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# BASINS Technical Note 3

## NPSM/HSPF Simulation Module Matrix

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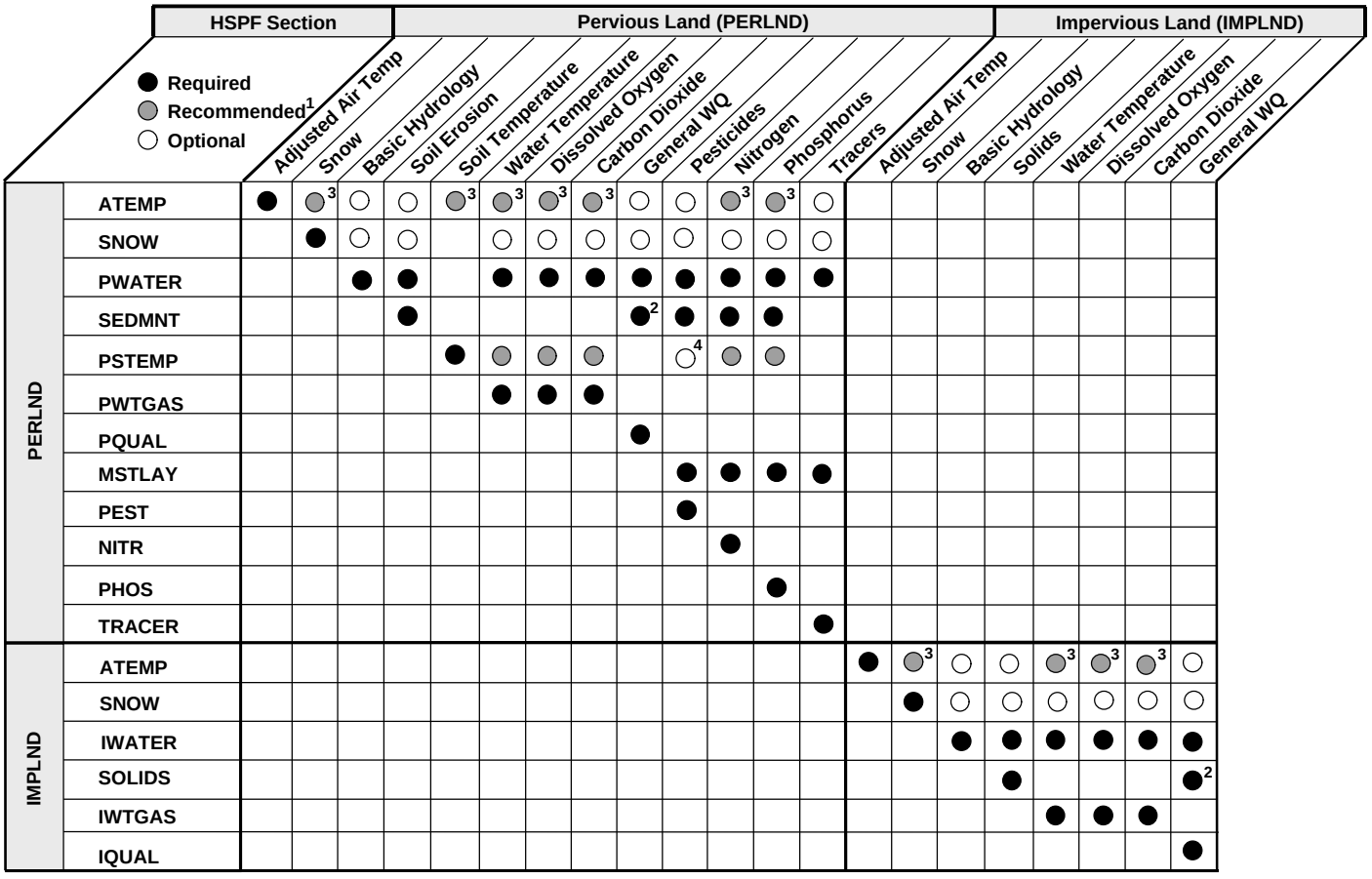
March 31, 1999

