Hydrogeology Concepts and Considerations for RCW 90.94 Streamflow Restoration in WRIAs 22 & 23

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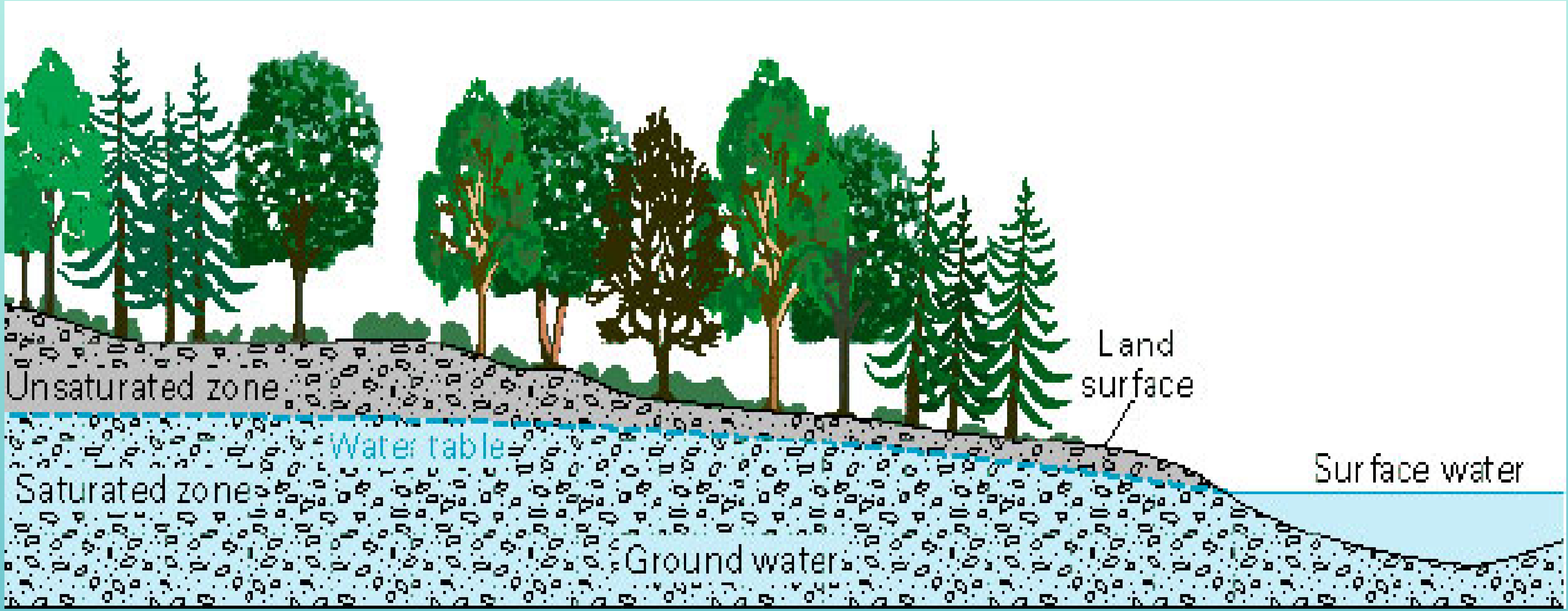
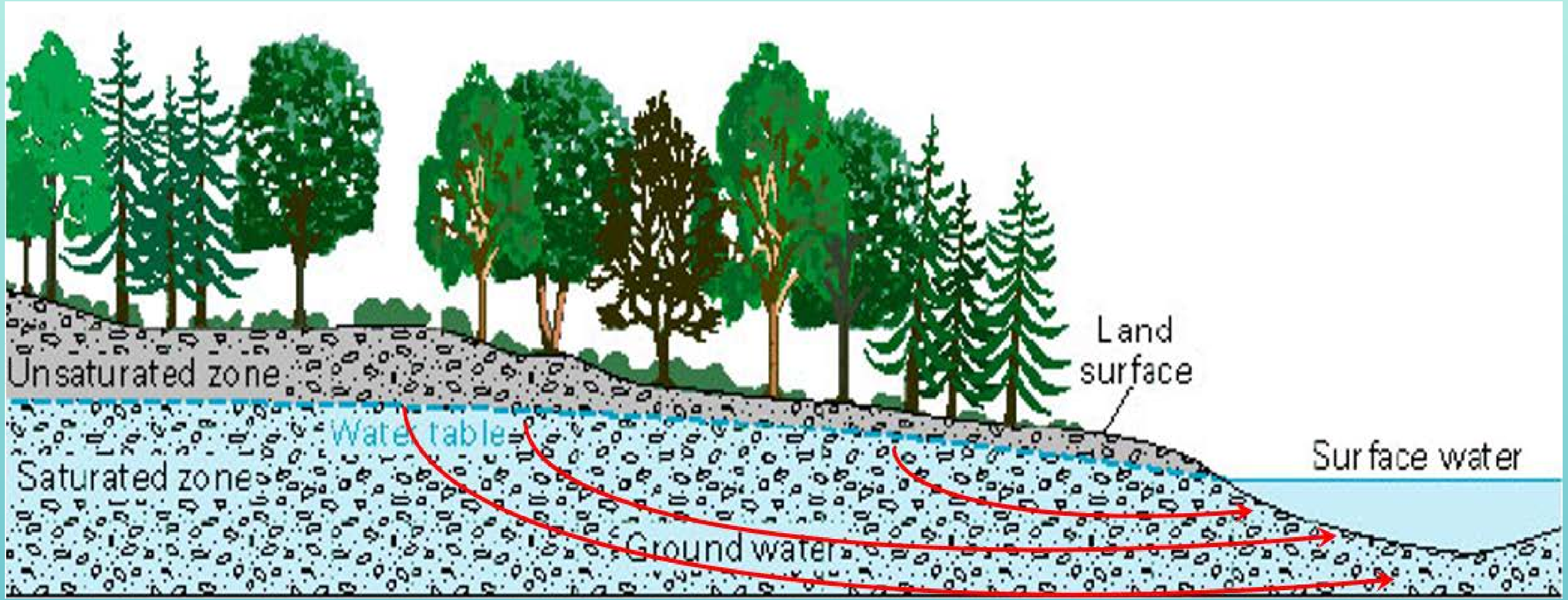
Tom Culhane
Washington State Department of Ecology
Tom.Culhane@ecy.wa.gov

- All pore spaces (openings) below the water table are full of groundwater
- Tops of water tables generally mimic surface topography, and fluctuate seasonally and from year to year



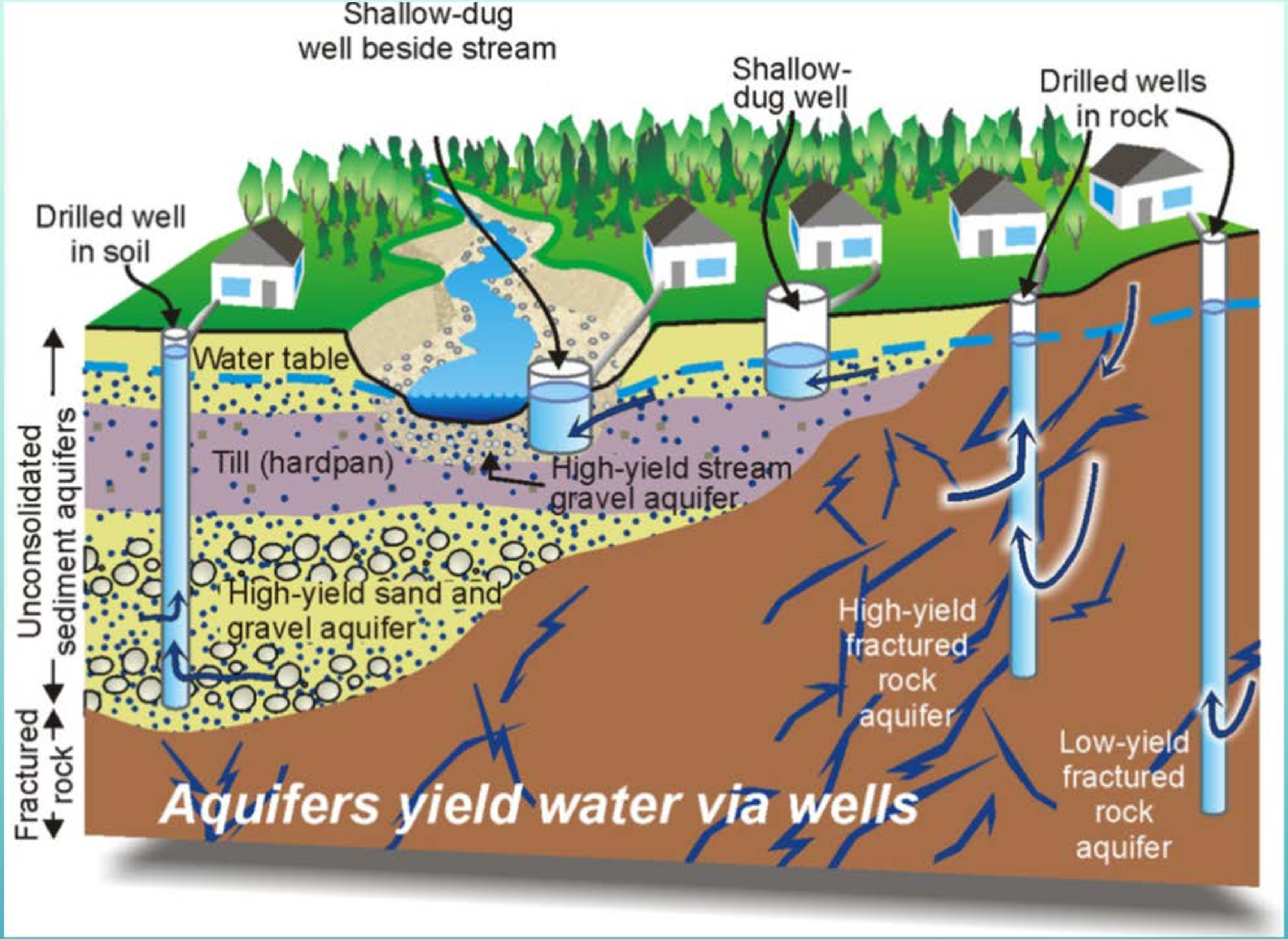
Under natural conditions, groundwater moves from areas of recharge to areas of discharge at springs or along streams, lakes, and wetlands

