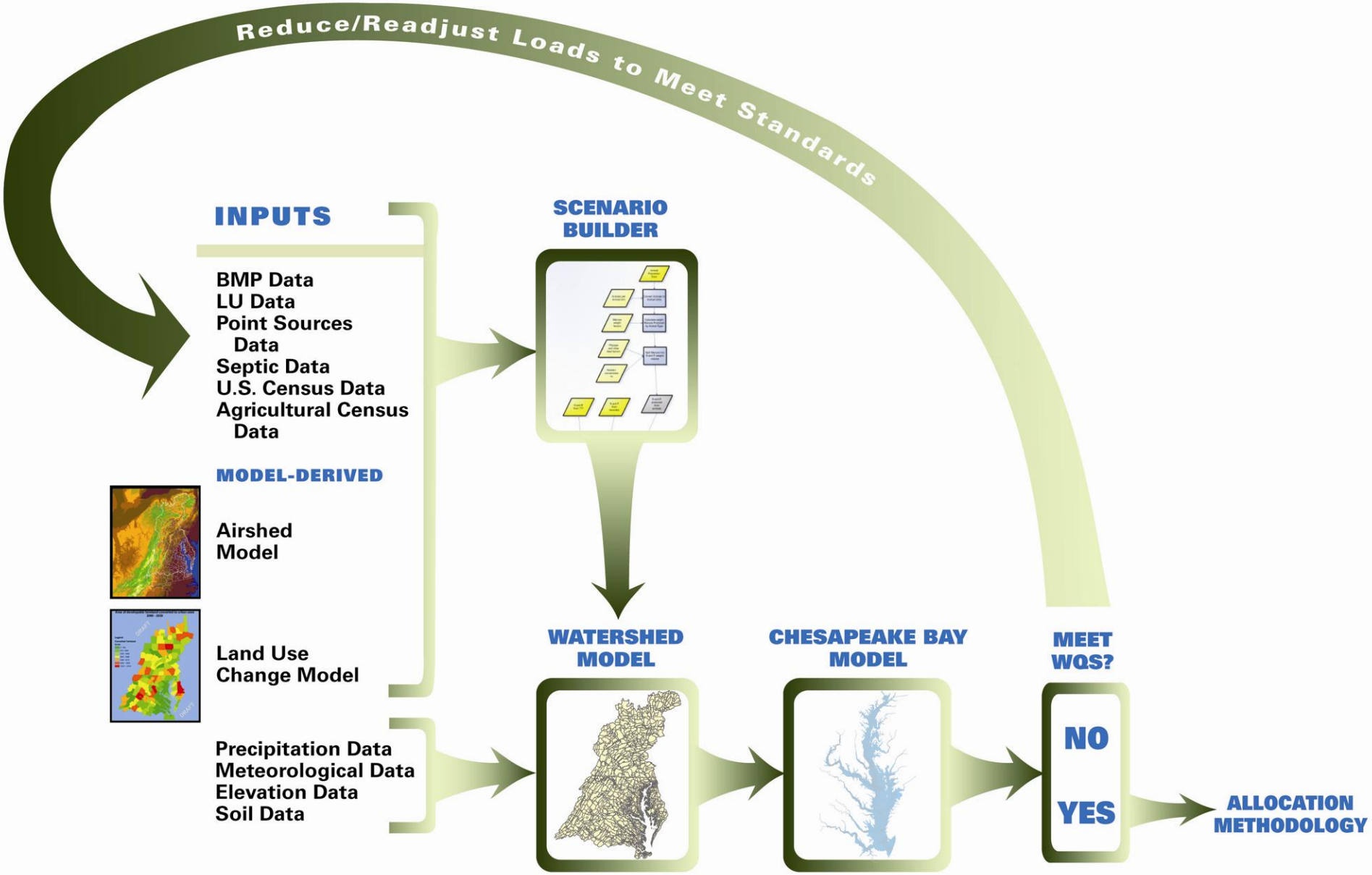
Land Use in the Chesapeake Bay Program Partnership's Watershed Model

Gary Shenk
Land Use Work Group
9/17/12

Chesapeake Bay Partnership Models

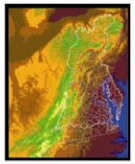


Chesapeake Bay Partnership Models

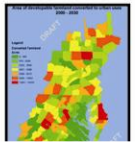
INPUTS

BMP Data
LU Data
Point Sources Data
Septic Data
U.S. Census Data
Agricultural Census Data

