Influence of the Missoula Floods on Willamette Valley Groundwater

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Geosciences, OSU

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Overview

- Missoula Floods 12.5-15ka
  - catastrophic floods, huge impact on landscape
- Left thick silt (up to 30 m) unit over most of Willamette Valley - “Willamette Silt”
- Underlying unit is Willamette Aquifer
- WS has two major effects on groundwater:
  - hydrologically buffers groundwater in WA from surface water and vice versa
  - protects groundwater from pollutants

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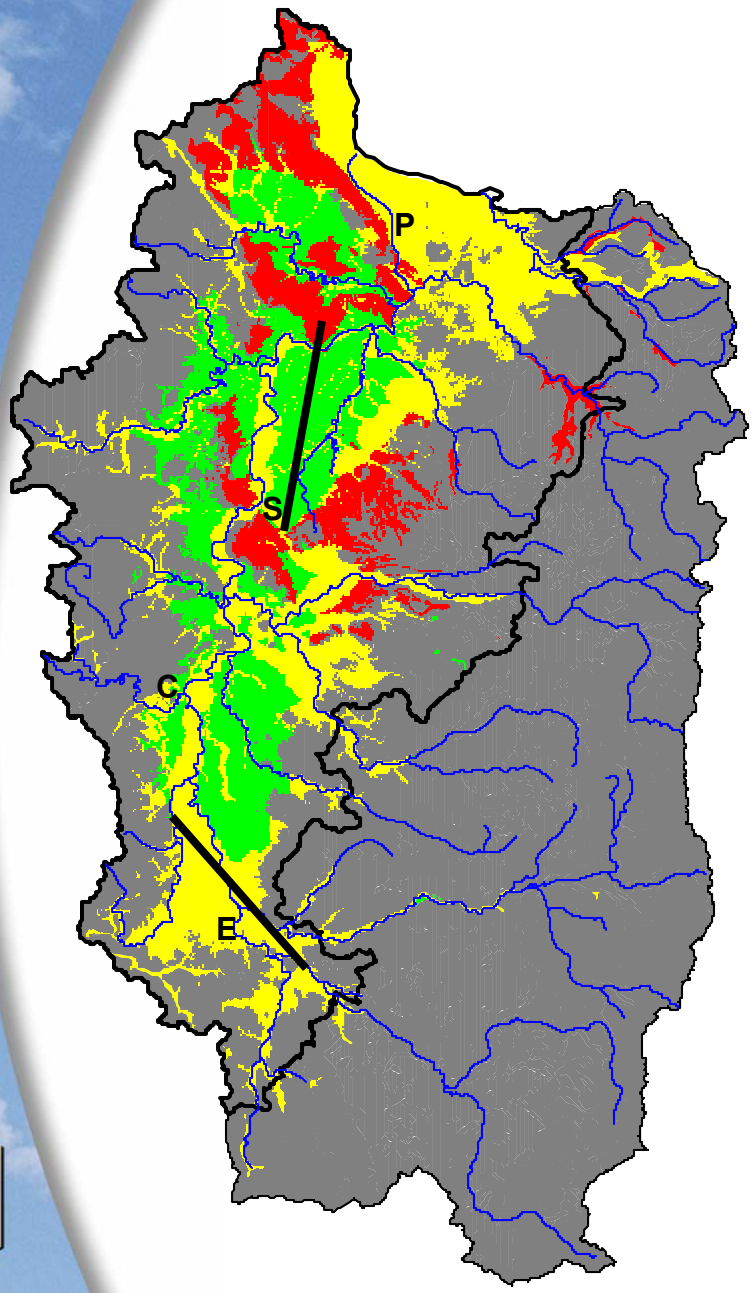
Generalized Geology of the Willamette Valley



- Willamette Silt
- Alluvium and basin-fill sediment
- Columbia River Basalt Group
- Marine sedimentary rocks and Cascade Range rocks

Gannett & Caldwell, 1998

0 10 20 30 MILES

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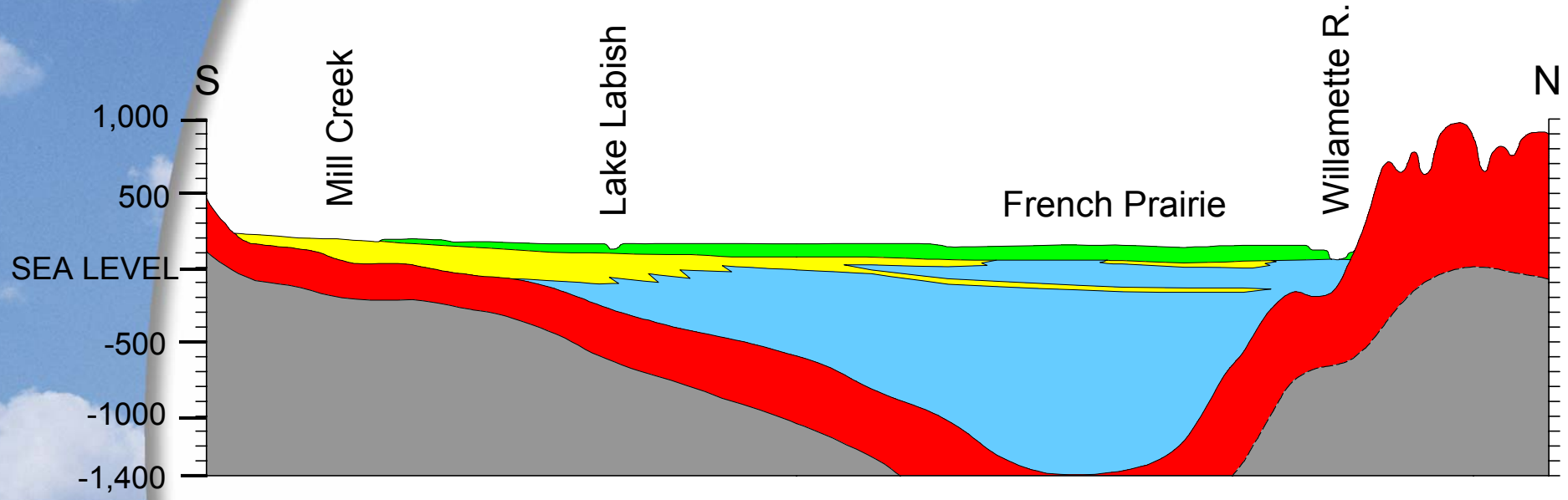
NORTH-SOUTH SECTION THROUGH THE CENTRAL WILLAMETTE VALLEY



Willamette Silt

Alluvium and coarse-grained basin-fill deposits

Fine-grained basin-fill deposits

Columbia River Basalt Group lava

Marine sediments and Western Cascade rocks

Gannett & Caldwell, 1998

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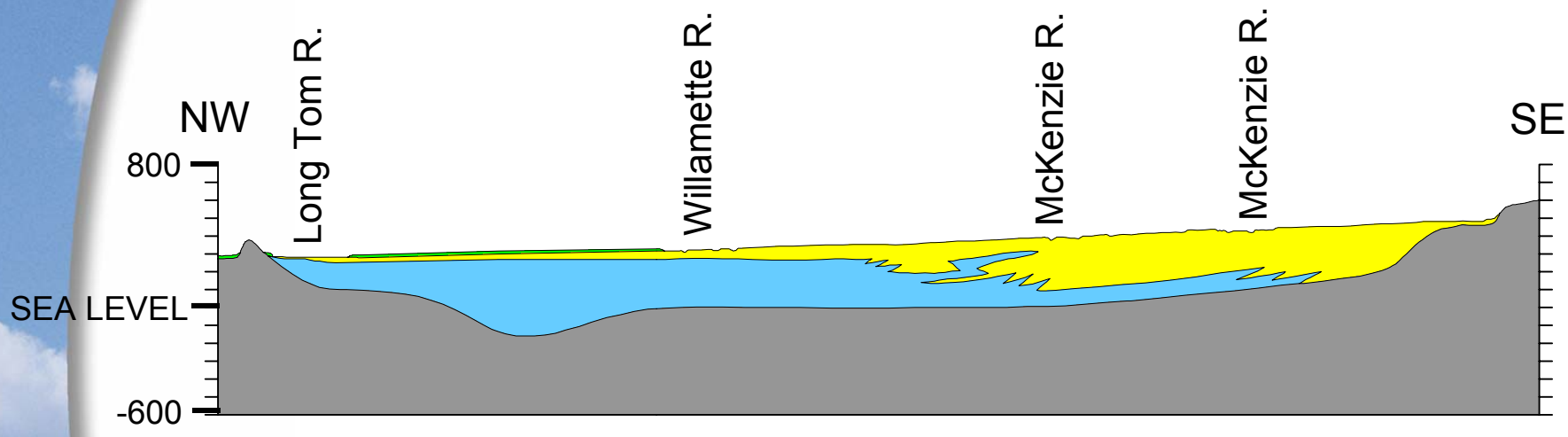
NORTHWEST-SOUTHEAST SECTION THROUGH THE SOUTHERN WILLAMETTE VALLEY



