



Western Washington University
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Salish Sea Ecosystem Conference

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Apr 6th, 9:00 AM - 9:15 AM

Groundwater availability for summer low flows: co-production and shared application of hydrogeologic tools and information

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Groundwater Availability for Summer Stream Flows

April 6, 2018

Session 3.1.A: The Application and Creation of Knowledge that Leads
to Action to Restore and Protect an Ecosystem

Rick Dinicola (presenter), Lonna Frans, Wendy Welch
US Geological Survey Washington Water Science Center

We readily share visions and words about rivers...

I am a river,
The source or running water.
I end at the sea.



Dept. of Ecology photograph, North Fork Stillaguamish River, courtesy of Steve Hirshey. Haiku by Davis Guest.

...but not so much about groundwater



From a permit-exempt well owner:
“Just enough to supply my family
home”

...but not so much about groundwater

From a farmer:
“Yes, a bit more, but I help
to feed my community”



...but not so much about groundwater



Groundwater dreams of a salmon:
“Stuff of life!”

...but not so much about groundwater

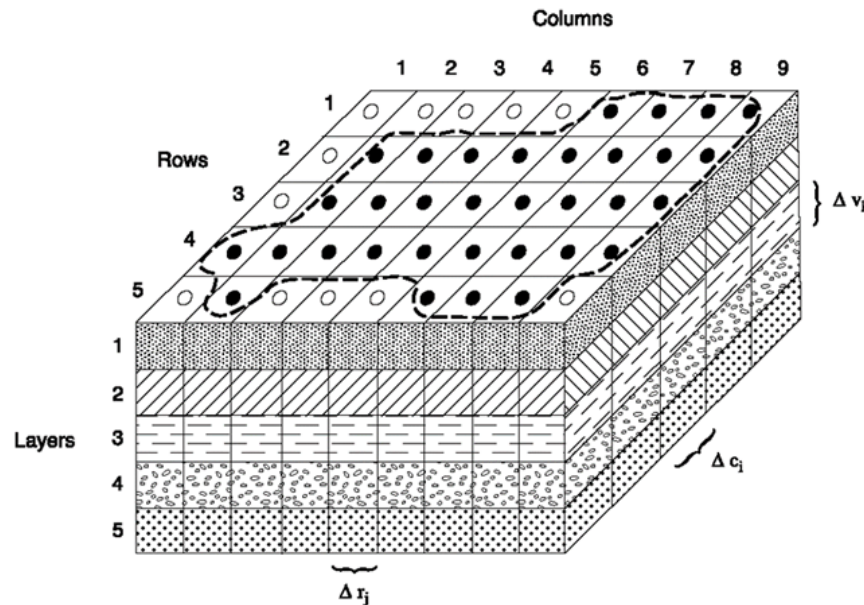
Or heaven forbid through the eyes of a hydrogeologist!

INHOMOGENEOUS ANISOTROPIC UNCONFINED AQUIFER

$$\frac{\partial}{\partial x} \left(K_x \frac{\partial h}{\partial x} \right) + \frac{\partial}{\partial y} \left(K_y \frac{\partial h}{\partial y} \right) + \frac{\partial}{\partial z} \left(K_z \frac{\partial h}{\partial z} \right) = 0$$

INHOMOGENEOUS ANISOTROPIC CONFINED AQUIFER

$$\frac{\partial}{\partial x} \left(K_x \frac{\partial h}{\partial x} \right) + \frac{\partial}{\partial y} \left(K_y \frac{\partial h}{\partial y} \right) + \frac{\partial}{\partial z} \left(K_z \frac{\partial h}{\partial z} \right) = S_s \frac{\partial h}{\partial t}$$

