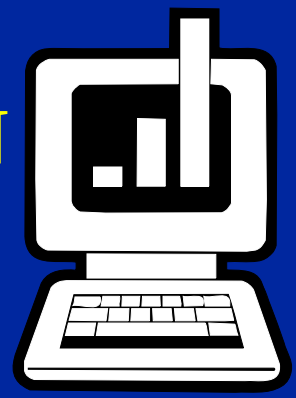
LECTURE #2

INTRODUCTION TO HSPF AND THE MODEL APPLICATION PROCESS

United States Environmental Protection Agency

HSPF: HYDROLOGIC SIMULATION PROGRAM - FORTRAN

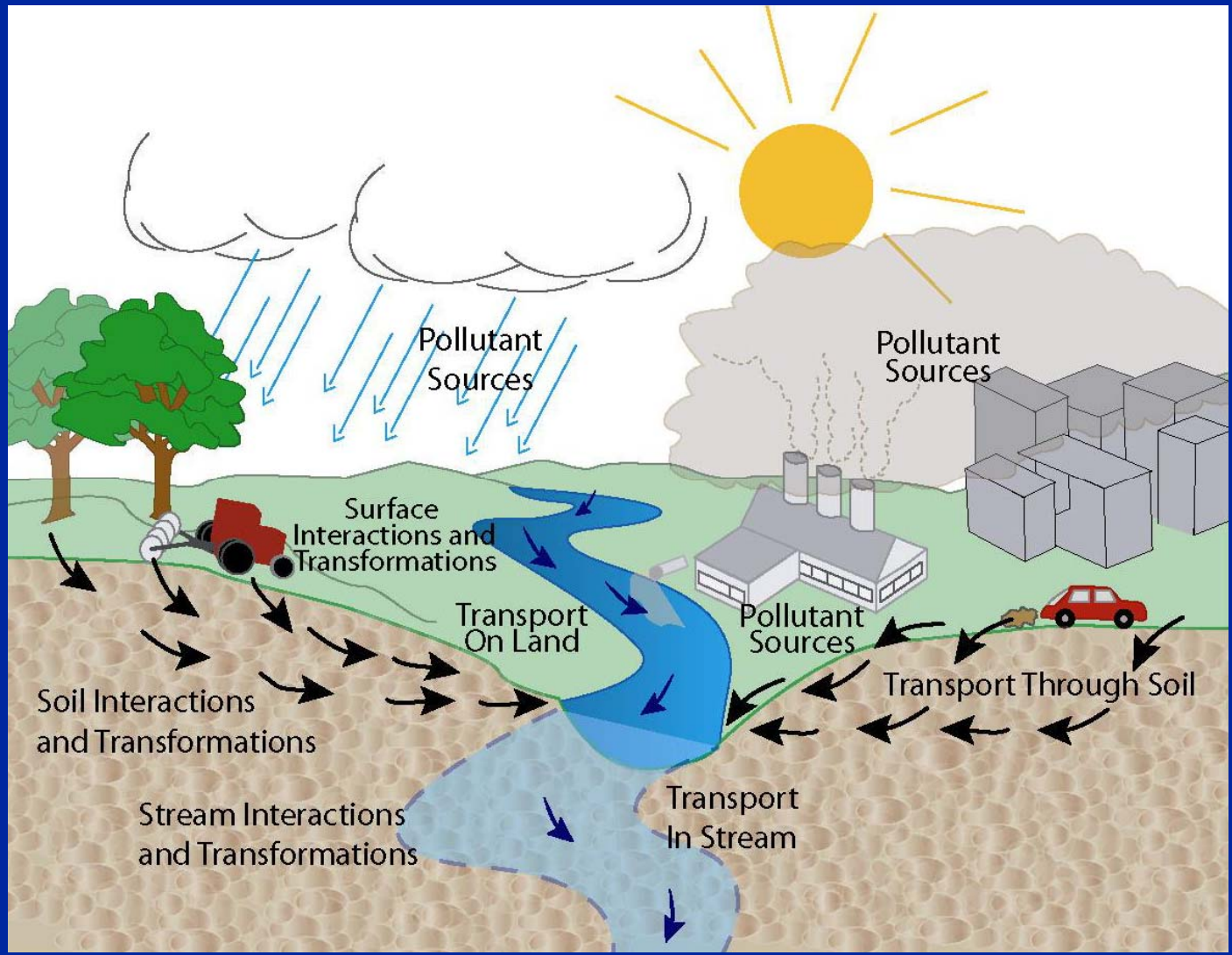


- Continuous simulation model
- Natural and developed watersheds and water systems
- Land surface and subsurface hydrology and quality processes
- Stream/lake hydraulics and water quality processes
- Time series data management and storage
- Time series data statistical analysis and operations
- Core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

AQUA TERRA CONSULTANTS

United States Environmental Protection Agency

COMPONENTS OF WATER QUALITY PROBLEMS AND POLLUTION



AQUA TERRA CONSULTANTS

United States Environmental Protection Agency

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

AQUA TERRA CONSULTANTS

United States Environmental Protection Agency

HSPF APPLICATION & UTILITY MODULES (Version 12, 2001)

