Hillsborough County SWMM4.31B

User's Manual

Stormwater Management Section
Public Works Department
Hillsborough County

Tampa, Forida

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1. Introduction

The Storm Water Management Model (SWMM) was developed for the Environmental Protection Agency in 1969-1971 as a single-event model for simulation of quantity processes in combined sewer systems (Metcalf and Eddy et al., 1971). It has since been applied to virtually every aspect of urban drainage, from routine drainage design to sophisticated hydraulic analysis to non-point source runoff quality studies, using both single event and continuous simulation. Through subdividing large catchments and flow routing down the drainage system, SWMM can be applied to catchments of almost any size, from parking lots to subdivisions to cities.

The current version of SWMM4.31 is segmented into several computational “Blocks”:

- The Runoff block generates runoff from rainfall using a nonlinear reservoir method and does simple flow routing by the same method. Subsurface flow routing of water infiltrated through the soil surface is optional.
- The Thansport block performs flow routing using a kinematic wave technique.
- The Extran block performs flow routing by an explicit finite-difference solution of the complete St. Venant equations.
- The Storage/Treatment block routes through storage units using the Puls (storage indication) method.
- The Statistics block separates continuous simulation hydrographs and pollutographs (concentration vs. time) into independent storm events, calculates statistical moments, and performs elementary frequency analyses.

Water quality may also be simulated in all blocks except Extran, and the output from continuous simulation may be analyzed by the statistics block.

Hillsborough County of Florida has been using SWMM model for many years. Mostly only Runoff and Extran blocks were used. While using this model, the storm water modeling group of Hillsborough County made many modifications based on the watershed conditions of the county. All the modifications will be summarized in the following sections.

2. Runoff Calculation

In the Hillsborough County version of SWMM model, the SCS-CN method, rather than the nonlinear reservoir method, was used to calculate the runoff discharge used in Extran Block.

2.1 SCS-CN method

The Soil Conservation Service-curve number (SCS-CN) method is one of the most popular methods for computing the volume of surface runoff for a given rainfall event from small watersheds. Kent (1973) described and examined this method in detail. The SCS-CN method is based on the water balance equation and two fundamental hypotheses. The first hypothesis states that the ratio of the actual amount of direct runoff to the maximum potential runoff is equal to the ratio of the amount of actual infiltration to the amount of the potential maximum retention. The second hypothesis states that the amount of initial abstraction is some fraction of the potential maximum retention. Expressed mathematically, the water balance equation and the two hypotheses, respectively, are

$$P = I_a + F + P_E \qquad (2\text{-}1)$$

$$\frac{P_E}{P - I_a} = \frac{F}{S} \qquad (2\text{-}2)$$

$$I_a = \lambda S \qquad (2\text{-}3)$$

where P = total precipitation, inch;

I_a = initial abstraction, inch;

F = cumulative infiltration excluding I_a, inch;

l = non-dimensional parameter;

P_E = direct runoff, inch; and

S = potential maximum retention or infiltration, inch

The current version of the SCS-CN method assumes l equal to 0.2 for usual practical application. As the initial abstraction component accounts for surface storage, interception, and infiltration before runoff begins, l can take any value ranging from 0 to 1. Combining (2-1) and (2-2), we can write an equation for P_E as follows:

$$P_E = \frac{(P - I_a)^2}{P - I_a + S} \qquad (2\text{-}4)$$

If l =0.2, then

$$P_E = \frac{(P - 0.2S)^2}{P + 0.8S} \qquad (2\text{-}5)$$

By studying the relationships of many different watersheds, the SCS further introduced a dimensionless number, CN, called curve number. The curve number and S are related by

$$S = \frac{1000}{CN} - 10 \qquad (2\text{-}6)$$

The curve number is a function of land use, cover, soil classification, hydrologic conditions, and antecedent runoff conditions. The variation in infiltration rates of different soils is incorporated in curve number selection through the classification of soils into four hydrologic soil groups: A, B, C, and D. These groups, representing soils having high, moderate, low, and very low infiltration rates, are as follows:

Group A: soils have low runoff potential and high infiltration rates even when thoroughly wetted. They consist chiefly of deep, well to excessively drained sands or gravels and have a high rate of water transmission (greater than 0.30 in/h).

Group B: soils have moderate infiltration rates when thoroughly wetted and consist chiefly of moderately deep to deep, moderately well drained to well drained soils with moderately fine to moderately coarse texurse. These soils have a moderate rate of water transmission (0.15-0.30 in/h).

Group C: soils have low infiltration rates when thoroughly wetted and consist mainly of soils with a layer that impedes downward movement of water and soils with moderately fine to fine texture. These soils have a low rate of water transmission (0.05-0.15 in/h).

Group D: soils have high runoff potential. They have very low infiltration rates when thoroughly wetted and consist chiefly of clay soils with a high swelling potential, soils with a permanent high water shallow soils over nearly impervious material . These soils have a very low rate of water transmission (0-0.05 in/h)

Runoff curve numbers for urban areas, cultivated and other agricultural lands, and arid and semiarid rangelands are shown in Table 2.1

Table 2.1a Runoff Curve Numbers for Urban Areas*

Cover type and hydrologic condition	Average percentage of impervious area**	Curve numbers for hydrologic soil group			
		A	B	C	D
Fully developed urban areas (vegetation established) Open space (lawns, parks, golf courses, cemeteries, etc.)***					
Poor condition (grass cover < 50%)		68	79	86	89
Fair condition (grass cover 50% to 75%)		49	69	79	84
Good condition (grass cover > 75%)		39	61	74	80
Impervious areas:					
Paved parking lots, roofs, driveways, etc. (excluding Right-of-way)		98	98	98	98
Streets and roads:					
Paved; curbs and storm sewers (excluding right-of-way)		98	98	98	98
Paved; open ditches (including right-of-way)		83	89	92	93
Gravel (including right-of-way)		76	85	89	91
Dirt (including right-of-way)		72	82	87	89
Western desert urban areas:					
Natural desert landscaping (pervious areas only)		63	77	85	88
Artificial desert landscaping (impervious weed barrier, desert shrub with 1- to 2-inch sand or gravel mulch, and basin borders		96	96	96	96
Urban districts:					
Commercial and business	85	89	92	94	95
Industrial	72	81	88	91	93
Residential districts by average lot size:					
1/8 acre or less (town house)	65	77	85	90	92
¼ acre	38	61	75	83	87

1/3 acre	30	57	72	81	86
½ acre	25	54	70	80	85
1 acre	20	51	68	79	84
2 acre	12	46	65	77	82
Developing urban areas:					
Newly graded areas (pervious areas only, no Vegetation)		77	86	91	94
Idle lands (CNs are determined through the use of cover types similar to those for other agricultural lands.)					

* Average runoff condition, and $I_a = 0.2S$.

** The average percentage of impervious area shown was used to develop the composite CNs. Other assumptions are as follows: Impervious areas are directly connected to the drainage system; impervious areas have a CN of 98; and pervious areas are considered equivalent to open space in good hydrologic condition.

*** CNs shown are equivalent to those of pasture. Composite CNs may be computed for other combinations of open space cover type.

Table 2.1b Runoff Curve Numbers for Cultivated Agricultural Lands *

Cover type	Treatment**	Hydrologic Condition***	Curve numbers for hydrologic soil group			
			A	B	C	D
Fallow	Bare soil		77	86	91	94
	Crop residue cover (CR)	Poor	76	85	90	93
		Good	74	83	88	90
Row crops	Straight row (SR)	Poor	72	81	88	91
		Good	67	78	85	89
	SR+CR	Poor	71	80	87	90
		Good	64	75	82	85
	Contoured (C)	Poor	70	79	84	88
		Good	64	74	81	85
	C+CR	Poor	69	78	83	87
		Good	64	74	81	85
	Contoured and terraced (C&T)	Poor	66	74	80	82
		Good	62	71	78	81
	C&T+CR	Poor	65	73	79	81
		Good	61	70	77	80
Small grain	SR	Poor	65	76	84	88
		Good	63	75	83	87
	SR+CR	Poor	64	75	83	86
		Good	60	72	80	84
	C	Poor	63	74	82	85
		Good	61	73	81	84
	C+CR	Poor	62	73	81	84
		Good	60	72	80	83
	C&T	Poor	61	72	79	82
		Good	59	70	78	81
	C&T+CR	Poor	60	71	78	81
		Good	58	69	77	80

Close-seeded or broadcast legumes or rotation meadow	SR	Poor	66	77	85	89
		Good	58	72	81	85
	C	Poor	64	75	83	85
		Good	55	69	78	83
	C&T	Poor	63	73	80	83
		Good	51	67	76	80

* Average runoff condition, and $I_a = 0.2S$.

** Crop residue cover applies only if residue is on at least 5% of the surface throughout the year.

*** Hydrologic condition is based on a combination of factors that affect infiltration and runoff, including (a) density and canopy of vegetative areas, (b) amount of year-round cover, (c) amount of grass or close-seeded legumes in rotations, (d) percentage of residue cover on the land surface (good $\geq$ 20%), and (e) degree of surface roughness.

Poor: Factors impair infiltration and tend to increase runoff.

Good: Factors encourage average and better-than-average infiltration and tend to decrease runoff.

Table 2.1c Runoff Curve Numbers for Other Agriculture Lands [1]

Cover type	Hydrologic condition	Curve numbers for hydrologic soil group			
		A	B	C	D
Pasture, grassland, or range-continuous forage for grazing[2]	Poor	68	79	86	89
	Fair	49	69	79	84
	Good	39	61	74	80
Meadow-continuous grass, protected from grazing and generally mowed for hay		30	58	71	78
Brush—brush-weed-grass mixture with brush the major element[3]	Poor	48	67	77	83
	Fair	35	56	70	77
	Good	30[4]	48	65	73
Woods—grass combination (orchard or tree farm)[5]	Poor	57	73	82	86
	Fair	43	65	76	82
	Good	32	58	72	79
Woods[6]	Poor	45	66	77	83
	Fair	36	60	73	79
	Good	30[4]	55	70	77
Farmsteads—buildings, lanes, driveways, and surrounding lots		59	74	82	86

[1] Average runoff condition, and $I_a = 0.2S$.

[2] Poor: <50% ground cover or heavily grazed with no mulch.

Fair: 50% to 75% ground cover and not heavily grazed.

Good: >75% ground cover and lightly or only occasionally grazed.

[3] Poor: <50% ground cover.

Fair: 50% to 75% ground cover.

Good: > 75% ground cover.

[4] Actual curve number is less than 30; use CN=30 for runoff computations.

[5] CNs shown were computed for areas with 50% woods and 50% grass(pasture) cover. Other combinations of conditions may be computed from the CNs for woods and pasture.

[6] Poor: Forest litter, small trees, and brush are destroyed by heavy grazing or regular burning.

Fair: Woods are grazed but not burned, and some forest litter covers the soil.

Good: Woods are protected from grazing, and litter and brush adequately cover the soil.

