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# Nitrate Tracking in the Lower Yakima Basin

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U.S. Geological Survey

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DEPARTMENT OF THE INTERIOR

# WATER-SUPPLY

AND

# IRRIGATION PAPERS

OF THE

UNITED STATES GEOLOGICAL SURVEY

No. 55

GEOLOGY AND WATER RESOURCES OF A PORTION OF YAKIMA COUNTY, WASH.—SMITH

WASHINGTON
GOVERNMENT PRINTING OFFICE
1901



DEPARTMENT OF THE INTERIOR
UNITED STATES GEOLOGICAL SURVEY
GEORGE OTIS SMITH, DIRECTOR

WATER-SUPPLY PAPER 339

# QUALITY OF THE SURFACE WATERS OF WASHINGTON

BY

WALTON VAN WINKLE

Prepared in cooperation with the State Board of Health of Washington

WASHINGTON
GOVERNMENT PRINTING OFFICE
1914

# GWMA objectives

- “reduce nitrate concentrations in groundwater below state drinking water standards”
- “address all the significant sources of nitrate and bacterial pollution in a comprehensive manner”
- “contamination threat will be reduced or stabilized within 5 years”
- “reductions of contaminants will be measured… and shared with the public by 2013”
- “will identify and describe the contributing activities to groundwater contamination based on scientific data”

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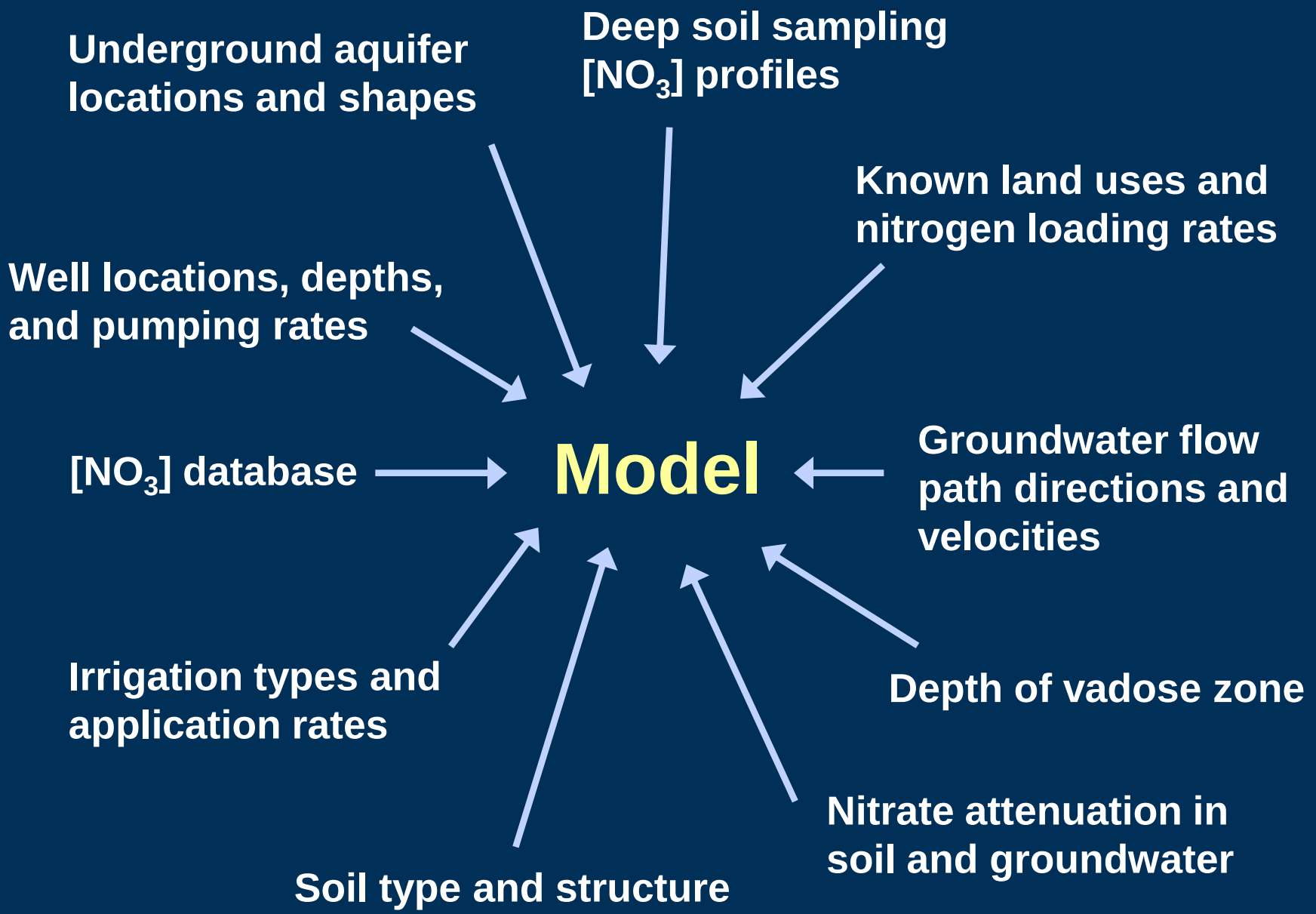
Underground aquifer locations and shapes
Deep soil sampling [NO3] profiles
Known land uses and nitrogen loading rates
Well locations, depths, and pumping rates
[NO3] database
Model
Groundwater flow path directions and velocities
Irrigation types and application rates
Depth of vadose zone
Nitrate attenuation in soil and groundwater
Soil type and structure

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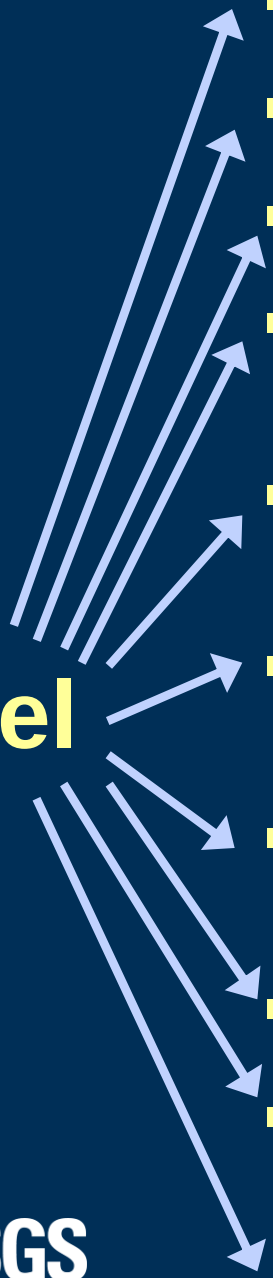
# Model



- Defined recharge areas for all wells
- [$NO_3$] plume maps
- Plume velocities and directions
- Total N budget that is spatially and temporally discretized
- Identification of relative N contribution from each potential source
- Site-specific N loading rates that are protective of groundwater
- Expected time delay until surface changes show up in wells
- Identification of locations best suited to N removal
- Expected impacts of proposed changes to nutrient management
- Compliance scenarios

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# How do nutrients get from land surface to the water table?

