P8
URBAN CATCHMENT MODEL

USER'S MANUAL

Version 1.1

Prepared For:

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1.0 INTRODUCTION

The Urban Catchment Model, P8, is a model for predicting the generation and transport of stormwater runoff pollutants in urban catchments. Residential and commercial developments have appeared in increasing numbers in recent years throughout the Rhode Island (RIDEM, 1988). This increase in development causes a number of impacts on the surrounding environment. In particular, as land is converted from open or forested land to developed land, the area of impervious surfaces increases dramatically, while surfaces available for infiltration of precipitation decline. These hydrologic modifications tend to increase the proportion of water which leaves a given site as surface runoff. In developed areas, pollutants which accumulate ("build up") during dry periods are "washed" off as runoff passes over the land surface. In contrast, undeveloped lands have characteristics (low imperviousness, high infiltration, vegetative cover) which reduces surface runoff and the transport of pollutants in that surface runoff. Nationally, nonpoint sources of pollution, account for about 45%, 76%, and 65% of the degradation of estuaries, lakes, and rivers, respectively (EPA, 1989). On the other hand, municipal and industrial point source discharges account for only 9 - 30% of the degradation of these water resources.

Through sound land use planning and review processes, contributions of contaminants in urban runoff can be minimized, and water, wetland, and wildlife resources protected. Therefore, under a contract with the Narragansett Bay Project, the P8 Urban Catchment Model was developed. The intent was to provide local and state land use planners and engineers with a tool for evaluating the impacts of development on water quality, with a minimum of site-specific data.

2.0 MODEL OVERVIEW

The user is referred to the P8 Program Documentation for a detailed documentation of the P8 Model including applications, limitations, reference citations, and simulation methods. Single-event or continuous simulation of rainfall events can be completed for user-defined systems consisting of a maximum of (24) watersheds, twenty-four (24) stormwater management devices (BMPs), five (5) particle size classes, and ten (10) water quality components. Simulations are driven by continuous hourly rainfall time series. Figure 1 illustrates the conceptual organization and functional components and variables simulated by the model. P8 consists primarily of algorithms derived from other tested urban runoff models (i.e., SWMM, HSPF, D3RM, TR-20). However, P8 has been designed to require a minimum of site specific data, which is expressed in terminology familiar to most local engineers and planners. Extensive user interface, including spreadsheet-like menus and on-line help documentations facilitate model use. The model will simulate a variety of treatment devices (BMPs), including swales, buffer strips, detention ponds (dry, wet, extended), flow splitters, and infiltration basins (offline and online) as illustrated in Figure 2. Initial calibration of certain water quality parameters has been completed, such that runoff concentrations correspond to values measured under the Nationwide Urban Runoff Program (NURP; Athayde et al., 1983).

FIGURE 1

P8 MASS-BALANCE SCHEMATIC

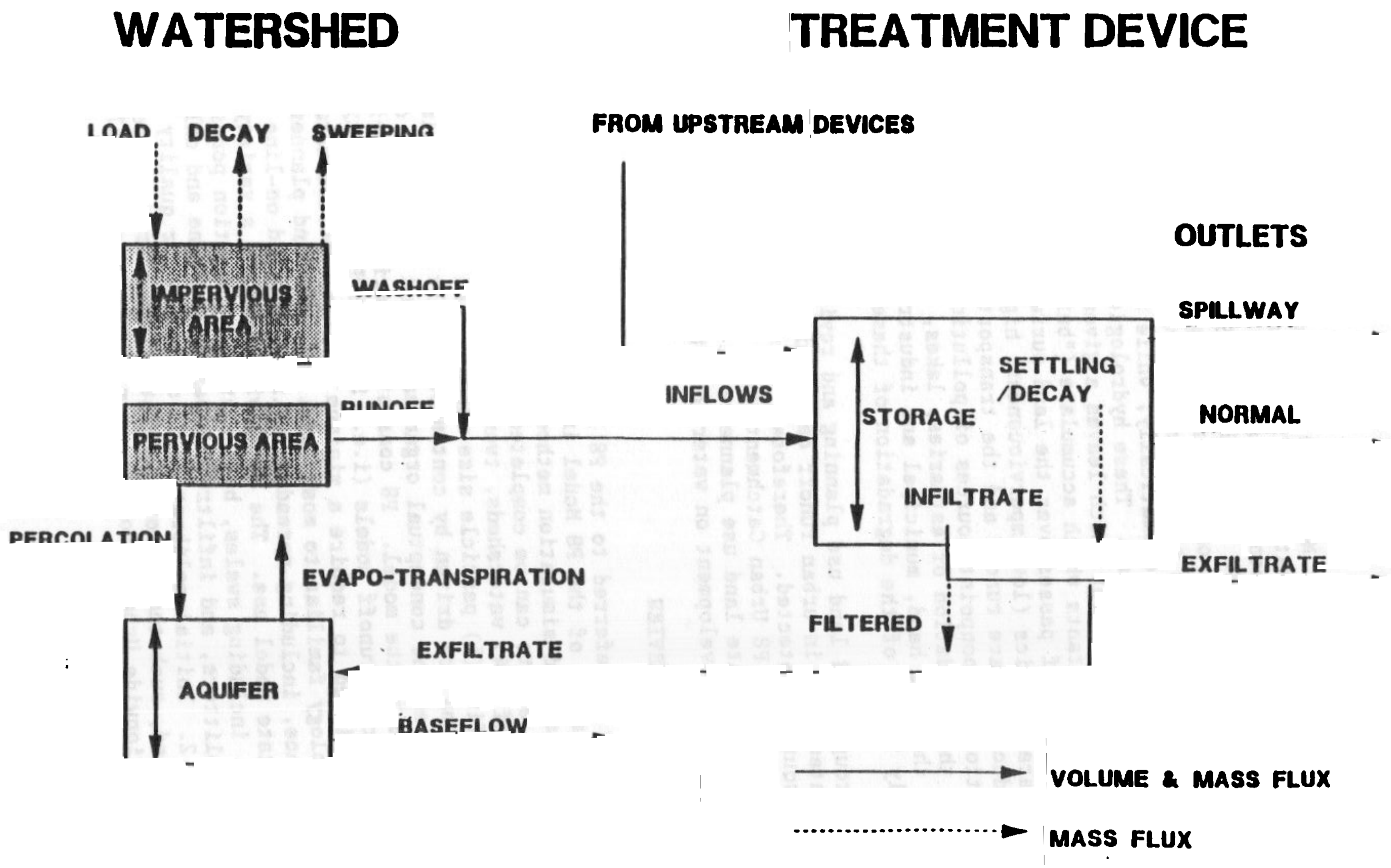
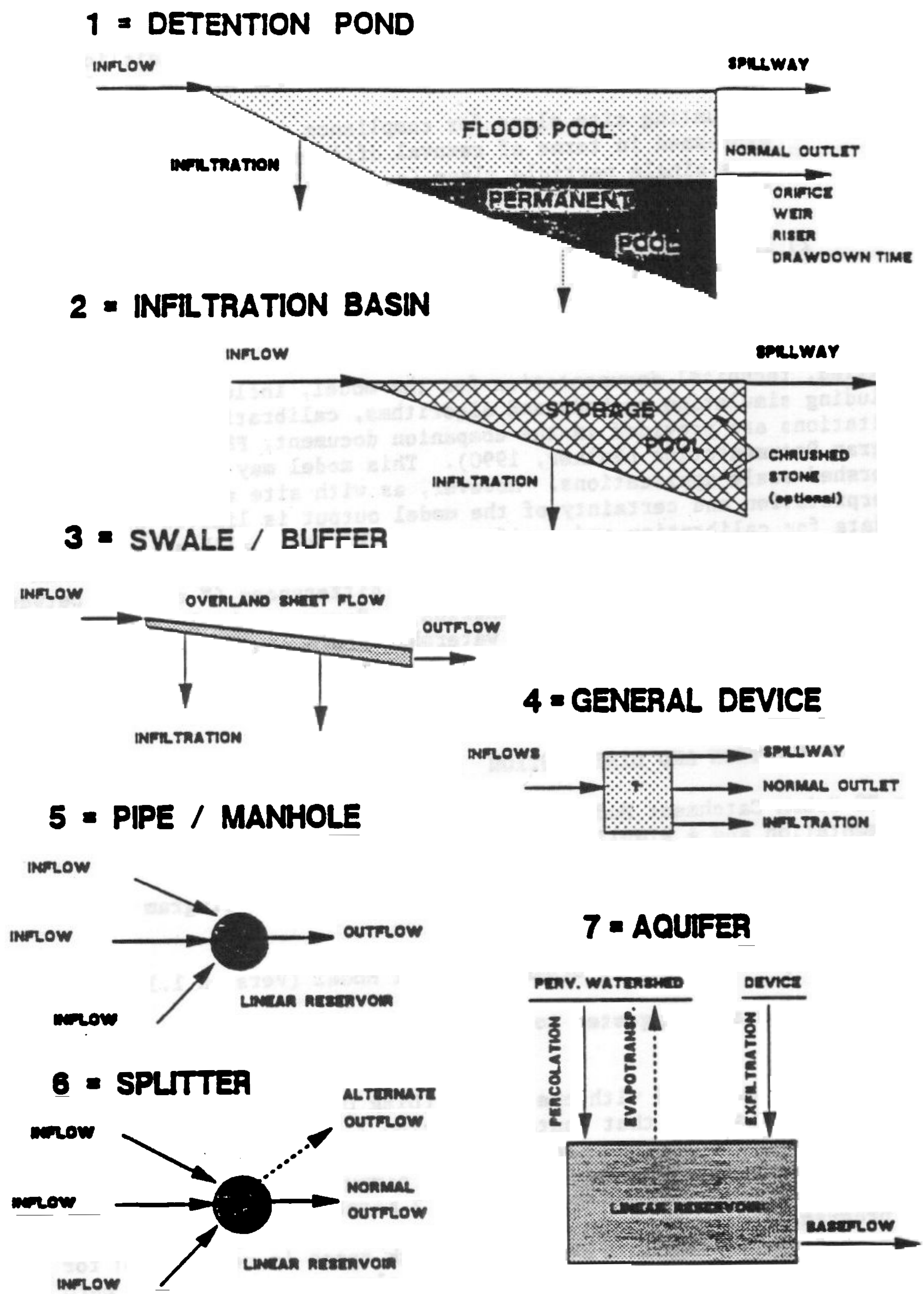


FIGURE 2

P8 DEVICE TYPES



Because of model limitations, discussed in detail in the Program Documentation (Walker, 1990), absolute predictions of concentrations, loads, or violation frequencies are less reliable, as compared to relative predictions of removal efficiencies. Therefore, the primary intended uses of the model include:

1) Evaluating site plans for compliance with a treatment objective, expressed in terms of removal efficiency for total suspended solids, or a single particle class (e.g., 70% or 85% TSS removal, RIDEM, 1988).