APPLICATION MODULES

PERLND	IMPLND	RCHRES	BMP
Snow	Snow	Hydraulics	Flow
Water	Water	Conservative	Any constituent simulated in PERLND, IMPLND or RCHRES
Sediment	Solids	Temperature	
Quality	Quality	Sediment	
Pesticide		Nonconservative	
Nitrogen		BOD/DO	
Phosphorus		Nitrogen	
Tracer		Phosphorus	
		Carbon	
		Plankton	

UTILITY MODULES

COPY, MUTSIN, PLTGEN, DURANL, GENER, DISPLY, REPORT

AQUA TERRA CONSULTANTS

United States Environmental Protection Agency

PERLND STRUCTURE CHART

PERLND
Simulate a pervious land segment

ATEMP
Correct air temperature

SNOW
Simulate snow and ice

PWATER
Simulate water budget

SEDMNT
Simulate sediment

PSTEMP
Estimate soil temperature(s)

PWTGAS
Estimate water temperature and gas concentrations

PQUAL
Simulate general quality constituents

AGCHEM

MSTLAY
Estimate solute transport

PEST
Simulate pesticides

NITR
Simulate nitrogen

PHOS
Simulate phosphorus

TRACER
Simulate a conservative tracer

AQUA TERRA CONSULTANTS

IMPLND STRUCTURE CHART

IMPLND

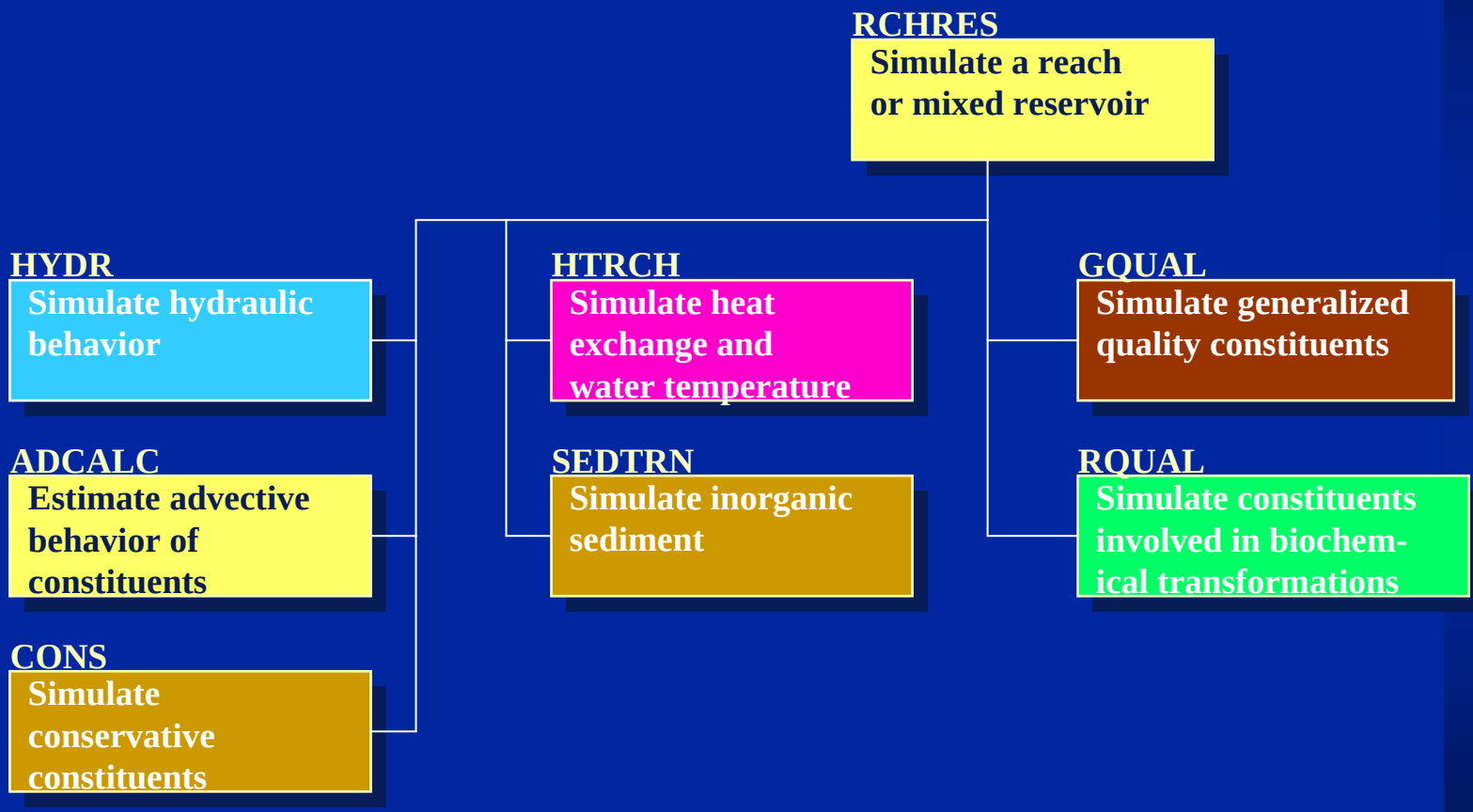
Simulate a segment of impervious land

ATEMP	SNOW	IWATER	SOLIDS	IWTGAS	IQUAL
(see module PERLND)	(see module PERLND)	Simulate water budget for impervious land segment	Accumulate and remove solids	Simulate water temperature and dissolved gas concs.	Simulate quality constituents using simple relationships with solids and/or water yield