Table 2.1d Runoff Curve Numbers for Arid and Semiarid Rangeland*

Cover Type	Hydrologic condition**	Curve numbers for hydrologic soil group			
		A***	B	C	D
Herbaceous—mixture of grass, weeds, and low-growing brush, with brush the minor element	Poor		80	87	93
	Fair		71	81	89
	Good		62	74	85
Oak-aspen—mountain brush mixture of oak brush, aspen, mountain mahogany, bitter brush, maple, and other brush.	Poor		66	74	79
	Fair		48	57	63
	Good		30	41	48
Pinyon-juniper—pinyon, juniper, or both; grass understory.	Poor		75	85	89
	Fair		58	73	80
	Good		41	61	71
Sagebrush with grass understory.	Poor		67	80	85
	Fair		51	63	70
	Good		35	47	55
Desert shrub—major plants include saltbush, greasewood, creosote bush, blackbrush, bursage, paloverde, mesquite, and cactus.	Poor	63	77	85	88
	Fair	55	72	81	86
	Good	49	68	79	84

*Average runoff condition, and $I_a = 0.2S$. For range in humid regions, use the table for other agriculture lands.

** Poor: <30% ground cover (litter, grass, and brush overstory.

Fair: 30% to 70% ground cover.

Good: > 70% ground cover.

*** Curve numbers for group A have been developed for desert shrub only.

2.2 SCS Dimensionless Hydrograph

The SCS dimensionless hydrograph is a synthetic unit hydrograph in which the discharge is expressed by the ratio of discharge Q to peak discharge Q_p and the time by the ratio of time t to the time of rise of the unit hydrograph, T_p. The unit peak discharge is calculated by

$$U_p = \frac{KA}{T_p} \qquad (2\text{-}7)$$

where U_p = unit peak discharge, cfs/inch;

A = drainage are, mile^2 ;

K = hydrograph shape factor, ranging from 300 for flat swampy areas to 600 in steep terrain. SCS standard K value = 484.

T_p = time to peak, in hours.

$$T_p = \frac{t_r}{2} + t_p \qquad (2\text{-}8)$$

where t_r = storm duration, hours;

t_p = drainage area lag, hours.

$$t_p = 0.6T_c \qquad (2\text{-}9)$$

where T_c = time of concentration, hours.

Figure 2.1 shows the definition of U_p, T_p, for a triangular unit hydrograph used in Hillsborough County version of SWMM model.

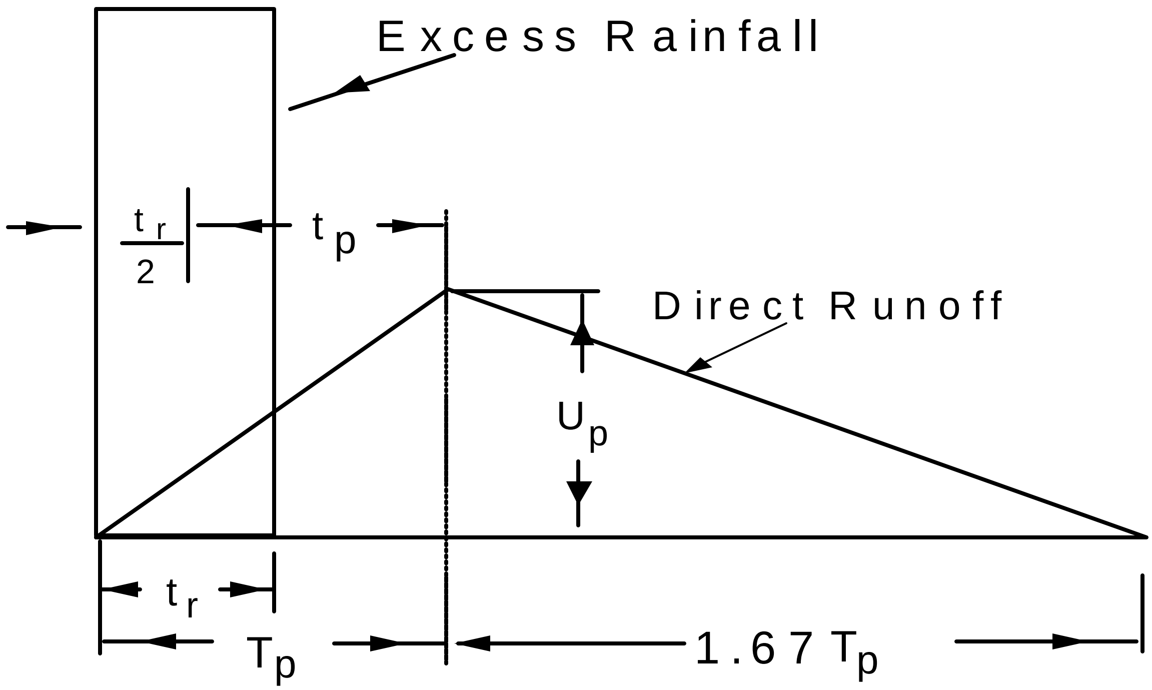

Figure 2.1 Definition of Unit Hydrograph

The peak discharge for a given rainfall is calculated by

$$Q_p = U_p P_E \qquad (2\text{-}10)$$

where Q_p= peak discharge, cfs. P_E is calculated with Eq. (2-5).

2.3 Model implementation

The convolution method is used to yield the direct runoff hydrograph. The convolution equation is

$$Q_n = \sum_{m=1}^{n \le M} P_{Em} U_{n-m+1} \qquad (2\text{-}11)$$

where P_{Em} = excess rainfall of *mth* pulse, inch;

U_{n-m+1} = unit direct runoff at time nDt of *mth* rainfall pulse, interpolated from Fig. 2.1, cfs/inch;

Dt = time step, minutes;

Q_n = total runoff at time nDt, cfs;

M = total pulses of excess rainfall.

Following are detail procedures to calculate the direct runoff at each time step: One thing needs to be pointed out is that, compared with original SWMM model, a new input file was introduced. The extension of this file is .WPX. This file contains all the information of rainfall and each sub-basin's area, CN number, T_c , I_a , and K. The detail of this file will be discussed in Appendix B.

1) Read rainfall information from file *.WPX ;
2) Read sub-basin information, i.e. base *ID*, area (in acres), T_c (in minutes.), *CN* number, I_a , and *K*, from file *.WPX ;
3) convert T_c into hour, i.e., $T_c = T_c/60$ (the model input is in minutes for convenience)*;*
4) Determine time step $Dt = 0.24T_c$; If $Dt>0.5$, $Dt = 0.11T_c$;
5) Determine excess rainfall based on Eq. (2-5), and interpolated to Dt time series ;
6) Calculate the direct runoffs Q(t) at each time step based on Eq. (2-11);
7) Double check model accuracy with

$$e = 100 \bullet \frac{\left| P_{ESCS} - \dfrac{\int Q(t)dt}{A} \right|}{P_{ESCS}} \qquad (2\text{-}12)$$

where

$$P_{ESCS} = \frac{(P_{total} - 0.2S)^2}{P_{total} + 0.8S} \qquad (2\text{-}13)$$

8) Interpolate $Q(t)$ to SWMM model time step $Q_{yn}(t)$;

9) Write out $Q_{yn}(t)$ to a interface file (if required).

2.4 Discussion on hydrograph shape factor, K

Theoretically speaking, the hydrograph shape factor, K, only affects the peak runoff, and should not affect the total runoff volume. In other words, no matter what the shape factor we use, the total runoff volume should be the same – mass conservative. However, based on the conventional way, this mass conservative can not guarantee. Refer to Fig. 2.1, the conventional way is,

$$Q_p = \frac{KAP_E}{T_p} \qquad (2\text{-}13),$$

and

$$T_b = T_p + 1.67T_p = 2.67T_p \qquad (2\text{-}14)$$

where T_b = base time;

Q_P = peak runoff due to excess rainfall P_E.

The direct runoff at each time step can be calculated by

$$Q(t) = \begin{cases} \dfrac{Q_p}{T_P} t & t \le T_p \\ Q_p \dfrac{2.67T_p - t}{1.67T_p} & T_p < t \le T_b \end{cases} \qquad (2\text{-}15)$$

The total direct runoff volume is

$$V_t = \int_0^{T_b} Q(t)dt = 1.335KAP_E \qquad (2\text{-}16)$$

That means V_t is changed with K, mass are not conservative.

To avoid this, a parameter, R, was introduced.

$$R = \frac{2.67K_0}{K} - 1.0 \qquad (2\text{-}17)$$

where K_0 = standard shape factor. Here use SCS standard value of 483.4.

Redefine T_b as

$$T_b = (1+R)T_p \qquad (2\text{-}18)$$

Then the direct runoff is

$$Q(t) = \begin{cases} \dfrac{Q_p}{T_P} t & t \le T_p \\ Q_p \dfrac{T_b - t}{T_b - T_p} & T_p < t \le T_b \end{cases} \qquad (2\text{-}19)$$

The total volume of direct runoff is

$$\begin{aligned} V_t &= \int_0^{T_b} Q(t)dt = Q_p T_b / 2 \\ &= 2.67K_0 AP_E / 2 \qquad (2\text{-}20) \\ &= 646.14AP_E \end{aligned}$$

That means the total direct runoff volume has nothing to do with the shape factor. The shape factor only affects the peak runoff. Mass is conservative. If $K=K_0$, Eq. (2-16) is identical to Eq. (2-20).

2.5 Input Format

The input format is identical to that of EXTRAN. That is, the first two columns are group identifier, and 3 to 232 columns are data line (See SWMM User's Manual and EXTRAN User's Manual).

Variable	Description	Default
ID	Group Identifier	None
ALPHA	Description of computer run (2 lines maximum of 80 Columns per line).	Blank

Variable	Description	Default
IT	Group Identifier	None
NMIN	Increment for runoff hydrograph storage	0.0 minutes
DATE	Rainfall date	Blank
ITIME	Rainfall start time	Blank
NQ	Number of sub-basins	Blank

(note, DATE, ITIME, and NQ are not used in the model yet, and can be blank.)

Variable	Description	Default
IO	Group Identifier	None
IPRT	Print controller (see description below)	0
IPLT	Plot controller (see description below)	0

IPRT =

0,1,2	All
3	Input Data and Intermediate and Master Summaries
4	Input Data and Master Summary
5	Job specification and Master Summary Only

IPLT =

0,1	No Printer Plots--Can be overriden on KO record
2	Plot All

(note, the IPRT and IPLT functions are not implemented yet.)

JR	Group Identifier	None
PRCARD	Card Name	PREC
PTOTAL	Total Rainfall (inch)	0.0

(note, PRCARD is not used in the model yet.)

PG	Group Identifier	None
GAGEN	Rainfall Gage name	Blank
PRAIN	Total Rainfall at this gage (inch)	0.0

(note, 1. PRAIN is not used in the model; 2. Total gages should be less than 11.)

IN	Group Identifier	None
DTRAINX	Time step of rainfall at this gage, minutes.	0.0
RDATE	Rainfall date	None
DUMMY	Dummy parameter	0

(note, DUMMY is not used in the model.)

PC	Group Identifier	None

RAIN(i,1)	The first rainfall distribution value	None
RAIN(i,2)	The second rainfall distribution value	None

.
.
.

(Input the unit hydrograph for this gage. 10 numbers each line. Every new line should begin with PC identifier. See the following example.)

PR	Group Identifier	None
GAGEN	Gage name to be used in this run.	None

(note, GAGEN should be identical to one of the names in PG cards.)

WP	Group Identifier	None
IBASIN	Sub-basin ID, integer	None
JCTID	Junction ID in the sub-basin	None
TCMIN	Time of concentration, minutes	0.0
ACRES	Areas of the sub-basin, acres	0.0
CN	CN curve number of the sub-basin	0
CIA	Initial abstraction of the sub-basin	0.2

(note, this value has been fixed in the model. Don’t try to change it.)

K	Shape factor of the sub-basin	0.0
IWPPRT	Print control parameter	0

(note, IWPPRT is not used in model.)