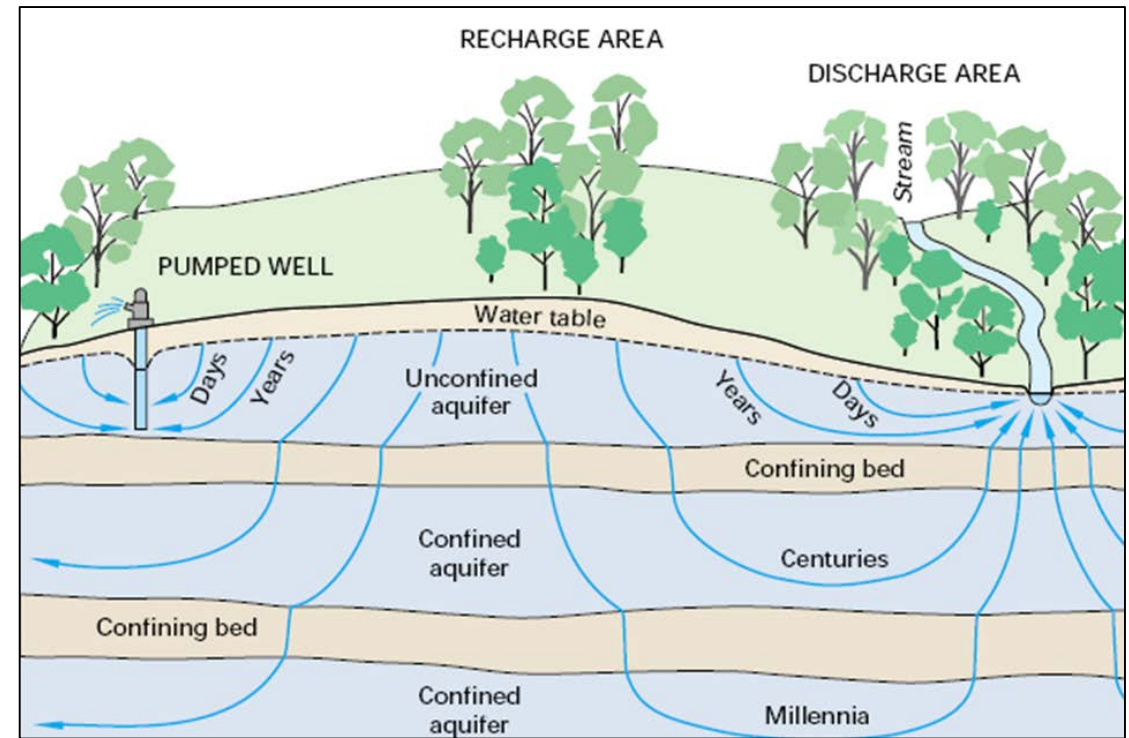


A shared understanding groundwater is a “wicked problem”

- Generally underground, out of sight
- Big ranges of space and time scales
- Complex language/jargon
- Unwieldy computer models
- Hard to illustrate how it flows
- Much conventional wisdom about groundwater is not wise...
...but true wisdom is difficult to gain!

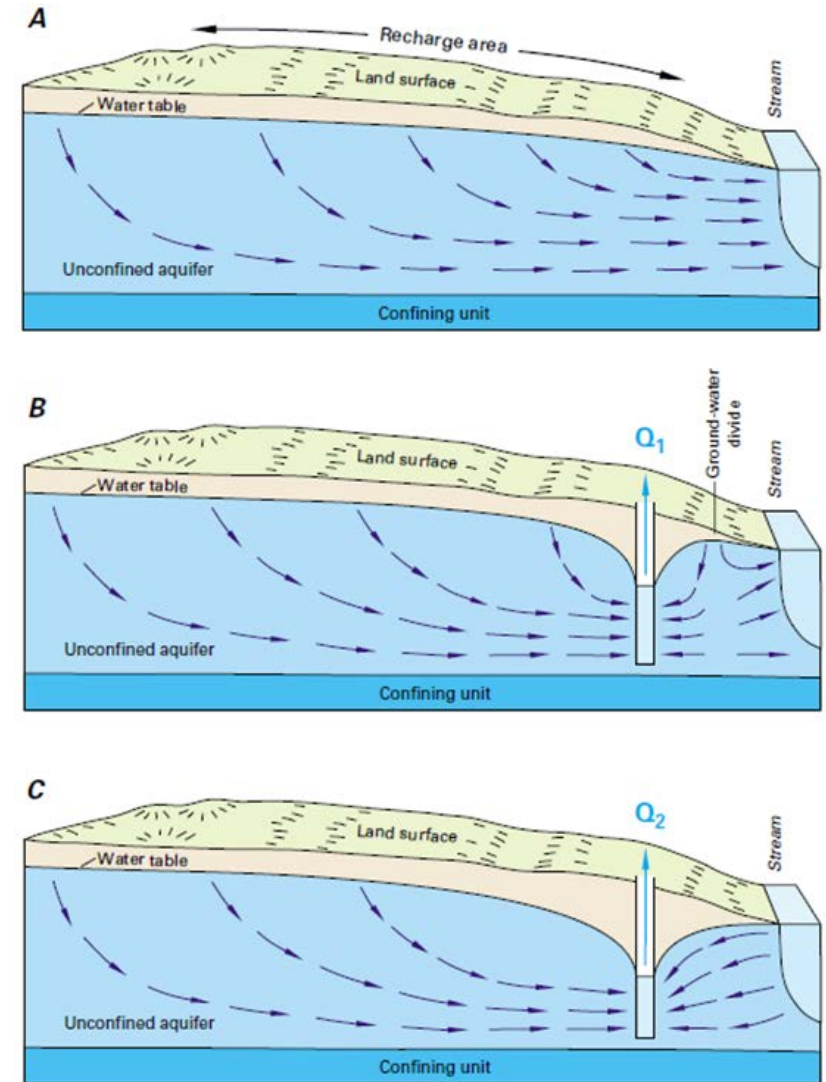
Today's Goals

- Garner interest in developing a shared understanding of groundwater in Puget Sound
- Describe USGS groundwater activities to facilitate such understanding through collaborative work with “science users”