MODEL-DERIVED

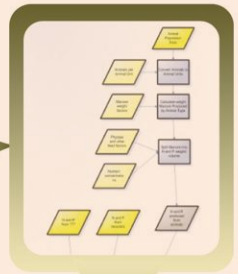


Airshed Model



Land Use Change Model

SCENARIO BUILDER



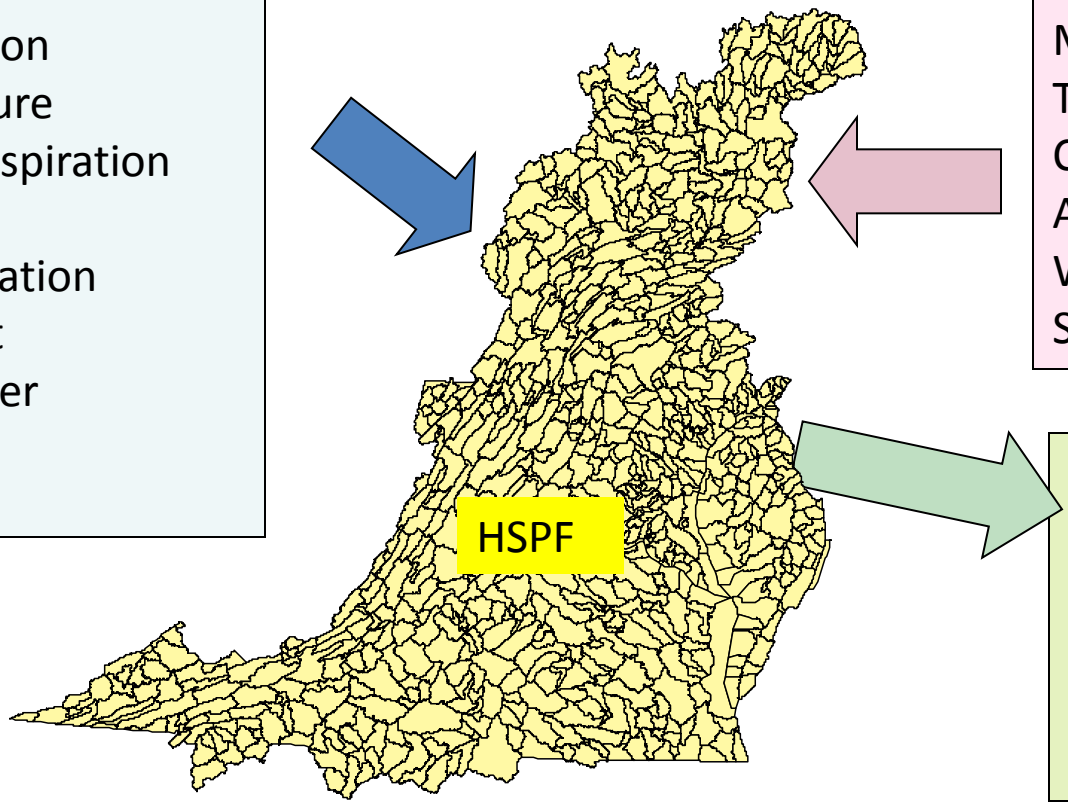
WATERSHED MODEL

How the Watershed Model Works

Calibration Mode

Hourly or daily values of Meteorological factors:

Precipitation
Temperature
Evapotranspiration
Wind
Solar Radiation
Dew point
Cloud Cover



Annual, monthly, or daily values of anthropogenic factors:

Land Use Acreage
BMPs
Fertilizer
Manure
Tillage
Crop types
Atmospheric deposition
Waste water treatment
Septic loads

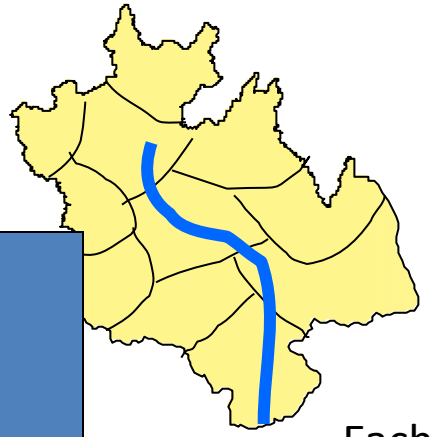
Daily flow, nitrogen, phosphorus, and sediment compared to observations over 21 years