Following is a example.

```
* ============================================================================
*                        EAST    LAKE     AREA
*                        Rainfall Distributions
*                        JULY 13-19 1990 STORM EVENT
* ============================================================================
*THE FOLLOWING WPX HAS BEEN UPDATED WITH NEW CN's 3/19/99 - JG
*==============================================================================
ID                 East Lake Area
ID        Hillsborough County BOCC--Dept of Public Works
*
*
*   This is a standard HEC-1 file.  RDHEC copies the ID, *, IT, IO, JR,
*       PG, IN, PC, and PR records from this file.  It ignores other records.
*
*FREE
*DIAGRAM
*   NMIN    DATE   ITIME      NQ
IT    10 21JAN98       0     601
*
*NOLIST
*   IPRT    IPLT
*   0,1,2         All
*       3         Input Data and Intermediate and Master Summaries
*       4         Input Data and Master Summary
*       5         Job specification and Master Summary Only
*
*            0,1  No Printer Plots--Can be overriden on KO record
*              2  Plot All
*
IO     3       0
*
* MULTIRATION ANALYSIS--DO NOT USE
*   Use Only one ratio per run for SWMM.
* ####################################################
*  TIA RF JULY 13-19 1990 STORM EVENT
JR  PREC     8.0
* ####################################################
* ####################################################
*    SCS 24-HR, TYPE II FLORIDA MODIFIED DISTRIBUTION (30 MIN INCREMENTS)
PGFLMOD     1.0
*    SCS 24-HR, TYPE II FLORIDA MODIFIED DISTRIBUTION (30 MIN INCREMENTS)
IN    30 14JAN98       0
PC  .000    .006    .012    .019    .025    .032    .039    .047    .054    .062
PC  .071    .080    .089    .099    .110    .122    .134    .148    .164    .181
PC  .201    .226    .258    .308    .607    .719    .757    .785    .807    .826
PC  .842    .857    .870    .882    .893    .904    .913    .923    .931    .940
PC  .948    .955    .962    .969    .976    .983    .989    .995    1.00    1.00
*
PGEL790
IN    60  13JUL90       0
*This is Accumulative Rain fall for July 13-19 1990 Storm event (60min Increment)
PC 0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000
```

```
PC 0.002   0.002   0.048   0.053   0.053   0.053   0.053   0.053   0.053   0.053
PC 0.053   0.053   0.053   0.053   0.096   0.096   0.096   0.096   0.096   0.096
PC 0.096   0.248   0.254   0.257   0.257   0.265   0.520   0.649   0.664   0.684
PC 0.693   0.693   0.693   0.693   0.693   0.693   0.693   0.693   0.693   0.693
PC 0.693   0.693   0.693   0.693   0.693   0.693   0.693   0.693   0.693   0.693
PC 0.693   0.695   0.708   0.713   0.713   0.713   0.713   0.713   0.713   0.713
PC 0.713   0.713   0.713   0.713   0.713   0.713   0.713   0.713   0.713   0.713
PC 0.713   0.713   0.713   0.713   0.713   0.713   0.713   0.713   0.713   0.713
PC 0.713   0.713   0.713   0.713   0.713   0.713   0.713   0.713   0.713   0.713
PC 0.713   0.713   0.713   0.713   0.713   0.713   0.713   0.713   0.713   0.713
PC 0.713   0.713   0.811   0.822   0.822   0.822   0.822   0.822   0.822   0.822
PC 0.822   0.822   0.822   0.822   0.822   0.822   0.822   0.822   0.822   0.822
PC 0.822   0.822   0.822   0.822   0.822   0.993   0.998   1.000   1.000   1.000
* ===========================================================================
*  THE FOLLOWING RECORD (PR) DETERMINES WHICH OF THE ABOVE DISTRIBUTIONS
*  WILL BE USED FOR THE CURRENT RUN.
*
PREL790
* ===========================================================================
ZZ
*       NODE#     BASIN                         OLD
*       NUMBER                        25AREA    CN      Ia       FC       KI
WP        100999  100999      62    17.8      73      0.2      256        0
WP        104007  104007      24    11.7      64      0.2      256        0
WP        104020  104020      22    25.2      74      0.2      256        0
WP        104023  104023      15    17.6      76      0.2      256        0
WP        104025  104025      15       4      76      0.2      256        0
WP        104030  104030      15       3      76      0.2      256        0
WP        104045  104045      15      29      78      0.2      256        0
WP        104050  104050      15     9.6      77      0.2      256        0
WP        104060  104060      15     6.9      82      0.2      256        0
WP        104063  104063      15     2.1      65      0.2      256        0
WP        104075  104075      30      34      64      0.2      256        0
WP        104080  104080      15    11.8      87      0.2      256        0
WP        104085  104085      24    15.6      90      0.2      256        0
WP        104090  104090      15    10.6      81      0.2      256        0
WP        104095  104095      15     3.4      91      0.2      256        0
WP        104100  104100      15     9.5      85      0.2      256        0
WP        104130  104130      34    17.5      74      0.2      256        0
WP        104145  104145      21    14.9      71      0.2      256        0
WP        104165  104165      33    12.4      73      0.2      256        0
WP        104205  104205      19    15.4      83      0.2      256        0
WP        104208  104208      15     4.9      83      0.2      256        0
WP        104215  104215      15     3.1      85      0.2      256        0
WP        104400  104400      15    12.9      73      0.2      256        0
WP        104407  104407      38       9      65      0.2      256        0
WP        104416  104416      34     8.1      70      0.2      256        0
WP        104424  104424      15     4.1      93      0.2      256        0
WP        104428  104428      22    11.8      78      0.2      256        0
WP        104432  104432      15    10.3      91      0.2      256        0
```

3. Modifications of Extran Block

Several minor modifications have been carried out in Extran Block. These minor modifications are: minor losses, pipe extension, pipe shape, and input format.

3.1 Minor Losses

Minor head losses have been included in the model (subroutine HEADLOSS). In B0 card, another input flag, *KMFLAG*, was added (the third one). If *KMFLAG = 1*, the minor losses will automatically taken into account. In this case, three minor loss coefficients, $K_{entrance}$, K_{extent}, and K_{others}, for each pipe are required (*C1* card). If *KMFLAG=0*, minor losses are not calculated.

Assume the minor losses are uniformly distributed along the pipe, based on Chezy's Law, the minor losses can be converted into an equivalent Manning's coefficient, which is

$$n_1 = \sqrt{n_0^2 + K_t \frac{C^2 R^{4/3}}{2gL}} \qquad (3\text{-}1)$$

where n_0 = the natural Manning's of the pipe;

$K_t = K_{entrance} + K_{extent} + K_{others}$, total minor loss coefficient;

R = hydraulic radius;

g = gravity;

L = pipe length;

C = Unit conversion factor, = 1 for metric system, and = 1.486 for US custom system;

n_1 = equivalent Manning's coefficient including minor losses.

3.2 Pipe extension (subroutine STRETCH)

In order to avoid the stability problem, an equivalent longer pipe can be developed for an extremely short pipe. Assuming that the equivalent pipe will have the same discharge, same area, and same hydraulic radius, based on Checy's Law, an equivalent Manning's coefficient for the longer pipe can be derived as

$$n_e = n_0 \sqrt{\frac{L_0}{L_e}} \qquad (3\text{-}2)$$

where n_0 = natural Manning's coefficient of the pipe;

L_0 = initial pipe length;

L_e = extended pipe length;

n_e = equivalent Manning's coefficient.

The *KMFLAG* was also applied to pipe extension. That is, if *KMFLAG =1*, pipe extension will automatically considered in the model. In this case, a parameter, *SFACTOR,* is required in the C1 card. $SFACTOR = L_e/L_0$.

3.3 Pipe shape

In this version, the pipe types are classified as

Table 3.1 Pipe Type Classification

Type	Pipe Shape	Comments
1	Circle	
2	Rectangle	
3	Elliptical	Horizontal. The lookup tables for hydraulic radius and cross-section area are derived analytically.
4	Arch	
5	Basket Handler	
6	Trapezoidal	
7	Parabolic	
8	Natural Channel	
9		

3.4 Input format

All the original input formats for vertical distances, for example, ZP(1) (distance of conduit invert above junction invert at NJUNC(1)) and ZP(2) (distance of conduit invert above junction invert at NJUNC(2)), have been changed to real elevation. Table 3.2 lists all these changes.

Table 3.2 Changes of input format

Variable	Card	Original	Change to	Comments
ZP(1)	C1	Distance of conduit invert above junction invert at NJUNC(1)	Conduit invert at upstream	
ZP(2)	C1	Distance of conduit invert above junction invert at NJUNC(2)	Conduit invert at downstream	
QCURVE	E2	Depth above junction at point 1	Elevation at point 1	
ZP	F1	Distance of orifice invert above junction floor	Orifice invert	
YCREST	G1	Height of weir crest above invert	Elevation of weir crest	
YTOP	G1	Height of top of weir opening above invert (surcharge level)	Elevation of top of weir opening (surcharge level)	

4. Modifications of Combine Block

Because of the modifications of runoff calculation, the COMBINE block was also modified accordingly. The A1 card in COMBINE block now has 10 options as listed in Table 4.1.

Table 4.1 List of A1 Card Options

ICOMB	Option	Comments
0	Collate Option	
1	Combine Option	
2	Extract (and optionally renumber) nodes from a single input file.	
3	Read file header.	
4	Create ASCII file from binary interface file	
5	Calculate the simple statistics of an interface file.	
6	Calculate the simple statistics of a rain block interface file.	
7	Calculate the simple statistics of a TEMP block interface file.	Not implemented yet.
10	Read a hec-1 Tape21 file to interface file.	New
11	Generate SCS hydrograph to interface file.	New

5. Input of EXTRAN and COMBINE BLOCK

EXTRAN INPUT GUIDELINES

There have been many changes made to the input format of EXTRAN. Following is a short list of the major changes along with explanations and guidelines.

1. Free format input. Input is no longer restricted to fixed columns. Free format has the requirement, however, that at least one space separate each data field. Free format input also has the following strictures on real, integer, and character data.

   a. No decimal points are allowed in integer fields. A variable is integer if it has a 0 in the default column. A variable is real if it has a 0.0 in the default column.

   b. Character data must be enclosed by single quotation marks, including both of the two title lines. Use a double single-quote ('') to represent an apostrophe within a character field, e.g., USER''S MANUAL.

2. Data group identifiers are a requirement and <u>must</u> be entered in columns 1 and 2. The program uses these for line and input error identification, and they are an aid to the EXTRAN user. 99999 lines no longer are required to signal the end of sets of data group lines; the data group identifiers are used to distinguish one data group from another.

3. The data lines may be up to 230 columns long.

4. Input lines can wrap around. For example, a line that requires 10 numbers may have 6 on the first line and 4 on the second line. The FORTRAN READ statement will continue reading until it finds 10 numbers, e.g.,

```
Zl 1  2  3  4   5    6
   7  8  9 10
```

Notice that the line identifier is not used on the second line.

5. In most cases an entry must be made for every parameter in a data group, even if-it is not used or zero and even if it is the last required field on a line. Trailing blanks are not assumed to be zero. Rather, the program will continue to search on subsequent lines for the "last" required parameter. Zeros can be used to enter and "mark" unused parameters on a line. This requirement also applies to character data. A set of quotes must be found for each character entry field. E.g., if the two run title lines (data group Al) are to consist of one line followed by a blank line, the entry would be:

Al ‘This is line 1.’
Al ‘ ‘

6. See Section 2 of the SWMM User's Manual for use of comment lines (indicated by an asterisk in column 1) and additional information.