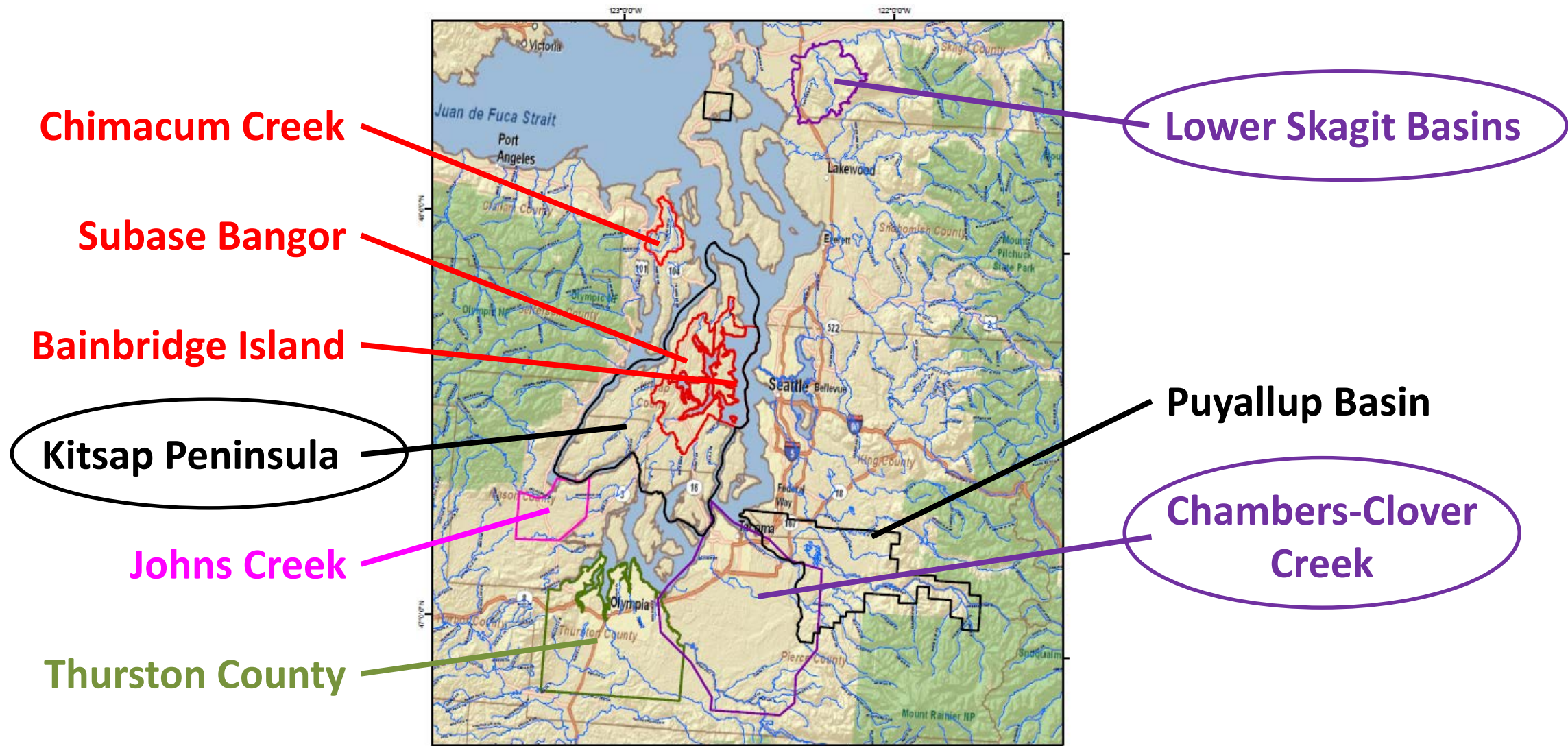


Groundwater availability and summer stream flows

- Groundwater availability includes:
 - Quantity and quality of groundwater
 - Laws, rules, regulations, and socioeconomic factors
- It is intricately tied to availability of surface water
- Groundwater discharge sustains summer low flows
Salmon spawn in groundwater!
- Groundwater also sustains municipal/domestic uses, irrigation, fish hatcheries, drought mitigation...
- Thus, groundwater availability is often at the core of conflict between water use and instream flows



