Shallow Groundwater in the Matanuska-Susitna Valley, Alaska

Colin Kikuchi, USGS

Mat-Su Salmon Symposium

November 7-8, 2012

U.S. Department of the Interior
U.S. Geological Survey

Overview

1. Study Objectives
2. Data Sources
3. System Conceptualization
4. Hydrogeologic Framework
5. Groundwater Budget
6. Groundwater Flow Model

Study Objectives

- **Provide a scientific framework for the analysis of regional-scale groundwater availability**

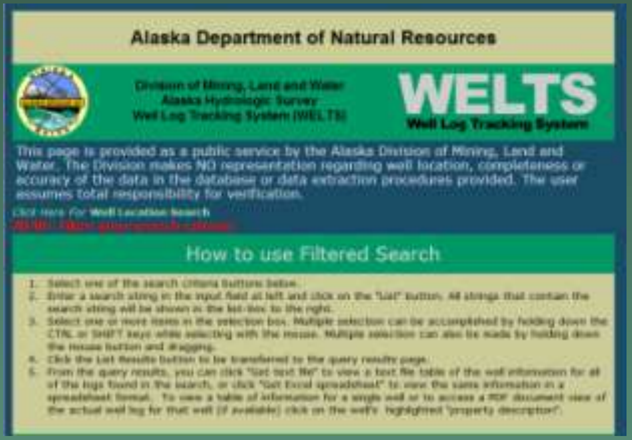
1. Compile existing hydrologic data and collect new data

2. Develop and calibrate a numerical groundwater flow model

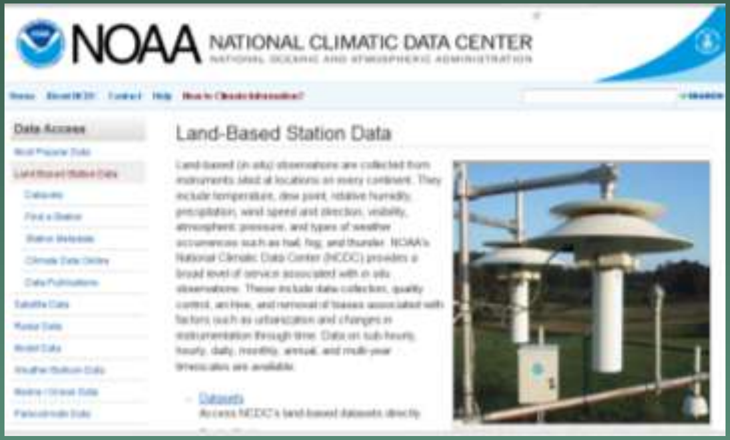
USGS

Data Sources

Existing, publicly available data



http://www.navmaps.alaska.gov/welts/



http://www.ncdc.noaa.gov/land-based-station-data

http://alaska.usgs.gov/science/water/index.php

Data Sources

Measurement campaigns (2009 – present)

Manual groundwater – level measurements

Groundwater sampling

Seepage investigations

USGS

Data Sources

Monitoring stations

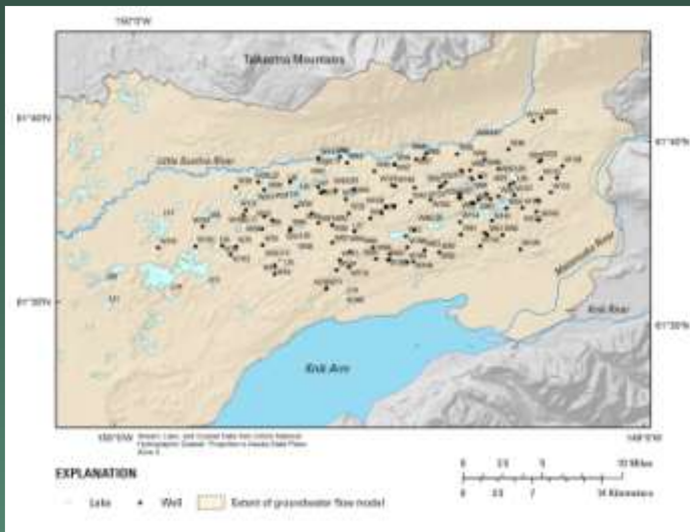
Groundwater level monitoring

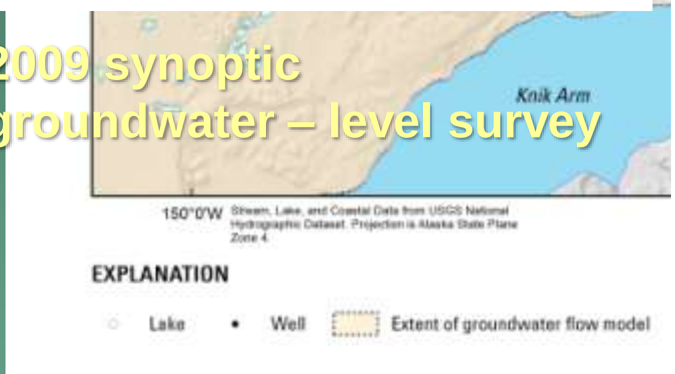
Lake stage monitoring

Meteorological data

Data Sources

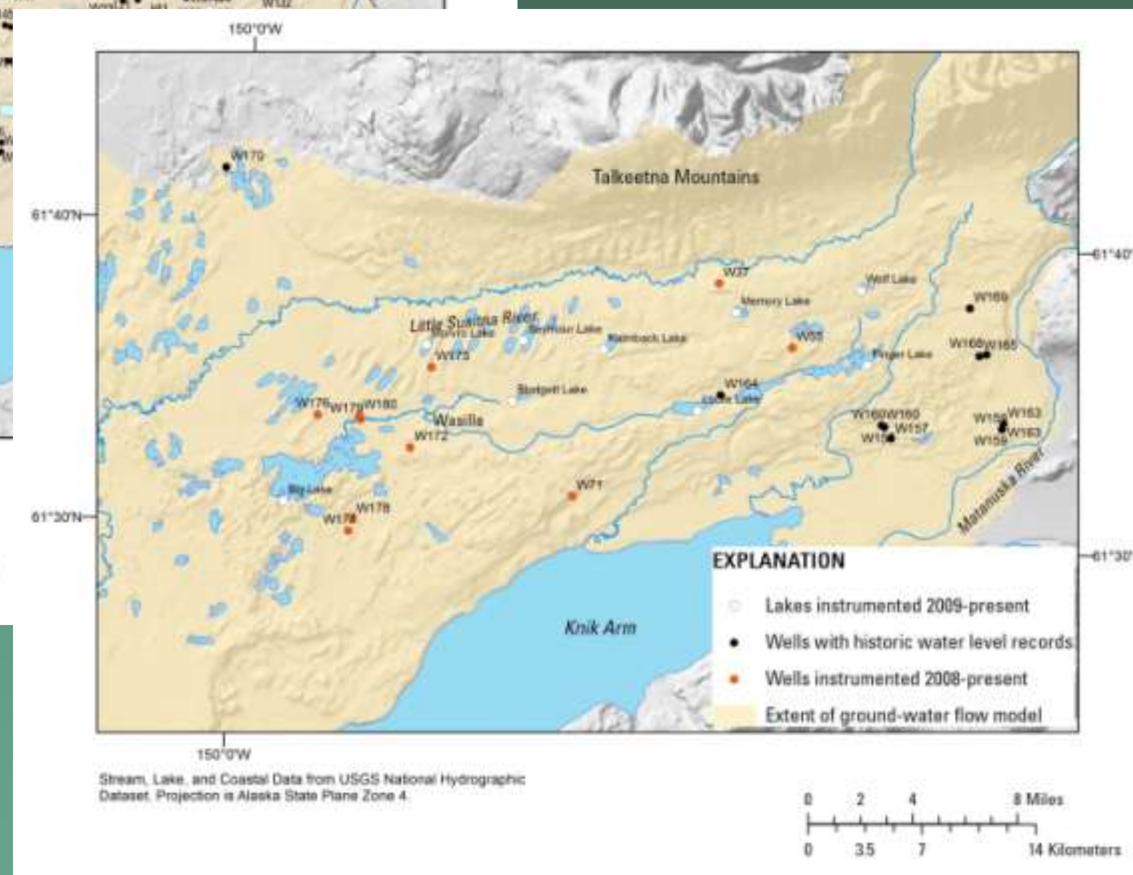
1. Study Objectives
2. **Data Sources**
3. System Conceptualization
4. Hydrogeologic Framework
5. Groundwater Budget
6. Groundwater Flow Model