2) In a design mode, selecting and sizing BMP's to achieve a given treatment objective. The program automatically scales BMP's to match user-defined watersheds, storm time series, target particle class, and target removal efficiency.

Detailed, technical documentation for the model, including simulation methods, including simulation methods and algorithms, calibration, testing, and limitations are provided in the companion document, P8 Urban Catchment Model Program Documentation (Walker, 1990). This model may also be used for watershed-scale applications. However, as with site applications, the interpretation and certainty of the model output is limited by the availability of data for calibration and verification. Without calibration, "absolute" predictions (e.g., concentration, load, flows) are less reliable than "relative predictions (e.g., comparing the relative differences (% change) between a number of different built-out scenarios). However, absolute predictions are typically of greater interest in watershed-scale applications, but the reliability of predictions will often be limited by a lack of calibration data. Therefore, the use of the model for "absolute" predictions applications are considered secondary uses of the model at this time.

3.0 DOCUMENTATION AND DISTRIBUTION

The P8 Urban Catchment Model is documented in two forms (a technical documentation and a simplified user's manual):

Walker, W.W. 1990. P8 Urban Catchment Model: Program Documentation. Version 1.1. Final Report.

IEP, Inc. 1990. P8 Urban Catchment Model (Version 1.1): User's Manual.

Both documents are suggested to operate the model and interpret the model output.

You have been provided with one MS DOS (Disk Operating System) high density 1.2 megabyte diskette that contains Version 1.1 of the P8 Urban Catchment Model. This model and its support programs and files are designed for interactive applications on the IBM PC or compatible computer system with 640k available Random Access Memory (RAM) and at least 2 megabytes of Hard Disk Storage. The program and sample input files occupy approximately 1.2 megabyte of disk space, and an additional 1 megabyte of disk space is recommended for working files. An AT (80286 processor) or higher class computer with a hard disk and numeric coprocessor are recommended to accelerate computations. The program is written in FORTRAN-77 and compiled using the Microsoft, Inc. Version 5.0 optimizing compiler (emulator library). Supporting subroutine libraries (graphics, screen control, character manipulation) include ASMUTIL 2 and BUTILE from Impulse Engineering, San Francisco.

For technical assistance or further information contact:

4.0 INSTALLATION AND DISK FILES

4.1 Installation Procedure

The following procedure is used to install P8 on your hard drive from the distribution diskette. This procedure is provided on the distribution diskette under filename 'Readme'. This file can be accessed using the >Type command in DOS.

1. Place the distribution diskette in Disk Drive A:
2. Enter the following line:
   >A:

3. To install on the hard Disk (C) in a directory called P8, enter one of the following lines depending upon the type of graphics available on your system:

   - For Computers with EGA graphics:
     > INSTALL C P8 EGA
   - For Computers with VGA graphics:
     > INSTALL C P8 VGA
   - For Computers with CGA (Standard IBM-PC) color graphics:
     > INSTALL C P8 CGA
   - For Computers with CGA monochrome graphics:
     > INSTALL C P8 MCGA
   - For Computers with other graphics:
     > INSTALL C P8 XXX

4. Add the following line to the CONFIG.SYS file in the root directory of your hard disk:

   FILES=20

5. To run P8 program, enter the following lines:

```
>C:        (to switch to hard drive)
>cd\P8     (to access P8 directory)
>P8        (to run P8)
```

Notes: The graphics resolution is poor in CGA mode and monochrome version (MCGA) is suggested. MCGA has higher resolution that CGA, but no color, and will run with either color or monochrome monitors. If installed on computers with other graphics or no graphics (XXX mode), the program will run but without plotting routines.

The program is now loaded on your hard disk, and can be accessed for future use using step 5 of the installation procedure. If you want to change driver later, enter switch XXX = EGA, VGA, CGA, etc. (see 'Readme' file for further details).

4.2 Disk Files

The P8 installation disk has 91 disk files, including sample case files and input data files. Sample case files may be used for instructional purposes or to serve as templates for building a new case file. Case files (.CAS) included on the distribution diskette include:

SIMPLE EXAMPLES/TEMPLATES:
DEFAULT.CAS - loaded automatically when program starts
WETPOND.CAS - 1 watershed with wet detention pond
DRYPOND.CAS - 1 watershed with dry detention (flood control) pond
EXTPOND.CAS - 1 watershed with extended detention pond
ONLINE.CAS - 1 watershed with on-line infiltration (retention) basin
OFFLINE.CAS - 1 watershed with offline infiltration (retention) basin
BUFFER.CAS - 1 watershed with buffer strip

MORE COMPLEX EXAMPLES/TEMPLATES:
HIGHWAY.CAS - highway/swale simulation
MYHOUSE.CAS - rooftop drainage simulation using traced devices
DYPOND.CAS - peak flow simulation, extended detention pond
PONDSWAL.CAS - pond-->swale vs. swale-->pond comparison
BASEPOND.CAS - effect of baseflow on wet pond performance
RIVBAS.CAS - simulation of runoff & baseflow using aquifer device
TEST.CAS - illustrates each device type
SENSIT.CAS - used in sensitivity analysis (see program documentation)
SWEEP.CAS - effect of street-sweeping freq. on watershed loads
IMPACT.CAS - pre-development vs. post-development analysis - runoff only
IMPACT2.CAS - same as IMPACT.CAS; includes baseflow simulation

REAL WORLD:
ESM_U.CAS - emerald square mall - upper detention facility
ESM_L.CAS - emerald square mall - lower detention facility
TRACER.CAS - one tracer lane offline infiltration basin, wet pond
HUNT.CAS - hunt/potowomut watershed (daily streamflow simulation)

The four input files for particle characteristics provided on the distribution diskette are listed below. These input data have been calibrated the Nation-wide Urban Runoff Program (NURP; Athyade et al., 1983). In NOVICE mode, one of the following particle files (.PAR) must be specified. However, if sufficient site-specific data is available, particle characteristics may be entered or edited in the ADVANCED mode using the Case Edit Particles - 'CEP' command sequence.

SIMPLE.PAR	- one particle class (NURP 10% Settling Velocity)
NURP50.PAR	- calibrated to NURP median event-mean runoff concentrations
NURP90.PAR	- calibrated to NURP 90th percentile sites
BARESOIL.PAR	- NURP50.PAR with pervious runoff concs. increased to reflect bare soil conditions (e.g., construction sites)

Several precipitation files for the Providence NOAA station are included on the distribution diskette for convenience. In addition, the UTILITIES function in the P8 MENU allows the user to convert hourly precipitation data available on diskette for any NOAA weather station or period of record. Storm files (.STM) provided on the distribution diskette include:

PROV##.STM	(record for year specified ##, including:	
	## = 65, 81	dry years
	## = 74, 76, 80	average years
	## = 79, 83	wet years
	## = 87	others
PROV6987.STM	(complete record at Providence 1969-1987)	
TYPE2.STM	(one inch, 24 hour storm with SCS Type II distribution)- to approximate long-term TSS removal efficiency in Rhode Island, use this file with PASSES > = 5	
AVERAGE.STM	(.4 inch, 6 hour, 75 hour total interval)-typical for Northeast	

5.0 PROGRAM MECHANICS

The program is operated from a MENU, has two USER MODES, and provides on-line HELP documentation.

5.1 User Modes

The program runs in either of two USER MODES (NOVICE MODE or ADVANCED MODE), selected based upon the users level of experience. The NOVICE MODE provides access to the 43 basic program functions, while restricting access to functions which are supplementary to the primary operation of the model. While, the ADVANCED MODE provides access to all 132 of the program functions and options. New users may find the NOVICE MODE, with a limited number of option choices, less difficult to follow. At startup, the program is set to NOVICE MODE. To change to ADVANCED MODE (or to return to novice mode), press <Shift> and <F1> keys simultaneously from any location in the program menu. message will appear indicating the new mode. Press any key to continue.

5.2 Program Functions

The MENU, appearing in a blue box at the top of the computer screen, operates similar to a spreadsheet, and provides access to up to four tiers of program options or functions (Figure 3). The bottom portion of the MENU screen describes the current application or CASE. The primary menu options include:

CASE -	Enter/edit, read, list or save input data
RUN -	Execute model
LIST -	List output
PLOT -	Plot output (advanced mode only)
UTILITIES -	Supplementary functions (advanced mode only)
HELP -	Access on-line help screens
QUIT -	End session and return to DOS

Additional functions are provided in lower levels of the MENU for each of the primary options. Cursor arrows can be used to maneuver around the menu. However, a faster method is to enter the letter of the desired choice at each menu level (e.g., 'CEDI' - Case Edit Device Index). A description of the various program options are provided in Appendix A. A more detailed discussion of model input, output, and utilities is presented in section 6.0 of this document and the companion program documentation.

5.3 On-line Help Documentation

HELP SCREENS included in the program provide extensive on-line documentation for the program. These screens can be accessed by pressing the HELP KEY <F1> while in the main menu, data-entry screens, or output screens. HELP SCREENS are also accessible from the HELP selection in the main menu, or by running the independent utility 'help.exe' from DOS. These utilities permit the user to view help screens in groups, organized by topic, or to search the help file for all screens containing a user defined phase.

