LECTURE #1

INTRODUCTION TO BASINS AND TMDLS

Utah State University

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United States Environmental Protection Agency

WHAT IS BASINS?

Better Assessment Science Integrating Point and Nonpoint Sources

Integrated GIS, data analysis and modeling system designed to support watershed based analysis and TMDL development

- ***Data:*** national data sets with options to import local data
- ***Tools:*** provide quick access to analysis techniques for watershed assessment
- ***Models:*** provide more detailed analysis and predictive evaluations to support studies

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WHAT IS THE PURPOSE OF BASINS?

To assist in watershed management and TMDL development by:

1. **Characterization of Water Quality Data**
2. **Identification of Pollution Sources**
3. **Load Allocations**

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BASINS DEVELOPMENT PHILOSOPHY

Builds on existing, documented technology

- Integrates existing models (i.e., HSPF, SWAT)
- Incorporates national derived data coverages (i.e., PCS, STORET…)

Ease of use

- GIS technology supports organization, display, selection, and analysis of information
- Windows technology provides graphical user interfaces (GUI) that facilitate interaction with the data and analytical tools
- Automatic linkage streamlines the flow of information

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BASINS 4.0 System Overview

BASINS GIS

Web Data Download Tool

Political Boundaries

TIGER Line and Census Data

Monitoring Data

Hydrography

Land Use

Digital Elevation Data

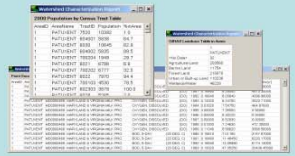
State Soils Data

Meteorological Data (Weather Stations)

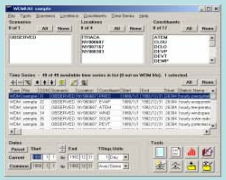
Additional User Supplied Data

Tools and Utilities

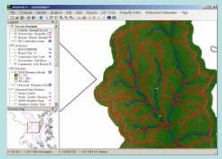
Watershed Reports



WDMUtil



Watershed Delineation (Automatic or Manual)

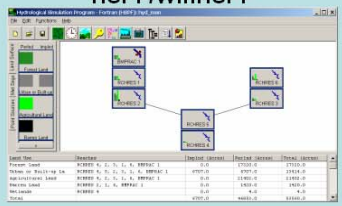


Parameter Estimation

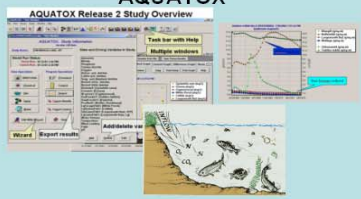
HSPFParm

Watershed Modeling

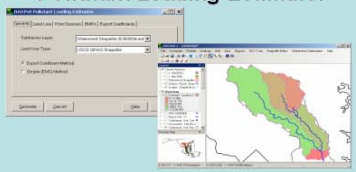
HSPF/WinHSPF



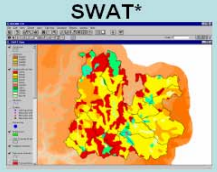
AQUATOX



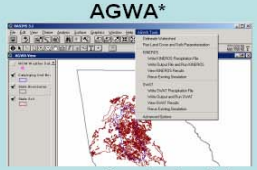
Pollutant Loading Estimator



SWAT*



AGWA*

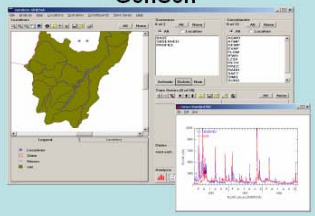


*coming in a future update

Decision Making and Analysis

PostProcessing

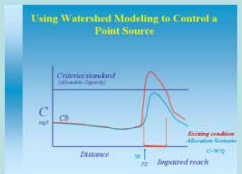
GenScn

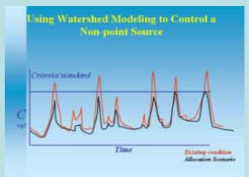


Watershed Management

Sensitivity Analysis

Nutrient Management





Source Water Protection

TMDLs

UAAs

WHAT IS BASINS AGAIN?