USGS Collaborative Groundwater Studies in Puget Sound

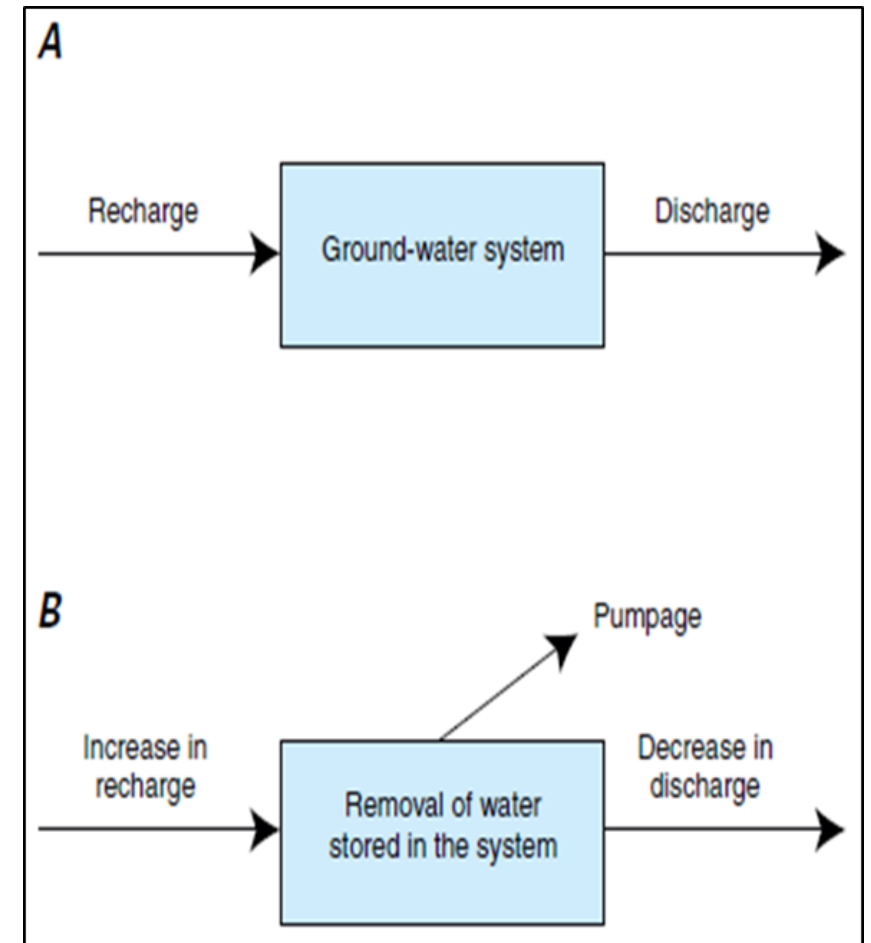


Regionalizing groundwater knowledge across Puget Sound

2016-0103 NTA - Groundwater Budgets and Summer Low Flows (in progress)

- Generate current and future GW budgets for all Puget Sound subbasins
 - Current and future (~2050) monthly recharge, pumpage, groundwater discharge, streamflows
