storage devices to be used as part of the input to other blocks. A typical run usually involves only one or two computational blocks together with the Executive Block. A summary of the four computational blocks in SWMM are shown in Table 2.1. This table explains the model capability, flow routing characteristics, and quality by block.

The Runoff Block is a critical block to the SWMM simulation. This block receives meteorological data from either Rain and/or Temp Blocks or user defined hyetographs (rainfall intensity vs. time) and then simulates the rainfall-runoff process using a nonlinear reservoir approach, with an option for snowmelt simulation. Groundwater and unsaturated zone flow and outflow are included using a simple lumped storage scheme. At the end, the Runoff Block produces hydrographs and pollutographs at inlet locations. This block may be run for periods ranging from minutes to years. Simulations less than a few weeks will henceforth be called single event mode and longer simulations will be called continuous mode. With the slight exception of snowmelt, all computations are done identically for the two cases (Huber and Dickinson, 1988). Quality processes in the Runoff Block include generation of surface runoff constituent loads through a variety of options: 1) build-up of constituents during dry weather and wash-off during wet weather, 2) "rating curve" approach in which load is proportional to flow rate to a power, 3) constant concentration (including precipitation loads), and/or 4) Universal Soil Loss Equation (Donigian and Huber, 1991). The overall catchment may be divided into a maximum of 200 subcatchments and 200 channel/pipes plus inlets. The Runoff Block transfers hydrographs and pollutographs for as many as 200 inlets and 10 constituents through an assigned interface file to other SWMM blocks.

The Transport block is one of the subsequent blocks and performs the detailed flow and pollutant routing through the sewer system. In the Transport Block, flow routing is accomplished using the kinematic wave method, while quality processes include first-order decay and simulating scour and

Table 2.1 Summary of Computational Blocks in SWMM

Block	Capability			Flow Routing Characteristics		Quality
	Description	Quantity (Inlets)	Quality (pollutants)	Method	Backwater Effects	Method
Runoff	simulate quantity and quality runoff of a drainage basin, route flows and pollutants to major sewer lines, produce hydrographs and pollutographs at inlet locations	200	10	Non-linear reservoir, cascade of conduits	No	1) build-up/wash-off; 2) rating curve approach; 3) const. concentration; 4) USLE.
Transport	routes flow and pollutant through the sewer system, determine quantity and quality of dry-weather flow, calculate system infiltration, land, capital, operation and maintenance costs of two internal storage tanks	200	4	Kinematic wave, cascade of conduits	No	Shield's criterion for initiation of motion, and generation of simulation of dry-weather flow and quality.
Extran	routes flow through the sewer system, simulate backwater profiles (flows) in open channel and/or closed conduit systems, a drainage system can be represented as links and nodes, looped pipe networks, weirs, orifices, pumps, and system surcharges	200	0	Dynamic wave, complete equations, interactive conduit network	Yes	No water quality simulation
Storage/ Treatment	characterize the effects of control devices upon flow and quality, simulate removal in S/T devices, calculate costs	**5 units or processes**	3	Storage routing		1) first order decay; 2) removal functions; 3) sedimentation dynamics.

deposition within the sewer system based on Shiled's criterion for initiation of motion, and generation of dry-weather flow and quality. The Transport Block uses inlet hydrographs and pollutographs generated either from the Runoff Block via the interface file or from the user defined option as the input, then determines the quantity and quality of dry weather flow, the system infiltration, pollutant loadings for each channel/pipe, and study area.

The Storage/Treatment (S/T) Block is a special type of element of the Transport Block. The S/T Block simulates the routing of flows and up to three pollutants through a dry- or wet-weather S/T tank containing up to five units or processes. It also simulates removal in S/T devices by 1) first-order decay coupled with complete mixing or plug flow, 2) removal functions (e.g., solids deposition as a function of detention time), or 3) sedimentation dynamics. Additionally, capital cost and operation and maintenance cost can be estimated for each unit.

The Extended Transport (EXTRAN) Block provides the SWMM with dynamic wave simulation capability (Roesner, L.A. et al, 1988). The EXTRAN Block is the most comprehensive simulation program available in the public domain for a drainage system hydraulics and simulates branched or looped networks; backwater resulting from tidal or nontidal conditions; free-surface flow; pressurized flow or surcharges; flow reversals; flow transfer by weirs, orifice; and pumping facilities; and storage at on-line or off-line facilities. EXTRAN uses a link-node description of the sewer system that facilitates the discrete representation of the physical prototype. The conduit system is idealized as a series of links and channels/conduits, which are connected as nodes or junctions. Links and nodes have well-defined properties which, taken together, permit representation of the entire pipe network. Links permit flow from node to node. Nodes are the storage elements of the system and correspond to manholes or pipe junctions in the physical system. Inflows, such as inlet hydrographs, and outflows, such as weir diversions, take place at the nodes of the idealized sewer system.

These four computational blocks can be run either independently or in any sequence. Additionally, service blocks are available for supporting the computational blocks. They are statistical analysis of the output time series (Statistics Block), input and manipulation of precipitation, evaporation, and temperature time series (Rain and Temp Blocks), line printer graphics (Graph Block), and output time series manipulation (Combine Block).

2.3 Data Requirements

Depending upon the simulation objective, input data requirements can range from minimal to extensive. For simulation of a complete drainage network, data collection can be accomplished within a few days, but reducing the data for input to the model may take up to 3 person-weeks for a large area (e.g., greater than 2000 acres). For an EXTRAN simulation of sewer hydraulics, expensive and time-consuming field verification of sewer invert elevations is often required. On an optimistic note, however, most data reduction, i.e., tabulation of slopes, lengths, and diameters, is straightforward (Ambrose and Barnwell, 1989).

Categories of Data:

1) Weather Data: hourly or daily precipitation; daily or monthly evaporation rates. Snowmelt: daily max - min temperatures, monthly wind speeds, melt coefficients and base temperatures, snow distribution fractions and areal depletion curves (continuous only), and other melt parameters.

2) Surface quantity: area, imperviousness, slope, width, depression storage and Manning's roughness for pervious and impervious areas; Horton or Green-Ampt infiltration parameters.

3) Subsurface quantity: Porosity, field capacity, wilting point, hydraulic conductivity, initial water table elevation, ET parameters; coefficients for groundwater outflow as function of stage and tail water elevations.

4) Channel/pipe quantity: linkages, shape, slope, length, Manning's roughness. EXTRAN transport also requires invert and ground elevation, storage volumes at manholes and other structures; geometric and hydraulic parameters for weirs, pumps, orifices, storage, etc.; infiltration rate into conduits.

5) Storage/sedimentation quantity: stage-area-volume-outflow relationship, hydraulic characteristics of outflows.

6) Surface quality: land use; total curb length; catchbasin volume and initial pollutant concentrations; street sweeping interval, efficiency and availability factor; dry days prior to initial precipitation; dust/dirt and/or pollutant fraction parameters for each land use, or pollutant rating curve coefficients; concentrations in precipitation; erosion parameters for Universal Soil Loss Equation, if simulated.

7) Dry-weather flow constant or on basis of diurnal and daily quantity/quality variations, population density, other demographic parameters.

8) Particle size distribution, Shields parameter decay coefficients for channel/pipe quality routing and scour/deposition routine (optional).

9) Storage/treatment: parameters defining pollutant removal equation; parameters for individual treatment options such as particle size distribution, maximum flow rates, size of unit, outflow characteristics; optional dry-weather flow data when using continuous simulation.

10) Storage/treatment cost: parameters for capital and operation and maintenance costs as function of flows, volumes and operating time.

In order to create SWMM input files, the users have to follow certain sequences within one particular block or between blocks. In the Runoff Block, for example, the Group Identifiers, i.e., SWMM ID, are defined as the order of input data and are characterized into five sections: general input and control data, meteorological data, surface quantity, surface quality, and print control. Each section may be divided into subsections, e.g., meteorological data include snow data, precipitation data, and evaporation data. Many individual parameters are entered in those data categories.

2.4 Output

SWMM produces a time history of flow, stage and constituent concentration at any point in the watershed for Runoff, Transport, Storage/Treatment Blocks. Seasonal and annual summaries are also produced, along with continuity checks and other summary output. Simulation output in the Extran takes the form of water surface elevations and discharges at selected system locations.

CHAPTER 3

IMPLEMENTATION OF SWMM IN WINDOWS

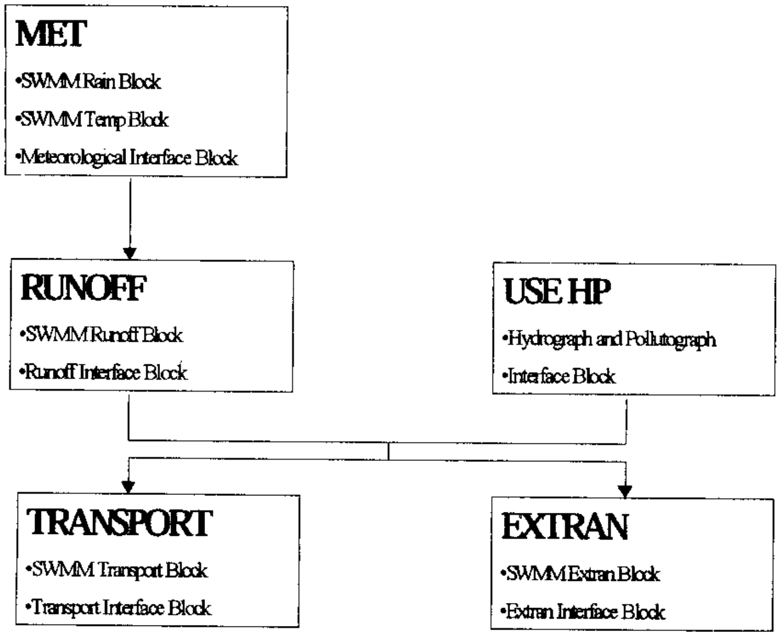
The SWMM Windows interface is designed to be as user-friendly as possible. The SWMM Windows interface consists of five interface blocks: METeorological data (MET), RUNOFF, USEr defined Hydrographs and Pollutographs (USEHP), TRANSPORT, and EXTRAN. Basically, the MET function acts as the Rain and Temp blocks. The RUNOFF, TRANSPORT, and EXTRAN interface blocks perform the same functions as the Runoff, Transport, and EXTRAN Blocks do in SWMM 4.3. The USEHP function allows the user to define time series of flows and concentrations at desired inlets.

A key feature of the design of a "Windows" user interface for SWMM 4.3 is the separation of meteorological data from the Runoff Block of user input. Users will access the MET interface to create and edit meteorological data. Selection of meteorological data for use in a RUNOFF run will occur as part of the RUNOFF function. The goal of this function is to consolidate user interaction and input of meteorological data in SWMM into one separate module. From a user's perspective, all meteorological data will be accessed unambiguously by a single file name. This therefore, eliminates meteorological data entry in the RUNOFF input file. Similar consideration made in the TRANSPORT and EXTRAN functions is the separation of user defined hydrographs and pollutographs from the TRANSPORT and EXTRAN user input. The USEHP function handles all user-supplied flows and concentrations.

The normal execution sequence for the SWMM Windows interface is indicated by an arrow symbol as shown in the screen in Figure 3.1. Usually, MET should be executed first to create interface files that are required input to the Runoff Block. Likewise, RUNOFF creates an interface file that is required input to the Transport and EXTRAN Blocks. USEHP serves the same function for input to the Transport and EXTRAN Blocks as the runoff interface file does. TRANSPORT or EXTRAN can be executed independently when either a Runoff interface file or a USEHP file exists.

3.1 MET

As mentioned earlier, MET allows the user to create and edit meteorological data. Input data in MET consists of three data components: general meteorological parameters, precipitation and evaporation, and snow data. Those three elements take a total of six screens (see Table 3.1). The first screen describes the control variables in MET, such as the types of meteorological data and units associated with the MET data. The selections on the first screen determines which subsequent screens are accessible. The next two screens contain raingage stations and precipitation data. The fifth screen defines monthly average evaporation and/or wind speed. Air temperatures are stored on the fourth screen for continuous snowmelt simulation, and on the last screen for single event snow melt simulation. RAIN (precipitation) and evaporation data are always required in MET. Wind speed and temperature data are needed when the snowmelt is simulated .



- SWMM Graph Block replaced by SWMM post-processor
- There no Windows interface for: Storage/Treatment Block, Graph Block, Statistics Block or Combine Block

Figure 3.1 SWMM Windows Interface Functions

Precipitation data are the single most important group of hydrologic data required by SWMM. SWMM requires a hyetograph of rainfall intensities versus time for the period of simulation. For single event simulation, this is usually a single storm, and data for up to ten raingages may be entered. For continuous simulation, hourly, daily or other continuous data from at least one gage are required. RAIN data can be selected from a NOAA data file, an existing user-created file, or a new file. NOAA data files are obtained from the EPA Environmental Research Lab in Athens, Georgia. They contain 35-year daily weather data for all NOAA first order stations in the United States. At present only one raingage is available when the user selects the NOAA data option from our meteorological database. The RAIN data should be entered in the Rain Data Table on Screen No. 3. Input variables for this screen are listed in Table A.1. The format used in Rain Data Table is the same one stored in the Rain Block interface file of SWMM, which is an unformatted binary file. Thus, the RAIN data can be handled through the Rain Data Table instead of using the Rain Block and E1-E3 data groups in Runoff Block.

NWS precipitation data can be also read into the MET function. The data include: 1) hourly and 15-min precipitation data for NWS Release B Condensed (IFORM=4 in the Rain Block); and 2) hourly precipitation data for NWS Card Deck 488 file (IFORM=2 in the Rain Block).

Evaporation can be input either by entering monthly average rates or using default rates that are internally supplied in the SWMM model. Wind speed and temperature data are needed, if snowmelt simulations are included. Similar to evaporation rates, a monthly average wind speed should be provided. When a daily NOAA data file is selected, MET will automatically compute monthly values for evaporation and wind speed.

Air temperature can be entered on either Screen No.4 or Screen No. 6 based upon the types of snowmelt simulation. Continuous snowmelt simulation requires a complete time history of daily maximum and minimum temperatures on Screen No. 4. These maximum/minimum temperatures are supplied in the NOAA data file. A single event snowmelt simulation receives air temperatures from Screen No. 6 for a given time step entered on the first screen. The temperatures are constant over the time interval.

After all the data are entered, MET will generate four MET interface files: a RAIN data interface file, a TEMP data interface file, an evaporation and wind speed file (EVAWIND), and a single event snow melt temperature file (SINAIR). The first two interface files are the SWMM scratch files processed during the execution of the Runoff block. The other two files would be processed into the Runoff Block input file. The evaporation and wind speed data from the EVAWIND file will be placed on F1 and C2 data group lines in the RUNOFF input file, respectively. The air temperature from the SINAIR file will be input to C5 data group line.

Table 3.1 Data Category and Screen Input in MET interface

Data Element	Category			Screen Title	Data Requirement	Screen No.
1	General Meteorological Parameters				Units, control variables	1
2	Precipitation			Station Table	Raingage station number (max=10)	2
				Rain Data Table	Hourly, daily, and any time step precip. values	3
	Evaporation			Avg. EVAP & WINDSPEED Table	Default evap. rates	1
					Monthly evap. rates	5
3	SNOW	Windspeed			Monthly windspeed rates	5
		Temp	Single Event	Single Event Snow Melt Air Temp. Table	Time interval, air temp values	6
			Continuous	TEMP Data Table	Daily Max & Min temp. data	4

3.2 RUNOFF

The RUNOFF interface block assist in creating the Runoff input file and call the SWMM Runoff Block for execution. It is designed to closely follow the input representation order in the Runoff Block of SWMM 4.3. Input data in RUNOFF are divided into five data elements: general control parameter, meteorological data, water quality, description of a drainage system, and print control. The general control parameter includes identifying a MET file, unit, simulation length, starting date, time step, and type of simulations. These selections determine whether subsequent screens or controls are accessible. The meteorological data include precipitation, evaporation, temperature, and wind speed, which should be generated through the MET function. Water quality simulation requires the user to specify up to ten pollutants and appropriate parameters to buildup and washoff mechanisms, and up to five land uses to characterize different subcatchments. Erosion and groundwater simulations are optional. A drainage system can be described as number of subcatchments (subwatersheds) connected with channels/pipes. Necessary inputs associated with subcatchment are surface area, width, ground slope, Manning's roughness coefficient, and infiltration rates. Channel descriptions are the length, Manning's roughness coefficient, invert slope, diameter for pipes, and cross-sectional dimensions of the channel. Other inputs are discussed in Section 2.1.

There are a total of twenty-three screens in the RUNOFF interface. The screen input sequence

Table 3.2. Screen Input Sequence in RUNOFF Interface

Data El.	Category	Content			SWMM ID	Screen No.
1	General Control Parameter	Titles			A1	1
		Units			B1	2
		Simulation	Starting, ending time, time step		B1, B3	1
		Simulation Type: Groundwater Flow & Quality (J1)				2
2	Meteorologic Data (B1)	Precipitation (D1)	hyetographs (1-10)		E1-E3	2
			RAIN (database)			
		Evaporation	default rates		F1	
			monthly rates			
			TEMP (database)			
		Snow (B1)	no		C1-C5	2,3,4,5
			single event			
			continuous			
3	Water Quality	Pollutants (1-10)			J3	6 & 7
		Land uses & fractions			J2 & J4	8 & 9
		Groundwater Concentration			J5	10
4	Description of a Drainage System	Channel/Pipe	#,inlet #, length,slope, Manning's n		G1-G2	11
		Watershed/ Subcatchment	Surface Water	#, inlet	H1	12 & 13
				infiltration		
			Groundwater	physical	H2-H4	14
				empirical		
			Snow		I1-I2	15 & 16
			Erosion		K1	17
			Quality		L1-L2	18
5	Print control	SWMM output, Inlet hydrographs, pollutographs, inflows, outflows, channel depths.			B2, M1-M3	19-23

(see Table 3.2) reflects the overall structure of the Runoff Block. Screen numbers are assigned corresponding to the data elements and to cover all the input requirements. Table 3.2 also shows the relationship between the screen numbers in the RUNOFF interface and SWMM ID (Group Identifiers) in a RUNOFF input file. Furthermore, a spreadsheet (see Table A.2) is generated to identify the controls (variables) for each screen. This table defines the following for RUNOFF:

1. variable name in the Runoff Block of SWMM 4.3,

2. the description of the variable,

3. SWMM ID in the Runoff Block of SWMM 4.3 (SID),

4. screen number (SCR),

5. control number (CS),

6. control type (CT), item, range, default, and unit.

Each variable in the Runoff Block for SWMM 4.3 has a unique control number on a particular screen in the RUNOFF interface. For example, in the first page of Table A.2, a variable WET in SWMM 4.3 is interpreted as Wet time step (sec), which is the eighth control on the first screen in the RUNOFF Windows interface.

For WET, the SID (SWMM ID) should be under Group B3, the type is floating, the range must be equal or greater than one, the default should be 3600.0 seconds, and the unit is in seconds. The relationship between variables of SWMM 4.3 and controls of SWMM interface can be easily checked in Table A.2.

3.3 USEHP

The USEHP function is designed to create and edit user-defined inlet flows and concentrations. This option is preferable to the RUNOFF interface file option for those users who wish mainly to use the Transport Block or the EXTRAN Block. For EXTRAN, the user should provide only inlet hydrographs in USEHP since EXTRAN is not capable of simulating water quality. Any quality information that is input to EXTRAN is ignored by the program.

There are a total of five screens in the USEHP interface block and input requirements are listed in Table 3.3. USEHP will generate four USEHP files (see Table 5.1) as input to the Transport and Extran Blocks. As shown in Table 3.3, the values stored in USEHP correspond to the variables and data group lines in either a Transport Block input or an EXTRAN Block input. For a Transport input file, two variables, (i.e., NINPUT and NCNTRL) and two data lines (i.e., I1 and R1) are used for inlet hydrographs; and a variable (NPOLL) and two data lines (i.e., F1 and R1) are used for inlet pollutographs. Similarly, for an EXTRAN input a variable, NJSW, and K1-K3 data lines are used for the inlet hydrographs.

Table 3.3 Screen Input Sequence in USEHP interface

Data Element	Category	Data Requirement	Transport Block	Extran Block	Screen No.
1	General Control Parameters	Units, # of inlets, # of pollutants, # of data points	NINPUT NPOLL	NJSW	1
2	List of Inlet Numbers	Inlet number	I1	K2	2
	Pollutant Name Table	Pollutant name, input and output unit	F1	No	3
	Time of day	Time in hours	R1	K1,K3	4
	Hydrograph/Pollutograph Table	Time series of flows and concentrations			5

Table 3.4 Screen Input Sequence in TRANSPORT Interface

Data Element	Category	Content		SWMM ID	Screen No.
1	TRANSPORT Simulation Control	Title		A1	1
		Inlet Hydrographs and Pollutographs		B3	
		Computational Control		B1,B3	
		Simulation Type	Simulation Type	B3	2
			Unit	B1	
			# of Constituents	B1	
2	Sewer System Description	Sewer System Table		E1	3
		Special Types of Sewer Element	Storage Tank	G1-G5	
			New Shapes	C1,D1-D9	
			Natural Channel (HEC-2 format)	E2-E4	
3	Water Quality			F1	4
4	Infiltration and Dry-Weather Flow			K1,K2,L1-L3, M1-M4	5,6,7,8
5	Study Area Description	Study Area Parameters		N1,O1,O2	9 & 10
		Process Flow Characteristics		P1	11
		Categorized Study Area		Q1	12
6	Print Control	Printed non-conduit elements for hydrograph & pollutograph	Transferred to Graph Block	B1,C1,H1	13 & 14
			Input	J1	15
			Output	J2	16
		Printed conduit elements for depths		I2	17

3.4 TRANSPORT

The Transport Block of SWMM 4.3 was implemented following the same procedure as used for the Runoff Block of SWMM 4.3. Table 3.4 indicates the screen input sequence in the TRANSPORT interface as compared to in the SWMM model. The TRANSPORT interface is characterized into six data components, namely TRANSPORT simulation control, sewer system description, water quality, infiltration and dry-weather flow, study area description, and print control. TRANSPORT simulation control defines an inlet hydrograph and pollutograph file, computational parameters, units, and types of simulation. Sewer system description provides the physical characteristics of the conveyance system. Quality data identify pollutants to be routed and their characteristics. Infiltration and Dry-Weather Flow (DWF) data describe the necessary drainage area characteristics to permit the computation of the respective inflow quantities and qualities. Print control reports a time history of inlet hydrographs and pollutographs, and a time history of channel depths.