Monitoring stations

2009 synoptic groundwater – level survey



2009 synoptic groundwater – level survey

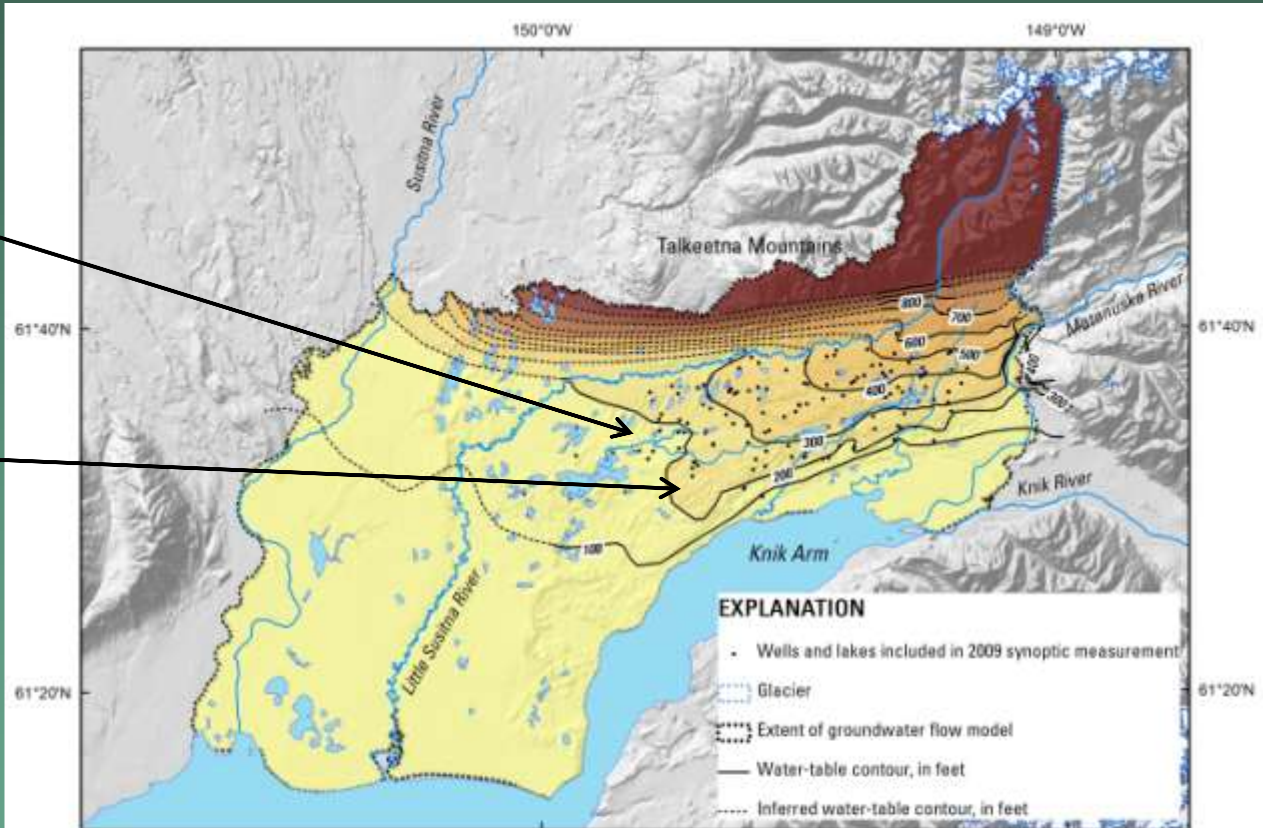
USGS

System Conceptualization

What are the patterns in regional groundwater flow?

Contours near apparently gaining stream

Groundwater mound

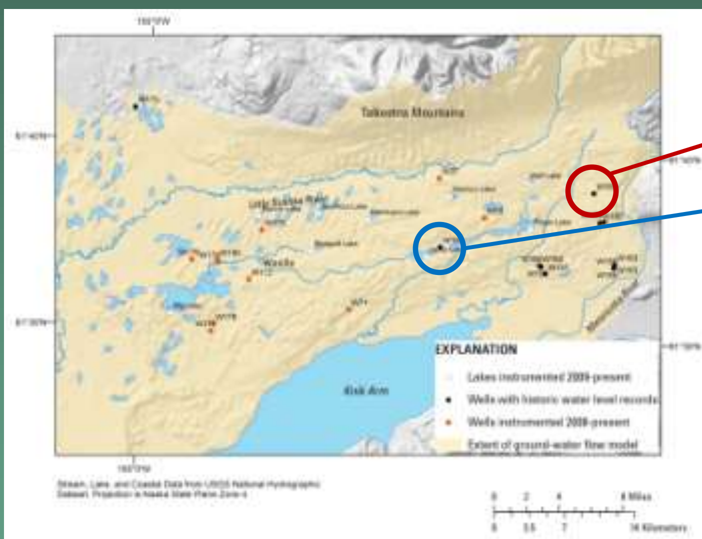


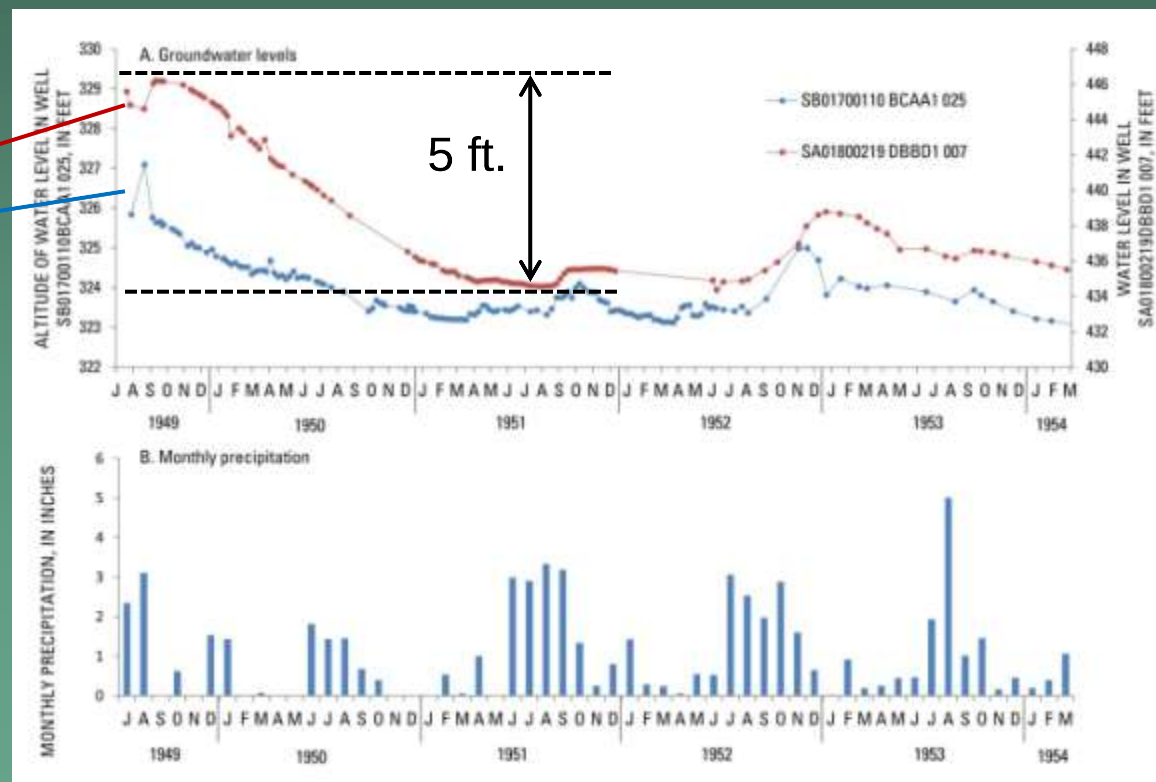
Base modified from U.S. Geological Survey digital data. Stream, lake, and coastal data from USGS National Hydrographic Dataset. Horizontal coordinate system is referenced to NAD 83, Alaska State Plane Transverse Mercator Projection, Zone 4. Water-table altitudes relative to NAVD88

USGS

System Conceptualization

How do groundwater levels change through time?