- **GIS interface with BASINS specific tools and functionality**
  - Tools and functionality exist in a modular structure that are included as BASINS components.
- **Umbrella structure that holds and links data, tools, and models**

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BASINS VERSIONS

- 1.0 – May 1996
- 2.0 – January 1999
- 3.0 – June 2001
- 3.1 – August 2004 incremental release
- 4.0 – Significant re-factoring, ‘beta’

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BASINS 4.0

- Builds off BASINS 3.1
- Significant restructuring to be GIS platform independent
- Accommodating both ArcView 3.x and ArcGIS
- Based on a non-proprietary, open-source GIS foundation (MapWindow)

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BACKGROUND OF MAPWINDOW

- MapWindow was originally developed at the Utah Water Research Laboratory at Utah State University
- Developed to assist in watershed management related activities and funded by a variety of agencies and organizations including the Idaho National Engineering Laboratory.
- Development and maintenance of core GIS components and additional plug-ins at Idaho State University, Utah State University, AQUA TERRA Consultants, and many others.
- www.mapwindow.org

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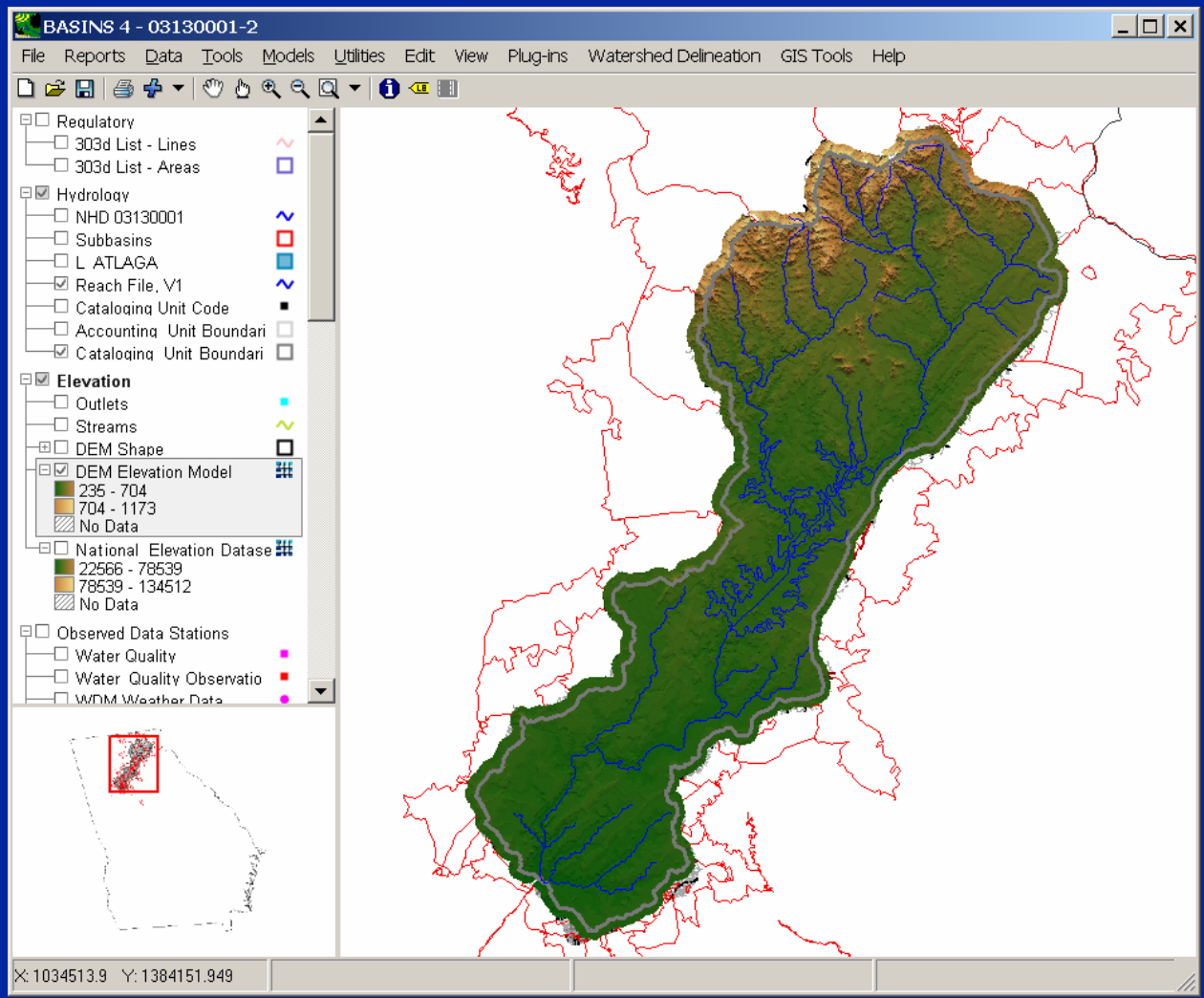
BASINS 4.0 GIS INTERFACE