AQUA TERRA CONSULTANTS

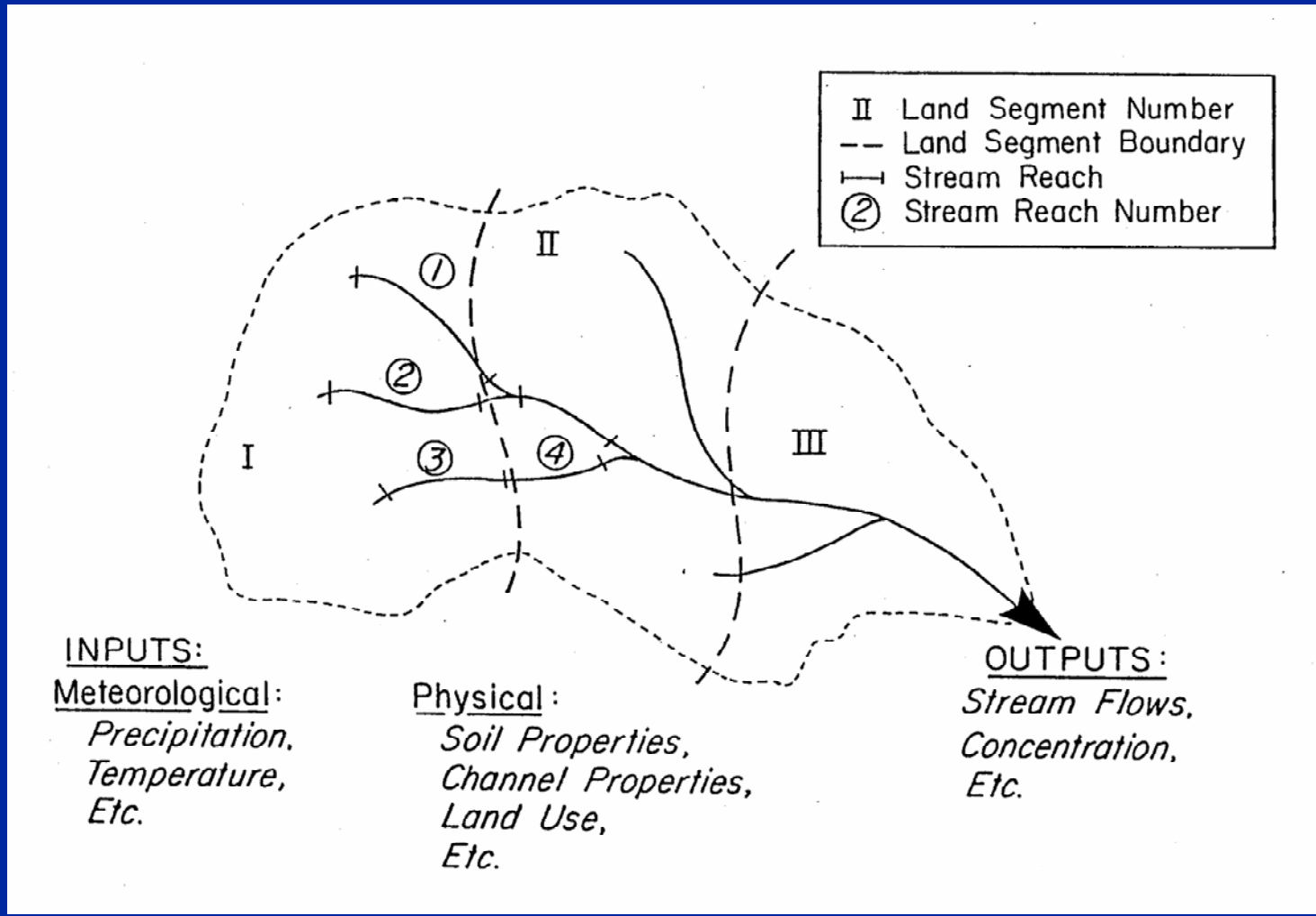
United States Environmental Protection Agency