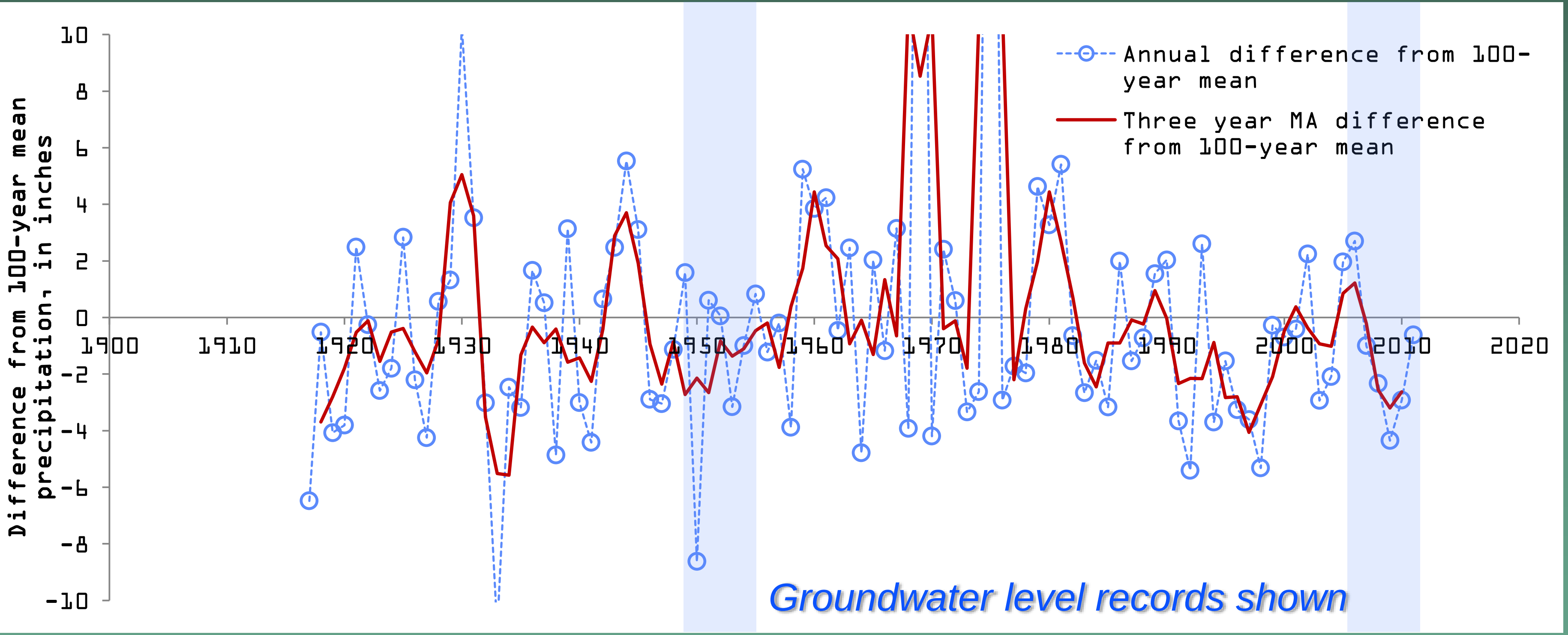




USGS

System Conceptualization

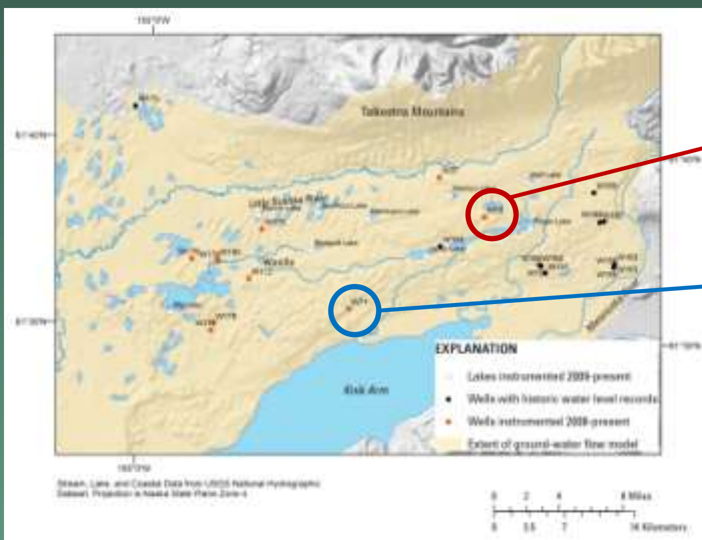
Long-term climate variability…

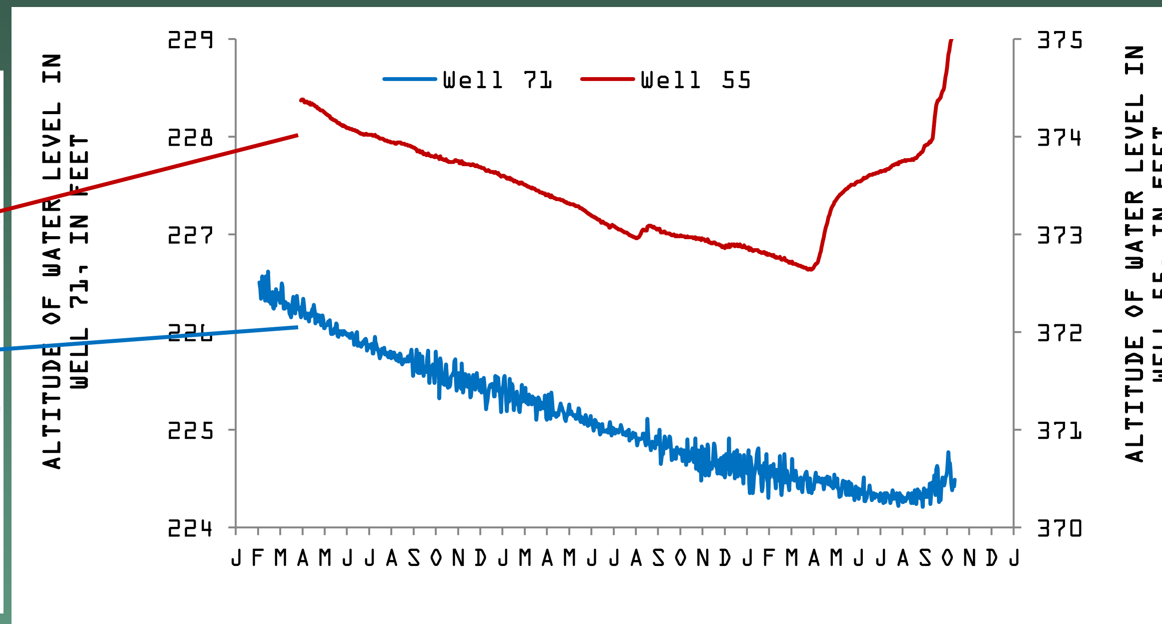


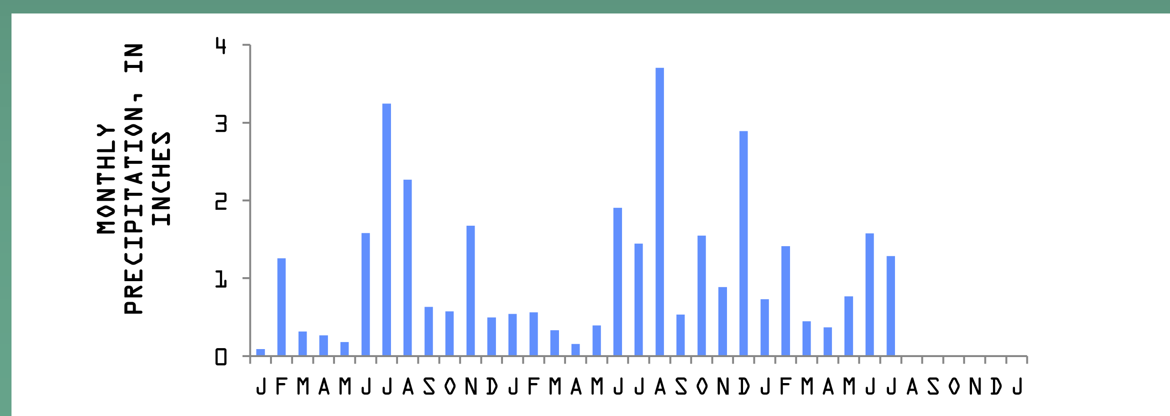
USGS

System Conceptualization

Recent changes in groundwater levels





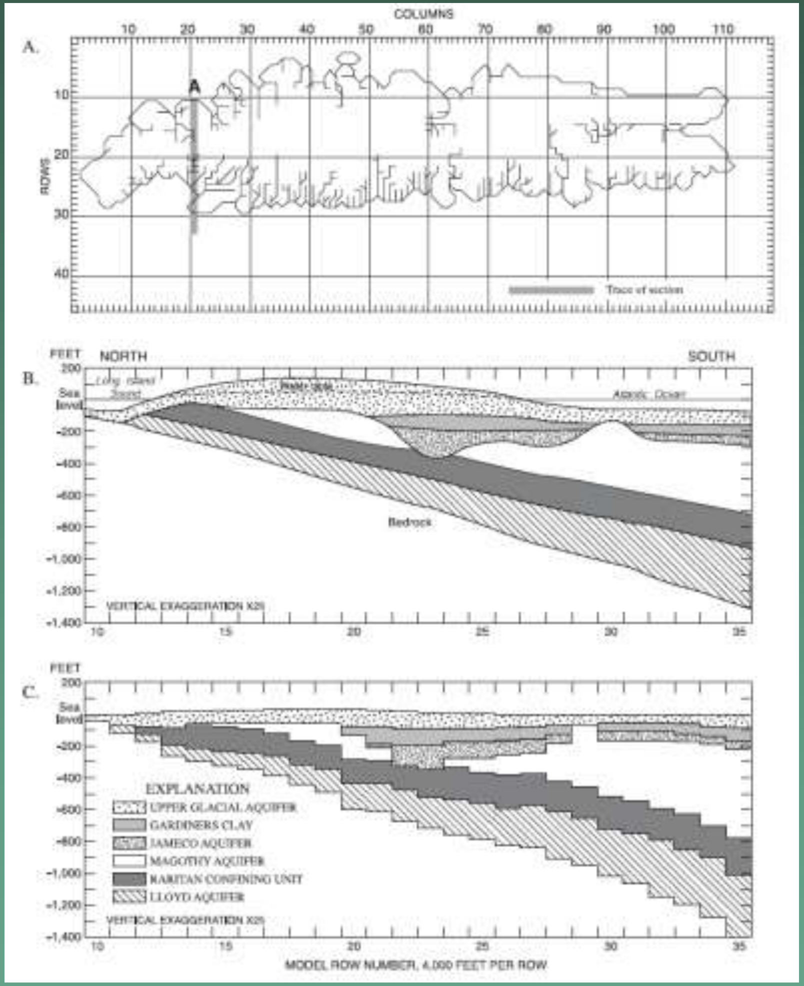


USGS

Hydrogeologic Framework

What do we need to know about the subsurface, and why?

- Aquifer distribution
- Aquifer thickness
- Aquifer properties



Buxton, H.T., and Smolensky, D.A., 1999, Simulation of the effects of development on the ground-water flow system of Long Island, New York: U.S. Geological Survey Water-Resources Investigations Report 98-4069, 57 p.