The physical representation of the sewer system is a key input to the TRANSPORT simulation. The sewer system is classified as a certain type of "element." All elements in combination form in a manner similar to that of links and nodes (Huber and Dickinson, 1988). Elements in a real system can be described as a network of conduits (e.g., channels/pipes) joined with non-conduits such as manholes. Conduits themselves may be of different element types depending upon their geometrical cross-section. Non-conduits must be located at points corresponding to inlet points for hydrographs generated by either the Runoff Block or USEHP. According to SWMM documentation, there is a total of twenty-five types of elements that are available for use in Transport Block (See Table 3.5). Eighteen of them are conduit elements and seven are non-conduit elements. For the elements with regular shapes, data requirements are usually the tabulation of shape, dimension, slope, and roughness parameters. While for the elements with irregular shapes, supplemental data are required, such as flow-area and depth-area relationships of the elements. The irregular shapes are new shapes and natural channels with HEC-2 format for conduit elements and storage tanks for non-conduit elements.

Only up to four pollutants can be handled for water quality simulation in the Transport Block. Pollutants may be introduced to the sewer system by either the RUNOFF interface or USEHP using the data group I1 and R1 in the Transport input file.

The TRANSPORT interface contains a total of seventeen screens. The data components associated with screen numbers in the interface and SWMM ID in SWMM 4.3 are presented in Table 3.4. Table A.4 contains a description of the TRANSPORT data requirements including variable definitions, SWMM ID, screen number, control number, control type, control item, type, range, default, and units. This table was designed to assist in assembling data for implementing WINDOWS processes of SWMM and give a clear picture of identifying the variables used in TRANSPORT interface as compared to SWMM 4.3.

The TRANSPORT interface reads the data for conduit and non-conduit elements from the Sewer System Table on Screen No. 3. Different element types supplied with the TRANSPORT block and corresponding element names used in the TRANSPORT interface are listed in Table 3.5. Three irregular shapes of elements are a natural channel, a user-supplied shape, and a storage unit. They are treated as special elements and have to be separate functions in the TRANSPORT interface. Currently, the TRANSPORT allows the user to specify three types of files, which correspond to three types of sewer elements. They are defined as follows:

Special Elements	**SWMM Data Groups in Transport Block**	**File Name Used in TRANSPORT interface**
HEC-2 forma	E2-E3	XHEC2*.PIP
User supplied	C1, D1-D9	XSHAP*.PIP
Storage unit	G1-G5	XTANK*.PIP

The files must contain the input parameters and data group lines required by the TRANSPORT input. The three types of files are XHEC2###.PIP for a natural channel, XSHAP###.PIP for a user supplied shape, and XTANK###.PIP for a storage unit. For example, you define a non-conduit element as a storage tank, you need to prepare a data file containing G1-G5 data group lines using any text editor outside of the Windows interface. You should save this file as

XTANK*.PIP. Next, go to the fourth column under TYPE on Screen 3 in the TRANSPORT interface and specify the file that you created. Table 5.1 presents files created by TRANSPORT

3.5 EXTRAN

There are three data components included in the Extran Block: EXTRAN simulation control, sewer system description, and output print and plot. The EXTRAN simulation control defines the simulation, an inlet hydrograph file, computational control, and simulation methods. Like the TRANSPORT interface, EXTRAN gets inlet flows from either a RUNOFF interface file or a USEHP file. Therefore, the user must run either RUNOFF or USEHP before proceeding with EXTRAN. The sewer system description is divided into two sections: identification of channels/conduits and junctions. The cross sections of channels/conduits can be regular or irregular. For regular channels, input data are relatively simple. For irregular channels, however, data are complex and a detailed description to define cross sections for each channel is needed. Junction data can be described as regular junctions and special flow devices that divert sanitary sewage out of a combined sewer system or relieve the storm load on sanitary interceptors. The five types of junctions are storage, orifice, weir, pump, and outfall. Like irregular channels, those special junctions may require detailed input describing a time-history curve for stage, volume, flow, etc. Output print and plot determine number junctions and channels for printing and plotting of heads and flows.

There are twenty-three screens for the EXTRAN interface, as shown in Table 3.6. Sixteen of these screens are for inputs for channels and junctions. Two looping screens are developed to handle large input depending upon the type of channel or junction. Variable input sequences on each screen are given in Table A.5 which defines the variable name, the descripyion of variable, SWMMID, screen number, control number and the variable's usage. Screens No. 4 and 5 are designed to store the data for natural channels, which use the same format as used in the HEC-2 model.

Table 3.5 **Different Element Types in Transport Block**

NTYPE	Transport Block	TRANSPORT interface
CONDUIT ELEMENTS		
1	Circular	Circular
2	Rectangular	Rectangular
3	Phillips standard egg shape	Egg shape
4	Boston horseshoe	Horseshoe
5	Gothic	Gothic
6	Catenary	Catenary
7	Louisville semielliptic	Semielliptic
8	Basket-handle	Baslet-Handle
9	Semi-circular	Semi-circular
10	Modified basket-handle	Modified B-H
11	Rectangular, triangular bottom	R + tri bottom
12	Rectangular, round bottom	R + round bottom
13	Trapezoid	Trapezoid
14	Parabolic	Parabolic
15	Power Function	Power F
16	HEC-2 Format - Natural Channel	XHEC2###.PIP
17, 18	User supplied	XSHAP###.PIP
NON-CONDUIT ELEMENTS		
19	Manhole	Manhole
20	Lift station	Lift station
21	Flow divider	Flow divider
22	Storage unit	XTANK###.PIP
23	Flow divider - weir	Flow divider-weir
24	Flow divider	Flow divider
25	Backwater element	Backwater

Table 3.6 Screen Input Sequence in EXTRAN Interface

Data Element	Category	Content		SWMM ID	Screen No.
1	EXTRAN Simulation Control	Title		A1	1
		Inlet Hydrographs		B3,K1,K2,K3 (if USEHP is selected)	
		Computational Control and Unit		B1,B3,B2	
		Simulation and print control	Solution technique, flow condition, and conduit elevation	B0,BB	2
			Print cycle	B1	
2	Sewer System Description	Channels/Conduits	Channels/Conduits Table	C1	3
			Natural Channel (HEC-2 format)	C2-C4	4-5
		Junctions	Regular Junction	D1,I1,I2,J1	6
			Storage Junction	E1,E2	7-8
			Orifice	F1,F2	9-12
			Weir	G1	13-14
			Pump	H1	15-16
			Outfall	J2-J4	17-18
3	Output print and plot	Printed and plotted Junctions for elevations		B4,B6	19,21
		Printed and plotted channels for flows and velocities		B5,B7	20,22
		Plotted channels for US/DS elevations		B8	23

MINIMUM SYSTEM REQUIREMENTS AND SOFTWARE INSTALLATION

4.1Minimum System Requirements

The system runs under Microsoft® Windows. The minimum system requirements are provided below:

- Windows Version 3.1
- 80386 Processor
- 4 Megabytes RAM
- 10 Megabytes hard disk space

NOTE: A math co-processor is recommended but not required.

4.2 Installing the Software

STEP 1. Insert the SWMM Setup Disk (i.e., SWMM - DISK 1), into drive A: or B:

NOTE: User must have 10 Megabytes of space on the hard disk drive on which you are installing SWMM for Windows. **Also close all open applications including FILE MANAGER before you start the SETUP program.**

STEP 2. Start Windows and, at the Program Manager, choose File | Run.

STEP 3: Type A:SETUP.EXE ("B:" if the disk is on the B: drive) and press ENTER.

STEP 4: User will be asked to enter the path of the directory where you would like SWMM to be installed. When you accept the default path or enter a new directory path, the installation will begin.

The SWMM Windows interface consists of three disks.

STEP 5. User is now ready to use SWMM.

The executable for which the SETUP program has already created an icon is described below.

Executable	**Description**
SWMM.EXE	The main SWMM executable. This executable allows user access to the two SWMM options:

The Windows Interface Option:
This option calls up all the windows implementations of the various blocks of SWMM as explained in Section 3.

Manual Run Option:
For experienced users of SWMM and those familiar with the structure of the input files, this option allows user to edit input files directly using a data editor.

NOTE: The working directory option should be the one containing the executables since SWMM requires certain table files in order to create the input files.

CHAPTER 5

USING THE SWMM WINDOWS INTERFACE

Once the software is installed, user will be ready to access the SWMM Windows Interface and Manual Run option. Whenuser selects the Windows Interface option, a flow-chart that is shown as in Figure 3.1 that shows the various interface blocks that are available and the sequence to be followed in accessing them. All the interface blocks share certain characteristics since they are all in Windows. This chapter details how to use the capabilities available in the various interface blocks in SWMM. In addition, it will detail the Manual Run option as well. This section describes the following:

- Accessing An Existing File or Opening a New File
- SWMM File-Naming Conventions
- Saving Input Files
- Setting Up a Default Editor for Viewing Output Files
- Submitting an Input File to the Model
- SWMM Windows Interface Commands and Function Keys
- Import File Option in SWMM
- Export Function
- Array Screen Capabilities
- Using the Manual Run option

5.1 Accessing an Existing File or Opening a New File

When user first enters any of the Windows SWMM Blocks, .he will be automatically assigned a new file. The new file name and number will appear at the top of the screen in parentheses.

To access an existing file, click on the FILE option on the very top line, select the OPEN option and select the file that .is required from the list that appears.

NOTE: The input files must be in the same location as the *.EXE files (the SWMM executable files). If ser elects to read in an existing file from a different directory, the directory that the file is in becomes the default directory for SWMM. All the data files for

> SWMM must exist in the default directory. So It is strongly recommended that user does not save input files in any location other than the SWMM directory.

If user selected an existing file to edit, when you choose to save the file, the existing file will be rewritten with the new values unless user chooses the SAVE AS option and assign a new file name. If user is assigning a new name to a file, follow the naming conventions followed by SWMM explained in the next subsection.

5.2 SWMM File Naming Conventions

The naming convention of files in SWMM is as follows: the first four characters are the interface block name, the next three digits are sequentially assigned numbers that indicate the number of the input file that user is currently creating, and the file extension indicates the file type. Table 5.1 summarizes naming conventions of the SWMM interface for each function. There are three file extensions in the MET input files. The first extension is .MET which indicates user defined meteorological data, the second one is .DAT that contains hourly precipitation data, and the last one is .ATH that indicates long term meteorological data obtained from the EPA Athens Lab. The file extensions in the RUNOFF and TRANSPORT interfaces are also standardized. For instance, *.INP is the input file and *.OUT is the output file.

Additional files for RUNOFF and TRANSPORT are post-processor files, which include the Tables, Graphics, and Calibration files. They are defined below:

The RUNOFF Interface:

SWRPP*.INP	Tables file based on RNOFF*.INT
SWRGR*.INP	Graphics file based on RNOFF*.INT
SWRCA*.INP	Calibration file based on RNOFF*.INT

The TRANSPORT Interface:

SWTPP*.INP	Tables file based on TRANS*.INT
SWTGR*.INP	Graphics file based on TRANS*.INT
SWTCA*.INP	Calibration file based on TRANS*.INT

5.3 Saving Input Files

SWMM will ask user whetherhe wishes to save the input file when exiting an interface block or when reaching the last screen of an interface function. However, if user has accessed an existing file and made all the changes before reaching the last screen, he may save the input file by proceeding to the FILE option and selecting the SAVE option. Once an input file is completed, it is submitted to the SWMM model for execution. When user submits the input file to the model, the input file will be validated by the Windows interface. If any errors are detected during the validation, he will be informed of them and brought to the incorrect entry so that you might effect the change immediately.

Table 5.1 Naming Conventions of SWMM Interface

Interface Blocks	File Name	File Type (Fmt)[1]	Content
METeorological data editor (MET)	SMET###.MET	Input (A)	MET Windows interface input.
	*.DAT	Input (A)	Hourly precipitation data.
	*.ATH	Input (A)	Daily meteorological data for NOAA first order stations in the U.S. Provided by the EPA in Athens, GA.
	SMET###.MT1	Output/Input (B)	A Rain interface file that contains precipitation data. An input file to the Runoff Block.
	SMET###.MT2		A Temp interface file that contains maximum and minimum temperatures. This is an input file to the Runoff Block.
	SMET###.MT3		An monthly evaporation and wind speed file. To be placed in F1 and C2 lines in a Runoff input file.
	SMET###.MT4		A air temp data file for single snow melt simulation. To be placed in C5 line in a Runoff input file.
RUNOFF	RNOFF###.INP	Input (A)	RUNOFF Windows interface input.
	RNOFF###.RUN	Input (A)	RUNOFF run file which can be executed under DOS.
	RNOFF###.OUT	Output (A)	Runoff output generated by SWMM.
	RNOFF###.INT	Output (B)	Runoff interface file generated by SWMM.
USEr defined Hydrographs and Pollutographs (USEHP)	USEHP###.HP	Input (A)	USEHP Windows interface input.
	USEHP###.HP1	Output/Input (A)	An inlet hydrograph and/or pollutograph file. To be placed in the NINPUT, NPOLL, F1, I1, and R1 lines in a Transport input file.
	USEHP###.HP2		
	USEHP###.HP3		
	USEHP###.HP4		An inlet hydrograph file to be placed in K1-K3 lines and NJSW in EXTRAN input file.
TRANSPORT	TRANS###.INP	Input (A)	TRANSPORT Windows interface input.
	XTANK###.PIP		Storage tank data file defined by the user.
	XSHAP###.PIP		New shapes data file defined by the user.
	XHEC2###.PIP		Natural channel (HEC-2 format) file defined by the user.
	TRANS###.RUN		TRANSPORT run file which can be executed under DOS.
	TRANS###.OUT	Output (A)	Transport output generated by SWMM
	TRANS###.INT	Output (B)	Transport interface file generated by SWMM.
EXTRAN	EXTRN###.INP	Input (A)	EXTRAN Windows Interface input
	EXTRN###.RUN		EXTRAN run file which can be executed under DOS.
	EXTRN###.OUT	Output (A)	Extran output generated by SWMM
	EXTRN###.INT	Output (B)	Extran interface file. can be used for subsequent blocks.

[1] File format can be either ASCII (A) or Binary (B).

5.4 Setting Up a Default Editor for Viewing Output Files

The default editor for viewing and editing SWMM output files is the WRITE program in Windows. However, users may choose any other data editor (e.g., EDIT.EXE) for viewing the output by selecting the Utilities menu on the top line of the screen and using the Setup Output File Viewer option. The path and executable name of the output file editor should be specified under this option.

This output viewer is automatically activated each time a SWMM run is completed. To view the model output (rather than submitting a SWMM model run), the editor can be used outside the SWMM Windows interface. Using the appropriate file manipulations of the editor, the SWMM output file can be opened, edited, and saved.

5.5 Submitting an Input File to the Model

When the input file for the interface is completed, select the RUN button to run the model with the input file created. When user selects the RUN option, all the entries in the file will be validated. If any errors are detected during the validation, SWMM will put up a message informing the type of error detected and will then take to the prompt that is incorrect. Once all the values are valid, the file is submitted to the appropriate block for execution. An icon will appear at the bottom of the screen for those blocks for which the SWMM model is called. When the processing of the input file is complete and the output results, SWMM will ask whether user wishes to view them. If you indicated that you did wish to view the output file, SWMM will show them using a data editor allowing you to annotate the results if the user chooses. To exit from the Data File Editor, press the ALT and F4 function keys simultaneously. User will be returned to the interface block that he was in previously.

5.6 SWMM Windows Interface Commands and Function Keys

The Windows Interface options all have a series of "buttons" designed to make using the system as easy as possible. These buttons and the commands they represent are accessible in three ways: (1) click on the button with the mouse key to access the function that button represents, (2) press the ALT along with the underlined letter in the button title (e.g. ALT/H for Help), or (3) select the TOOL option and select the option under there from the list presented.

The buttons and the commands they represent are explained below:

The NEXT Button This option allows to move to the next screen in the interface. If there are incorrect values on the screen that user is in currently and attempts to move to another screen, SWMM will inform of the error and allow the option of going back (and correcting the error at a later time) or correcting the error. The cursor will blink at the prompt with the incorrect entry, if user elects to correct the error before moving on.

The BACK button This button allows to move back one screen. If there are incorrect values on the screen that user is in currently and attempts to move to another screen, SWMM will inform of the error and allow the option of going back (and correcting the error at a later time) or correcting the error. The cursor will blink at the prompt with the incorrect entry, if user elects to correct the error before moving on.

The INDEX Function Instead of moving backwards and forwards through the screens,user may use the INDEX feature to hop back and forth between screens. To access this feature, move the cursor over the INDEX button and click with the mouse button, or enter ALT, I. All the screens available in this option will be displayed with the screen title and the screen numbers. Certain screens will be grayed out. This indicates that these screens are not accessible due to selections made on other screens. The screen that user was in when he selected the INDEX button will be highlighted in blue text.

If user wishes to see the prompts that appear on each screen, press the EXPAND button at the bottom of the INDEX screen. The screen names and numbers will then include all the prompts contained in the screens. User may contract the screen again to the normal display of just the screen names and number by clicking on the CONTRACT button.

To move to the screen that user wants, move the cursor over the screen number of any non-gray screen and click the left mouse button. He is taken immediately to that screen. To exit the INDEX screen and return to the previous screen, click on the CANCEL button.

The HELP Button This option allows user access help information on that interface. There are two different types of help: **Prompt-Level Help** which contains information on the specific prompt that thecursor is on or on which user is entering data and **General Help** which contains a general description of the SWMM system.

To access **General Help**, move cursor to the tool bar and the select the HELP option, or enter ALT, H from the keyboard. A menu will appear. Select the HELP INDEX option or enter I from the key board.

To access **Prompt-Level Help**, move cursor over to the prompt on which user would like information and press either the **F1** function key or move cursor over to the HELP button and click.

A window will appear in either case displaying broad help or prompt-specific help. If accessing prompt-specific help, user may browse through the helps for all the additional prompts that are related to the prompt by accessing the forward and backward BROWSE keys.

All words or sentences that are in green and underlined have further information on them. Move cursor over the phrase on which further information is required and click. User will be taken to that option.

There is a search function within the HELP functions that allows to type in a word and find all the help available on the word typed. To access this, select the SEARCH key in the HELP window and follow instructions.

When viewing help, exit the help window by either entering ALT, F4 from the keyboard or by moving the cursor over to the icon on the top left corner of the window and double clicking the left mouse button. It will be returned to the previous screen.

The CALC Button This option allows to access the Calculator Function within Windows, required for the use of a calculator at any screen in SWMM.

The TOP Button This option allows to move to the first screen in SWMM from any screen without having to use the INDEX function.

The RUN Button This option allows to submit an input file thatwas created to the SWMM model for execution. If there are incorrect entries in the file when clicked on this button, SWMM will inform of the incorrect values and take to the appropriate prompt so that user may correct the value and resubmit the file.

The RESTORE Button This option allows to restore the default values that were in the file before starting making changes for this screen. This is an option that allows to start again without having to exit the system or go back to every variable that you changed.

The TABLES Button This option allows to tabulate the SWMM output results. The Tables function presents the user with two types of tables: Summary table and Event Mean Concentrations (EMCs) table.

The GRAPHICS Button This option allows to graph the SWMM output results. There are six different types of graphs available: hydrograph, pollutograph, loadograph, flow volume, mass, and land use.

The CALIBRATION Button This option allows to perform the calibration based on the SWMM results. This option can be used to compare simulated results with observed data. Two types of graphs and one statistical table are generated at the end of the calibration. Refer to Accessing The Calibration Routine for details (Section 7.3).

5.7 Import File Option In SWMM

The import file option allows the user to access existing input files that are generated from other model runs. The SWMM interface can import three types of files: NWS rainfall data can be imported into the MET interface for the Rain Block, an existing runoff input file can be imported into the Windows interface for the RUNOFF block and existing transport input files can be imported into the Windows interface for the TRANSPORT block.

Procedure for Using the Import Functions

The Import option is selected from the main menu bar at the top of MET, RUNOFF, or TRANSPORT interfaces. When the import option is selected, the Runoff file will appear as an option. Select this option.

A window will appear with a list of Runoff Input file that are in the SWMM directory. To see a list of files with extensions other than .DAT extension, select the List Files of Type option at the bottom of the window. The second option will be to see a list of all the files in the directory. To import a file from the list, bring the cursor to the file that user would like to import and click twice in quick succession or click on the OK button when the cursor is on the file. A description line, which consists of the top line of the file (i.e., the A1 card in the Runoff input), is provided to help identify the file when the cursor is on the file name.