To view a help screen for any procedure in the main menu:
- Move the cursor to the desired procedure and press <F1>

To view a help screen for any output screen:
- Press <F1> in response to any hold screen <H> prompt which will appear in the lower left-hand corner of the screen

To view a any help screen or group of help screens from the main MENU:
- Select HELP option from top tier of MENU

To get help from any data entry screen:

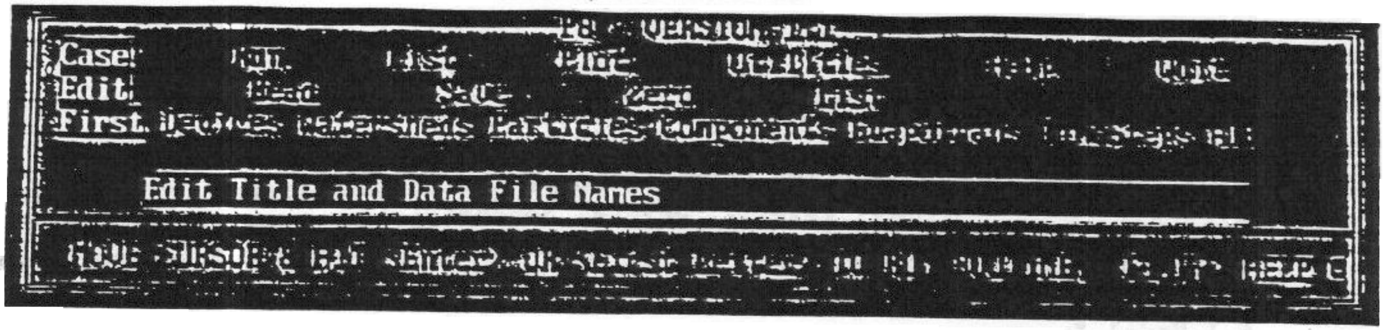
- <F1> = help for data entry screen
- <F7> = help for use of editor
- <F8> = help for current input field (cursor location)
- <F9> = help for any F8 function

To view help screens from DOS using 'help.exe':

- >help

FIGURE 3

P8 Main Menu Screen




```
CASE FILE             = DEFAULT.CAS
CASE TITLE            = P8 startup case
STORM FILE            = type2.stm
DATE RANGE            =        0 TO         0
AIR TEMP. FILE        = prov6988.tmp
PARTICLE FILE         = SIMPLE.PAR
WATERSHEDS            =           1
TREATMENT DEVICES     =           1
TRACED DEVICES        =           0
PARTICLE FRACTIONS    =           1
WATER QUALITY COMP    =           0
```

OUTPUT ROUTED TO: SCREEN

Menu Operation

Program MENU is a Tree with Up to 4 LEVELS and 10 CHOICES Per LEVEL.
Operation is similar to spreadsheet menus.

To Make a CHOICE at a given LEVEL:
Use Cursor Arrows to Find Desired Procedure
<LEFT> <RIGHT> <HOME> <END> to Move Around Current LEVEL
<ENTER> to Make CHOICE
or:
<First letter> to Jump Directly to CHOICE

Press <UP>,<ESC>, or <PgUp> to Move up One LEVEL.

Once a CHOICE is made, the following will occur:
If CHOICE is at End of Branch, Execute Corresponding Procedure.
else
Move Down one LEVEL to Next Set of CHOICES

Press <F1> to get HELP regarding a particular ITEM.
Press <F7> to display this screen.

6.0 MODEL OPERATION

This section provides a brief description of the command groups utilized to enter/edit data and view output. Several demonstration cases are provided in Appendix C, illustrating frequently used commands, data entry procedures, and output formats.

6.1 Model Inputs

The first step in defining and entering a new case is to compile the necessary input data for the watershed characteristics and device design specifications. The process is facilitated by first constructing a schematic diagram of the site which illustrates the linkage of watershed and treatment devices (similar to diagrams used in TR-20 applications) as illustrated in Figure 4. Data entry worksheets are provided in Appendix B to expedite the data collection and entry process. The screens which are used to enter or edit data are illustrated in the appendices of the P8 Urban Catchment Model Program Documentation. Data entry/editing is performed using the following commands:

CEF	Case Title & Storm File
CEDI	Device Index
CEDD	Device Data (Separate Screen for Each Device Type)
CEWI	Watershed Index
CEWD	Watershed Data (Separate Screen for Each Watershed)
CEE	Evapotranspiration Parameters
CET	Simulation Time Steps
CRP	Read Particle Characteristics file from disk
CEP	Particle Characteristics (ADVANCED USER MODE only)
CECF	Water Quality Components (ADVANCED USER MODE only)

General help screens are accessed by pressing <F1>. More detailed help on certain data input values (e.g., infiltration rates, Curve Numbers, Manning's n) are accessed by pressing <F8> when pointing to the input field on a date-entry screen. Lookup tables for infiltration rates, curve numbers and Manning's n, provided in the on-line help screens are printed at the end of this section for easy reference. Input data can be listed using the 'CLS' (= Case List Site) command, stored in a disk file using 'CSI' (= Case Save Inputs), and subsequently retrieved using 'CRA' (= Case Read All).

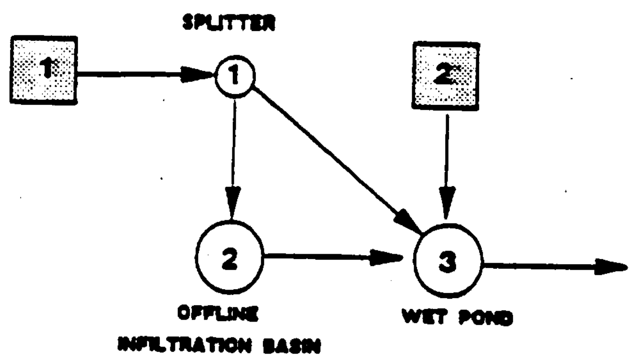
When the model is executed for a given set of input values and storm sequence, results are saved in a temporary disk file for subsequent use by listing and plotting routines. A "Model Executed" message appears on lower right screen. Output for a given run is available until input values are changed or a new case is read from the disk. Stored values normally include event total flows and loads for each device, particle class, and mass-balance term.

FIGURE 4

SCHEMATIC DIAGRAMS - P8 TEST CASES

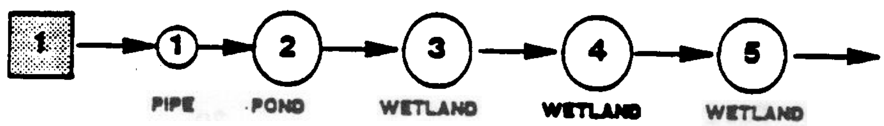
ONE TRACER LANE, LEXINGTON, MA

TRACER.CAS

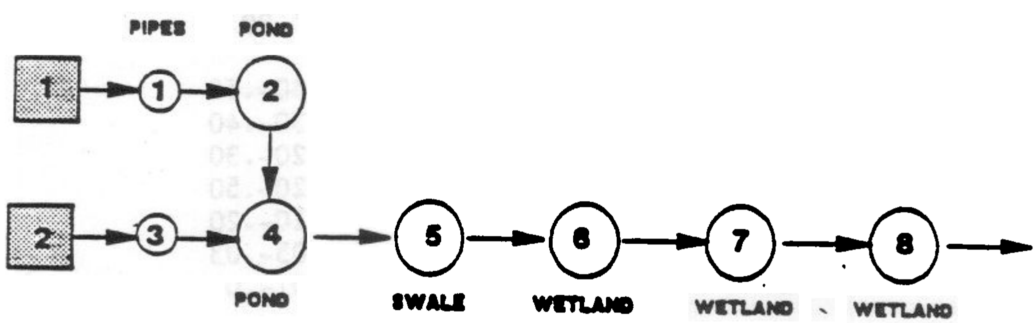


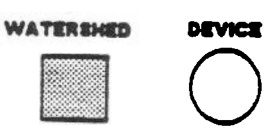
EMERALD SQUARE MALL, N. ATTLEBORO, MA

ESM_U.CAS



ESM_L.CAS





INFILTRATION RATE - LOOKUP TABLE

Infiltration Rates (in/hr)

References	(a)	(b)
SOIL TEXTURE		
Sand*	4.64	8.27
Loamy Sand*	1.18	2.41
Sandy Loam*	.43	1.02
Silt Loam	.26	.27
Loam	.13	.52
Sandy Clay Loam	.06	.17
Clay Loam	.04	.09
Silty Clay Loam	.04	.06
Sandy Clay	.03	.05
Silty Clay	.02	.04
Clay	.01	.02

SCS SOIL GROUP	(a)	(c)
A	.43	.30-.45
B	.26	.15-.30
C	.13	.05-.15
D	.03	.00-.05

SCS "Soil Survey Interpretations" provide data on infiltration rate (permeability) for specific soils.

* Yousef et al., (1986) recommend using infiltration rate of ~ 1 in/hr for designing retention basins in sandy and sandy loam soils.

MANNING'S N - LOOKUP TABLE

Cover Type	Manning's N	Source
Light Turf	.20	a
Dense Turf	.35	a
Forest w/Dense Undergrowth	.80	a
Dense Growth	.40-.50	d
Pasture	.30-.40	d
Lawns	.20-.30	d
Bluegrass Sod	.20-.50	d
Shortgrass Prairie	.10-.20	d
Sparse Vegetation	.05-.03	d
Bare Clay-Loam Soil	.01-.03	d

Sources: a - McCuen (1982); b - Shaver (1986); c - Musgrave (1985); d - Bedient and Huber (1988)

RUNOFF CURVE NUMBERS - LOOKUP TABLE

LAND USE	HYDROLOGIC CONDITION	Hydrologic Soil Group A	B	C	D
Grassed Areas	Good (>75% cover)	39	61	74	88
	Fair	49	69	79	84
	Poor (<50% cover)	68	79	86	89
Meadow or Idle Land	Good	38	58	71	78
Woods	Good (thick forest)	25	55	70	77
	Fair	36	60	73	79
	Poor (thin, no mulch)	45	66	77	83
Construction Sites	Newly graded Areas	81	89	93	96

* Lawns normally assumed to be in good hydrologic condition
Source: USDA, SCS (1977)