The Nonpoint Source Model (NPSM), the GIS and Windows interface to the Hydrologic Simulation Program Fortran (HSPF), is a flexible watershed simulation model that permits users to simulate a large number of pollutants over a range of simplistic to complex formulations. The HSPF program has a modular structure in which pervious and impervious land segments define the first two modules, and free flowing reaches and reservoirs define the third. Each module contains specialized algorithms, or sections, for simulating the environmental fate processes important to a particular pollutant or group of pollutants (e.g. the pesticide section simulates absorption/desorption and volatilization). While all modules and sections can be selected, the typical model simulation requires only a limited selection. Additionally, however, some sections are dependent on output from other modules and NPSM/HSPF will not function with an improper combination of sections selected. Also, by starting simple and gradually building the model's complexity, a user increases their ability to trap errors and will thus reduce the time required to build a functioning, complex NPSM/HSPF simulation. Finally, some sections need not be simulated as long as the user can supply a time-series of data for the output from that section. This technical note, then, is meant to answer the following two key questions: 1)What is the minimum necessary set of modules and sections for modeling my pollutant of concern?; and 2) In what order should I add modules such that I can slowly build the complexity of my model?

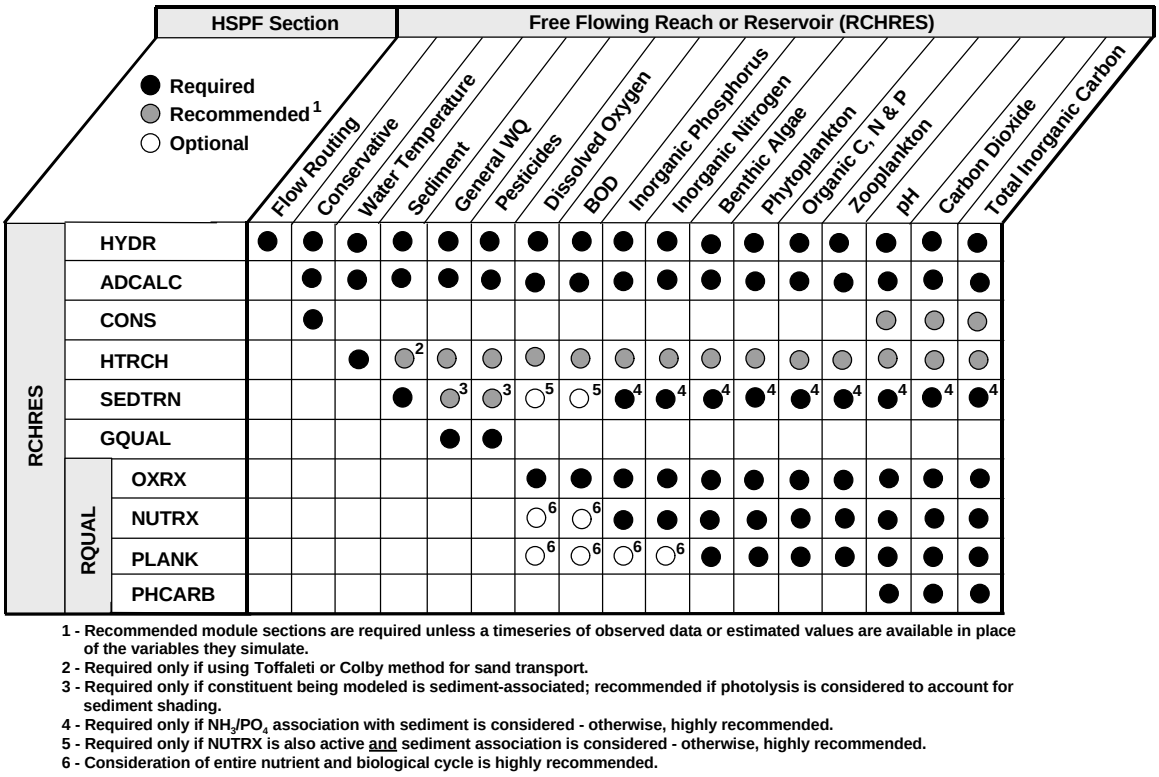
The matrix (see Figure 1, below) shows the hydrologic process or pollutant to be simulated along the top, and the HSPF modules and sections along the left. A set of notes, at the end, provides additional details about the conditions under which a section is required, recommended, or optional. To read the matrix, select the process or pollutant you wish to model, and read down that column to determine which HSPF sections you must simulate as well as those which are recommended or optional. For example, to simulate pesticides, reading down the column in the PERLND block, shows ATEMP and SNOW as optional (only necessary if snow is significant in your watershed), PWATER and SEDMNT as required, PSTEMP as only necessary if first-order adsorption-desorption is selected, and MSTLAY (soil moisture storage and fluxes) and PEST (by definition) as required. Reading down the pesticide column in the RCHRES module, HYDR and ADCALC are required, HTRCH is recommended, SEDTRN is recommended to account for reduced photolysis due to sediment shading (and is required if the pesticide is sediment associated) and GQUAL is required. While NPSM/HSPF does not simulate pesticide application or fate and transport on impervious land segments, you still need to model the simulation elements that will effect quantities in the receiving water body: i.e. ATEMP and SNOW (if simulated in the PERLND module), IWATER (for hydrology), IWTGAS (for temperature if HTRCH selected in RCHRES module) and SOLIDS (if SEDTRN selected in RCHRES).