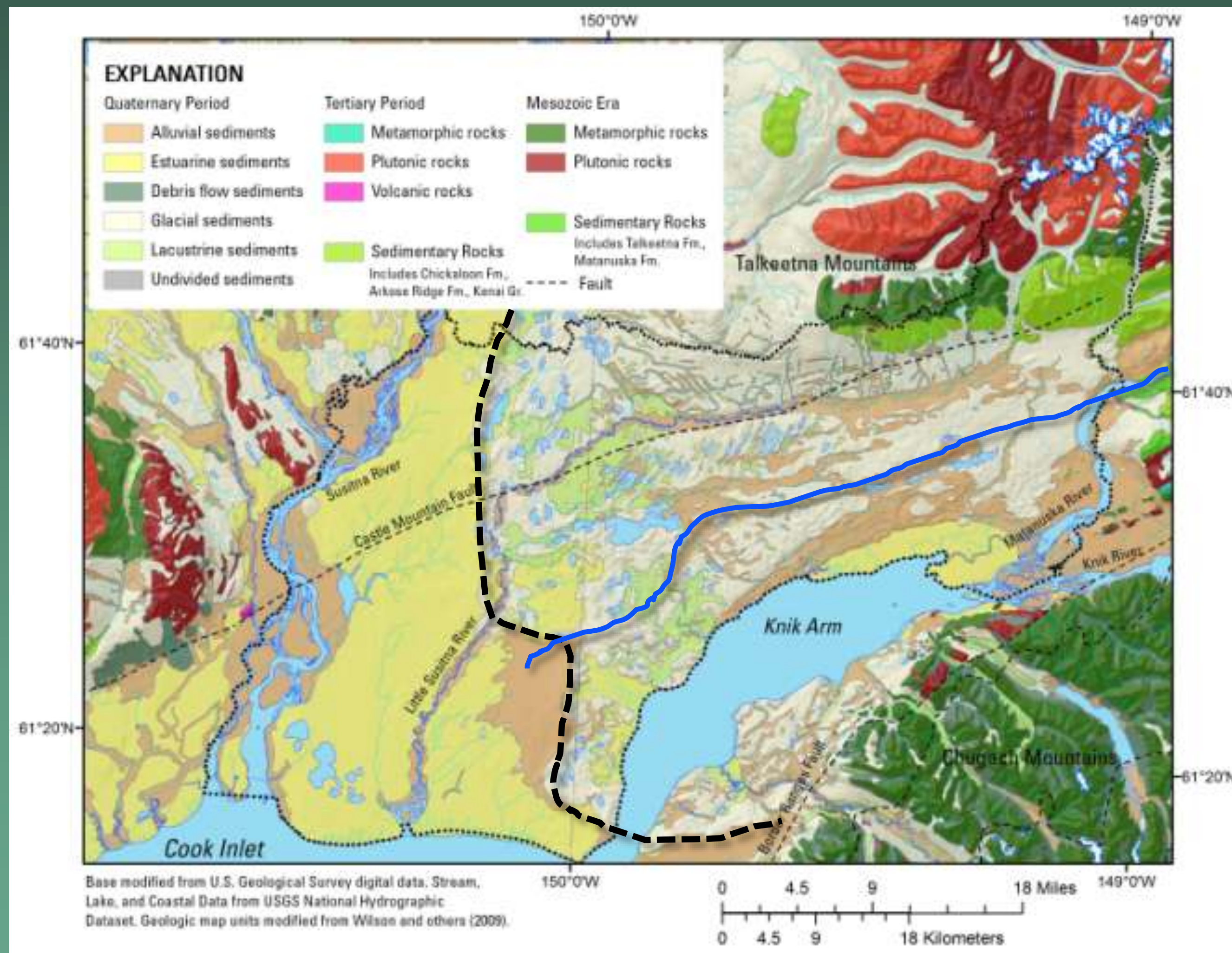
USGS

Hydrogeologic Framework

Geologic setting

Noteworthy features:

1. **Elmendorf moraine**
2. **Ancient Matanuska River**

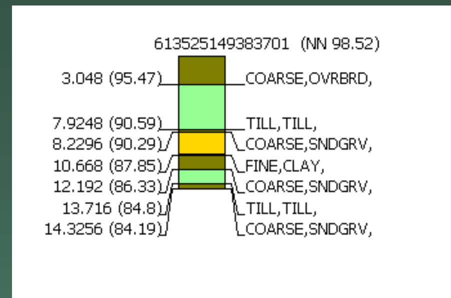


Hydrogeologic Framework

Compile well driller's logs from WELTS, geologic map data

↓

Classify borehole lithologic material, build hydrogeologic sections



ACE WATER WELL DRILLING
P.O. Box 877149
8124 W. Tia Terrace
Wasilla, Ak. 99687
aceh2o@mtaonline.net
(907) 357-7987 fax (907) 376-7987 (907)354-1398 cell

Well Owner: **Troy Davis Homes** Use of Well: **Domestic**

Location: **Lot 1 Block 3 Bridle Path**

Date of Completion: **08-16-02** Job # **02-83**

Size of Casing: **6"** Depth of hole: **197 feet** Cased to: **197 feet**

Static Water Level: **130 feet** below/~~above~~ land surface.

Finish of Well (X) Open End ( ) Grout/Seal ( ) Screen ( ) Perforated

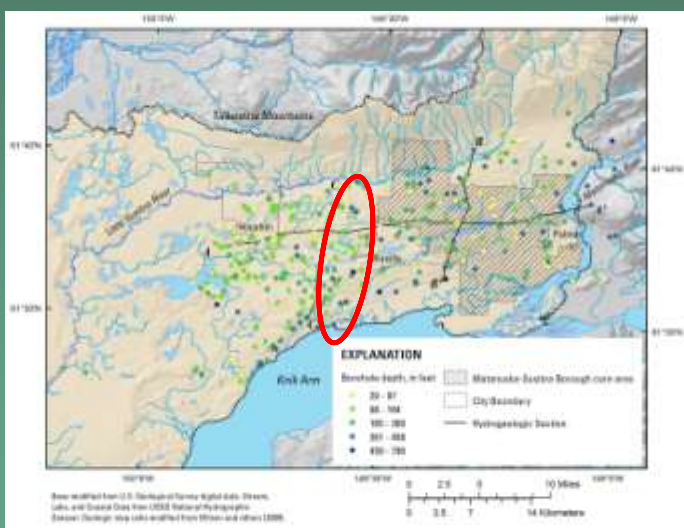
Describe screen, seal, or perforation: **None**

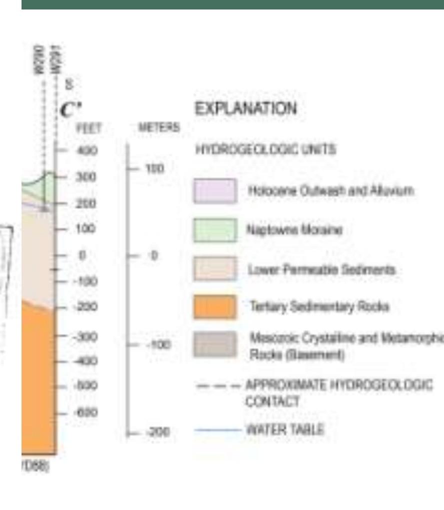
Well Pumping Test at **20** Gallons per ( ) hour (X) minute for **1** hours with **100%** of draw down from static level.

RECEIVED AUG 29

Depth in feet from casing top	Details of Formations/size/color/ etc
0 to 2 feet	Casing stick up
2 to 65 feet	Silty gravel
65 to 140 feet	Silty gravel, loose
140 to 155 feet	Silty, sandy gravel
155 to 183 feet	Silty clay
183 to 197 feet	Water gravel

Driller Signature Date: 8-16-02





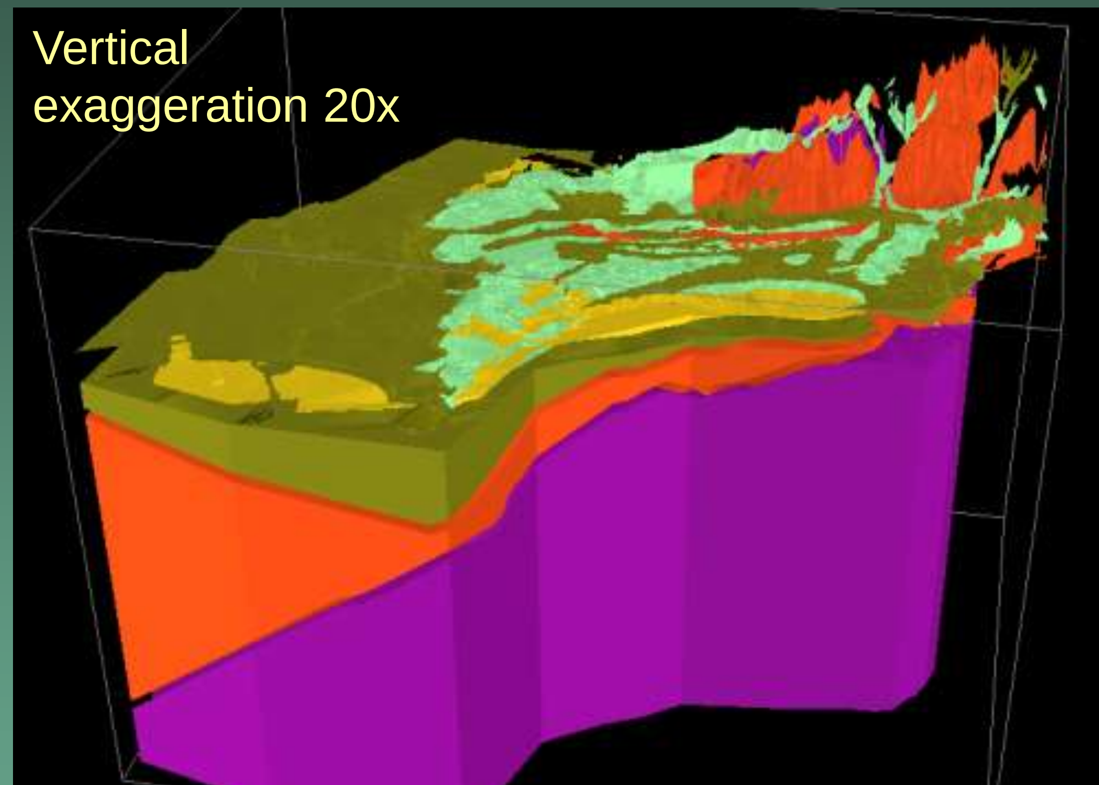
USGS

Hydrogeologic Framework

Classify borehole lithologic material, build hydrogeologic sections (28 total)