Willamette Silt

Alluvium and coarse-grained basin-fill deposits

Fine-grained basin-fill deposits

Columbia River Basalt Group lava

Marine sediments and Western Cascade rocks

Gannett & Caldwell, 1998

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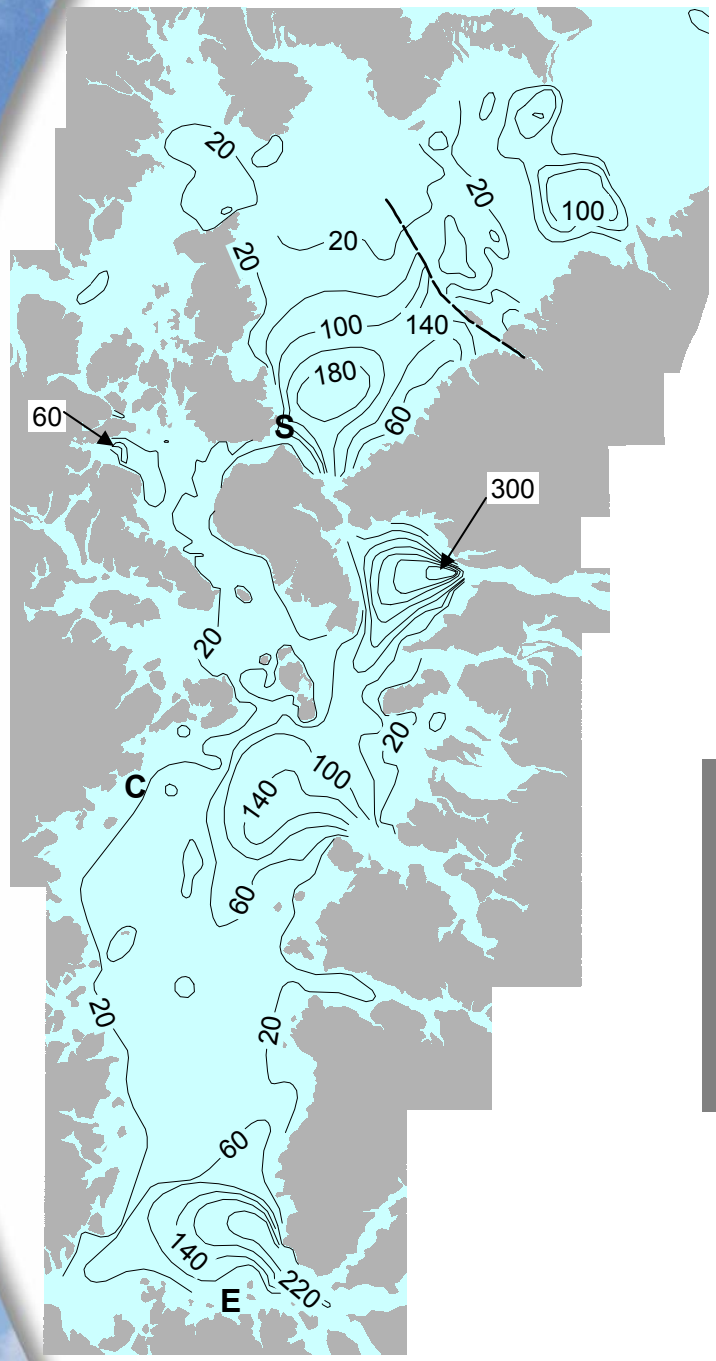

Thickness of the Coarse-Grained Basin-Fill Deposits

(contour interval 40 ft)

Marshall Gannett, 2003

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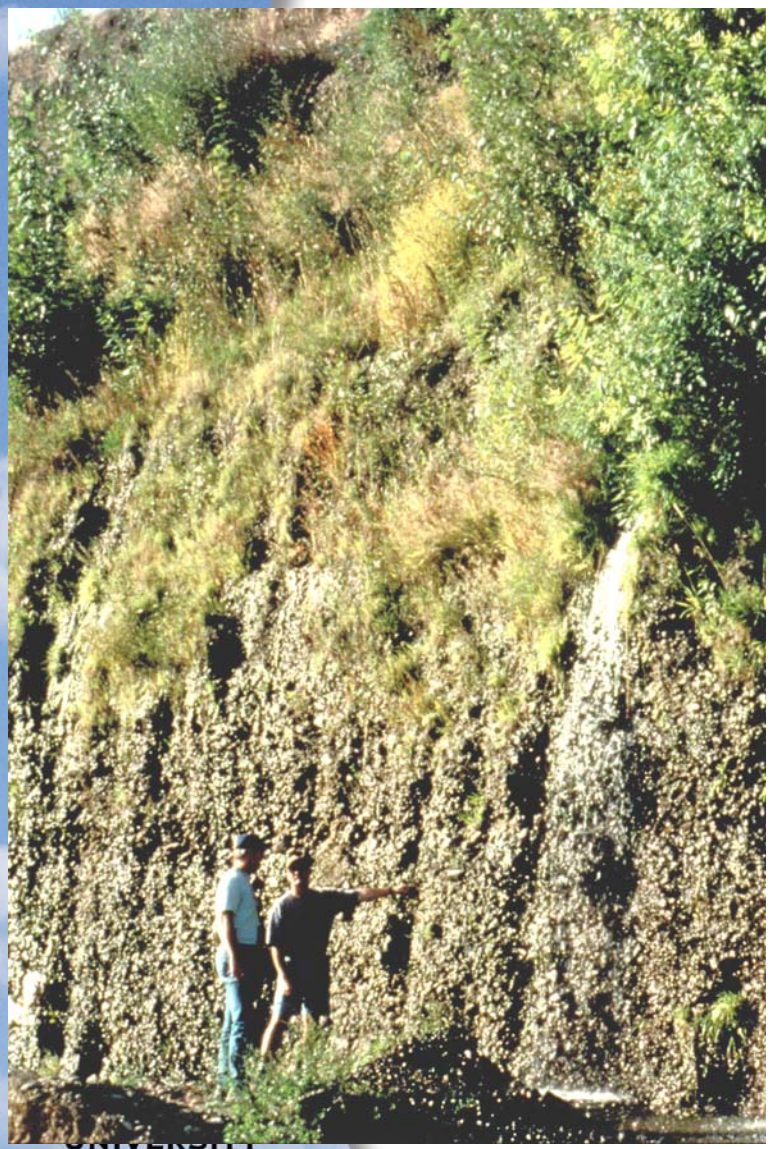
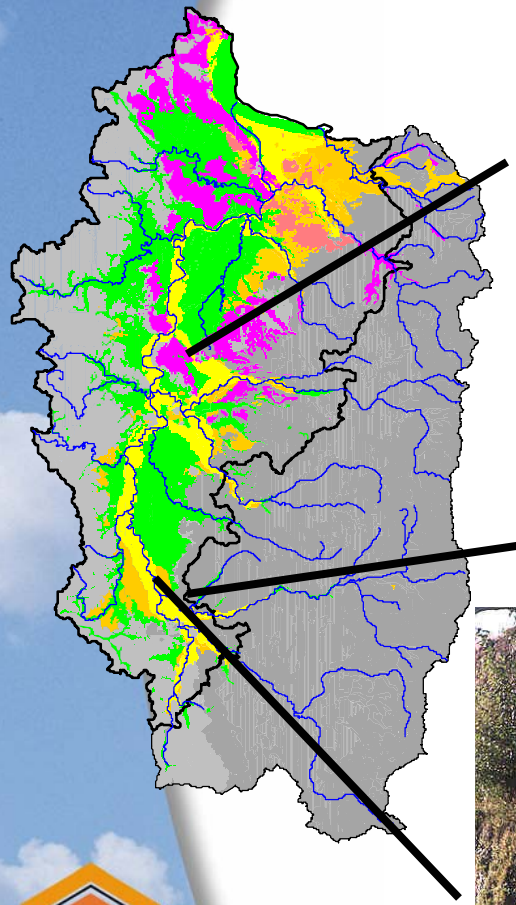
Pleistocene River Alluvium

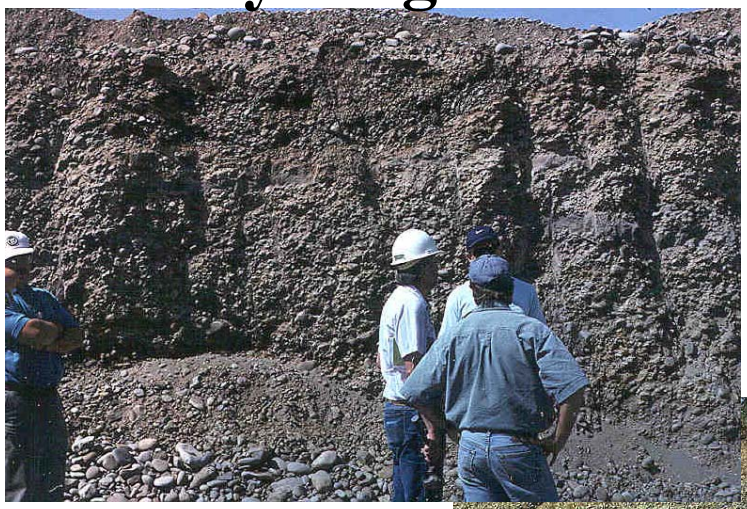


Up to 100 m thick.
Includes lahars from Mt. Jefferson and a Middle Fk. Willamette(?) source.
Locally older than 420 ka.
Locally younger than 23 ka.
Deposited in broad braidplains.