Note, each module (Pervious Land [PERLND], Impervious Land [IMPLND], and Free Flowing Reach or Reservoir [RCHRES]) is essentially its own separate matrix since they can each be run independently of the others (e.g. running general water quality constituent simulations in a RCHRES segment does not require a constituent load from either a PERLND or IMPLND; similarly, modeling nutrient washoff in a PERLND does not require you to route the runoff to a RCHRES segment).




1 - Recommended module sections are required unless a timeseries of observed data or estimated values are available in place of the variables they simulate.
2 - Activate only if constituent being modeled is associated with sediment.
3 - ATEMP is recommended to adjust for any elevation differences between the observation site and the watershed.
4 - PSTEMP is required only if the first-order adsorption-desorption is selected instead of the equilibrium Freundlich approach.

Figure 1. Matrix of HSPF Sections Required vs. Pollutants and Processes Modeled




1 - Recommended module sections are required unless a timeseries of observed data or estimated values are available in place of the variables they simulate.
2 - Required only if using Toffaleti or Colby method for sand transport.
3 - Required only if constituent being modeled is sediment-associated; recommended if photolysis is considered to account for sediment shading.
4 - Required only if $NH_3/PO_4$ association with sediment is considered - otherwise, highly recommended.
5 - Required only if NUTRX is also active and sediment association is considered - otherwise, highly recommended.
6 - Consideration of entire nutrient and biological cycle is highly recommended.

Figure 1. Matrix of HSPF Sections Required vs. Pollutants and Processes Modeled (cont.)

Table Notes:

**Key**
Q: “required”
R: “recommended”
O: “optional”

PERLND

| | | |
|---|---|---|
| Adjusted Air Temp | | |
| ATEMP | Q | by definition; used to adjust for air temperature differences between meteorologic station and site due to elevation differences (HSPF uses lapse rate that varies between 0.0035 and 0.005 degrees-F/ft) |
| Snow | | |
| ATEMP | R | can be bypassed, in HSPF by adjusting gage temperature directly (required in NPSM if SNOW simulated). |
| SNOW | Q | by definition |
| Basic Hydrology | | |
| ATEMP | O | results used only if SNOW is simulated (required in NPSM if SNOW simulated) |
| SNOW | O | only needed in regions where snow is significant hydrologic cycle component |
| PWATER | Q | by definition |
| Soil Erosion | | |
| ATEMP | O | results used only if SNOW is simulated (required in NPSM if SNOW simulated) |
| SNOW | O | only needed in regions where snow is significant hydrologic cycle component |
| PWATER | Q | surface quantities SURO and SURS used in SEDMNT routine |
| SEDMNT | Q | by definition |
| Soil Temperature | | |
| ATEMP | R | can be bypassed, in HSPF by adjusting gage temperature directly |
| PSTEMP | Q | by definition |