VARIABLE	DESCRIPTION	DEFAULT
	Executive Block Input Data	
	I/O File Assignments (Unit Numbers)	
SW	Group identifier	None
NBLOCK	Number of blocks to be run (max of 25).	1
JIN(1)	Input file (logical unit number) for the first block.	0
JOUT(1)	Output file for the first block.	0
.		
.		
.		
JIN(NBLOCK)	Input file for the last block.	0
JOUT(NBLOCK)	Output file for the last block.	0
	Scratch File Assignments (Unit Numbers)	
MM	Group identifier	None
NITCH	Number of scratch files to be opened (max of 6). EXTRAN requires at least one scratch file.	0

NSCRAT(1)	First scratch file assignment.	0
.		
.		
.		
NSCRAT(NITCH)	Last scratch file assignment.	0

VARIABLE	DESCRIPTION	DEFAULT

Control Data Indicating Files To Be Opened and/or Permanently Saved.
Note that different from EPA SWMM, the runoff block input file has to be opened here.

REPEAT THE @ LINE FOR EACH FILE TO BE SAVED.

@	Group identifier	None
FILENUM	Unit number of the JIN, JOUT, or NSCRAT file to be permanently saved (or used) by the SWMM program.	None
FILENAM	Name for permanently saved file. Enclose in single quotes, e.g. 'SAVE.OUT'.	None

Enter $ANUM in columns 1-5 in order to use alphanumeric conduit/junction names in this (and all following) block(s).

Enter $COMBINE in columns 1-7 to call the COMBINE block

COMBINE Block Controller

A1	Group Identifier	None
ICOMB	COMBINE block switch	0
	= 0, COLLATE OPTION = 1, COMBINE OPTION = 2, EXTRACT (AND OPTIONALLY RENUMBER) NODES FROM A SINGLE INPUT FILE. = 3, READ FILE HEADER = 4, CREATE ASCII FILE FROM BINARY INTERFACE FILE = 5, CALCULATE THE SIMPLE STATISTICS (SUMS) OF AN INTERFACE FILE = 6, CALCULATE THE SIMPLE STATISTICS (SUMS) OF A RAIN BLOCK INTERFACE FILE = 7, CALCULATE THE SIMPLE STATISTICS OF	

VARIABLE	DESCRIPTION	DEFAULT
	A TEMP BLOCK INTERFACE FILE (Not implemented) = 10, READ A HEC-1 TAPE21 FILE TO INTERFACE FILE = 11, GENERATE SCS HYD TO INTERFACE FILE	
B1	Comment line (2 lines). maximum of 80 columns per line). Both lines must be enclosed in quotes.	Blank

Enter $EXTRAN in columns 1-7 to call the EXTRAN Block.

Run Title

Al	Group identifier	None
ALPHA	Description of computer run (2 lines, maximum of 80 columns per line). Both lines must be enclosed in quotes. Will be printed on output (2 lines).	Blank

Optional Routing Solution Control Parameters
This data group is not a requirement and may be omitted.

B0	Group identifier	None
ISOL	Solution technique parameter (see Appendix C). = 0, Explicit solution of Section 5 (default), = 1, Enhanced explicit solution, = 2, Iterative explicit solution using variable time-steps < DELT (group Bl). Iteration limit is ITMAX and convergence criterion is SURTOL (group B2).	0
KSUPER	= 0, Use minimum of normal flow and dynamic flow when water surface slope < conduit slope (default), = 1, Normal flow always used when flow is supercritical.	0

VARIABLE	DESCRIPTION	DEFAULT
KMFLAG	= 0, No minor loss and pipe extension = 1, With minor loss and pipe extension.	0

Input and Run Control Parameters (optional)

BB	Group identifier	None
JELEV	Conduit inverts input option = 0, input upstream(ZD) and downstream(ZU) inverts as offsets of junction inverts; = 1, input upstream(ZD) and downstream(ZU) inverts as elevation (suggested)	0
JDOWN	Outfall water depth option = 0, HD = minimum(normal depth, critical depth);	0

= 1, HD = critical depth;
= 2, HD = normal depth.
Where HD = down steam water depth of free outfall conduit.

First Group of Run Control Parameters

Bl	Group identifier	None
NTCYC	Number of time-steps desired.	1
DELT	Length of time-step, seconds.	1.0
TZERO	Start time of simulation, decimal hours. Time zero is midnight (beginning) of first simulation day.	0.00
NSTART	First time-step to begin print cycle.	1
INTER	Interval between intermediate print cycles during simulation. Number of cycles printed is (NTCYC - NSTART)/INTER.	1

VARIABLE	DESCRIPTION	DEFAULT
JNTER	Interval between time-history summary print cycles at end of simulation. Number of cycles printed is NTCYC/JNTER.	1
JREDO	Hot-start file manipulation parameter. = 0, No hot-start file is created or used, = 1, Read NSCRAT(2) for initial flows, heads, areas, and velocities, = 2, Create a new hot-start file on NSCRAT(2), = 3, Create a new hot-start file but use the old file as the initial conditions. The old file is subsequently erased and a new file created.	0
IDATZ	Initial date (optional)	0

Second Group of Run Control Parameters

B2	Group identifier	None
METRIC	U.S. customary or metric units for input/output. = 0, U.S. customary units, = 1, Metric units.	0
NEQUAL	Modify short pipe lengths using an equivalent pipe to ease time step limitations. = 0, Do not modify, Please always use 0, = 1, Modify short pipe lengths.	0
AMEN	Default surface area for all manholes ft^2 (m^2) Used for surcharge calculations in Extran. Manhole default diameter is 4 ft (1.22 m).	12.566
ITMAX	Maximum number of iterations to be used in surcharge and iterative calculations (30 recommended).	None
SURTOL	Fraction of average flow in surcharged areas to be used as convergence criterion for surcharge iterations (0.05 recommended). Also, convergence	None

VARIABLE	DESCRIPTION	DEFAULT
	criterion during flow iterations, ISOL - 2.	

Third Group of Run Control Parameters

B3	Group identifier	None
NHPRT	Number of junctions for detailed printing of head output (30 nodes max.).	0
NQPRT	Number of conduits for detailed printing of discharge output (30 conduits max.).	0
NPLT	Number of junction heads to be plotted (30 max.).	0

LPLT	Number of conduits for flows to be plotted (30 max.).	0
NB8	Number of conduits for flows to be both printed and plotted Not implemented yet. Just input 0.	0
NB9	Number of junctions for water levels to be both printed and plotted Not implemented yet. Just input 0.	0
NJSW	Number of input junctions (data group K2), if user input hydrographs are used (65 max).	0

Note: For groups B4 - B8, enter each name in single quotes if alphanumeric option is being used.

Printed Heads

Enter 10 junction numbers per line. Data group B4 is required only if NHPRT > 0 on data group B3.

B4	Group identifier	None

VARIABLE	DESCRIPTION	DEFAULT
JPRT(1)	First junction number/name for detailed printing.	0
JPRT(2)	Second junction number/name, etc., up to number of nodes defined by NHPRT.	0

Printed Flows

Enter 10 conduit numbers per line. Data group B5 is required only if NQPRT > 0 on data group B3.

B5	Group identifier	None
CPRT(1)	First conduit number/name for detailed printing.	0

CPRT(2)	Second conduit number/name, etc., up to number of nodes defined by NQPRT.	0

Plotted Heads

Enter 10 junction numbers per line. Data group B6 is required only if NPLT > 0 on data group B3.

B6	Group identifier	None
JPLT(1)	First junction number/name for plotting.	0
JPLT(2)	Second junction number/name, etc., up to number of nodes defined by NPLT.	0

Plotted Flows

VARIABLE	DESCRIPTION	DEFAULT

Enter 10 conduit numbers per line. Data group B7 is

required only if LPT > 0 on data group B3.

B7	Group identifier	None
KPLT(1)	First conduit number/name for plotting.	0
KPLT(2)	Second conduit number/name for plotting, etc., up to the number of nodes defined by LPLT. This option is for the conduit flow rate.	0

Upstream/Downstream Heads Plotted on Same Graph for Conduits

Enter 30 conduit numbers per line. Data group B8 is optional and may be omitted.

B8	Group identifier	None

NSURF	Number of conduit upstream/downstream plots.	1
JSURF(1)	First conduit number/name for plotting.	0
JSURF(2)	Second conduit number/name for plotting, etc., up to the number of conduits defined by NSURF.	0

Conduit Data (1 line/conduit)

C1	Group identifier	None
NCOND(N)	Conduit number (any valid integer), or conduit name (enclose in single quotes).	1 'Name'
NJUNC(N,l)	Junction number at upstream end of conduit, or Junction name (enclose in single quotes).	0
NJUNC(N,2)	Junction number at downstream end of conduit, or junction name (enclose in single quotes).	0
Q0 (N)	Initial flow, cfs [cms].	0.0

VARIABLE	DESCRIPTION	DEFAULT
NKLASS(N)	Type of conduit shape.	

1 - circular
2 - rectangular
3 - elliptical
4 - arch
5 - baskethandle.
6 - trapezoidal channel
7 - parabolic/power function channel
8 - irregular (natural) channel

(Types 9 and 10 are used internally for orifice and weir connections.)

Note: A negative NKIASS(N) creates a flap gate that will only let water move from the downstream (lower elevation) node to the upstream node.

AFULL(N)	Cross sectional area of conduit, ft^2 [m^2] enter only for types 4 and 5. (Geometric properties for types 4 and 5 may be found in Section 6 of the main SWMM User's Manual.)	0.0
DEEP(N)	Vertical depth (diameter for type 1) of conduit, ft [m]. Not required for type 8.	0.0
WIDE(N)	Maximum width of conduit, ft [m] Bottom width for trapezoid, ft [m] Top width for parabolic, ft [m] Not required (N.R.) for types 1 and 8.	0.0
LEN(N)	Length of conduit, ft [m] for type 8, enter it here for reference and also enter in data group C3.	0.0

Note: A negative LEN(N) creates a flap gate that will only let water move from the upstream (higher elevation) node to the downstream node.

ZP (N, 1)	Invert of conduit at NJUNC(N,1), ft [m]	0.0

VARIABLE	DESCRIPTION	DEFAULT
ZP(N, 2)	Invert of conduit at NJUNC(N,2), ft [m]	0.0
ROUGH(N)	Manning coefficient (not includes entrance, exit, expansion, and contraction losses). **N.R. for type 8. Uses XNCH in data group C2.**	0.014
STHETA(N)	Slope of one side of trapezoid. Required only for type - 6, (horizontal/vertical; 0 - vertical walls). For type 7, the channel exponent(2.0, 3.0, etc.). For type 8, the cross-section identification number (SECNO, group C3) of the cross section used for this EXTRAN channel. Unlike HEC-2, EXTRAN uses only a single cross section to represent a natural channel reach for type 8 channels. A negative STHETA(N) will eliminate the printing of the dimension-less curves associated with each natural channel or	0.0

	power-function channel.	
SPHI(N)	Slope of other side of trapezoid. Required only for type - 6, (horizontal/vertical; 0 - vertical walls). The average channel slope for type 8. This slope is used only for developing a rating curve for the channel. Routing calculations use invert elevation differences divided by length.	0.0

(Following three fields only needed when KMLAG = 1 in B0 card.)