RCHRES STRUCTURE CHART



AQUA TERRA CONSULTANTS

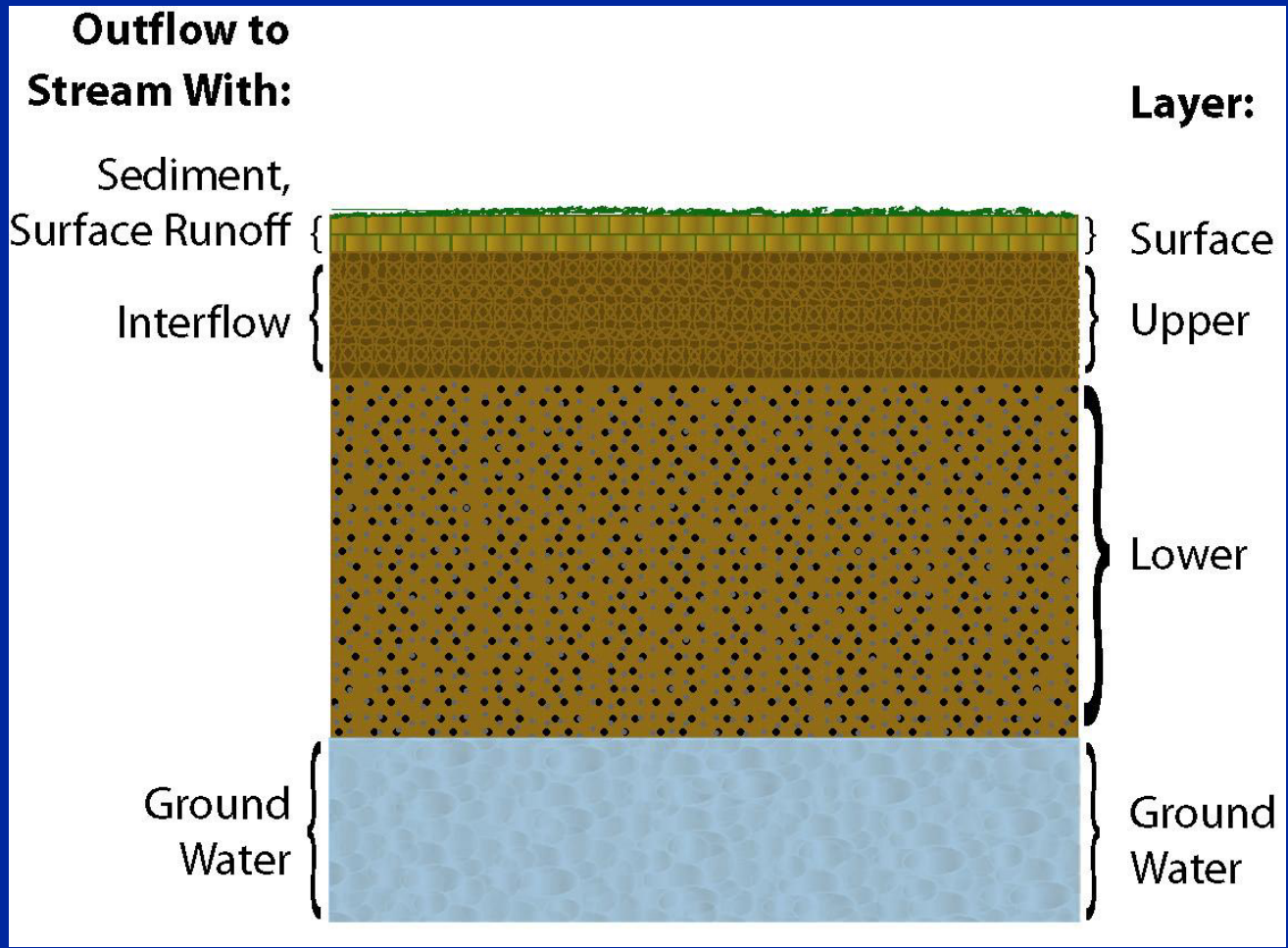
SEGMENTATION OF COMPLEX WATERSHEDS FOR MODELING



AQUA TERRA CONSULTANTS

United States Environmental Protection Agency

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.

AQUA TERRA CONSULTANTS

United States Environmental Protection Agency

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

AQUA TERRA CONSULTANTS

United States Environmental Protection Agency

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)

AQUA TERRA CONSULTANTS

United States Environmental Protection Agency

THE BASINS/HSPF APPLICATION PROCESS

AQUA TERRA CONSULTANTS

United States Environmental Protection Agency

THE MODELING PROCESS

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

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

Model Testing

Phase III
- Analysis of alternatives

AQUA TERRA CONSULTANTS

United States Environmental Protection Agency

HSPF APPLICATION PROCESS

- Study definition
- Development of modeling strategy
- Learn operational aspects of HSPF
- Input/management of time series data
- Parameter development
- Calibration/validation
- Analysis of alternate scenarios

AQUA TERRA CONSULTANTS

United States Environmental Protection Agency

STUDY DEFINITION

- Problems/questions for analysis, study goals
- Data availability
- Project resource availability (time, money, expertise)