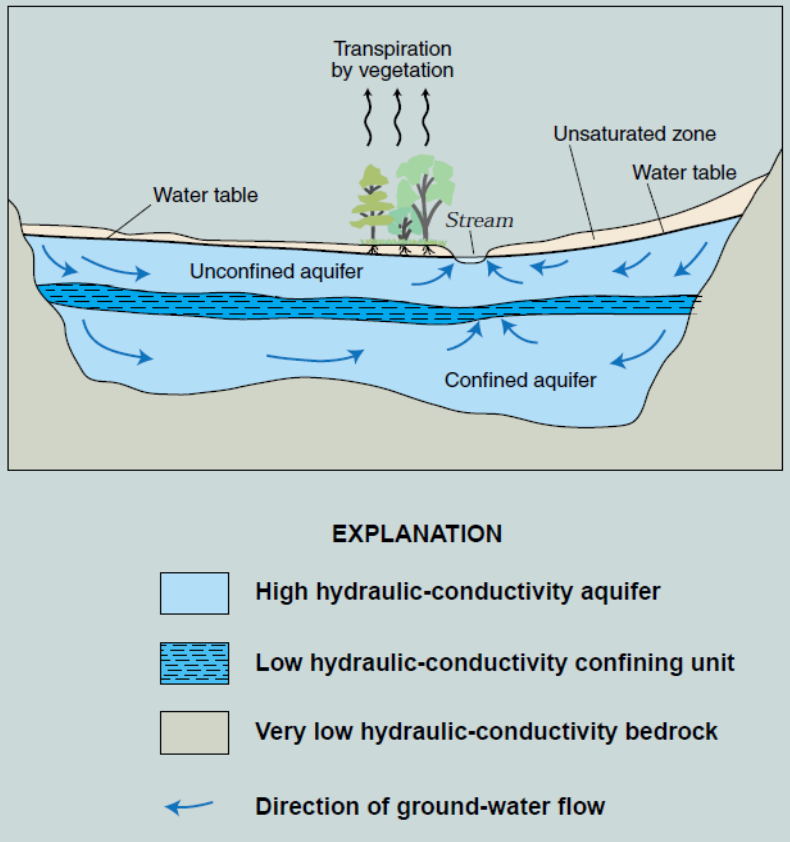


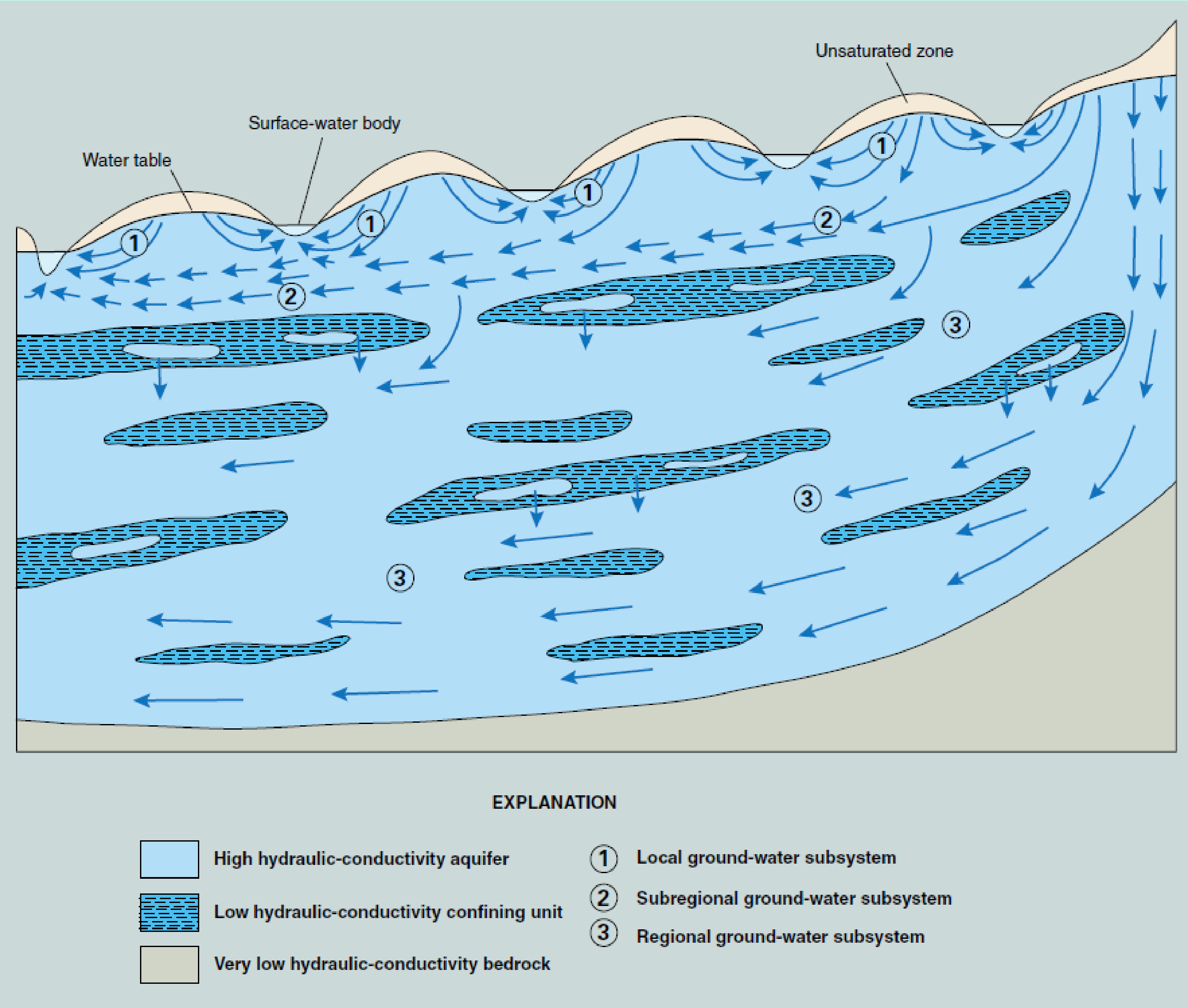
Aquifer -- saturated geologic material permeable enough to yield economical quantities of water

Aquitard -- saturated geologic material with low permeability; well yields low; also called “confining layer”

Confined Aquifer -- saturated material below aquitard permeable enough to transmit useful water quantities

