Factors to consider when modeling
Are models reliable?

In the real world, there are many natural processes.

A model may use
one set of equations
(simple empirical models)
or
many equations
(complex models)
Are models reliable?

- Poor quality data
- No model is perfect
- All models involve uncertainty, especially if not carefully constructed or applied
- Poor results
If a model is needed...

- Select a model which best simulates your target pollutant and expressions (e.g. load vs. concentration)
- Select the simplest model possible that meets your needs
- Or simply build on/modify an existing model already used for the watershed
Selecting a Model

- More than 1 model will likely be needed to address different needs and questions.
- A watershed model must be able to:
  - transport the pollutant through the system
  - determine chemical, physical, and biological reactions
  - as well as effects of inputs and withdrawals of that pollutant
- Select the simplest model possible
Considerations when selecting a model

Consider:

- Is a model needed at all? *(In some cases, impairment may only occur during low flow conditions and therefore, no modeling would be needed)*

- What questions must the model answer?

- What model matches the scale *(spatial and temporal)* of the issue we are addressing?
Selecting a Model

Consider:

- Who will run the model?
- Will they require special training?
- How long will it take to set up?
- How much will it cost vs. value of information generated?
- How accurately will the model represent the real world?
Common pitfalls when selecting models for TMDLs

- Not deciding what questions you need to answer *before* selecting a model.
- Lack of data: climate, land use, land management, etc.
- Selecting the wrong model for a given situation (don’t necessarily accept a model suggested by consultants).
- Lack of experience using the models.
Common pitfalls when using models for TMDLs

- Underestimating model complexity (e.g., need for large input of data, calibration and validation)
- Underestimating time needed to build model (minimum 2 years)
- Difficulty translating/communicating results to public/stakeholders
- Results are interpreted as absolute truth

Even under the best circumstances, modeling results are estimates!
How much data do you need?

- Each model has different data input needs
- The more complicated the model, the more data you need
- Contiguous data is usually preferred
- Land use, land management, meteorological, and drainage data are as important as water quality data
What should you consider when choosing a model?

- Relevance
- Transparency
- Ease of use
- Utility
- Scale
- Predictive capability
Make sure model is relevant to your TMDL project needs – for example:

- Models developed for urban or forested rural areas may not be a good choice for an agricultural watershed.
- Lumped parameter models (like HSPF) **not** a good choice for field scale simulations.
Seek a model that is transparent.

Preferably, use only models which are:
- technically supported
- widely used in public arena
- free – in the public domain
Ease of use

Matches user experience

- New users will likely need training
- Some models are simple spreadsheets
- Some models require complex software packages (e.g. GIS)
Utility

Model should be **useful**

- Model should be able to predict watershed changes when land use changes
- To select correct model, must know what management practices will likely be used
- How will model be used in the future? As a management tool or to track progress?
Select a model that can be applied at the appropriate scale.

- Select appropriate spatial scale (Minn. River basin vs. small subwatershed)
- Select appropriate temporal scale (hourly vs. seasonal simulations)
Seek models that can predict changes you need:

- Need to predict phosphorus loadings at the watershed outlet after BMPs are implemented?
- Need to determine in-stream dissolved oxygen concentrations during critical conditions?
- Need something else?
The modeling process

Phase I
- Identify output requirements
- Collect data
- Prepare input files
- Evaluate parameters

Phase II
- Calibrate (if needed)
- Validate

Phase III
- Analyze scenarios for implementation planning

US EPA, 2005
Time and Money Involved in all Modeling Processes

- **Time** to collect various model inputs and setting up model
- **Money** invested in collecting data

- **Time** to calibrate and validate model
- **Money** to attend workshops/training to learn calibration and validation

- **Time** to simulate alternative management practices
- **Money** to attend workshops/training to learn simulating alternative practices
Build the model

- Identify output requirements: define exactly what you want the model to predict or do
- Collect data: pull together lots of existing data from many sources
- Prepare input files: review for quality, completeness; organize into categories
- Evaluate parameters
Data Requirements by Models

• Every model needs **data** simulate model
  – Simple model: Small amounts of data
    • Eg. Load duration curve:-
      – Flow and pollutant concentration at the outlet of watershed
    • Eg. STEPL model:-
      – Landuse, animal, soil within watershed
  – Mid range model: Medium amounts of data
    • Eg. SWAT:-
      – Landuse, Soil, Slope, Management, Weather (daily temperature and precipitation) to setup the model
      – Flow, constituents of interest (sediment, nutrients, bacteria) etc. to calibrate and validate the model
— Complex Models: Large amount of Data

• Eg. HSPF:-
  – Landuse, Soil, Slope
  – Channel dimensions
  – Meteorological records of precipitation
  – Estimates of potential evapotranspiration
  – Air temperature, dewpoint temperature, wind, and solar radiation
  – Flow, constituents of interest (sediment, nutrients, bacteria etc.) to calibrate and validate the model
Data Sources

• Digital Elevation Model (DEM):
  – 10 and 30m DEMs – USGS
  – Lidar DEMs – USGS, State agencies

• Landuse:
  – General landuse – NLCD
  – Detailed landuse -- NASS, CDL

• Soil:
  – General soils: STATSGO
  – Detailed soils: SSURGO

• Weather (precipitation, temperature, solar radiation, windspeed, relative humidity)
  – Precipitation
    • Rain gauge data: NCDC
    • Nexrad: NCDC
    • Interpolated global precip data: NCEP (National center for Environmental Prediction)
  – temperature, solar radiation, windspeed, relative humidity
    • NCDC
    • State and federal agencies

• Management Practices
  – Local agencies, stakeholders and farmers in the watershed of interest

• Calibration data
  – Streamflow: USGS or locally installed ISCO samplers
  – Constituents: USGS or locally installed ISCO samplers
Other important data sources

- USGS (LTRMP)
- US Army Corps of Engineers
- Local, state and federal agencies
- Agricultural Statistics
- Population Census
- Municipalities
- US Forest service
Calibration and validation

Phase II

- Calibrate:
  Adjust model parameters so that model outputs resembles available observed data

- Validate:
  Input data from different time periods to evaluate performance & ensure output values are reasonable; model output must match record
More about calibration and validation

**Inputs**
- Actual historical data sets
  - e.g. 1991-1995
  - Physical
  - Water chemistry
  - Climate

**Model**
- Calibrate
  - Refine/tweak parameters to try to approximate reality

**Outputs**
- Predictions based on historical data
  - Streamflow data
  - Water quality data

**Validate**
If predictions satisfactory, test model using a different water quality data set
Implementation planning

Phase III

- Analyze scenarios: Apply model to project future loads under new conditions (after implementing BMPs)

  Use model to evaluate impact of different land use practices (new BMPs, cultivation techniques, etc.) on water quality