**Process-Based Groundwater Vulnerability Assessment (P-GWAVA)**

- Mechanistic, not statistical model
- Uses USDA model (RZWQM) for nutrient transport and reactions in the vadose zone
- Uses NRCS (SSURGO) soil property data to estimate model input parameters
- Attenuates applied nutrients before delivery to groundwater

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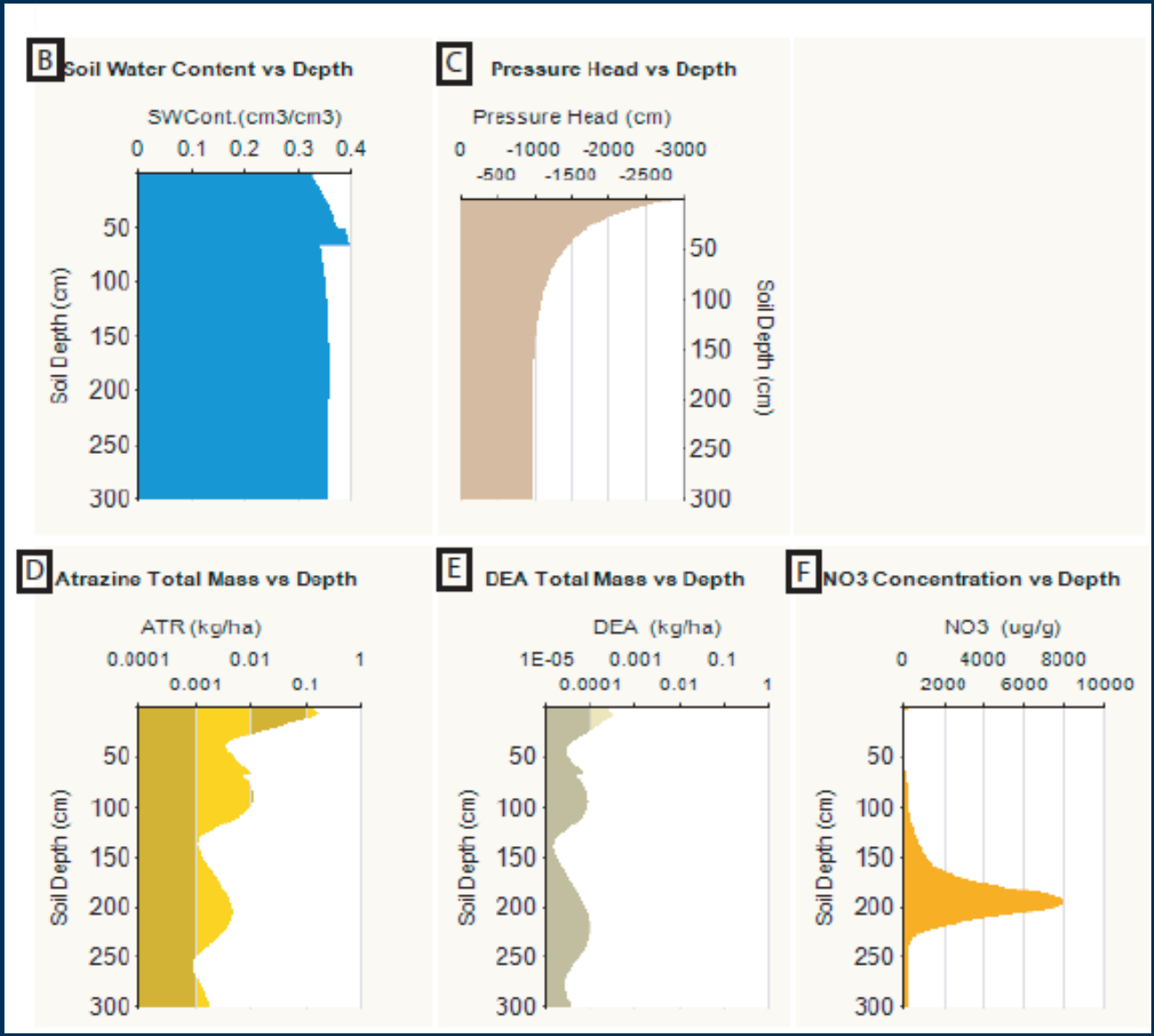
- **P-GWAVA generates nutrient profiles based on land use and soil type**

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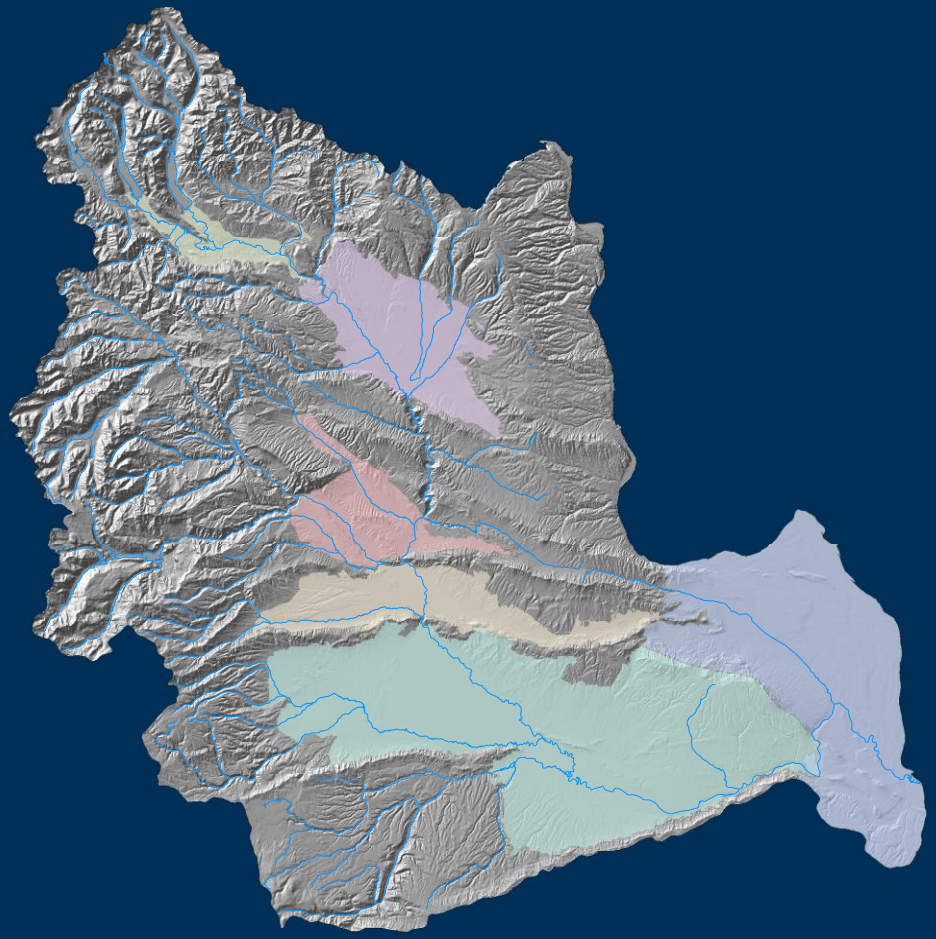
# How do nutrient plumes move in groundwater?