MAJOR CHANGES FOR BASINS 4.0

- Uses open-source GIS tools and non-proprietary data formats
- The core of BASINS becomes independent of any proprietary GIS platform
- BASINS still accommodates users of several different GIS software platforms
- Migration of some BASINS components to version 4.0 is ongoing

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OPEN SOURCE ADVANTAGES

- No need to purchase expensive proprietary GIS products
- Source code for all components, including the foundational GIS software, will always be available to end users and the federal government
- Provides greater stability and transparency

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MAPWINDOW GIS FUNCTIONALITY

- Ability to add components using a plug-in extension interface
- Active and supportive international developer community
- Supports both vector and raster data manipulation in most common file formats

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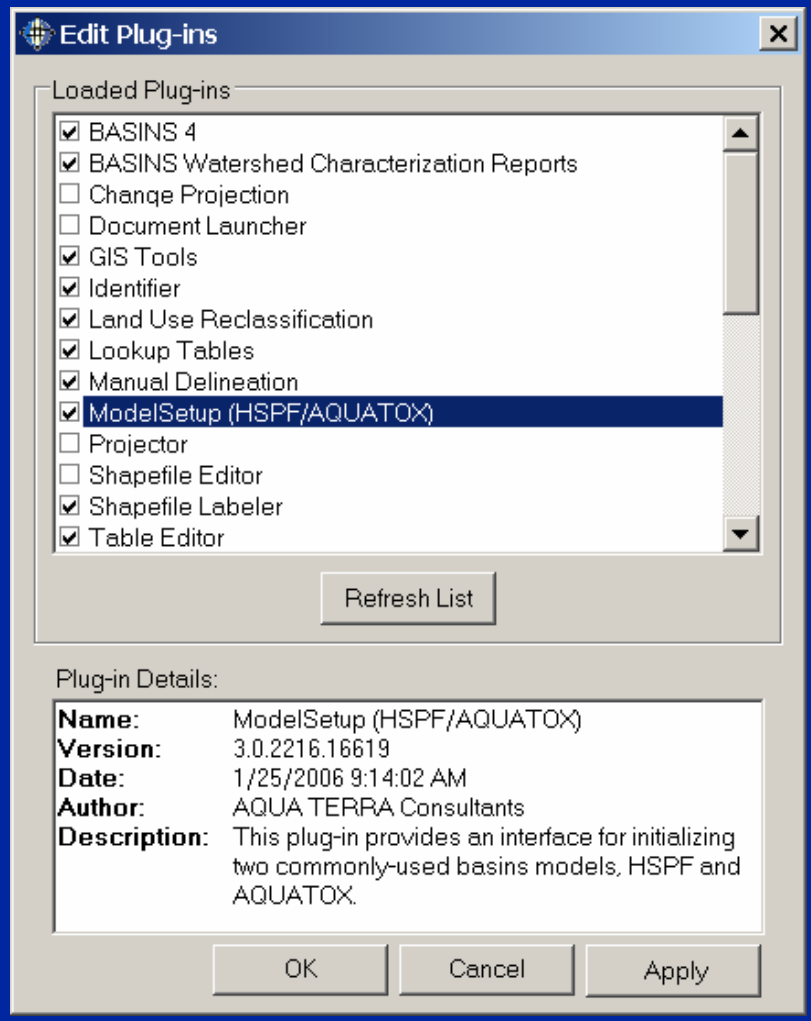
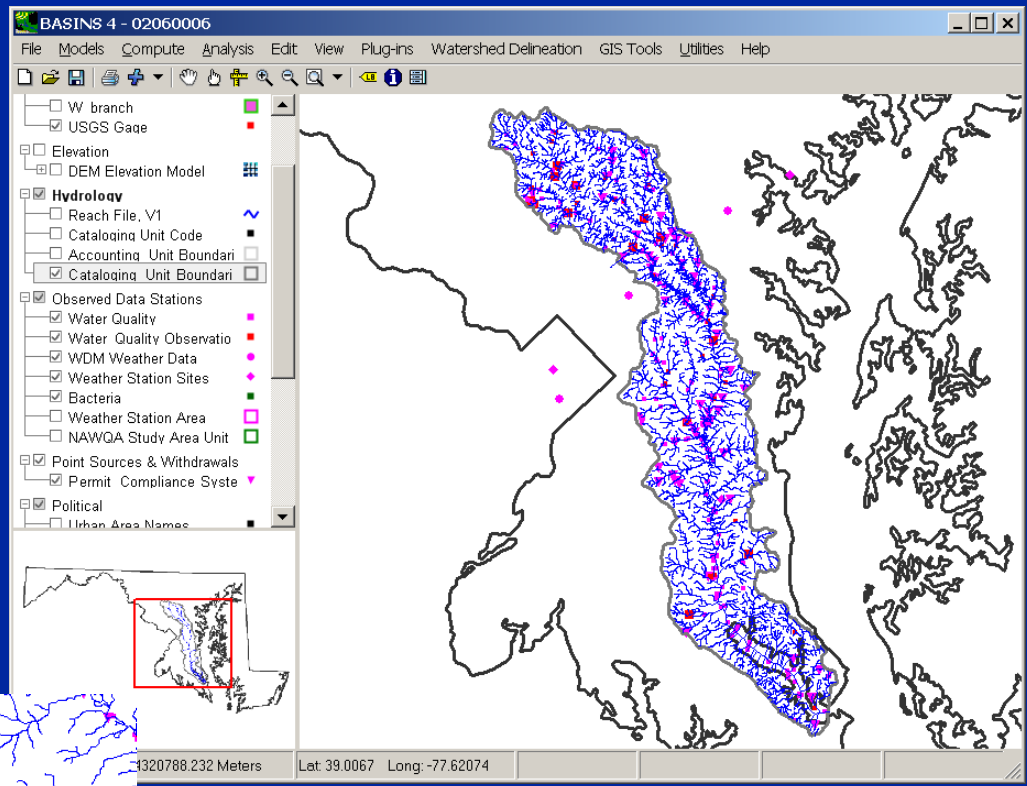
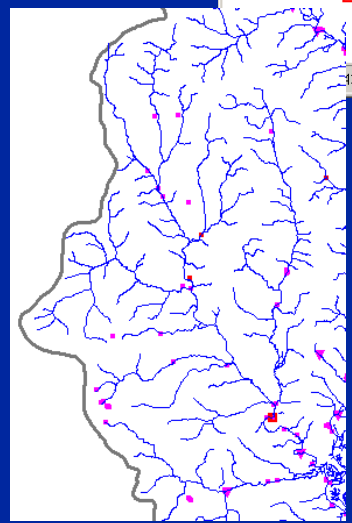
MAPWINDOW PLUG-IN MANAGER



DATA IN BASINS



Select data layers to display



Zoom to area of interest

Data included:

- Streams - Reach File 1, NHD
- Watershed boundaries
- Point source locations
- Monitoring locations

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BASINS SPATIALLY DISTRIBUTED DATA

- Land use and land cover (shape and grid)
- Urbanized areas
- Reach file 1
- National Hydrography Data (NHD)
- Major roads
- TIGER Line Files (detailed roads and census boundaries)
- USGS hydrologic unit boundaries (accounting and catalog units)
- EPA region boundaries
- State boundaries
- County boundaries
- DEM (shape and grid)
- National Elevation Dataset (NED)
- Ecoregions
- NAQWA study unit boundaries
- Soil (STATSGO)