↓

Build 3D hydrogeologic framework model



USGS

Groundwater Budget

- Inflows:
  - In-place recharge — Deep Percolation Model
  - Surface water bodies — Field investigations
  - Septic effluent, irrigation return flows

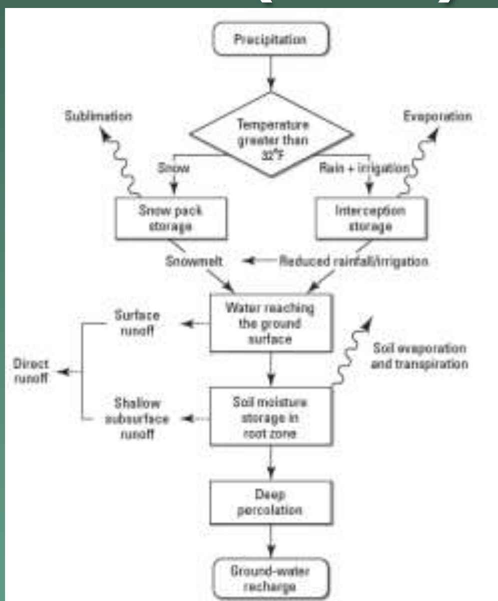
Estimate from water rights and geospatial data

- Outflows
  - Groundwater withdrawals
  - Surface water bodies
  - Knik Arm — No data available

USGS

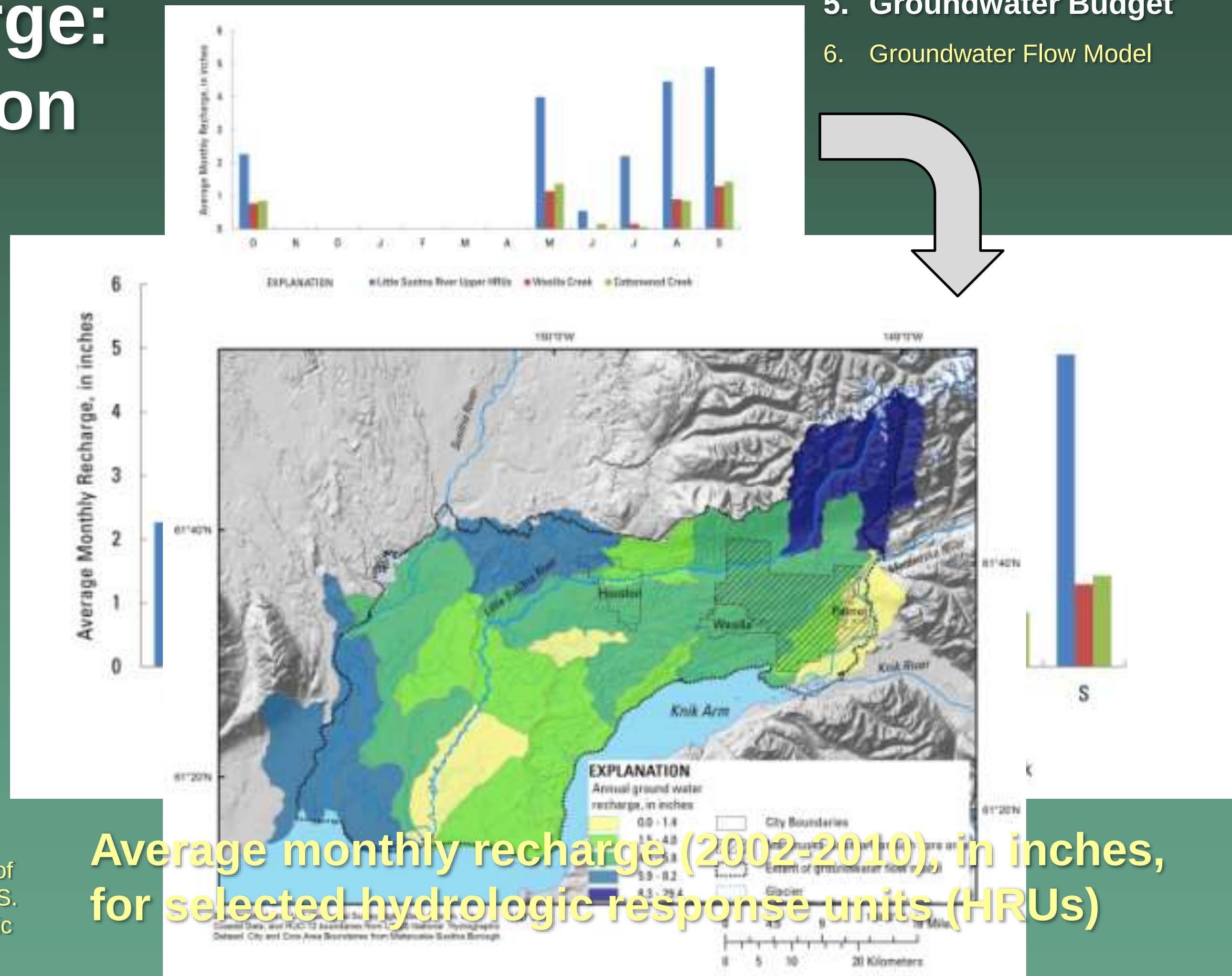
Groundwater Budget

In-place recharge: Deep Percolation Model (DPM)



Vaccaro, J.J., 2007, A deep percolation model for estimating ground-water recharge: Documentation of modules for the modular modeling system of the U.S. Geological Survey: U.S. Geological Survey Scientific Investigations Report 2006-5318, 30 p.

USGS

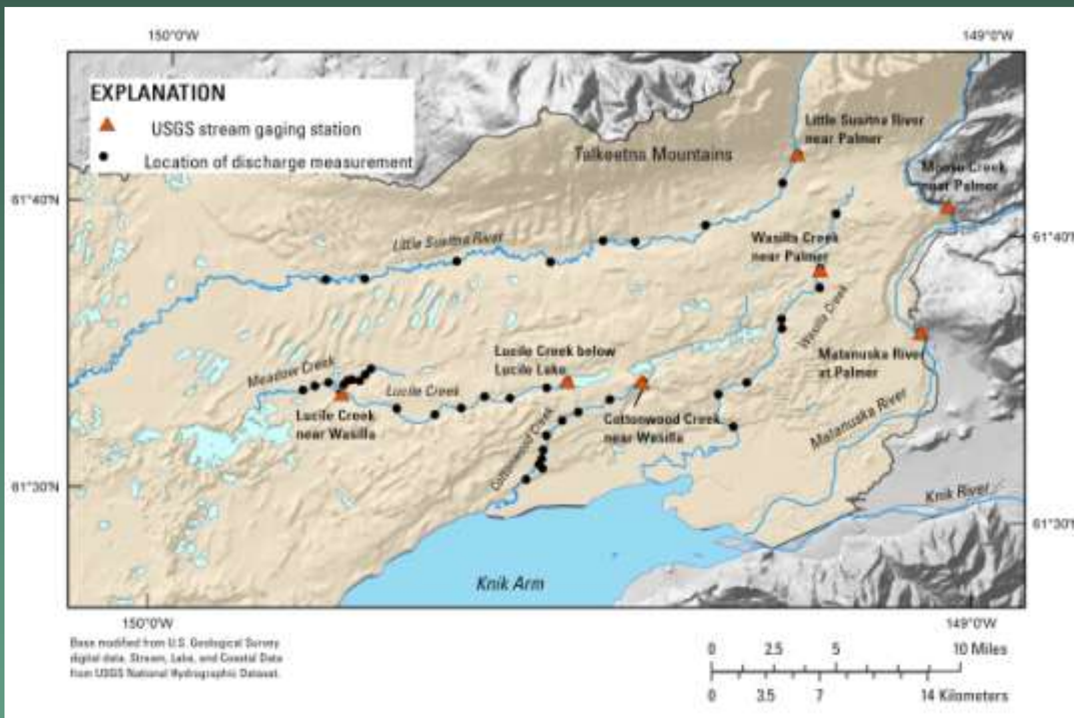


Average monthly recharge (2002-2010), in inches, for selected hydrologic response units (HRUs)