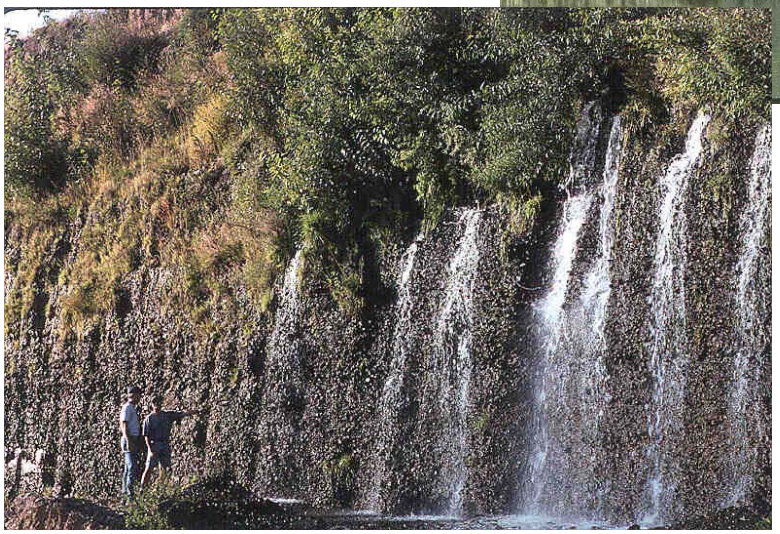
Jim O'Connor, 2003

Basin-fill—older and younger coarse-grained deposits





Gravels,
Walling Pit
Turner, OR



Gravels and
Lahar (0.4 Ma),
Delta Pit,
Eugene, OR

Gravels,
Delta Pit,
Eugene, OR

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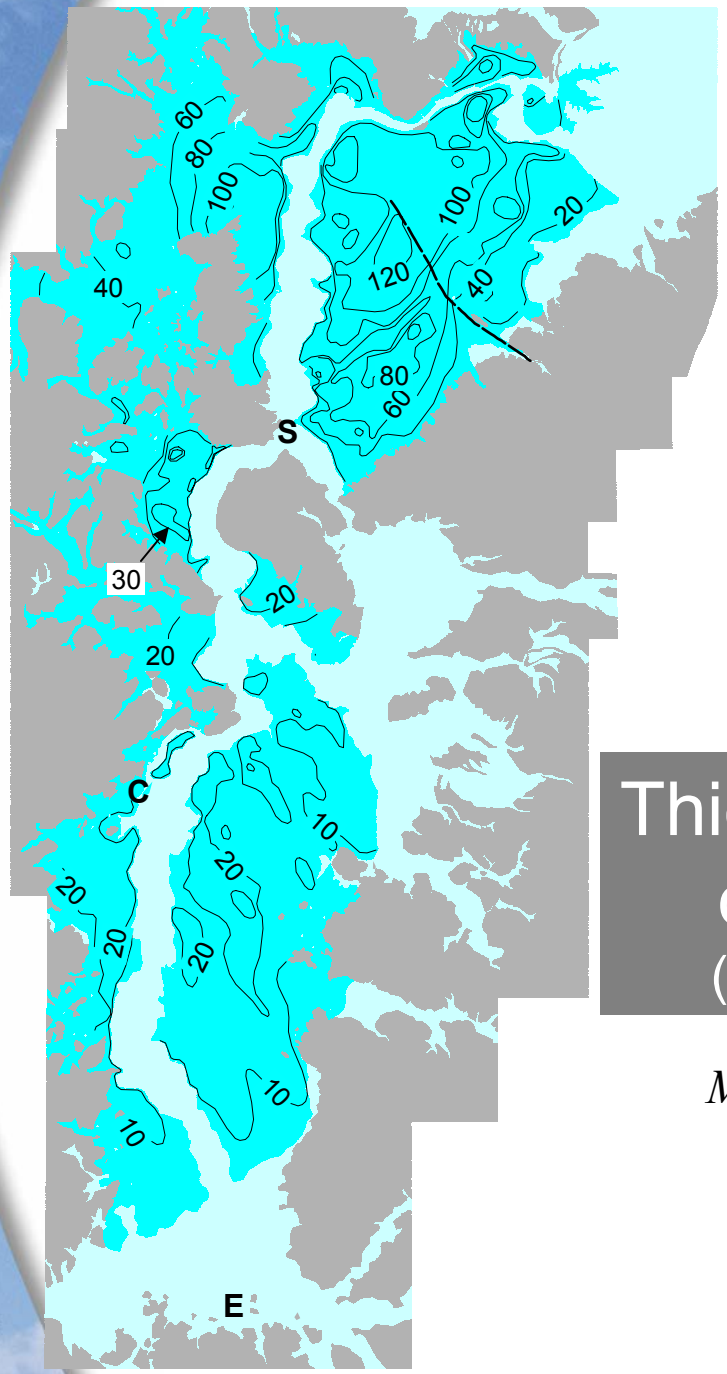
Terrence Conlon, 2003



Thickness and Distribution of the Willamette Silt

(contour interval 10 and 20 ft)

Marshall Gannett, 2003

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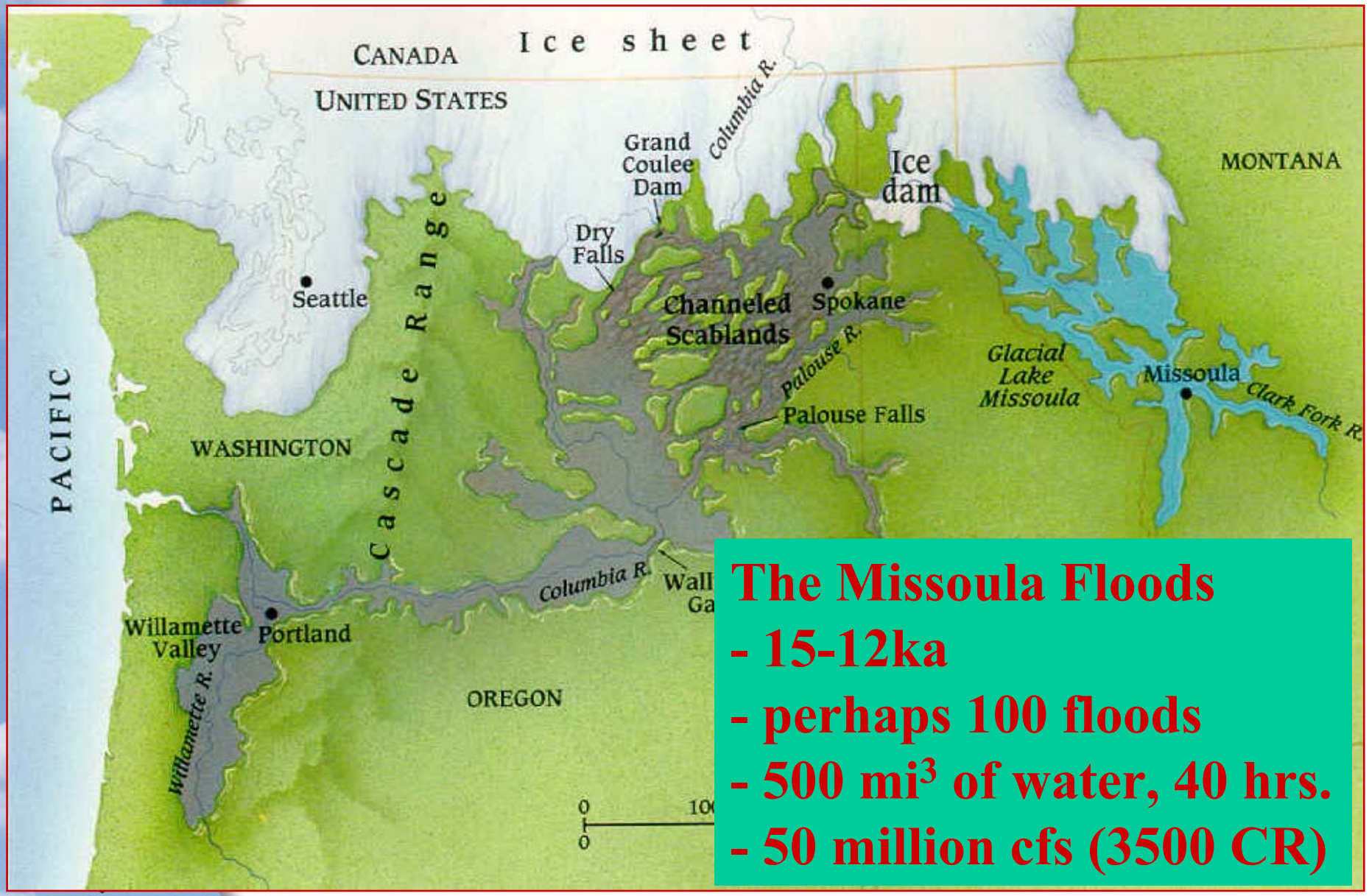

