Documentation for P8 Version 2.0

prepared for

Wisconsin Department of Natural Resources
and
Minnesota Pollution Control Agency

by

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The following pages contain text from help screens describing revisions to the model. The revised model will read case files created by previous versions. The storm data file format has been revised. Storm files used with the previous version must be converted using the separate utility 'P8CONV.EXE'.

P8 Version 2.0 Enhancements - June 1997

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-> Runoff driven by rainfall & snowmelt. Snow accumulation & melt
   driven by total precip & air temperature.  Modified algorithm
   for pervious area runoff taken from GWLF model (Haith et al, 1992)

-> Option to specify effective runoff coefficient for impervious area
   in any watershed

-> Simplified precipitation data file format.  External utility
   'P8CONV.EXE' translates Version 1 storm files for use with Version 2.

-> Enhanced street sweeping routine

-> Modified case file format.  Reads Version 1 case files.

-> New detailed output formats - see 'List Files'

-> Date formating changed for survival in new millenium

See 'Help   New in Version 2.0' for more details.
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Changes to P8 Menu Structure

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P8 Version 1.1         P8 Version 2.x
'Utilities Convert'    precip file conversion in separate utility P8CONV.EXE
'List Violations'      consolidated with 'List Detailed'
'Case Edit TimeSteps'  replaced by 'Case Edit Other'
'Utilities Convert'    replaced by 'List Files ...'
'List Detailed'        provides concentration statistics only
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NA 'Plot Events Rain+Melt' (rainfall + snowmelt)
NA 'Plot Events SnowMelt'

Air temperature file specified on 'Case Edit First' screen instead of 'Case Edit Evapotranspiration' screen.

Snowmelt & other global parameters specified on 'Case Edit Other' Screen.

Viewing & Saving Output

Requested table output is automatically directed to file 'OUTPUT.PRN'.

Output file is displayed after completion of calculations.

Bottom line shows viewing options.

Use keypad to move backward or forward through output file.

Press <F8> to make a permanent copy of output for later use.

File viewer is restricted to 80 columns.

Precipitation & Air Temperature Data

Runoff simulations are driven by continuous hourly precipitation & daily air temperature time series. Runoff results from rainfall and snowmelt. A file of hourly precipitation files from the Providence Airport weather station is provided. A separate utility 'P8CONV.EXE' can be used to translate hourly precipitation data files obtained from the National Climatic Data Center and other sources. There is no limit (except for disk storage capacity) on the length of precipitation files.

Short storm sequences ("design storms") can be used in preliminary model runs. Experience with the model indicates that a reasonable approximation of long-term-average particle removal efficiency can be achieved by using a 1-inch, 24-hr, SCS Type II design storm with a 75-hour interval between storm midpoints.

Air temperatures are used in computing evapotranspiration & snowfall/ snowmelt. A file containing daily values from Providence Airport (1969-1988) is provided.

Precipitation Data Files

The following precipitation input files are provided:

PROV6987.PCP - Providence Airport

TYPE2.PCP
24-hour, SCS Type 2 Storm, 1-inch, 75-hr interval

AVERAGE.PCP
one average storm, .4 inches, 6-hr duration, 75-hr interval

Air Temperature File & Offset

Mean daily air temperature drives simulation of evapotranspiration from aquifer devices & snowfall/snowmelt.

File contains one record per month in the following format:

YYYY MM T1 T2 ..... TN

where,

YYYY = calendar year (YY format recognized & converted to YYYY)
MM = month
Ti = mean daily air temperature for day i of month, N=days/month

Sample file = 'PROV6988.TMP' Providence Airport

If valid file name is specified on P8 file input screen ('Case Edit First'), values from file will be used. Otherwise, long-term monthly-mean air temps specified on evapotranspiration input screen will be used.

AIR TEMPERATURE OFFSET is added to input air temperatures from either source. It adjusts input data for differences in elevation. Air temp. typically declines by 3-5 deg F for each 1000 ft of elev.

Impervious Area Runoff Simulation

Runoff from impervious areas is governed by the following equations:

Yt = cumulative rainfall + snowmelt at end of hour t in current event (in)
yt = incremental rainfall + snowmelt occuring in hour t (in)
Si = impervious depression storage for watershed i (inches)
Fi = runoff coefficient for impervious areas in watershed i (dimensionless)
Et = cumulative excess rainfall + snowmelt at end of hour t (inches)
rit = impervious runoff rate in hour t (inches/hr)
qit = infiltration rate from impervious area in hour t (inches/hr)

cumulative rain+melt:	Yt = Yt-1 + yt
excess rain+melt:	Et = MAX [(Yt-Si),0]
runoff:	rit = Fi (Et - Et-1)
infiltration:	qit = (1 - Fi) (Et - Et-1)

Particle washoff is goverened by sum of rit & qit. In P8 Version 1.1, impervious runoff coefficients (Fi) were fixed at 1.0.