## Existing Yakima groundwater model, converted to MT3D

- 1,000 x 1,000-ft cells
- 4.6 million active cells
- 5,575 cubic miles of aquifer material
- 48 hydrogeologic units
- 24 model layers
- Simulation Period: 1960-2001
- 1-month time steps (504 stress periods)



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- **MT3D conversion of Yakima model**
  - **Simulates reactive contaminant transport in groundwater**
  - **Generates groundwater concentration plumes and evolves them over time**
  - **Includes irrigation rate, groundwater pumping, and streamflow impacts on subsurface flow**
  - **Particle tracking results already finished**

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# What is the time scale of connection between land application and drinking water well?

- Vadose zone transport plus groundwater transport time
- Requires both models
- Typically measured in decades, not months

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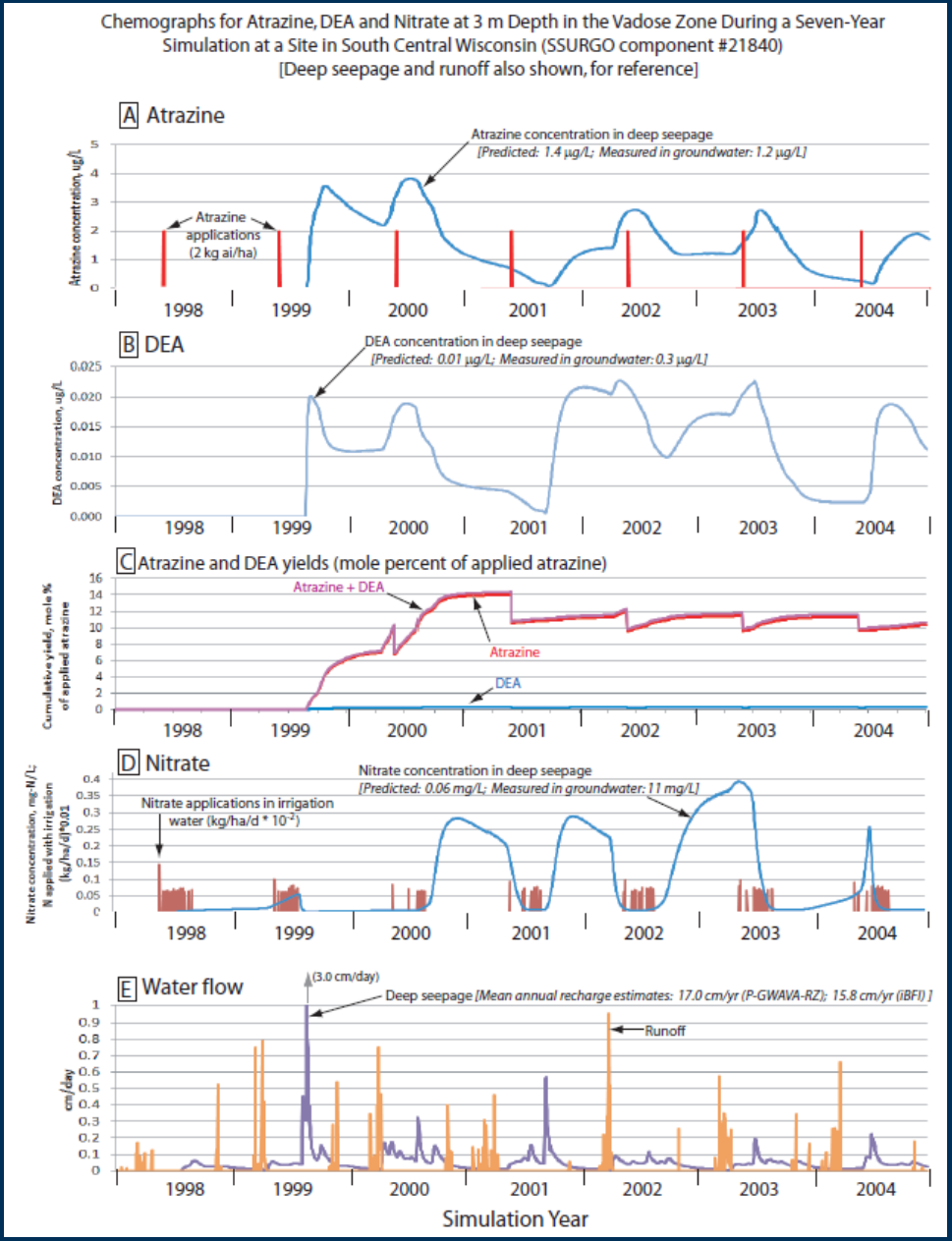
- **P-GWAVA simulations in vadose zone can be calibrated to GWMA soil sampling results**

- **MT3D simulations in groundwater can be calibrated to GWMA nitrate assessment results**