 - Future reflects Δ population, land-cover, climate
- Identify relative resilience of summer low flows
- Collaborate with users how to best compile and deliver information
 - WRIAs or smaller? Uplands and lowlands?
 - Story Maps? Interactive website?

Looking for feedback!

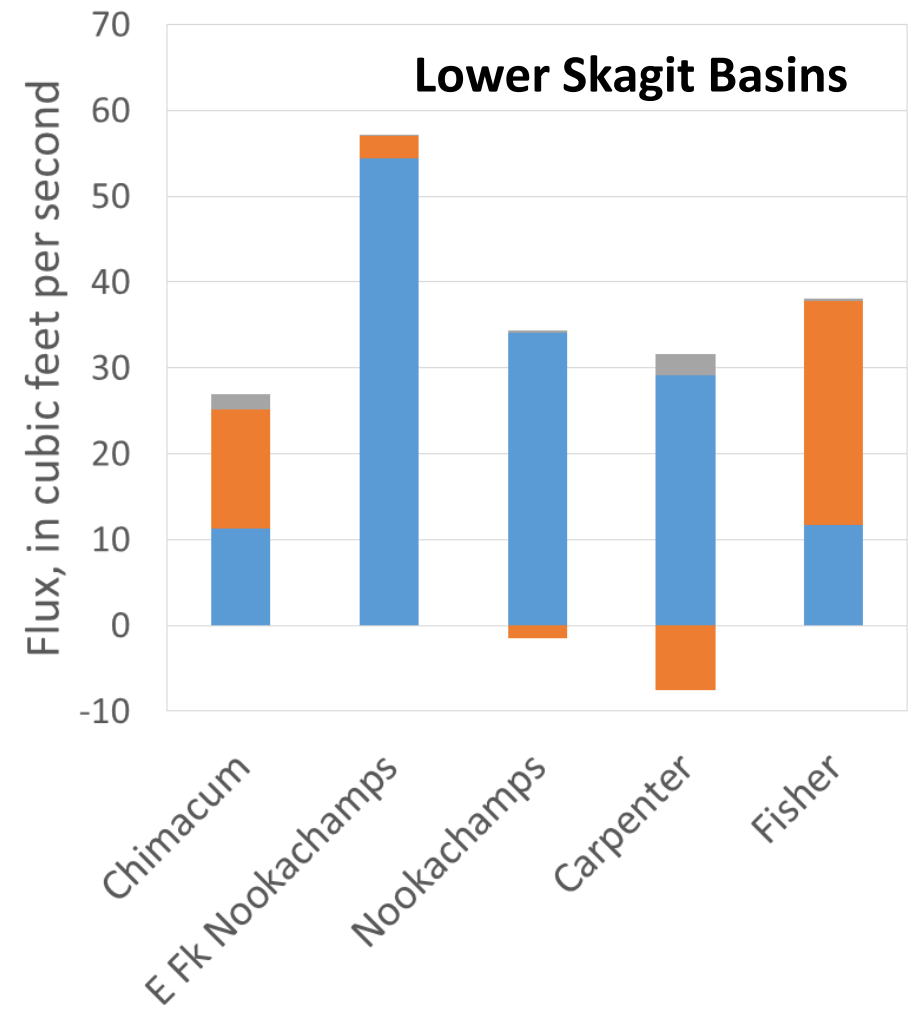
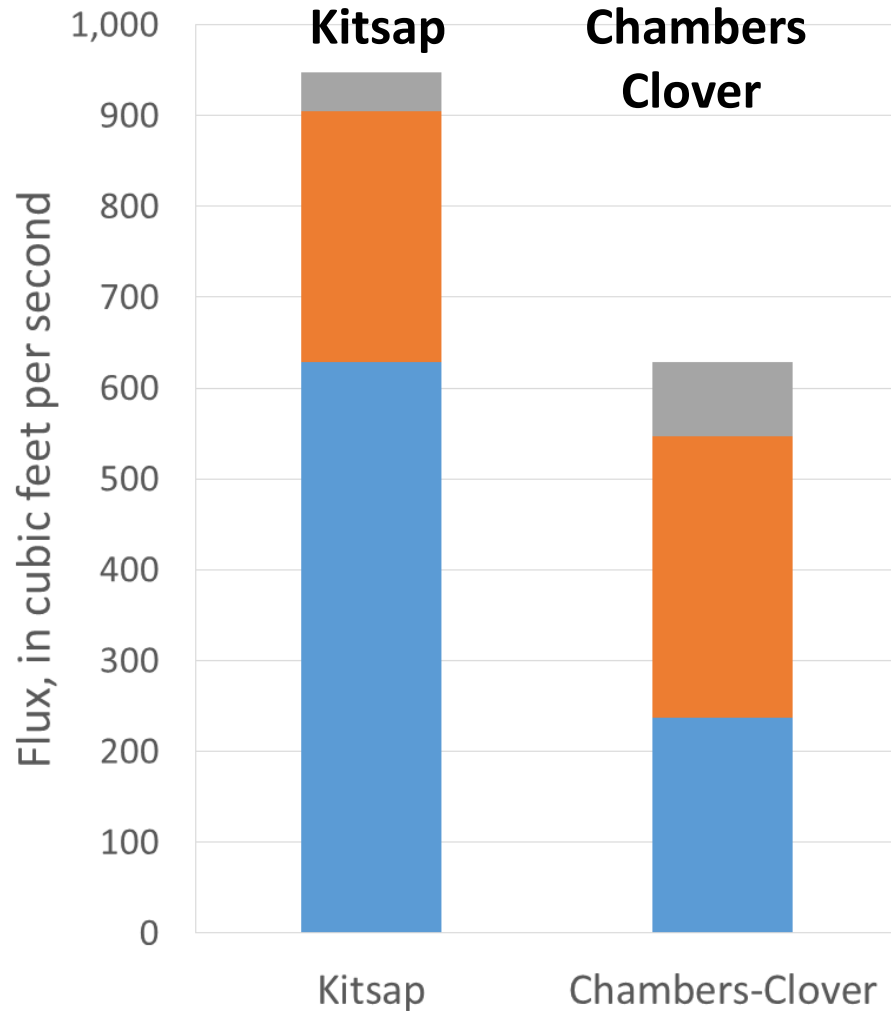