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BASINS ENVIRONMENTAL MONITORING DATA

- Water quality monitoring station summaries
- Bacteria monitoring station summaries
- Permit compliance system sites and computed annual loadings
- Weather station sites
- USGS gaging stations
- Legacy STORET
- New STORET

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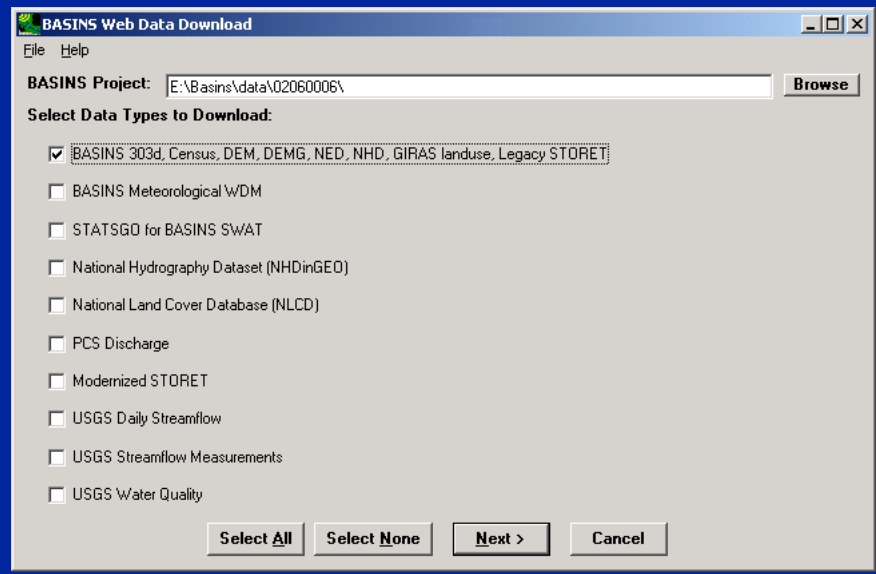
DATA DOWNLOAD TOOL

- Automatically downloads selected data from the web
- Projects shape and grid data
- Imports layers into the BASINS project



BASINS WATERSHED CHARACTERIZATION REPORTS

- Permitted Point Source Facilities Table
- 1990 Population and Sewerage by Census Tract
- 2000 Population and Census Tract Table
- 303d Listed Segment Tables
- Landuse Distribution Table
- Point Source Discharge Concentration and Loading Table
- Water Quality Observations Stations Table
- Plus custom reports through scripts

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MODELING CAPABILITIES IN BASINS

- **Models to address multiple objectives**
  - Source assessment
  - Receiving water evaluation
- **Models which operate on various scales**
  - Local scale
  - Watersheds
  - Basins
- **Models which can be applied at various levels of complexity**
  - Screening
  - Detailed

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BASINS MODELS

- **PLOAD**
  - Screening tool
  - Provides estimates of nonpoint sources of pollution on an annual average basis
  - Models any user-specified pollutant
  - Uses either the export coefficient or simple method approach

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BASINS MODELS

- **SWAT**
  - Physical based, watershed scale model
  - Developed to predict impacts of land management practices on water, sediment, and agricultural chemical yields in large complex watersheds

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BASINS MODELS

- **AGWA**
  - developed by the U.S. Agricultural Research Service's Southwest Watershed Resource Center
  - multipurpose hydrologic analysis system for performing watershed- and basin-scale studies
  - provides the functionality to conduct a watershed assessment for two watershed hydrologic models: KINEROS2 (designed for small semi-arid watersheds) and SWAT.