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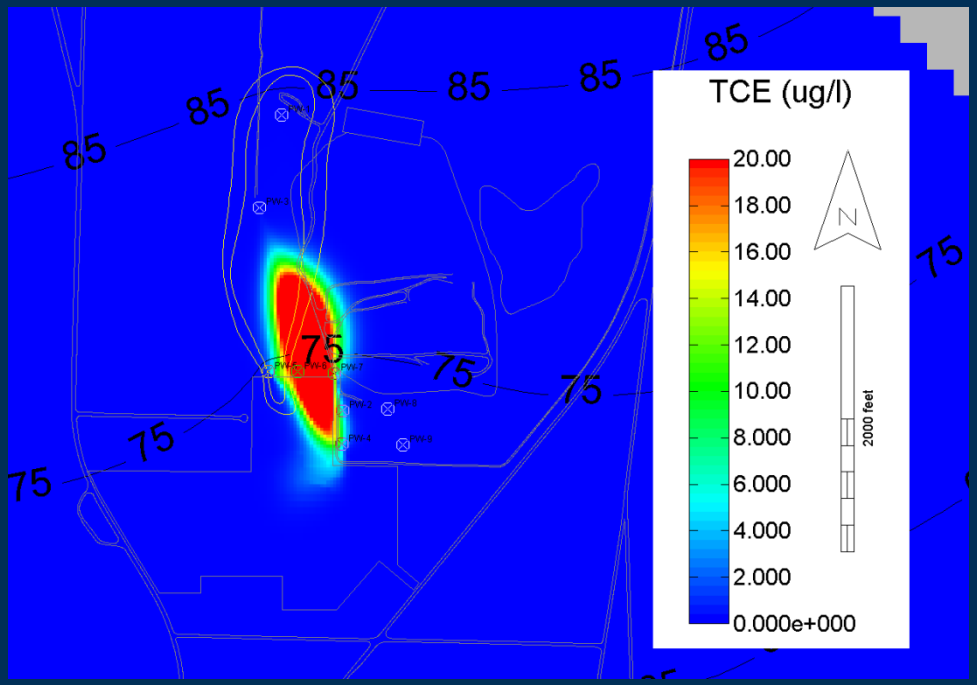
# How will nutrient concentrations change over time under alternative futures?

**Loading rates and management practices: P-GWAVA**

**Groundwater plumes: MT3D**

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# Proposed Work

- Specify N loading rates at land surface
- Convert P-GWAVA from a site-specific to a basin-wide model
- Convert Yakima groundwater model to MT3D
- Link P-GWAVA loading rates to MT3D input rates
- Calibrate combined transport model to the GWMA's nitrate assessment