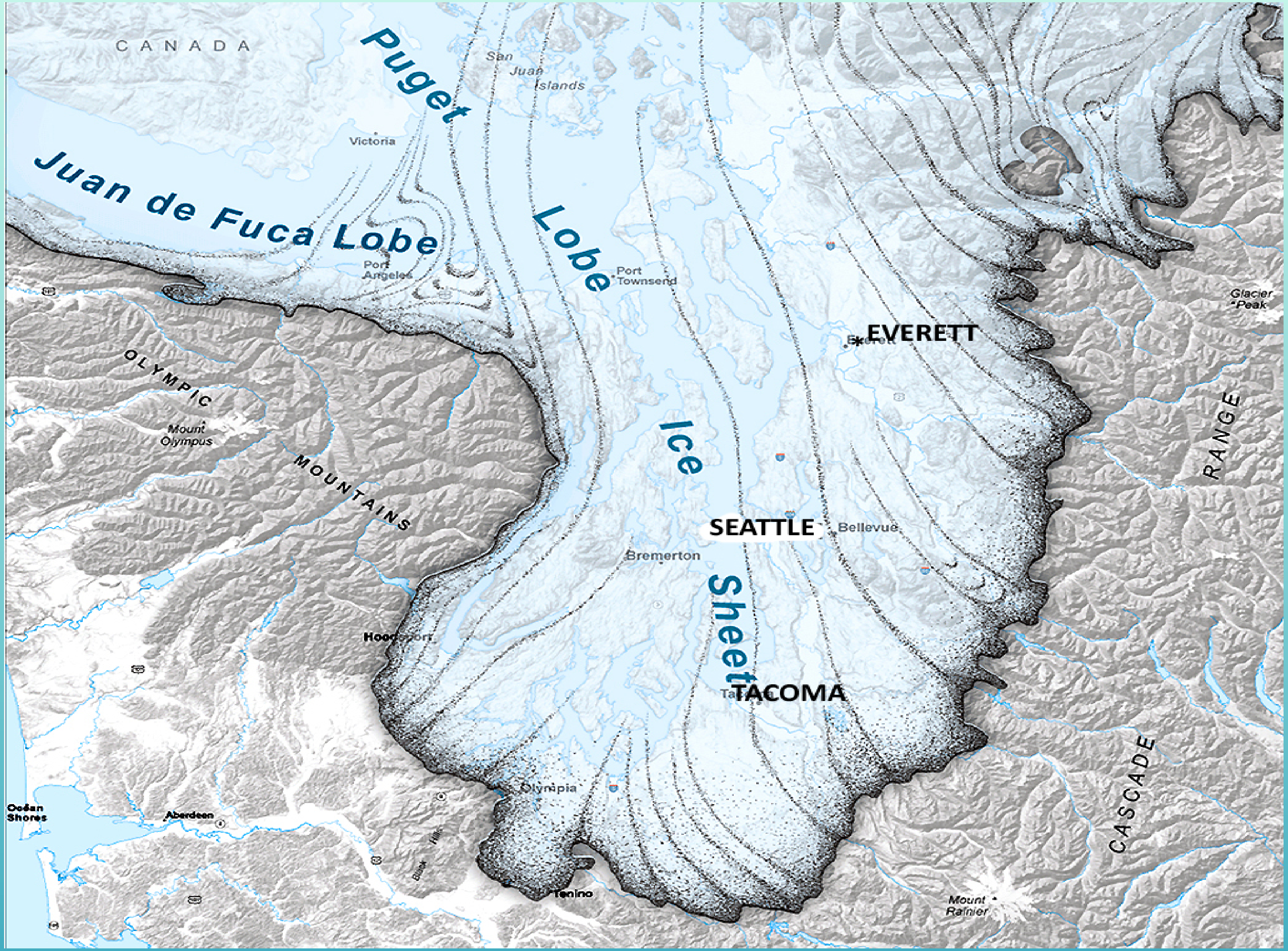






USGS Circular 1186

Vashon Glaciation lasted about 19,000 to 16,000 BP



Washington Department of Natural Resources

Pierce County Geology

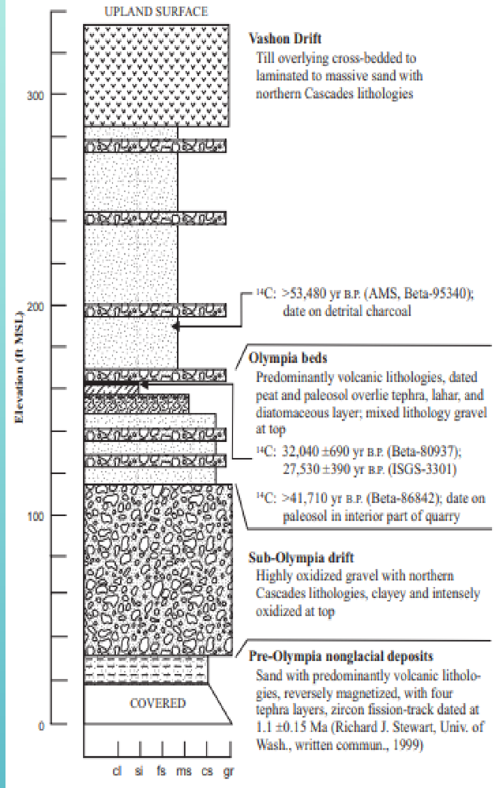
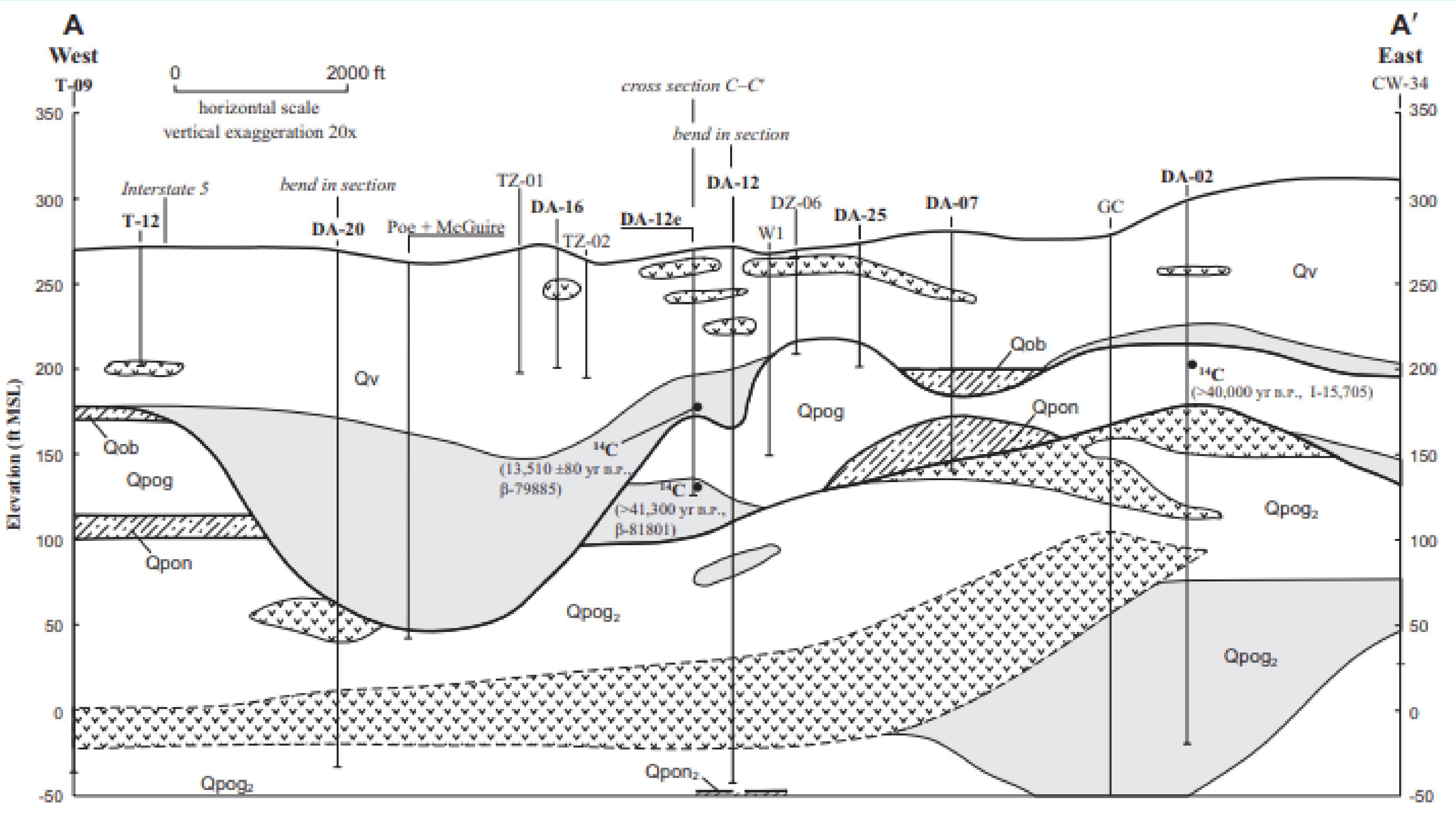
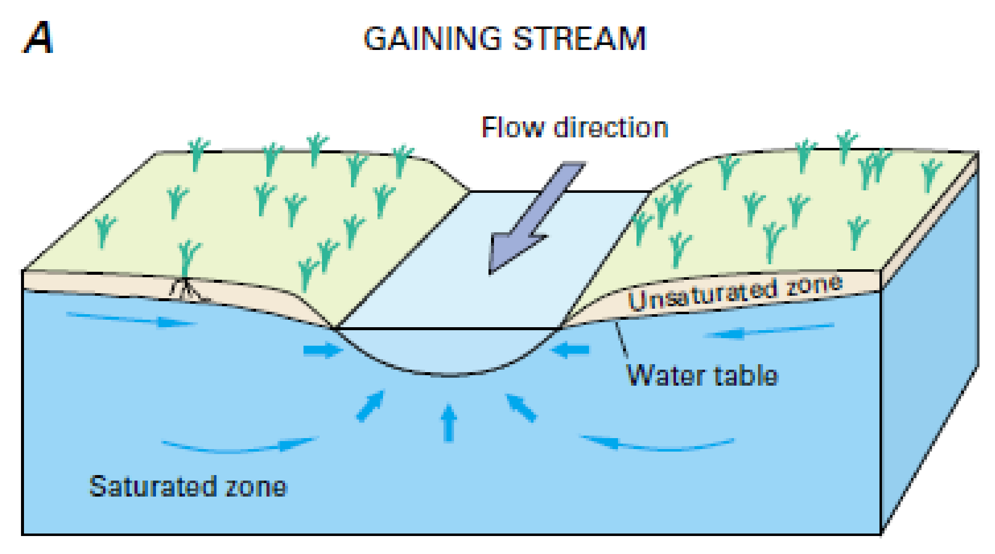


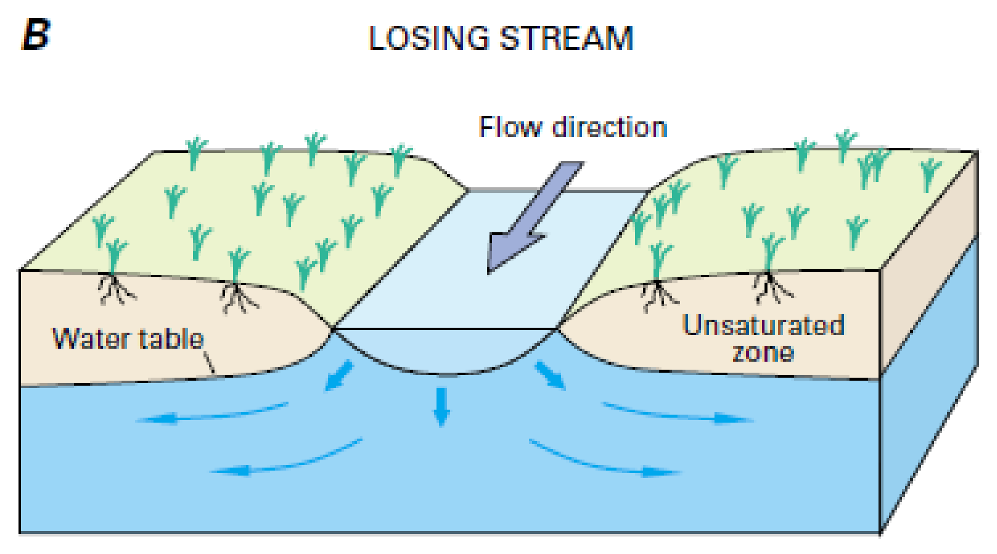
Figure 6. Woodworth quarry composite measured section, Poverty Bay 7.5-minute quadrangle, lat 47.2729 N, long 122.3728 W.