Impervious Area Runoff Coefficient

In P8 Version 1.1, runoff from impervious areas equalled precip in excess of depression storage. This assumption is probably appropriate to generate conservative BMP designs in absence of site-specific calibration data. In P8 Version 2.0, an imperv runoff coef. (0 to 1) can be specified. If < 1, remainder of excess rainfall & snowmelt is assumed to infiltrate & is routed to specified AQUIFER device. Value entered on watershed input screen.

Value	Description
1.0	Recommended to produce conservative BMP designs
0.9	'Simple Method' Schueler (1987)
0.54	Wisconsin Residential Watershed (Monroe Street, 233 acres)
0.76	Wisconsin Mixed Urban Watershed (Lincoln Creek, 6399 acres)

Nearly same effect can be generated by adjusting imperv. area ('effective imperv area' <= total) & setting imperv. runoff coefs = 1. This method increases size of pervious area (generating more pervious runoff) instead of generating infiltration.

Street Sweeping Parameters & Particle Load Factors

Each watershed can have up to 2 types of impervious surfaces (SWEPT and NOT SWEPT) (e.g., streets/parking areas vs. rooftops)

SWEEPING START DATE	mmdd	first julian date of sweeping (def =0101)
SWEEPING STOP DATE	mmdd	last julian date of sweeping (def = 1231)

adjust values to reflect seasonal sweeping schedule (e.g., nonwinter)

SCALE FACTOR FOR SWEEPING EFFICIENCY (normally = 1)

multiplied by SWEEPER EFFICIENCY values specied on Particle Input Screen
adjust upwards to reflect tight parking controls
adjust downwards to reflect weak or no parking controls

SCALE FACTOR FOR PARTICLE LOADS (normally = 1)
applied to each predicted particle loads for each impervious area type

Curve Number Adjustment based on Antecedent Moisture Condition

Reference: GWLF Model (Haith et al, 1992)

P5 = 5-day antecedent rainfall + snowmelt (prior to start of event)
T5 = 5-day antecedent average air temperature at start of event (deg-F)
RAMC2, RAMC3 = P5 value corresponding to AMC 2 & 3 (inches)
CN1,CN2,CN3 = curve numbers for amc 1, 2, & 3 for current event
TFREEZE = T5 value forcing AMC 3 (deg-F)
RAMC2 & RAMC3 defined separately for growing & non-growing seasons.

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CN1 = CN2 / (2.334 - .01334 CN2 )
CN3 = CN2 / (0.04036 + .0059 CN2 )

IF (T5 < TFREEZE) or (Snowmelt Event) or (P5 >=RAMC3), then
    CN = CN3
Else If P5 <=RAMC2, then
    CN = CN1 + (CN2 - CN1)*P5/RAMC2
Else
    CN = CN2 + (CN3 - CN2)*(P5 - RAMC2)/(RAMC3 - RAMC2)
Endif
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SnowFall / SnowMelt Simulation

Simulation is water blance with melting governed by SCS degree-day equation.

Tair = mean daily air temperature (deg-F)
St = snowpack at end of hour t (inches, water equivalent)
Mt = snowmelt occuring in hour t (inches)
Pt = total precipitation in hour t (inches)
Rt = rainfall occuring in hour t (inches)
Xt = snowfall occuring in hour t (inches)
Tsnow = air temperature generating snowfall (deg-F)
Tmelt = minimum air temperatore for snowmelt (deg-F)
SMCoef = snowmelt coefficient (inches/degreeF-day)

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If Tair <= Tsnow,  then Xt = Pt, Rt = 0
                   else Xt = 0, Rt = Pt