WATERSHED IMPERVIOUS FRACTIONS - LOOKUP TABLE

Impervious Fractions vs. GIS Land Use - Hunt Potowomut Watershed

GIS LAND USE	CODE/CATEGORY	EQUIVALENT	AVERAGE	RANGE
Residential	111 High Density	>8 Units/acre	.44	.32-.60
Residential	113 Medium Dens,	1-3, 9 Units/ac	.27	.29-.38
Residential	114 Med-Low Dens.	.5-.9 Units/ac	.25	.06-.79
Residential	115 Low Density	.2-.49 Units/ac	.14	.10-.18
Residential	116 Rural Density	<.2 Units/ac	.85	.03-.06
Commercial	128		.62	.44-.92
Industrial	131 Heavy		.81	.74-.93
Industrial	132 Medium		.77	.59-1.0
Transportation	141 Roads, Interch., Service		.41	.23-.60
Institutional	188 Educ., Health, Prisons, Milit.		.47	.30-.77

Impervious Fractions vs. Land Use Classifications (USDA, 1985)

Residential Areas

Lot Size (acres):	<=1/8	1/4	1/3	1/2	1
Impervious Fraction:	.65	.38	.38	.25	.20

Industrial Areas	.72
Commercial & Business	.85

6.2 Model Output

Once the input data have been entered for a given case, the model must be executed via the 'RM' (= 'Run Model') command. The sequence of storms is tracked on the screen until the simulation is completed. A red message 'MODEL EXECUTED' appears in the lower right corner of the menu screen to indicate that the simulation is complete. Simulation results are stored in disk files for later access by reporting and graphing routines. Tabular output are accessed using the following commands:

LBA	List water and mass balances by device and component
LR	List removal efficiencies by device and component
LT	List comparison of flow, loads, and concs. across devices
LV	List violation frequencies for event-mean concentrations
LP	List peak elevation and outflow ranges for each device
LS	List sediment accumulation rates by device
LM	List mean inflow or outflow concs. by device and component
LD	List detailed statistical summaries by device and component
LC	List continuity (mass-balance) check on simulation results

Tabular output may be displayed on the screen or routed to a disk file for subsequent printing or other use (see 'UO' = 'Utilities Output').

Graphic output (to screen only) is available in the following formats:

PE	Plot simulation results by event precip., flows, loads, concs., etc., in 5 formats: time series cumulative time series cumulative frequency distributions log normal frequency plots scatter plots
PM	Plot time series of monthly total precip., flows, or loads
PY	Plot time series of yearly total precip., flows, or loads
PT	Plot detailed time series of precipitation, elevation, volume, discharge, concentrations, or loads for specific devices.

Independent screen-dump utilities may be used to print screen displays. (See 'Help - Program - Printing Graphs' for a list of such utilities). Plot data may be dumped to disk in ASCII format convenient for input to spreadsheets or word processors (Press "d" when viewing graphic screen). Graphic routines have been developed primarily for use in model development and testing. They are accessible only in the **ADVANCED USER MODE**.

Some output procedures produce several series. In order to stop the output sequence and return to menu, press <Esc> when the <H> prompt occurs. In general, the <Esc> key (sometimes hit more than once) provides a quick route back to the program menu.

6.3 Other Functions and Utilities

Design Mode

The model can be used in a "design mode" to select and size devices appropriate for treating runoff from specified watershed(s). Step-by-step procedures for using the program in a design mode are provided in the Program Documentation and in Appendix C of this document.

One procedure ('RDL' = 'Run Design Lookup') selects and sizes a device to achieve ~70% or ~85% total suspended solids removal for one user-defined watershed. To use this routine, a valid case with at least one watershed and one device must be pre-defined. The program disk contains a catalogue of devices sized to achieve total suspended solids removal efficiencies of 70% and 85%, based upon simulation of Providence 1980 rainfall data.

The user specifies the watershed to be treated, the device prototype, and the location for the new device (overwrites any pre-defined device). This provides an "initial guess" of design requirements for a particular watershed, device type, and TSS removal objective.

Another procedure ('RDT' = 'Run Design Tune') tunes or rescales device(s) to achieve a user-defined removal efficiency for any particle class or water quality component. In order to use this procedure, the user must first define a case containing a preliminary design and execute it via the 'Run Model' command. User is prompted for list of devices to be rescaled, target particle class, and target removal efficiency. Rescaling options include areas, volumes, outlet capacities (detention ponds only). The model is run repeatedly using the specified storm sequence. Solutions are not always feasible. A maximum of 12 iterations is performed.

Trace Device

In order to save results for each time step, devices must be TRACED. Trace switches are set using the 'UT' = 'Utilities Trace' command (ADVANCED USER MODE). Tracing is not required unless plotting of within-event variation or daily-average values is desired. Since tracing consumes disk space and computer time, devices should be traced only when necessary.

Sensitivity Analysis

Another procedure ('RS' = 'Run Sensitivity') tests sensitivity of removal efficiency and device outflow concentration to each model input value. Each input value is increased by a fixed percentage (one at a time). The model is re-executed. Effects on removal efficiency and outflow concentration are tabulated. Tested inputs include watershed variables, device variables, particle parameters, and storm scale factors. The resultant percent removal and outflow concentration are reported for each variable charged during the sensitivity analysis. In addition, the relative change and percent change in both percent removal and concentration is reported for each input variable. The sensitivity coefficient is the percent increase in the output value relative to the percent change in the input variable (i.e., SENS = % increase in Y/% increase in X). This procedure is especially useful for obtaining perspectives on which model inputs have the greatest impact on model predictions, and are therefore most important to estimate accurately (Walker, 1982).

Calibration

When applying the P8 model to a large watershed application (e.g., the Hunt-Potowomut watershed), calibration of the model to predict measured daily flow time series is facilitated by the 'RC' (= 'Run Calibrate') command. This procedure compares predicted daily-mean outflow time series from a specified device with measured values contained in a disk file. The model must be executed beforehand ('RM' command), and the device used in the calibration must be traced in order to obtain daily output values ('UT' = 'Utilities Trace' command). The program merges observed and predicted daily flows by date. Moving averages are calculated at a user-defined interval. Observed and predicted time series are plotted and compared statistically. This procedure is not relevant to designing BMP's for individual developments. A detailed discussion of this function and its applications to the Hunt Potowomut watershed is provided in the P8 Urban Catchment Model Program Documentation.

To utilize this function, an AQUIFER is used to simulate baseflow, and a PIPE is used to collect surface runoff from the various watershed areas. The combined outflow from the AQUIFER and PIPE are routed to a second PIPE to obtain total outflow. Calibration is acccomplished through adjusting, time of concentrations, and other scaling factors, provided for various input variables.

Batch files

Batch files may be used to execute a number of cases in sequence. This information is accessed by 'Utilities Batch'- 'UB' in the ADVANCED MODE. The user also has the option of archiving or not archiving the model output. If the noarchive option is selected results will only be stored in a temporary disk file. This model utility is particularly useful when running a large number of cases or when it is desired to run several cases for one or more years. Batch . files may be created using any line editor with the case file name given in columns 0-31, and the desired storm file beginning on column 32. If no stormfile is specified, the storm file specified in the case file will be used.

Output Destination

The user may select to send the model output to the screen (default) or to a disk file. To send the output to a disk file use the 'Utilities Output File' - 'UOF' command. This option is only available in the ADVANCED mode

View

The 'Utilities View'- 'UV' command may be used to view any DOS text/ASCII file without exiting the P8 program.

NOAA

Additional storm files can be created by the user utilizing the 'Utilities NOAA'- 'UN' command in the ADVANCED mode. This function reads hourly precipitation data which can be purchased for any first order NOAA weather station in the US.

The National Climatic Data Center in Ashville, NC can provide hourly precipitation data on diskette for NOAA weather stations in the U.S.. Call 704-259-0682 to order. The cost is ~$90/station for the period of record (~33 yrs.). Request files in RELEASE B/CONDENSED FORMAT. Each file typically contains 5 years of data.

File names specified on this screen will be read and a single storm file (.STM) will be generated for subsequent use by P8. Use a text editor to break up the .STM file into separate years or other time frames. MINIMUM INTER-EVENT TIME (MIT) - wet hours within MIT hours of each other are considered part of the same "storm" (typically 3-10 hrs.). See Bedient and Huber (1986); Huber and Dikinson (1988). The Providence files supplied with the program were generated with an MIT value of 5 hours. Storm years in input files must be between 1942 and 1999. The NOAA input file must be "normal", containing no missing or otherwise obtuse records. This is usually not a problem (based upon experience with Providence and Boston data files).

6.4 Getting Started: Step-by-Step

The following are step-by-step instructions for creating, entering, and executing a new case. The reader is referred to Appendix B for data entry worksheets and Appendix C for example case runs.

1. Assemble reference materials for site (maps, engineering reports).

2. Construct schematic diagram illustrating downstream linkage of watersheds and devices.

3. Assign a name (<=8 characters) and number (1-24) to each watershed. Write these on your schematic.

4. Tabulate basic watershed characteristics needed for model input, as indicated on worksheets in Appendix B.

5. Assign a name (<=8 characters), number (1-24), and device type code (1-7) to each device. It is often convenient (but not necessary) to assign device numbers in downstream order. Write these on your schematic.

6. Tabulate basic device characteristics needed for model input, as indicated on worksheets in Appendix B.

7. Run program. Move to program directory on hard disk and enter 'P8'.

8. Review introductory help screens (to skip these, press <ESC>).

9. Clear existing data (Procedure = 'CZ' = 'Case Zero').

10. Enter site data (Procedure - 'CEA' - 'Case Edit All'). Refer to your schematic to identify device/watershed numbers and names.

11. Load desired particle file (Procedure = 'CRP' = 'Case Read Particles'); suggest using 'SIMPLE.PAR' and 'TYPE2.STM' in preliminary runs; this will speed computations.

12. Print a copy of the watershed/device network linkage for future reference; Procedure = 'CLN' - 'Case List Network'; hit 'Print Scrn' key at <H> prompt.

13. Save input case values on disk (Procedure = 'CSI' = Case Save Inputs').

14. Run simulation (Procedure = 'RM' = 'Run Model') etc.

6.5 Watershed Scale Applications

In order to utilize the P8 Model for watershed-scale applications, a similar procedure is used to that outlined in Section 6.4, but simply focusing on a larger scale. Watershed characteristics from (i.e., infiltrations rates, impervious areas, areas, etc.) are obtained from land use/land cover and soils information available in RIGIS. A lookup table has been provided on Page 13 to convert land usage into impervious areas for watershed-scale applications. Again, each subbasin of the watershed may be modeled as separate watersheds and linked by the PIPE and AQUIFER devices (see section 6.3 Calibration for additional details on linking watersheds to the AQUIFER and PIPE devices). The number of subwatersheds modeled is selected based upon the users knowledge of the overall watershed, and the variability of characteristics within the watershed. More complex modeling on the basin or watershed level which accounts for the attenuation of pollutants in wetlands and/or buffer zones is also possible. This would require routing the watershed runoff to the specific buffers or wetland areas, and having sufficient information regarding the characteristics of buffers or wetlands to supply model inputs for these treatment areas.