AQUA TERRA CONSULTANTS

United States Environmental Protection Agency

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

AQUA TERRA CONSULTANTS

United States Environmental Protection Agency

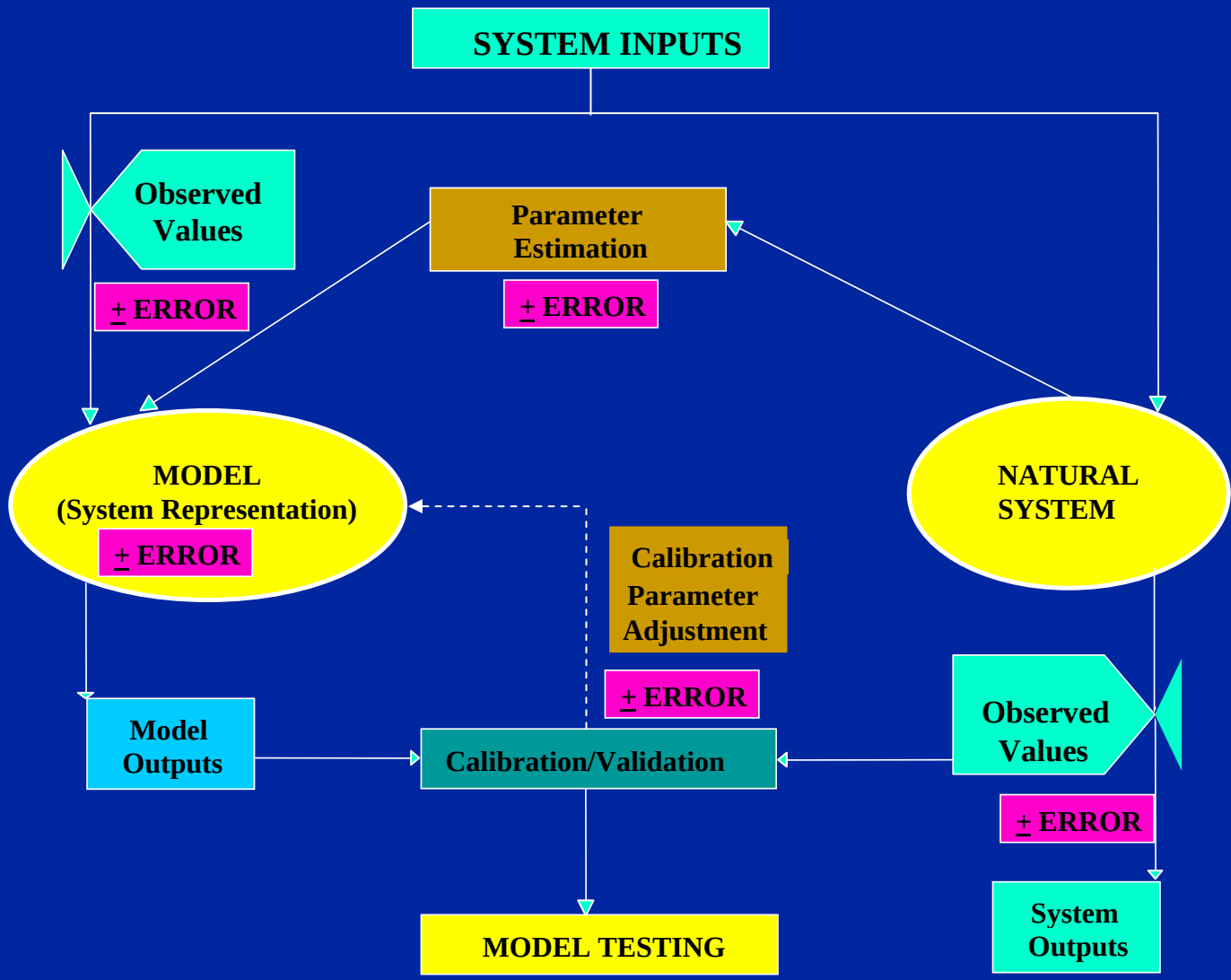
CONSTITUENT SOURCES IN HSPF

- Initial storages
- Nonpoint loadings
- Point loadings
- Atmospheric deposition
- Chemical transformations
- Releases from the channel bottom
- Atmospheric gas invasion