Mean annual recharge (2002-2010), in inches

Groundwater Budget

Surface water bodies: seepage runs

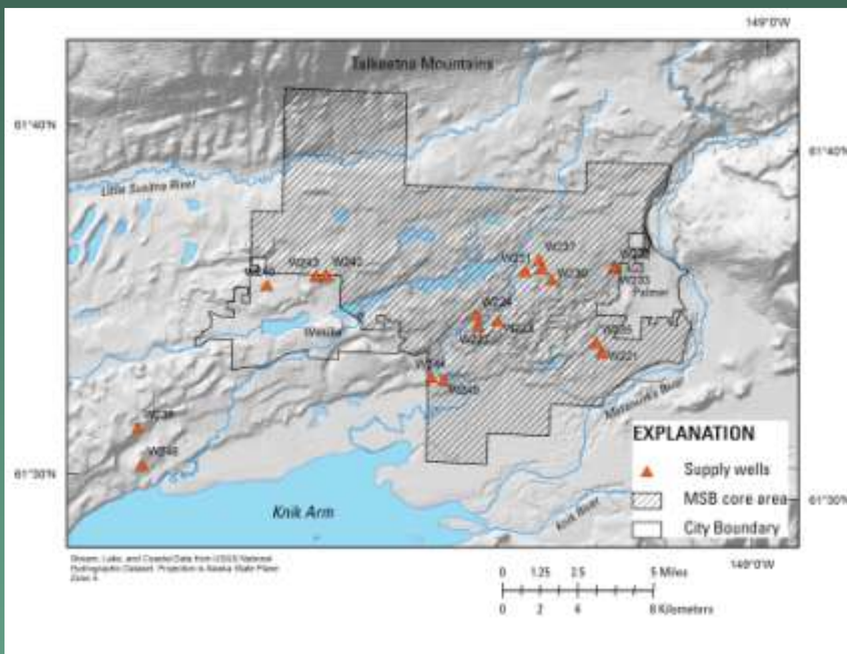


Measurement site or gaging station	River mile	August 2, 2011	
		Streamflow (ft^3/s)	Gain or loss (ft^3/s)
Wasilla Creek at Yarrow Road	1.74	7.4	--
Wasilla Creek at Palmer-Fishhook Road (15285000)	4.61	8.2	0.8
Carnegie Creek at Palmer-Fishhook Road[b]	5.52	1.1	--
Wasilla Creek at Bogard Road	7.76	12.5	3.2
Walby Lake tributary at Trunk Road	8.16	1.2	--
Wasilla Creek at Lower Road	11.09	12.7	-1.0
Wasilla Creek at Parks Highway	12.38	9.9	-2.8
Wasilla Creek at Nelson Road	14.27	15.6	5.7

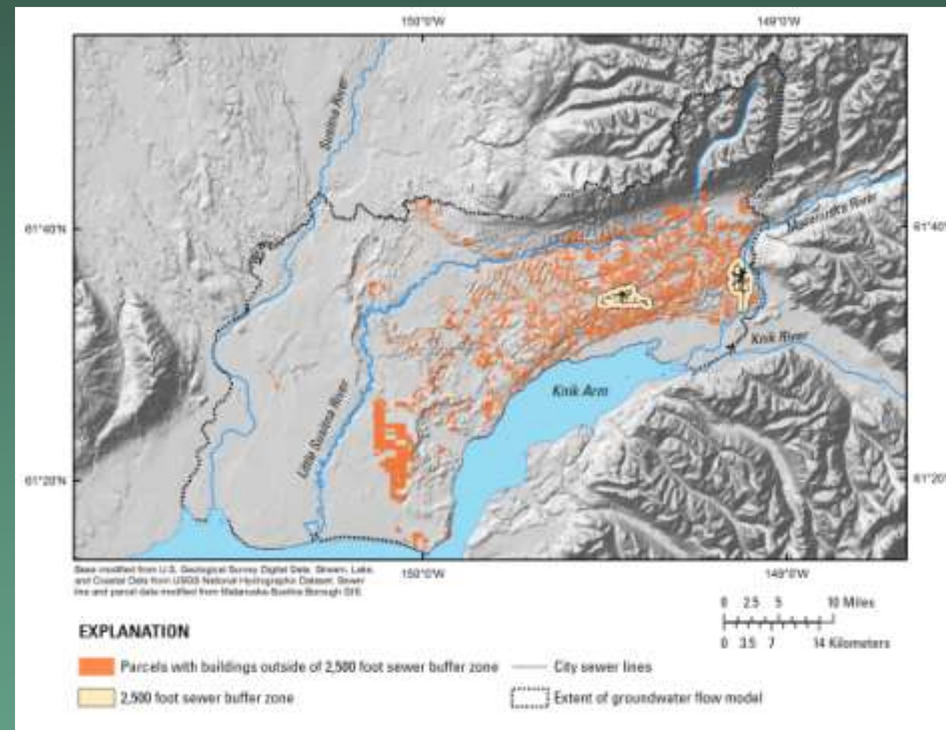
USGS

Groundwater Budget

Groundwater withdrawals, septic or irrigation return flows



Municipal/community wells



Domestic parcels

Estimated return flow percentages

Septic: 95% Irrigation: 54%

USGS

Groundwater Budget

- **Inflows**
  - **In-place recharge: 259,703 acre-ft/year**
  - **Surface water bodies: nd**
  - **Septic effluent, irrigation return flows: 6,774 acre-ft/year**
- **Outflows**
  - **Groundwater withdrawals: 5,808 acre-ft/year**
  - **Surface water bodies (streams): 10,728 acre-ft/year**
  - **Knik Arm: nd**

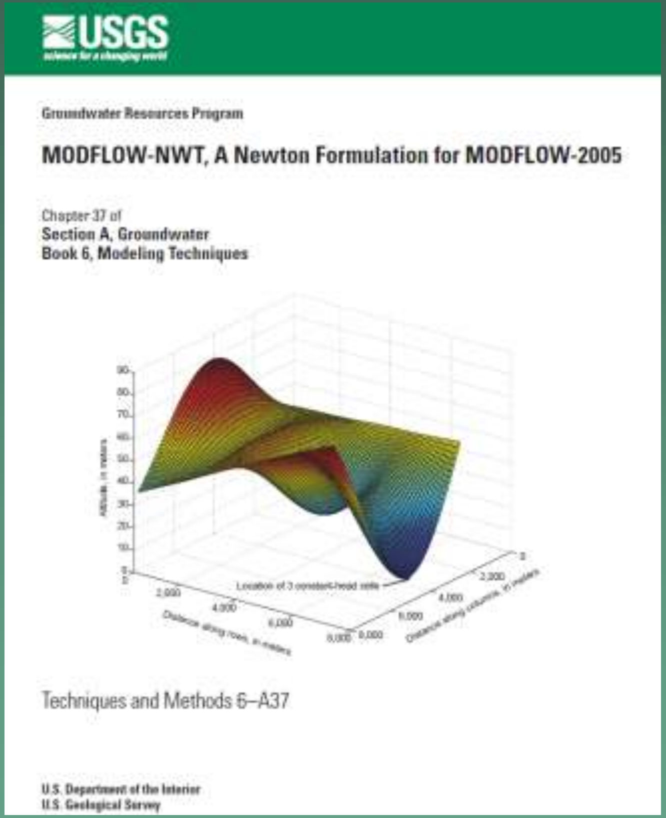
USGS

Remaining 249,941 acre-ft/year
→ surface water bodies, Knik Arm

1. Study Objectives
2. Data Sources
3. System Conceptualization
4. Hydrogeologic Framework
5. Groundwater Budget
6. **Groundwater Flow Model**

Groundwater Flow Model

- **General specifications:**
  - **Steady state**
  - **Three model layers**
  - **Model grid cell size**
    - **Horizontal: 2,000 ft. x 2,000 ft.**
    - **Vertical: Variable height**
  - **MODFLOW-NWT (Niswonger and others, 2011)**