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… dry “falls”

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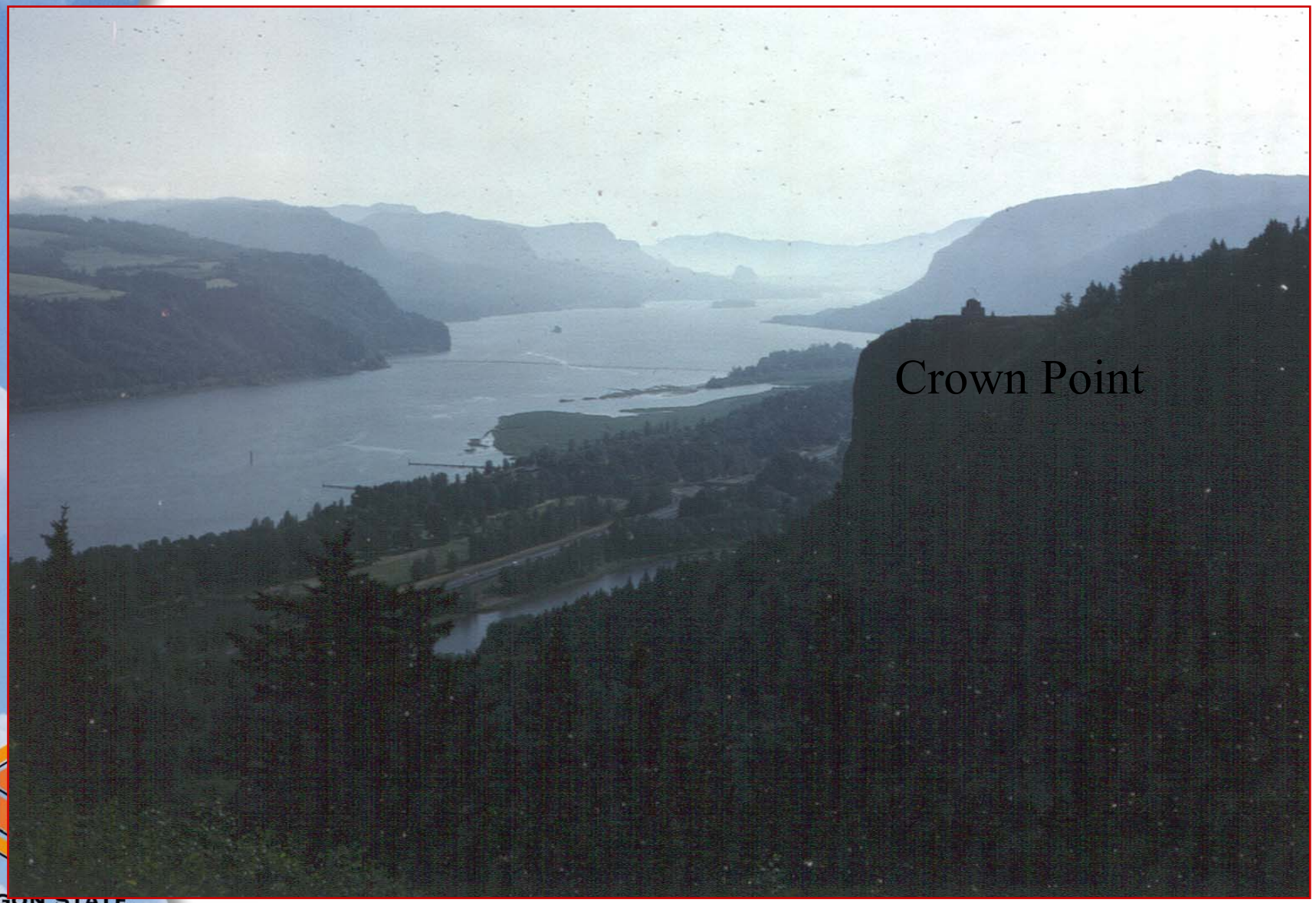
Columbia River Gorge



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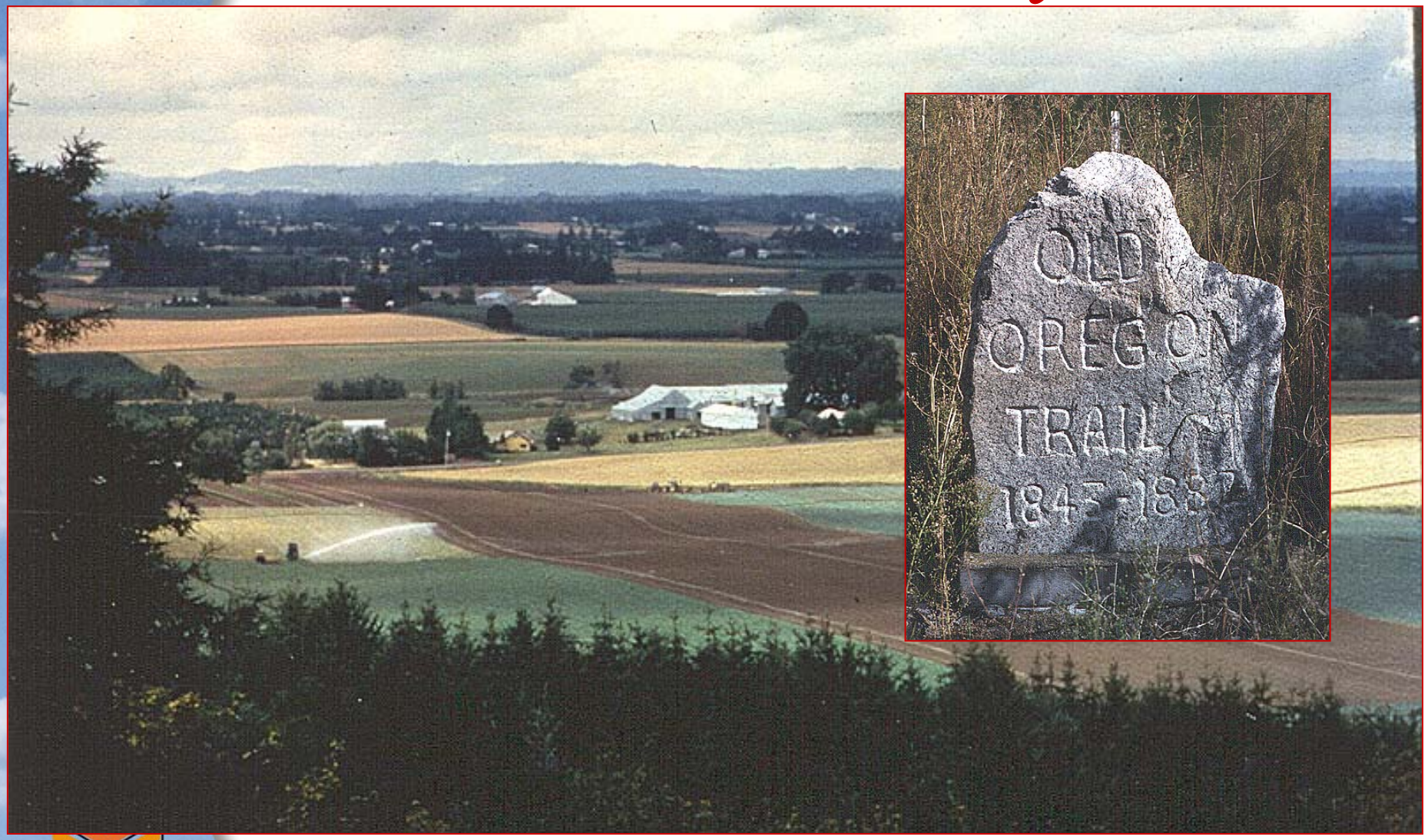
Willamette Valley



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Missoula Flood Deposits

Up to 30 m thick in the northern valley.
Deposited in as many as 40 beds up to 2 m thick.
Deposited between 15-12 ka.
Contains ice-rafted erratics.