AQUA TERRA CONSULTANTS

United States Environmental Protection Agency

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

AQUA TERRA CONSULTANTS

United States Environmental Protection Agency

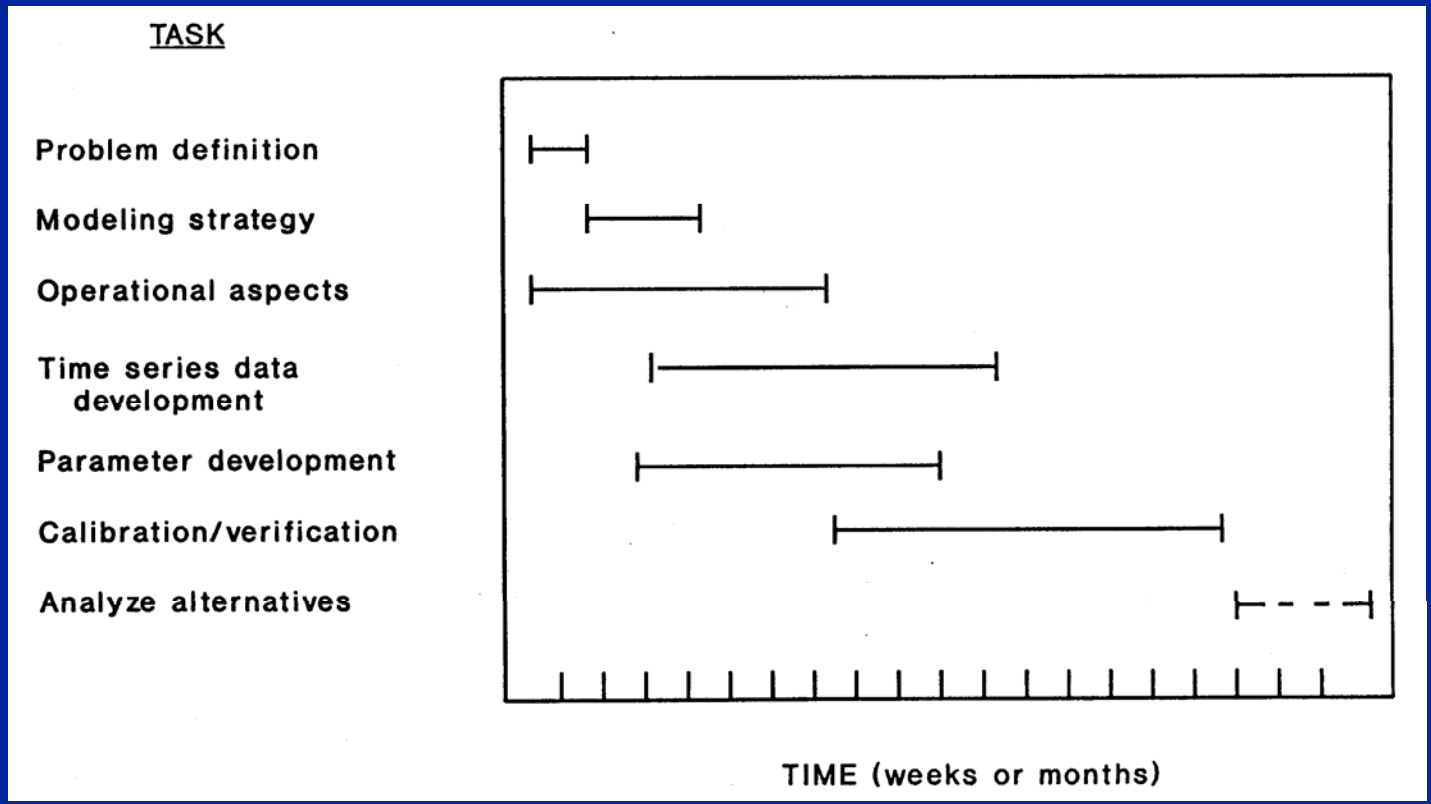
RELATIVE EFFORT FOR HSPF APPLICATION STEPS (through calibration/validation)

TASK	% EFFORT
• Problem definition	5
• Modeling strategy	10
• Learn operational aspects	10
• Development and input of time series	30
• Parameter development	15
• Calibration and validation	30

AQUA TERRA CONSULTANTS

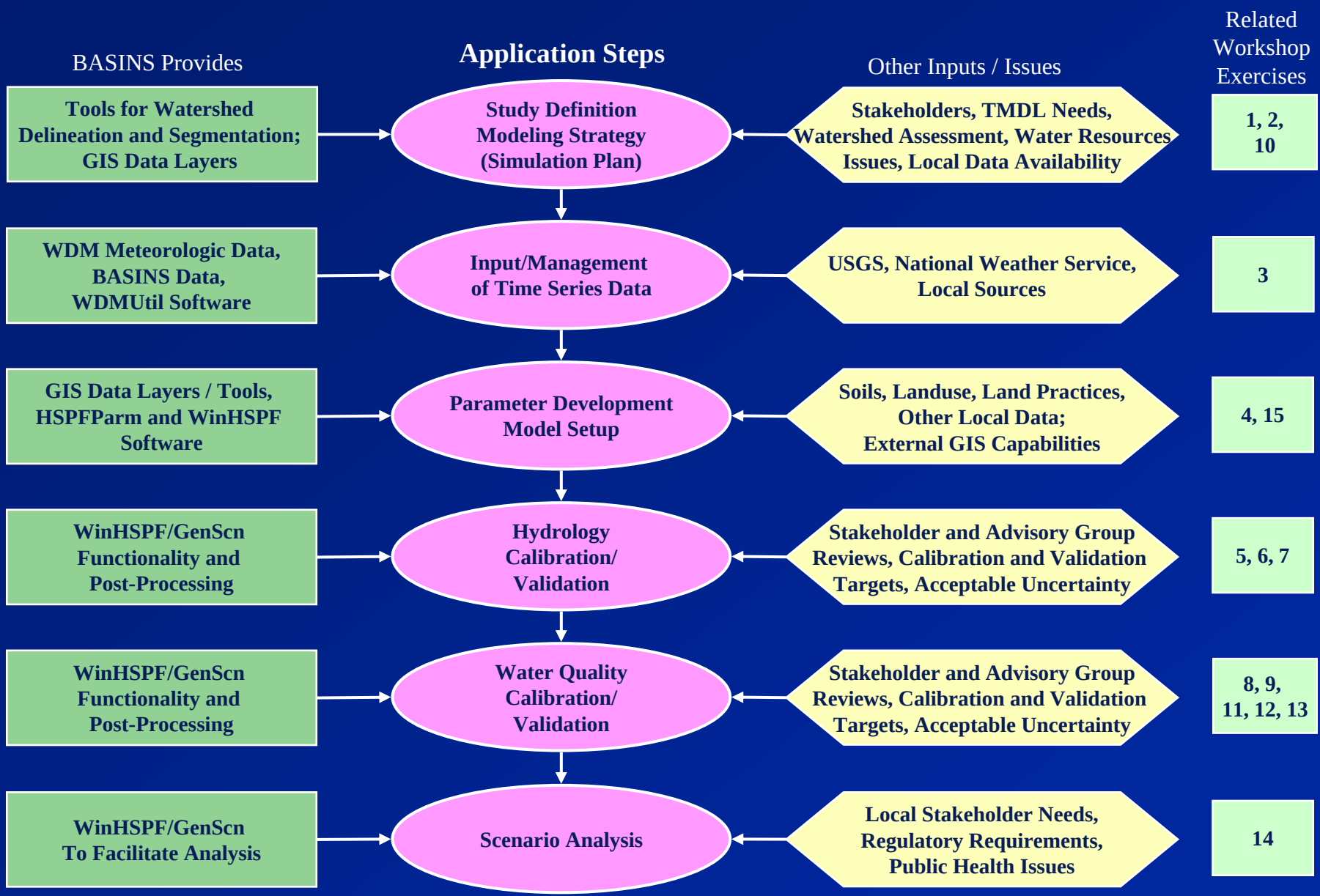
United States Environmental Protection Agency