The SWMM interface currently supports the SWMM 4.2 version, although the SWMM 4.3 execution file (05/25/94) is used. Not all the SWMM input cards in the SWMM blocks can be read into the interfaces. For example, the L2 card in the Runoff Block cannot be imported to the RUNOFF interface. To find a list of the SWMM ID cards and variables that can be read into the interface refer to Appendix B. A message will be displayed on the screen when reading the new SWMM cards.

The weather data handled in SWMM interface is different from the Runoff Block of the SWMM model. The interface allows the user to enter all the weather data in MET while the Runoff Block lets the user enter the rainfall data either in the Rain Block or in the Runoff input itself. When importing an existing Runoff input file, the RUNOFF interface reads most of the data lines except E1-E3, D1, and F1 lines in the Runoff input file (see SWMM manual by Huber, W.C. and Dickinson, R.E., 1988, for explanation of data lines). Those rainfall and evaporation data should be entered in the MET interface. In other word, the user should interpret E1-E3, D1, and F1 lines and generate a new SMET*.MET file. A complete runoff interface file must include a MET file.

Existing input files can contain only one data block. Multiple blocks are not allowed. The interface Import function can read existing input files containing single block information, although the SWMM model allows the user to put more than one data block in one input file.

5.8 Export Function

The Export function is a function available under the Tables option that allows to export Summary data or EMCs tables to another file for export into a spreadsheet program or another analytical or graphical program. The Export function is available under the Edit option at the top of the screen.

Using the Export Function

STEP 1. Highlight the block of data (either rows or columns or both) that user wants to export. To select a block that is larger or wider than a screen, proceed to the cell that will begin block and click with the left mouse button. Next move to the last cell in the block that wanted and press the SHIFT key and the left mouse button simultaneously.

STEP 2. Select Edit at the top line of the window screen (ALT, E). Next, select Export. An Export screen will appear. There are two options for storing the data: table delimited or comma delimited. The table-delimited option will save the data in fixed columns, which is appropriate for a word processor. The comma-delimited option will separate the variables using commas; this option is appropriate for database and spreadsheet programs. After selecting the file format, provide a file name and hit the OK button. The highlighted block of data will be written into the file specified.

5.9 Array Screen Capabilities in SWMM

There are many array screens (the screens where the same variable requires a row of entries) in SWMM, such as hydraulic data, initial conditions, etc. At these screens, there are two additional capabilities that are not available on regular screens in SWMM.

1. EDIT: Copy and Paste

This option is available from the menu bar at the top of the Window (ALT, E). This capability may be used to select a block of data (either rows or columns or both) and paste it to another area if the same data is to be duplicated or copy data from a spreadsheet program where user may have climatological data, for instance, and copy it for use by SWMM. The first cell selected will be highlighted rather than in reverse video as are the remaining cells in the area that were selected.

To select a block that is larger or wider than a screen, proceed to the cell that will begin block and click with the left mouse button. Next move to the last cell in the block and press the SHIFT key and the left mouse button simultaneously. This will highlight the area wanted.

To paste the block that was just copied, move to the area that is wanted to copy the block to and select the paste option from EDIT. User will see a message advising that any data existing in the area selected will overwritten.

2. ARITHMETIC BOX

One of key features with the SWMM Windows interface is to provide mathematical calculations in columns so that the user can easily change a row of values in an array screen. This is because input values of variables in several groups or cards (e.g., G1 card) of the SWMM input may require "-1" or "-2" indicate a multiply ratio or a default value. This feature is selected by clicking on the variable title in any array, for instance, WIDTH (of subcatchment). A window will appear allowing you to do arithmetic operations for that column for a user-specified number of rows. User is able to access an arithmetic function that allows you to add, subtract, multiply or divide any single or range of values for that variable. He may also set default values for a variable in any array screen. For example, user may choose to multiply all the values in the rainfall intensity when performing sensitivity analyses.

5.10 Manual Run Option

This option is one of two main options available in the SWMM main menu. This option allows to edit input files and submit the appropriate ones to the model. Table 5.1 gives a summary of all the input and output files generated by SWMM and their file formats. User may only edit ASCII files. This option requires some expertise in SWMM, so it is recommended to use the Windows interface option to familiarize with the SWMM Model prior to using this option. To change the default file editor, select the Utilities option at the top of the screen. Click on Setup Output File Viewer. It will then be required to enter the location and executable name of the output file editor.

There are two options for the SWMM Input files:

EDIT User may edit two types of files using this option: *.RUN, which are the files generated by the RUNOFF, TRANSPORT, and EXTRAN interfaces for input to SWMM or *.DAT files, which are the traditional files created for the DOS model version of SWMM that user might have created previously or came with the SWMM model (the example runs that are provided, see chapter 6).

RUN Once user has edited either the *.RUN files or the *.DAT files, he may submit them for processing by the SWMM model by selecting this button.

CHAPTER 6

EXAMPLE RUNS

This section contains four example runs (with est data) to illustrate how to best use the SWMM Windows interface. The example runs are given in the windows interface. A matrix of SWMM interface with the various runs is shown in Table 6.1. The SWMM interface contains five blocks: MET, RUNOFF, USEHP, TRANSPORT, and EXTRAN. Each block has its own components, and each component may be divided into sections if applicable. Five SWMM interface blocks and their subdivisions are listed in the first column. The four example runs are given on the top row of Table 6.1. For a given example, two or more blocks may be used depending on the level of complexity of the simulation. Example 2 shown in Table 6.1, for instance, illustrates the combination of three blocks: MET, RUNOFF, and TRANSPORT. It includes the applications on 1) how to generate precipitation data for a single event simulation using MET; 2) how to describe a drainage system with channels and subwatersheds and simulate runoff and water quality using RUNOFF; and 3) how to apply TRANSPORT to a sewer system for the simulations of infiltration, dry weather, and water quality.

These examples were obtained from the EPA and demonstrated the applications on the Rain, Temp, Runoff, Transport, and Extran Blocks in the SWMM model. The interface runs can be checked using the input files supplied by EPA along with the distribution package for SWMM. The example input files prepared for testing the SWMM Windows interface and corresponding ones used for SWMM 4.3 are listed in Table 6.2. This table indicates the relationship between blocks used in the SWMM interface and Blocks in SWMM 4.3 for each example run. The first example is a screening level example: the rainfall-runoff was simulated through a single watershed. The first run shows the use of the MET and RUNOFF blocks, while the second one presents a user-supplied hyetograph utilizing MET, RUNOFF, and TRANSPORT. The sequence of running the SWMM Windows interface is given in the FUNCTION column of Table 6.2. In example 1, MET produces an input file called SMET001.MET, and further generates a Rain interface file after a RUN button is selected. This is equivalent to running the Rain Block using two input files: RAIN8.DAT and USRN4.DAT. A RUNOFF input file, RNOFF001.INP, generated by the interface can be checked with a Runoff Block input file, RUNOFF36.DAT.

6.1 Example 1—A User-Defined Hyetograph (A Screening-Level Example)

This is an example of a user-defined time series of rainfall with a total precipitation of 28.0 mm. A user defined hyetograph is shown in Table 6.3. The format (see Table 6.3) required by MET is the same one used in Rain Block interface file. A single catchment with a total drainage area of 300 hectares receives rainfall through an inlet. The catchment characteristics are 20% of impervious area, 100 meters long for catchment width, and 0.001 for ground slope. The total simulation length lasts 3 days.

This example shows how to use MET and RUNOFF together to perform a Runoff Block Run. Only hydrologic simulation is involved.

The steps that must be followed for this screening-level example are explained in detail below:

STEP 1. Select the SWMM Windows Interface option from the main SWMM menu. Next, select the MET Block, which is the first option in the flow chart, by clicking on the option.

STEP 2. Select the example MET data that has been created for you by clicking on the FILE option, followed by the OPEN option. Select the first file listed: SMET001.MET. The file will be loaded into the MET interface. Move through the screens and familiarize with the MET option. Use the HELP button to answer any questions Compare the input to Table 6.3 to make sure that it is the right file.

STEP 3. Next, click on the RUN button. MET will then generate a Rain Block interface file.

The RUN button must have been used before proceeding to the next block in SWMM.

STEP 4. Exit the MET option by pressing the ALT key and F4 function key. It will be returned to the SWMM Windows Interface menu. Select the RUNOFF option.

STEP 5. Click on the FILE option, select the OPEN File option. A list of Runoff Input Files will appear. Select the RNOFF001.INP file for this example run. Once this option is selected, the parameters for this example run will be entered from the file. The first screen for the RUNOFF block also allows to enter the Meteorological Inputfile. If the file that was created for the MET option does not show in the input option for the file name, click on the arrow key to the right of the option. A list of existing meteorological file names will appear. Select SMET001.MET. It is to be noted that, if userdid not use the RUN button from the MET interface, he will not be able to use the MET data since the interface file will not exist. He will be informed by the interface that the input file could not be read if he did not create the Rain Block Interface file in MET.

STEP 6. Familiarize with the screens in the RUNOFF option by moving through the screens using either the NEXT, BACK or INDEX options. Refer to Section 5 for more information on these buttons. Certain important screens are detailed below.

Screens 1 and 2:
The hydrologic simulation starts at January 1, 1988 and the simulation length is three days. Three time steps should be entered. Screen 2 in RUNOFF determines

Table 6.1 Example Run Matrix for SWMM Windows Interface

			EXAMPLE RUN			
BLOCKS			1	2	3	4
MET						
Precipitation			●	●		
Rain gage	- Single		●	●		
		- Multi				
Evaporation		- Default rates		●		
		- Monthly rates	●			
Snow	- Wind Speed					
	- Temp	- Single Event				
		- Continuous				
RUNOFF						
Drainage System						
		- Channels/Pipes		●		
		- Watersheds/ Subcatchments	●	●		
Snow	- Single Event					
	- Continuous					
Groundwater						
Water Quality				●		
Erosion						
USEHP						
Inlet	- Single				●	
	- Multi					●
Flow					●	●
Pollutant					●	
TRANSPORT						
Sewer System				●	●	
		- Storage Tank				
		- New Shape				
		- Natural Channel				
Infiltration Inflow				●		
Dry Weather Inflow				●		
Water Quality				●	●	
		- RUNOFF Interface		●		
		- USEHP			●	
EXTRAN						
Sewer System						
		- Channels				●
		- Junctions (one free outfall)				●
		Boundary Conditions				
Inlet Hydrographs						
		- RUNOFF Interface				
		- USEHP				●

Table 6.2 Example Input files with SWMM Windows and SWMM 4.3

	SWMM Windows Interface		SWMM 4.3	
Example	Block	Input File	Block	Input File
1	MET	SMET001.MET	Rain	RAIN8.DAT USRN4.DAT
	RUNOFF	RNOFF001.INP	Runoff	RUNOFF36.DAT
2	MET	SMET002.MET	Runoff	RUNOFF3.DAT
	RUNOFF	RNOFF002.INP		
	TRANSPORT	TRANS001.INP	Transport	TRANS1.DAT
3	USEHP	USEHP002.HP	Transport	TRANS35.DAT
	TRANSPORT	TRANS002.INP		
10	USEHP	USEHP001.HP	Extran	EXAM1.DAT
	EXTRAN	EXTRN001.INP		

Table 6.3 A User-Defined Hyetograph in MET

Julian Date	Hour[1] (second)	Time Interval THISTO (second)	Rainfall Intensity (mm/hr)
88001	3600	300	12
88001	7200	300	24
88001	10800	300	0
88001	25200	300	12
88001	26100	300	12
88001	27900	300	12
88001	30600	300	24
88001	34000	300	42
88002	37800	300	54
88002	41400	300	66
88002	45000	300	78

[1] Daytime (starting storm) hour in seconds from midnight

the complexity of the simulation. In this case, snowmelt is not included; default evaporation rates are used; and metric units are selected. Screens 3 through 8 are grayed because no snowmelt is simulated.

Screen 10:
This screen gives the physical representation of the watershed. For this example, there is a single watershed without a connecting channel. One inlet is defined as a raingage station in MET for this watershed. The raingage station in MET must

match the hyetograph number in RUNOFF. For this example, raingage station number is 1.

Screen 12:
Two infiltration equations are available to you in this screen: (1) the Horton and (2) the modified Green-Ampt equation. The Horton model is empirical and is perhaps the best known of the infiltration equations. Many hydrologists have a "feel" for the best values for its three parameters despite the fact that little published information is available.

The Green-Ampt equation is a physically-based model that can give you a good description of the infiltration process. The Mein-Larson (1973) formulation of the Green-Ampt equation is a two-stage model. The first step predicts the volume of water, which will infiltrate before the surface becomes saturated. From this point onwards, infiltration capacity is predicted directly by the Green-Ampt equation. This equation is applicable also if the rainfall intensity is less than the infiltration capacity at the beginning of the storm. New data have been published to help users evaluate the parameter values (e.g. Carlisle et al. 1981). Both equations require three different coefficients. The user will be required to enter these coefficients in Screen 13. The Windows interface has an additional function to help users with these coefficients. Depending on the equation selected by the user, definitions of each of these coefficient will appear when the user clicks on the appropriate variable.

For this example, the Green-Ampt equation has been selected. The three coefficients are 4.0 for the average capillary suction of water, 1.0 for the saturated hydraulic conductivity of soil, and 0.34 for the initial moisture deficit for soil.

STEP 7. Submit the RUNOFF input file to the SWMM model for execution by clicking on the RUN button. An icon will appear on the bottom of the screen with the words SWMM MODEL EXECUTION on the icon. When the processing is complete, the output will be shown in the default output file viewer. View the output carefully and see how the SWMM model blocks in this screening level example. Press the ALT/F4 sequence to exit when through. It will be returned to the RUNOFF block. Press the ALT/F4 sequence again until back at the SWMM main menu.

6.2 Example 2—Steven's Avenue Drainage District in Lancaster, PA (MET, RUNOFF, and TRANSPORT)

The 67 hectare Stevens Avenue Drainage District in Lancaster, Pennsylvania is a relatively steep (average slope = 0.046) combined sewered catchment with its overflow tributary to Conestoga Creek. It has been the site of intermittent monitoring activity since 1972 due to its selection as the location of a swirl concentrator from an EPA demonstration grant. Although several storms were monitored prior to construction activities, the measurement technique used the Manning's equation to develop a rating curve in a supercritical flow pipe section ("manhole 51" of SWMM schematization). As a result, measured flows (at 1.5 minute intervals) are very "flashy" and erratic; 6-min averages have been used in the SWMM calibration using the storm of November 28, 1973, taken from the EPA Urban Rainfall-Runoff-Quality Data Base (Huber et al., 1981). Further information about the catchment and sampling is given in the Data Base report and by Heaney et al. (1975). Quality concentration data have also been used for SS, BOD5, and COD calibrations using the same storm. Artificially high COD values are input at selected manholes to produce dry-weather flow COD values since the dry-weather flow generated by subroutine FILTH cannot generate any COD (see SWMM manual by Huber, W.C. and Dickinson, R.E., 1988, for explanation).

This watershed is a complex drainage system and is divided into 29 subwatersheds and 35 channels. There are 15 inlets in the drainage system. Seven pollutants are included for water quality simulations: (1) Total Solids (TS), (2) Total Suspended Solids (TSS), (3) BOD-5, (4) COD, (5) Total Coliform, (6) Ammonia nitrogen (NH_3-N), and (7) Total Phosphate (T-PO_4-P). Each subcatchment supplies one of five land uses: single family residential, multi-family residential, commercial, school, and parkland. The storm of November 28, 1975 with a rainfall duration of 40 minutes is used in the simulation. This example shows the use of MET, RUNOFF, and TRANSPORT.

The steps and the sequence of blocks for this example run are explained below:

STEP 1. Select the SWMM Windows Interface option from the main SWMM menu and select the MET option.

STEP 2. Select the example MET data that has been created by clicking on the FILE option, followed by the OPEN option. Select the second file listed: SMET002.MET. The file will be loaded into the MET interface. Move through the screens and familiarize yourself with the MET option. Use the help information available through the HELP button to answer any questions about any prompts. Next, click on the RUN button. MET will then generate a Rain Block interface file. User must have used the RUN button before proceeding to the next block in SWMM.

STEP 3. Exit the MET option by pressing the ALT key and F4 function key. User will be returned to the SWMM Windows Interface menu. Select the RUNOFF option.

STEP 4. Click on the FILE option, select the OPEN File option. A list of Runoff Input Files will appear. Select the RNOFF002.INP file for this example run. Once this option is selected, the parameters for this example run will be entered from the file. The first screen for the RUNOFF interface also allows to enter the Meteorological Input file. If the file created for the MET option does not show in the input option for the file name, click on the arrow key to the right of the option. A list of existing meteorological file names will appear. Select SMET002.MET. If user did not use the RUN button from the MET interface, he will not be able to use the MET data since the interface file will not exist. He will be informed by the interface that the input file could not be read if hedid not create the Rain Block Interface file in MET.

STEP 5. Familiarize with this input file and the screens in the RUNOFF option by moving through the screens using either the NEXT, BACK or INDEX options. Refer to Section 5 for more information on these buttons.

Screens Six through Eight and Eighteen are controlled by the selection of water quality simulation and will become available for data entry when user selects the water quality simulation option on Screen 2. He will be required to enter all the input values related to the water quality simulation. For water quality variable estimates, the user should read the file called README.2ND that is supplied with the SWMM 4.3 model released by the EPA (it will be in the SWMM directory). This file has more information on the sample data files.

User may easily change a row of values in an array screen using a feature available within array screens (screens where the same variable requires a row of entries). If he clicks on the variable name in these screens, he will be able to access the row arithmetic function that allows to add, subtract, multiply or divide for any single or range of values for this variable. He may therefore change all zero values for a variable to a single default by adding the default value that he wants to all the zero values in the array.

STEP 6. Submit the RUNOFF input file to the SWMM model for execution by clicking on the RUN button. An icon will appear on the bottom of the screen with the words SWMM MODEL EXECUTION on it. If user clicks on this option, he will see the processing of the DOS SWMM model 4.3. When the processing is complete, the output will be shown in the default output file viewer. View the output carefully. The Runoff Block has generated 15 inlet hydrographs in a file named RNOFF002.INT. This file is used as the hydrograph and pollutograph input file for the Transport Block. User is now ready to move to the next and final block in this sequence, the TRANSPORT interface.

STEP 7. Exit from RUNOFF by pressing the ALT key and F4 function key simultaneously. Select the TRANSPORT interface from the SWMM Windows Interface Menu. It will be taken to the Transport Block.

STEP 8. Select the transport input file for this example by clicking on the FILE option, followed by the OPEN option. Select the TRANS001.INP file. The first screen in the TRANSPORT interface also contains the option for the selection of the Inlet Hydrograph file. RNOFF002.INT, which is the file that was just created in the RUNOFF Block, should be the default file. If user did not use the RUN button in the RUNOFF interface, he will not be able to use the data since the interface file, i.e., RNOFF002.INT will not exist. He will be informed by TRANSPORT that the input file could not be read, if he did not have a RUNOFF interface run. In this file, seven constituents (pollutants) have been simulated. However, since the TRANSPORT is limited to a maximum of four constituents, only BOD5, TSS, Total Coliform and CODhave been selected for this run (see screen 4). The CUNIT and

Table 6.4 User-Defined Hydrograph and Pollutographs in USEHP

Time (hr)	Flow (cfs)	TSS (mg/L)	BOD (mg/L)
0	1.0	10.0	10.0
1.0	100.0	100.0	100.0
2.0	1.0	10.0	10.0
3.0	1.0	10.0	10.0
24.0	1.0	10.0	10.0

TYPE UNIT variables on Screen 4 have been grayed since both units will be the same as that entered earlier in the RUNOFF block.

Sewer infiltration inflow and dry-weather sewage inflow are simulated in this example.User has to enter the number of pollutants in Screen 2 only if the RUNOFF interface file has been selected, as is the case for this example.

Screen 3 is a critical screen in this block since it contains the parameters necessary for describing a complete sewer system. The process of describing a complex sewer system can be difficult. The process can be simplified by using the following structured approach. First, identify the non-conduit elements such as manholes and conduit elements, e.g., channel/pipes. Next, assign a number to each non-conduit and conduit element. For this example, the sewer system contains 25 manholes, one lift station, one flow divider, and 24 channels. Manhole 50 is an outfall.

STEP 9. Use the NEXT, BACK and INDEX buttons along with the HELP button to move through the screens and familiarize with both the TRANSPORT block and with this input file. When done, submit this input file by pressing the RUN button. The SWMM model icon will appear in the bottom of the screen with the title SWMM model execution. When the processing is complete, user will be asked whether he wishes to see the output file that has been created. If indicated YES, he will view the output file using the Output File Editor. Examine the output file carefully and press the ALT/F4 sequence to exit when hrough. User will be returned to the TRANSPORT block. Press the ALT/F4 sequence again until back at the SWMM main menu.

6.3 Example 3—Simulation of a Simple One-Pipe System with Two Manholes (USEHP & TRANSPORT)

In this example, simulation is being done a simple one-pipe system with a small slope and water quality for a Transport run. The one-pipe system has two manholes. The first manhole is specified through the USEHP interface. The constituents TSS and BOD5 with decay are simulated without scour/deposition. A user-supplied hydrograph and two pollutographs for inlet number

1000 are shown in Table 6.4 below.

The steps that must be followed for this screening-level example are explained in detail below:

STEP 1. Select the SWMM Windows Interface option from the main SWMM menu. Next, select the USEHP option.

STEP 2. Select the example USEHP file that has been created by clicking on the FILE option, followed by the OPEN option. Select the second file listed: USEHP002.HP. The file will be loaded into the USEHP Interface. Move through the screens and familiarize with this option. Use the help information available through the HELP button to answer any questions about any prompts. Compare the input to Table 6.4 above to make sure that it is the right file.