St = St-1 + Xt - Mt

Mt = MIN [ MAX [ 0., SMCoef ( Tair - Tmelt )/24 ] , St-1 + Xt ]
```

Sum of Mt & Rt drives runoff simulation from pervious & impervious areas.

Snowfall & Snowmelt Parameters

Precipitation is snow if air temp <= SNOWFALL TEMP, rain otherwise.

Snowmelt occurs if air temp >= SNOWMELT TEMP & Snowpack exists.

Rate of snowmelt governed by degree-day equation:

Snowmelt Rate (in/day) = SNOWMELT COEF x (Air Temp - SNOWMELT TEMP)

Rate is expressed in water-equivalents (not actual snow depth).

Typical values for SNOWMELT COEF = 0.04 - 0.16 inches/day/deg-f Leeden et al. (1990).

Snowfall is assumed to be uniformly distributed over each watershed.

The sum of rainfall & snowmelt generates runoff.

Snowmelt Coefficient

The rate of snowmelt is governed by the SCS degree-day equation:

SnowMelt (inches/day) = MeltCoef x (AirTemp - MeltTemp)

MeltTemp = 32 deg F (typically)

Typical Values for MeltCoef (in/day/deg-F)

GLWF	.098	Haith et al, 1992
various studies	.03-.16	Water Encyclo,Leeden et al.,1995
heavily forested / north slopes	.04-.06	SCS National Eng Handbook 1964
open country / south slopes	.06-.08	" "
average	.06	" "

Appropriate value correlated with specified maximum abstraction scale FACTOR for snowmelt. SCS values (e.g., .04-.08) assume FACTOR ~0 (all melt becomes runoff. Higher values (e.g. GWLF = .098) assume FACTOR = 1 (melt driven by curve number).

Simulating Runoff from Frozen Soil

The Soil Freeze Temperature (TFreeze,'Case Edit Others' input screen) can be adjusted to control the rate of runoff from pervious areas when the soil is likely to be frozen.

At the start of each event, P8 computes the 5-day-average antecedent air temperature (TAir). If TAir < TFreeze, the following adjustments are made to the runoff simulation for the duration of the event:

-> Antecedent Moisture Condition = 3

-> Maximum Abstraction computed from Curve Number is multiplied by the SCALE FACTOR for maximum abstraction specified on the 'Case Edit Others' screen. SCALE FACTOR would range from 0-1. If SCALE FACTOR = 0, the soil will be treated as completely impervious.

This capability has been included to permit simulation of conditions in northern climates (e.g., long cold spell followed by rainfall). To turn this option off, set Tfreeze to a very low number (e.g.,-50).

Scale Factor for Maximum Abstraction Under SnowMelt or Frozen Conditions

SCALE FACTOR influences simulation of snowmelt from pervious areas. SCALE FACTOR modifies maximum abstraction (inches) computed from the curve number (CN) during events triggered by snowmelt or when the average 5-day antecedent air temperature is < TFREEZE. Typically, this would be between 0 and 1. The Default value is 1.

Value	Result
1	maximum abstraction unmodified (assumed in GWLF model)
.5	maximum abstraction is reduced by 50%
0	all snowmelt & rainfall in current event become surface runoff

MAXIMUM ABSTRACTION = 100 x (100 / CN - 10) x SCALE FACTOR

This is provided as a empirical calibration factor for snowmelt periods.

Aquifer Depletion Impacts on ET Rate & Base Flow Computations

AQUIFER devices are used to simulate stream base flow according to the following equations:

Aquifer Outflow = Stream Base Flow = 2.303 x Aquifer Volume / TOC
Aquifer Inflow = Percolation from Watersheds + Exfiltration from Devices
Change in Aquifer Volume = Inflow - Outflow - ET

where TOC = time of concentration & ET = Evapotranspiration rate.

The ET rate is set to 0.0 if it results in a negative aquifer volume. This will tend to happen in summer dry spells with low aquifer TOC. This may cause under-estimation of ET & over-estimation of Base Flow. Warning messages are issued if this situation occurs.

This effect can be reduced by increasing Aquifer TOC and/or by increasing the number of PASSES through the storm file

'List Detailed'

Lists detailed statistical summary of event-, hourly-, or daily-mean values for each outlet or mass-balance term.

Calculates exceedence frequencies for water quality components.

Only non-zero events or intervals are considered. If no flow occurs for a given device, event, & mass-balance term, it is not included in the statistical summary. Statistics are flow-weighted across events or time intervals. Exceedence frequencies represent fraction of flow volume.

'Events' - Summary of event-mean values
'Hourly' - Summary of hourly-mean values (traced devices only)
'Daily' - Summary of n-day average values (" "), n = user specified

This format replaces 'List Violations' in P8 Version 1.0.

'List Files'

Use these routines to convert model output files to ASCII (text) format for later use by spreadsheets, word-processors, etc.

'Summary'	SUMMARY.PRN	Total Flows & Flow-Weighted-Mean Concs
'Daily'	DAILY.PRN	Daily Total Rainfall & Snow Simulation
'Events'	EVENTS.PRN	Rainfall, Snowfall, AMC Calcs by Event
'Loads'	LOADS.PRN	Total Flow & Loads by Event
'Concs'	CONCS.PRN	Flow-Weighted-Mean Concentrations by Event
'Traced'	TRACEnn.PRN	Hourly or Daily-Average for Traced Devices

The first 80 columns of each output file is displayed. Use Keypad to scroll forward or backward through file. Press <F8> to save file with a new name for subsequent use outside of P8.