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# Available datasets

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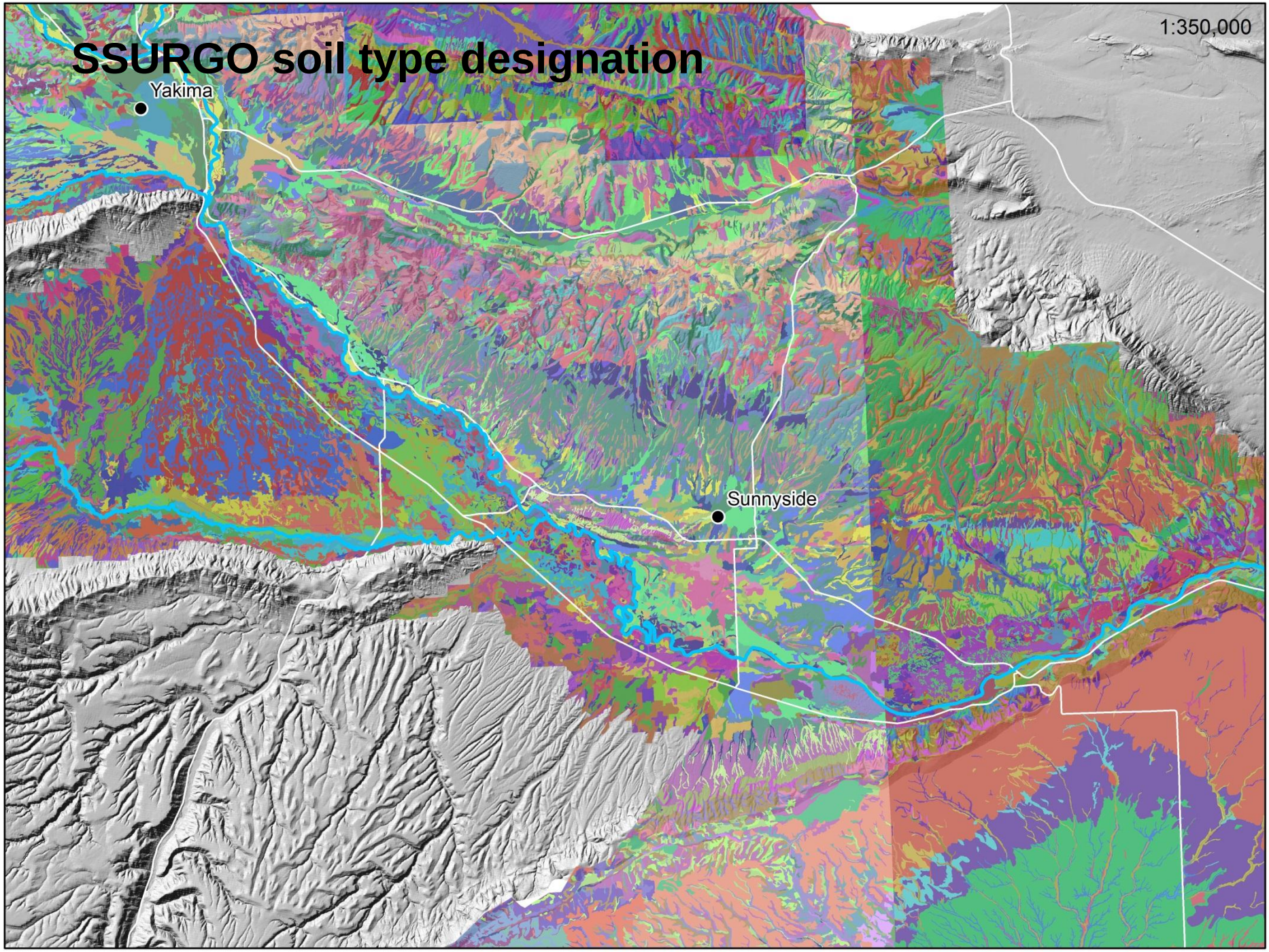