Again, as mentioned in Section 2.0 without calibration, "relative" predictions (i.e. % change) are more reliable than "absolute predictions" (concentration, flow, and load). Once the user has calibrated the model using data of suitable detail and quality, the model may be used to predict absolute changes of various land use scenarios with a known degree of certainty. Without such calibration, the model should only be utilized for relative predictions.

7.0 APPENDICES

APPENDIX A
Menu Structure

APPENDIX A
P8 Menu Structure

PROCEDURE	DESCRIPTION	HELP	MODE
Case	Define Case	180	0
Edit	Edit Case Variables	180	0
First	Edit Title, Data File Names, Storm File Names, Storm Dates	5	0
Devices	Edit Device Index or Data	70	0
Index	Edit Device Index (Device Labels & Types)	9	0
Data	Edit Device Data (Dimensions, Infiltration Rates, Slopes, etc.)	10	0
Watersheds	Edit Watershed Index or Data	40	0
Index	Edit Watershed Index (Watershed Labels & Outflow Devices)	7	0
Data	Edit Watershed Data (Area, Imperv. Frac., Curve Number, etc.)	8	0
Particles	Edit Particle Data (Runoff Conc., Settling Veloc., etc.)	4	1
Components	Edit Water Quality Components & Criteria	17	1
First	Edit First Group (Components 1 - 5)	17	1
Second	Edit Second Group (Components 6 - 10)	17	1
Evapotrans	Edit Evapotranspiration Factors	98	1
TimeSteps	Edit Time Step Lengths & Continuity Error Limit	18	1
All	Edit All Site Input Data Groups	19	0
Read	Read Input Data File	20	0
All	Read All Input Data Groups from a Disk File	20	0
Particles	Read Particle/Component Input Data Groups from Disk File	20	0
Save	Save Input Data File	22	0
Inputs	Save all Input Data Groups in a Disk File	22	0
Particles	Save Particle/Component Input Groups in a Disk File	22	1
Archive	Save All Input Data Groups and Output Files	22	1
Zero	Erase All Case Input Values	24	0
List	List Input Values for Current Case	1	0
Site	List Watershed & Device Input Data	1	0
Network	List Watershed / Device Network	1	0
Tables	List Device Morphometry & Outflow vs. Elevation Tables	33	0
Parameters	List Particle & Water Quality Component Input Data	1	0
Run	Run Model or Size Devices	180	0
Model	Run Model for Current Watershed/Device Network	25	0
Design	Select / Size Devices for Defined Watershed(s)	77	0
Lookup	Retrieve Preliminary Designs for One Device	78	0
70%	Retrieve a Device to Achieve TSS Removal = 70%	78	0
85%	Retrieve a Device to Achieve TSS Removal = 85%	78	0
Tune	Rescale Device(s) to Achieve Target Removal Efficiency	79	0
One	Target Removal Efficiency for One Device	79	0
All	Target Removal Efficiency for Entire Device Network	79	0
Sensitivity	Run Sensitivity Analysis on Model Input Variables	89	1
Watersheds	Run Sensitivity Analysis on Watershed Input Variables	89	1
Devices	Run Sensitivity Analysis on Device Input Variables	89	1
Both	Run Sensitivity Analysis on Watershed & Device Inputs	89	1
Particles	Run Sensitivity Analysis on Particle Parameters	89	1
All	Run Sensitivity Analysis on All Input Variables	89	1
Calibrate	Run Flow Calibration - Compare Observed & Predicted Flows	97	1
List	List Model Output (Must Run Model First)	23	0
Balances	Water & Mass Balances by Device & Component	27	0
All	Water & Mass Balances for All Storms	27	0
Each	Water & Mass Balances for Each Storm Separately	27	1
Removals	List Removal Efficiencies (%) by Device & Component	29	0
Terms	List/Plot Flow & Mass-Balance Terms by Device & Component	90	0
Outflow	List/Plot Device Total Outflows (Infilt.+Normal+Spillway)	90	0
Surface	List/Plot Device Surface Outflows (Normal + Spillway)	90	0
Inflow	List/Plot Device Total Inflows	90	0
Any	List/Plot Any Mass-Balance Term	90	0
Violations	Violation Frequencies for Event-Mean Concentrations	28	1
Outflow	Violation Frequencies for Total Outflow Concentrations	28	1
Surface	Violation Frequencies for Surface Outflow Concentrations	28	1
Inflow	Violation Frequencies for Total Inflow Concentrations	28	1
Any	Violation Frequencies for Any Mass-Balance Term	28	1
Peaks	List Maximum Elevations, Outflows, and Velocities by Device	81	0
Sedim	List Sediment Accumulation Rates by Device	37	0
Means	List Flow-Weighted-Mean Concentrations Device & Component	21	1
Inflow	List Flow-Weighted-Mean Inflow Concentrations	21	1
Outflow	List Flow-Weighted-Mean Total Outflow Concentrations	21	1
Surface	List Flow-Weighted-Mean Surface Outflow Concentrations	21	1
Any	List Flow-Weighted-Mean Concs for Any Mass-Balance Term	21	1

P8 Menu Structure (ct.)

PROCEDURE	DESCRIPTION	HELP	MODE
Detail	Detailed Statistical Summaries of Simulation Results	30	1
Flows	Summarize Event-Total Flows (acre-ft)	30	1
Loads	Summarize Event-Mean Loads (lbs)	30	1
Concs	Summarize Event-Mean Concentrations (ppm)	30	1
Precip	Summarize Event-Mean Precipitation (inches)	30	1
Traced	Detailed Output Statistics by Time Step for Traced Devices	31	1
Continuity	List Continuity (Water-Balance & Mass-Balance) Errors	32	1
Plot	Plot Simulation Results (Must Run Model First)	188	1
Events	Plot Event Summary Values	71	1
Timeser	Plot Event Time Series	71	1
Volumes	Plot Event Total Flow Volume (ac-ft) vs. Time (Julian Day)	71	1
Loads	Plot Event Total Loads (lbs) vs. Time (Julian Day)	71	1
Concs	Plot Event Mean Concentrations (ppm) vs. Time (Julian Day)	71	1
Precip	Plot Event Total Precipitation (inches) vs. Time (Julian Day)	71	1
Elev	Plot Event Maximum Elevations (ft) vs. Time (Julian Day)	71	1
Flows	Plot Event Maximum Flows (cfs) vs. Time (Julian Day)	71	1
Other	Plot Other Storm Values vs. Time (Julian Day)	71	1
Cumulatives	Plot Event Cumulative Totals vs. Time (Julian Day)	72	1
Flows	Plot Cumulative Flows (ac-ft) vs. Time (Julian Day)	72	1
Loads	Plot Cumulative Loads (lbs) vs. Time (Julian Day)	72	1
Precip	Plot Cumulative Precip. (inches) vs. Time (Julian Day)	72	1
Frequency	Plot Cumulative Frequency Distributions of Event Values	73	1
LogNormal	Plot Frequency Distributions of Event Values - Lognormal Scale	74	1
Scatter	Scatter Plots for Event-Mean Values	75	1
1CvsQ	Plot Event-Mean Concentration (ppm) vs. Event-Mean Flow (cfs)	75	1
2CvsP	Plot Event-Mean Concentration (ppm) vs. Event Total Precip (in)	75	1
3CvsI	Plot Event-Mean Concentration (ppm) vs. Precip Intens (in/hr)	75	1
4Other	Scatter Plot of Other Variables	75	1
Yearly	Plot Yearly Total Flows, Loads, or Precip. vs. Year	99	1
Flows	Plot Yearly Total Flows (ac-ft) vs. Year	99	1
Loads	Plot Yearly Total Loads (lbs) vs. Year	99	1
Precip	Plot Yearly Total Precipitation (inches) vs. Year	99	1
Monthly	Plot Monthly Total Flows, Loads, or Precip. vs. Date	99	1
Flows	Plot Monthly Total Flows (ac-ft) vs. Date	99	1
Loads	Plot Monthly Total Loads (lbs) vs. Date	99	1
Precip	Plot Monthly Total Precipitation (inches) vs. Date	99	1
Daily	Plot Daily-Average Time Series - for Traced Devices Only	34	1
Precip	Plot Daily Avg. Precipitation Intensity (in/hr) vs. Julian Day	34	1
Elevations	Plot Daily Avg. Device Elevations (ft) vs. Julian Day	34	1
Volumes	Plot Daily Avg. Storage Volumes (ac-ft) vs. Julian Day	34	1
Flows	Plot Daily Average Surface Outflows (cfs) vs. Julian Day	34	1
Traced	Plot Time-Step Results for Traced Devices	35	1
Precip	Plot Precipitation Intensity (in/hr) vs. Julian Hours	35	1
Elevations	Plot Device Elevations (ft) vs. Julian Hours	35	1
Volumes	Plot Device Storage Volumes (ac-ft) vs. Julian Hours	35	1
Flows	Plot Device Surface Outflows (cfs) vs. Julian Hours	35	1
Concs	Plot Surface Outflow Concentrations (ppm) vs. Julian Hours	35	1
Loads	Plot Surface Outflow Loads (lbs/hr) vs. Julian Hours	35	1
Utilities	Program Utilities	180	1
Output	Select Destination for Program Output	194	1
Screen	Send Output to Screen (Default)	194	1
File	Send Output to Disk File	194	1
Trace	Select Devices to be Traced - Save Time-Step Results	38	1
Some	Trace Simulation Results for Specific Devices	38	1
None	Do Not Trace Results (Default)	38	1
All	Trace All Devices (Careful !! - Ample Disk Space Required)	38	1
View	View any DOS Text/ASCII File	186	1
NOAA	Translate NOAA/NCDC Hourly Precipitation File	43	1
Batch	Batch Processing - Run Model for List of Cases	76	1
NoArchive	Batch - Do Not Archive Results	76	1
Archive	Batch - Archive Results - Save Output for Future Analysis	76	1
Help	View Supplementary Help Screens	195	0
Quit	End Session	180	0