Water Temperature, Dissolved Oxygen, Dissolved CO2

| | | |
|---|---|---|
| ATEMP | R | results used only if SNOW or PSTEMP simulated |
| SNOW | O | only needed in regions where snow is significant hydrologic cycle component |
| PWATER | Q | runoff components SURO, IFWO AGWO are the key simulation elements |
| PSTEMP | R | observed/estimated soil temps may be input instead |
| PWTGAS | Q | by definition |

General WQ

| | | |
|---|---|---|
| ATEMP | O | results used only if SNOW is simulated |
| SNOW | O | only needed in regions where snow is significant hydrologic cycle component |
| PWATER | Q | surface quantities SURO and SURS used in SEDMNT routine |
| SEDMNT | Q | only needed if water quality constituent is sediment-associated |
| PQUAL | Q | by definition |

Pesticides

| | | |
|---|---|---|
| ATEMP | R | results used only if SNOW or PSTEMP simulated (required in NPSM if SNOW simulated) |
| SNOW | O | only needed in regions where snow is significant hydrologic cycle component |
| PWATER | Q | soil moisture fluxes/storages are the key simulation elements |
| SEDMNT | Q | soil erosion must be simulated |
| PSTEMP | R | observed/estimated soil temps may be input directly in HSPF |
| MSTLAY | Q | leaching factors must be simulated |
| PEST | Q | by definition |

Nitrogen

| | | |
|---|---|---|
| ATEMP | R | results used only if SNOW or PSTEMP simulated (required in NPSM if SNOW simulated) |
| SNOW | O | only needed in regions where snow is significant hydrologic cycle component |
| PWATER | Q | soil moisture fluxes/storages must be simulated |
| SEDMNT | Q | soil erosion must be simulated |
| PSTEMP | R | observed/estimated soil temps may be input directly in HSPF |
| MSTLAY | Q | leaching factors must be simulated |
| NITR | Q | by definition |

Phosphorus

| | | |
|---|---|---|
| ATEMP | R | results used only if SNOW or PSTEMP simulated (required in NPSM if SNOW simulated) |
| SNOW | O | only needed in regions where snow is significant hydrologic cycle component |
| PWATER | Q | soil moisture fluxes/storages must be simulated |
| SEDMNT | Q | soil erosion must be simulated |
| PSTEMP | R | observed/estimated soil temps may be input directly in HSPF |
| MSTLAY | Q | leaching rate must be simulated |
| PHOS | Q | by definition |

Tracer

| | | |
|---|---|---|
| ATEMP | O | results used only if SNOW is simulated |
| SNOW | O | only needed in regions where snow is significant hydrologic cycle component |
| PWATER | Q | soil moisture fluxes/storages must be simulated |
| MSTLAY | Q | leaching rate must be simulated |
| TRACER | Q | by definition |

IMPLND

| | | |
|---|---|---|
| Adjusted Air Temp | | |
| ATEMP | Q | by definition; used to adjust for air temperature differences between meteorologic station and site due to elevation differences |
| Snow | | |
| ATEMP | R | can be bypassed, in HSPF by adjusting gage temperature directly (required in NPSM if SNOW simulated). |
| SNOW | Q | by definition |
| Basic Hydrology | | |
| ATEMP | O | results used only if SNOW is simulated (required in NPSM if SNOW simulated) |
| SNOW | O | only needed in regions where snow is significant hydrologic cycle component |
| IWATER | Q | by definition |
| Solids | | |
| ATEMP | O | results used only if SNOW is simulated (required in NPSM if SNOW simulated) |
| SNOW | O | only needed in regions where snow is significant hydrologic cycle component |
| IWATER | Q | surface runoff must be simulated |
| SOLIDS | Q | by definition |
| Water Temperature, Dissolved Oxygen, Dissolved CO2 | | |
| ATEMP | R | can be bypassed, in HSPF by adjusting gage temperature directly (required in NPSM if SNOW simulated). |
| SNOW | O | only needed in regions where snow is significant hydrologic cycle component |
| IWATER | Q | surface runoff must be simulated |
| IWTGAS | Q | by definition |
| General WQ | | |
| ATEMP | O | results used only if SNOW is simulated (required in NPSM if SNOW simulated) |
| SNOW | O | only needed in regions where snow is significant hydrologic cycle component |
| IWATER | Q | surface runoff must be simulated |
| SOLIDS | Q | only needed if water quality constituent is sediment-associated |
| IQUAL | Q | by definition |