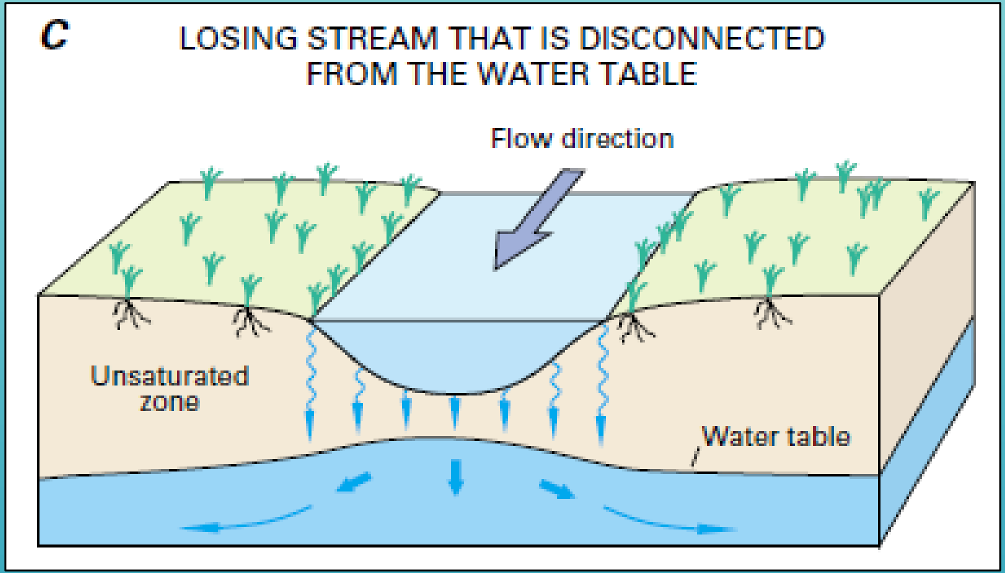


WA DNR Report of Investigations 33

Groundwater – Surface Water Relationships







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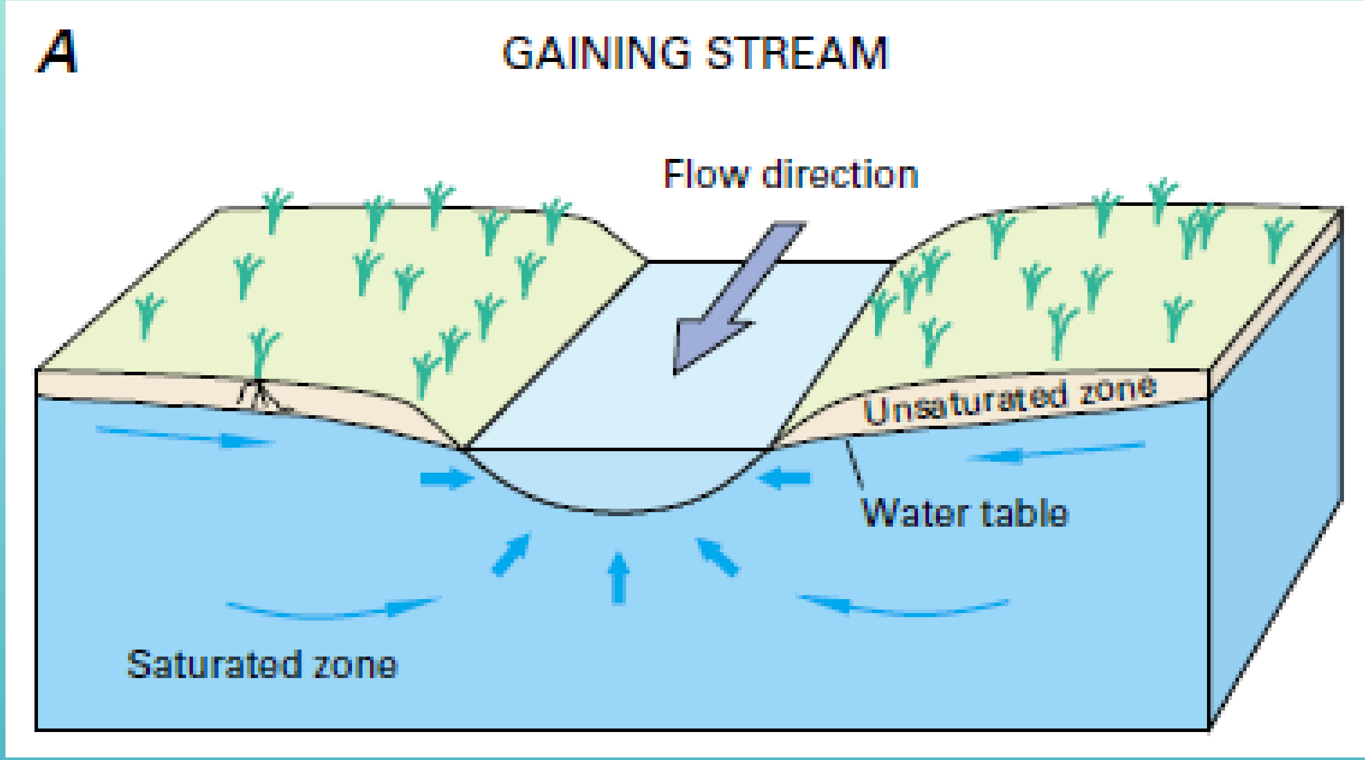
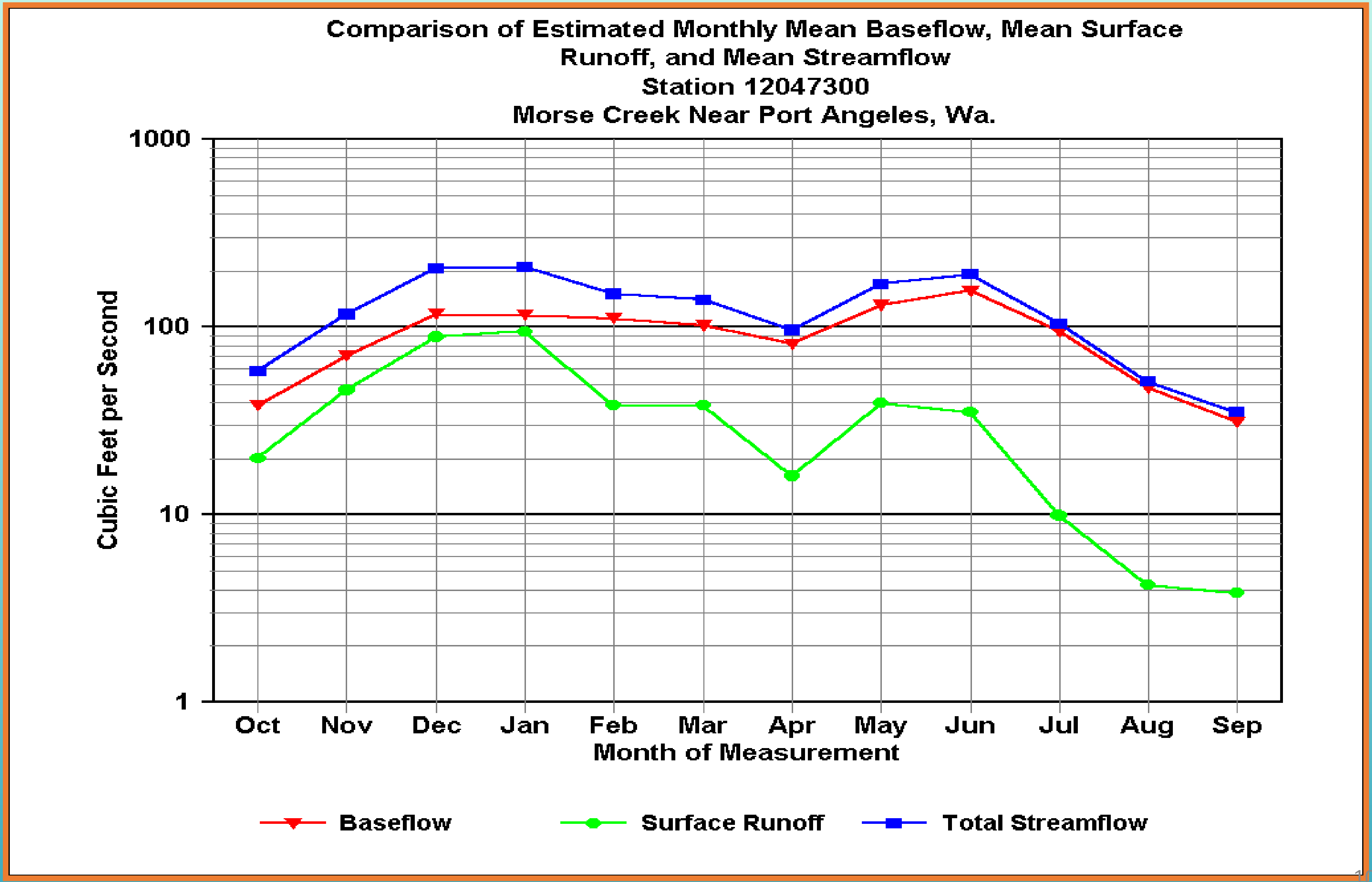
Baseflow: component of streamflow derived from groundwater inflow or discharge.

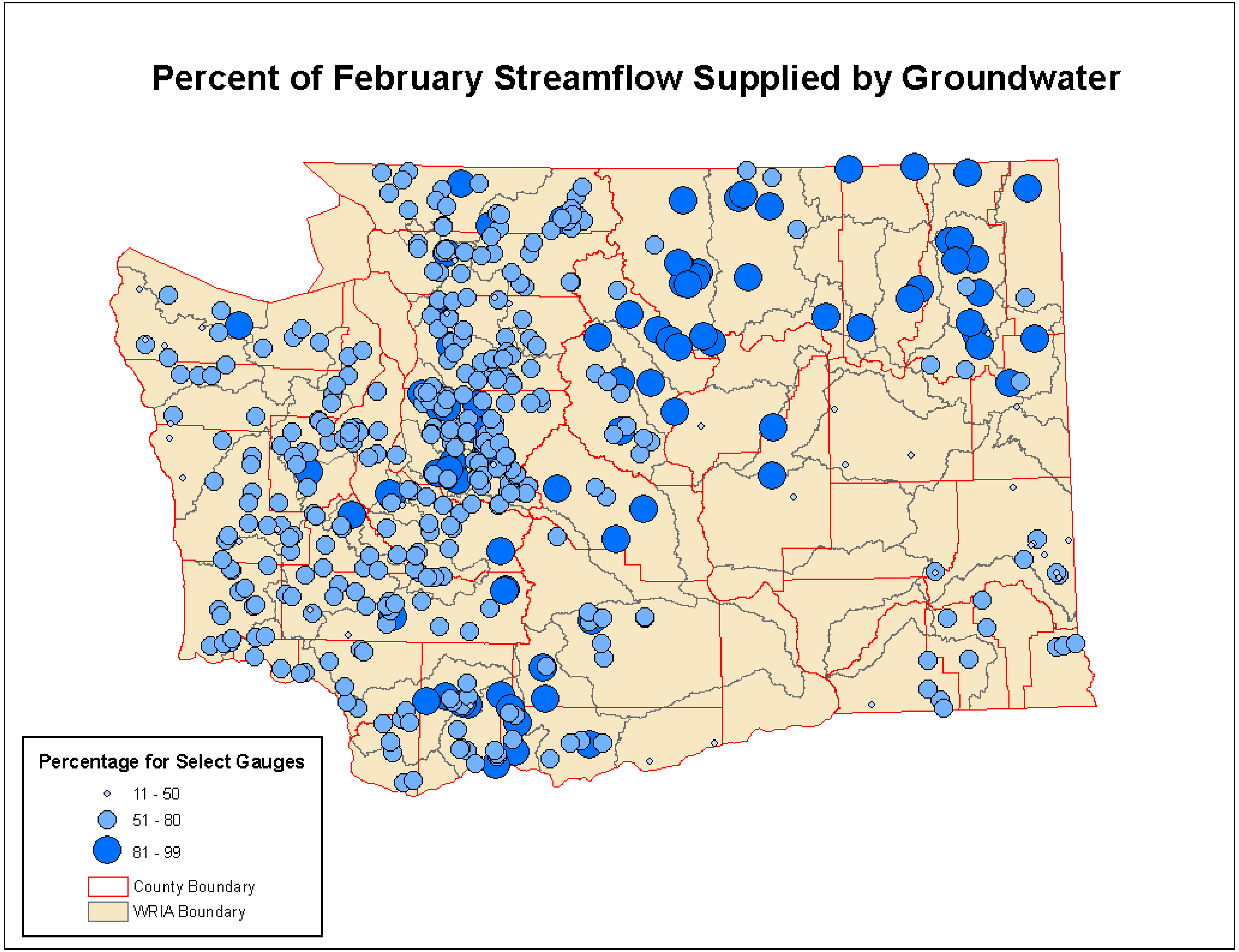


Baseflow is important for both water quantity and temperature.