How the Watershed Model Works

Each segment consists of 30 separately-modeled land uses:

- Pervious Developed
- Impervious Developed
- Construction
- Extractive
  - Variants for regulated, unregulated, and combined sewer
- Wooded / Open
- Disturbed Forest

- Manure-eligible High Till
- Manure-eligible Low Till
- Other Row Crops
- Alfalfa
- Nursery
- Pasture
- Degraded Riparian Pasture
- Afo / Cafo
- Fertilized Hay
- Unfertilized Hay
  - Nutrient management versions of the above



Plus: Point Source and Septic Loads, and Atmospheric Deposition Loads

Each calibrated to nutrient and Sediment targets

How the Watershed Model Works

Precipitation

Fertilizer
Manure
Atmospheric deposition

Management filter

Runoff

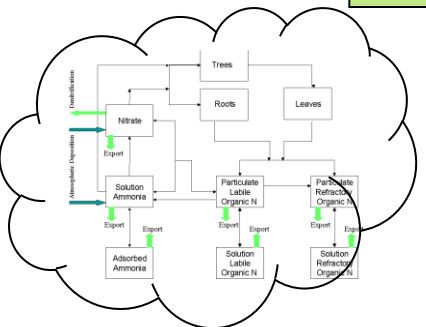
River

Hydrology submodel

Sediment submodel

Phosphorus submodel

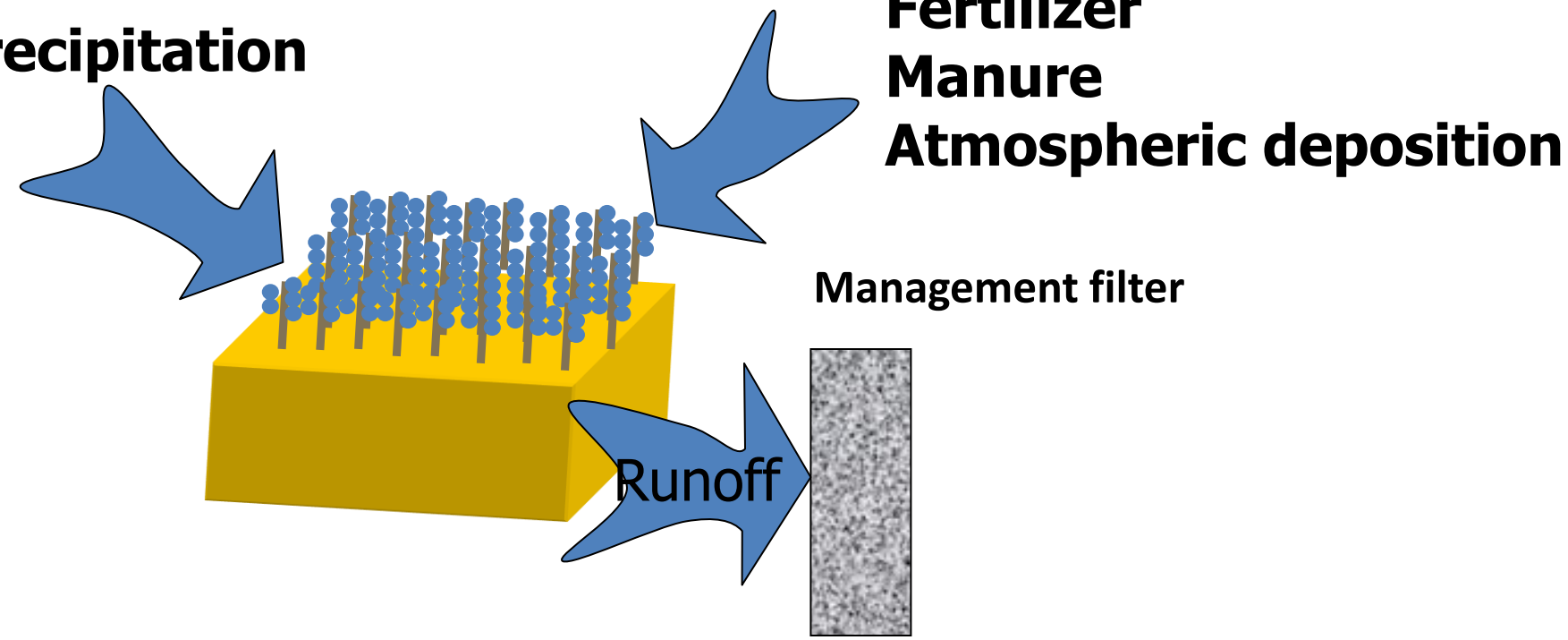
Nitrogen submodel



hourly

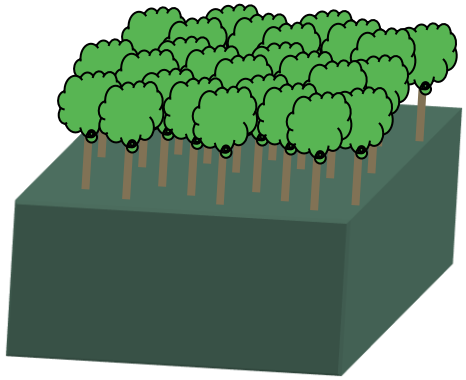
Point Sources
Septic

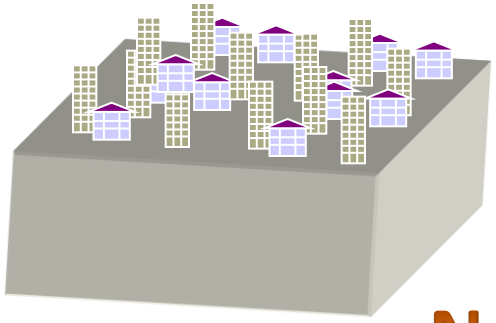
How the Watershed Model Works

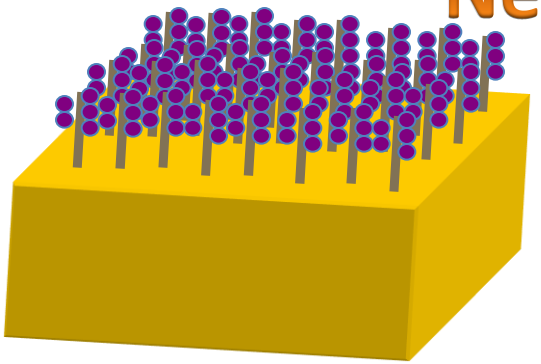


Need estimates of inputs and management

How do we match observations?