REPRESENTATIVE HSPF PROJECT SCHEDULE



AQUA TERRA CONSULTANTS

WATERSHED ASSESSMENT WITH BASINS/HSPF

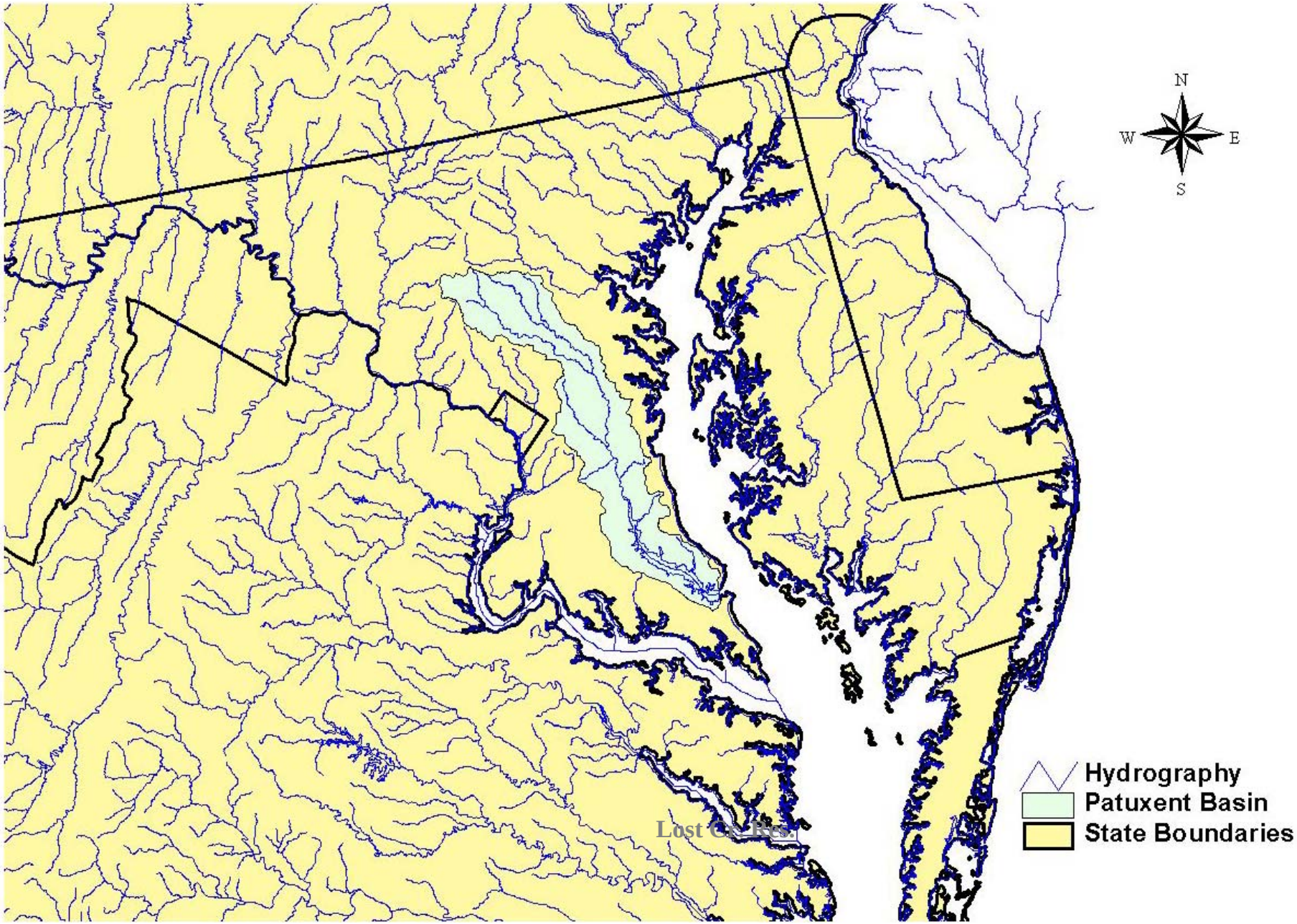


CASE STUDY INTRODUCTION

AQUA TERRA CONSULTANTS

United States Environmental Protection Agency

PATUXENT RIVER BASIN



PATUXENT STUDY

- Initiated in 1985 by the U.S. Geological Survey and the Maryland Department of the Environment
- Nonpoint source nutrient loadings
- Representative of other subbasins of the Chesapeake Bay