Jim O'Connor, 2003

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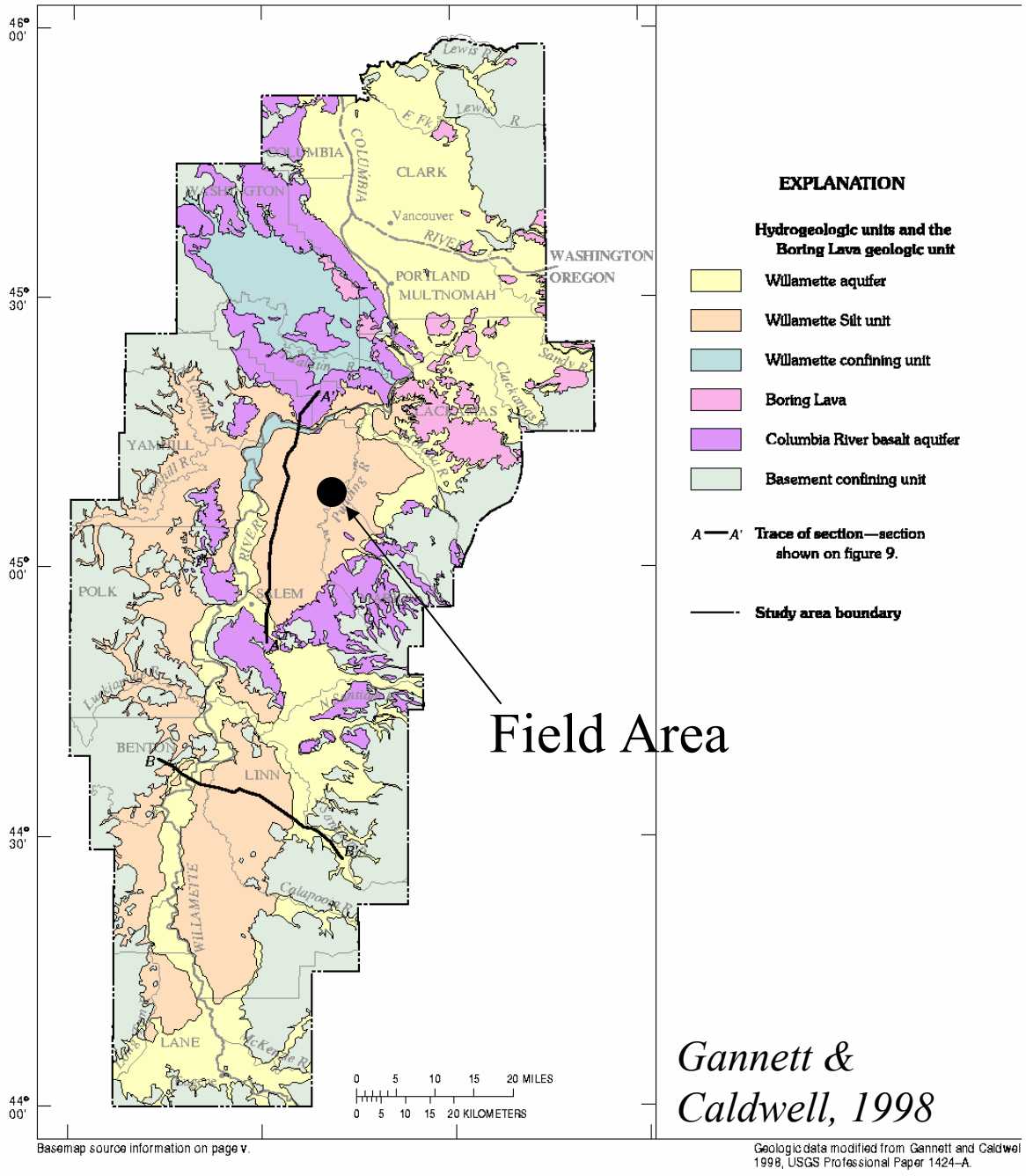
Jim O'Connor, 2003

Hydrogeology Fieldwork

1. What is impact of pumping from WA on surface water?

2. Transport of ag. chemicals across WS?



Gannett & Caldwell, 1998

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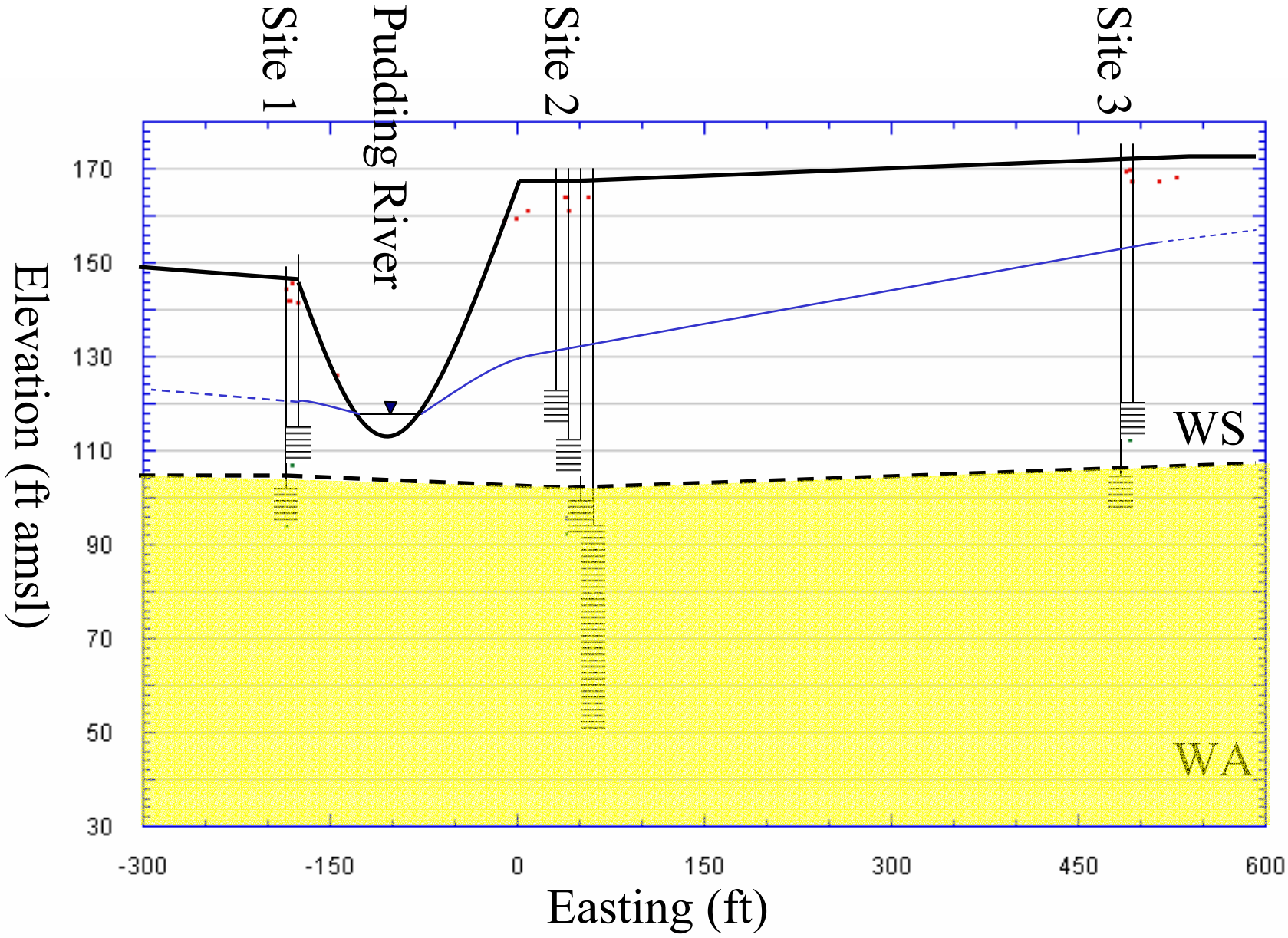
Field Site Cross Section

with August 2001(near min.) Water Table



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Measurements & Analyses

- Water level monitoring
- Pump test
- Slug tests at all site piezometers
- Permeameter tests
- Grain-size & porosity measurements
- Numerical model
- Measurement of major cations, anions