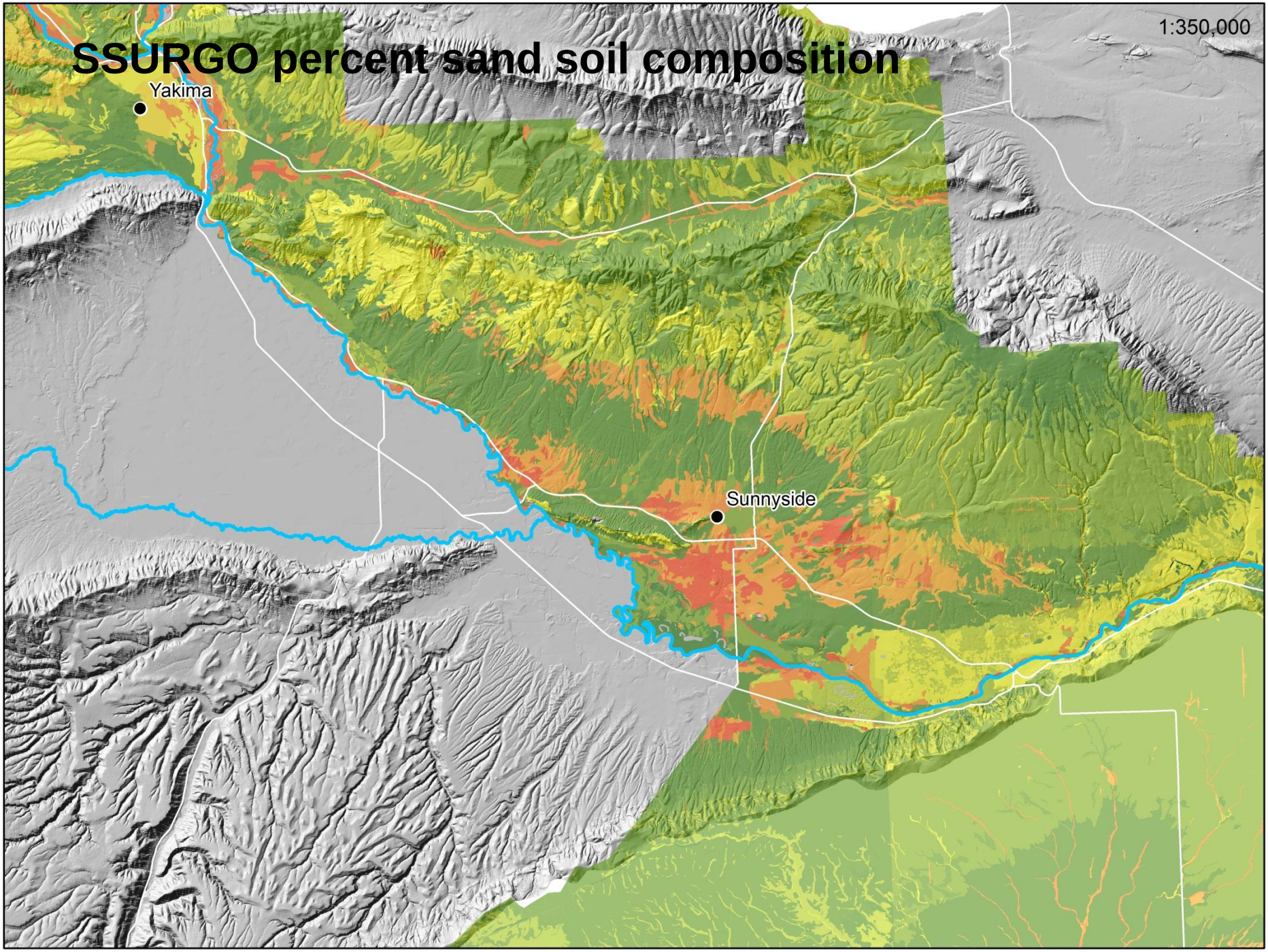
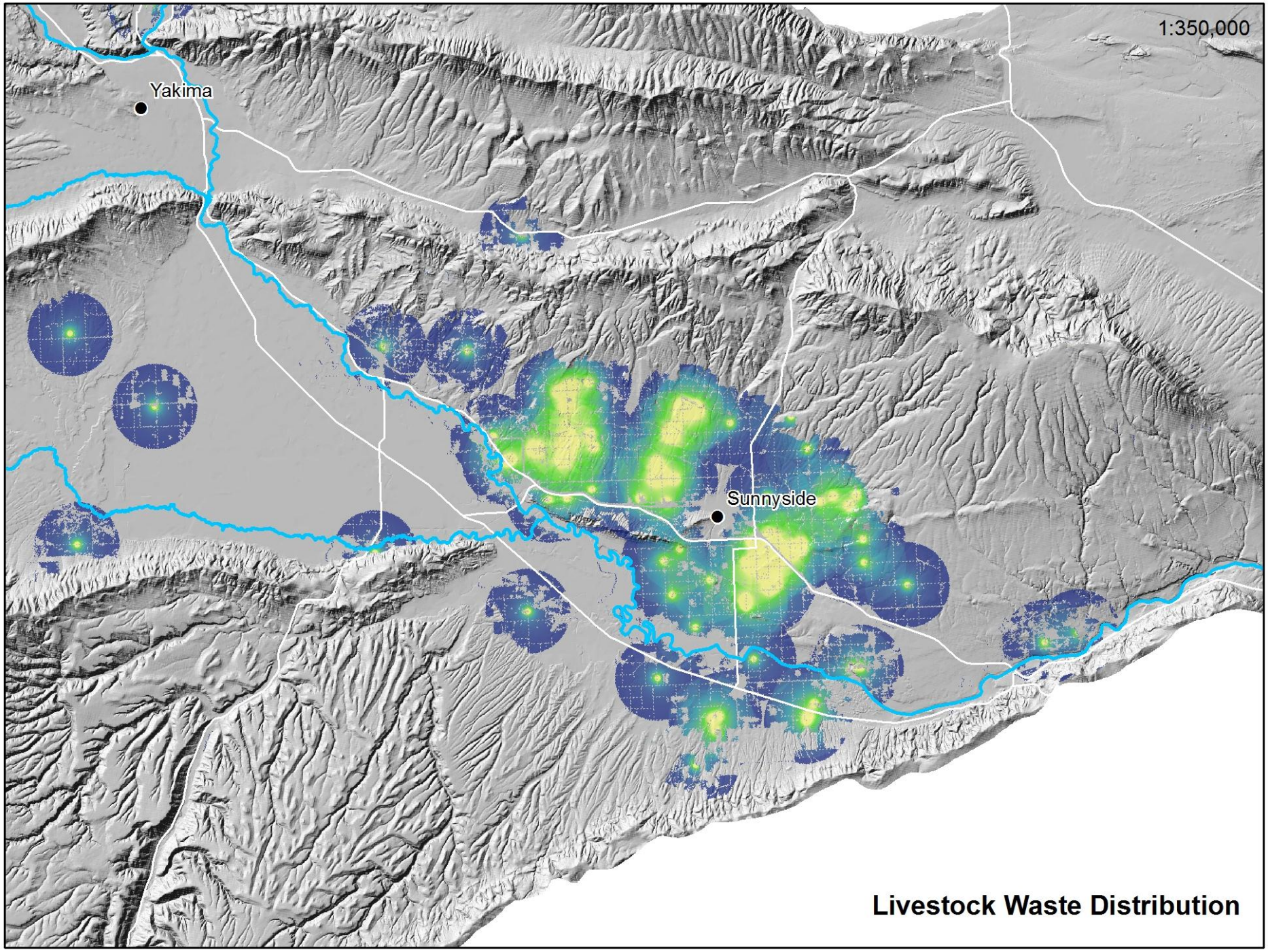
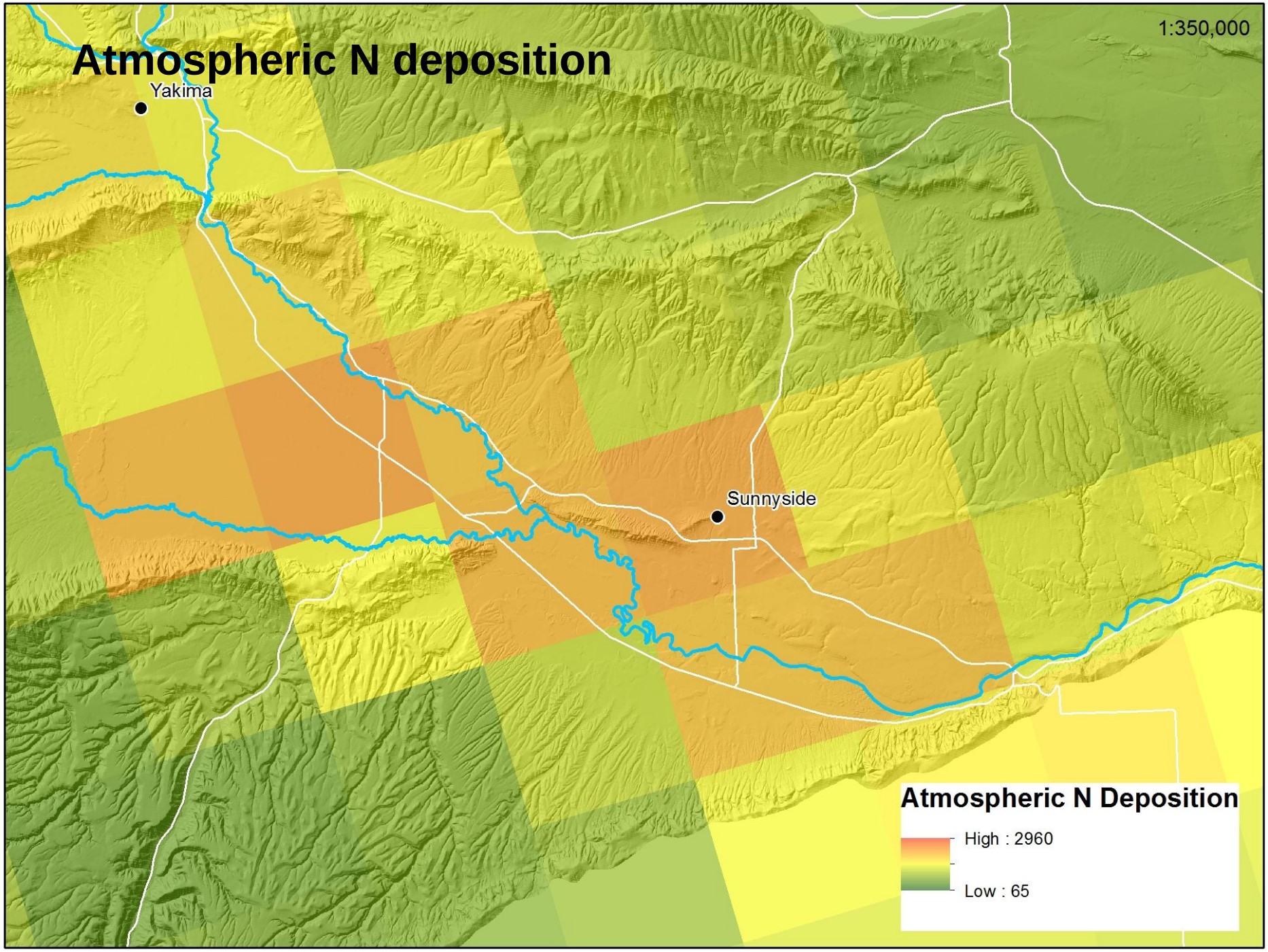
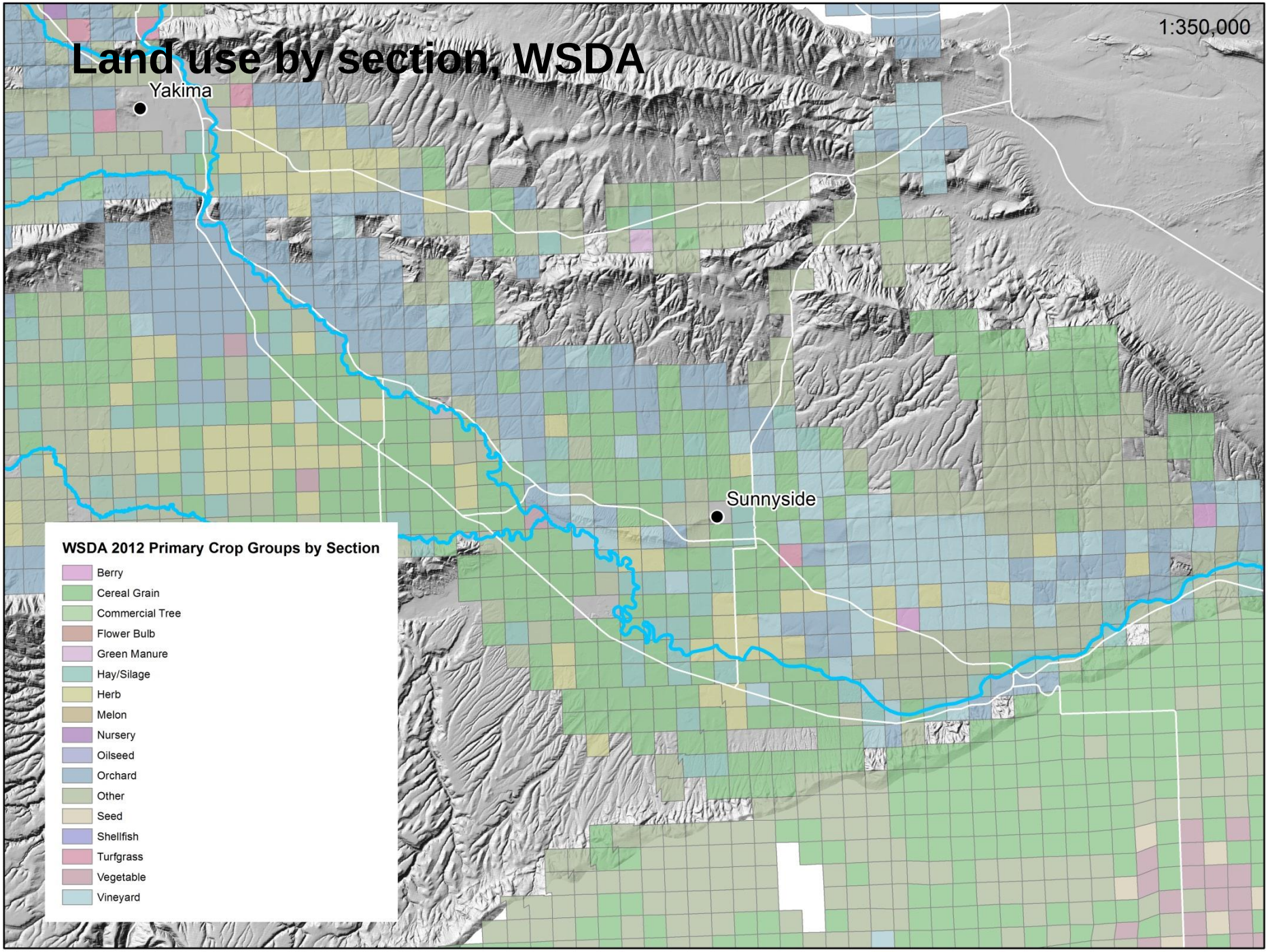
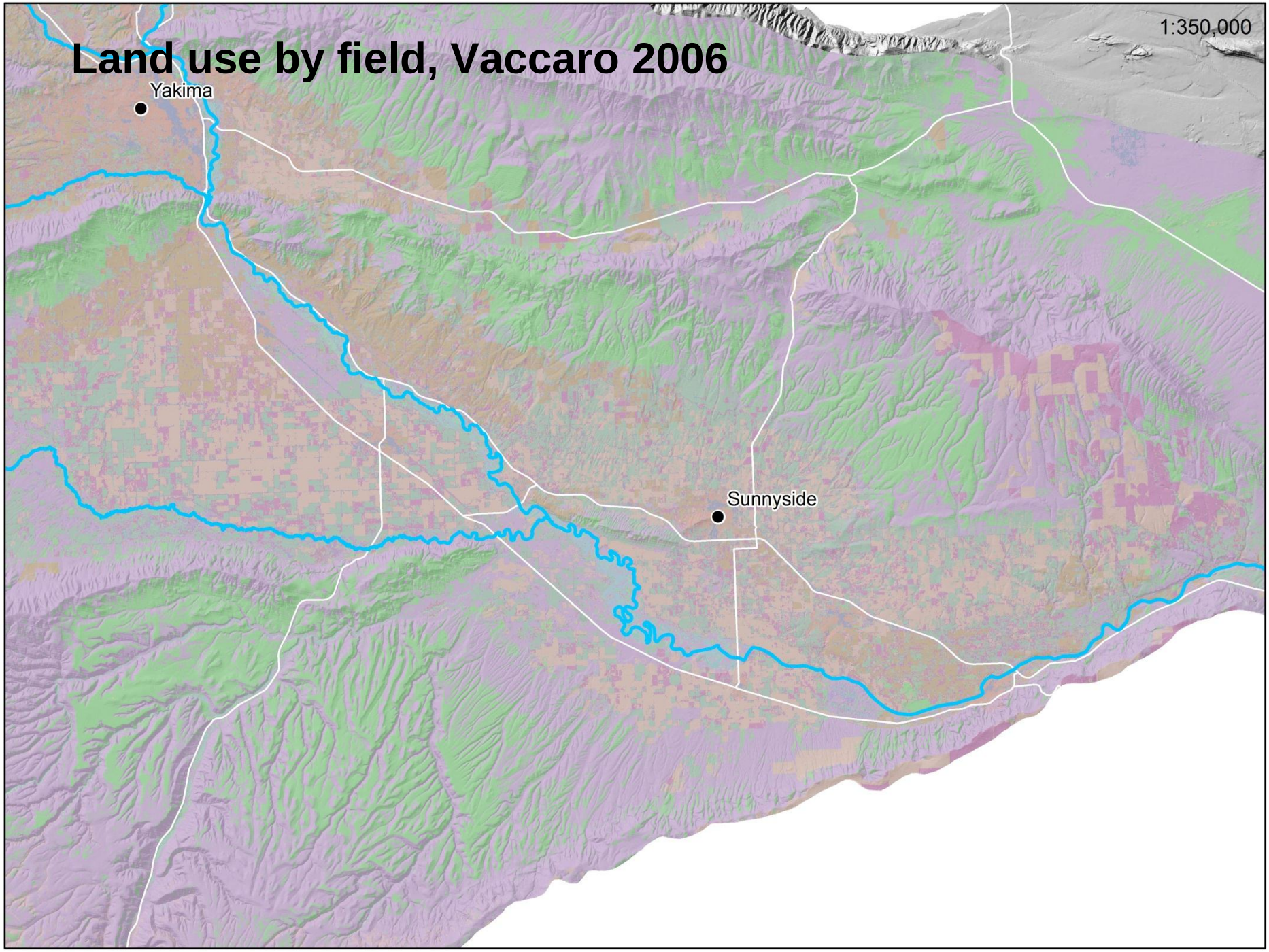