AQUA TERRA CONSULTANTS

United States Environmental Protection Agency

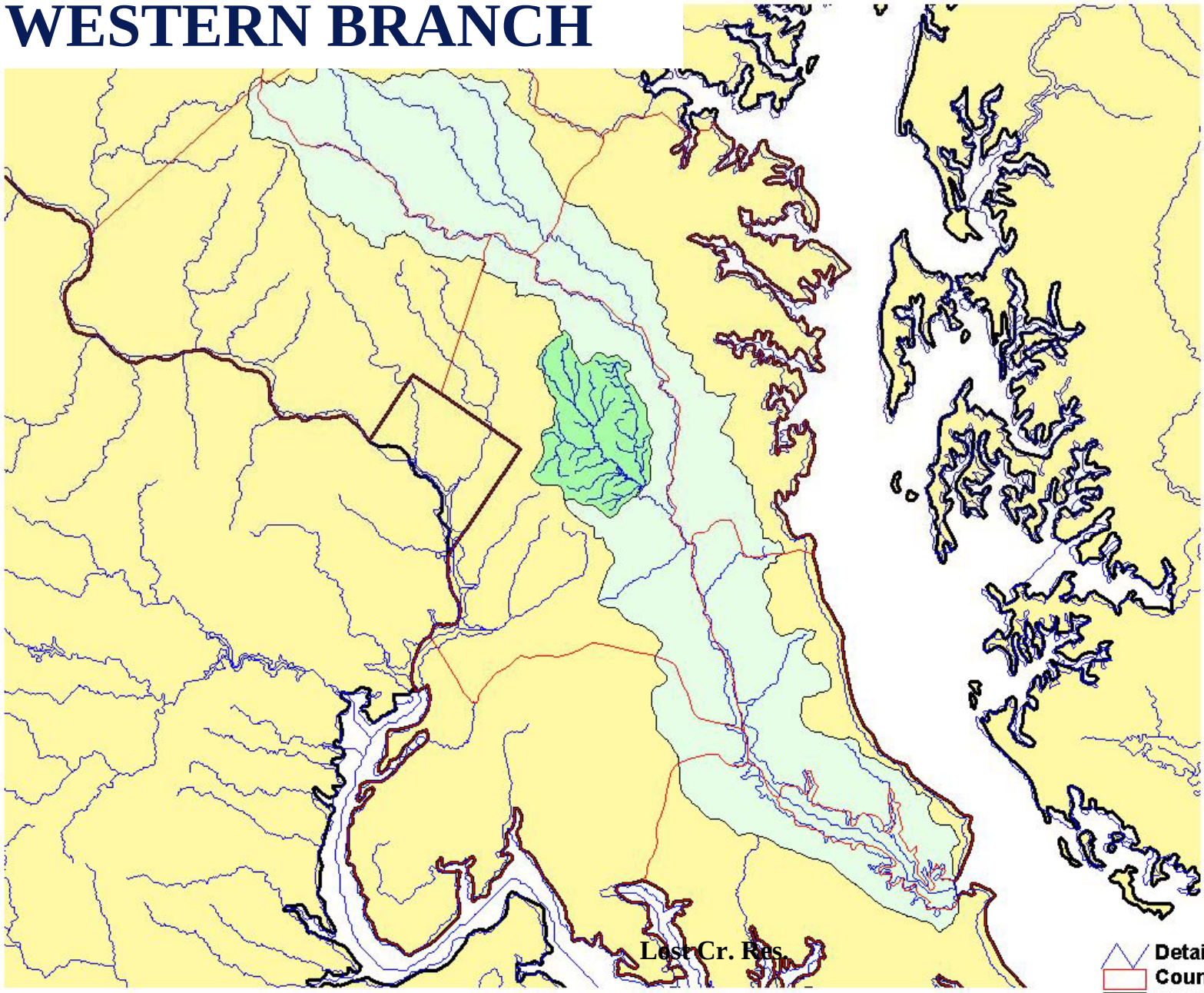
MAJOR ISSUES

- Substantial commercial, residential, and industrial development
- Investigate effects of future growth on water quality
- Planning growth to minimize potential adverse effects

AQUA TERRA CONSULTANTS

United States Environmental Protection Agency

WESTERN BRANCH



WESTERN BRANCH

- Discharges directly to the Patuxent estuary
- Land use 45% Forest/Wetland, 25% Agriculture, 25% Urban
- Gage at Upper Marlboro, drainage area about 90 square miles

AQUA TERRA CONSULTANTS

United States Environmental Protection Agency

WATER QUALITY CONSTITUENTS SIMULATED

- Water Temperature
- Sediment
- Dissolved Oxygen, BOD
- Nitrogen – NH_3, NO_2/NO_3, Org N
- Phosphorus – PO_4, Org P
- Plankton – Phytoplankton, Benthic Algae (as Chl a)

AQUA TERRA CONSULTANTS

United States Environmental Protection Agency