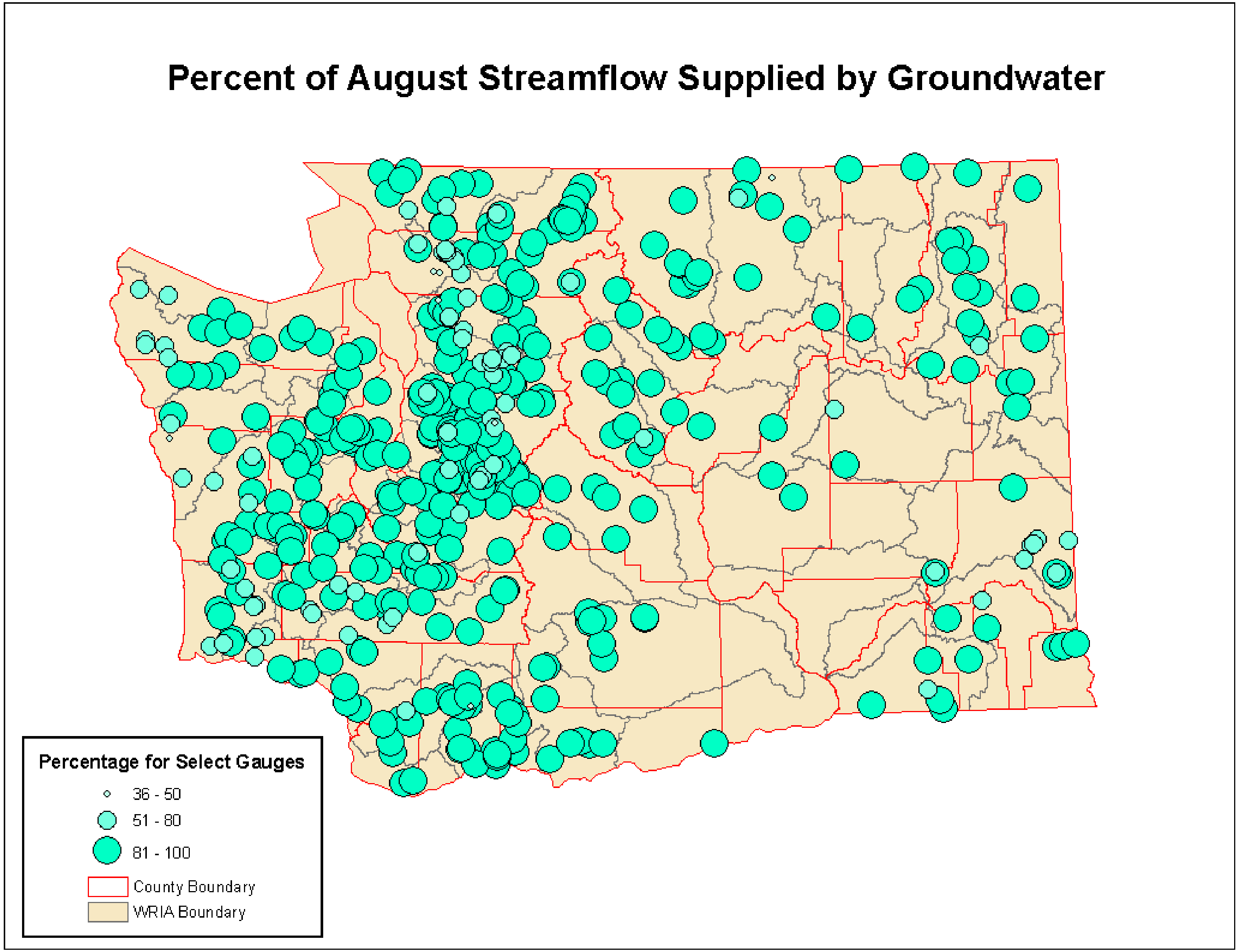
Note: vertical axis presented in **log scale**



Baseflow maintains summer streamflow throughout most of Washington

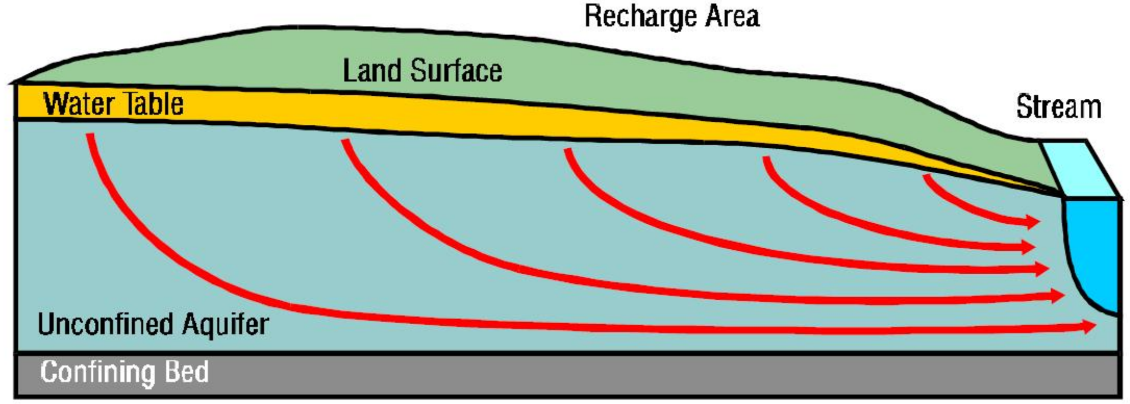


In Washington groundwater baseflow contributes 68% of total annual flow for 594 studied gages (WSB 60)

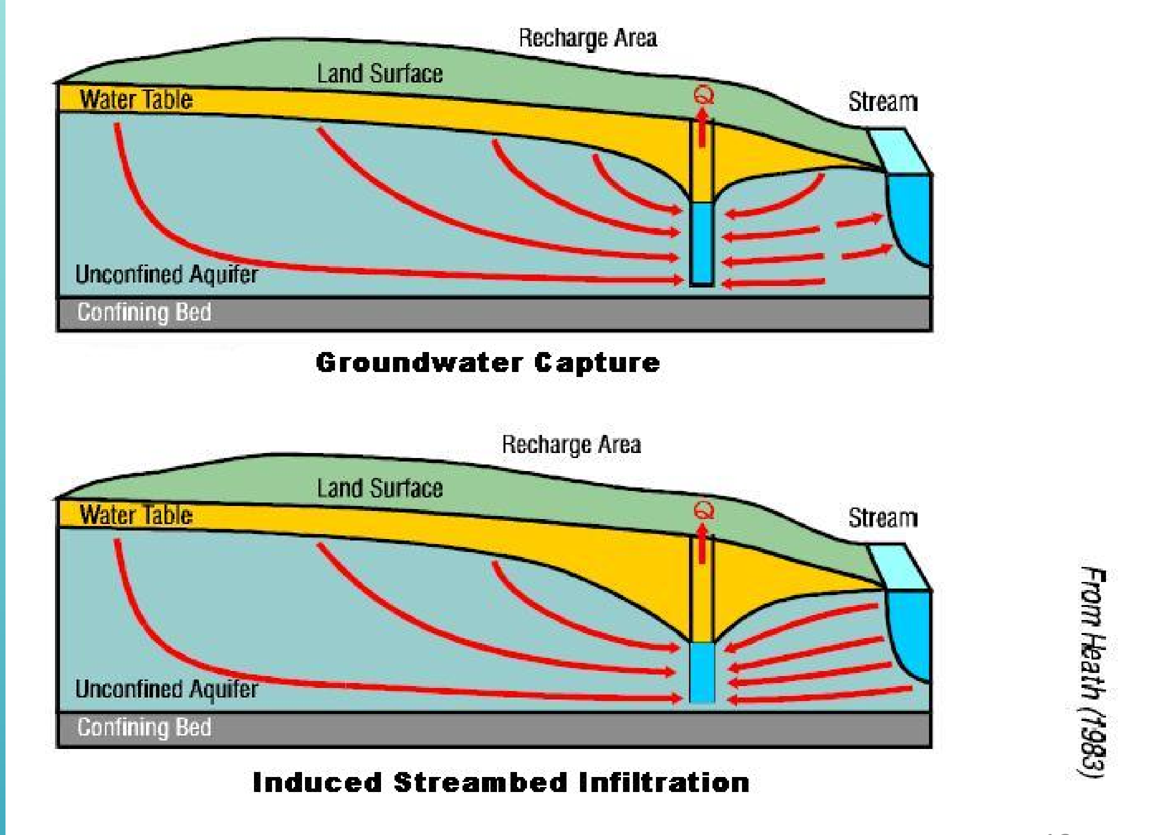


Groundwater pumping can generally deplete streamflow in two ways:

- **Groundwater capture** - interception of groundwater flow that is tributary to a stream. This effect usually continues after pumping ends.
- **Induced streambed infiltration** - groundwater pumping pulling surface water from a stream toward a well.