USER MODES <SHIFT><F1>: 0=NOVICE, 1=ADVANCED, HELP: Screen Numbers Listed in Appendix D

APPENDIX B
Data Entry Worksheets

P8 URBAN CATCHMENT MODEL
DATA ENTRY WORKSHEET

CASE EDIT WATERSHEDS INDEX (define list of watersheds for simulation; 8 character watershed label, and downstream discharge location)

NO.	LABEL*	OUTFLOW DEVICE$	NO.	LABEL*	OUTFLOW DEVICE$	NO.	LABEL*	OUTFLOW DEVICE$
1	________	____	9	________	____	17	________	____
2	________	____	10	________	____	18	________	____
3	________	____	11	________	____	19	________	____
4	________	____	12	________	____	20	________	____
5	________	____	13	________	____	21	________	____
6	________	____	14	________	____	22	________	____
7	________	____	15	________	____	23	________	____
8	________	____	16	________	____	24	________	____

CASE EDIT WATERSHEDS DATA (specify watershed specific data)

Watershed Number (as specified in watershed index): ____*
Watershed Label (as specified in watershed index): ________*

Outflow device number (downstream surface water device sequence): _____$
Aquifer Device Number (down gradient movement to aquifer): ______$

Total Area (acres): ______$
Impervious Fraction (impervious area/total area): _____$

Depression Storage (inches): ______@
Sweeping Frequency (times/week, if applicable): ___$

Pervious Curve Number (based on hydrologic soils group): _____@

Scale Factor for Pollutant Load (default value = 1): ___+

P8 URBAN CATCHMENT MODEL
DATA ENTRY WORKSHEET

Notes:

1) Data inputs denoted with an "*" are user defined inputs (labels, notes, filenames)
2) Data inputs denoted with a "$" should be available from drainage plan (hydrologic sequence, watershed and device characteristics)
3) Data inputs denoted with "@" should be taken from look up tables provided on the model help screens or from other available sources
4) Data inputs denoted by a number in parentheses (#) are selected from available computer disk files.
5) Data inputs denoted by "+" Use default values unless more detailed site-specific information is available.

CASE EDIT FIRST (title, file names, user reference notes)

Case Title (Label): ______________________________ *
Case Data File (Filename.cas): ____________________ *
Storm Data File (Filename.stm): ____________________ (1)

Notes (User reference about case): _________________ *

Site Schematic Diagram:

CASE EDIT DEVICE INDEX (define list of treatment devices for simulation)

NO.	LABEL*	TYPE$	NO.	LABEL*	TYPE$	NO.	LABEL*	TYPE$
1	______	___	9	______	___	17	______	___
2	______	___	10	______	___	18	______	___
3	______	___	11	______	___	19	______	___
4	______	___	12	______	___	20	______	___
5	______	___	13	______	___	21	______	___
6	______	___	14	______	___	22	______	___
7	______	___	15	______	___	23	______	___
8	______	___	16	______	___	24	______	___

1=detention pond 2=infiltration basin 3=svale/buffer 4=general
5=pipe/manhole 6=splitter 7=aquifer

P8 URBAN CATCHMENT MODEL
DATA ENTRY WORKSHEET

CASE EDIT DEVICE DATA - DETENTION POND

Device No. (specified in device index): ____*
Label (specified in device index): _________*
Bottom Elevation (feet; for reference only): ________$

	Area (acres)	Volume (ac-ft)
Pond Bottom	___________	____________$
Permanent Pool	___________	____________$
Flood Pool	___________	____________$

Infiltration Rate (in/hr; flood pool only): _______@

Normal Outlet (specify only one)$:

Flood Pool Drawdown Time (hours): ______

Outlet orifice diameter (inches): ______

Outlet weir length (feet): ______

Riser Height (feet): _____ Holes (#): ____ Hole diameter (inches): ____

Outlet Device Numbers (downstream flow direction):$
Normal Outlet: ______
Spillway: _____
Infiltration: ______

To direct flow out of system set device number to "0" or to other device number listed in device index.

P8 URBAN CATCHMENT MODEL
DATA ENTRY WORKSHEET

CASE EDIT DEVICE DATA - INFILTRATION BASIN

Device Number (specified in Device index): __*
Device Label (specified in device index): ___*

Bottom Elevation (feet): _______$
Bottom Area (acres): _______$
Storage Pool Area (acres): _______$
Storage Pool Volume (acre-ft): ________$

Void Volume Percent (%; default = 100): _____+

Infiltration Rate (inches/hour): ________@

Outflow Device Numbers:
Overflow: _____$
Exfiltrate: _____$

CASE EDIT DEVICE DATA - SWALE/BUFFER STRIP

Device Number: ____*
Device Label: _____*

Bottom Elevation (feet): _______$
Flow Path Length (feet): _______$
Flow Path Slope (%): _______$

Bottom Width (feet): _______$
Side Slopes (ft-h/ft-v): _______$

Maximum Depth (feet): ______$
Manning's N: ______@
Infiltration Rate (in/hr): _____@

Outflow Device Numbers:
Overflow: _________$
Exfiltrate: _____$

To direct flow out of system set device number to "0" or to other device number listed in device index.

P8 URBAN CATCHMENT MODEL
DATA ENTRY WORKSHEET

CASE EDIT DEVICE DATA - PIPE/MANHOLE

Device Number: ____*
Device Label: ________*

Time of Concentration (hrs; default = 0): ____________+

Outflow Device Number: _____$

CASE EDIT DEVICE DATA - FLOW SPLITTER

Device Number: ____*
Device Label: ________*

Outflow to Device: _________$ If Surface Elev. < ________ Feet

Otherwise, outflow to alternative device: ________

Time of Concentration (hrs; default = 0): ____________+

CASE EDIT DEVICE DATA - AQUIFER

Device Number: ____*
Device Label: ________*

Outflow Device Number: _____$

Time of Concentration (hrs; default = 0): ____________+

To direct flow out of system set device number to "0" or to other device number listed in device index.

CASE EDIT DEVICE DATA - **GENERALIZED DEVICE**

-Defines elevation, area, discharge table for device with up to three outlets; similar input is required for hydrologic models (i.e., TR-20)

Device No. (specified in device index): ________*
Label (specified in device index): ____________*

	INFILTR.	NORMAL OUTLET	SPILLWAY
OUTFLOW DEVICE NUMBERS	______	______	______$

ELEVATION feet$	AREA acres$	OUTFLOW RATES cfs$		
______	___ ______	______	______	
______	___ ______	______	______	
______	___ ______	______	______	
______	___ ______	______	______	
______	___ ______	______	______	
______	___ ______	______	______	
______	___ ______	______	______	
______	___ ______	______	______	
______	___ ______	______	______	
______	___ ______	______	______	
______	___ ______	______	______	
______	___ ______	______	______	

To direct flow out of system set device number to "0" or to other device number listed in device index.

APPENDIX C
Example Case Applications

This appendix provides several demonstration examples illustrating typical model applications. General instructions for running sample cases, entering new cases, and designing Site BMPs is provided in Appendix E of the Program Documentation (Walker, 1990). A case scenario and command sequence is provided for each example, followed by the MENU screen, data entry screens, and model output. The example scenarios include:

CASE 1) Running a sample case (one device-one watershed)
CASE 2) Evaluate proposed BMP design for residential development
CASE 3) Lookup an extended wetpond design for a given watershed

CASE 1: RUNNING A SAMPLE CASE

Scenario: This example illustrates the basic model functions (CASE, RUN, LIST) using the BUFFER.CAS sample case file provided on the distribution diskette.

Command Sequence:

1) Load Case File:
   - Select 'Case Read All'- CRA **
   - Press return for listing of disk case files (use cursor arrows to select file, press return) or Press <ESC> to enter filename and path directly.
   - The Hold Screen prompt <H> will appear when file is loaded; press any key to continue or <F1> for help.

2) View the input data:
   - Select 'Case List Site' - CLS
   - Press any key to view next screen at <H>; program will return to MENU after passing through all screens; press escape to go back to main MENU at any point.

3) Execute model:
   - Select 'Run Model' - RM (WAIT - will flash in the upper right corner of the screen while model is running)
   - Press any key at <H> to return to MENU

4) List percent pollutant removal:
   - Select 'List Removals' - LR

** This procedure may be used to read any case file from the disk

P8 - VERSION 1.1

Case	Run	List	Plot	Utilities	Help	Quit
Edit	Read	Save	Zero	List		
Site	Network	Tables	Areas	Parameters		

List Watershed & Device Input Data

MOVE CURSOR & HIT <Enter> OR <First Letter> TO RUN ROUTINE, <F1,F7> HELP

```
CASE FILE             = BUFFER.CAS
CASE TITLE            = buffer strip
STORM FILE            = prov87.stm
DATE RANGE            =     870201 TO      870601
AIR TEMP. FILE        = prov6988.tmp
PARTICLE FILE         = NURP50.PAR
WATERSHEDS            =          1
TREATMENT DEVICES     =          1
TRACED DEVICES        =          0
PARTICLE FRACTIONS    =          5
WATER QUALITY COMP    =          7
```

OUTPUT ROUTED TO: SCREEN

```
watershed        =  1  watershd
surface runoff device =  1  buffer
percolation device    =  0

watershed area                       acres      =    100.000
impervious fraction                             =       .250
impervious depression storage     inches        =       .020
scs curve number (pervious portion)             =     74.000
sweeping frequency              times/week      =       .000
water quality load factor             -         =      1.000
```

```
device =  1  buffer  ,  type  =  3  buffer

bottom elevation        feet      =      .000
length of flow path     feet      =   294.248
slope of flow path       %        =     2.000
bottom width            feet      =   500.000
side slope           ft-h/ft-v    =     1.000
maximum flow depth      feet      =      .100
infiltration rate      in/hr      =   .500000
mannings n               -        =      .400
particle removal scale factor =         1.000

exfiltrate routed to device        0   OUT
normal outlet routed to device     0   OUT
```