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BASINS MODELS

- **HSPF/WinHSPF (Hydrologic Simulation Program, FORTRAN)**
  - Continuous simulation model with fixed, user-selected, time steps
  - Predicts loadings in mixed land use settings for:
    - Nutrients
    - Toxics
    - Bacteria
    - Sediment
  - Considers point source and nonpoint source loadings and trading

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CONNECTION BETWEEN BASINS AND HSPF

BASINS/GIS data layers provided for HSPF setup

- DEM (grid)
  - *Used to determine the boundaries of the subwatersheds when delineating.*
- Land Use (NLCD or GIRAS)
  - *Used to calculate land use distributions within each subwatershed.*
  - *Each land use is parameterized separately.*
- Reach File, Version 1 or NHD
  - *One representative reach is selected for each subwatershed.*
  - *Shapefile is used to determine some of the necessary inputs associated with the stream network setup within the model*

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CONNECTION BETWEEN BASINS AND HSPF

BASINS data provided for HSPF

- Permit Compliance System (PCS)
  - *Nodes for PCS sites are added when delineating the subwatersheds.*
  - *PCS loading information input to HSPF.*
- BASINS Meteorological Data
  - *Meteorological data provided for many locations within each state in the contiguous U.S.*
- STORET Data
  - *Users can download water quality data from the EPA STORET website.*
- USGS Data
  - *Users can download flow data from the USGS website.*

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CLEAN WATER ACT OBJECTIVE

- **"It is a national goal that the discharge of pollutants into the navigable waters be eliminated by 1985."**
- **TMDL focused on protection of surface water resources**
  - Streams
  - Reservoirs
  - Estuaries
- **The ultimate goal of the TMDL process is to meet the water quality standards and ultimately improve habitat in a watershed.**

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THE TMDL PROGRAM

- **The TMDL program**
  - Requires states to develop TMDLs for waters on the 303(d) list
    - *Section 303(d) requires the identification and prioritization of waters* not *meeting in-stream water quality standards*
  - The TMDL includes a distribution of pollutant loading (allocation) that results in attainment of water quality standards
- **Five key steps to TMDL development**
  - Identify water quality-limited waters (303(d) list)
  - Prioritize water quality-limited waters
  - Develop the TMDL plan for each water quality limited stream segment
  - Implement the water quality improvement for each segment
  - Assess water quality improvement for each segment

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TMDL FOCUS

To determine the amount of pollution the water is capable of assimilating while maintaining its intended beneficial uses.

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EPA TMDL EQUATION

Citizens

Politicians and Scientists

Managers and Engineers

$$\text{TMDL} = \text{WLA} + \text{LA} + \text{MOS}$$

(total max. daily load) **(point source waste load allocation)** **(nonpoint load allocation)** **(margin of safety)**

State water quality standard for the pollutant given the stream's designated beneficial use

TMDL development phase

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WHAT ARE EPA'S EXPECTATIONS AND RECOMMENDATIONS?

- **Scientific proof**
  - Must use credible tools for data analysis
- **Data**
  - CWA requires the use of credible and defensible data for decision making
  - Monitoring
    - Monitoring is required to prove the TMDL is appropriate and requirements are being met.

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WHERE DOES BASINS FIT INTO THE TMDL PROCESS?

- Minimizes data collection
- Provides data visualization tools
- Provides simple data analysis tools
- Provides water quality models and data for populating models
- Models provide a framework for scenario generation and TMDL allocations.
- Communication with stakeholders through GIS and modeling output
- Source identification

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THE GOALS OF MODELING

1. What is the current loading in the stream?

2. What will be the loading under proposed load allocations?

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ASSIMILATIVE CAPACITY TECHNICAL TOOLS

Why models?

- Determine maximum load a stream can receive without exceeding allowable assimilative capacity

– Point sources

- Linkage between discharges and waterbody response
- Simple dilution models, steady-state water quality simulations (QUAL2E), dynamic water quality simulation (WASP) depend on pollutant type and waterbody

– Nonpoint sources

- Linkage between all sources and waterbody response
- Nonpoint source is wet-weather driven and critical condition may be at medium or high flow condition
- Watershed-receiving water response models (HSPF, SWMM, any linked watershed and receiving model)

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TMDL TYPES

- **Point sources and low flow condition**
  - Use steady state model
  - Use an appropriate design flow
  - Determine the magnitude of the impairment and endpoint
  - Develop scenarios of point source waste load allocations that will meet the allowable assimilative capacity