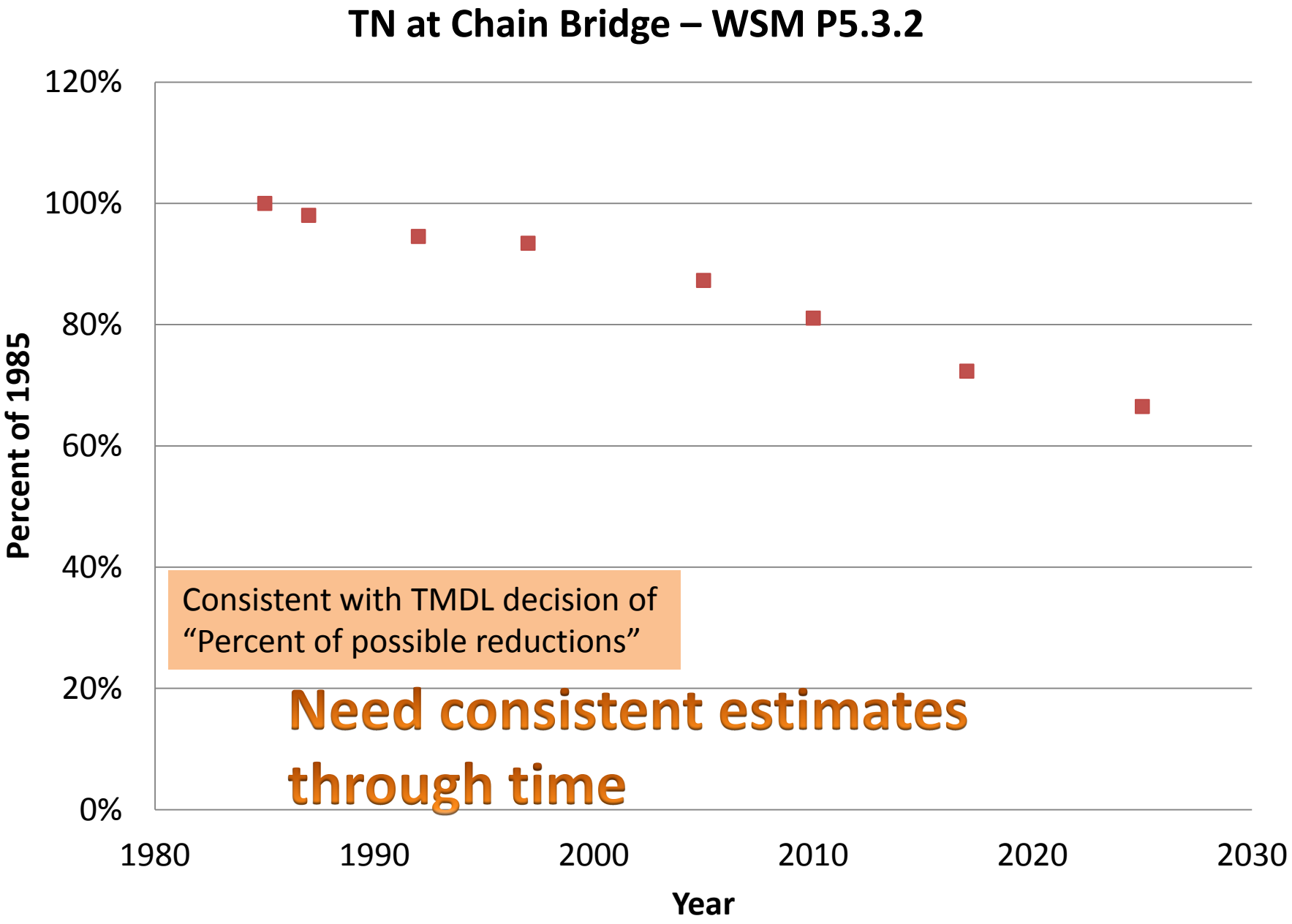
Iterative solution

River Reach

Reasonable values of sediment, nitrogen, and phosphorus

Need estimates of export

Observations of flow, sediment, nitrogen, and phosphorus


TN at Chain Bridge – WSM P5.3.2
120%
100%
80%
60%
40%
20%
0%
Percent of 1985
1980
1990
2000
2010
2020
2030
Year
Consistent with TMDL decision of "Percent of possible reductions"
Need consistent estimates through time

Developed Land Uses

	Regulated	Unregulated	Combined Sewer
Pervious	✓	✓	✓
Impervious	✓	✓	✓
Construction	✓		✓
Extractive	✓	✓	✓

- **Regulated vs Unregulated normally corresponds to MS4 and non-MS4. Loading rates are identical so these categories are a convenience for the state partners.**
- **Combined Sewer land uses have zero loads. The loads from WWTPs and CSOs in combined sewer areas are in the model, so including these would be double counting**

- **Determined directly from the CBP Land Data Team analysis at roughly 10 year increments**

Agricultural Land Uses

- Manure-eligible High Till
- Manure-eligible Low Till
- Other Row Crops
- Fertilized Hay
- Unfertilized Hay
- Alfalfa
- Pasture
- Degraded Riparian Pasture
- Nursery
- Afo / Cafo

- Nutrient Man. High Till
- Nutrient Man. Low Till
- Nutrient Man. Row Crops
- Nutrient Man. Fertilized Hay
-
- Nutrient Man. Alfalfa
- Nutrient Man. Pasture
-
-
-

- Determined by analysis of USDA-NASS Census of Agriculture by county for five year increments. Interpolated between those years.
- Nutrient management from reported BMP implementation submissions by states