<H>

removal efficiencies (%) vs. device and particle class

device	1 P0%	2 P10%	3 P30%	4 P50%	5 P80%
1 buffer	49.4	68.7	86.5	95.3	99.4
25 OVERALL	49.4	68.7	86.5	95.3	99.4

removal efficiencies (%) vs. device and water quality component

device	tss	tp	tkn	cu	pb	zn	hc
1 buffer	89.9	70.9	67.3	67.3	84.5	67.3	84.5
25 OVERALL	89.9	70.9	67.3	67.3	84.5	67.3	84.5

<H>

SELECT PARTICLE CLASSES / WQ COMPONENTS

VARIABLE
P0%
P10%
P30%
P50%
P80%
* tss
tp
tkn
cu
pb
zn
hc

PRESS <SPACE> TO SELECT(*) OR NO( ), <ENTER>=DONE, <a>= ALL, <n>=NONE

number of storms = 31
interval = 2864. hrs, storm duration = 319. hrs, precip = 14.72 inches
device = 1 buffer , type = buffer , variable = tss

mass-balance term	flow acre-ft	load lbs	conc ppm
01 watershed inflows	38.71	7746.24	73.6215
03 infiltrate	20.87	762.66	13.4440
04 exfiltrate	20.87	.00	.0000
05 filtered	.00	762.66	.0000
06 normal outlet	13.84	522.99	13.8987
07 spillway outlet	3.76	261.79	25.6404
08 sedimen + decay	.00	6197.47	.0000
09 total inflow	38.71	7746.24	73.6215
10 surface outflow	17.60	784.78	16.4046
11 groundw outflow	20.87	.00	.0000
12 total outflow	38.47	784.78	7.5050
13 total trapped	.00	6960.12	
14 storage increase	.00	1.33	
15 mass balance check	.24	.00	

load removal efficiency = 89.85 %, adjusted = 89.85 %
continuity errors: volume = .62 %, load = .00 %
<H>

CASE 2: SITE PLAN/BMP EVALUATION

Scenario: A residential development is proposed adjacent to a recreational lake. You have been provided with a site plan and preliminary design specifications for wet pond to treat the stormwater runoff leaving the site. Approximately 235 acres of the parcel drain to the lake via 4 existing drainage swales. The dominant hydrologic soil group on the site is Class B with grass cover in fair condition. The 235 acre parcel has been divided into four subcatchment areas, each with a wet pond designed to with a capacity equal to the volume of runoff from the mean storm of 0.4 inches. The following table has been provided by the site engineer:

			BASIN	
Subcatchment #	Drainage Area (ac)	Imperv. Area (ac)	Volume (ac-ft)	Area (ac)
1	32.7	10.3	0.46	0.23
2	54.8	14.3	0.64	0.32
3	71.0	22.5	1.41	0.40
4	76.8	17.8	1.10	0.31

You would like to evaluate the preliminary pond sizing for each subcatchment to determine if the 85% removal criteria for Total Suspended Solids (TSS) will be met.

Command Sequence:

1) Compile case data:
   - Draw Schematic diagram of the system
   - Complete data entry worksheets as necessary

2) Create new case file:
   - 'Case Edit All' - CEA (enter data for all data entry screens)
   - 'Case Read Particles' - CRP (read desired particle characteristic file)

3) Save input data:
   - 'Case Save Input' - CSI (saves input data to disk file name specified in first data entry screen)

4) Execute Model:
   - 'Run Model' - RM

5) View Results:
   - 'List Removal' - LR (lists percent removal for each subcatchment device)

   Note: 85% TSS Removal criteria not met; request proponent to redesign or resizing of treatment systems to achieve removal target. The 'Run Design Tune' - RDT function of P8 may be used to provide an initial re-scaling to the pond area and volume or the outlet configuration necessary to meet the 85% TSS removal (The Type 2 or Average storm file should be used for this operation).

```
P8 - VERSION 1.1
 Case      Run      List      Plot      Utilities      Help      Quit
 Edit      Read      Save      Zero      List

      Define Case

 MOVE CURSOR & HIT <Enter> OR <First Letter> TO RUN ROUTINE, <F1,F7> HELP
```

```
CASE FILE            = CASE_2.CAS
CASE TITLE           = CASE 2 BMP EVALUATION
STORM FILE           = PROV6987.STM
DATE RANGE           =     800101 TO      801231
AIR TEMP. FILE       = prov6988.tmp
PARTICLE FILE        = NURP50.PAR
WATERSHEDS           =           4
TREATMENT DEVICES    =           4
TRACED DEVICES       =           0
PARTICLE FRACTIONS   =           5
WATER QUALITY COMP   =           7
STORMS =  109, PRECIP =   36.11, DURATION =   602., INTERVAL =   8704.

OUTPUT ROUTED TO: SCREEN                                  MODEL EXECUTED
```

```
                         WATERSHED DATA
WATERSHED NUMBER                                       1
WATERSHED LABEL                                   BASIN1

OUTFLOW DEVICE NUMBER                                  1 <-- for surface runoff

AQUIFER DEVICE NUMBER                                  0 <-- for percolation

TOTAL AREA                       acres    32.7
IMPERVIOUS FRACTION                -      .31
DEPRESSION STORAGE              inches    .02
SWEEPING FREQUENCY              1/week    0
PERVIOUS CURVE NUMBER              -      69

SCALE FACTOR FOR POLLUTANT LOADS 1
```

```
        watershed label

F1=HELP,  F2=DONE/SAVE,  F3=EDIT FIELD,  F7=HELP/EDITOR,  <ESC>=ABORT
```

```
                          DETENTION POND
DEVICE NO.    1    LABEL POND1      BOTTOM ELEV feet 0

                   SURFACE          STORAGE          INFILTRATION
                   AREA (acres)     VOLUME (ac-ft)   RATE (in/hr)
POND BOTTOM          .170605
PERMANENT POOL       .227474           .454948            0
FLOOD POOL           0                 0                  0

NORMAL OUTLET - DRAINS FLOOD POOL - SPECIFY ONLY ONE TYPE:
ORIFICE DIAMETER inches  0          ORIF DISCHARGE COEF .6
WEIR LENGTH             feet  0     WEIR DISCHARGE COEF 3.3
RISER HEIGHT   ft 0      HOLES 0    HOLE DIAMETER inches 0
FLOOD POOL DRAWDOWN TIME hours 0

PARTICLE REMOVAL SCALE FACTOR: 1       ~1.0

OUTFLOW DEVICE NO'S:   INFILTR    0  NORMAL    0  OVERFLOW    0
```

```
        device label

F1=HELP,  F2=DONE/SAVE,  F3=EDIT FIELD,  F7=HELP/EDITOR,  <ESC>=ABORT
```

removal efficiencies (%) vs. device and particle class

device	1 P0%	2 P10%	3 P30%	4 P50%	5 P80%
1 POND1	.0	39.0	56.4	75.0	95.1
2 POND2	.0	38.0	55.1	73.7	94.7
3 POND3	.0	40.7	58.9	74.2	94.2
4 POND4	.0	38.7	56.3	71.6	93.1
25 OVERALL	.0	39.3	56.9	73.5	94.1

removal efficiencies (%) vs. device and water quality component

device	tss	tp	tkn	cu	pb	zn	hc
1 POND1	72.1	40.4	34.8	34.8	65.3	34.8	65.3
2 POND2	71.2	39.4	33.9	33.9	64.4	33.9	64.4
3 POND3	72.4	41.3	35.6	35.6	65.6	35.6	65.6
4 POND4	70.6	39.2	33.7	33.7	63.7	33.7	63.7
25 OVERALL	71.6	40.2	34.6	34.6	64.7	34.6	64.7

<H>

number of storms = 109
interval = 8704. hrs, storm duration = 602. hrs, precip = 36.11 inches
device = 1 POND1 , type = pond , variable = tss

mass-balance term	flow acre-ft	load lbs	conc ppm
01 watershed inflows	33.68	9691.54	105.8604
07 spillway outlet	33.68	2698.00	29.4702
08 sedimen + decay	.00	6988.07	.0000
09 total inflow	33.68	9691.54	105.8604
10 surface outflow	33.68	2698.00	29.4702
12 total outflow	33.68	2698.00	29.4702
13 total trapped	.00	6988.07	
14 storage increase	.00	5.45	
15 mass balance check	.00	.00	

load removal efficiency = 72.10 %, adjusted = 72.10 %
continuity errors: volume = .00 %, load = .00 %

<H>

CASE 3: DESIGN BMP FOR A SITE

Scenario: You have a residential development planned on a 100 acre parcel. The down gradient site boundary follows a small Class A stream. The predominant hydrologic soil group falls into Class C, with good condition grass cover. The proposed development will result in an impervious area of 25 acres. You would like to design an extended detention pond to treat the storm water runoff. Because the stream is of high quality (Class A), you would like to achieve a minimum of 85% percent removal of suspended solids under worst case conditions.

Command Sequence:

1) Enter case file information:
   - 'Case Edit First' - CEF
     Storm File: TYPE2.STM
     Passes: 5
   - 'Case Read Particle' - CRP
     Particle File: NURP90.PAR

2) Enter watershed data:
   - 'Case Edit Watershed Data' - CEWD
     Total Area: 100 acres
     Impervious Fraction: 0.25
     Depression Storage: 0.02
     SCS Curve Number: 74

3) Look up a design:
   'Run Design Lookup 85%' - RDL8 (select a dry pond with a 48 hour drawdown time, 3.5 ft depth).