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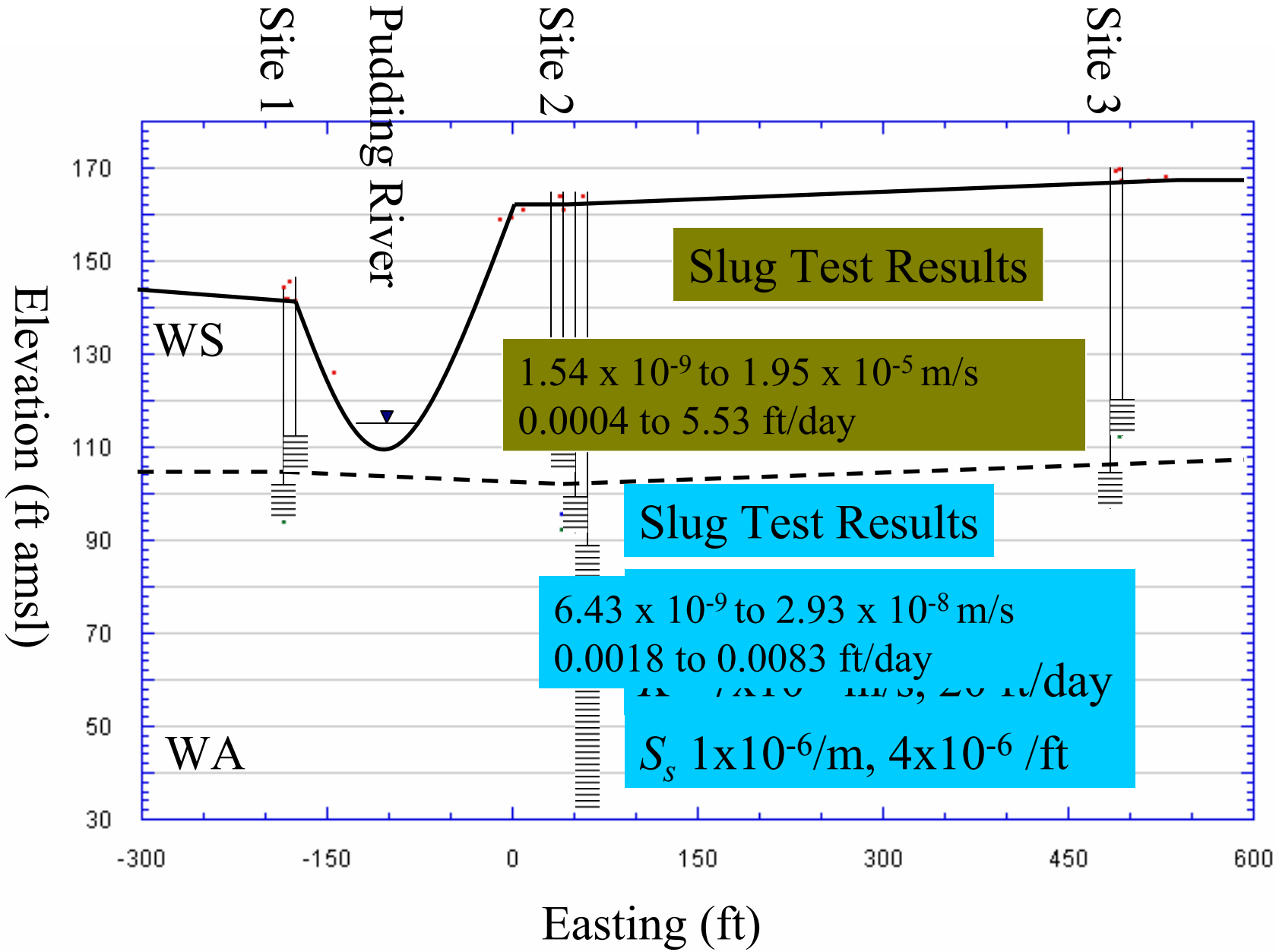
Field Site Cross Section



Lab Test Results

- Permeameter Test
  - WS average K_v ~ 3 x 10^{-7} m/s (0.008 ft/day)
- Grain-size analysis
  - WS average porosity = 0.40

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Numerical Model Purpose and Approach

- Determine the interaction between WA, WS, and Pudding River under the influence of pumping.
- Model three day pump test and use volumetric balance analysis to determine percent removed water from boundaries, storage, and Pudding River leakage.

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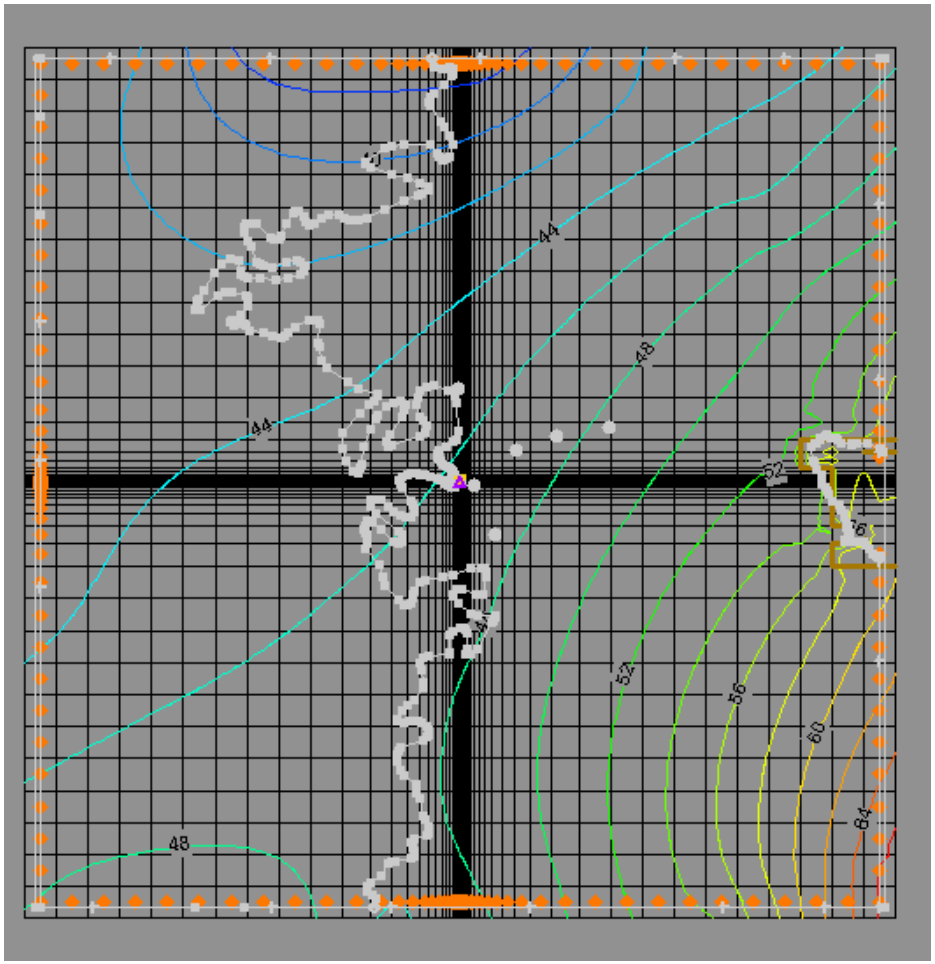
Numerical Model Boundary and Initial Conditions

- Initial Conditions based on *Gannett and Caldwell*, 1998 data
- Few physical boundaries
  - Mt. Angel Fault
  - otherwise boundaries are beyond zone of influence for 3-day pump test



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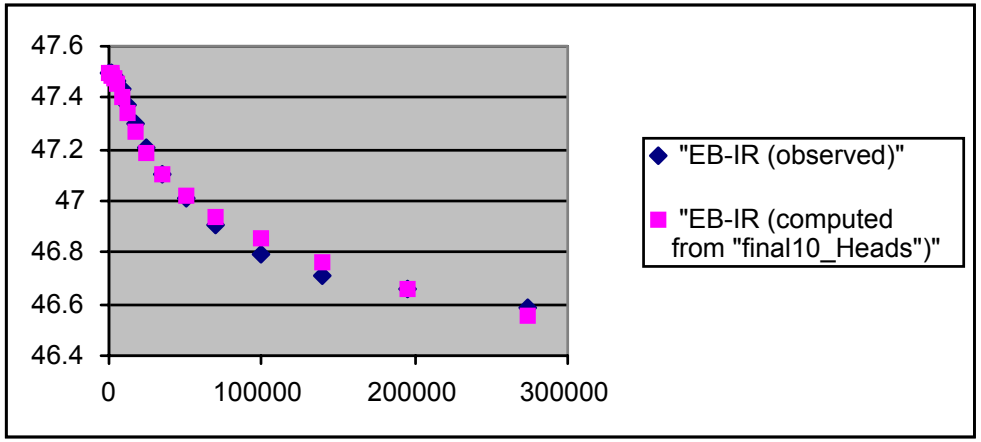
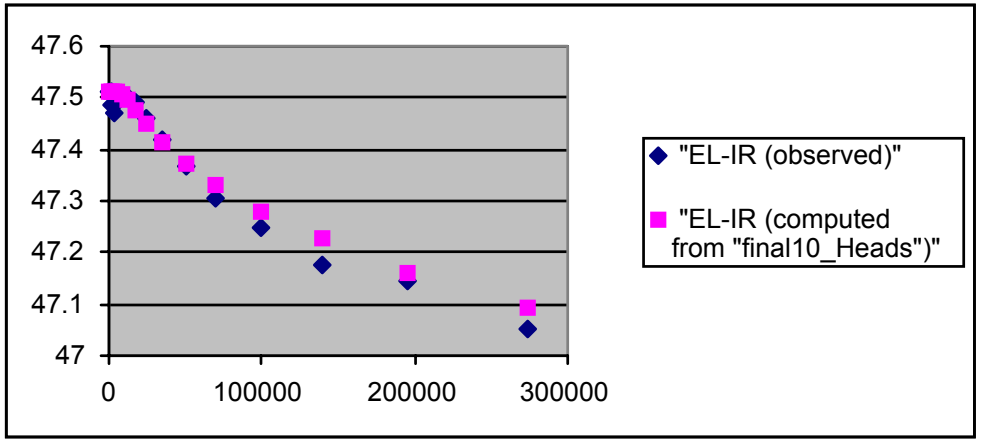
Numerical Model Optimized Parameters