ENTRANCE	Entrance loss coefficient	0.0
EXIT	Exit loss coefficient	0.0
OTHER	Other minor loss coefficient	0.0
SFACTOR	Pipe extension factor	1.0

The C2 (NC) or NH, C3 (Xl), and C4 (GR) data lines for any type 8 conduits follow as a group after all Cl lines have been entered. The sequence for channels must be in the same order as the earlier sequence of type-8 Cl-lines.

VARIABLE	DESCRIPTION	DEFAULT

Data groups C2, C3 and C4 correspond to HEC-2 lines NC, Xl'and GR. HEC-2 input may be used directly if desired. Lines may be identified either by EXTRAN identifiers (C2, C3, C4) or HEC-2 identifiers (NC, Xl, GR). NH line is for multi-Manning's n option. When more than three Manning's n are required for a given cross-section, NH line, rather than C2 line, should be prepared.

Channel Roughness

This is an optional data line that permanently modifies the Manning's roughness coefficients (n) for the remaining natural channels. This data group may repeated for later channels. It must be included for the first natural channel-modeled.

C2 or NC	Group identifier	None
XNL	n for the left overbank. = 0.0, No change,	0.0

	> 0.0, New Manning's n.	
XNR	n for the right overbank. = 0.0, No change, > 0.0, New Manning's n.	0.0
XNCH	n for the channel. = 0.0, No change, > 0.0, New Manning's n.	0.0

Note, XNCH is used to develop normalized flow routing curves.

Or

NH	Group identifier for more than three Manning’s n channel	none
NXNL	left bank number of Manning’s n	1
NXNR	right bank number of Manning’s n	1
XNL1(1)	the first Manning’s n on left bank	0.0
XNL1(2)	the second Manning’s n on left bank	0.0
.		
.		
XNL1(NXNL)	the NXNL Manning’s n on left bank	0.0
XNR1(1)	the first Manning’s n on right bank	0.0
XNR1(2)	the second Manning’s n on right bank	0.0
.		
.		
.		

XNR1(NXNR)	the NXNR Manning’s n on right bank	0.0
XNCH	Main channel Manning’s n	0.0

Cross Section Data

Required for each type 8 conduit in earlier Cl data lines. Enter pairs of C3 and C4 lines in same sequence as appearance of corresponding type 8 conduit in earlier Cl lines.

C3 or Xl	Group identifier	None
SECNO	Cross section identification number.	1
NUMST	Total number of stations on the following C4 (GR) data group lines. NUMST must be < 99.	0

VARIABLE	DESCRIPTION	DEFAULT
STCHL	The station of the left bank of the channel, ft [m]. Must be equal to one of the STA(N) on the C4 (GR) data lines.	0.0
(enter NXNL coordinates sequentially here if NH line prepared)		
STCHR	The station of the right bank of the channel, ft [m]. Must be equal to one of the STA(N) on the C4 (GR) data lines.	0.0
(enter NXNR coordinates sequentially here if NH line prepared)		
XLOBL	Not required for EXTRAN (enter 0.0).	0.0
XLOBR	Not required for EXTRAN (enter 0.0).	0.0
LEN(N)	Length of channel reach represented by this cross section, ft [m].	0.0

PXSECR	Factor to modify the horizontal dimensions for a cross section. The distances between adjacent C4 (GR) stations (STA) are multiplied by this factor to expand or narrow a cross section. The STA of the first C4 (GR) point remains the same. The factor can apply to a repeated cross section or a current one. A factor of 1.1 will increase the horizontal distance between the C4 (GR) stations by 10 percent. Enter 0.0 for no modification.	0.0
PSXECE	Constant to be added (+ or -) to C4 (GR) elevation data on next C4 (GR) line. Enter 0.0 to use C4 (GR) values as entered.	0.0

Cross-Section Profile

Required for type 8 conduits in data group Cl.
Enter C3 and C4 lines in pairs.

C4 or GR	Group identifier	None
EL(l)	Elevation of cross section at STA(l). May be positive or negative, ft [m].	0.0
STA(1)	Station of cross section 1, ft [m].	0.0
EL(2)	Elevation of cross section at STA(2), ft [m].	0.0
STA(2)	Station of cross section 2, ft [m].	0.0

Enter NUMST elevations and stations to describe the cross section. Enter 5 pairs of elevations and stations per data line. (Include group identifier, C4 or GR, on each line.) Stations should be in increasing order progressing from left to right across the section. Cross section data are traditionally oriented looking downstream (HEC, 1982).

Junction Data (1 line/junction.)

VARIABLE	DESCRIPTION	DEFAULT
Dl	Group identifier	None

JUN(J)	Junction number (any valid integer), or junction name (enclose in single quotes).	0
GRELEV(J)	Ground elevation, ft [m].	0.0
Z(J)	Invert elevation, ft [m].	0.0
QINST(J)	Net constant flow into junction, cfs [m^3 /s] Positive indicates inflow. Negative indicates withdrawl or loss.	0.0
Y0(J)	Initial water elevation, ft [m]	Z(J)

Storage Junctions

Note: Each storage junction must also have been entered in the junction data (Group DI).

El	Group identifier	None
JSTORE(I)	Junction number containing storage facility, or junction name (enter in single quotes).	0
ZTOP(I)	Junction crown elevation (must be higher than	0.0

VARIABLE	DESCRIPTION	DEFAULT
	crown of highest pipe connected to the storage junction), ft [m].	
ASTORE(J) .	Storage volume per foot (or meter) of d I pth (i.e., constant surface area) ft^3/ft [m^3 /m]. Set ASTORE(J) < 0 to indicate a variable-area storage junction.	0.0
	NUMST required only if ASTORE < 0.	
NUMST	Total number of stage/storage area points on following E2 data lines. NUMST < 99. Enter a value of -2 for NUMST to generate area vs. stage using a power function, $A = a\ depth^b$.	0

Follow El line with E2 line(s) only if ASTORE < 0,
or NUMST equals -2 on line El.

Variable-Area Storage Junction, Stage vs. Surface Area Points

E2	Group identifier	None
QCURVE(N,1,1)	Surface area of storage junction at depth point 1, acres [hectares]. If NUMST equals -2 this is the coefficient of the power function.	0.0
QCURVE(N,2,1)	Elevation at point 1, ft [m]. If NUMST equals -2 this is the exponent of the power function. This is the last value entered if NUMST equals -2.	0.0
QCURVE(N,1,2)	Surface area of storage junction at depth point 2, acres [hectares].	0.0
QCURVE(N,2,2)	Elevation at point 2, ft [m].	0.0
.		
.		
.		
.		

VARIABLE	DESCRIPTION	DEFAULT

Continue entering total of NUMST (data group El) area-stage points.
Use only one E2 group identifier for the E2 data group. If more than one line is required leave the first two columns blank.

Orifice Data (60 Max.)

Fl	Group identifier	None
NJUNC(N,l)	Junction number containing orifice, or junction name (enter in single quotes).	None
NJUNC(N,2)	Junction number to which orifice discharges, or junction name (enter in single quotes).	None

NKIASS(N)	Type of orifice. 1 - side outlet, 2 - bottom outlet, -1 - time-history side outlet orifice, with data entered on data group F2. -2 - time-history bottom outlet orifice, with data entered on data group F2.	1
AORIF(I)	Orifice area, ft^2 [m^2].	0.0
CORIF(I)	Orifice discharge coefficient.	1.0
ZP(I)	Orifice invert (define only for side outlet orifices), ft [m].	0.0

Time-History Orifice Data

Each F2 line follows the appropriate Fl line.

F2	Group identifier	None
NTIME	Number of data points to describe the time	1

VARIABLE	DESCRIPTION	DEFAULT
	history of the orifice (50 max.).	
VORIF(I,1,1)	First time, hours, that the orifice discharge coefficient and area change values from intial settings of group Fl above. Time zero refers to beginning (midnight) of beginning day of simulation. E.g., VORIF(I,1,1) = 22.0 means first change in orifice setting occurs at 10:00 p.m. on first day of simulation. Increase hours past 24 (e.g., 25, 26) for multi-day simulations.	0.0
VORIF(I,1,2)	First new value of orifice discharge coefficient.	0.0

VORIF(I,1,3)	First new value of orifice area.	0.0
.		
.		
.		

Enter NTIME values of time/coefficient/area. Only one F2 group identifier is required, on the first data line. Subsequent lines (if required) should not include F2 identifier.

Weir Data (1 line/weir, 60 Max.)

Gl	Group identifier	None
NJUNC(N,1)	Junction number at which weir is located, or Junction name (enter in single quotes).	0
NJUNC(N,2)	Junction number to which weir discharges, or Junction name (enter in single quotes). Note: To designate outfall weir, set NJUNC(N,2) equal to zero or (one space between quotes).	0
KWEIR(I)	Type of weir. 1 = transverse	1

VARIABLE	DESCRIPTION	DEFAULT
	2 = transverse with tide gate, 3 = side flow, 4 = side flow with tide gate.	
YCREST(I)	Elevation of weir crest, ft [m].	0.0
YTOP(I)	Elevation of top of weir opening (surcharge level) ft [m].	
WLEN(I)	Weir length, ft [m].	0.0
COEF(I)	Coefficient of discharge for weir.	1.0

Pump Data (1 line/pump, 20 Max.)

Note: ONLY ONE PIPE CAN BE CONNECTED TO A TYPE 1 PUMP NODE.

Hl	Group identifier	None
IPTYP(I)	Type of pump. 1 = off-line pump with wet well (program will set pump junction invert to -100), 2 = in-line lift pump, 3 = three-point head-discharge pump curve.	1
NJUNC(N,l)	Junction number being pumped, or Junction name (enter in single quotes).	0
NJUNC(N,2)	Pump discharge goes to this junction number, or junction name (enter in single quotes).	0
PRATE(I,l)	Lower pumping rate, ft^3/s [m^3/s].	0.0

VARIABLE	DESCRIPTION	DEFAULT
PRATE(I,2)	Mid-pumping rate, ft^3/s [m^3/s].	0.0
PRATE(I,3)	High pumping rate, ft^3/s [m^3/s].	0.0
VRATE (I, 1)	If IPTYP = 1 enter the wet well volume for mid-rate pumps to start, ft^3 [m^3]. If IPTYP = 2 enter the junction depth for mid-rate pumps to start, ft [m]. If IPTYP = 3 enter the head difference (head at junction downstream of pump minus and head at junction upstream of pump) associated with the lowest pumping rate, ft [m]. (This will be the highest head difference.)	0.0

VRATE (I, 2)	If IPTYP = 1 enter the wet well volume for high-rate pumps to start, ft^3 [m^3] . If IPTYP = 2 enter the junction depth for high-rate pumps to start, ft [m] . If IPTYP = 3 enter the head difference associated with the mid-pumping rate, ft [m]	0.0

Non-zero VRATE(I,3) and VWELL(I) required only if IPTYP = 1 or 3.

VRATE(I,3)	If IPTYP = 1 enter total wet well capacity, ft^3 [m^3] If IPTYP = 3 then enter the head difference associated with highest pumping rate, ft [m]. (This will be the lowest head difference.)	0.0
VWELL(I)	If IPTYP = 1 then enter initial wet well volume, ft^3 [m^3] If IPTYP = 3 then enter the intial depth in pump inflow Junction, ft [m]	0.0
	Enter PON(I) and POFF(I) if IPTYP = 3	
PON(I)	Depth in pump inflow junction to turn pump on, ft [m].	0.0

VARIABLE	DESCRIPTION	DEFAULT
POFF(I)	Depth in pump inflow junction to turn pump off, ft [m].	0.0

Note: for groups Il and I2, enter junction name in single quotes if alphanumeric option is being used.

