INTRODUCTION TO HSPF, DATA NEEDS, APPLICATION PROCESS, & SELECTED APPLICATIONS
HSPF: HYDROLOGIC SIMULATION PROGRAM - FORTRAN

- Continuous simulation model
- Natural and developed watersheds and water systems
- Land surface and subsurface hydrology and quality processes
- Stream/lake hydraulics and water quality processes
- Time series data management and storage
- Time series data statistical analysis and operations
- Core watershed model in EPA BASINS and Army Corps WMS
- Development and maintenance activities sponsored by U.S. EPA and U.S. Geological Survey
COMPONENTS OF WATER QUALITY PROBLEMS AND POLLUTION
COMPONENTS OF WATERSHED WATER QUALITY MODELS

Nonpoint Loading Simulation

- Runoff quantity - surface and subsurface
- Sediment erosion/solids loading
- Runoff quality
- Atmospheric deposition
- Inputs needed by instream simulation

Instream Simulation

- Hydraulics
- Sediment transport
- Sediment-contaminant interactions
- Water quality constituents and processes
- Point source accommodation
- Lake/reservoir simulation
- Benthal processes and impacts
# HSPF APPLICATION & UTILITY MODULES (Version 12, 2001)

## APPLICATION MODULES

<table>
<thead>
<tr>
<th>PERLND</th>
<th>IMPLND</th>
<th>RCHRES</th>
<th>BMP</th>
</tr>
</thead>
<tbody>
<tr>
<td>Snow</td>
<td>Snow</td>
<td>Hydraulics</td>
<td>Flow</td>
</tr>
<tr>
<td>Water</td>
<td>Water</td>
<td>Conservative</td>
<td>Any constituent</td>
</tr>
<tr>
<td>Sediment</td>
<td>Solids</td>
<td>Temperature</td>
<td>simulated in PERLND,</td>
</tr>
<tr>
<td>Quality</td>
<td>Quality</td>
<td>Sediment</td>
<td>IMPLND or RCHRES</td>
</tr>
<tr>
<td>Pesticide</td>
<td></td>
<td>Nonconservative</td>
<td></td>
</tr>
<tr>
<td>Nitrogen</td>
<td></td>
<td>BOD/DO</td>
<td></td>
</tr>
<tr>
<td>Phosphorus</td>
<td></td>
<td>Nitrogen</td>
<td></td>
</tr>
<tr>
<td>Tracer</td>
<td></td>
<td>Phosphorus</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Carbon</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Plankton</td>
<td></td>
</tr>
</tbody>
</table>

## UTILITY MODULES

- COPY
- MUTSIN
- PLTGEN
- DURANL
- GENER
- DISPLY
- REPORT
SEGMENTATION OF COMPLEX WATERSHEDS FOR MODELING

INPUTS:
Meteorological:
Precipitation, Temperature, Etc.

Physical:
Soil Properties, Channel Properties, Land Use, Etc.

OUTPUTS:
Stream Flows, Concentration, Etc.
SOIL PROFILE REPRESENTATION BY THE AGCHEM MODULE
HSPF - STRENGTHS

• Comprehensive representation of watershed land and stream processes
• Comprehensive representation of watershed pollutant sources, including nonpoint sources (by multiple land uses), point sources, atmospheric, etc.
• Flexibility and adaptability to a wide range of watershed conditions
• Well-designed code modularity and structure
• Companion database and support programs to assist model users (e.g., WDMUtil, WinHSPF, GenScn, HSPEXP)
• Ongoing development and support by U.S. EPA and U.S.G.S.
• Continuing code enhancements funded by numerous groups
• Strict code version control through joint agreement of U.S. EPA & U.S.G.S.
HSPF - IDENTIFIED/PERCEIVED LIMITATIONS AND WEAKNESSES

- Extensive data requirements (e.g., hourly rainfall)
- User training normally required
- No comprehensive parameter estimation guidance available
- Limited spatial definition (i.e., lumped parameter approach)
- Hydraulics limited to non-tidal freshwater systems and unidirectional flow
- Simplified representation of urban drainage systems (e.g., culverts, pipes, CSOs)
- Limited representation of algal species - phytoplankton, zooplankton, benthic algae
HSPF - RECENT ENHANCEMENTS AND DEVELOPMENTS

- Wetlands and shallow water-table hydrologic capabilities (funded by SFWMD)
- Implementation of water quality linkage between land segments for modeling buffer strips, riparian zones, grass waterways, etc. (funded by MPCA)
- Irrigation capabilities added to define application methods and sources (funded by SFWMD)
- Simplified snow algorithms (degree-day method) added to minimize meteorologic data needs (funded by EPA OW/OST for use within BASINS)
- Online interactive HSPF HELP available (complete HSPF Manual, V.11 in Windows) (funded by USGS)
- Development of Scenario Analysis (GENSCN) GUI software for generation, display, and evaluation of watershed model scenarios (funded by USGS & EPA)
- BMP and REPORT modules developed (funded by TMDL studies in Georgia)
- Multiple benthic algae species incorporated (Version 13, funded by NV group)
ALL MODELS ARE WRONG,

BUT....