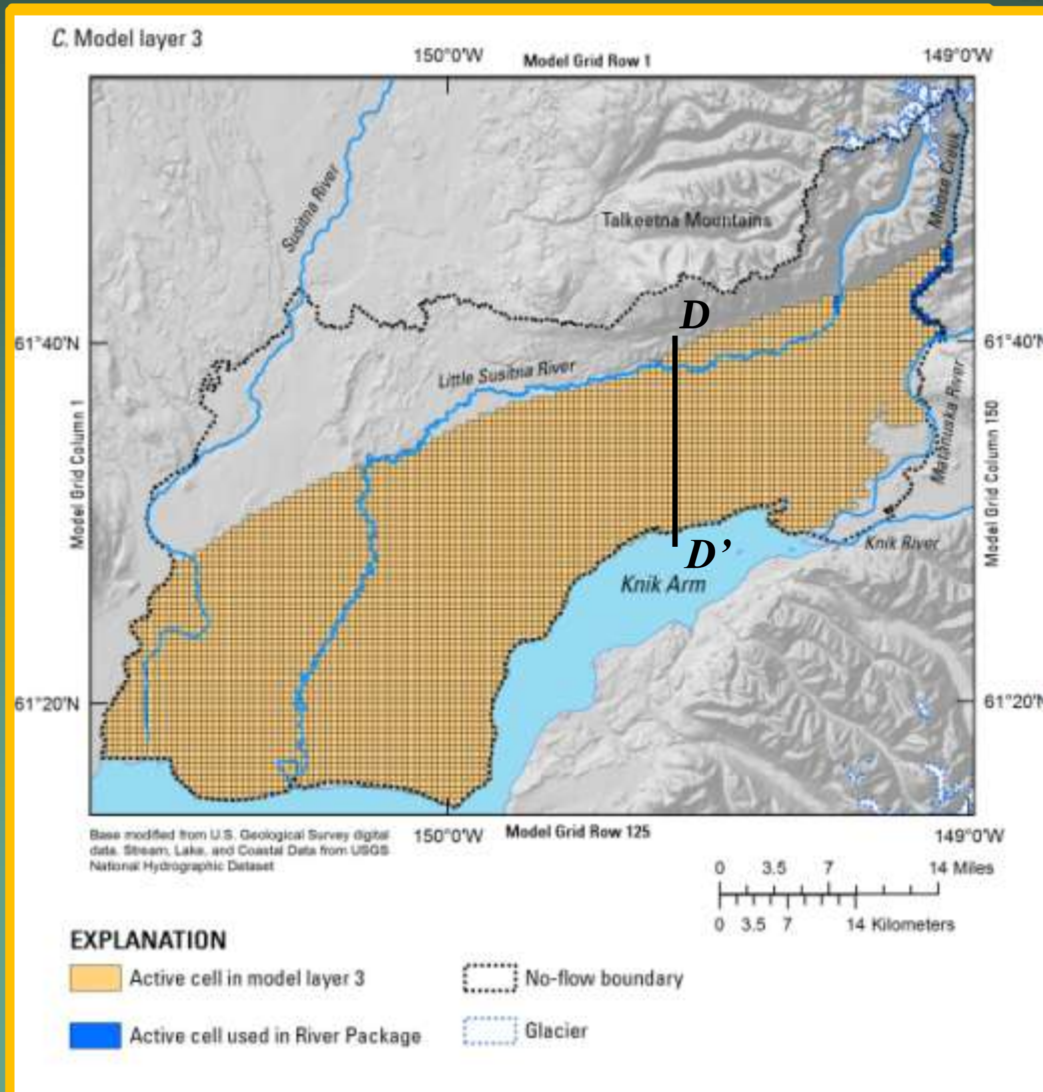
Niswonger, R.G., Panday, Sorab, and Ibaraki, Motomu, 2011, MODFLOW-NWT, A Newton formulation for MODFLOW-2005; U.S. Geological Survey Techniques and Methods 6-A37, 44 p.

USGS

Groundwater Flow Model

Model boundary conditions

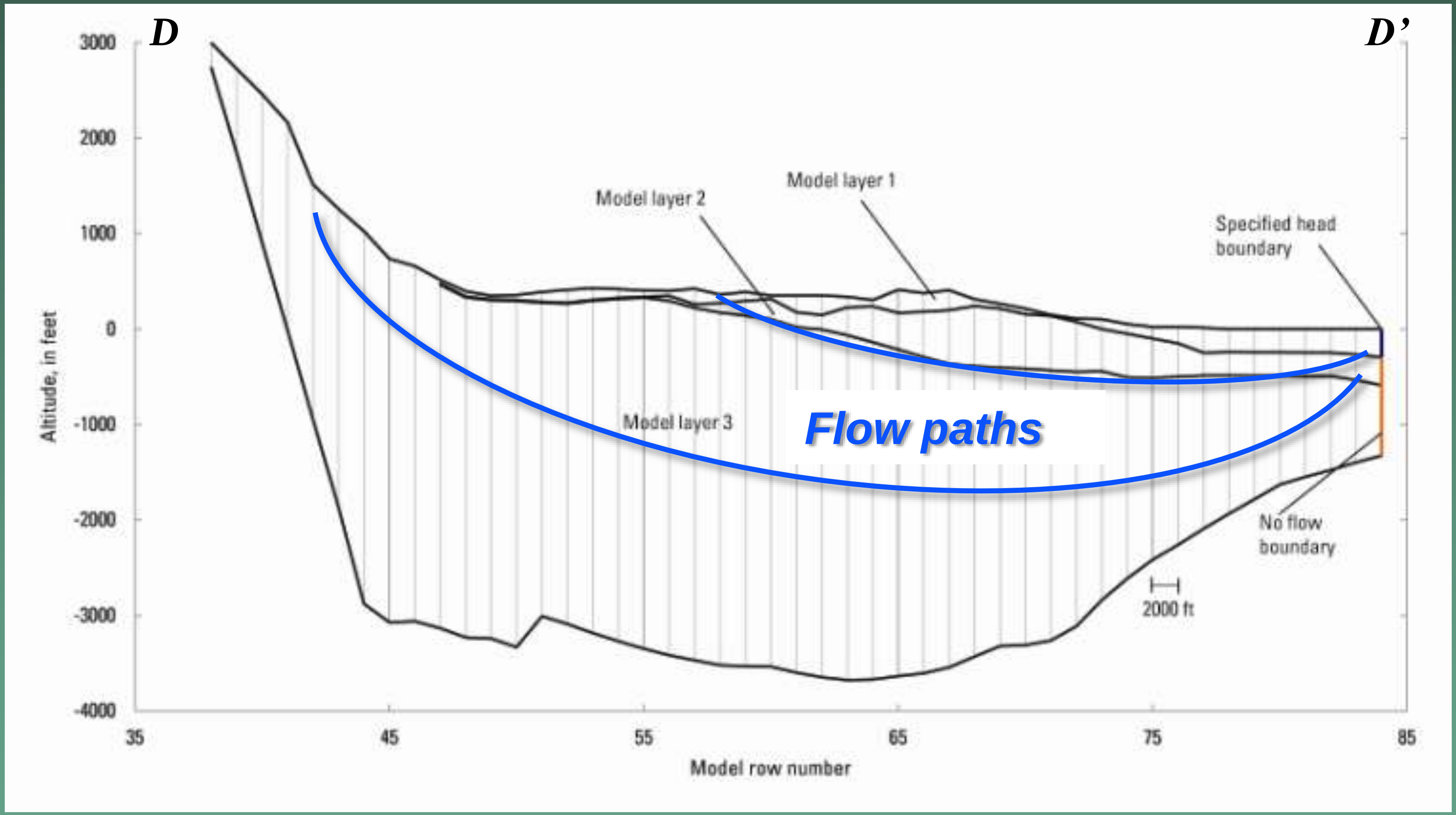
1. Study Objectives
2. Data Sources
3. System Conceptualization
4. Hydrogeologic Framework
5. Groundwater Budget
6. **Groundwater Flow Model**