Simple annual groundwater budgets

Explanation

Height of bar is total recharge

- Pumpage
- Discharge to Puget Sound/Skagit valley
- Discharge to streams/lakes



GW budgets with refined water use and discharge

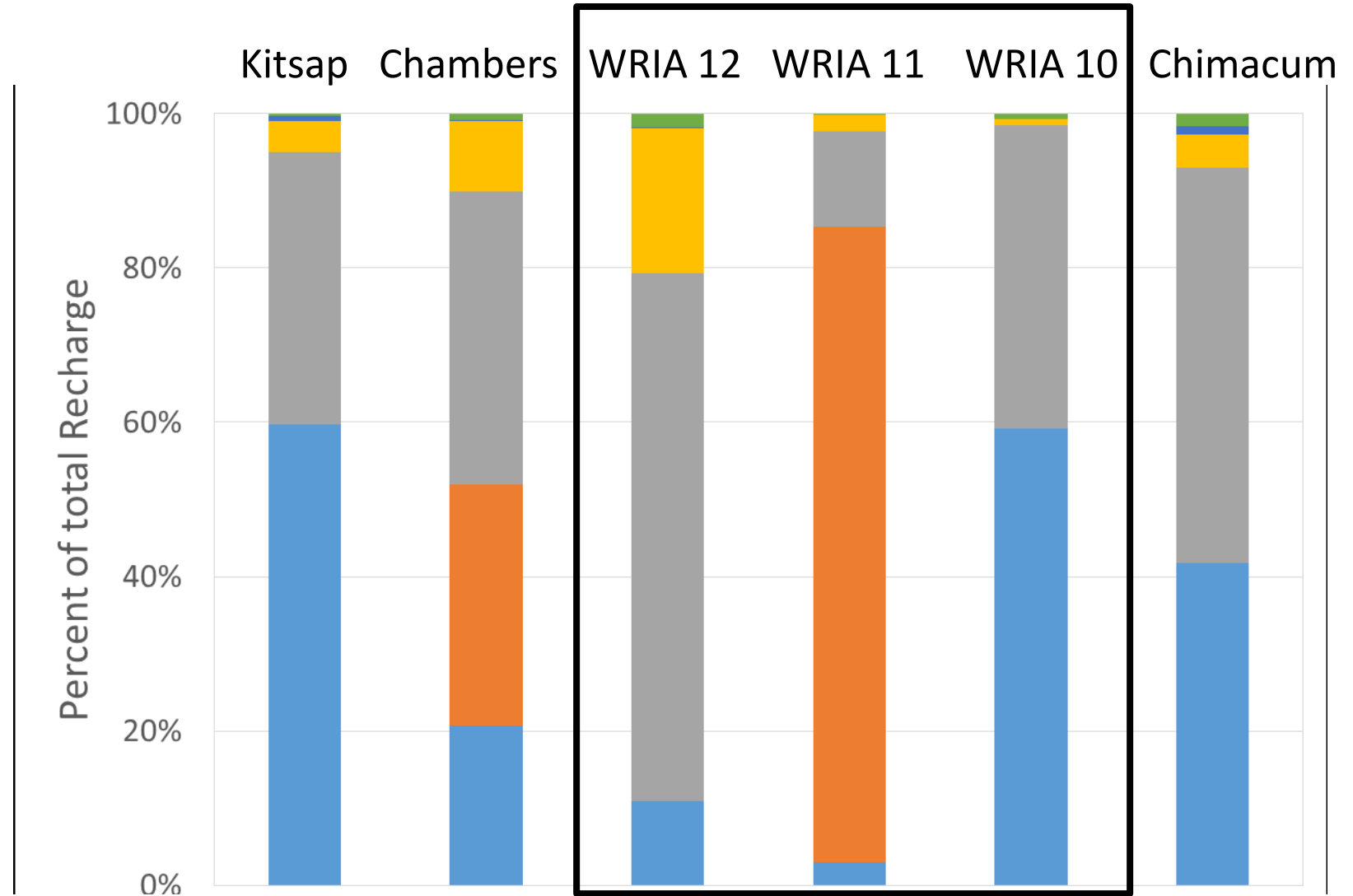
Explanation

Pumpage

- All other wells
- Domestic wells
- Public Supply wells

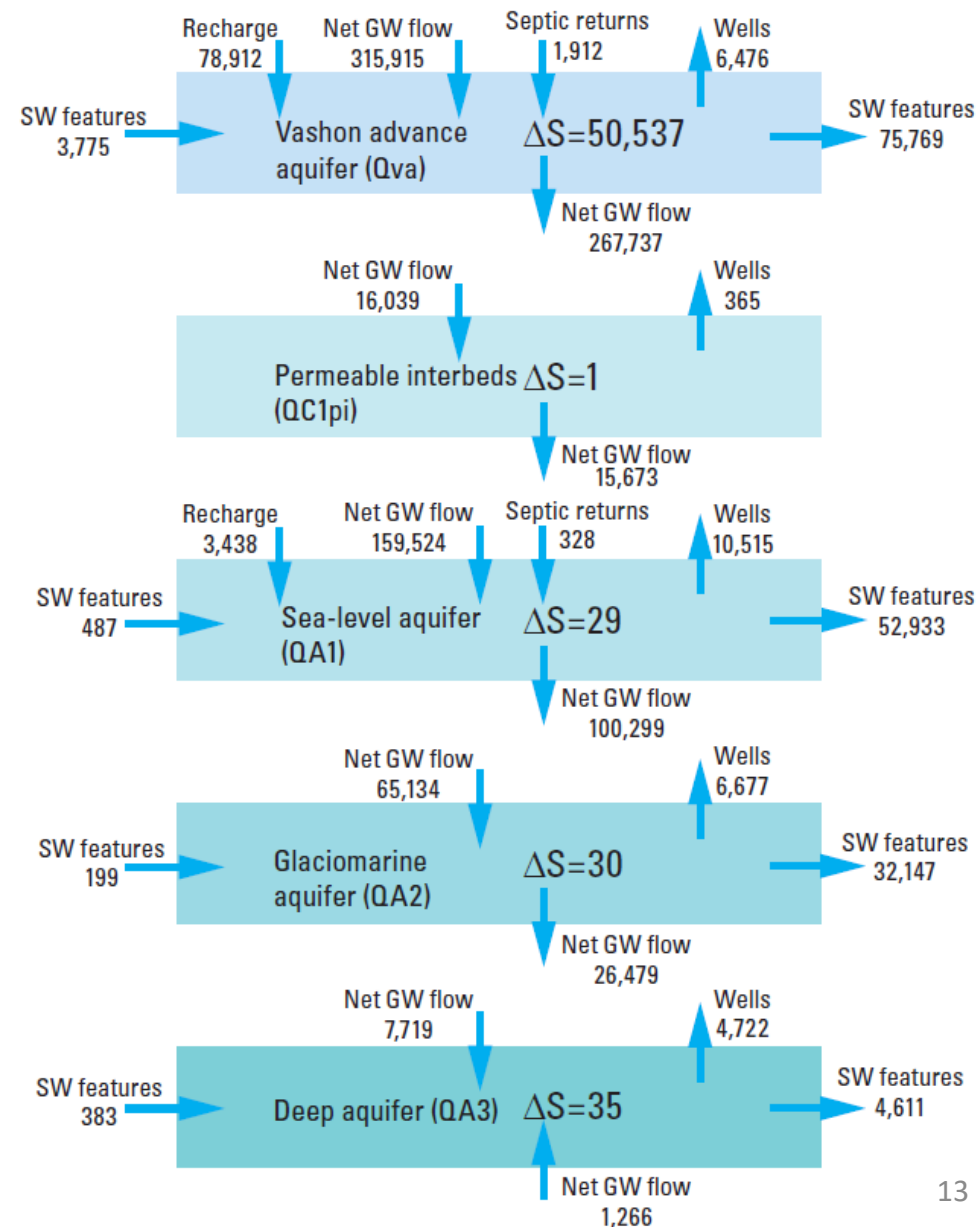
Discharge

- to Puget Sound
- to Nisqually River