STEP 3. Next, click on the RUN button. USEHP will then generate the USEHP interface files as input to the Transport Block. User must have used the RUN button before he may proceed to the next block in SWMM.

STEP 4. Exit this option by pressing the ALT key and F4 function key. User will be returned to the SWMM Windows Interface menu. Select the TRANSPORT option.

STEP 5. Click on the FILE option, select the OPEN File option. A list of Transport Input Files will appear. Select the TRANS002.INP file for this example run. Once user selects this option, the parameters for this example run will be entered from the file. The first screen for this interface also allows to select the USEHP file created before. As explained in the introduction to this example, this is a simple system containing one pipe and two manholes. The first manhole is the inlet that was specified in the USEHP002.INP file. The sequence of entering this system is to start with an inlet, then follow the channel and end with a manhole, i.e., an outfall. There are a total of nine screens available in this example.

STEP 6. Familiarize with the screens in this option by moving through the screens using either the NEXT, BACK or INDEX options. Refer to Section 5 for more information on these buttons. Also use the HELP buttons for any questions that user might have on any prompt. When he has completed your run-through, submit the input file to the SWMM model by clicking on the RUN button. The output file will be displayed to you when it is ready.

6.4 Example 4—Basic Pipe System (USEHP and EXTRAN)

This example is obtained from the EXTRAN user's manual (Roesner et al. 1988) described as Example 1: Basic pipe system. Figure 6.1 below shows a typical sewer system of conduits conveying stormwater flow. The system consists of nine channels and ten junctions with one free outfall. In this example, conduits are designated with four-digit numbers, while junctions have been given five-digit numbers. There are three junctions or inlets that receive inflows, which will be defined using the USEHP interface. The total simulation length is eight hours.

Two SWMM interfaces are used in running Example 4. First, the user should select the USEHP block to specify three inlet hydrographs. The user then should access EXTRAN in order to select an inlet hydrograph file that has been just generated by USEHP, and to enter a drainage system and simulation information for a EXTRAN run. A USEHP001.HP file and an EXTRN001.INP file are the input files for this example.

The steps in this example are explained below.

STEP 1. Select the SWMM Windows Interface option from the main SWMM menu. Next, select the USEHP option.

STEP 2. Select the example USEHP data that has been created by clicking on the FILE option, followed by the OPEN option. Select the first file listed: USEHP001.HP. The file will be loaded into the USEHP interface. Move through the screens and familiarize with this option. Use the help information available to you through the HELP button to answer any questions about any prompts. Next, click on the RUN button. USEHP will then generate four USEHP interface files. User must have used the RUN button before proceeding to the next block in SWMM.

STEP 3. Exit the USEHP option by pressing the ALT key and F4 function key. You will be returned to the SWMM Windows Interface menu. Select the EXTRAN option.

STEP 4. Click on the FILE option, select the OPEN File option. A list of EXTRAN Input Files will appear. Select the EXTRN001.INP file for this example run. Once this file is selected, the parameters for this example run will be entered from the file. The first screen for this interface also allows to enter the USEHP file. If user did not use the RUN button in the USEHP interface, he will not be able to use the data since the interface files will not exist. He will be informed by the interface that the input file could not be read if he did not create the USEHP Interface file.

STEP 5. Use the NEXT, BACK and INDEX buttons along with the HELP button to move through the screens and familiarize with both the EXTRAN block and with this input file. When done so, submit this input file to the RUN button. The SWMM model icon will appear in the bottom of the screen with the title SWMM MODEL EXECUTION. When the processing is complete,user will be asked whether he wishes to see the output file that has been created. If indicated YES, he will view

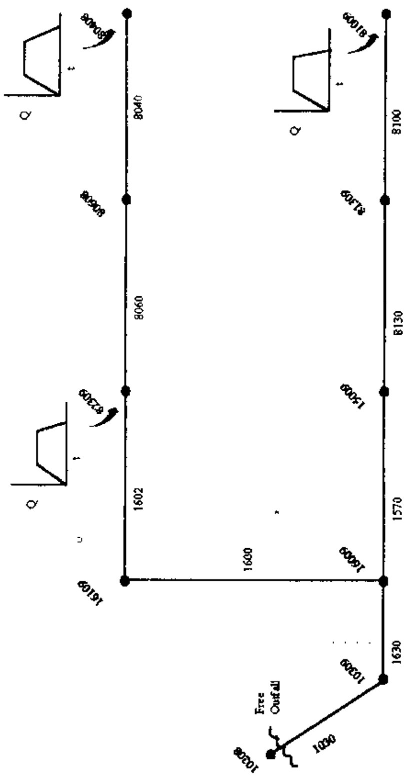


Figure 6.1 Basic System with Free Outfall. (After Camp, Dresser, and McKee, 1988.)

the output file using the Output File Editor. Examine the output file carefully and press the ALT/F4 sequence to exit when through. User will be returned to the EXTRAN block. Press the ALT/F4 sequence again until back at the SWMM main menu.

Summary of output from EXTRAN:

The first section is an echo of the input data and a listing of conduits created internally by EXTRAN to represent outfalls and diversions caused by weirs, orifices, and pumps.

The next section of the output is the intermediate printout. This lists system inflows as they are read by EXTRAN and gives the depth at each junction and flow in each conduit in the system at a user-input time interval. A junction in surcharge is indicated by printing an asterisk beside its depth. An asterisk beside a conduit flow indicates that the flow is set at the normal flow value for the conduit. The intermediate printout ends with the printing of a continuity balance of the water passing through the system during the simulation. Printed outflows from junctions not designated as outfalls in the input data set are junctions which have flooded.

The final section of the output gives the time history of depths and flows for those junctions and conduits input by the user, as well as a summary requested plots of junctions heads and conduit flows.

CHAPTER 7

SWMM POST-PROCESSOR

The SWMM Post-Processor consists of three parts:

- Summary Tables
- Graphics
- Calibration

The Summary Tables function presents flow rate (or volume) and pollutant concentrations (or loads) for desired inlets. The Tables function presents the user with two different types of tables: the summary table and the Event Mean Concentration (EMCs) table. The Graphics routine displays six different types of graphs: hydrograph, pollutograph, loadograph, flow volume, mass, and land use. The Calibration routine allows the user to compare observed data and predicted values.

These three functions are available from the RUNOFF interface and the TRANSPORT interface blocks. The results (Tables or Graphs) presented in the three functions are based on the values stored in either a RUNOFF interface file (RNOFF*.INT) or a TRANSPORT interface file (TRANS*.INT). Therefore, the user must provide a SWMM interface file.

The functions are accessible through three special buttons on the third line of each screen in RUNOFF and TRANSPORT.

7.1 The Tables Routine

The table function presents the user with two different types of tables:

- **The Summary Table**

The summary table presents flow rate (or volume) and pollutant concentrations (or loads) for desired inlets. There are four time increments given for this option: Event, Daily, Monthly, and Annual. Usually, Event may be applied to single-event simulations where the instantaneous flow rate and pollutant concentrations will be displayed in the summary table, while Daily, Monthly, or Annual may be used for continuous simulations where the flow volume and pollutant loads can be tabulated.

- **The Event Mean Concentrations (EMCs) Table.**

The EMCs table reports flow volume, duration, EMCs, and Loads for each storm event. Two parameters are required to be specified: minimum interevent time and base flow. The minimum interevent time indicates the minimum number of dry hours (or fractional hours) that will constitute an interevent. The baseflow or cutoff flow is used to separate the events. Flows greater than the baseflow are part of the event, conversely flows less than or equal to the baseflow are part of the interevent period. The default value of the baseflow may be set to zero.

The event mean concentrations are defined as the total pollutant mass divided by the total runoff volume for storm events. Separation of the data into events depends on the unique series of zero and non-zero instantaneous flow values found at each inlet location within the system being simulated. The results of the analyses would be expected to vary from location to location. The Statistics Block can analyze only one location at a time. However, the Windows post-processor can analyze multiple locations (the maximum inlets specified in the interface file).

Procedure for Generating a Table

STEP 1. The table option is accessible through a TABLES button on the third line of the screen, with the other button options available in RUNOFF and TRANSPORT. It is also accessible under the Utilities option in the main menu bar (ALT U, G).

STEP 2. The table program screen will appear. User must first select a Runoff or Transport interface file (depending on the module from where he selected graphics). To see a list of the files that exist in the default directory, click on the arrow to the right of the input cell asking you for the file name. To do this, select EDIT at the top of the screen, and select COPY.Select the file that user would like to tabulate the model results for the tables.

STEP 3. Select the type of table. Specify inlets of interest or the duration for the summary table.

STEP 4. Hit the NEXT button when you have completed the selections . The tables will loop through the number of inlets specified. One table represents the model results for a specified location (inlet).

STEP 5. Use the Export function to export summary data and EMCs tables to another file in either table delimited or comma delimited format.

7.2 The Graphics Routine

The Graphics option in SWMM provides access to six different type of graphs: hydrograph, pollutograph, loadograph, flow volume, mass, and land use. It is available from the RUNOFF module and the TRANSPORT module. The graphics option is provided to allow the user to represent the results in easy-to-understand graphs.

Accessing the Graphics Program

STEP 1. The graphics option is accessible through a GRAPHICS button on the third line of the screen, with the other button options available in RUNOFF and TRANSPORT. It is also accessible under the Utilities option in the main menu bar (ALT U, G).

STEP 2. The graphics program screen will appear. User must first select a Runoff or Transport interface file (depending on the module from where he selected graphics). To see a list of the files that exist in default directory, click on the Arrow to the right of the parameter asking you for the file name. Select the file to use as input for the graphics.

STEP 3. Select the type of graph from the list provided. Please note that depending on the input file that you selected, certain graphs such as pollutographs may not be available since the data in the file does not support that graph. The options that are unavailable will be grayed out. A list of inlet IDs will be presented when user selects an input file. He may select between one and three inlets to represent on the graph. For the Flow Volume and Mass Graph, it is required to select the Time Increment : daily, monthly, or annual. It will then be required to enter the period for which user would like to have for the graph. t the period shown when you select the Runoff file automatically shows the beginning and ending dates of the data contained in the file. You may only select a period with the dates shown if you wish to change the defaults.

STEP 4. Hit the RUN button when you have completed the selections that you wish. You will see a box informing you that the selections that you made will be saved under the filename shown at the top of the screen.

STEP 5. Next you will see a list of files in a box with the title of GRAPHIC SELECTION. The file that was just generated will be selected. You may select up to four graphs from the list presented. Hit the OK button to draw the graphs.

STEP 6. The graphs that you selected will be drawn on the screen. Once drawn, you have two options:

PRINT: To print the graph(s) that appear on the screen, select the GRAPH option at the top of the screen and select PRINT. The file will be printed to the default Windows printer.

EDIT: This option allows you to copy the image and transport it to any Windows program through the Cut and Paste option available with that program.

Features and Limitations of the Graphics Program

- The graphics routine can draw up to three inlets or pollutants for one graph. It can display two inlets or pollutants with two Y-axes for one graph.

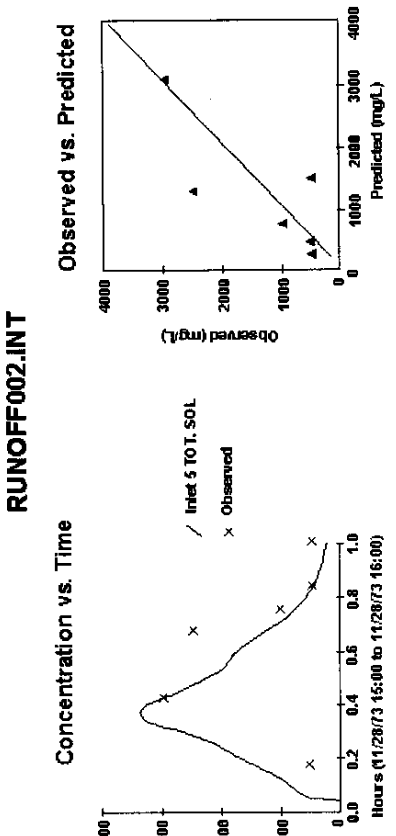
- To draw land use distribution, user must have two files: a Runoff interface file (RNOFF*.INT) and a RUNOFF windows interface file (RNOFF*.INP). The land use distribution is computed based on the data stored in the RNOFF*.INP file. This means that two interface files must be available when the user selects the land use option.

- User can display up to four graphs at a time. To create four different graphs at one session, user must loop through the graphics option screen using a different graphics input file name each time (this is the file name shown at the top of the screen: SWTGR*.INP for TRANSPORT graphs, and SWRGR*.INP for the RUNOFF graphs). If he does not select a new file name, then when he hits the RUN button, it will overwrite the graph that was just created since the graphs are organized by file names.

7.3 The Calibration Routine

The calibration routine can be accessed by clicking on the Calibration button with the mouse. A window similar to the Graphics Routine will appear. There are only two types of graphics available: hydrograph and pollutograph. The procedures to generate the graphs in the calibration routine are similar to the ones used in the graphics routine, except for observed data. Like the graphics routine, user should select a Runoff interface (i.e., RNOFF*.INT) file and specify the type of graph, the inlet number(s), time increment, beginning and ending time, and number of observed points. He then should provide observed data on Screen 3. User has options either to enter the data on Screen 3 or to import the observed data that are stored in a separate file. Refer to the How to Import Observed Data option in details. Click Run to view the calibration graphs.

The calibration routine produces two types of graphs and one statistical table. The first graph draws two sets of values over time: predicted values obtained from a RNOFF*.INT file for a continuous plot and observed data from the user input on Screen 3 for a scatter plot. The second graph shows observed data vs. predicted values and a best fit line, which is automatically generated by the calibration routine. The table displays several important parameters for predicted values and observed data. For a hydrograph, flow volume, peak flow, time to peak, and duration are reported. For a pollutograph, pollutant mass, peak concentration, Event Mean Concentration (EMC), time to peak, and duration are presented. Figure 7.1 presents the total solids calibration graphs from a RNOFF002.INT file.



	Mass (lb)	Peak Conc. (mg/L)	Event Mean Conc. (mg/L)	Time to Peak (hours)	Duration (hours)
Predicted	1156.92	3387.23	1767.96	0.35	1.00
Observed	1660.72	3000.00	1793.96	0.42	0.83

Figure 7.1 Total Solids Concentrations

- **Importing Observed Data**

If user has observed data stored in either a spreadsheet or an ASCII file, he can import the data directly to the observed data screen. The format in the data file should be consistent with the format defined on the observed data screen (Screen 3 in the calibration routine). Check the file format before importing the data. Select Edit at the top line of the observed data screen and select the Import option. Then, give a file name that contains the observed data. Click on OK. The data will be entered into the screen.

CHAPTER 8

REAL TIME APPLICATIONS OF THE SWMM MODEL

1. Management of time-series data for long-term , continuous stormwater modeling

This study investigates the utility of linking the continuous stormwater model (SWMM) with a standard time-series data management system (ANNIE) , thereby intergrating a widespread and diverse collection of stormwater modeling applications. By means of a new graphical user-interface, efficient manipulation and transfer of time-series data was demonstrated, as measured in terms of computer storage space and processing speed (Gregory M.and James W.; 1996).

2. Comparison of estimated and observed stormwater runoff for fifteen watersheds in West-Central Florida, using five common design techniques.

Hydrologists use several traditional techniques for estimating peak discharges and runoff volumes from ungaged watersheds. However, applying these techniques to watersheds in west-central Florida requires that empirical relationships be extrapolated beyond tested ranges. As a result there is some uncertainty as to their accuracy. Sixty six storms in 15 west-central Florida watersheds were modeled using (i) the rational method, (2) the U.S. Geological Survey regional regression equations, (3) the Natural Resources Conservation Service (formerly the Soil Conservation Service) TR-20 model, (4) the Army Corps of Enigneers HEC-1 model, and (5) the Environmental Protection Agency SWMM model (Trommer J.T.,Loper J.E., Hammett K.M., Bowman G.)

3. Reconciliation of hydrologic models to coastal flatland watersheds

Runoff hydrographs from coastal flatwood watersheds in Southwest Florida have been found to exhibit prolonged recession limbs. Commonly used hydrologic models with default parameters appear to have difficulty simulating these runoff hydrograph shapes. While adjustments to timing parameters seem to be effective in reducing and/or shifting the time of the peak runoff rate, they may not accurately account for the elongated shape of the runoff hydrograph. Stream flow and rainfall data collected by the U S Geological Survey and the Palmer Ranch Developer were used in an attempt to reconcile the SCS Unit Hydrograph model and Runoff Block of EPA's Stormwater Management Model (SWMM). (Solanki H., Suau S.M. ; 1995)

4. Modeling and Monitoring Inflow Reduction Programs

The purpose of this work is to discuss the methods and issues related to modeling and monitoring the inflow reduction programs currently being implemented by the City of Portland as part of its Combined Sewer Overflow Facilities Plain. The inflow reduction programs consist of the disconnection of roof downspouts from the combined system and the installation of infiltration sumps for residential stormwater runoff. The Storm Water Management Model (SWMM) is used to track the performance of the sump and downspout disconnection programs. This work describes the modeling of these sumps and downspout disconnections in SWMM, current monitoring and modeling practices for the City, concerns and limitations of modeling and monitoring, and recommendations for further monitoring. There are several concerns and limitations in modeling and monitoring these conditions accurately. The primary concern of this effort is to be certain that the inflow reduction technologies are performing as expected (Juza H.K., Vilhauer M.M., Adderley V.C.; 1995).

5. Calibration of SWMM-EXTRAN using short-term continuous simulation

As part of the city of Jacksonville Master Stormwater management Plan (MSMPO) , a short term continuous water quality model calbiration was performed for three primary stormwater management systems (PSWMS) to verify that design storm models accurately simulated a wide range of hydrologic and hydraulic charactersitics. This work presents a summary of the water quality methodology used for the Little Sixmile Creek calibration, the calibration results at the nine basin plans in the MSMP were completed from 1991 to 1993 . This calibration was performed for the month of January 1991. Prior to calibrating the model parameters used in the MSMP to the Little Sixmile Creek gage, the peak stages computed (CDM`s) Version of the United States Environmental Protection Agency (EPA) Storm Water Management Model (SWMM) MSMP RUNOFF and EXTRAN blocks were within 0.5 ft (150 mm) of the measured peak stages for all the events during the calibration period, and most peak stages were within 0.2 ft (60 mm). The calibration was used to make small adjustments in runoff volume, timing, and peak. Changes from the MSMP results based on the calibrated parameters were less than 0./5 ft (150 mm) at all locations along the PSWMS (Schmidt M.F., Bergman M.J., Smith D.R., Cunningham B.A.; 1996).

6. Peak-flow forecasting with genetic algorithm and SWMM

This paper presents the application of a genetic algorithm (GA) in the search for the optimal values of catchment calibration parameters. GA is linked to the widely used catchment model, the storm water management model (SWMM) and applied to a catchment in Singapore of about 6.11 km super (2) in size. Six storms were considered: three for calibration and three for verification. The study shows that GA requires only a small number of catchment-model simulations and yet yields relatively high peak-flow prediction accuracy. The prediction error ranges from 0.045% to 7.265% (Liong Shie-Yui, Chan Weng-Tat, ShreeRam J.; 1995).

7. Hydrodynamic and constitutent transport modeling of coastal wetlands

In this paper, use of SWMM-EXTRAN and TRANS as planning and design tools in modeling hydrodynamics and water qaulity of coastal wetlands is presented through the description of the restoration efforts of Ballona Wetlands, one of the most significant wetlands in Southern California. The main objectives in this restoration are: biotic habitat development, flood control, and cleansing of stormwater runoff. Among other objectives are recreation, research and education also. Use of EXTRAN allowed the sizxing of storm drains, wetland circulation culverts and channels, computation of maximum water surface elevations in each wetland cell, and estimates of tidal or freshwater delivery volumes under both flood condition and tidal influence. Use of TRANS allowed calculation of salinity, and residence time within the wetland cells. The coupling of these two models was found very useful in the planning alternative evaluation and design of this complex project (Tsihrintzis V.A., Vasarhelyi G.M., Lipa J.; 1995).

8. Simulation of rinfall-runoff for basins in the Rolla, Missouri area

Important rainfall-runoff characteristics for basins in the Rolla, Missouri area were determined to be overland flow, interception storage, interception losses, evaporation, and infiltration. Using these characteristics, the U.S.Environmental Protection Agency`s Stormwater Management Model (SWMM) was configured for basins in the study area. The data network for the model calibration consisted of four continuous rainfall gages and three continuous streamflow gages. The model was calibrated, using observed data from three runoff events, by minimizing ojbective functions representing peak discharges, volume of runoff, and time to peak discharge from the beginning of simulation. The absolute mean percentage difference between the simulated and observed data for peak discharge, volume of runoff, and time to peak discharge are 9.47, 10.8 and 19.6 percent. A sensitivity analysis of SWMM parameters was performed on a simplified drainage basin. The output of runoff (volume, peak, and timing) in SWMM was determined to be most sensitive to subarea width, percentage impervious area, saturated hydraulic conductivity, and initial moisture deficit. The volume of runoff was affected by percentage impervious area, saturated hydraulic conductivity, and initial moisture deficit. The peak flow rate was affected by subcatchment width and percentage impervious area, whereas the time to peak was affected by subcatchment width. The model also was determined to be sensitive to the time step in the stream flow routing part (Holmes R.R.Jr., East J.M.; 1994).