   Note: Model will overwrite any existing design specification

4) Execute Model
   - 'Run Model' - RM

5) View results:
   - 'List Removal' - LR

6) Verify removal efficiency using continuous storm series:
   - 'Case Edit First' - CEF (Change to design storm file: PROV80.STM)
   - 'Run Model' - RM
   - 'List Removals' - LR

P8 - VERSION 1.1

Case Run List Plot Utilities Help Quit

Edit Read Save Zero List

Define Case

MOVE CURSOR & HIT <Enter> OR <First Letter> TO RUN ROUTINE, <F1,F7> HELP

CASE FILE	=	CASE_3.CAS
CASE TITLE	=	CASE 3: DESIGN A BMP
STORM FILE	=	type2.stm
DATE RANGE	=	0 TO 0
AIR TEMP. FILE	=	prov6988.tmp
PARTICLE FILE	=	NURP90.PAR
WATERSHEDS	=	1
TREATMENT DEVICES	=	1
TRACED DEVICES	=	0
PARTICLE FRACTIONS	=	5
WATER QUALITY COMP	=	7

OUTPUT ROUTED TO: SCREEN

WATERSHED DATA

WATERSHED NUMBER		1
WATERSHED LABEL		watersh
OUTFLOW DEVICE NUMBER		1 <-- for surface runoff
AQUIFER DEVICE NUMBER		0 <-- for percolation
TOTAL AREA	acres	100
IMPERVIOUS FRACTION	-	.25
DEPRESSION STORAGE	inches	.02
SWEEPING FREQUENCY	1/week	0
PERVIOUS CURVE NUMBER	-	74
SCALE FACTOR FOR POLLUTANT LOADS		1

watershed label

F1=HELP, F2=DONE/SAVE, F3=EDIT FIELD, F7=HELP/EDITOR, <ESC>=ABORT

PRESS <ESC> TO STOP SIMULATION
CASE TITLE = CASE 3: DESIGN A BMP
CASE FILE = CASE_3.CAS
STORM FILE = PROV6987.STM
KEEP STORM DATES: 800101 ---> 801231

DEVICES = 1
WATERSHEDS = 1

PASS = 1/ 1 STORM = 109 DATE = 801229
PRECIP = .45 DURATION = 11 INTERVAL = 75
KEEP = 1

warning: device overflow: 1 dry pond, storm = 16

RUN TIME = 3.229 MINUTES. = 3.212 MINUTES/DEVICE/YEAR
calculating totals over all storms...
<H>

removal efficiencies (%) vs. device and particle class

	1	2	3	4	5
device	P0%	P10%	P30%	P50%	P80%
1 dry pond	.0	46.8	84.1	95.3	99.4
25 OVERALL	.0	46.8	84.1	95.3	99.4

removal efficiencies (%) vs. device and water quality component

device	tss	tp	tkn	cu	pb	zn	hc
1 dry pond	85.0	53.3	45.9	45.9	76.8	45.9	76.8
25 OVERALL	85.0	53.3	45.9	45.9	76.8	45.9	76.8

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APPENDIX D

Help Screen Index

Titles to help screens provided with the program are listed below. These titles are indexed numerically, but are otherwise in no particular order. These screens are accessed through the main program (<F1>, <F8> keys) or through the independent utility 'HELP.EXE' provided with the program. This program can be used to search the entire help data base for any user-defined phrase. For additional details, see USER's MANUAL.

1 'Case List'
2 Particle Removal Scale Factor
3 Orifice & Weir Coefficients
4 'Case Edit Particles' - Define Particle Characteristics
5 'Case Edit First'
6 Storm Data File Format
7 'Case Edit Watersheds Index'
8 'Case Edit Watersheds Data'
9 'Case Edit Devices Index'
10 'Case Edit Devices Data'
11 'Case Edit Devices Data' - Detention Pond (TYPE = 1)
12 'Case Edit Devices Data' - Infiltration Basin (TYPE = 2)
13 'Case Edit Devices Data' - Swale/Buffer (TYPE = 3)
14 'Case Edit Device Data' - General Device (TYPE = 4)
15 'Case Edit Device Data' - Pipe (TYPE = 5)
16 'Case Edit Device Data' - Flow Splitter (TYPE = 6)
17 'Case Edit Components'
18 'Case Edit TimeSteps'
19 'Case Edit Data All'
20 'Case Read'
21 'List Means'
22 'Case Save'
23 'List'
24 'Case Zero'
25 'Run Model'
26 Run Times
27 'List Balances'
28 'List Violations'
29 'List Removals'
30 'List Detail'
31 'List Detail Traced'
32 'List Continuity'
33 'Case List Tables'
34 'Plot Daily'
35 'Case Edit Device Data' - Aquifer (TYPE = 7)
36 'Plot Traced'
37 'List Sedim'
38 'Utilities Trace'
39 Simulation Methods - Device Concentrations (ct.)
40 'Case Edit Watersheds'
42 Simulation Methods - Device Flows (ct.)
43 'Utilities NOAA'
44 Simulation Methods - Watershed Runoff
45 Simulation Methods - Watershed Loadings
46 Simulation Methods - Buildup and Washoff
47 Simulation Methods - Device Flows
48 Simulation Methods - Device Concentrations
49 Device Outlets
50 Warning: Device Overflow
51 Run Times vs. Hardware
52 File Errors
53 Device Elevations
54 Time of Concentration
55 Illegal Device Linkage
56 Computer System Requirements
57 Mass Balance Terms 01-05
58 Mass Balance Terms 06-12
59 Mass Balance Terms 13-15
60 Mass Balance Equations
61 Particle/Component Files
62 Air Temperature Files
63 Storm Data Files

Help Screen Index (ct.)

P8 URBAN CATCHMENT MODEL

INTRODUCTION

P8 is a model for predicting the generation & transport of storm-water runoff pollutants in small urban catchments.

Continuous water-balance and mass-balance calculations on a user-defined system consisting of up to:

—> 24 WATERSHEDS

—> 24 TREATMENT DEVICES "BMP's"

—> 5 PARTICLE CLASSES

—> 10 WATER QUALITY COMPONENTS

Simulations are driven by hourly rainfall & daily air-temperature time series.

The model is intended primarily for use by engineers & planners in designing & evaluating runoff treatment systems (BMP's) for existing or proposed urban developments with minimal site-specific data.

PRIMARY USES OF PROGRAM ("Relative Predictions")

-> Evaluating site plans for compliance with treatment objective, expressed in terms of removal efficiency for total suspended solids or a single particle class.

For Example (RIDEM,1988):
85% TSS Removal in "Sensitive Areas"
70% TSS Removal in "Insensitive Areas"

-> In a design mode, selecting & sizing BMP's to achieve treatment objective. The program will automatically size BMP's to match user-defined watersheds, storm time series, target particle class, & target removal efficiency.

These applications are insensitive to errors associated with predicting untreated runoff water quality and are therefore more accurate than predictions of concentrations or loads.

SECONDARY USES OF PROGRAM ("Absolute Predictions"):

-> Predicting runoff water quality, loads, violation frequencies

-> Predicting water quality impacts due to proposed development
Upstream vs. Downstream Changes
Existing vs. Future Changes

-> Generating loads for driving receiving water quality models

-> Watershed-Scale Land-Use Planning

These types of applications are subject to greater error because of the high degree of site-to-site and storm-to-storm variability associated with urban runoff quality, as documented under the EPA's Nationwide Urban Runoff Program (Athayede et al., 1983).

Local calibration may reduce absolute prediction error, but is rarely feasible.

WATERSHEDS

WATERSHEDS consist of pervious and impervious areas, defined based upon the following characteristics:

—> Total area
—> Impervious fraction
—> Impervious depression storage
—> Street-sweeping frequency
—> SCS runoff curve number for pervious portion

Runoff from impervious areas is equal to rainfall, once depression storage is exceeded. Particle buildup & washoff processes are modeled using equations derived largely from the EPA's Stormwater Management Model (SWMM).

Runoff from pervious areas is predicted using the SCS Curve Number technique (USDA,SCS, 1964). Antecedent Moisture Conditions are ..sted based upon 5-day antecedent rainfall and season.

..olation from pervious areas is calculated by water balance. It can .. ignored or routed to an "aquifer" for simulation of baseflow.

DEVICES

DEVICES are defined based upon factors controlling hydraulic response and particle removal efficiency:

-> Dimensions (areas, volumes, lengths, widths, elevations)
-> Outlet configuration
-> Infiltration rate
-> Slope, Roughness (for overland flow areas)

Specific inputs vary with DEVICE TYPES, which include:

-> 1 Detention Pond	(Wet, Dry, Extended)
-> 2 Infiltration Basin	(Online, Offline)
-> 3 Swale/Buffer	(Overland Flow Area)
-> 4 General	(User-Defined Elev/Area/Outflow Table)
-> 5 Pipe/Manhole	(Collector with One Outlet)
-> 6 Splitter	(Collector with Two Outlets)
-> 7 Aquifer	(Approx. Groundwater Budget, Baseflow Calc.)

Devices have up to three outlets, which are routed to other devices or out of the system (to receiving waters).

PARTICLE CLASSES

PARTICLE CLASSES are defined based upon factors controlling watershed export & dynamics in treatment devices:

-> Accumulation/washoff parameters
-> Runoff concentrations
-> Street-sweeper efficiencies
-> Settling velocities
-> Decay rates (first-order, second-order)
-> Filtration efficiencies

FLOW and <=5 PARTICLE CLASSES are routed simultaneously from the watershed sources through the network of treatment devices.

Default input values for PARTICLE CLASSES are provided, based upon calibration to "typical urban runoff" concentrations and settling velocities measured under NURP (Athayede et al.,1983,1986; Driscoll, 1983).

WATER QUALITY COMPONENTS

WATER QUALITY COMPONENTS are defined based upon their weight distribution across PARTICLE CLASSES (mg/kg).

Default values for WATER QUALITY COMPONENTS are provided, based upon calibration to median, event-mean concentrations reported by NURP (Athayede et al., 1983). Alternative input data sets are calibrated to NURP sites in the 50th and 90th percentiles. These can be used to generate "typical" and "worst-case" water quality predictions.

The following COMPONENTS are included in the initial calibrations:

-> Total Suspended Solids (sum of PARTICLE CLASSES)
-> Total Phosphorus, Total Kjeldahl Nitrogen
-> Lead, Copper, Zinc
-> Hydrocarbons

If available, local or regional runoff quality data may also be used for calibration.

PROGRAM DISTRIBUTION & SUPPORT

P8 software and documentation are available from:

Narragansett Bay Project
291 Promenade Street
Providence, Rhode Island 02908-5767

TEL 401-277-3165
FAX 401-521-4230

Program Documentation:

Walker, W.W., "P8 Urban Catchment Model - Program Documentation", prepared for IEP, Inc. & Narragansett Bay Project. 73 pp., 5 Appendices. October 1990.

IEP Inc., "P8 Urban Catchment Model - User's Manual", prepared for Narragansett Bay Project. October 1990.