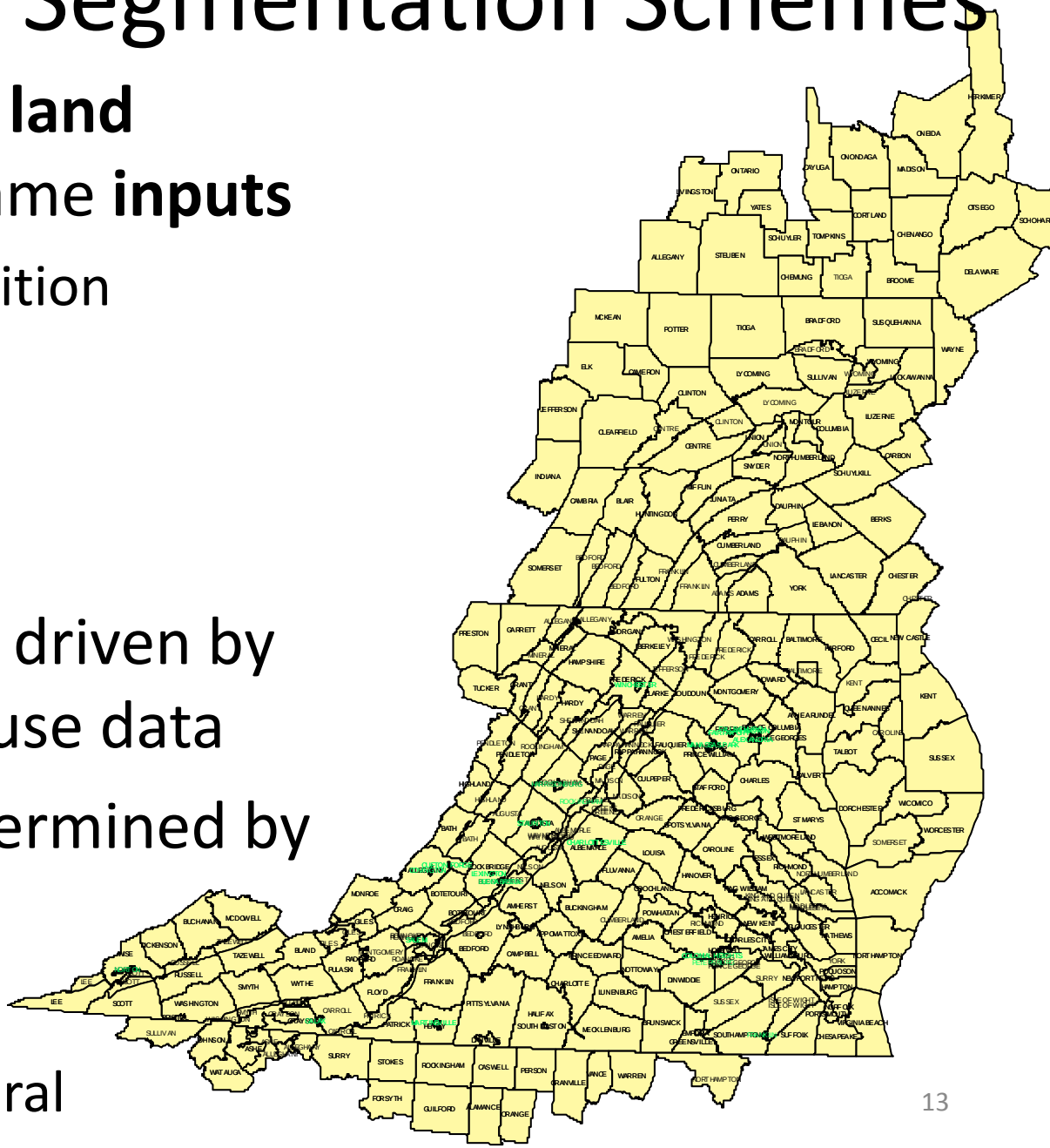
Natural Land Uses

- **Open Water**
- **Wooded / Open**
- **Disturbed Forest**

  - **Water determined by CBP Land Data Team**
  - **Wooded / Open determined by subtraction of water, developed, and agricultural from total area in a segment.**
  - **Disturbed forest assumed to be a constant 1% of the total wooded and open**