- to streams/lakes

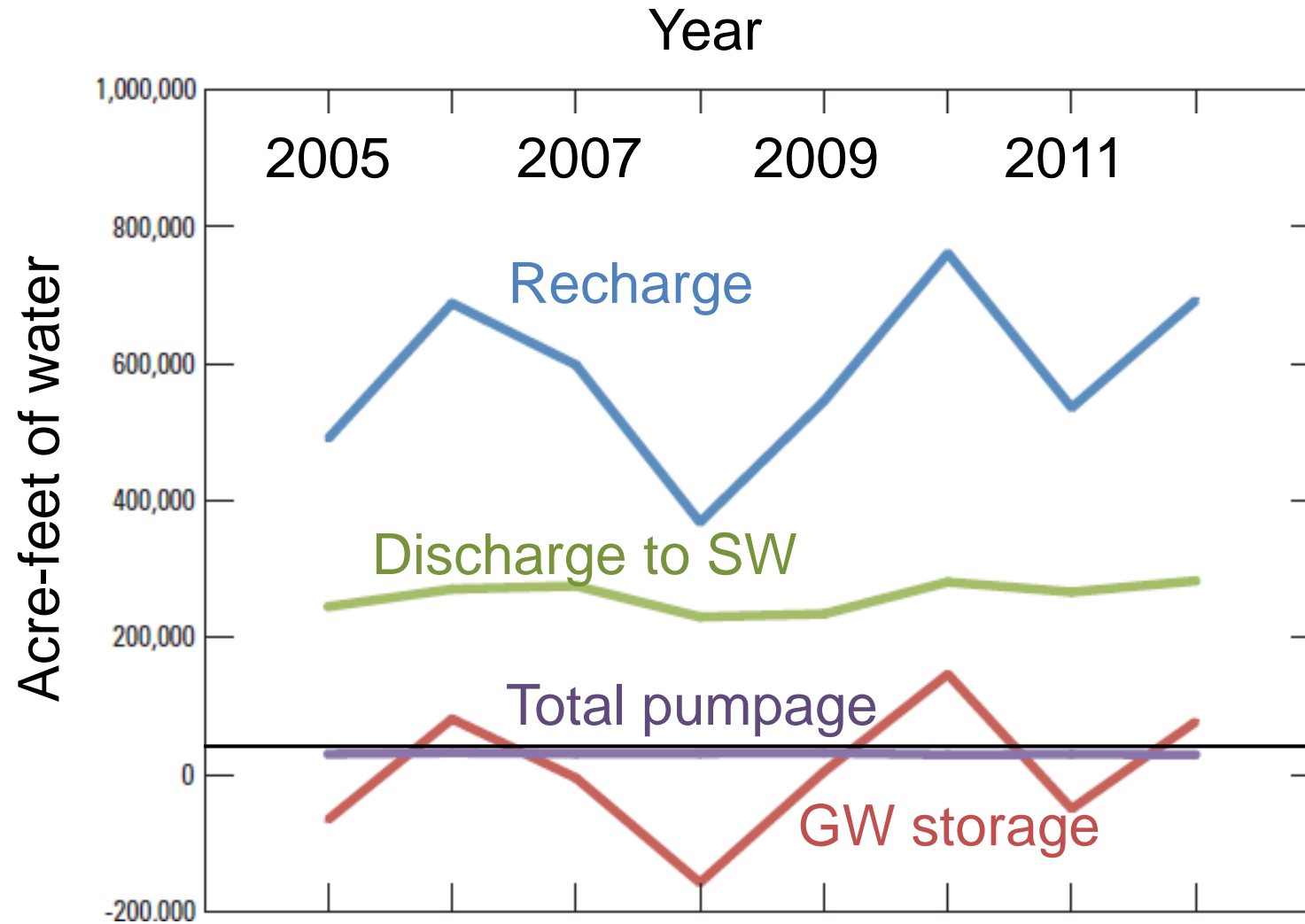


GW budgets by individual aquifers (Kitsap Model)

- Requires a transient GW flow model (adds complexity)
- Water budgets (in-out-up-down) generated for each aquifer
- Pumpage assigned to specific aquifers, thus...pumping impacts for different aquifers simulated
- Changes in storage over time
- Highlights dynamics and exchanges between all aquifers and surface water