SOME ARE USEFUL !

(Depends on the Model Testing Process)

(Source: G.E.P. Box, 1979)
THE MODELING PROCESS

Phase I
- Data collection
- Model input preparation
- Parameter evaluation

Phase II
- Calibration
- Validation
- (Post-audit)

Phase III
- Analysis of alternatives

Model Testing
STUDY DEFINITION

• Problems/questions for analysis, study goals

• Data requirements/availability

• Project resource availability (time, money, expertise)
HSPF Data Requirements

• Input/execution data
  – Precip & Met data, diversions, point sources, atmos deposition

• Parameter evaluation/charac. data
  – GIS: land use/cover, soils, DEM, hydrography
  – Watershed characterization, channel, bed char.

• Calibration/validation data
  – Flow, sediment (with PSD), WQ
  – Snow, bed composition
# HSPF WEATHER DATA REQUIREMENTS

<table>
<thead>
<tr>
<th>PERLND/IMPLND</th>
<th>RCHRES</th>
</tr>
</thead>
</table>

- **Required**
- **Optional**

- **Precipitation**
  - [1] For PWATER
  - [2] For PSTEM
  - [3] If volatilization from lake is simulated
  - [4] If photolysis is simulated
  - [5] If RCHRES is a lake

- **Pot. ET**
- **Air Temperature**
  - [1]
  - [2]

- **Wind Speed**
- **Solar Radiation**
- **Dewpoint Temp.**
- **Cloud Cover**

*Ag. Chemicals include nutrients and pesticides**

**Degree Day option only requires precip and air temp**

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MODELING STRATEGY

- Processes, constituents, and sources to be modeled
- Watershed segmentation (spatial and temporal detail)
- Channel segmentation and tributary areas
- Data to support modeling effort
- Human impacts, alternatives to be analyzed
- Develop simulation plan
MODEL VERSUS NATURAL SYSTEM: INPUTS, OUTPUTS, AND ERRORS
ANALYSIS OF ALTERNATIVES

- Definition of alternatives
- Selection of constituents and numeric/statistical measures
- Representation of alternatives
  - input changes
  - system configuration
  - parameter changes
BASINS 4.0 System Overview

Tools and Utilities
- Watershed Reports
- WDMulti
- Watershed Delineation (Automatic or Manual)
- Parameter Estimation
- PEST
- HSPFParm

Watershed Modeling
- HSPF/WinHSPF
- AQUATOX
- Pollutant Loading Estimator
- SWAT*
- AGWA*

Decision Making and Analysis
- Post Processing
  - GenScn
- Watershed Management
- Sensitivity Analysis
- Climate Analysis Tool
- Nutrient Management
- Source Water Protection
- TMDLs
- UAAs
WATERSHED ASSESSMENT WITH BASINS/HSPF

**BASINS Provides**
- Tools for Watershed Delineation and Segmentation; GIS Data Layers
- WDM Meteorologic Data, BASINS Data, WDMUtil Software
- GIS Data Layers / Tools, HSPFParm and WinHSPF Software
- WinHSPF/GenScn Functionality and Post-Processing
- WinHSPF/GenScn To Facilitate Analysis

**Application Steps**
- Study Definition
- Modeling Strategy (Simulation Plan)
- Input/Management of Time Series Data
- Parameter Development
- Model Setup
- Hydrology Calibration/Validation
- Water Quality Calibration/Validation
- Scenario Analysis

**Other Inputs / Issues**
- Stakeholders, TMDL Needs, Watershed Assessment, Water Resources Issues, Local Data Availability
- USGS, National Weather Service, Local Sources
- Soils, Landuse, Land Practices, Other Local Data; External GIS Capabilities
- Stakeholder and Advisory Group Reviews, Calibration and Validation Targets, Acceptable Uncertainty
- Stakeholder and Advisory Group Reviews, Calibration and Validation Targets, Acceptable Uncertainty
- Local Stakeholder Needs, Regulatory Requirements, Public Health Issues

**Related Workshop Exercises**
- 1, 2, 10
- 3
- 4, 15
- 5, 6, 7
- 8, 9, 11, 12, 13
- 14
RECENT CA APPLICATIONS

• Arroyo Simi, Ventura County
• Calleguas Creek, Ventura County
• San Francisco Bay Copper Loads from Brake Pads
HSPF APPLICATION TO THE ARROYO SIMI WATERSHED

VENTURA COUNTY, SOUTHERN CA
STUDY OBJECTIVES

• Develop hydrologic model of watershed
• Assess potential urbanization impacts
• Assess impacts of detention on flows and flood peaks
• Provide tool for TMDLS, hydrograph modification, urban stream erosion assessment (ongoing efforts)
LOCATION OF ARROYO SIMI WATERSHED

Mugu Lagoon
Calleguas Creek Watershed
City of Simi Valley
Los Angeles
Ventura

Model Area

10 0 10 20 Miles

24 of 56
SCENARIOS

• Natural, Pre-development

• 10% increase in urban fringe areas

• 30% increase in urban fringe areas

• 50% increase in urban fringe areas

• Detention Basins implemented with 50% increase in urban fringe areas
FLOW DURATION CURVES FOR MADERA USEP SITE FOR ALL SCENARIOS

[Graph showing flow duration curves for different scenarios.