9. Sizing storm-water detention basins for pollutant removal

A statistical formulation for estimating the average time of detention within a pond for a captured runoff volume is presented. For a conservative estimator, it is assumed that mixing takes place during an event and that settling occurs over a period to empty the captured volume or the time between successive events, whichever is smaller. This analytically determined detention time is used in conjunction with a pollutant settling efficiency detention time curve to estimate the settling efficiency. This curve is generated from Stormwater management Model(SWMM) program simulations and shown to be independent of runoff statistics, pond configuration and arbitrary but constant influent concentration under complete mixing. The alaytical detention time estimate, in combination with the settling efficiency curvce provides a valuable desk top method for the planning level design of detention basins for pollutant removal. The method performs quite well compared to the results obtained from long term SWMM simulation runs (Loganathan G.V., Watkins E.W., Kibler D.F.; 1994).

10. Application of linked model to Winter Haven chain of lakes

AGIS-SWMM-WASP linked model was developed. The linked model was applied to the Winter Haven chain of lakes and its watershed to predict pollutant loading to the lakes and the impact of the loading on the lakes water quality. GIS data consisting of land use and soil types were used to produce an electronic file which was input to a preprocessor for creating a SWMM file. The SWMM program utilized the GIS produced information in addition to hourly rainfall for one year to produce daily flows and nutrient loading of nitrogen, phosphorus, and BOD to the lakes. The results were linked with WASPS to simulate in lake concentrations of ammonia, nitrate-nitrite, organic nitrogen, orthophosphate, organic phosphorus, BOD, dissolved oxygen and chlorophyll. The model was calibrated with one year of data. The calibrated model was then used for a series of simulations that showed the lakes response to reducing nutrient loads (Karkowski R., Walters M; 1994).

11. The Linked Watershed/Waterbody Model (LWWM): A watershed management modelling system

Determining the sources and impacts of nutrient loadings from the watershed to a receiving waterbody can be a difficult but critical step in developing nutrient reduction strategies or waste load allocations. This assessment is typically accomplished using runoff and routing models (e.g. SWMM) to predict the non point source loads and entering the information into hydrodynamic and water quality models of the waterbody (e.g. WASP). The Linked Watershed/Waterbody Model (LWWM) was developed to facilitate the model linkages. LWWM provides user friendly software that aids the user in the development of input data sets for the models and processsing of the simulation results. LWMM also provides a linkage to geographical information systems (GIS) where watershed definitions and characterizations information can be obtained (Wool T.A., Martin J.L.,Schottman, R.W.; 1994).

12. Parameter uncertainty propagation analysis for urban rainfall runoff modelling

This paper proposes a strategy for model uncertainty propagation analysis. As an example, parameter uncertainty propagation analysis in the runoff block of the HYSTEM-EXTRN model is carried out. The model is a modification of the SWMM (Storm Water Management Model). Uncertainty propagation methods such as first order anlaysis, sensitivity anlaysis, statistical linearization and Monte-Carlo analysis are discussed and applied. A pathway of parameter uncertainty propagation analysis is given based on validity, simplicity, and computational requirements. It is shown that recommendations about parameter sensitivity cannot be generalized for a given rainfall-runoff model, but depend on the type and the range of the model output variable. It is shown that the type of probability density function describing the parameter uncertainty with known mean and variance has only a small effect on the results of the model output uncertainty (Aei J., Schilling W.;1994).

13. Computer-aided catchment-calibration model

A new version of a computer aided catchment model, KBSWMM version 2, is presented. The model essentially contains the following features: (i) preprocessors for the Runoff and Extran blocks of the widely used Storm Water Management Model, SWMM. These preprocessors are developed on X Window system; (ii) flow routing components of the Runoff and Extrran blocks; (iii) a probabilistic based catchment calibration model; and (iv) a postprocessor to display the computational results in both text and graphical forms. The application of KBSWMM is demonstrated on the catchment in Singapore. The data entry of KBSWMM is very user friendly, the built-in automatic catchment calibration process requires minimal effort to achieve the optimum set of values for the calibration parameters, and the computational results are presented in self explanatory graphical forms (Liong Shie-Yui, Ibrahim Y., Chan Weng-Tat, Law Chee-Liang; 1993).

14. Interior Drainage Analysis, West Columbus, OH

The interior drainage anlaysis is of the West Columbus, Ohio area poses a challenge to standard techniques and methodologies of hydrologic investigation. Located along a long meandering bend of the Scioto River, this highly urbanized area is drained by an extensive storm and sewer system that provides a relatively low level of protection against interior storm events. The Corps of Engineers has designed a levee and floodgate system which will provide protection against flooding from an exterior source, but has not resolved the issue of residual flooding associated with an interior storm event. The analysis performed by the Corps of Engineers addressed coincidental frequency of flooding, flood warning systems, existing capacity of storm and sanitary systems, existing pump station capacities, and routing of flows across a maze of geometric controls. The modeling efforts included use of the Storm Water Management Model (SWMM) developed by the Environmental Protection Agency; HEC-1, Flood Hydrograph Package and HECIFH, HEC Interior Flood Hydrology, both developed by the Corps of Engineers Hydrologic Engineering Center. The problems encountered during this study clearly indicate the need for development of a comprehensive model that can accommodate the variety of drainage conditions associated with urban drainage systems (Bhamidipaty S., Webb J.W.; 1993).

15. The use of continuous SWMM for water resources conservation planning

This paper presents the use of the SWMM for continuous simulation to evaluate the potential for fresh water conservation by reducing overdrainage of a sand ridge and wetland system in central Florida. The program goals are to conserve fresh water, hydrate wetlands, and increase aquifer recharge by increased infiltration to a sole source aquifer while minimizing flood impacts and maintaining or improving water quality. The analysis included calibration of SWMM results to two United States Geological Survey (USGS) stream gages and to results from a regional groundwater model to develop an average annual mass balance of water resources. This mass balance was then used to identify project impacts, costs, and relative benefits to determine project feasibility (Schmidt M., Mack B.; 1995).

16. Rainfall-runoff modelling of partly urbanized watersheds: Comparison between a distributed model using GIS and other models sensitivity analysis

This paper presents an original integrated approach to rainfall-runoff modelling for partly urbanized watersheds. A digital terrain model (DTM) , allowing use of GIS techniques, was built not only for representing the undeveloped part of the catchment but also the urbanized area. For each cell of the DTM grid, a water budget was computed, providing runoff and interflow amounts. The water volumes generated at each cell were moved along the steepest slopes with a accelerity depending on this slope, until they reach the outlet and contribute to the resulting hydrograph. The model was tested in a partly urbanized catchment, specially equipped with rain and flow measurement station. Comparisons with other procedures, mainly with SWMM and WALLRUS models, shows that the proposed model seems to be one of the most accurate (Zech Y., Sillen X. Debources C, Van-Hauwaert A.).

17. Efficacy of SWMM application

In this paper, the storm water management model (SWMM) has been applied to a 10 sq.mi urbanized residential area (Bachman Branch watershed, Dallas, Texas). The application was constrained intentionally to a rather gross spatial scale (no modeling of storm sewer transport to mimic anticipated regional modeling efforts. Three different levels of watershed spatial abstraction were investigated together with the impact of using two different parameters for model calibration (pervious depression storage and percent imperviousness) along with three separate calibration events. The calibrated SWMM model performed quite well at predicting both total runoff volume and peak flow rate. Successful application was most sensitive to calibration event selection, with the smallest event resulting in the worst overall performance. The importance of watershed conceptualization level was less significant, with no noticeable difference between the highest abstraction levels. Use of percent imperviousness as the single model calibration parameter generally was more successful than adjustment of pervious depression storage. SWMM water-quality simulation also was quite acceptable, but with a consistent underestimation of the in-stream total suspended solids concentrations (Warwick J.J., Tadepalli P.; 1991).

18. Application of SWMM in the new Orleans Area

A review of recent applications of SWMM in the New Orleans Metropolitan area is presented. The city and adjoining areas of Jefferson Parish are entirely enclosed by levees, have very little surface relief, and have drainage systems which are thoroughly interconnected and subject to reversals of flow. Rainfall amounts are heavy. The normal annual percipitation exceeds 60 inches and individual storms may produce totals of 10-12 inches in as many hours. In recent years extensive property damage resulting from flooding has been the impetus for studies intended to improve the capacity of systems which, in at least some case, were built to dewater marsh and swamp land and are now used to drain developed urban areas. The standard SWMM blocks RUNOFF, TRANSPORT , and EXTRAN have all been used depending upon the particular circumstance. In addition, certain modifications have been made which make the model more useful in the New Orleans region. Among these are the use of Standard Streets in a manner analogous to that employed in the Chicago Drainage Model, inclusion of user-defined conduits in EXTRAN, and improvement of the pumping calaculations in discharge bay elevations. Simulation of storms in excess of the drainage system capacity illustrated the deficiencies by showing discharges at internal points. The inadequate sections were increased in dimension and other modifications were made in the modeled system unit it was capable of conveying the flow to the pump stations without flooding (Yasenchak M.L., McGhee T.J.; 1989).

19. Use of SWMM/EXTRAN and TR-20 to Develop Regional Stormwater Detention Plans in the Washington, D.C. Region.

In this paper, stormwater models were applied to develop a regional detention basin master plan for Fairfax county, Virginia, along with a preliminary stormwater management investigation for Montgomery County, Maryland. Following the selection of regional detention basin sites and the completion of conceptual designs the SWMM/EXTRAN model and the Soil Conservation Service TR-20 model were used to determine the watershed wide impacts of alternative detenton systems. To assess regional benefits, various locational schemes were analyzed for both county plans. The Fairfax County plan included the design of maximum efficiency basins which utilize lower maximum release rates to compensate for areas not controlled by regional facilities. The regional detention basin network, recommended in the Montgomery County investigation, demonstrated the use of extended detention on top of a permanent pool for water quality benefits. In several cases, in addition to water quality benefits, this type of design reduced the post-development 2 year peak flows to levels less than pre-development conditions (Hartigan J.P., George T.S., Mack B.W.; 1989).

20. Hyetograph Compositing Effects on Urban Runoff Modelling

Rainfall and runoff data from a 3.08 sq mi urban watershed in Denver, Colorado was used to investigate the effects of compositing several recorded rainstorm hyetographs on urban stormwater runoff modelling results. The watershed in this semi-arid region had data at five rain gages and two flow gages, which provided the basis for calibrating an Urban Drainage and Flood Control District version of the storm Water Management Model (SWMM). The calibrated model was then used to examine the effects of runoff calculations using a single composite hyetograph for each storm. Compositing of hyetographs was performed using two types of area weighted techniques. The five hyetographs were then composited directly using the recorded rainfall depth at each clock time interval. In addition, the hyetographs were composited using a technique that first shifted the five gage records so the peak rainfall time increments of each hyetograph were aligned. In this study very little difference was found in peak flow and runoff volume simualtions between the two types of hyetographs compositing techniques, namely compositing straight across or compositing using peak preservation. However, both methods tended to underestimate peak flows and volumes when compared against the calibrated multi-rain gage hyetograph runs using a calibrated SWMM model. (Urbonas B.R. and Jansekok M.P., 1989).

21. Storm Water Management Model for Urban Areas in Kuwait

In this, a comprehensive study was conducted to implement the Storm Water management Model (SWMM) for urban areas in Kuwait. The updated version of the model designed to run on an IBM Personal Computer and compatibles was utilized. Urban runoff simulation in arid areas by the SWMM model is a powerful and efficient tool in designing drainage systems and as such, a vaiable replacement of the commonly used rational method. It was found that only the streets and paved areas that are hydraulically connected to the drainage system contribute to runoff. Fine and coarse discretization approaches were used in the study. The difference between the hydrographs simulated by the two approaches were relatively small. The performance of the existing drainage system and the accuracy of the design method used were tested using a 25 year storm. The result of the simulation revealed that the storm sewers were oversized by factors ranging from 1.2 to 3.6. The SWMM model was used to estimate the storm water runoff volume collected from all urbanized areas in Kuwait City. The annual expected harvested runoff water was found to be significant; however, the quality of runoff water needs to be assessed before a decision is made on its reuse (Al-Shurbaji A.R.M. and Zaghloul N.A.; 1990).

22. Microcomputer Model for Simulating Pressurized Flow in a Storm Sewer System

In this paper, a study is being conducted on the development of a microcomputer model for simulating storm sewer flow under surcharged or pressurized conditions. Several existing models, including the EPA Storm Water Management Model (SWMM) and the Illinois Urban Drainage Simulation (ILLUDAS) , have been reviewed. It was concluded that the SWMM program's EXTRAN subroutine would be suitable for this purpose. Certain modifications of EXTRAN will be necessary, and the modified subroutine will be incorporated into the Federal Highway Administration's Pooled Fund Storm Sewer Program PFP-HYDRA. EXTRAN uses a full dynamic wave approach that can better simulate unsteady flow characterisitics in a sewer system. In addition it has the capability to handle both free-surface flow and pressurized flow.

EXTRAN can be modified in several ways: (1) excess surface water could be stored in a detention area connected to the manhole and treated as if it will return to the sewer system at a later time; (2) the numerical scheme could be modified by increasing the accuracy of the solution of the differential equations; (3) some less important hydraulic structures and pipe shapes and plot subroutines, could be dropped from EXTRAN in order to reduce the running time; and/or (4) a modified EXTRAN could aid PFP-HYDRA in its analysis mode to give the user options to route free surface flow or open-channel and surcharged flows. It would predict the location of the surcharge pipe, the duration of the surcharge, and the flow and hydraulic gradeline at selected locations in the system (Uu S.L. and Wu Y.; 1988).

23. Stormwater Master Planning in urban Coastal Areas: The Virginia Beach Master Plan

The Virginia Beach stormwater management study produced a comprehensive storm water master plan for a rapidly growing urban coastal community. The study developed conceptual designs of $18 million in stormwater management facilities and identified cost-effective nonstructural stormwater management controls which will provide adequate drainage under the City's ultimate development plan. About $12 million of known cost savings were achieved by eliminating and/or downsizing previously proposed drainage improvements. The US EPA Stormwater management Model (SWMM) accurately simulated many unique hydrologic/hydraulic phenomena found in coastal areas, including severe backwater, interconnected drainage ways, wetland regions, flow reversals, and tidal boundary conditions. Therefore, SWMM facilitated identification of innovative and cost-effective solutions to drainage problems (Aldrich J.A., Cave K.A., Swanson J.E., Hartigan J.P.; 1989).

24. Economic and Predictive Reliability Implications of Stormwater Design Methodologies

In this paper, seven alternative analytical methodologies for drainage design and hydrologic analysis were compared; rational method, synthetic unit hydrograph method, SCS peak discharge method, SCS tabular hydrograph method, regression equations, modeling with synthetic design storms, continuous simulation with historic storms, and USGS flood frequency methods. Modelling was accomplished using the EPA Storm Water Management Model (SWMM). The SWMM model was calibrated on each catchment and then run continuously for the number of years of hourly data available from the National Weather Service (22-38 years) . The SWMM statistics Block was then used to rank storm runoff volumes and storm runoff peaks in order to perform a frequency analysis on these two parameters. Results were compared to the conventional methods listed above and current USGS urban flood frequency results. Simulated real events tended to have higher peaks than did the USGS estimates , and the highest simulated peak from the long-term record was higher than the 25 years SCS peak for four out of the five catchments. These results generally contradict conventional wisdom which assumes that synthetic design storms will give higher (more conservative) peak flows than will historic flows. Man-hours for design efforts are greatest for the continuous simulation approach and least for the rational method. Construction costs vary widely depending on peak flows predicted by each method and resulting pipe sizes (Cunningham B.A and Huber W.C.; 1987).

25. Use of RORB and SWMM Models to an Urban Catchment in Singapore

In this paper, the Runoff Routing Model (RORB) and the Storm Water Management Model (SWMM) are evaluated for the purpose of storm water drainage and management in an urban catchment in Singapore. Data preparation for testing the models are highlighted and sample runs are carried out for an actual storm event. Comparison of the runoff results are made between RORB and SWMM models. Both models can be incorporated without much difficulty to simulate urban drainage system in Singapore. (Selvalingam S., Liong S.Y., Manoharan P.C.; 1987).

26. Development of an Expert System for the Analysis of Urban Drainage using SWMM (Storm Water Management Model)

An expert system has been built to facilitate and to automate the calibration of the runoff block of the Storm Water Management Model (SWMM) . It acts as a front end to counsel the user on the choice of parameters, it interprets the result and suggests some useful changes in the value of significant parameters thus reducing the user's time and effort. The integration of new expert systems and traditional simulation models is best achieved through the use of modern expert system shells (Baffaut C., Bernabdallan S., Wood D., Delleur J., Houck M.; 1987).

27. Chimney Hill Off-Site Drainage Study

This project describes the successful application of the SWMM II model to the drainage system for the Chimney Hill subdivision of Virginia Beach, VA. The SWMM version II model with EXTRAN option has been successfully applied to the simulation of a series of large storage canals, linked by culverts, and discharging into tidal estuary. The results from the SWMM Version II model seem reasonable. However, due to shortcomings in the model, it would be beneficial to apply the Version III model to the data. A capability which would be very useful in the EXTRAN model would be the ability to simulate in-line weirs, as well as diversion weirs. In this study, weirs were simualted using short conduits, but instability in the model was a problem. Overall, SWMM Version II worked quite well in simulating the canal system, and the results confirmed the results of the hand claculations performed earlier (Normann J.M., Estes E.R.; 1982).

28. Attempt to Implement SWMM in Tunisia

To aid the city of Tunisia in stormwater management, a cooperative project was undertaken by the Universities of Lund and Tunis to apply the Storm Water Management Model (SWMM) to the city's problems. The project also sought to teach local research personnel how to handle the model. In roder to obtain input data for model calibration, rainfall and runoff data from the Guereb-Roriche catchment which covers about 20 sq km, was used. Significant differences between Swedish and Tunisian urban areas coupled with climatic differences caused significant differences in the input parameters of the model. Also a lack of understanding of the modeling philosophy and a lack of trained hydrologists who know how to run the computer further complicated the use of the SWMM. Despite these problems, it was possible to reproduce the observed hydrographs quite well as long as the areal distribution of rainfall was taken into account (Niemczynowicz J.; 1983).

29. Sensitivity Analysis of the SWMM Runoff-Transport Parametrs and the Effects of Catchment Discretisation

A detailed sensitivity analysis is conducted on the main parameters of the Runoff-Transport Blocks to establish which are them ost sensitive parameters affecting the Runoff-Transport simulation. The result of the study indicates a relative influence of the major parameters used in both the Runoff and Transport Blocks. Hence, the SWMM default values can be used adequately. The costs of setting up and running a SWMM simulation are largely determined by the level of discretization used for a particualr catchment. The purpose of this part of the study is to investigate the level of discretization needed to adequately represent an urban watershed and to illustrate the effects of reducing the number of subcatchments on the accuracy of runoff simulation. A methodology is defined to achieve a representative equivalent catchment from applications on both hypothetical and real areas (Zaghloul N.A.; 1983).

30. Urban Runoff Peak Frequency Curves

Runoff peak frequency curves were produced for a fully urbanized catchment from five years of observations and from runoff simulations for storms observed in the catchment and at another station 10.6 km west of the catchment. The simulations were performed by means of the calibrated SWMM III model and, whenever sewer surcharging was encountered, the pressurized flow routing was accomplished by means of the EXTRAN model. The most important parameter for the calibration of runoff peaks was the catchment imperviousness which was calibrated by a regression analysis of observed rainfall and runoff volumes. Observed runoff hydrographs indicated that in the Malvern catchment, which can be characterized by an intermediate imperviousness and well-drained soils, the pervious areas barely contributed to the generation of runoff peaks with return periods up to five years. With a calibrated model, runoff frequency curves can be derived from discrete-event runoff simulations with a better accuracy than that typically achieved for individual events. The SWMM model reproduced the observed runoff peaks fairly well. Results confirm the feasibility of using design storms for establishing design runoff flows provided that the normal antecedent conditions are specified. Such findings may be limited to similar catchments. In catchments with low imperviousness and poorly drained soils, they performed satisfactorily in pressurized flow routing. For proper simulation of head losses in the sewer network, head losses at sewer junctions were approximated by increasing the adjacent conduit roughness. The scope of the runoff peak frequency curve decreased in the pressurized flow region. For overflows out of the system at junction manholes (Marsalek J., 1984).

31. Cost-Effective Program for Combined Sewer Overflow Abatement

The magnitude of combined sewer overflow (CSO) problems in Onondaga County, New York, was assessed using the SWMM and simplified SWMM models to analyze the interrelationships between dry weather flow, storm patterns, runoff rates, and sewer system constraints. In addition, monitoring at 25 selected overflows confirmed model results and located areas of high pollutant loading. Evaluation of several abatement alternative options produced a comprehensive master plan based on CSO collection and treatment in drainage areas. The plan included installation of 6400 m of CSO transmission pipelines, construction of 6 CSO treatment facilities, and modification of 2 existing demonstration CSO practices/system improvements program (BMP) included overflow dam modififcations, backwater gate installations, regulator pipe capacity increases, in-line grit chamber construction, and modifications to allow CSO storage in systems showed that total overflow volume will be reduced by 31% total suspended solids and BOD by 28% , volatile suspended solids and total Kjeldahl nitrogen loadings by 31% , total inorganic P by 26% and fecal coliform loading by 33% (Ganley,R.C., Kirsch B.N., Oliver A.J., Karnik J.M.; 1982).