SSURGO soil type designation
Yakima
Sunnyside
1:350,000


SSURGO percent sand soil composition
1:350,000
Yakima
Sunnyside


1:350,000
Yakima
Sunnyside
Livestock Waste Distribution


Atmospheric N deposition
1:350,000
Yakima
Sunnyside
Atmospheric N Deposition
High : 2960
Low : 65


Land use by section, WSDA
1:350,000
Yakima
Sunnyside
WSDA 2012 Primary Crop Groups by Section
Berry
Cereal Grain
Commercial Tree
Flower Bulb
Green Manure
Hay/Silage
Herb
Melon
Nursery
Oilseed
Orchard
Other
Seed
Shellfish
Turfgrass
Vegetable
Vineyard


Land use by field, Vaccaro 2006
1:350,000
Yakima
Sunnyside

# Proposed Work

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# How USGS might help

- **Monitoring and Assessment - $417 unallocated**
  - Groundwater monitoring system
  - Database construction
- **Nutrient loading/Nitrogen budget - $50k unallocated**
  - Develop mass balance approach to N loading
- **Best Management Practices - $107k unallocated**
  - Evaluate BMPs for effectiveness
  - Address specific nitrate sources
- **Irrigation Water Management - $704k unallocated**
  - Develop management strategies specific to land use to reduce leaching of nitrate to groundwater

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# Project Logistics

- Showcase for new nutrient modeling technology
  - Increases likelihood of USGS matching funds
- Project duration 18 months to three years, depending on desired outcomes
- Will require working closely with the GWMA
- Should have cooperation of basin partners
  - Ecology
  - EPA
  - Dept. of Ag
  - Dept . of Health
  - Yakima County
  - Yakama Nation
  - Producers