Groundwater Flow Model

Model boundary conditions

Talkeetna Mountains



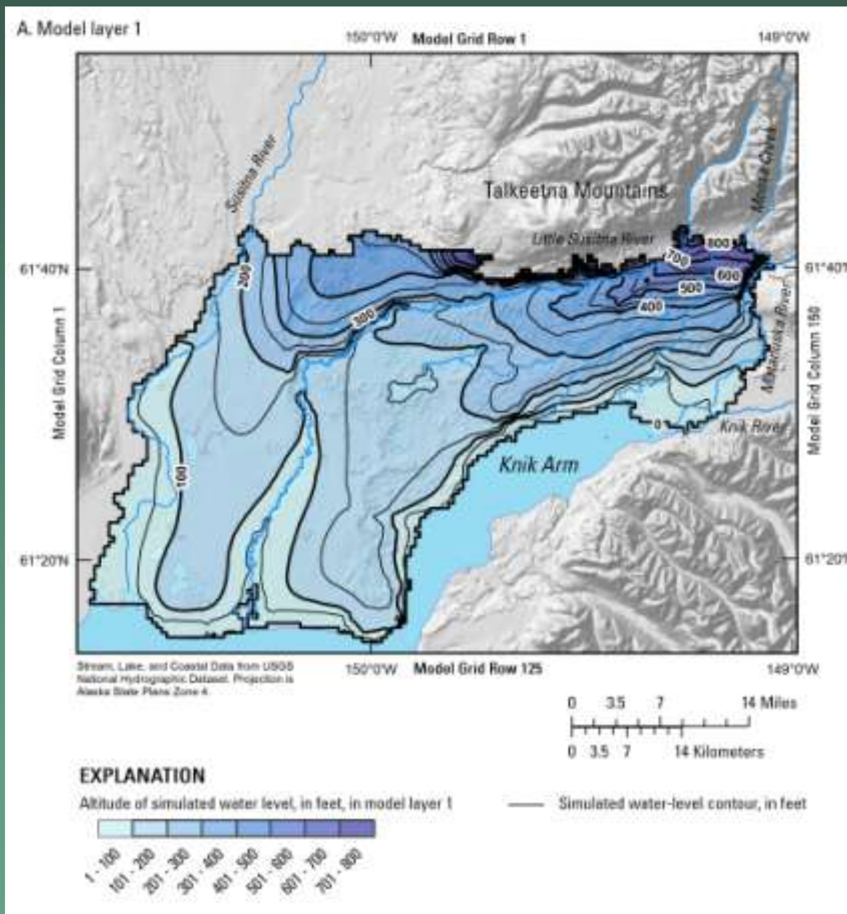
Knik Arm

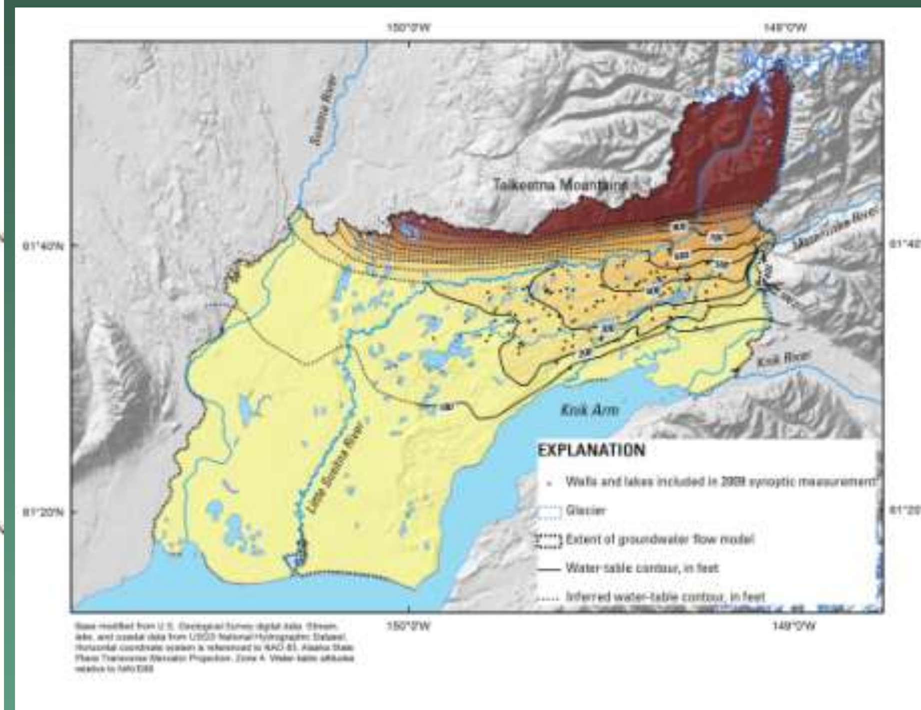
USGS

Groundwater Flow Model

1. Study Objectives
2. Data Sources
3. System Conceptualization
4. Hydrogeologic Framework
5. Groundwater Budget
6. **Groundwater Flow Model**

Simulated water levels

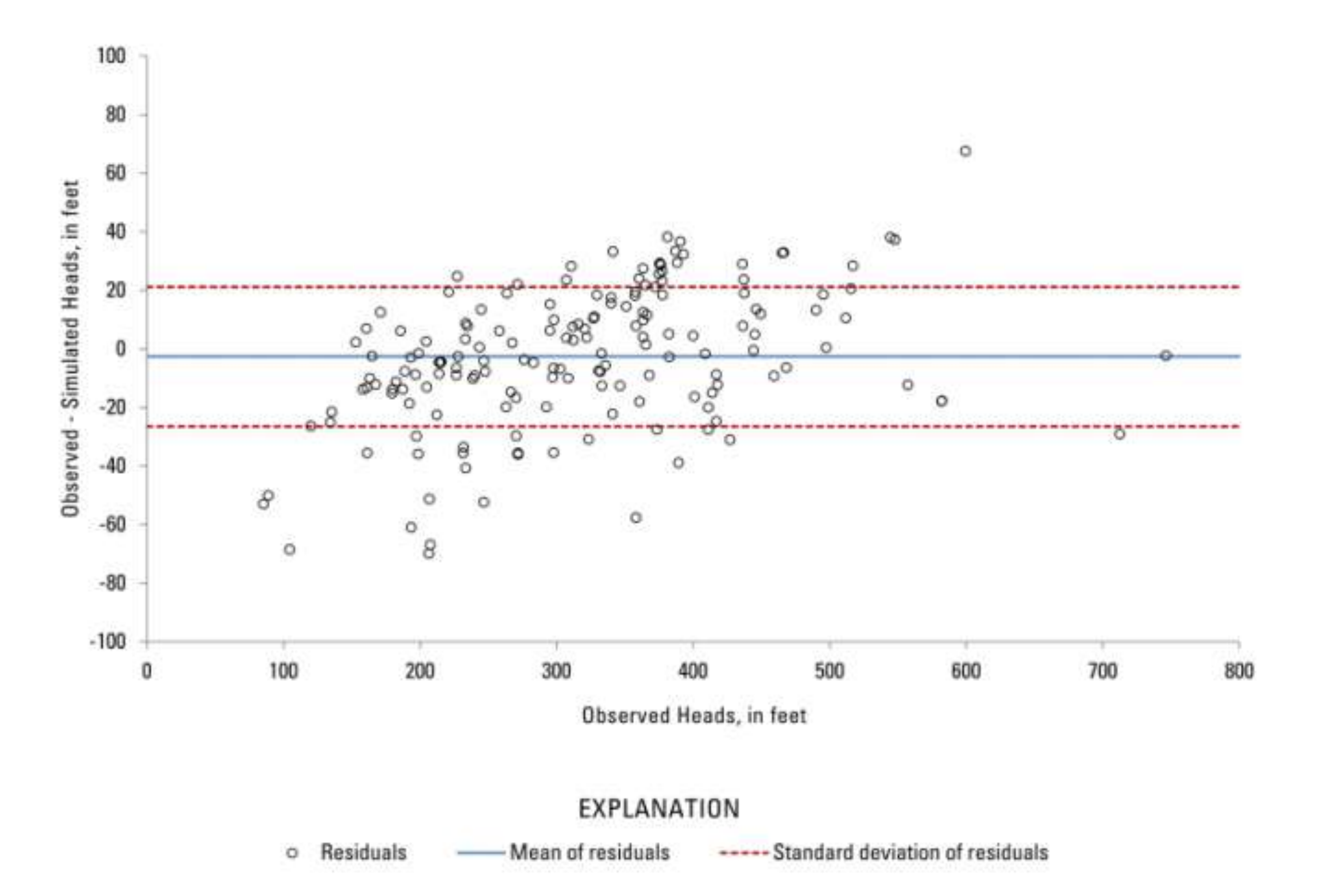




Observed water levels

Groundwater Flow Model

Assessing model performance: heads



USGS

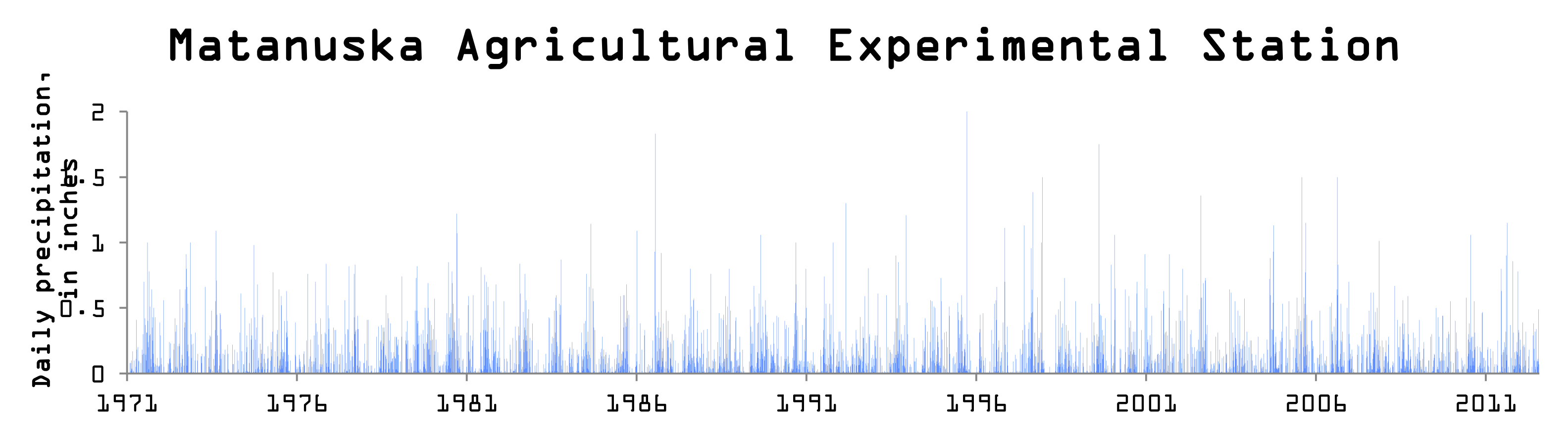
Model applications

- Suitable for…
  - Assessing long-term hydrologic effects of…
    - Groundwater withdrawals
    - Changes in groundwater recharge
  - Generating defensible boundary conditions for site-specific problems (local grid refinement)
- <u>Not</u> suitable for:
  - Transport modeling
  - Site specific problems

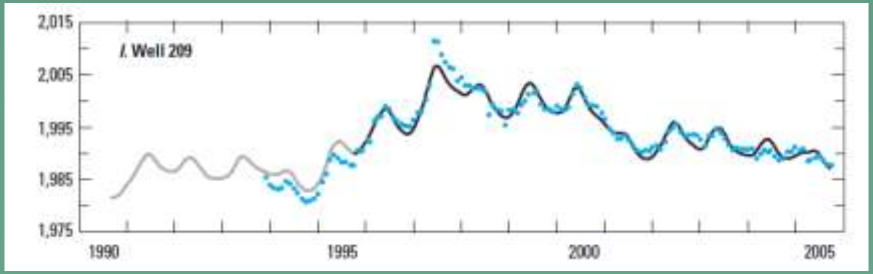
USGS

Ongoing and future efforts

- Toward a transient groundwater model…
  - Estimate historic groundwater recharge



  - Simulate groundwater levels through time, compare to well hydrographs



Hsieh, P.A., Barber, M.E., Contor, B.A., Hossain, Md. A., Johnson, G.S., Jones, J.L., and Wylie, A.H., 2007, Ground-water flow model for the Spokane-Valley Rathdrum Prairie Aquifer, Spokane County, Washington, and Bonner and Kootenai Counties, Idaho: U.S. Geological Survey Scientific Investigations Report 2007-5044, 78 p.

USGS

Acknowledgements

- Mat-Su Valley residents
- Roy Ireland, ADNR