32. Modelling Side Weir Diversion Structures for Stormwater Management

A model has been formualted of the Hamilton, Ontario urban drainage system in order to estimate annual loadings of the harbor receiving water of suspended solids, BOD5 , nitrogen , and phosphates. In this city combined sewer diversions are designed to divert significant flows directly to the receiving water during rainstorms. it was necessary to compute continuous hydrographs and pollutographs for the full period of potential overflow in order to estimate pollutant loadings to the recipient water. Since the diversion is active only during part of a storm, diverting only part of the flow, a rating curve for the diversion structure had to be obtained. Few structures have been adequately calibrated, and their rating curves are not usually available. The hydraulics of the side spillways and the SWMM-EXTRAN computer program were reviewed. A new program called OVERFLO3 was developed to dovetail with the SWMM package. Internal SWMM coding has not been changed. As a stand alone program, OVERFLO3 will produce rating curves for side weir diversion structures. The program was applied to the urban catchments in Hamilton. The general conclusions were that simulation of side weir diversion flows in the SWMM EXTRAN program appeared unacceptable for certain conditions, that the program OVERFLO3 appeared to provide a more satisfactory method for computing side weir water surface profiles and overflows than is presently provided by SWMM EXTRAN, and that the new block SIDWEIR can be used to produce overflow hydrographs for diversion structures with side weirs, using a slightly modified form of the SWMM package (James W. and Mitri H.; 1982).

33. Design of Dual Drainage System Using SWMM

This paper points out errors inherent in the traditional approach to modeling of dual drainage systems for urban areas using the Storm Water Management Model (SWMM) and suggests improvements in the procedure. Storm Water drainage systems normally have dual components, minor (underground pipe system) and major (surface overland flow). The two stage approach historically used in modeling produces erroneous responeses because inputs from the two components do not reflect each other's presence. System flow is underpredicted, and pollutant maximum flux is overpredicted. To improve model performances, the system is left untouched. A case study involving a 50 acre subdivision in ontario illustrates the adjustment procedure. Good results were obtained after 6 model parameter iterations (Ellis J.H., McBean E.A., Mulamoottil G.; 1982).

34. SWMM Model and Level of Discretization

The accepted level of discretization used for flow simulation over an urban area was investigated, and the effect of reducing the number of subcatchments on the accuracy of runoff simulation was studied. Methodology is defined to achieve a representative equivalent catchment from theoretical considerations. Verification of the procedures involved series of applications on both hypothetical and real areas. The simualtion results of the simplified (coarse) discretization are compared with those of the detailed (fine) discretization of the same rainfall storms. The accuracy of the simulation is maintained by careful aggregation of the subcatchment parameters and proper selection of the aggregated hydraulic width. It was concluded that surface runoff hydrographs generated from both the detailed subcatchments and the aggregated equivalent catchment will be similar. The weighted average properties of the detailed sewer system will provide an aggregated equivalent transport system. In the proposed simplified simulation using a single catchment and the Runoff Block, the hydraulic width of the single catchment should be reduced to account for the loss in conduit storage by increasing surface storage. The accuracy of the simulation using the Runoff and Transport Blocks and the simplified procedure using only the Runoff Block is maintained by careful aggregation of the subcatchment parameters and proper selection of aggregated hydraulic width. Conduit routing for small areas proved insignificant. The SWMM simulation using coarse discretization will result in reducing setting up and computer costs (Zaghloul, N.A.; 1981)

35. Comparing Urban Runoff Models

Three urban runoff models were compared with data on two urban watersheds, Oakdale in Chicago, Illinois (5.42 ha of residential area, 45.8% impervious) and Calvin Park in Kingston, Ontario (36.2 ha of residential area, 27% impervious). The runoff models were the Road Research Laboratory Model (RRLM), the University of Cincinnati Urban Runoff Model (CURM), and the EPA Storm Water Management Model (SWMM) . Using the hydrograph peak and its time for evolution showed that no one model was uniformly better than another. For hydrograph peak time estimates, RRLM was better than SWMM and CURM on both watersheds. For hydrograph peak estimation on SWMM was better than CURM and RRLM on Oakdale watershed; RRLM was better than SWMM and CURM on Calvin Park watershed. Therefore, the choice of a model depends on the criterion of comparison and the watershed in question (Singh V.P.; 1981),

36. Optimal Parameter Estimation and Investigation of Objective Functions of Urban Runoff Models

This report deals with improvements of urban hydrologic models. Two areas are considered, namely; the optimal estimation of parameters, and the selection of an objective function to produce the best results. Three urban runoff models, ILLUDAS, SWMM and MINNOUR were studied and results showed that the optimal parameter estimates gave better regeneration and prediction performances than cases where the parameters were arbitrarily specified. Another result was that the complexity of the model structure did not guarantee better performance. Two sets of the objective functions were tested by using the data from the Upper Ross Ade (West Lafyette, Ind.) and the Oakdale Avenuye (Chicago) watersheds. The sum of the squared deviations between the observed and the calculated hydrograph ordinates has been the most frequently used objective function in the past and the results of the present study show that this gives the best overall performance (Han.J. and Rao A.R. 1980).

37. Combined Sewer System Analysis Using Storm and SWMM for the City of Cornwall

In the City of Cornwall, Canada, the flow from combined sewers is intercepted through regulator chambers, designed to intercept 2.5 times dry weather flow. All flows exceeding this amount are discharged directly to the St. Lawrence River. At present, the plant is operating in an overloaded condition, and high bacteria levels have been measured at swimming beaches along the river shore. The Storage Treatment Overflow Model (STORM) was used to screen a number of control alternatives, and develop statistics with respect to system operation for various levels of both storage and treatment capacities. Subsequently, the Storm Water Management Model (SWMM) was used to assess selected control alternatives under individual event operation. After the STORM model was calibrated and modified for local conditions, a simulation of the system operation was undertaken over a period of one year, comparing both volume of overflow and number of events to those actually measured. Control alternatives considered include: various levels of treatment plant capacity expansion in-system storage, diversion of storm flows from the combined sewer system , improvements in street sweeping practices and industrial flow control or abatement. The most promising alternative is some combination of storage and treatment. SWMM was used to assess the hydraulic operation of the interceptor sewer under individual event operation with the easterly overflows closed and the entire wet weather flow intercepted (Anderson J.C.; 1980).

38. Methodology for Lumped SWMM Modelling

A systematic methodology is presented for lumping or aggregating urban drainage areas when using the Storm Water management Model (SWMM) to simulate the rainfall runoff process. In a lumped model the study area is discretized into large subcatchments. and as such the spatial details of hydrologic characteristics and the internal drainage system are not explicitly modelled. As a part of the simplified methodology, the concept of equivalent gutter was introduced in RUNOFF block simulation to compensate for the eliminated conduit storage existing within the lumped catchment. A set of generalized curves relating in-system conduit storage to impervious area were developed using relevant data from new residential and industrial subdivisions in Edmonton, Canada. Curves relating the drainage area to the peak flow for a range of imperviousness values were also generated. A systematic step by step procedure that uses these curves to determine the overland flow width parameter and the dimensions for the representative equivalent gutter appropriate for the lumped catchment was formualted. The lumping methodology was tested against detailed simulations using rainfall and flow measurements for three recorded storm events for the Norwood test area. Modelling results employing lumped and detailed schemes, respectively, were also compared for the 5-year design storm using the catchment data for the Fulton Drive basin. Comparisons for detailed and lumped simulations for both test areas were found to be reasonably good. A significant reduction both in the amount of effort required in input data preparation and in the overall simulation costs can be achieved by employing this lumping methodology (AhmedM.; 1980).

39. Analysis of Receiving Stream Impacts on the Milwaukee River

Extensive monitoring and modeling efforts were performed to quantify the receiving water impacts of the combined sewers on the Milwaukee River, Milwaukee, Wisconsin. The models used were the EPA's SWMM and the Corps of Engineers STORM models. The inflow of Lake Michigan into the river was a major difficulty in the modeling. Final model calibration using a linearly decreasing flux was found to match the continuous dissolved oxygen (DO) data generated during two years of record. Field monitoring showed that the cause of the large DO sags in the lower reaches of the river following runoff events are due to bottom sediments scoured out by the submerged combined sewer outfalls. The receiving water model was modified to include an expression which would predict the extent and duration of the scour action from the submerged outfalls. Long term simulations of DO and other parameters were calibrated and verified using the response of the river to a multitude of rainfall events. The use of this model network in the evaluation of possible actions for abating combined sewer overflows produced magnitudes of DO and fecal coliform impacts for each action using 20 yrs of rainfall record. Cost benefit analyses were performed for: existing conditions; partial separation; complete separation; out of basin (storage conveyance treatment); end of pipe; and 100% combined sewer outflow removal (Ecol Sciences Inc,Milwaukee, WI; 1980).

40. Sediment-Pollutant Relationships in Runoff from Selected Agricultural, Suburban, and Urban Watersheds; A Statistical Correlation Study

Data from agricultural, suburban, and urban watersheds were subjected to statistical correlation analysis to estimate potency factors. These factors are coefficients that, when multiplied by sediment mass emission rates (transported in runoff), provide esitmates of mass emission rates for other pollutants. The potency factors are required input for such lumped-parameter runoff models as the Nonpoint Source (NPS) Model and the Stormwater Management Model (SWMM). The temporal variance of suspended sediment concentration in storm runoff can account for a relatively small proportion of the temporal variance of nearly all other water quality constituents considered. Potency factors computed for urban runoff are more reliable than those developed for suburban, rural, and agricultural areas. There is a large degree of uncertainty in the values, so care must be taken in applying them in models of non-urban watersheds. The data were also subjected to multiple regression analysis to examine the effect of storm parameters on runoff water quality and the interrelationship among runoff water quality constituent concentrations themselves (other than sediment load). The multiple regression analysis was primarily exploratory with the objectives of explaining variance of water quality and identifying important independent expressions (Zison S.W.; 1980).

41. Cost-Effective Combined Sewer Overflow Pollution Abatement Planning

The interaction of elements in a combined sewer system (collection system, interceptors, storage, and treatment works) was analyzed and methods developed to evaluate alternatives for cost effective solutions for overflow pollution abatement. The tools included two mathematical models (EPA's SWMM, Storm Water Management Model; and Corps of Engineer's STORM, Storage, Treatment, Overflow, and Runoff Model), a normalized hydrograph, and a synthetic rainfall hydrograph developed to reproduce probable frequency volumes. The information was applied to data collected in Elizabeth, New Jersey. Several conclusions were apparent. For pollution abatemen, it is important to caputre the first flush of the combined sewers after a dry period. This low volume water contains high concentrations of pollutants. Sewer flushing during dry weather may reduce first flush pollutant concentrations significantly. Other measures which can improve pollution control are containment of overflow for later treatment, upstream storage and infiltration ponds, peak storm flow storage in enlarged laterals or parallel sewers, and flow routing (Kaufman H.L. and Lai F.; 1980).

42. Testing of Several Runoff Models on an Urban Watershed

Six models plus two variants of one and a variant of another, were tested with the objective of making a preliminary evaluation of their relative capabilities, accuracies, and ease of application. For four of the models, plus two variants of one of them, the primary performance criterion was the degree to which simulated values matched observed daily and monthly runoff volumes for the 5.5 square mile Castro Valley Watershed near Oakland, California. In addition, tests were performed for several individual runoff events for all six models. The results showed that each model could be calibrated on single set of data and verified with acceptable accuracy on a different data set. The ease of application was decidedly different for all models, due to the differing level of detail in input data required. Going from the simplest to most difficult to apply, the continuous models rank as follows: STORM, HEC-1c, SSARR, and HSP. Similar ranking fo the single-event models is : HEC-1, SWMM, and MITCAT. Also, a recent capability added to the STORM model (i.e., SCS procedures for computing runoff and routing) produced more accurate results than the coefficient method of computing quantity of runoff incorporated in the original version of STORM. These limited tests were not intended to serve as a basis for comparison of the accuracy of the various models. However, they did show that the more complex models did not produce better results than the simple models for the Castro Valley Watershed data. (Abbott, J.; 1978)

43. SWMM Application to Combined Sewerage in New Haven.

Storm Water management Model (SWMM) of EPA was calibrated to predict runoff flows in the central portion of the city of New Haven, Connecticut. The study area is served by combined sewers and overflow structures to divert excess wet weather flow into the adjacent receiving waters. For application of SWMM, the project area was divided into 23 subcatchments, and two of them were selected for model calibration. During storm events, the rainfall hyetographs, the runoff hydrographs, and combined sewage quality perameters were measured in each of the two subcatchments. Using these data in SWMM, calibration and verification of flow quantities were accomplished successfully. However, problems were encountered in the quality calibration. The calibrated model (quantity portion only) was subsequently used to predict runoff flows for the design storm in each of the 23 subcatchments. A two year storm was selected as design storm from the available 35 years of rainfall record. Literature values of BOD and SS were used to predict wet weather waste loads (Cermola JH.A., DeCarli S., Sachdev D.R. El-Baroudi H.M.; 1979).

44. Maximum Utilization of Water Resources in a Planned Community: Executive Summary.

Seventeen storms were monitored in six watersheds in the Houston, Texas, area during 1975 and 1976 to evaluate the physical, chemical and biological effects of the water management plan used for the Woodlands, an ecologically planned community. The Woodlands water amangement plan is designed to avoid adverse water quality and hydrologic effects caused by urbanization. A comprehensive sampling and analaytical program was used that monitored various chemical parameters including nitrogren, phosphorous, dissolved oxygen, pH, specific conductance, and chlorinated hydrocarbons. Also monitored were indicator bacterial organisms and aquatic and edaphic algae for stormwater runoff, disinfectant demand and algal bioassys were conducted. Using the relationships between stormwater runoff quality, land use, and runoff quantities, the Stormwater Management Model (SWMM) was expanded to allow for separate sewer systems, urbanization effects on base flows, economics of natural draiange systems, Kjeldahl nitrogen, nitrates, and phosphates for a natural draiange system. The model was then used to simulate stormwater runoff quality and quantity for watersheds. Extensive results on the Woolands system and SWMM are provided including the following: The greatest producers of suspended solids and nutrient loads are urban watersheds, urban stormwater runoff contains higher bacterial concentrations than forested area runoff, excessive dose of chlorine or ozone are required for effective stormwater runoff disinfection from an urban area, and lakes serve as effective traps for excessive sediments transported by construction site runoff (Characklis W.G., Gaudet F.J., Roe F.L, Bedient P.B.; 1979).

CHAPTER 9

CONCLUSIONS

EPA's Storm Water Management Model (SWMM) simulates all aspects of the urban hydrologic and quality cycles, including surface runoff, transport through the drainage network, storage and treatment and recieving water effects. It can be used for planning, design and operational purposes and therefore is an appropriate tool for city engineers, especially when the sewer network is large or complex or when quality is to be simulated.

SWMM model is constructed in the form of blocks computational blocks (Runoff,Transport, Extran, Storage/Treatment) and service blocks (Executive, Rain, Temp, Graph, Statistics, Combine). Each block has a specific function, and the results of each block are entered on working storage devices to be used as part of the input to other blocks. A typical run usually involves only one or two computational blocks together with the executive block.

All the blocks of the model have been described briefly in the report and the data requirements in each case have been identified. The data entry alongwith the screen sequences have also been described for each of the blocks. Four example runs have also been given with test data to show the performance of the model.

A detailed literature review has been done and some real time applications of the SWMM model have been presented which shows the wide applicability of the model.

SWMM is a relatively old model (the first version goes back to 1971) that has been improved several times. In addition, it has been widely used in the United States and Canada as well as other parts of the world and has been subject to numerous comments and critiques that have contributed to make it a very sophisticated simulation model. However the implementation of SWMM on an actual site is not a trivial endeavor. It requires an expert hydrologist knowlegeable in modeling techniques such as nonlinear reservoir and kinematic waves and in the modeling of free surface and pressure flow networks through the use of St. Venant's equations and the associated numerical solution techniques. It requires an environmental engineer with expertise in the buildup and wash-off of pollutants in the recieving water body. It requires a computer specialist to prepare the data files and coordinate the execution of the modules of the computer program. The coordinated efforts of all these experts are required to select the appropriate options provided by the model. The selection of the appropriate values of many of the input variables also requires the professional judgement of these experts. These coordinated efforts are also needed to evaluate and interpret the model outputs, to diagnose possible malfunctions of the drainage system and to suggest remedies. In actual situations, the model calibration can take several person months depending upon the complexity of the problem.

The above limitations have been overcome to some extent by the windows interface of the SWMM model which is designed to be as user friendly as possible. In the present study, implementation of the windows interface of SWMM has been presented. However, the SWMM Windows Interface has several limitations. These limitations are summarized below:

1. In the RUNOFF Windows interface, the maximum number of watersheds and channels

allowed is 100. For the SWMM Model 4.3, the maximum number allowed is 200. In the TRANSPORT and EXTRAN Interfaces, the maximum number of inlets and channels allowed is 100, while the maximum number of inlets and channels allowed in the SWMM model is 200.

2. Due to problems with the subcatchment number variable, which would not accept names, all IDs in all the Windows interfaces have to be integers instead of characters. User cannot enter a name for pipes, subcatchments, inlet numbers.

3. Due to problems encountered with the snow melt simulation and with the conversion of the pan evaporation data, daily evaporation rate and wind speed data from the MET interface for continuous snowmelt simulation will be converted to monthly data.

APPENDIX A

SWMM WINDOWS INTERFACE DESIGN

This appendix contains the structures and variables for the five window interface portions of SWMM. There are five tables in this appendix:

Table A.1 Input Variables and Screen Sequence in MET

Table A 2. Input Variables and Screen Sequence in RUNOFF

Table A.3 Input Variables and Screen Sequence in USEHP

Table A.4 Input Variables and Screen Sequence in TRANSPORT

Table A.5 Input Variables and Screen Sequence in EXTRAN

The screen design for the interfaces that are the same as the SWMM Model 4.3 blocks (RUNOFF, TRANSPORT and EXTRAN) provide the following information:

1. The variable name for the model block in SWMM (if there is one),
2. the description of the variable
3. SWMM ID (SID)
4. screen number (SCR)
5. control number (CS)
6. control type (CT), item, range, default, and unit.

User is therefore able to match the Windows Interface variable name with the SWMM Model Variable names, see where it occurs in the interface, read a description, see what type of variable, the unit type and the range, all by referring to the table for the block in which he was interested.

For those for which there are no corresponding blocks in SWMM (MET and USEHP), the following is provided:

1. Screen Number
2. Variable Name
3. Definition of the variable
4. Unit Type

This will give all the information about each variable in the interface. Refer to Sections 2 and 3 for more general information about SWMM and the Windows implementation.

Table A.1 Input Variables and Screen Sequence in MET

Screen No.	Variables	Definition	Unit
1	Description	Description of this run	
	UNITS	Input meteorological data units either in U.S. units or [Metric units]	
	Number of rain gages	Number of raingage stations	
	Number of rain data values	Number of data values for precipitation on Screen No. 3	
	Time interval in hours	Time interval for single event snowmelt simulation	
	Number of air temperatures	Number of values for air temperature on Screen No. 6	
	Number of TEMP data values	Number of data values for TEMP Data Table on Screen No. 4	
2	STATION	An integer (1-10) for raingage station number	
3	JUL.DATE	An integer for the Julian date in the format YYDDD	
	HOUR	A real number for the daytime hour from midnight	second
	THISTO	A real number for the time interval between precipitation data values (A variable time interval is allowed)	second
	PRECIP(i)	A real number for rainfall intensity with the its raingage number (i - raingage, max = 10)	in/hr [mm/hr]
4	JUL.DATE	An integer for the Julian date in the format YYDDD	
	MAX TEMP.	A real number for maximum temperature for the date	°F [°C]
	MIN TEMP.	A real number for minimum temperature for the date	
5	EVAP	A real number for monthly average evaporation rate	in/day [mm/day]
	WINDSPEED	A real number for monthly average wind speed rate	mile/hr [km/hour]
6	TAIR	A real number for air temperature for single event snowmelt simulation	°F [°C]

Table A.2 Input Variables and Screen Sequence in RUNOFF

Variable	Description	SID	SCR	CS	CT	Item	Type	Range	Default	Units
	RUNOFF Simulation Time Control									
TITLE	Description of this run	A1	1	1	1		C160			
	Meteorologic Data		1	2	1		C40			
	Simulation Time Period		1		5					
NHR	Starting time of the storm hr	B1	1	3	1		I	0-24	0	
NMN	min	B1	1	4	1		I	0-60	0	
NDAY	Day storm starts [mm/dd/yy]	B1	1	5	1		I	0-31		
MONTH		B1	1	5	1		I	0-12		
IYRSTR		B1	1	5	1		I	00-99	42	
LONG	Simulation Length	B3	1	6	1		F			
LUNIT	Units of simulation length	B3	1	7	3		C11			
	Seconds		1		9	1			0	
	Minutes		1		9	2			1	
	Hours		1		9	3			2	
	Days		1		9	4			3	
	Ending Date		1		9	5			4	
WET	Wet time step (sec)	B3	1	8	1		F	>=1	3600.0	second
WETDRY	Transition time step (sec)	B3	1	9	1		F		7200.0	second
DRY	Dry time step (sec)	B3	1	10	1		F		86400.0	second
	Simulation Control Parameters		2							
	Simulation Type		2		5					
	Groundwater Flow		2	1	4		I	0,1		
KWALTY	Quality Simlation	B1	2	2	4		I	0,1	1	
ISNOW	Snowmelt Simulation	B1	2	3	5		I	0-2	0	
ISNOW	Not simulated	B1	2	4	6		I	0		
ISNOW	Single event	B1	2	5	6		I	1		
ISNOW	Continuous	B1	2	6	6		I	2		
IVAP	Evaporation	B1	2	7	5			0,>0	>0	
	Evaporation data from met. data file		2	8	6					
	Default evaporation rate		2	9	6				0	
METRIC	UNIT	B1	2	10	5		C15	0,1	0	
	U. S. units		2	11	6			0		
	Metric units		2	12	6			1		
	Snow Melt		3							
ELEV	Average watershed elevation	C1	3	1	1		F		0.0	ft [m]
FWFRAC(1)	Ratio of free water holding capacity to snow	C1	3	2	1		F		0.0	w.e. in [mm]
	depth on snow covered impervious area									
FWFRAC(2)	Ratio of free water holding capacity to snow	C1	3	3	1		F		0.0	w.e. in [mm]
	depth on snow covered pervious area									
FWFRAC(3)	Ratio of free water holding capacity to snow	C1	3	4	1		F		0.0	w.e. in [mm]
	depth for snow on normally bare impervious area									
SNOTMP	Dividing temp. between snow and rain	C1	3	5	1		F		0.0	F [C]
SCF	Snow gage correction factor	C1	3	6	1		F		1.0	