- Willamette Silt
  - K_h 1 x 10^{-7} m/s
  - K_v 1.8 x 10^{-9} m/s
  - S_s 8.7 x 10^{-4}/m
- Willamette Aquifer
  - K_h 2.4 x 10^{-5} m/s
  - K_v 2.4 x 10^{-5} m/s
  - S_s 3.2 x 10^{-6}/m





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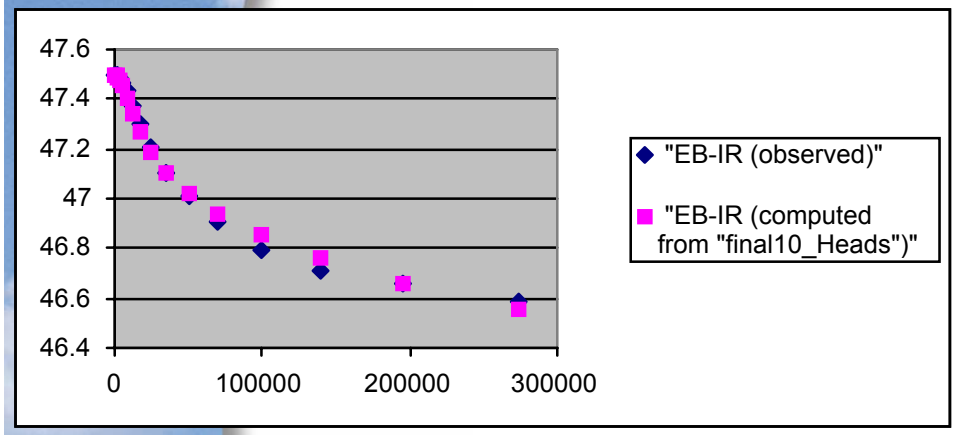
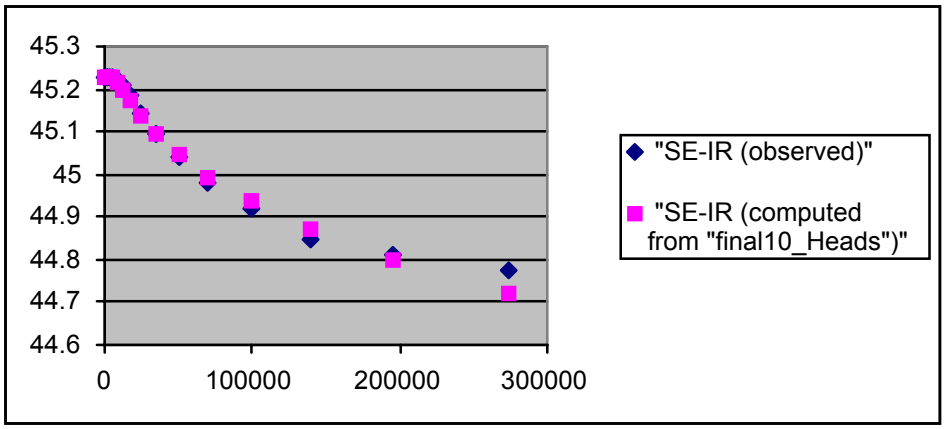
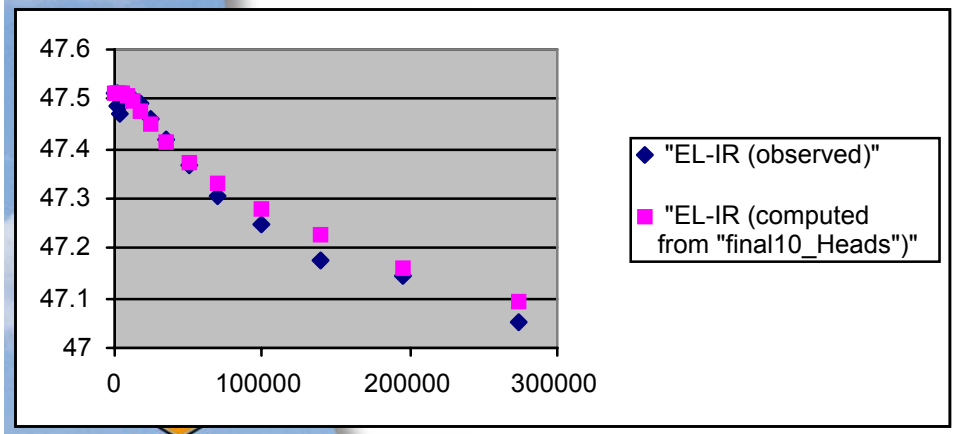
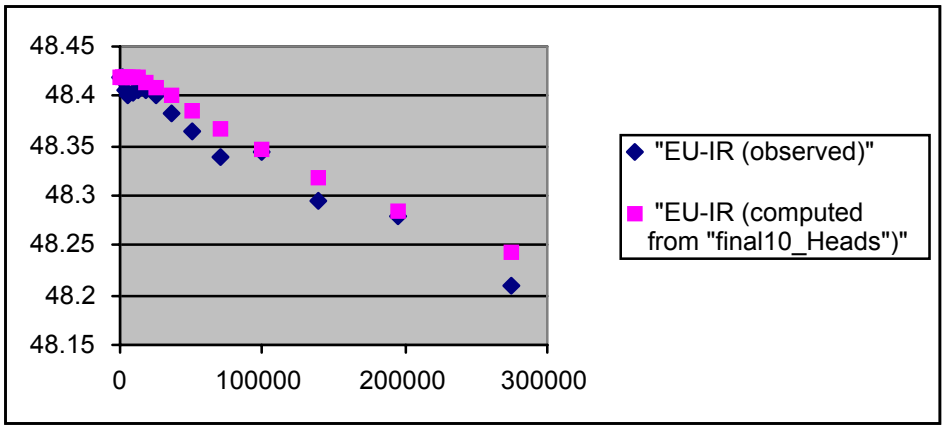
Numerical Model
Wells with Good Fits