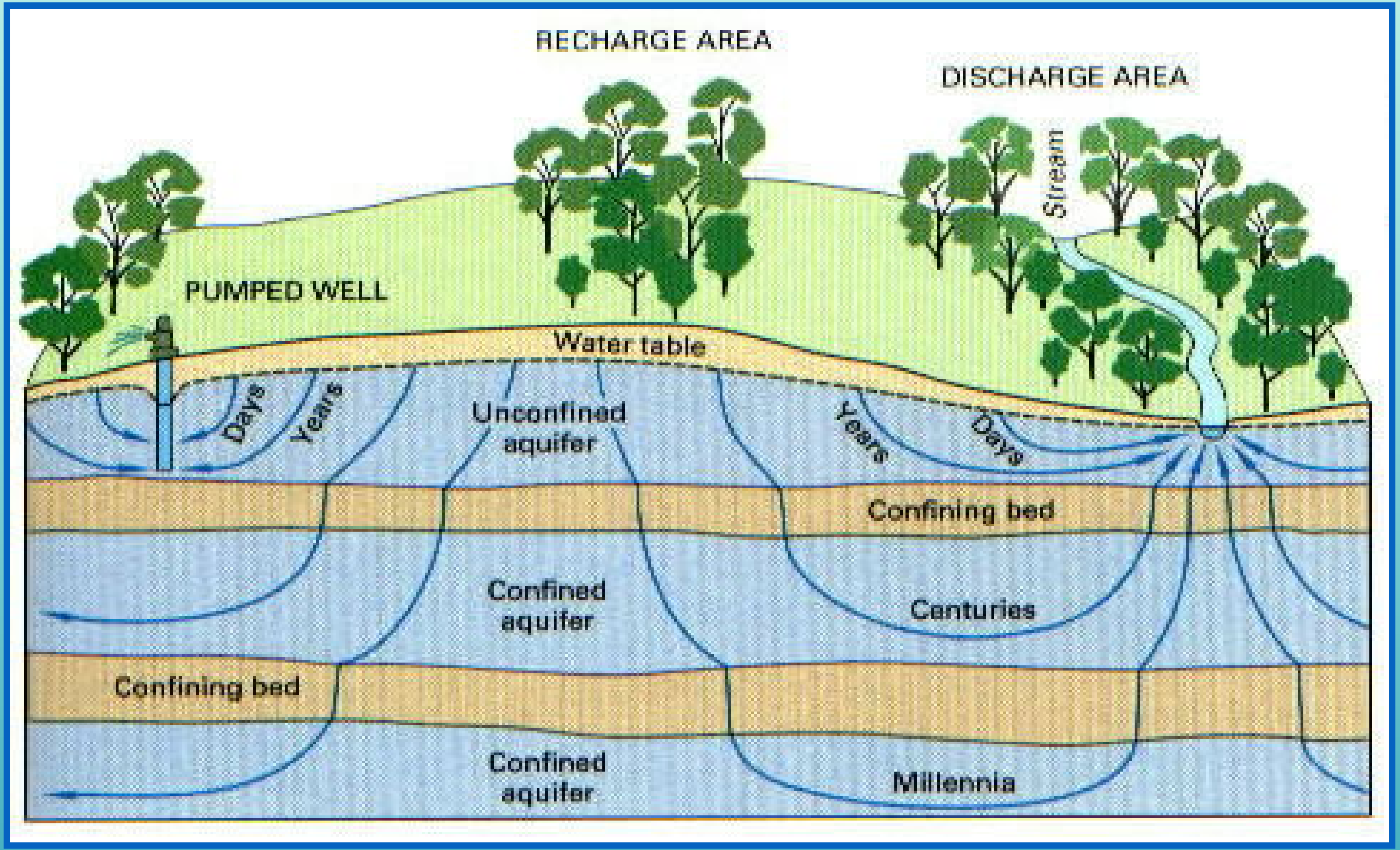
Discharge (D) = Recharge (R)



Groundwater Velocities are Generally Low

- Groundwater movement normally occurs as slow seepage through pore spaces in unconsolidated earth or networks of fractures and solution openings in consolidated rocks.
- A velocity of 1 foot per day or more is a high rate of movement, and velocities can be as low as 1 foot per year or decade.
- By contrast streamflow velocities generally are measured in feet per second. A velocity of 1 foot per second equals about 16 miles per day.

Groundwater travel time is not an indication of the speed at which pumping effects propagate



USGS C1139

WRIAs 22 & 23 Hydrogeology

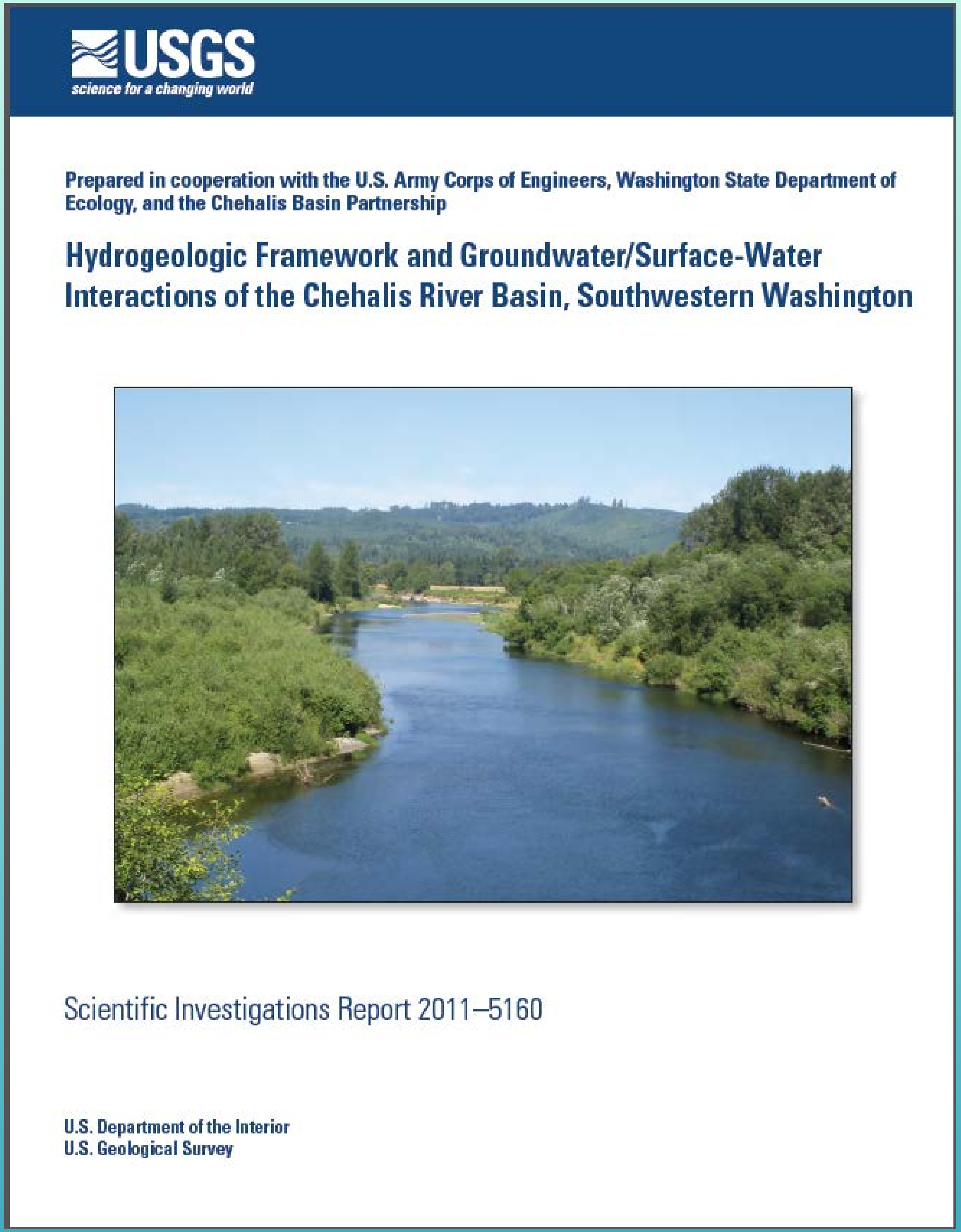
Some Significant WRIAs 22 & 23 Hydrogeology Studies

Gendaszek, 2011. Hydrogeologic Framework and Groundwater/Surface-Water Interactions of the Chehalis River Basin, Southwestern Washington; USGS SIR 2011–5160

Gendaszek and Welch, 2018. Water budget of the upper Chehalis River Basin, southwestern Washington; USGS SIR Report 2018-5084

USGS SIR 2011-5160

Report describes generalized hydrogeologic framework of Chehalis River basin, and characterizes interactions between groundwater-flow system and river and its major tributaries.



USGS
science for a changing world

Prepared in cooperation with the U.S. Army Corps of Engineers, Washington State Department of Ecology, and the Chehalis Basin Partnership

Hydrogeologic Framework and Groundwater/Surface-Water Interactions of the Chehalis River Basin, Southwestern Washington

Scientific Investigations Report 2011–5160

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

Geology consists of 5 hydrogeologic units that include aquifers within unconsolidated glacial and alluvial sediments separated by discontinuous confining units.

Table 1. Hydrogeologic units in the Chehalis River basin, southwestern Washington.

[Hydrogeologic units defined in this study are delineated in plate 1. Hydrogeologic units of previous studies are defined in cited references. **Abbreviations:** –, not differentiated]

Period	Epoch	Hydrogeologic units defined in this study	Range of thickness [estimated average thickness] (feet)	Number of wells open to unit	Hydrogeologic units of previous studies				
					Drost (1998)	Pitz and others (2005)	Weigle and Foxworthy (1962)	Eddy (1966)	Noble and Wallace (1966)
Quaternary	Holocene to Pleistocene	A	4–150 [20]	100	Qvr	Qa, Qgo(g), Qapo(h)	Qal, Qt, Qo, Qnt, Qlc	Qal, Qb, Qtv, Qto	Qal, Qvr, Qvr1
	Pleistocene	B	5–52 [21]	0	Qvt, Qvrm	–	–	–	Qvm, Qvt
		C	25–42 [36]	18	Qva	–	–	–	Qva
		D	16–203 [91]	41	–	Qapo(lh), Qal	Qlh	QTu	Qlh
		E	18–15 [100]	42	Qf,Qc,TQu	Qago(g)	–	–	Qss1, Qss2, Qk, Qpu
Tertiary	Eocene to Pliocene	BDRK	Not applicable	149	Tb	Mc(w), Tb(bslt), Tbu, Qal	Tu, Tcr	Tu	Ts, Tv

USGS SIR 2011–5160

Map showing water-table altitudes and inferred direction of groundwater flow in surficial aquifers, August–September 2009