Table A.2 - continued

Variable	Description	SID	SCR	CS	CT	Item	Type	Range	Default	Units
TIPM	Weight used to compute antecedent temp. index	C1	3	7	1		F	0.0-1.0	0.0	
RNM	Ratio of negative melt coeff. to melt coeff.	C1	3	8	1		F		0.6	
ANGLAT	Average latitude of watershed (degree north)	C1	3	9	1		F		0.0	
DTLONG	Longitude correction	C1	3	10	1		F		0.0	min
	Areal Depletion Curve for Impervious Area (%)		4					0.0-1.0		
ADCI(1)	ADCI (1-10)	C3	4	1	1		F		0.0	
	Aeral Depletion Curve for Pervious Area (%)		5					0.0-1.0		
ADCP(1)	ADCP (1-10)	C4	5	1	1		F		0.0	
	Water Quality		6							
NQS	Number of constituents (1-9)	J1	6	1	1		I	1-9		
JLAND	Number of land uses (1-5)	J1	6	2	1		I	1-5	0	
DRYDAY	Number of dry days prior to storm	J1	6	3	1		F	>0.0	0.0	days
CBVOL	Average catchbasin storage volume	J1	6	4	1		F		0.0	ft3 [m3]
DRYBSN	Dry days required to recharge to catchbasin	J1	6	5	1		F	>0.0	1.0	days
IROS	Erosion Simulation	J1	6	6	4		I		0	
IROSAD	Erosion added to constituent number	J1	6	7	1		I		0	
RAINIT	Higest average 30-minute rainfall intensity	J1	6	8	1		F		0.0	in/hr
										[mm/hr]
	Groundwater Quality		6	9	4					
	Street Sweeping Parameters				5					
REFFDD	Street sweeping efficiency for "dust and dirt"	J1	6	10	1		F		0.0	
KLNBGN	Day of year on which street sweeping begins	J1	6	11	1		I		0	
KLNEND	Day of year on which street sweeping ends	J1	6	12	1		I		367	
	Constituent Table	J3	7							
PNAME(K)	CNAME	J3	7	1	1		C			
PUNIT(K)	CUNIT	J3	7	2	1		C			
NDIM(K)	TYPE UNIT	J3	7	3	2		C	0-2	0	
	mg/l		7			1		0		
	MPN/l		7			2		1		
	OTHER		7			3		2		
KALC(K)	BUILDUP	J3	7	4	2		C	0-4	0	
	Fraction		7			1		0		
	Power-linear		7			2		1		
	Exponential		7			3		2		
	Mich-Men		7			4		3		
	No buildup		7			5		4		
KWASH(K)	WHSHOFF	J3	7	5	2		C	0-2	0	
	Power-Exp		7			1		0		
	R. Curve/N		7			2		1		
	R. Curve/B		7			3		2		

Table A.2 - continued

Variable	Description	SID	SCR	CS	CT	Item	Type	Range	Default	Units
KACGUT(K)	FUNCTION	J3	7	6	2		C	0-2	0	
	F(gutter len)		7			1		0		
	F(area)		7			2		1		
	Constant		7			3		2		
LINKUP(K)	LINK-SNOW	J3	7	7	2		C	0,1	0	
	No		7			1		0		
	Yes		7			2		1		
QFACT(1,K)*	LIMIT	J3	7	8	1		F		0.0	
QFACT(2,K)*	POWER	J3	7	9	1		F		0.0	
QFACT(3,K)*	COEFF	J3	7	10	1		F		0.0	
QFACT(4,K)*	FOURTH	J3	7	11	1		F		0.0	
QFACT(5,K)*	FIFTH	J3	7	12	1		F		0.0	
WASHPO(K)*	POWERW	J3	7	13	1		F		0.0	
RCOEF(K)*	COEFFW	J3	7	14	1		F		0.0	
CBFACT(K)*	INICON	J3	7	15	1		F		0.0	8(3)
CONCRN(K)*	CONPRE	J3	7	16	1		F		0.0	8(3)
REFF(K)*	EFFI	J3	7	17	1		F		0.0	
	Land Use Table		8							
LNAME(J)	LNAME	J2	8	1	1		C			
METHOD(J)	METHOD	J2	8	2	3		C	-2,-1,0-2	0	
	New values		8			1		-2		
	New Ratio		8			2		-1		
	Power-linear		8			3		0		
	Exponential		8			4		1		
	Michaelis-Menton		8			5		2		
JACGUT(J)	FUNCTION	J2	8	3	3		C	0-2	0	
	F(gutter len)		8			1		0		
	F(area)		8			2		1		
	Constant		8			3		2		
DDLIM(J)*	LIMIT	J2	8	4	1		I		10	
DDPOW(J)*	POWER	J2	8	5	1		F		0.0	
DDFACT(J)*	COEFF	J2	8	6	1		F		0.0	
CLFREQ(J)*	DAYS1	J2	8	7	1		F		0.0	days
AVSWP(J)*	FRACTION	J2	8	8	1		F		0.0	
DSLCL(J)*	DAYS2	J2	8	9	1		F		0.0	days
	Fractional Constituent Table	J4	9							
KTO	CNAME1	J4	9	1	1		I		0	
KFROM	CNAME2	J4	9	2	1		I		0	
F1(KTO,KFROM)	FRACTION	J4	9	3	1		F		0.0	
	Groundwater Concentration	J5	10							
	GCONC(1-10)				1		F		0.0	8(3)
	*** Array									
	Channel /Pipe Table	G1	11							
NAMEG	NAME	G1	11	1	1		C			
NGTO	CHA/INLET #	G1	11	2	1		C			
NPG=NP	TYPE	G1	11	3	3		C	1-7		

Table A.2 - continued

Variable	Description	SID	SCR	CS	CT	Item	Type	Range	Default	Units
	Trapezoidal		11			1		1		
	Circular		11			2		2		
	Dummy		11			3		3		
	Parabolic		11			4		4		
	Trap w/ weir		11			5		5		
	Cir w/weir		11			6		6		
	Par w/weir		11			7		7		
GWIDTH*	WIDTH	G1	11	4	1		F		0.0	ft [m]
GLEN*	LENGTH	G1	11	5	1		F		0.0	ft [m]
G3*	INV SLOPE	G1	11	6	1		F			ft/ft
GS1	L SLOPE	G1	11	7	1		F			ft/ft
GS2	R SLOPE	G1	11	8	1		F			ft/ft
G6*	Manning's n	G1	11	9	1		F		0.014	
DFULL*	DEPTH	G1	11	10	1		F			ft [m]
GDEPT*	INI DEPTH	G1	11	11	1		F			ft [m]
WTYPE	WTYPE	G2	11	12	3			0,1,2	0	
	B N weir		11			1	C	0		
	V N weir		11			2	C	1		
	Orifice		11			3	C	2		
WELEV	WELEV	G2	11	13	1		F		0.0	ft [m]
WDIS	COEEF	G2	11	14	1		F		3.3	ft1/2/s
										[m1/2/s]
SPILL	SPILL	G2	11	15	1		F		1.0	
	Watershed Parameters (subcatchments)		12							
	Number of subcatchments (1-100)		12	1	1		I			
INFILM	Infiltration Equation	B1	12	2	3		C	0	0	
	Horton		12			1		0		
	Green-Ampt		12			2		1		
REGEN	Regeneration coeff. using Horton Eq.	B4	12	3	1		F		0.01	
PCTZER	Percent of impervious area with zero detention	B4	12	4	1		F		25	%
	Subcatchment Surface Water Table		13							
JK	HYETO #	H1	13	1	1		I		1	
NAMEW	NAMEW	H1	13	2	1		C			
NGTO	CHA/INLET #	H1	13	3	1		C			
WW(1)*	WIDTH	H1	13	4	1		F		0.0	ft [m]
WAREA*	AREA	H1	13	5	1		F		0.0	area [ha]
WW(3)*	% IAREA	H1	13	6	1		F		0.0	%
WSLOPE*	SLOPE	H1	13	7	1		F		0.0	ft/ft
WW(5)*	IMP 'n'	H1	13	8	1		F		0.0	
WW(6)*	PER 'n'	H1	13	9	1		F		0.0	
WSTORE1*	ISTORE	H1	13	10	1		F		0.0	in [mm]
WSTORE2*	PSTORE	H1	13	11	1		F		0.0	in [mm]
WLMAX*	COEFF1	H1	13	12	1		F		0.0	
WLMIN*	COEFF2	H1	13	13	1		F		0.0	
DECAY*	COEFF3	H1	13	14	1		F		0.0	

Table A.2 - continued

Variable	Description	SID	SCR	CS	CT	Item	Type	Range	Default	Units
	Subcatchment Groundwtaer Table	H2	14							
NMSUB	NAMEW	H2	14	1	1		C		0.0	
NGWGW	CHA/INLET #	H2	14	2	1		C		0.0	
ISFPF	GPRINT	H2	14	3	3		I	0,1	0	
	Yes					1	I	0		
	No					2	I	1		
ISFGF	GGRAPH	H2	14	4	3		I	0,1	0	
	Yes					1	I	0		
	No					2	I	1		
BELEV	BELEV	H2	14	5	1		F		0.0	ft [m]
GRELEV	GELEV	H2	14	6	1		F		0.0	ft [m]
STG	IELEV	H2	14	7	1		F		0.0	ft [m]
BC	CB/TS ELV	H2	14	8	1		F		0.0	ft [m]
TW	TW	H2	14	9	1		F		0.0	
A1*	GCOEFF	H3	14	10	1		F		0.0	in/hr-ft
			14							[mm/hr-m]
B1*	GEXPON	H3	14	11	1		F		0.0	
A2*	CHCOEFF	H3	14	12	1		F		0.0	in/hr-ft
			14							[mm/hr-m]
B2*	CEXPON	H3	14	13	1		F		0.0	
A3*	GCCOEFF	H3	14	14	1		F		0.0	in/hr-ft
			14							[mm/hr-m]
PRO*	PROSITY	H3	14	15	1		F		0.0	
WP*	WP	H3	14	16	1		F		0.0	
FC*	FC	H3	14	17	1		F		0.0	
HKSAT*	HKSAT	H3	14	18	1		F		0.0	in/hr [cm/hr]
TH1*	TH1	H3	14	19	1		F		0.0	
HCO*	HCO	H3	14	20	1		F		0.0	
PCO*	PCO	H4	14	21	1		F		0.0	ft/frac [m/frac]
CET*	CET	H4	14	22	1		F		0.0	
DP*	DP	H4	14	23	1		F		0.0	in/hr [cm/hr]
DET*	DET	H4	14	24	1		F		0.0	ft [m]
	Subcatchment Snow Melt Data		15							
JK1	NAMEW	I1	15	1	1		C			
SNN1	FRACIMP	I1	15	2	1		F		0.0	
SNCP(N)	FRACPER	I1	15	3	1		F		0.0	
WSNOW(N,1)	DEPIIMP	I1	15	4	1		F		0.0	w.e. in [mm]
WSNOW(N,2)	DEPIPER	I1	15	5	1		F		0.0	w.e. In [mm]
FW(N,1)	FWIMP	I1	15	6	1		F		0.0	in [mm]
FW(N,2)	FWPER	I1	15	7	1		F		0.0	in [mm]
DHMAX(N,1)*	MELTIMP	I1	15	8	1		F		0.0	in w.e./hr -F
									0.0	mm w.e./hr -C
DHMAX(N,2)*	MELTPER	I1	15	9	1		F		0.0	in w.e./hr -F
									0.0	mm w.e./hr -C
TBASE(N,1)*	TBASEIMP	I1	15	10	1		F		32.0	F [C]
TBASE(N,2)*	TBASEPER	I1	15	11	1		F		32.0	F [C]
	Subcatchment Snow Input for Continuous Simulation		16							
JK2	NAMEW	I2	16	1	1		C			
WSNOW(N,3)	DEPIMP	I2	16	2	1		F		0.0	in [mm]

Table A.2 - continued

Variable	Description	SID	SCR	CS	CT	Item	Type	Range	Default	Units
FW(N,3)	WATIMP	I2	16	3	1		F		0.0	in [mm]
DHMAX(N,3)*	MAXCOE	I2	16	4	1		F		0.0	in w.e/hr-F
										[mm w.e./hr-C]
TBASE(N,3)*	TEMIMP	I2	16	5	1		F		32.0	F [C]
DHMIN(N,1)*	MINSIMP	I2	16	6	1		F		0.0	in w.e/hr-F
										[mm w.e./hr-C]
DHMIN(N,2)*	MINSPER	I2	16	7	1		F		0.0	in w.e/hr-F
										[mm w.e./hr-C]
DHMIN(N,3)*	MINBEAR	I2	16	8	1		F		0.0	in w.e/hr-F
										[mm w.e./hr-C]
SI(N,1)*	DEPSIMP	I2	16	9	1		F		0.0	w.e. in [mm]
SI(N,2)*	DEPSPER	I2	16	10	1		F		0.0	w.e. in [mm]
WEPLOW(N)	REDISTR	I2	16	11	1		F		0.0	w.e. in [mm]
SFRAC(N,1)	FRATIMP	I2	16	12	1		F	0.0-1.0	0.0	
SFRAC(N,2)	FRATPER	I2	16	13	1		F	0.0-1.0	0.0	
SFRAC(N,3)	FRATLAS	I2	16	14	1		F	0.0-1.0	0.0	
SFRAC(N,4)	FRATOUT	I2	16	15	1		F	0.0-1.0	0.0	
SFRAC(N,5)	FRACIMP	I2	16	16	1		F	0.0-1.0	0.0	
	Subcatchment Erosion Table		17							
NAMEW	NAMEW	K1	17	1	1		C			
ERODAR*	EAREA	K1	17	2	1		F		0.0	acres [ha]
ERLEN*	ELENG	K1	17	3	1		F		0.0	ft [m]
SOILF*	SOIL K	K1	17	4	1		F		0.0	
CROPMF*	CROP C	K1	17	5	1		F		0.0	
CONTPF*	CONT P	K1	17	6	1		F		0.0	
	Subcatchment Quality Table									
N=NAMEW	NAMEW	L1	18	1	1		C			
KL	LAND USE	L1	18	2	1		C			
BASIN(N)*	# CHACHBA	L1	18	3	1		F		0.0	
GQLEN(N) *	CURBL	L1	18	4	1		F		0.0	100 ft [km]
	*** number of constituents up to 10									
PSHED(1,N)	INI LOAD (1)	L1	18	5	1		F		0.0	
		L1	18		1		F		0.0	
PSHED(10,N)	INI LOAD (10)	L1	18	14	1		F		0.0	
	Print Control									
IPRN(1)	RUNOFF Input	B2	19	1	5		C21	0-7	0	
	Print all input data	B2	19	2	6	1		0		
	Control information	B2	19	3	6	2		1		
	Possible combinations	B2	19	4	6	3				
	Channel/Pipe	B2	19	5	4	4		2		
	Snowmelt	B2	19	6	4	5		3		
	Subchachment	B2	19	7	4	6		4		
	Water Quality	B2	19	8	4	7		5		
	RUNOFF Output									
IPRN(3)	SWMM output control	B2	19	9	5		C	0-2	0	
	Do not print totals		19	10	6	1		0		
	Monthly and annual totals only		19	11	6	2		1		

Table A.2 - continued

Variable	Description	SID	SCR	CS	CT	Item	Type	Range	Default	Units
	Daily, monthly and annual totals		19	12	6	3		2		
IPRN(2)	Plot graphs	B2	19	13	4		I	0,1	0	
INTERV	Detailed print option	M1	19	14	5			0	0	
	statistical summary only		19	15	6	1	C	0		
	every time step		19	16	6	2		1		
	every K time steps		19	17	6	3		K		
	K=		19	18	1		I			
	*** provide starting and ending date Max=10									
	Detailed Printout Periods (mm/dd/yy)									
STAPTP(1-NDET)	STARTING DATE (mm/dd/yy)	M2	20	1	1		I		0	
STOPPR(1-NDET)	ENDING DATE (mm/dd/yy)	M2	20	2	1		I		0	
NDET	Number of detailed printout periods	M2					I			
	Channel/Inlet Number for Printing Inflows and Concentrations									
IPRNT(1-NPRNT)	Channel/Inlet number	M3	21	1	7		I		0	
	Channel/Inlet Number for Printing Outflows and Concentrations									
IPRNT(1-NPRNT)	Channel/Inlet number	M3	22	1	7		I		0	
	Channel for Printing Depths		23							
KDEEP(1-MDEEP)	Channel number	M4	23	2	7		I		0	
NPRNT	Number of channels/inlets ffor which non-zero flows	M1					I			
	to be printed									
MDEEP	Number of depth locations for printout	M4					I			

Table A.3 Input Variables and Screen Sequence in USEHP

Screen No.	Variables	Definition	Unit
1	Description	Description of this run	
	UNITS	Units either in U.S. units or [Metric units]	
	Number of inlets	Number of inlets (non-conduit elements)	
	Number of pollutants	Number of pollutants (max = 4)	
	Number of data points	Number of data points to define hydrographs and/or pollutographs	
2	INLET #	Inlet number	
3	POLLUTANT	Pollutant name (character field)	
	UNIT	Pollutant input unit (character filed)	
	TYPE UNIT	Pollutant output unit. Three options: mg/l, MPN/l, or others	
4	TEO	Time of day in decimal hour (e.g., 6:30 p.m. = 18.5)	hour
5	INLET [TIME]	Inlet number supplied on Screen 2 [time of day provided on Screen 4]	[hour]
	FLOW	Input flow for the time step at the inlet	cfs [m^3/s]
	POLLUTANT [1]	Concentration for pollutant #1	unit supplied on Screen 3
	POLLUTANT [2]	Concentration for pollutant #2	unit supplied on Screen 3
	POLLUTANT [3]	Concentration for pollutant #3	unit supplied on Screen 3
	POLLUTANT (4)	Concentration for pollutant #4	unit supplied on Screen 3

Table A.4 Input Variables and Screen Sequence in TRANSPORT

Variable	Description	SID	SCR	CS	CT	Item	Type	Range	Default	Units
	TRANSPORT Control Parameters									
TITLE	Description of this run	A1	1	1	1		C160			
	Inlet hydrographs and pollutographs file		1	2	3					
DWDAYS	Number of days prior to simulation	B2	1	3	1		F		0	
GNU	Kinematic viscosity of water	B2	1	4	1		F		10^-5	ft2/s
									10^-2	cm2/s
TRIBA	Total catchment area	B2	1	5	1		F		0.0	ac [ha]
	Computational Control		1		5					
IDATEZ	Starting date of strom (mm/dd/yy)	B1	1	6	1		C		0	
TZERO	Starting time of the storm (hours)	B2	1	7	1		F		0	
NDT	Number of time steps	B1	1	8	1		I		0	
NITER	Number of iterations	B1	1	9	1		I		4	
DT	Time step (seconds)	B2	1	10	1		F		0	
EPSIL	Allowable error for convergence	B2	1	11	1		F		1e-04	
	Simulation Control		2							
	Simulation type		2		5		C25			
NINFIL	Sewer infiltration inflows	B3	2	1	4			1	0	
NFILTH	Dry-weather sewage inflow	B3	2	2	4			1	0	
NDESN	Hydraulic design	B3	2	3	4			1	0	
METRIC	Unit	B1	2	4	5			1	0	
	U. S. units		2	5	6	1	C15	0	0	
	Metric units		2	6	6	2	C15	1		
NPOLL	Number of constituents to be simulated	B1	2	7	1		I	0-4	0	
	*** Array (max=100)									
	Sewer System Table		3							
NOE	CNAME	E1	3	1	1		C			
NUE(1)	1st U/P	E1	3	2	1		I		0	
NUE(2)	2nd U/P	E1	3	3	1		I		0	
NUE(3)	3nd U/P	E1	3	4	1		I		0	
NTYPE	TYPE	E1	3	5	3		C17	1-25	1	
	Circular	E1	3			1		1		
	Rectangular	E1	3			2		2		
	Egg shape	E1	3			3		3		
	Horseshore	E1	3			4		4		
	Gothic	E1	3			5		5		
	Catenary	E1	3			6		6		
	Semielliptic	E1	3			7		7		
	Baslet-Handle	E1	3			8		8		
	Semi-circular	E1	3			9		9		