Outfalls Without Tide Gates (1 line/outfall, 25 Max.)

Note: ONLY ONE CONNECTING CONDUIT IS PERMITTED TO AN OUTFALL NODE.

I1	Group identifier	None
JFREE(I)	Number/name of outfall junction without tide gate (no back-flow restriction).	0
NBCF(I)	Type of boundary condition, from sequence of data group J1 - J4.	1

Outfalls with Tide Gates (1 line/outfall, 25 max.)

Note: ONLY ONE CONNECTING CONDUIT IS PERMITTED TO AN OUTFALL NODE.

I2	Group identifier	None
JGATE(I)	Number/name of outfall junction with tide gate (back-flow not allowed).	0
NBCG(I)	Type of boundary condition, from sequence of data groups Jl - J4.	1

VARIABLE	DESCRIPTION	DEFAULT

Boundary Condition Information

Note: Repeat sequence of data groups Jl-J4 for up to 20 different boundary conditions. Appearance in sequence (e.g., first, second... fifth...) determines value for NBCF and NBCG in data groups Il and I2.

J1	Group identifier	None
NTIDE(I)	Boundary condition index. 1 = No water surface at outfalls (elevated discharge), 2 = Controlling water surface at outfall at constant elevation Al (group J2), ft [m],	1

Types 3, 4 and possibly 5 are used for tidal variations at outfall.

3 = Tide coefficients (Group J2) provided by user,
4 = Program will compute tide coefficients,
5 = Stage-history of water surface elevations input by user. Program uses linear interpolation between data points.

Stage and/or Tidal Coefficients

Note: NOT REQUIRED (OMIT) IF NTIDE(I) = 1 OR 5 ON DATA GROUP Jl.

J2	Group identifier	None
Al(I)	First tide coefficient, ft [m].	0.0
W(I)	Tidal period, hours. Required only if NTIDE(I) = 3 or 4.	0.0

Note: NEXT SIX FIELDS NOT REQUIRED UNLESS NTIDE(I) = 3

VARIABLE	DESCRIPTION	DEFAULT
A2(I)	Second tide coefficient, ft [m].	0.0
A3(I)	Third tide coefficient, ft [m].	0.0
A4(I)	Fourth tide coefficient, ft [m].	0.0
A5(I)	Fifth tide coefficient, ft [m].	0.0
A6(I)	Sixth tide coefficient, ft [m].	0.0
A7(I)	Seventh tide coefficient, ft [m].	0.0

Tidal/Stage Information

REQUIRED ONLY IF NTIDE = 4 OR 5

J3	Group identifier	None
K0	Type of tidal input. = 0, Input is in the form of a time series of NI tidal heights. This parameter is not used if NTIDE equals 5. =1, Input is in the form of the high and low water values found in the tide tables, (HHW, LLW, LHW, and HLW). NI must be 4.	0
NI	Number of information points.	4
NCHTID	Tide information print control. = 0, Do not print information, = 1, Print information on tide coefficients or stage history.	1
DELTA	Convergence criterion for fitting of tidal function, ft [m]. Not required for NTIDE = 5.	0.005

VARIABLE	DESCRIPTION	DEFAULT

Time and stage information

REQUIRED IF NTIDE = 4 OR 5

J4	Group identifier	None
TT(l) -	Time of day, first information point, hours. (Increase hours past 24 if necessary.)	0.0
YY(I)	Tide/stage at time above, ft [m].	0.0
TT(2)	Time of day, second information points, hours.	0.0
YY(2)	Tide/stage, at time above, up to number	0.0

of points as defined by NI, ft [m].

Note**:** Enter 5 pairs of time and stage information per data line.
(Repeat group identifier on each line.)

User Input Hydrographs

IF NJSW = 0 (GROUP B3), SKIP DATA GROUPS Kl, K2 AND K3

Kl	Group identifier	None
NINC	Number of input nodes and flows per line in group K3.	1

VARIABLE	DESCRIPTION	DEFAULT
	Hydrograph Nodes	
K2	Group identifier	None
JSW(1)	First input node number for line hydrograph, or node name (enter in single quotes).	0
JSW(2)	Second input node number for line hydrograph, or node name (enter in single quotes).	0

Enter NINC nodes per line until NJSW nodes are entered.
(Repeat group identifier on each line.)

	User Input Hydrographs	
K3	Group identifier	None
TEO	Time of day, decimal hours.	0.0
QCARD(l,l)	F13w ratq for first input node, JSW(l), ft^3 [m^3].	0.0
QCARD(2,1)	Flsw rat I for second input node, JSW(2), ft^3 [m^3].	0.0

Enter TEO plus NINC flows per line until NJSW flows are entered. Enter TEO only on first of multiple ("wrapped around") lines and do not include group identifier K3 on lines that are "wrapped around.' Repeat the sequence for each TEO time. Times do not have to be evenly spaced; linear interpolation is used to interpolate between entries. The last K3 line will signal the end of the user hydrograph input. The last TEO value should be $\geq$ length of simulation. Increase TEO past 24 for multi-day simulations.

END OF EXTRAN DATA INPUT

Control now returns to the Executive Block of SWMM.

If no more SWMM blocks are to be called, end input with $ENDPROGRAM in columns 1-11.