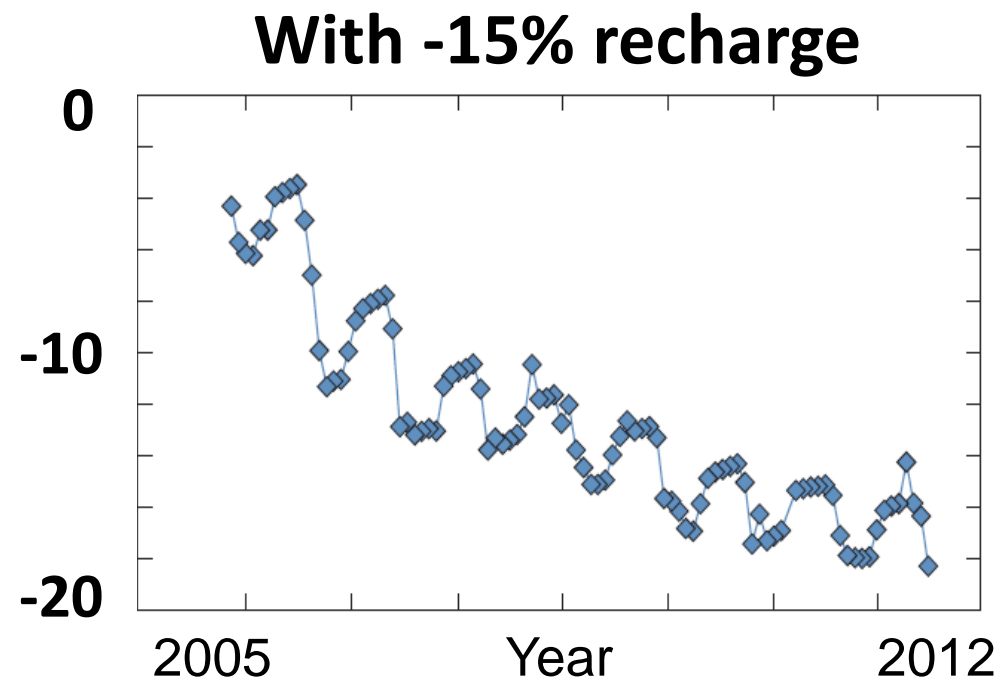
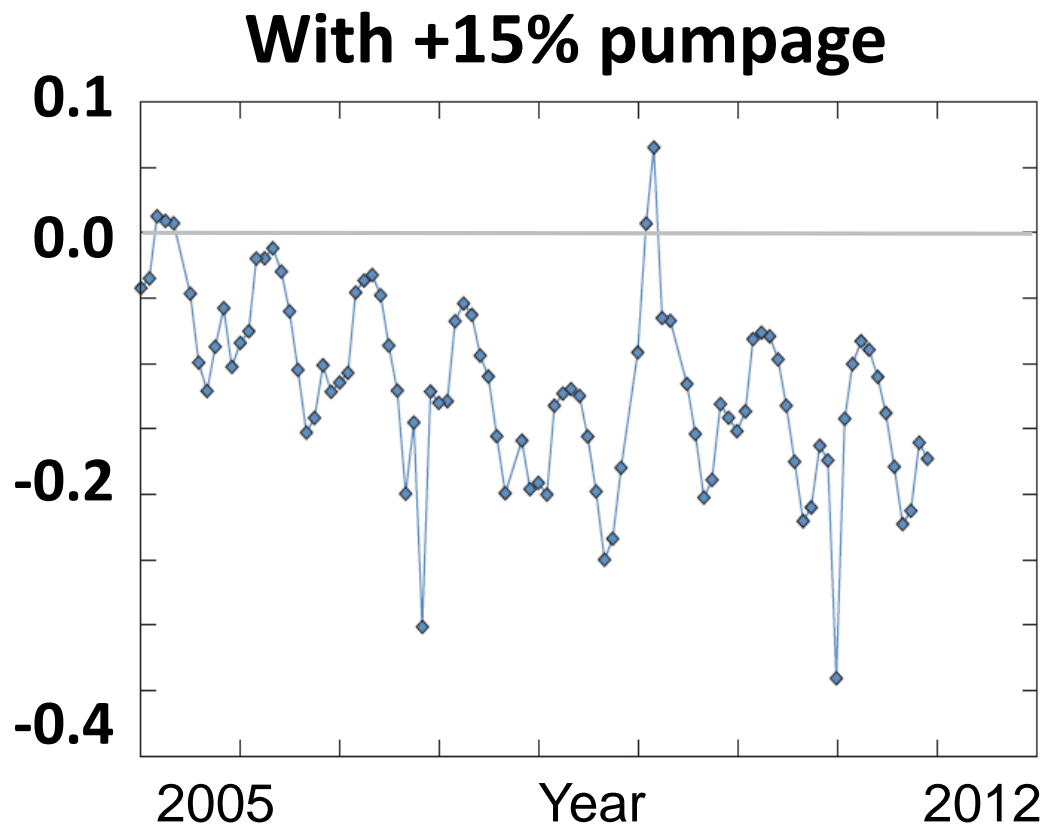


Variation in annual GW budgets over time (Kitsap model)



GW budgets under Δ water-use & climate scenarios (Kitsap Model)

Percent Change in Monthly Freshwater Discharge to Streams



Next steps towards regionalizing GW knowledge

2018-20 Near-Term Action proposals

- Collaborative integration of GW budget data into ESSB 6091 (“Hirst fix”) watershed planning/restoration efforts
- Technical support for a Summer Stream Flow Implementation Strategy
- Streamlined modeling approaches focused on pumping and Summer Stream flows

ESSB 6091 Net Ecological Benefits Assessment Process

- More facilitating shared understanding of groundwater

Working towards a comprehensive model for the Puget Sound Regional Aquifer System



Teanaway River; Washington Water Trust

Conclusions

- Collaboration with users/stakeholders allows us to chip away at the “wicked problem” of groundwater
- Regionalizing knowledge helps inform where to focus protection/restoration of summer stream flows across Puget Sound
- Findings to date highlight that we are blessed with (relatively) abundant groundwater, but with equally abundant socioeconomic, legal, and cultural challenges
- With our reliable recharge and modest groundwater use, many options are available for sustainable paths forward



Thank you