Table A.4 - continued

Variable	Description	SID	SCR	CS	CT	Item	Type	Range	Default	Units
	Modified B-H	E1	3			10		10		
	R+tri bottom	E1	3			11		11		
	R+round bottom	E1	3			12		12		
	Trapezoid	E1	3			13		13		
	Parabolic	E1	3			14		14		
	Power F	E1	3			15		15		
	Manhole	E1	3			16		19		
	Lift station	E1	3			17		20		
	Flow divider	E1	3			18		21		
	Flow divider/weir	E1	3			19		23		
	Flow divider	E1	3			20		24		
	Backwater	E1	3			21		25		
	XTANK001.DAT	G1-G5	3							
	XHEC2001.DAT	E2-E4	3							
	XSHAP001.DAT	D1-D9	3							
DIST*	LENGTH	E1	3	6	1		F		0.0	ft [m]
GEOM1*	GEOM1	E1	3	7	1		F		0.0	
SLOPE*	SLOPE	E1	3	8	1		F		0.0	
ROUGH*	MANNING'S n	E1	3	9	1		F		0.0	
GEOM2*	GEOM2	E1	3	10	1		F		0.0	
BARREL	BARREL	E1	3	11	1		F		1.0	
GEOM3*	GEOM3	E1	3	12	1		F		0.0	
	*** Array (max=4)									
	Water Quality Table		4							
PNAME	POLLUTANT	F1	4	1	3		C8			
PUNIT	CUNIT	F1	4	2	1		C8			
NDIM	TYPE UNIT	F1	4	3	3		C11	12	0	
	mg/l					1		0		
	Other/l					2		1		
	Other units					3		2		
DECAY	DECAY	F1	4	4	1		F		0.0	1/day
SPG	GRAVITY	F1	4	5	1		F		0.0	
PSIZE(2)	SIZE (2)	F1	4	6	1		F		0.0	mm
PGR(2)	GR(2) %	F1	4	7	1		F		0.0	
PSIZE(3)	SIZE (3)	F1	4	8	1		F		0.0	mm
PGR(3)	GR(3) %	F1	4	9	1		F		0.0	
PSIZE(4)	SIZE (4)	F1	4	10	1		F		0.0	mm
PGR(4)	GR(4) %	F1	4	11	1		F		0.0	
PSIZE(5)	SIZE (5)	F1	4	12	1		F		0.0	mm
PGR(5)	GR (5) %	F1	4	13	1		F		0.0	
PSDWF	MAX SIZE	F1	4	14	1		F		0.0	mm
	Infiltration Inflows		5							
DINFIFL	Base dry weather infiltration	K1	5	1	1		F		0.0	cfs [m3/s]

Table A.4 - continued

Variable	Description	SID	SCR	CS	CT	Item	Type	Range	Default	Units
GINFIL	Groundwater infiltration	K1	5	2	1		F		0.0	cfs [m3/s]
RINFIL	Rainwater infiltration	K1	5	3	1		F		0.0	cfs [m3/s]
RSMAX	Peak residual moisture	K1	5	4	1		F		0.0	cfs [m3/s]
CPINF(1)	Concentration of constituent #1	K1	5	5	1		F		0.0	
CPINF(2)	Concentration of constituent # 2	K1	5	6	1		F		0.0	
CPINF(3)	Concentration of constituent # 3	K1	5	7	1		F		0.0	
CPINF(4)	Concentration of constituent # 4	K1	5	8	1		F		0.0	
	*** Array (max=12) Jan, Feb,.... ,Dec									
	Average Monthly Degree-Days		6							
	Month		6	1	1					
NDD(1-12)	Degree-Days	K2	6	2	1		F		0.0	F
	*** Array (max=7) Sunday,..., Saturday									
	Daily Correction Factors for Flow and Concentrations		7							
	Day		7	1	1					
DVDWF(1-7)	SEWAGE FLOW	L1	7	2	1		F		1.0	
NVBOD(1-7)	BOD	L2	7	3	1		F		1.0	
DVSS(1-7)	SS	L3	7	4	1		F		1.0	
	*** Array (max=24) 1 am, 2 am,..., 11 pm									
	Hourly Correction Factors for Flow and Concentrations		8							
HVDWF(1-24)	SEWAGE FLOW	M1	8	1	1		F		1.0	
HVBOD(1)	BOD	M2	8	2	1		F		1.0	
HVSS(1)	SS	M3	8	3	1		F		1.0	
HVCOLI(1)	TOTAL COLIFORM	M4	8	4	1		F		1.0	
	Study Area Description		9							
KTNUM	Total number of subareas within a given study area	N1	9	1	1		I		1	
NPF	Number of process flows	N1	9	2	1		I		0	
KDAY	Day of the week begins simulation	N1	9	3	1		I		1	
CPI	Consumer price index	N1	9	4	1		F		125.0	
CCCI	Composite construction cost index	N1	9	5	1		F		110.0	
POPULA	Total population in all areas	N1	9	6	1		F		0.0	thousands
KASE	Estimate sewage quality from treatment plant records	N1	9	7	4		I		0	
	Study Area Parameters		10							
	Total study area data		10							
ADWF	Sewage flow	O1	10	1	1		F		0.0	cfs [m3]
ABOD	BOD	O1	10	2	1		F		0.0	mg/l
ASUSO	SS	O1	10	3	1		F		0.0	mg/l
ACOLI	Coliform	O1	10	4	1		F		0.0	mg/l
	Categorized contributing Area									

Table A.4 - continued

Variable	Description	SID	SCR	CS	CT	Item	Type	Range	Default	Units
TOTA	BOD and SS	O2	10	5	1		F		0.0	acre [ha]
TINA	Industrial	O2	10	6	1		F		0.0	acre [ha]
TCA	Commercial	O2	10	7	1		F		0.0	acre [ha]
	Residential area									
TRHA	High income	O2	10	8	1		F		0.0	acre [ha]
TRAA	Average income	O2	10	9	1		F		0.0	acre [ha]
TRLA	Low income	O2	10	10	1		F		0.0	acre [ha]
TRGGA	Additional waste	O2	10	11	1		F		0.0	acre [ha]
TPOA	Park and open area	O2	10	12	1		F		0.0	acre [ha]
	*** Array (max=NPF)									
	Process Flow Characteristics		11							
INPUT	MANHOLE #	P1	11	1	1		I		0	
QPF	FLOW	P1	11	2	1		F		0.0	cfs [m3/s]
BODPF	Q BOD	P1	11	3	1		F		0.0	mg/l
SUSPF	Q SS	P1	11	4	1		F		0.0	mg/l
	*** Array (max=KTNUM)									
	Categorized Study Area		12							
KNUM	KNUM	Q1	12	1	1		I		0	
INPUT	MANHOLE #	Q1	12	2	1		I		0	
KLAND	LAND	Q1	12	3	3		C15	1-5	5	
	Single-F R					1			1	
	Multi-F R					2			2	
	Commericial					3			3	
	Industrial					4			4	
	U/P lands					5			5	
METHOD	METHOD	Q1	12	4	3		C10		0	
	Metered					1			1	
	No metered					2			2	
KUNIT	UNIT	Q1	12	5	3		C15			
	Thousand gal/mo					1			0	
	Thousand cfs/mo					2			1	
	10^3 m3/mo					3			0	
MSUBT	PRINT	Q1	12	6	3		C3			
	No					1			0	
	Yes					2			1	
SAGPF	INDU Q	Q1	12	7	1		F		0.0	cfs [m3/s]
SABPF	BOD C	Q1	12	8	1		F		0.0	mg/l
SASPF	SS C	Q1	12	9	1		F		0.0	mg/l
WATER	WINTER USE	Q1	12	10	1		F		0.0	
PRICE	PRICE	Q1	12	11	1		F		0.0	cents/1000 gal
										cents/1000 m3
SEWAGE	SEWAGE	Q1	12	12	1		F		0.0	cfs [m3]

Table A.4 - continued

Variable	Description	SID	SCR	CS	CT	Item	Type	Range	Default	Units
ASUB	AREA	Q1	12	13	1		F		0.0	acre [ha]
POPDEN	DENSITY	Q1	12	14	1		F		0.0	pers/ac
										pers [ha]
DWLNGS	DWELNGS	Q1	12	15	1		F		10.0/ac	
FAMILY	FAMILY	Q1	12	16	1		F		0.0	
VALUE	VALUE	Q1	12	17	1		F		20.0	$1000
PCGG	% GARBAGE	Q1	12	18	1		F		0.0	
XINCOM	INCOME	Q1	12	19	1		F		value/2.	$1000/yr
	Print Control		13							
NPRINT	Error message suppressed	B1	13	1	4		I	1	0	
KPRINT	All shapes suppressed	C1	13	2	4		I	1	0	
INTPRT	Print interval	B1	13	3	1		I		0	
	List of Element Numbers for Hydrographs		14							
	and Pollutographs to be Transferred									
JN(1-NOUTS)	Non-conduit element number	H1	14	1	7		I		0	
NOUTS	Number of non-conduit elements with transferred	B1					I		0	
	routed hydrographs and pollutographs placed on the									
	interface file									
	List of Element Numbers for Input Hydrographs		15							
	and Pollutographs									
NYN(1-NNYN)	Non-conduit element number	J1	15	1	7		I		0	
NNYN	Number of non-conduit elements with input hydrographs	B1					I			
	and pollutographs printouts									
	List of Element Numbers for Output Hydrographs		16							
	and Pollutographs									
NPE(1-NNPE)	Non-conduit element number	J2	16	1	7		I		0	
NNPE	Number of non-conduit elements with output hydrographs	B1					I		0	
	and pollutographs printouts									
	List the Conduit Elements for Which Depths to be Printed		17							
JSURF(1-NAURF)	Conduit number	I2	17	1	7		I		0	
NAURF	Number of conduit elements									

Table A.4 - continued

Variable	Description	SID	SCR	CS	CT	Item	Type	Range	Default	Units
	*** Set NCNTRL=0									
NCNTRL	Control parameter specifying means to be used in	B3					I	1	0	
	transferring inlet hydrographs									
	*** set NINPUT=0									
NINPUT	Number of non-conduit elements with data input of	B1					I	1	0	
	hydrographs and pollutographs on data group R1									

Table A.5 Input Variables and Screen Sequence in EXTRAN

Variable	Description	SID	SCR	CS	CT	Item	Type	Range	Default	Units
	TRANSPORT Control Parameters									
TITLE	Description of this run	A1	1	1	1		C160			
	Inlet hydrographs and pollutographs file		1	2	3					
DWDAYS	Number of days prior to simulation	B2	1	3	1		F		0	
GNU	Kinematic viscosity of water	B2	1	4	1		F		10^-5	ft2/s
									10^-2	cm2/s
TRIBA	Total catchment area	B2	1	5	1		F		0.0	ac (ha)
	Computational Control		1		5					
IDATEZ	Starting date of strom (mm/dd/yy)	B1	1	6	1		C		0	
TZERO	Starting time of the storm (hours)	B2	1	7	1		F		0	
NDT	Number of time steps	B1	1	8	1		I		0	
NITER	Number of iterations	B1	1	9	1		I		4	
DT	Time step (seconds)	B2	1	10	1		F		0	
EPSIL	Allowable error for convergence	B2	1	11	1		F		1e-04	
	Simulation Control		2							
	Simulation type		2		5		C25			
NINFIL	Sewer Infiltration Inflows	B3	2	1	4			1	0	
NFILTH	Dry-weather sewage inflow	B3	2	2	4			1	0	
NDESN	Hydraulic design	B3	2	3	4			1	0	
METRIC	Unit	B1	2	4	5			1	0	
	U. S. units		2	5	6	1	C15	0	0	
	Metric units		2	6	6	2	C15	1		
NPOLL	Number of constituents to be simulated	B1	2	7	1		I	0-4	0	
	*** Array (max=100)									
	Sewer System Table		3							
NOE	CNAME	E1	3	1	1		C			
NUE(1)	1st U/P	E1	3	2	1		I		0	
NUE(2)	2nd U/P	E1	3	3	1		I		0	
NUE(3)	3nd U/P	E1	3	4	1		I		0	
NTYPE	TYPE	E1	3	5	3		C17	1-25	1	
	Circular	E1	3			1		1		
	Rectangular	E1	3			2		2		
	Egg shape	E1	3			3		3		
	Horseshore	E1	3			4		4		
	Gothic	E1	3			5		5		
	Catenary	E1	3			6		6		
	Semielliptic	E1	3			7		7		
	Basiet-Handle	E1	3			8		8		
	Semi-circular	E1	3			9		9		

Variable	Description	SID	SCR	CS	CT	Item	Type	Range	Default	Units
	Modified B-H	E1	3			10		10		
	R+tri bottom	E1	3			11		11		
	R+round bottom	E1	3			12		12		
	Trapezoid	E1	3			13		13		
	Parabolic	E1	3			14		14		
	Power F	E1	3			15		15		
	Manhole	E1	3			16		19		
	Lift station	E1	3			17		20		
	Flow divider	E1	3			18		21		
	Flow divider/weir	E1	3			19		23		
	Flow divider	E1	3			20		24		
	Backwater	E1	3			21		25		
	XTANK001.DAT	G1-G5	3							
	XHEC2001.DAT	E2-E4	3							
	XSHAP001.DAT	D1-D9	3							
DIST*	LENGTH	E1	3	6	1		F		0.0	ft [m]
GEOM1*	GEOM1	E1	3	7	1		F		0.0	
SLOPE*	SLOPE	E1	3	8	1		F		0.0	
ROUGH*	MANNING'S n	E1	3	9	1		F		0.0	
GEOM2*	GEOM2	E1	3	10	1		F		0.0	
BARREL	BARREL	E1	3	11	1		F		1.0	
GEOM3*	GEOM3	E1	3	12	1		F		0.0	
	***_Array (max=4)									
	Water Quality Table		4							
PNAME	POLLUTANT	F1	4	1	3		C8			
PUNIT	CUNIT	F1	4	2	1		C8			
NDIM	TYPE UNIT	F1	4	3	3		C11	12	0	
	mg/l					1		0		
	Other/l					2		1		
	Other units					3		2		
DECAY	DECAY	F1	4	4	1		F		0.0	1/day
SPG	GRAVITY	F1	4	5	1		F		0.0	
PSIZE(2)	SIZE (2)	F1	4	6	1		F		0.0	mm
PGR(2)	GR(2) %	F1	4	7	1		F		0.0	
PSIZE(3)	SIZE (3)	F1	4	8	1		F		0.0	mm
PGR(3)	GR(3) %	F1	4	9	1		F		0.0	
PSIZE(4)	SIZE (4)	F1	4	10	1		F		0.0	mm
PGR(4)	GR(4) %	F1	4	11	1		F		0.0	
PSIZE(5)	SIZE (5)	F1	4	12	1		F		0.0	mm
PGR(5)	GR (5) %	F1	4	13	1		F		0.0	
PSDWF	MAX SIZE	F1	4	14	1		F		0.0	mm
	Infiltration inflows		5							
DINFIFL	Base dry weather infiltration	K1	5	1	1		F		0.0	cfs [m3/s]
GINFIL	Groundwater infiltration	K1	5	2	1		F		0.0	cfs [m3/s]

Table A.5 - continued

Variable	Description	SID	SCR	CS	CT	Item	Type	Range	Default	Units
POPDEN	DENSITY	Q1	12	14	1		F		0.0	pers/ac
										pers [ha]
DWLNGS	DWELNGS	Q1	12	15	1		F		10.0/ac	
FAMILY	FAMILY	Q1	12	16	1		F		0.0	
VALUE	VALUE	Q1	12	17	1		F		20.0	$1000
PCGG	% GARBAGE	Q1	12	18	1		F		0.0	
XINCOM	INCOME	Q1	12	19	1		F		value/2.	$1000/yr
	Print Control		13							
NPRINT	Error message suppressed	B1	13	1	4		I	1	0	
KPRINT	All shapes suppressed	C1	13	2	4		I	1	0	
INTPRT	Print interval	B1	13	3	1		I		0	
	List of Element Numbers for Hydrographs		14							
	and Pollutographs to be Transferred									
JN(1-NOUTS)	Non-conduit element number	H1	14	1	7		I		0	
NOUTS	Number of non-conduit elements with transferred	B1					I		0	
	routed hydrographs and pollutographs placed on the									
	interface file									
	List of Element Numbers for Input Hydrographs		15							
	and Pollutographs									
NYN(1-NNYN)	Non-conduit element number	J1	15	1	7		I		0	
NNYN	Number of non-conduit elements with input hydrographs	B1					I			
	and pollutographs printouts									
	List of Element Numbers for Output Hydrographs		16							
	and Pollutographs									
NPE(1-NNPE)	Non-conduit element number	J2	16	1	7		I		0	
NNPE	Number of non-conduit elements with output hydrographs	B1					I		0	
	and pollutographs printouts									
	List the Conduit Elements for Which Depths to be Printed		17							
JSURF(1-NAURF)	Conduit number	I2	17	1	7		I		0	
NAURF	Number of conduit elements									

q

Table A.5 - continued

Variable	Description	SID	SCR	CS	CT	Item	Type	Range	Default	Units
TINA	Industrial	O2	10	6	1		F		0.0	acre [ha]
TCA	Commercial	O2	10	7	1		F		0.0	acre [ha]
	Residential area									
TRHA	High income	O2	10	8	1		F		0.0	acre [ha]
TRAA	Average income	O2	10	9	1		F		0.0	acre [ha]
TRLA	Low income	O2	10	10	1		F		0.0	acre [ha]
TRGGA	Additional waste	O2	10	11	1		F		0.0	acre [ha]
TPOA	Park and open area	O2	10	12	1		F		0.0	acre [ha]
	*** Array (max=NPF)									
	Process Flow Characteristics		11							
INPUT	MANHOLE #	P1	11	1	1		I		0	
QPF	FLOW	P1	11	2	1		F		0.0	cfs [m3/s]
BODPF	Q BOD	P1	11	3	1		F		0.0	mg/l
SUSPF	Q SS	P1	11	4	1		F		0.0	mg/l
	*** Array (max=KTNUM)									
	Categorized Study Area		12							
KNUM	KNUM	Q1	12	1	1		I		0	
INPUT	MANHOLE #	Q1	12	2	1		I		0	
KLAND	LAND	Q1	12	3	3		C15	1-5	5	
	Single-F R					1			1	
	Multi-F R					2			2	
	Commericial					3			3	
	Industrial					4			4	
	U/P lands					5			5	
METHOD	METHOD	Q1	12	4	3		C10		0	
	Metered					1			1	
	No metered					2			2	
KUNIT	UNIT	Q1	12	5	3		C15			
	Thousand gal/mo					1			0	
	Thousand cfs/mo					2			1	
	10^3 m3/mo					3			0	
MSUBT	PRINT	Q1	12	6	3		C3			
	No					1			0	
	Yes					2			1	
SAGPF	INDU Q	Q1	12	7	1		F		0.0	cfs [m3/s]
SABPF	BOD C	Q1	12	8	1		F		0.0	mg/l
SASPF	SS C	Q1	12	9	1		F		0.0	mg/l
WATER	WINTER USE	Q1	12	10	1		F		0.0	
PRICE	PRICE	Q1	12	11	1		F		0.0	cents/1000 gal
										cents/1000 m3
SEWAGE	SEWAGE	Q1	12	12	1		F		0.0	cfs [m3]
ASUB	AREA	Q1	12	13	1		F		0.0	acre [ha]

Table A.5 - continued

Variable	Description	SID	SCR	CS	CT	Item	Type	Range	Default	Units
RINFIL	Rainwater infiltration	K1	5	3	1		F		0.0	cfs [m3/s]
RSMAX	Peak residual moisture	K1	5	4	1		F		0.0	cfs [m3/s]
CPINF(1)	Concentration of constituent #1	K1	5	5	1		F		0.0	
CPINF(2)	Concentration of constituent # 2	K1	5	6	1		F		0.0	
CPINF(3)	Concentration of constituent # 3	K1	5	7	1		F		0.0	
CPINF(4)	Concentration of constituent # 4	K1	5	8	1		F		0.0	
	*** Array (max=12) Jan, Feb,.... ,Dec									
	Average Monthly Degree-Days		6							
	Month		6	1	1					
NDD(1-12)	Degree-Days	K2	6	2	1		F		0.0	F
	*** Array (max=7) Sunday,..., Saturday									
	Daily Correction Factors for Flow and Concentrations		7							
	Day		7	1	1					
DVDWF(1-7)	SEWAGE FLOW	L1	7	2	1		F		1.0	
NVBOD(1-7)	BOD	L2	7	3	1		F		1.0	
DVSS(1-7)	SS	L3	7	4	1		F		1.0	
	*** Array (max=24) 1 am, 2 am,..., 11 pm									
	Hourly Correction Factors for Flow and Concentrations		8							
HVDWF(1-24)	SEWAGE FLOW	M1	8	1	1		F		1.0	
HVBOD(1)	BOD	M2	8	2	1		F		1.0	
HVSS(1)	SS	M3	8	3	1		F		1.0	
HVCOLI(1)	TOTAL COLIFORM	M4	8	4	1		F		1.0	
	Study Area Description		9							
KTNUM	Total number of subareas within a given study area	N1	9	1	1		I		1	
NPF	Number of process flows	N1	9	2	1		I		0	
KDAY	Day of the week begins simulation	N1	9	3	1		I		1	
CPI	Consumer price index	N1	9	4	1		F		125.0	
CCCI	Composite construction cost index	N1	9	5	1		F		110.0	
POPULA	Total population in all areas	N1	9	6	1		F		0.0	thousands
KASE	Estimate sewage quality from treatment plant records	N1	9	7	4		I		0	
	Study Area Parameters		10							
	Total study area data		10							
ADWF	Sewage flow	O1	10	1	1		F		0.0	cfs [m3]
ABOD	BOD	O1	10	2	1		F		0.0	mg/l
ASUSO	SS	O1	10	3	1		F		0.0	mg/l
ACOLI	Coliform	O1	10	4	1		F		0.0	mg/l
	Categorized contributing Area									
TOTA	BOD and SS	O2	10	5	1		F		0.0	acre [ha]

Table A.5 - continued

Variable	Description	SID	SCR	CS	CT	Item	Type	Range	Default	Units
	*** Set NCNTRL=0									
NCNTRL	Control parameter specifying means to be used in	B3					I	1	0	
	transferring inlet hydrographs									
	*** set NINPUT=0									
NINPUT	Number of non-conduit elements with data input of	B1					I	1	0	
	hydrographs and pollutographs on data group R1									

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