Two Separate Segmentation Schemes

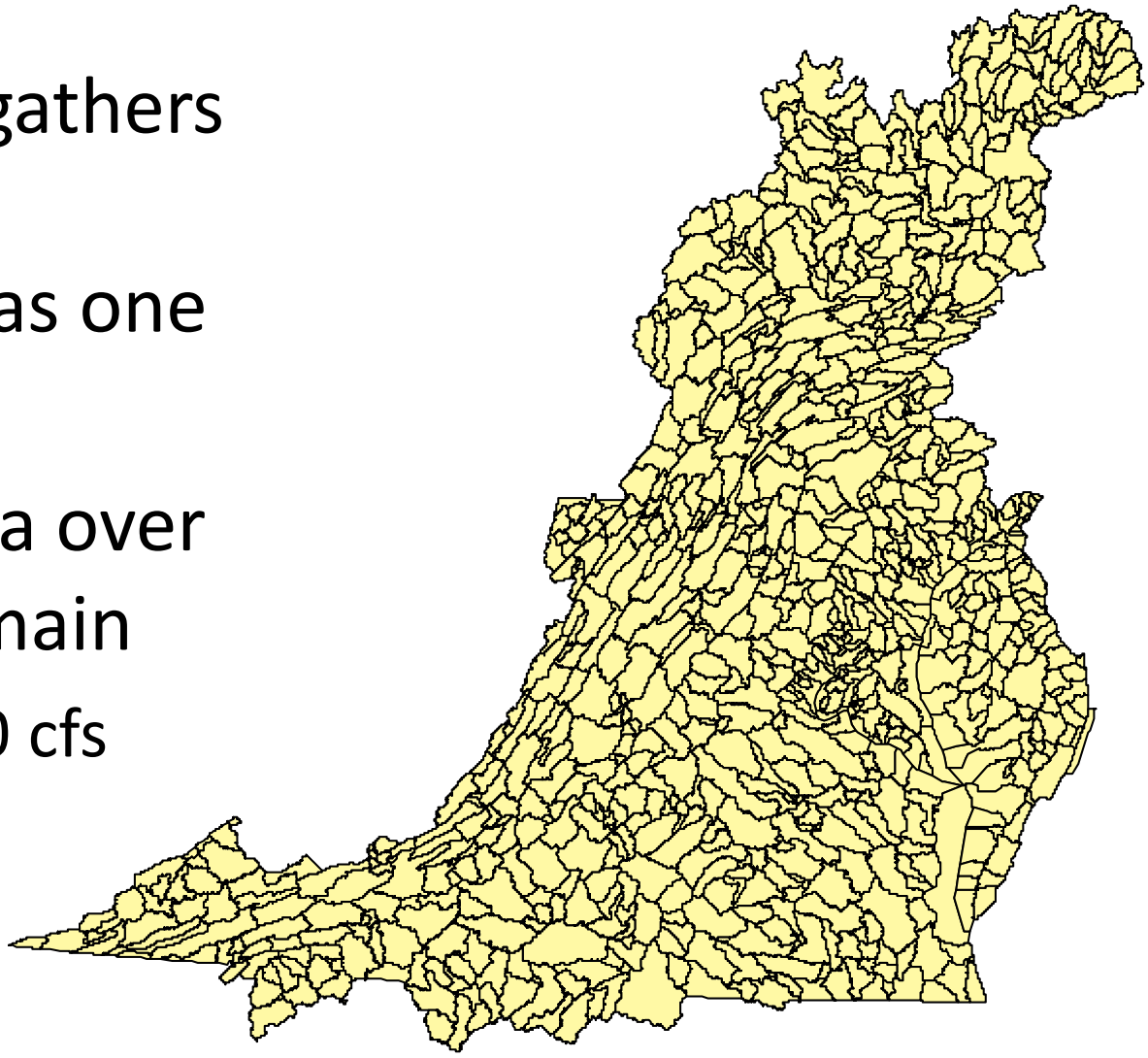
- A land use within a **land segment** has the same **inputs**
  - atmospheric deposition
  - fertilizer
  - manure
  - precipitation
- Land segmentation driven by availability of land use data
- Land segments determined by
  - County lines
  - Rainfall Variances
  - Federal / Non-Federal