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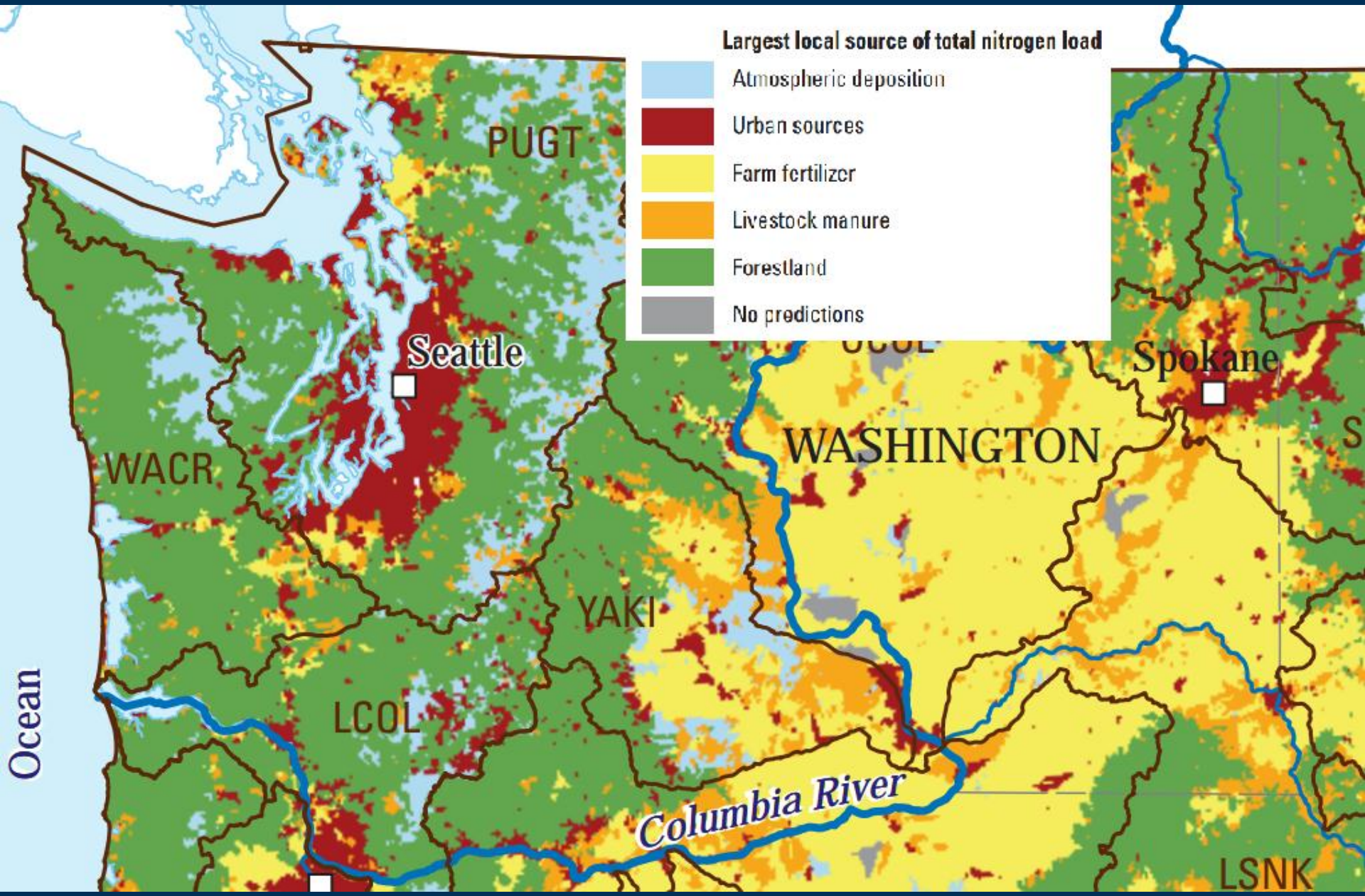
Largest local source of total nitrogen load
Atmospheric deposition
Urban sources
Farm fertilizer
Livestock manure
Forestland
No predictions
PUGT
Seattle
Spokane
WASHINGTON
WACR
YAKI
LCOL
LSNK
Columbia River
Ocean

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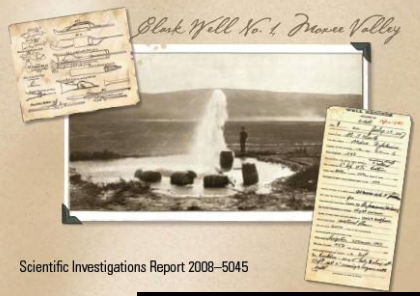
Prepared in cooperation with the Bureau of Reclamation, Washington State Department of Ecology, and the Yakama Nation

**Extent and Depth to Top of Basalt and Interbed Hydrogeologic Units, Yakima River Basin Aquifer System, Washington**




Scientific Investigations Report 2008–5045

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**Hydrogeologic Framework of Sedimentary Deposits in Six Structural Basins, Yakima River Basin, Washington**


Scientific Investigations Report 2006–5116

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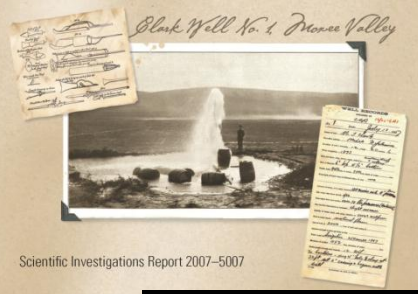
**Estimates of Ground-Water Recharge to the Yakima River Basin Aquifer System, Washington, for Predevelopment and Current Land-Use and Land-Cover Conditions**




Scientific Investigations Report 2007–5007

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**Estimates of Ground-Water Pumpage from the Yakima River Basin Aquifer System, Washington, 1960-2000**


Scientific Investigations Report 2006–5205
Version 1.1, October 2007

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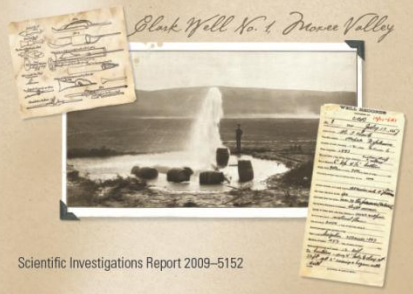
**Hydrogeologic Framework of the Yakima River Basin Aquifer System, Washington**

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**River-Aquifer Exchanges in the Yakima River Basin, Washington**


Scientific Investigations Report 2011–XXXX

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http://wa.water.usgs.gov/projects/yakimagw