RCHRES

Flow Routing

| | | |
|---|---|---|
| HYDR | Q | by definition |

Conservative Substance

| | | |
|---|---|---|
| HYDR | Q | flow routing must be simulated |
| ADCALC | Q | transport factors must be simulated |
| CONS | Q | by definition |

Water Temperature

| | | |
|---|---|---|
| HYDR | Q | flow routing must be simulated |
| ADCALC | Q | transport factors must be simulated |
| HTRCH | Q | by definition |

Sediment Transport

| | | |
|---|---|---|
| HYDR | Q | flow routing must be simulated |
| ADCALC | Q | transport factors must be simulated |
| HTRCH | R | required only if Toffaletti or Colby methods are used for sand, can be bypassed by inputting water temperature directly (in HSPF, but not in NPSM) |
| SEDTRN | Q | by definition |

General WQ, Pesticides

| | | |
|---|---|---|
| HYDR | Q | flow routing must be simulated |
| ADCALC | Q | transport factors must be simulated |
| HTRCH | R | can be bypassed by inputting water temperature directly |
| SEDTRN | R | only required if sediment-associated, otherwise is optional; recommended if photolysis is considered (to account for sediment shading); can be bypassed by inputting sediment concentration directly in HSPF |
| GQUAL | Q | by definition |

Dissolved Oxygen, BOD

| | | |
|---|---|---|
| HYDR | Q | flow routing must be simulated |
| ADCALC | Q | transport factors must be simulated |
| HTRCH | R | can be bypassed by inputting water temperature directly |
| SEDTRN | O | only if NUTRX used |
| OXRX | Q | by definition |
| NUTRX | O | nutrients usually important |
| PLANK | O | plankton usually important |

Inorganic Phosphorus, Inorganic Nitrogen

| | | |
|---|---|---|
| HYDR | Q | flow routing must be simulated |
| ADCALC | Q | transport factors must be simulated |
| HTRCH | R | can be bypassed by inputting water temperature directly |
| SEDTRN | Q | phosphate and ammonia adsorption usually important |
| OXRX | Q | DO and BOD must be simulated |
| NUTRX | Q | by definition |
| PLANK | O | plankton usually important |

Benthic Algae, Phytoplankton, Organic C, N, &P, Zooplankton

| | | |
|---|---|---|
| HYDR | Q | flow routing must be simulated |
| ADCALC | Q | transport factors must be simulated |
| HTRCH | R | can be bypassed by inputting water temperature directly |
| SEDTRN | R | can be bypassed by inputting sediment concentration directly (unless already needed by NUTRX) |
| OXRX | Q | DO and BOD must be simulated |
| NUTRX | Q | nutrients must be simulated |
| PLANK | Q | by definition |

pH, Carbon Dioxide, Tot Inorganic Carbon

| | | |
|---|---|---|
| HYDR | Q | flow routing must be simulated |
| ADCALC | Q | transport factors must be simulated |
| CONS | R | can be bypassed by inputting alkalinity concentration directly |
| HTRCH | R | can be bypassed by inputting water temperature directly |
| SEDTRN | R | only if needed by NUTRX |
| OXRX | Q | DO and BOD must be simulated |
| NUTRX | Q | nutrients must be simulated |
| PLANK | Q | plankton CO2 fluxes must be simulated |
| PHCARB | Q | by definition |