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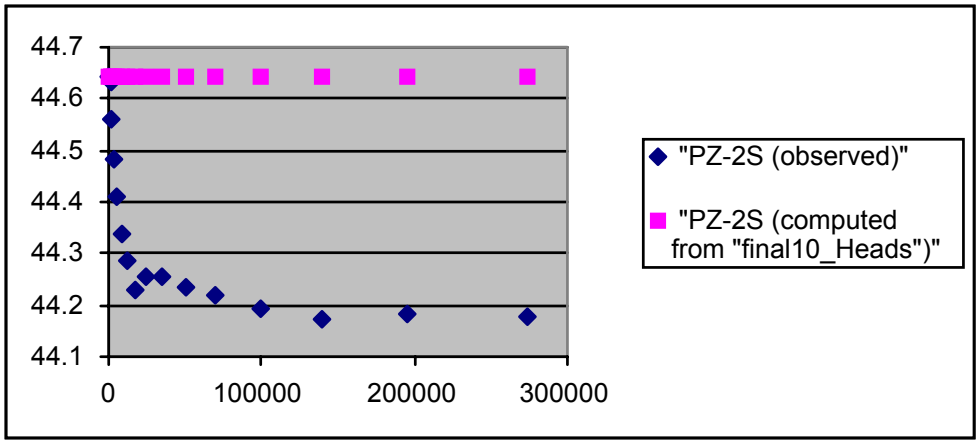
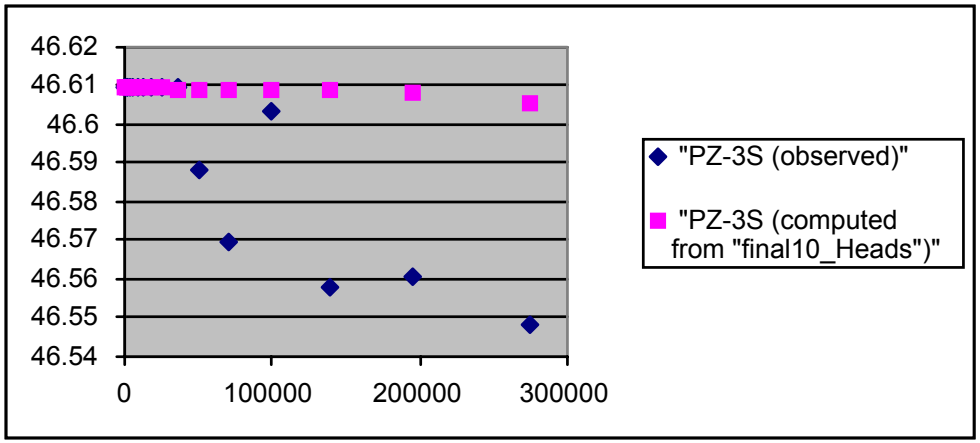
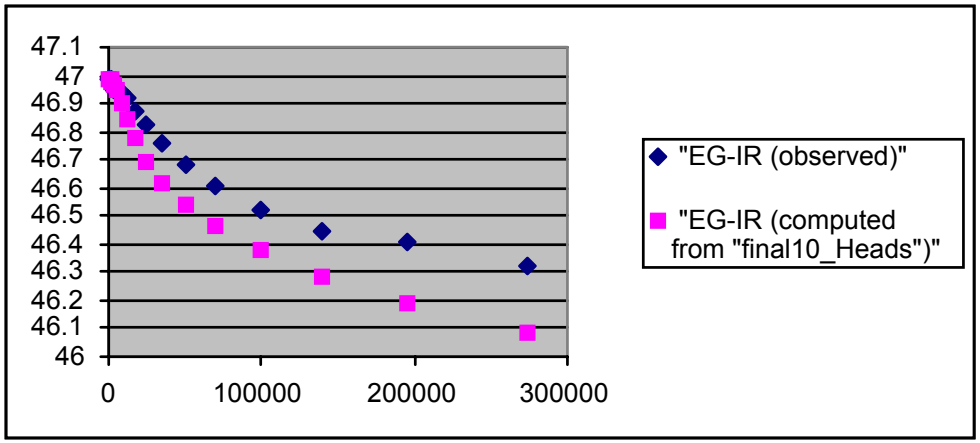
Numerical Model: Wells with Poor Fits







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Model Results

- Optimized parameters: Less than 1% of water pumped from the WA is recharged from the Pudding River.
- Lab-based parameters: 17% of water pumped from the WA is recharged from the Pudding River.
  - near maximum-value due to the proximity of the well to the Pudding River.

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WS as a Chemical Buffer

- Nitrate penetration front ~ 25 ft.
- Water table ~15 ft to surface
- Oxidized to ~ 25 ft with sharp "redoxcline"

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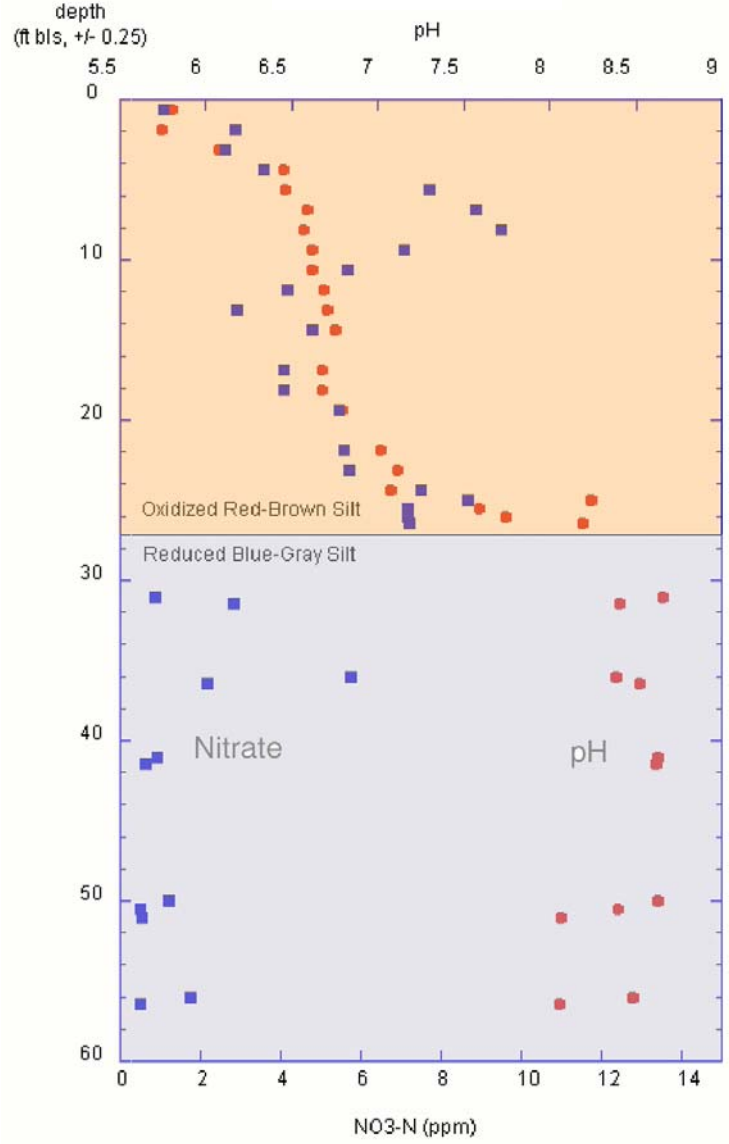
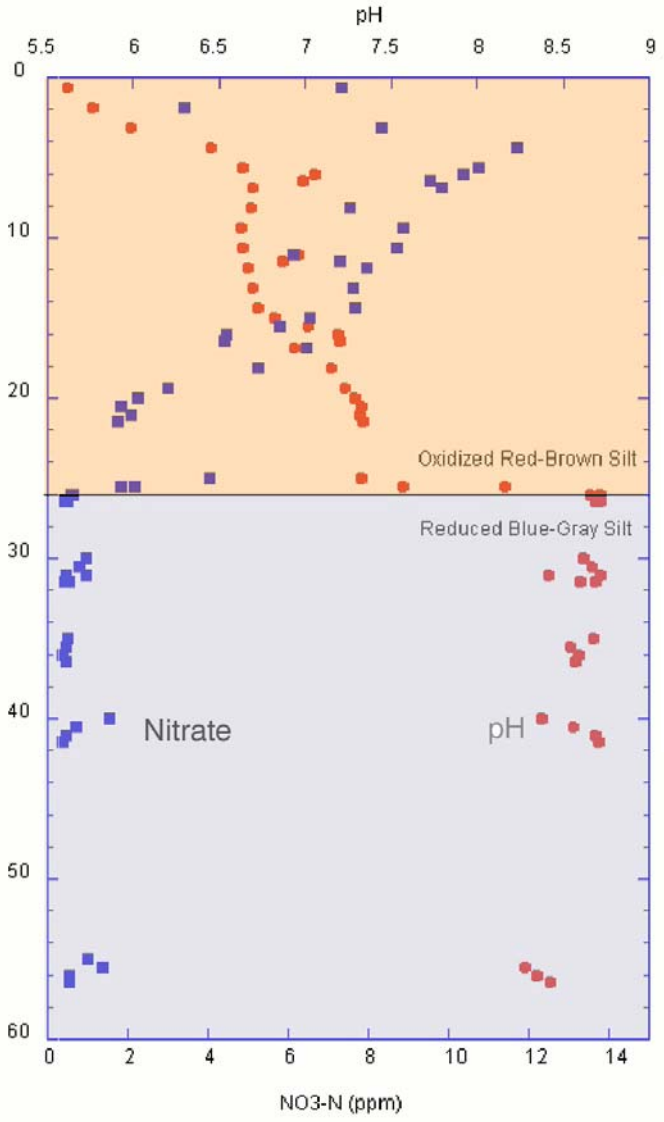
WS Chemical Buffering Capacity

Site 2



Site 3



Denitrification

- Conversion of nitrate to N_2 and N_2O gas
- 4 things needed:
  - nitrate
  - denitrifying bacteria
  - reducing conditions (no/low O_2)
  - electron donor (typically organic carbon) i.e., food for the bugs

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Overview

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- Willamette Silts (up to 30 m) cover most of Willamette Valley floor
  - confining unit to Willamette Aquifer
- WS has two major effects on groundwater:
  - hydrologically buffers groundwater in WA from surface water and vice versa
  - protects groundwater from pollutants

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