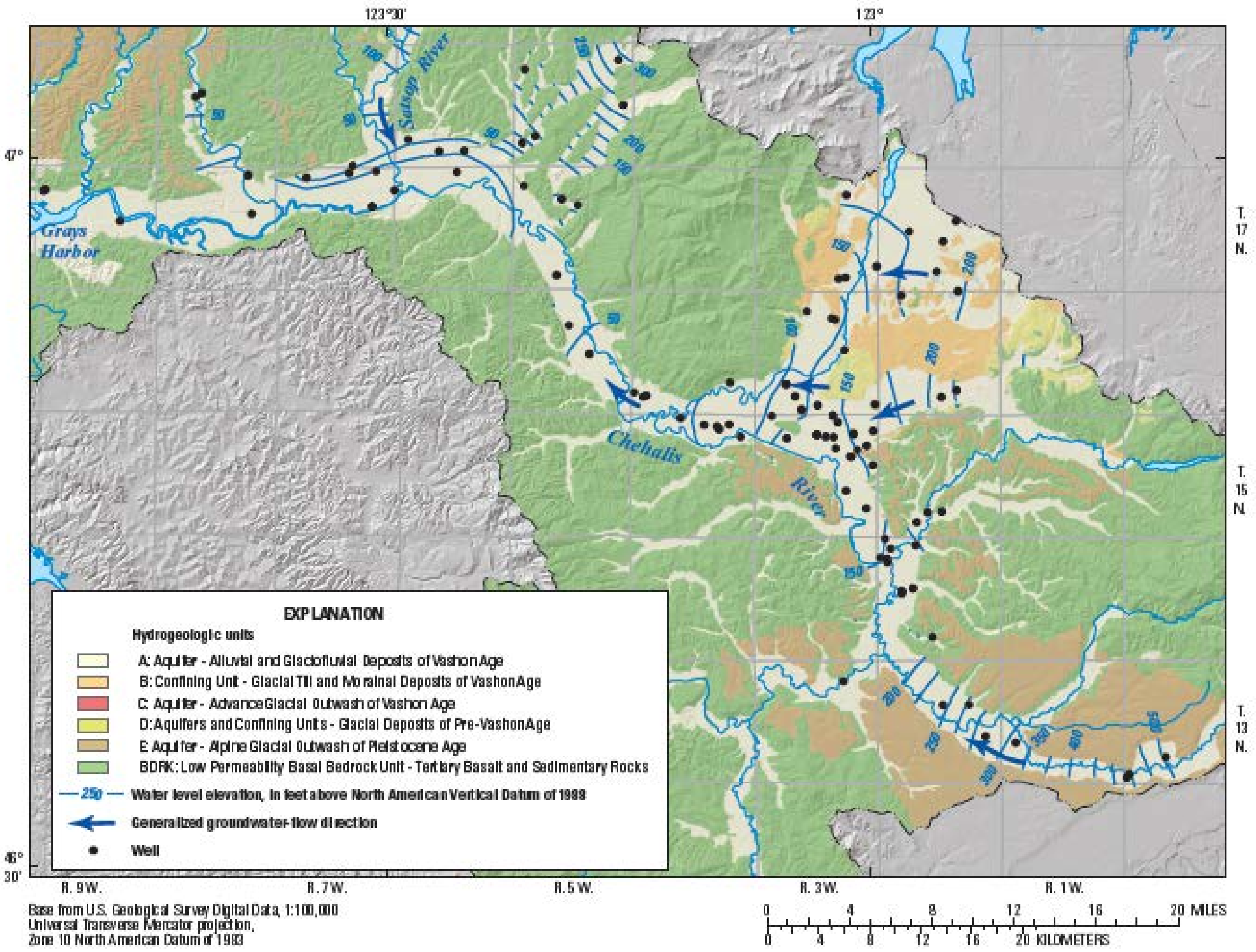


Figure 6. Water-table altitudes and inferred direction of groundwater flow in the surficial aquifers, Chehalis River basin, southwestern Washington, August–September 2009.

USGS SIR 2011–5160

Chehalis River Seepage Investigation

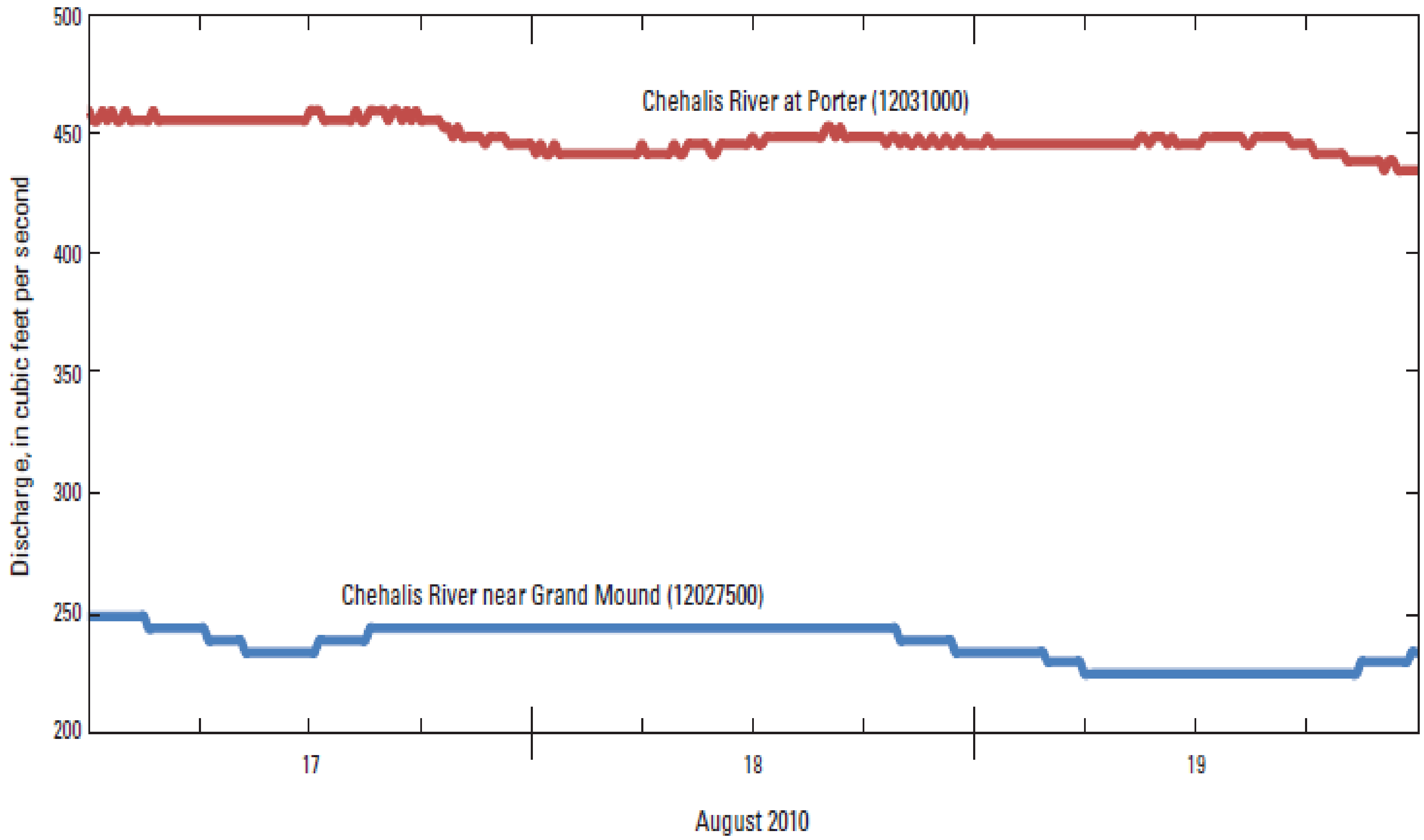


Figure 4. Discharge for two U.S. Geological Survey streamflow-gaging stations, Chehalis River basin, southwestern Washington, August 17–19, 2010.

USGS SIR 2011–5160

Gaining/Loosing Reaches in Chehalis River During Low Flow Conditions

Streamflow gains and losses were calculated for 18 reaches of the mainstem Chehalis River after an August 2010 seepage run. One reach was gaining flow, two were loosing, and the remainder were near neutral.

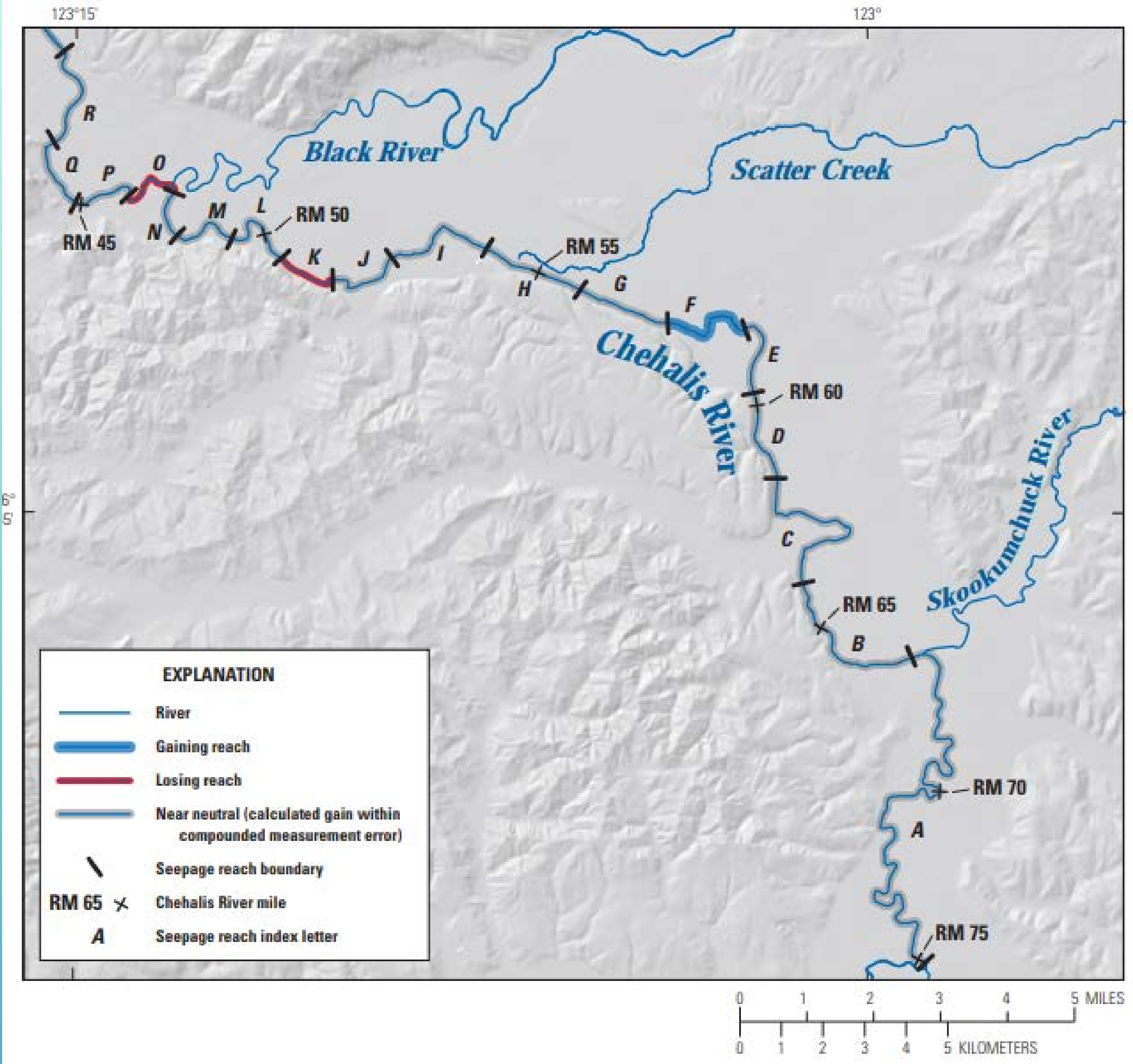


Figure 8. Streamflow gaining, losing, and near-neutral reaches, central Chehalis River Basin, southwestern Washington, August 2010.