Legend:
- Base Condition
- Natural Condition
- 10% Increase in Urban Land
- 30% Increase in Urban Land
- 50% Increase in Urban Land
- 60% Increase in Urban Land w/ 11 DBs]

Madera USEP - Hourly
Base Condition vs Multiple Alternatives, 10/01/1969-10/01/2000
Calleguas Creek Watershed Model, Ventura County, CA

• Development of a watershed model for general planning and assessment
• Potential Uses: flood control, storm drainage, HMP, urbanization impacts. WQ, TMDLs, etc.
• Funded by VCWPDP and CCWMP
• Area: 340 sq mi. Precip: 14-20 in, semi-arid mediterranean climate
• Land Use: -
  – Open, 44%
  – Agriculture, 25%
  – Residential, 21%
  – Comm/Ind/Other, 10%
Water Balance Components

Precipitation (+) 15.8"

Irrigation (+) 10.8"

Evapotranspiration (-) 20.5"

Channel Losses (-) 1.9"

Pumping (+) 0.1"

POTWs (+) 1.4"

Deep Ground Water Recharge (-) 3.2"

Outflow (-) 3.6"

Change in Soil, Active Groundwater, and Channel Storage (-) 1.1"

WY 1988- WY 2002

1 - Change in Temporary Shallow Ground Water Storage calculated prior to rounding fluxes
Water Balance Components

**Evapotranspiration**
- Lower Simi/Las Posas: (-) 15.9"
- Upper Arroyo Simi: (-) 15.5"
- Conejo Creek: (-) 29.0"
- Lower Calleguas Ck: (-) 28.1"

**Precipitation**
- Lower Simi/Las Posas: (+) 17.7"
- Upper Arroyo Simi: (+) 16.9"
- Conejo Creek: (+) 14.7"
- Lower Calleguas Ck: (+) 13.7"

**Irrigation**
- Lower Simi/Las Posas: (+) 8.3"
- Upper Arroyo Simi: (+) 4.6"
- Conejo Creek: (+) 8.6"
- Lower Calleguas Ck: (+) 21.8"

**Deep Ground Water Recharge**
- Lower Simi/Las Posas: (-) 3.7"
- Upper Arroyo Simi: (-) 3.6"
- Conejo Creek: (-) 3.6"
- Lower Calleguas Ck: (-) 1.7"

**Outflow**
- Lower Simi/Las Posas: (-) 3.3"
- Upper Arroyo Simi: (-) 8.0"
- Conejo Creek: (-) 6.8"
- Lower Calleguas Ck: (-) 28.1"

**Change in Soil, Active Ground Water, and Channel Storage**
- Lower Simi/Las Posas: 1 (-) 1.1"
- Upper Arroyo Simi: 1 (-) 0.8"
- Conejo Creek: 1 (-) 1.6"
- Lower Calleguas Ck: 1 (-) 0.8"

**POTWs**
- Lower Simi/Las Posas: (+) 2.3"
- Upper Arroyo Simi: (+) 3.7"
- Conejo Creek: (+) 2.3"
- Lower Calleguas Ck: (+) 0.5"

**Channel Losses**
- Lower Simi/Las Posas: (-) 4.0"
- Upper Arroyo Simi: (-) 10.0"
- Conejo Creek: (-) 1.1"
- Lower Calleguas Ck: (-) 1.1"

**WY 1988- WY 2002**

1 - Change in Temporary Shallow Ground Water Storage calculated prior to rounding fluxes
Brake Pad Partnership – Copper Contributions to SF Bay Water Quality

**Critical Elements of Project Approach**

- Watershed Modeling for Cu Loads to SF Bay
- Abide by existing approved work plan
- Use available BPP work products, e.g. DCIA/TIA, Cu sources report, air deposition rates.
- Respond to PR comments, to the extent possible
- Leverage recent/current modeling/data efforts:
  - ACCWP-sponsored BAHM watersheds and database
  - Current SCVURPPP watershed and data efforts
  - Current BASINS met data expansion work
BPP Technical Studies

- Representative Sample of Brake Pad Wear Debris (BMC/Link Test Labs)
- Physical & Chemical Characterization of Wear Debris (Clemson University)
- Water Quality Monitoring (ACCWP)
- Copper Source Loading Estimates (Process Profiles)
- Air Deposition Modeling (AER)
- Watershed Modeling (AQUA TERRA & U.S. EPA)
- Bay Modeling (URS)
- Final Report Data Assessment Conclusions

Steering Committee, Scientific Advisory Team, and Stakeholder Involvement Process (Sustainable Conservation)
Bay Area Watersheds
Rain Gages & Thiessen Analyses
Current Status

- Model Set up Completed
- Scenario Runs: with BP and without BP contributions completed
- Model output processed
- Draft Report submitted and under review