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TMDL TYPES

- **Point and nonpoint sources**
  - Probably need a time varying model
  - Include all sources and define when and where impairments occurs (critical condition)
  - Calculate loading under existing condition
  - Calculate loading under allocation scenarios that meet the target/standard
  - May need to negotiate with stakeholders

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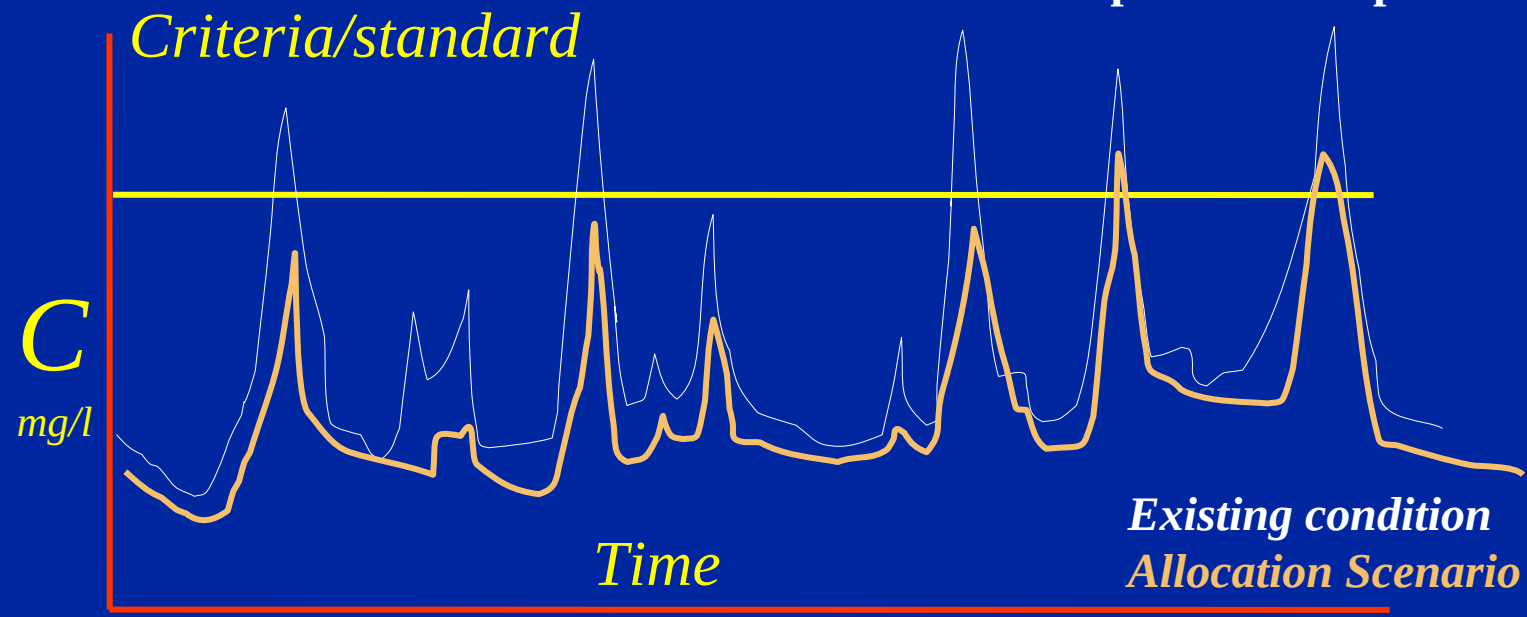
NONPOINT SOURCE TMDLS

Modeling Approach:
Use Continuous Simulation (HSPF)
Define critical/representative period



Scenario obtained through control of:

20% loading from Ag
15% from pastureland
20% urban
12% from point sources

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OTHER ISSUES IN TMDL DEVELOPMENT

- Scarcity of data in space and time
- Uncertainty in data and models
- Limitations in data analysis tools
- Difficulty with stakeholder involvement and input
- Limited expertise
- Limitations of models

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LIMITATIONS OF DETERMINISTIC MODELS

Although large and complicated, still simple in the description of complex chemical and biological processes

- usually assume first order chemical reactions
- only describe a small fraction of the food chain
- parameters estimated in a lab and selected from the model users manual or tabulation of coefficients
- model fitting often not verified on different data

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