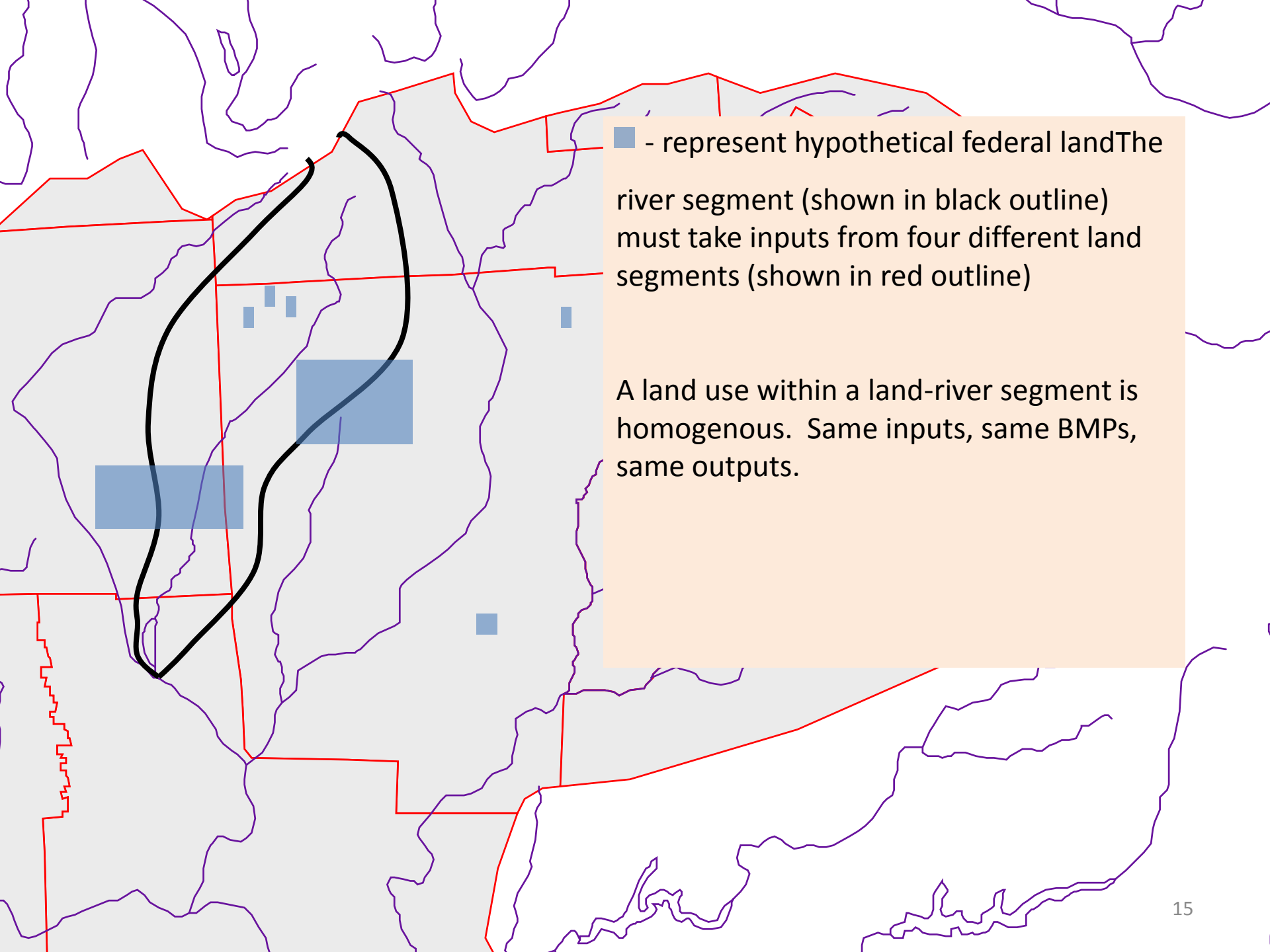


Phase 5 river segmentation

- A river segment gathers inputs from the watershed and has one simulated river
- Consistent criteria over entire model domain
  - Greater than 100 cfs

    or
  - Has a flow gage





- represent hypothetical federal landThe river segment (shown in black outline) must take inputs from four different land segments (shown in red outline)

A land use within a land-river segment is homogenous. Same inputs, same BMPs, same outputs.

Land Use Process

- **Land Data Team** provides lrseg acreages for developed land uses, water, row crop and pasture/hay.
- **Modeling team** calculates construction acreages based on change in imperviousness.
- **Scenario Builder** calculates 10 agricultural land uses by county
- **Scenario Builder** creates final land use data set by lrseg by meshing data sets and applying BMPs

Land Use Process

- Scenario Builder takes all data sets and produces the final land use, preferentially preserving the land uses with the least uncertainty
- BMPs are applied to create nutrient management land uses and to adjust for land use change BMPs.
- Forest/open is found by subtraction

1. Area of lrseg
2. Water area in lrseg
3. Urban area in lrseg other than unregulated pervious developed
4. Agricultural area by county
    1. Afo/cafo
    2. Row crops
    3. Pasture/hay

Reasons to designate a separate land use

- Makes a management difference
  - Regulated impervious and unregulated impervious have same modeled characteristics but are tracked separately
  - Afo and cafo
- Makes a modeling difference
  - Water land use has no BMPs, but need for atmospheric deposition load and water balance
- Most land uses fall into both categories

Requirements for a land use

- How much exists
- Where is it
- How is it managed
- What are the loading characteristics
- **Unbiased trend estimates**
  - Would like this information 1950-2100
  - Can settle for 1984-2025

GIS vs Tabular Land Use

- Have chosen tabular to get:
  - Agreement with ag census
  - Incorporation of non-observable land use differences (afo/cafo, nutrient management, etc)
- GIS-based is preferable
  - Communication
  - Sub-segment effects
- Consider probability-based layers