Example:

```
* ==========================================================================
*                         EXAMPLE OF SWMM INPUT
*
* ===========================================================================
*   NBLOCKS   INBLK1  OUTBLK1   INBLK2  OUTBLK2
SW    2         8         12      12       0
MM    6   10   11   13   14   15   16
@     8   'EXAMPL.WPX'
@    11   'EXAMPL.HOT'
@    12   'EXAMPL.INT'
@    15   'EXAMPL.SMX'
@    16   'EXAMPL.PLT'
$COMBINE
A1  11
B1  '  A1=11 GENERATE HYDROGRAPH FROM WPX FILE '
B1  '  MAKE SWMM INTERFACE FILE          '
*
$EXTRAN
*       ALPHA
A1      ' EXISTING CONDITION '
A1      ' DESIGN STORM EVENT'
*       ISOL     KSUPER
B0      2        0      1
BB      1        0
B1     86400     1.00      0.0        1     3600     3600        0
B2            0       0    12.6     30   0.05
*      H-prnt Q-prnt  H-plot  Q-plot
B3     3       2       3       2      0      0    1
B4     101005  100022  101007
B5     1101005 1101015
B6     101005  100022  101007
B7     1101005 1101015
*
*=============================================*
*    1. ORIENT PARK SYSTEM
K_ent  K_exit K_orther Stretch
*=============================================*
*  TW
C1 1101005 0101005 0100022 0.0 1 0.0 5.00 0.00  80.0 4.95 4.85 0.024 0.0 0.0 0.5 1.0 0.0 1.0
C1 2101005 0101005 0100022 0.0 1 0.0 5.00 0.00  80.0 4.95 4.85 0.024 0.0 0.0 0.5 1.0 0.0 1.0
*  WEIR     0101007  0101005
C1 9101010 0101010 0101007 0.0 8 0.0 0.00 0.00 400.0 8.95 6.95 0.0 –9101010 0.0030 0.0
0.0    0.0     1.0
*----BROADWAY
C1 1101015  0101015  0101010   0.0 1   0.0   7.50   0.00   150.0   9.05   8.95  0.00960
0.0000   0.0000    0.5     1.0    0.0     1.0
*  UPGRADE
C1 1101025  0101025  0101015   0.0 1   0.0   7.00   0.00   450.0   9.15   9.05  0.01200
0.0000   0.0000    0.5     1.0    0.0     1.0
*  UPGRADE
C1 1101030  0101030  0101025   0.0 1   0.0   6.50   0.00    50.0   9.20   9.15  0.01200
0.0000   0.0000    0.5     1.0    0.0     1.0
C1 9101035  0101035  0101030   0.0 8   0.0   0.00   0.00   400.0  14.80   9.20  0.00000   -
9101035   0.0110    0.0     0.0    0.0     1.0
*----76TH ST.        PICTURE ERCP
*
C1 1101040  0101040  0101035   0.0 2   0.0   4.00   8.00    40.0  15.30  14.80  0.01200
0.0000   0.0000    0.5     1.0    0.0     1.0
C1 9101045  0101045  0101040   0.0 8   0.0   0.00   0.00   200.0  16.36  15.30  0.00000   -
9101045   0.0080    0.0     0.0    0.0     1.0
*----75TH ST.
C1 1101050  0101050  0101045   0.0 2   0.0   4.00   8.00    40.0  16.57  16.36  0.01200
0.0000   0.0000    0.5     1.0    0.0     1.0
C1 9101055  0101055  0101050   0.0 8   0.0   0.00   0.00   190.0  17.73  16.57  0.00000  -
9101055    0.0010    0.0     0.0    0.0     1.0
*----MISSOURI  ST.   L=? 115 OR 40
C1 1101060  0101060  0101055   0.0 2   0.0   4.00   8.00    40.0  18.23  17.73  0.01200
0.0000   0.0000    0.5     1.0    0.0     1.0
```

```
C1 9101065  0101065  0101060   0.0 8   0.0   0.00   0.00   160.0  19.70  18.23  0.00000  -
9101065    0.0030    0.0     0.0    0.0     1.0
*----ORIENT RD.
C1 1101070  0101070  0101065   0.0 2   0.0   4.00   8.00    50.0  19.75  19.70  0.01200
0.0000   0.0000    0.5    1.0    0.0     1.0
C1 9101075  0101075  0101070   0.0 8   0.0   0.00   0.00   150.0  20.25  19.75  0.00000  -
9101075    0.0050    0.0     0.0    0.0     1.0
*----FIRST ASSEMBLY OF GOD
C1 1101080  0101080  0101075   0.0 1   0.0   3.00   0.00    37.0  20.43  20.25  0.01200
0.0000   0.0000    0.5    1.0    0.0     1.0
C1 1101090  0101090  0101080   0.0 1   0.0   3.00   0.00    62.0  20.51  19.89  0.01200
0.0000   0.0000    0.5    1.0    0.0     1.0
C1 1101095  0101095  0101090   0.0 3   0.0   4.00   2.50   112.0  20.90  20.43  0.01200
0.0000   0.0000    0.5    1.0    0.0     1.0
C1 1101105  0101105  0101095   0.0 1   0.0   3.00   0.00   285.0  23.69  20.94  0.01800
0.0000   0.0000    0.5    1.0    0.0     1.0
*----21ST ST. NEW SURVEY
C1 1101115  0101115  0101105   0.0 3   0.0   2.50   4.42    64.5  25.09  25.00  0.03400
0.0000   0.0000    0.5    1.0    0.0    10.0
C1 2101115  0101115  0101105   0.0 3   0.0   2.67   4.33    64.5  25.60  25.48  0.03400
0.0000   0.0000    0.5    1.0    0.0    10.0
C1 9101120  0101120  0101115   0.0 6   0.0  13.90   6.20  1000.0  24.89  24.50  0.04000
1.1300   1.1300    0.0    0.0    0.0     1.0
*  PROPOSED DETENTION PONDS
*  WEIR         120      117
*  WEIR         117      115
*----RHODE ISLAND    48"CMP    L=230'
C1 1101127  0101127  0101120   0.0 1   0.0   4.00   0.00   230.0  26.12  24.89  0.02400
0.0000   0.0000    0.5    1.0    0.0    10.0
*----VERMONT DRIVE
C1 1101140  0101140  0101127   0.0 1   0.0   2.50   0.00    36.7  27.12  27.11  0.01200
0.0000   0.0000    0.5    1.0    0.0     2.0
C1 9101145  0101145  0101140   0.0 6   0.0  13.10   3.00   500.0  28.30  27.12  0.04000
2.3300   2.3300    0.0    0.0    0.0     1.0
C1 9101150  0101150  0101145   0.0 8   0.0   0.00   0.00   550.0  29.63  28.30  0.00000   -
9101150  0.0270    0.0    0.0    0.0     1.0
*----CORPOREX PARK DRIVE
C1 1101160  0101160  0101150   0.0 3   0.0   4.00   6.33   100.0  29.93  29.63  0.01200
0.0000   0.0000    0.5    1.0    0.0     1.0
C1 2101160  0101160  0101150   0.0 3   0.0   4.00   6.33   100.0  29.93  29.63  0.01200
0.0000   0.0000    0.5    1.0    0.0     1.0
*----CITICORP BLVD
C1 1101170  0101170  0101160   0.0 1   0.0   4.00   0.00   120.0  30.10  30.00  0.01200
0.0000   0.0000    0.5    1.0    0.0     1.0
*----BRANCH
C1 1101146  0101146  0101150   0.0 1   0.0   2.50   0.00    45.0  30.90  30.64  0.01200
0.0000   0.0000    0.5    1.0    0.0     1.0
C1 1101148  0101148  0101150   0.0 3   0.0   1.58   2.50    36.0  30.90  30.68  0.01200
0.0000   0.0000    0.5    1.0    0.0     1.0
C1 1101161  0101161  0101160   0.0 1   0.0   2.00   0.00    24.0  31.50  31.40  0.01200
0.0000   0.0000    0.5    1.0    0.0     1.0
C1 1101163  0101163  0101160   0.0 1   0.0   1.50   0.00    24.0  31.50  31.40  0.01200
0.0000   0.0000    0.5    1.0    0.0     1.0
C1 1101171  0101171  0101160   0.0 1   0.0   2.50   0.00    24.0  30.70  30.60  0.01200
0.0000   0.0000    0.5    1.0    0.0    10.0
*----BRANCH (Tributary O2)
C1 1101210  0101210  0101120   0.0 1   0.0   2.00   0.00    72.0  28.84  28.15  0.01200
0.0000   0.0000    0.5    1.0    0.0     1.0
C1 1101220  0101220  0101210   0.0 1   0.0   1.25   0.00    70.0  29.36  28.84  0.01200
0.0000   0.0000    0.5    1.0    0.0     1.0
C1 2101220  0101220  0101210   0.0 1   0.0   1.25   0.00    66.0  29.74  29.64  0.01200
0.0000   0.0000    0.5    1.0    0.0     1.0
C1 1101235  0101235  0101220   0.0 1   0.0   1.25   0.00   140.0  30.08  29.49  0.02400
0.0000   0.0000    0.5    1.0    0.0     1.0
C1 1101245  0101245  0101235   0.0 1   0.0   2.00   0.00   130.0  31.85  31.21  0.01200
0.0000   0.0000    0.5    1.0    0.0     1.0
*----BRANCH
C1 9101430  0101430  0101425   0.0 6   0.0  12.00   1.50   687.0  29.93  29.63  0.04000
1.4000   1.4000    0.0    0.0    0.0     1.0
C1 9101435  0101435  0101430   0.0 6   0.0  13.00   6.00   250.0  30.55  29.33  0.04000
1.2000   1.2000    0.0    0.0    0.0     1.0
```

```
C1 1101445  0101445  0101435   0.0 1   0.0   1.50   0.00    38.0  30.99  30.22  0.02400
0.0000    0.0000    0.5     1.0    0.0     1.0
C1 1101450  0101450  0101445   0.0 1   0.0   1.50   0.00    38.0  30.86  30.75  0.01200
0.0000    0.0000    0.5     1.0    0.0     1.0
*----BRANCH-BETWEEN ORIENT PARK & JUDSON CREEK
*  TW
C1 1101505  0101505  0100025   0.0 1   0.0   4.00   0.00    50.0  22.86  22.76  0.01200
0.0000    0.0000    0.5     1.0    0.0     1.0
C1 1101520  0101520  0101505   0.0 1   0.0   5.00   0.00   120.0  21.08  21.21  0.02400
0.0000    0.0000    0.5     1.0    0.0     1.0
*- WEIR     0101535  0101520
*
*
*   CHANNEL IMPROVEMENTS  UP TP 1070
* --- Natural Channel Da  1005
C2  0.040    0.040    0.035
C3  9101010        6   100.00   130.00     0.00     0.00   400.00     0.00     0.00
C4  21.500   99.900
    15.500  100.000
    10.300  110.000
    10.300  120.000
    15.500  130.000
C4  21.500  130.100
* ---- Natural Channel Da  1030
C2   0.040    0.040    0.035
C3   9101035        7   100.00   130.10     0.00     0.00   400.00     0.00     0.00
C4   29.500   99.900
     19.500  100.000
     14.400  107.600
     13.900  112.600
     14.600  117.100
C4   19.200  130.100
     29.200  130.200
* ---- Natural Channel Da  1040
C2   0.040    0.040    0.035
C3   9101045    7   100.00   128.00     0.00     0.00   200.00     0.00     0.00
C4   31.400   99.900
     21.400  100.000
     17.300  105.000
     17.100  113.000
     18.200  121.000
C4   22.500  128.000
     32.500  128.100
* --*-- Natural Channel Da  1050
C2    0.040    0.040    0.035
C3   9101055        7   100.00   120.00     0.00     0.00   190.00     0.00     0.00
C4    31.700   99.900
      21.700  100.000
      18.500  108.600
      18.200  112.300
      18.500  116.000
C4    22.000  120.000
      32.000  120.100
* ----Natural Channel Da  1060
C2    0.040    0.040    0.035
C3    9101065        7   100.00   123.80     0.00     0.00   160.00     0.00     0.00
C4    32.100   99.900
      22.100  100.000
      18.900  105.700
      18.600  113.050
      18.900  120.400
C4    21.900  123.800
      31.900  123.900
*     CHANNEL IMPROVEMENTS UP TO D/S OF ORIENT ROAD
* ---- Natural Channel Da  1070
C2    0.040    0.040    0.040
C3    9101075        7   100.00   122.00     0.00     0.00   150.00     0.00     0.00
C4    33.500   99.900
      23.500  100.000
      20.000  103.000
      19.700  110.000
```

```
      19.700  117.000
C4    23.600  122.000
      33.600  122.100
* ---- Natural Channel Da  1145
C2    0.040    0.040    0.040
C3    9101150        7   100.00   115.50     0.00     0.00   550.00     0.00     0.00
C4    40.600   99.900
      30.600  100.000
      28.800  103.700
      28.200  107.900
      28.700  112.100
C4    30.500  115.500
      40.500  115.600
*==================================================*
*
D1    0100025     99     22.76    0    27.00
D1    0100026     99     24.45    0    28.00
D1    0100027     99     24.45    0    28.00
*------------------------------------------*
*     SOUTH SYSTEM
*     Orient Park Outfall
*------------------------------------------*
D1    0101005      99     4.95     0    9.70
D1    0101007      99     6.95     0    9.70
D1    0101010      99     8.95     0    9.70
D1    0101015      99     9.05     0    9.70
*D    0101020      99     9.15     0    9.70
D1    0101025      99     9.15     0    9.70
D1    0101030      99     9.20     0    9.70
D1    0101035      99    14.80     0   14.80
D1    0101040      99    15.30     0   15.40
D1    0101045      99    16.36     0   16.46
D1    0101050      99    16.57     0   16.57
D1    0101055      99    17.73     0   17.73
D1    0101060      99    18.23     0   18.39
D1    0101065      99    19.70     0   19.70
D1    0101070      99    19.75     0   19.85
D1    0101075      99    20.25     0   20.25
D1    0101080      99    20.43     0   20.53
D1    0101090      99    20.43     0   20.53
D1    0101095      99    20.90     0   21.00
D1    0101105      99    23.69     0   23.79
D1    0101115      99    24.50     0   24.50
*
*     PROPOSED POND LOCATION
D1    0101117      99    24.50     0   24.50
*
D1    0101120      99    24.89     0   24.99
D1    0101127      99    26.12     0   26.12
D1    0101140      99    27.12     0   27.12
D1    0101145      99    28.30     0   28.40
D1    0101146      99    30.90     0   32.30
D1    0101147      99    31.99     0   32.30
D1    0101148      99    30.90     0   32.30
D1    0101149      99    31.54     0   32.30
D1    0101150      99    29.63     0   32.30
D1    0101151      99    32.40     0   32.50
D1    0101160      99    29.93     0   32.30
D1    0101161      99    31.50     0   32.30
D1    0101162      99    31.50     0   32.30
D1    0101163      99    31.50     0   32.30
D1    0101164      99    31.50     0   32.30
*D    0101165      99    27.90     0   32.30
D1    0101170      99    30.10     0   32.30
D1    0101171      99    30.70     0   32.30
D1    0101172      99    32.76     0   32.86
* Trib. O2
D1    0101210      99    28.84     0   28.94
D1    0101215      99    29.36     0   29.46
D1    0101220      99    29.36     0   29.34
D1    0101235      99    30.08     0   30.18
```

```
D1    0101245      99    31.85     0   31.95
D1    0101305      99    20.75     0   20.85
* Trib. East of Orient Rd.
D1    0101425      99    29.63     0   29.73
D1    0101430      99    29.33     0   29.43
D1    0101435      99    30.22     0   30.32
D1    0101445      99    30.75     0   30.85
D1    0101450      99    28.98     0   29.08
* TL TAKEOFF
D1    0101505      99    21.21     0   27.00
D1    0101520      99    21.08     0   27.00
D1    0101535      99    25.69     0   25.79
*---------------------------------
*      SOUTH SYSTEM
*---------------------------------
*--------------------------------*
E1    0101007      99    5000     0
E1    0101025      99    2000     0
E1    0101065      99    2000     0
E1    0101080      99    2000     0
E1    0101090      99    2000     0
E1    0101095      99    2000     0
E1    0101145      99    2000     0
E1    0101146      99    2000     0
E1    0101148      99    2000     0
E1    0101150      99    5000     0
E1    0101161      99    2000     0
E1    0101163      99    2000     0
E1    0101171      99    2000     0
E1    0101210      99    2000     0
E1    0101215      99    2000     0
E1    0101220      99    2000     0
E1    0101235      99    6000     0
E1    0101425      99    2000     0
E1    0101505      99    2000     0
*  ===================================
E1    0101005      99      -1     6
E2      0.10    4.95
        0.15   10.11
        0.20   10.12
        1.20   13.12
        3.19   15.12
        6.69   17.12

E1    0101015      99      -1     5
E2      0.10    9.05
        0.15   18.99
        3.47   19.00
        4.42   20.00
        5.23   21.00

E1    0101030      99      -1     5
E2      0.10    9.20
        0.15   18.99
        1.99   19.00
        3.07   20.00
        6.63   21.00

E1   0101040      99      -1     4
E2      0.10    15.30
        0.15    20.00
        0.20    22.00
        0.91    23.00

E1    0101050      99      -1     5
E2      0.10    16.57
        0.15    20.00
        0.68    22.00
        1.65    23.00
        2.17    24.00
```

```
E1    0101060      99      -1     5
E2      0.10    18.23
        0.15    20.00
        0.35    22.00
        1.24    23.00
        2.02    24.00

E1    0101075      99      -1     7
E2      0.10    20.25
        0.15    21.99
        0.20    22.00
        0.90    23.00
        4.88    24.00
        8.86    25.00
       11.44    26.00
*
E1    0101105      99      -1     6
E2      0.10    23.69
        0.20    25.99
        1.00    26.00
        1.50    28.00
        2.00    30.00
        2.50    32.00
*     REVISED FOR PROPOSED DETENTION POND
E1    0101115      99      -1     6
E2      0.10    24.50
        0.15    28.99
        0.29    29.00
        0.93    30.00
        1.67    31.00
        1.72    32.00
*     PROPOSED DETENTION POND BETWEEN RHODE ISLAND & 21ST AVE.
E1    0101117      99      -1     6
E2      3.70    24.50
        4.00    26.50
        4.30    28.50
        5.93    30.00
        8.67    31.00
       11.72    32.00

E1    0101120      99      -1     6
E2      0.10    24.89
        0.15    28.99
        0.16    29.00
        0.83    30.00
        1.73    31.00
        2.46    32.00

E1    0101127      99      -1     5
E2      0.10    26.12
        0.15    29.99
        0.20    30.00
        0.91    31.00
        1.95    32.00

E1    0101140      99      -1     4
E2      0.10    27.12
        0.15    30.99
        0.30    31.00
        1.37    32.00

E1    0101147      99      -1     4
E2      0.51   31.99
        0.81   33.00
        0.91   36.00
        0.91   38.00

E1    0101149      99      -1     4
E2      1.05    31.54
        1.05    33.00
        1.10    34.23
```

	1.32	35.00		
E1	0101151	99	-1	4
E2	0.10	32.40		
	3.22	33.00		
	6.04	34.00		
	8.74	35.00		
E1	0101160	99	-1	4
E2	0.10	29.93		
	25.22	31.00		
	36.95	33.00		
	50.22	35.00		
E1	0101162	99	-1	5
E2	1.30	31.5		
	1.59	33.00		
	2.67	34.00		
	3.37	35.00		
	3.50	36.00		
E1	0101164	99	-1	4
E2	1.00	31.50		
	1.34	33.00		
	1.88	34.00		
	2.00	36.00		
E1	0101170	99	-1	4
E2	0.10	30.10		
	0.51	32.00		
	2.19	34.00		
	9.81	35.00		
E1	0101172	99	-1	3
E2	0.50	32.76		
	0.98	34.00		
	1.00	37.00		
E1	0101245	99	-1	5
E2	0.10	31.85		
	0.15	32.50		
	0.63	34.00		
	2.11	35.00		
	4.16	36.00		
E1	0101305	99	-1	4
E2	0.10	20.75		
	0.17	24.00		
	1.43	25.00		
	3.87	26.00		
E1	0101450	99	-1	4
E2	0.10	28.98		
	0.49	30.00		
	0.82	31.00		
	3.85	32.00		
E1	0101520	99	-1	7
E2	0.10	21.08		
	0.15	24.90		
	0.20	25.00		
	0.52	26.00		
	2.50	27.00		
	4.81	28.00		
	11.25	29.00		
E1	0101535	99	-1	4
E2	0.10	25.69		
	0.15	28.00		
	0.22	29.00		

```
        0.30    30.00
*------------------------------------------*
*  South system Orifice
*------------------------------------------*
*
F1    0101147  0101147  0101146     1   2.40  0.6   0.00
F1    0101149  0101149  0101148     1   1.69  0.6   0.00
*------------------------------------------*
*     ORIENT PARK
*------------------------------------------*
G1    8101007  0101007  0101005     1    9.20   99  14  3.1    1
G1    7101015  0101015  0101010     1   19.00   99  18  2.6    1
G1    7101025  0101025  0101015     1   19.00   99  24  2.6    1
G1    7101030  0101030  0101025     1   19.00   99  22  2.6    1
G1    7101040  0101040  0101035     1   21.99   99  28  2.6    1
G1    7101050  0101050  0101045     1   22.42   99  24  2.6    1
G1    7101060  0101060  0101055     1   22.35   99  24  2.6    1
G1    7101070  0101070  0101065     1   24.20   99  24  2.6    1
*----------------------------------*
*     CHURCH SITE ROAD OVERTOPPING WEIR
*     BASED ON SITE OBSERVATION  RULE*3
*----------------------------------*
G1    7101080  0101080  0101075     1   24.23   99  36  2.6    1
G1    7101090  0101090  0101080     1   24.80   99  36  2.6    1
G1    7101095  0101095  0101090     1   25.40   99  48  2.6    1
G1    7101105  0101105  0101095     1   28.52   99  36  2.6    1
G1    7101115  0101115  0101105     1   31.44   99  35  2.6    1
*     PROPOSED DETENTION & CONTROL STRUCTURE
G1    8101120  0101120  0101117     1   26.00   99  20  3.1    1
G1    8101117  0101117  0101115     1   28.00   99  20  3.1    1
*
G1    7101127  0101127  0101120     1   30.08   99  16  2.6    1
G1    7101140  0101140  0101127     1   31.10   99  10  2.6    1
G1    7101160  0101160  0101150     1   37.26   99  51  2.6    1
G1    7101170  0101170  0101160     1   36.35   99  16  2.6    1
*
G1    6101147  0101147  0101150     1   36.00   99  50  2.6    1
G1    6101149  0101149  0101150     1   34.23   99  50  2.6    1
G1    7101151  0101151  0101145     1   32.50   99  50  2.6    1
G1    7101162  0101162  0101160     1   35.00   99  50  2.6    1
G1    7101164  0101164  0101160     1   35.00   99  50  2.6    1
G1    7101172  0101172  0101160     1   36.45   99  50  2.6    1
G1    7101235  0101235  0101120     1   34.00   99  50  2.6    1
G1    6101245  0101245  0101151     1   35.30   99  50  2.6    1
G1    8101305  0101305  0101075     1   20.75 22.75  1.4 3.31   1
G1    7101305  0101305  0101075     1   24.29   99   50  2.6    1
G1    7101127  0101127  0101425     1   31.00   99   50  2.6    1
G1    8101127  0101127  0101425     1   29.74   99   0.8 3.1    2
G1    6101535  0101535  0101520     1   29.50   99   50  2.6    1
*- --------------------------*
I1  0100024      1
I1  0100025      2
I1  0100026      3
I1  0100027      4
* J-CARD GROUP 1
J1  5
J3  0  3  1
J4  0   2.5  15   2.5  240   2.5
* J-CARD GROUP 2
J1  5
J3  0  3  1
J4  0  27.0  15  27.0  240  27.0
* J-CARD GROUP 3
J1  5
J3  0  3  1
J4  0  27.0  15  27.0  240  27.0
* J-CARD GROUP 4
J1  5
J3  0  3  1
J4  0  28.0  15  28.0  240  28.0
$ENDPROGRAM
```

APPENDIX A, OVERLAND FLOW
MANNING'S N VALUES

Basin Type	Recommended value	Range of values
Concrete	0.011	0.01 - 0.013
Asphalt	0.012	0.01 - 0.015
Bare Sand	0.010	0.010 -- 0.016
Graveled Surface	0.012	0.012 - 0.030
Bare Clay-loam (eroded)	0.012	0.012 - 0.033
Fallow (no residue)	0.05	0.006 - 0.16
Chisel Plow (<1/4 tons/acre residue)	0.07	0.006 - 0.17
Chisel Plow (1/4 - 1 tons/acre residue)	0.18	0.07 -- 0.34
Chisel Plow (1 - 3 tons/acre residue)	0.30	0.19 -- 0.47
Chisel Plow (>3 tons/acre residue)	0.40	0.34 -- 0.46
Disk/Harrow (<1/4 tons/acre residue)	0.08	0.008 - 0.41
Disk/Harrow (1/4 -1 tons/acre residue)	0.16	0.10 -- 0.25
Disk/Harrow (1 - 3 tons/acre residue)	0.25	0.14 -- 0.53
Disk/Harrow (>3 tons/acre residue)	0.30	N/A
No Till (<1/4 tons/acre residue)	0.04	0.03 -- 0.07
No Till (1/4 - 1 tons/acre residue)	0.07	0.01 -- 0.13
No Till (1 - 3 tons/acre residue)	0.30	0.16 -- 0.47
Plow (fall)	0.06	0.02 -- 0.10
Coulter	0.10	0.05 -- 0.13
Range (natural)	0.13	0.01 -- 0.32
Range (clipped)	0.08	0.02 -- 0.24
Grass (bluegrass sod)	0.45	0.39 -- 0.63
Short grass praire	0.15	0.10 -- 0.20
Dense grass	0.24	0.17 -- 0.30
Bermudagrass	0.41	0.30 -- 0.48
Woods	0.45	N/A

APPENDIX B

CULVERT ENTRANCE LOSS COEFFICIENTS
OUTLET CONTROL, FULL OR PARTIALLY FULL

Type of Structure and Design of Entrance	Coefficient k_e
Pipe, Concrete	
Projecting from fill, socket end (groove-end)	0.2
Projecting from fill, square cut end	0.5
Straight headwall	
Socket end of pipe (groove-end)	0.2
Square-edge	0.5
Rounded (radius = 1/12D) (Indexes 250, 251, 252, 253, 255)	0.2
Mitered to conform to fill slope (Indexes 272, 273, 274)	0.7
End section conforming to fill slope'	0.5
Beveled edges, 33.7° or 45° bevels	0.2
Side- or slope-tapered inlet	0.2
Straight sand-cement (Index 258)	0.3
U-type with grate (Index 260)	0.7
U-type (Index 261)	0.5
Winged concrete (Index 266)	0.3
U-type sand-cement (Index 268)	0.5
Flared end concrete (Index 270)	0.5
Side drain, mitered with grate (Index 273)	1.0
Pipe or Pipe-Arch, Corrugated Metal	
Straight endwall--rounded (Radius=1/12 D) (Index 250)	0.2
Projecting from fill (no headwall)	0.9
Headwall or headwall and wingwalls, square-edge	0.5
Mitered to conform to fill slope (Indexes 272, 273, 271)	0.7
End section conforming to fill slope, paved or unpaved*	0.5
Beveled edges, 33.7° or 45° bevels	0.2
Side- or slope-tapered inlet	0.2
Box, Reinforced Concrete	
Headwall parallel to embankment (no wingwalls)	
Square-edged on three edges	0.5
Rounded on three edges to radius of 1/12 barrel dimension, or beveled edges on three sides (Index 290)	0.2

APPENDIX B (continue)

CULVERT ENTRANCE LOSS COEFFICIENTS
OUTLET CONTROL, FULL OR PARTIALLY FULL

Type of Structure and Design of Entrance	Coefficient k_e
Wingwalls at 30^o to 75^o to barrel	
Square-edged at crown	0.4
Crown edge rounded to radius of 1/12 barrel dimension, or beveled top edge	0.2
Wingwalls at 10^o to 25^o to barrel, square-edged at crown	0.5
Wingwalls parallel (extension of sides)	
Square edged at crown	0.7
Side- or slope-tapered inlet	0.2

*End sections conforming to fill slope, made of either metal or concrete, are the sections commonly available from manufacturers. From limited hydraulic tests, they are equivalent in operation to a headwall in both inlet and outlet control. Some end sections incorporating a closed taper in their design have a superior hydraulic performance.

Note: Entrance head loss, $H_e = K_e \frac{V^2}{2g}$

Reference : USDOT, FHWA, HEC-5 (1965).