USGS SIR 2011–5160

Chapter 173-522 WAC

Chapter 173-522 WAC

Last Update: 6/9/88

WATER RESOURCES PROGRAM IN THE CHEHALIS RIVER BASIN, WRIA-22 AND 23

WAC Sections

173-522-010
General provision.

These rules, including any subsequent additions and amendments, apply to waters within and contributing to the Chehalis River basin, WRIA-22 and 23 (see WAC 173-500-040). Chapter 173-500 WAC, the general rules of the department of ecology for the implementation of the comprehensive water resources program, applies to this chapter 173-522 WAC.

[Order 75-31, § 173-522-010, filed 3/10/76.]

173-522-020
Establishment of base flows.

(1) Base flows are established for stream management units with monitoring to take place at certain control stations as follows:

STREAM MANAGEMENT UNIT INFORMATION

Control Station No. Stream Management Unit Name	Control Station by River Mile and Section, Township and Range	Affected Stream Reach Including Tributaries
12.0200.00 Chehalis River Conf. w/Elk Creek	101.8 14-13-5W	From confluence with Elk Creek to headwaters except Elk Cr.
12.0205.00 Elk Creek	2.5 18-13-5W	From confluence with Chehalis River to headwaters.

Conditions Vary From Year to Year

August 2010 no significant gains or losses between RM 47 to 56, however, July 2007 the Chehalis River lost significantly between RM 44 and 47, then held steady from RM 47 to 53, then gained significantly between RM 53 and 54.

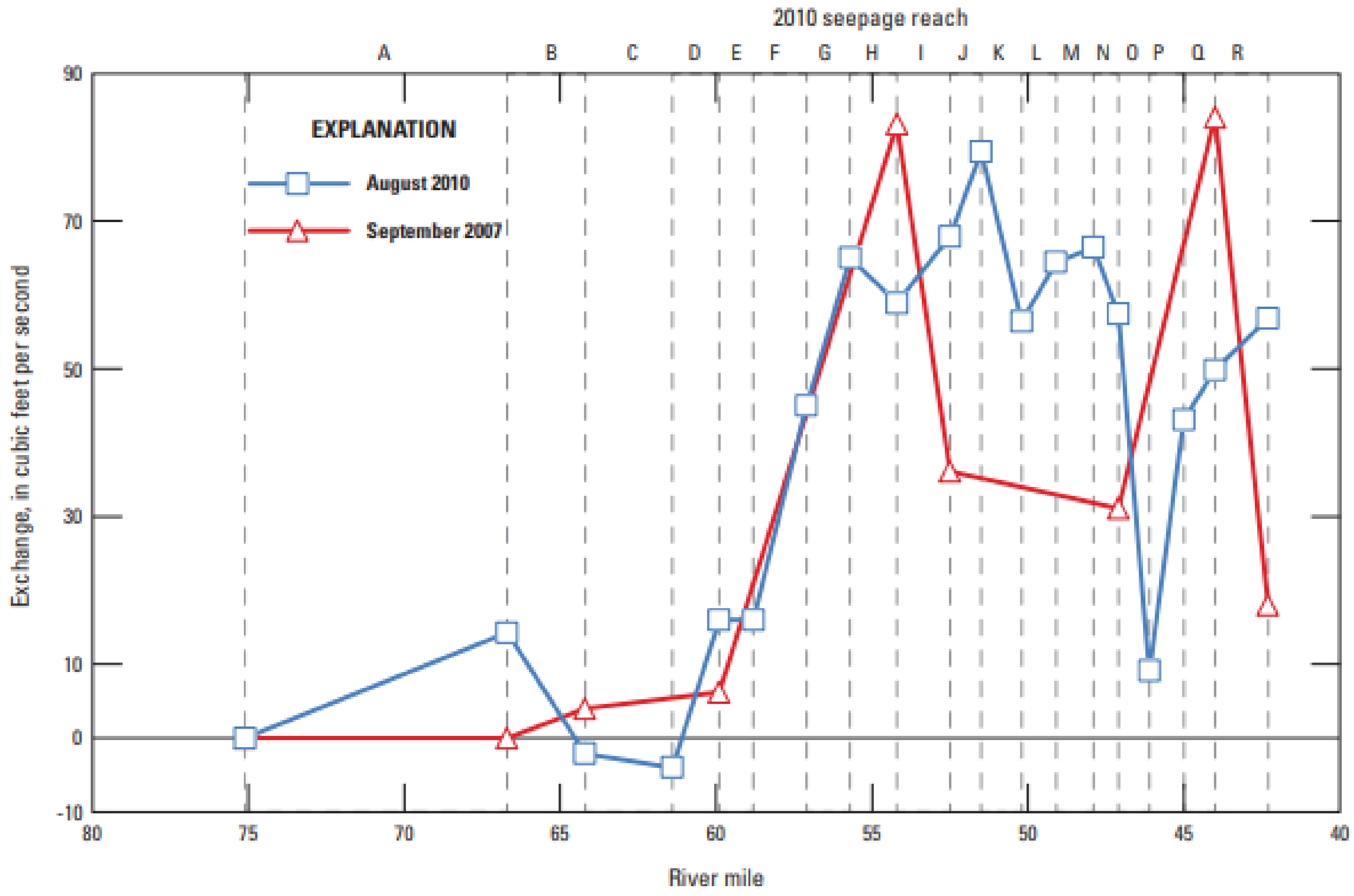


Figure 9. Cumulative river-aquifer exchanges for the central Chehalis River, southwestern Washington, August 2010 and September 2007.

USGS SIR 2011–5160

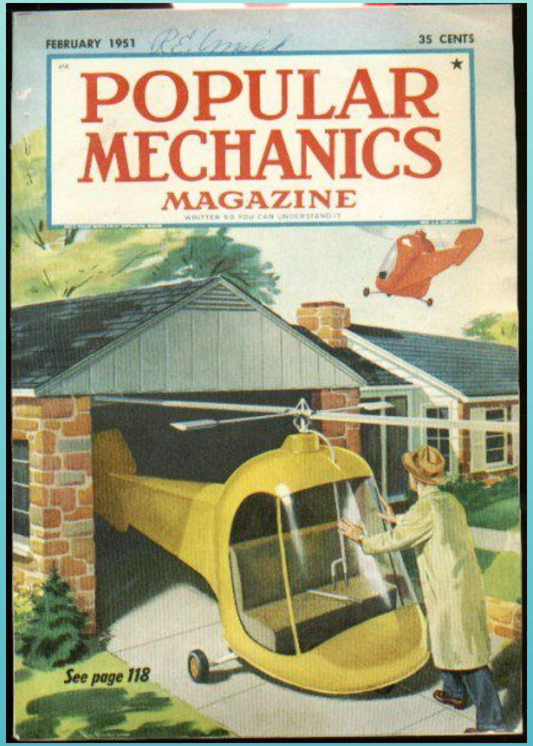
Chehalis River Basin Water Budget
USGS SIR 2018-5084 (Gendaszek and Welch, 2018)

- Water budget (including precipitation, interception, groundwater recharge, surface runoff, and groundwater pumping) developed for upper Chehalis River Basin, October 2001–September 2015.
- Water-budget components estimated from USGS Soil-Water-Balance (SWB) model except for groundwater pumping.
- Mean annual precipitation estimated at 72.6 inches, of which 35% lost to ET, 30% recharged to groundwater, 30% surface runoff, and 5% lost to interception.
- **Groundwater pumpage in basin estimated at 1% of groundwater recharge, and 0.8% of base flow estimated by hydrograph separation.**

RCW 90.94 Considerations

RCW 90.94 Planning Groups must describe Future Permit-Exempt Well Consumptive Use over Next 20 Years

- Ecology recommends relying on more than one method for estimating numbers of future wells including: population projections, historic building permit data, and/or historic well log drilling rates.
- To account for portion of water not consumptively used, water use estimates can be adjusted to account for water that will not return to hydrologic system.



From Ecology ESSB 6091 Streamflow Restoration Water Use Estimate Recommendations

Household Consumptive Indoor Water Use (HCIWU):

60 gpd X 2.5 people per house X 365 days X 0.00000307 AF/gal. X 10%[1] cons. use = 0.017 AF/YR

Household Consumptive Outdoor Water Use (HCOWU):

	May	June	July	August	Sept.	Total
Irrig. requirements (in.)[2]	0.63	2.72	4.11	2.75	0.90	11.11

Assuming outdoor watering area of 0.4 acre:

Irrigation Requirements (in.) = 11.11 inches/12 inches per feet X 0.4 acres = 0.37 AF/YR

Factoring in assumed application efficiency of 75 percent,

0.37 acre-feet ÷ 75% application efficiency = 0.49 acre-feet

Factoring assumed outdoor water use consumption of 80%:

0.49 acre-feet x 80% consumed (20% return flow) = 0.39 acre-feet

Basin-wide Household Consumptive Water Use (BHCWU):

Consumptive water use by future permit-exempt domestic wells for WRIA or subbasin:

BHCWU = number of houses served by permit-exempt domestic wells X (HCIWU + HCOWU)

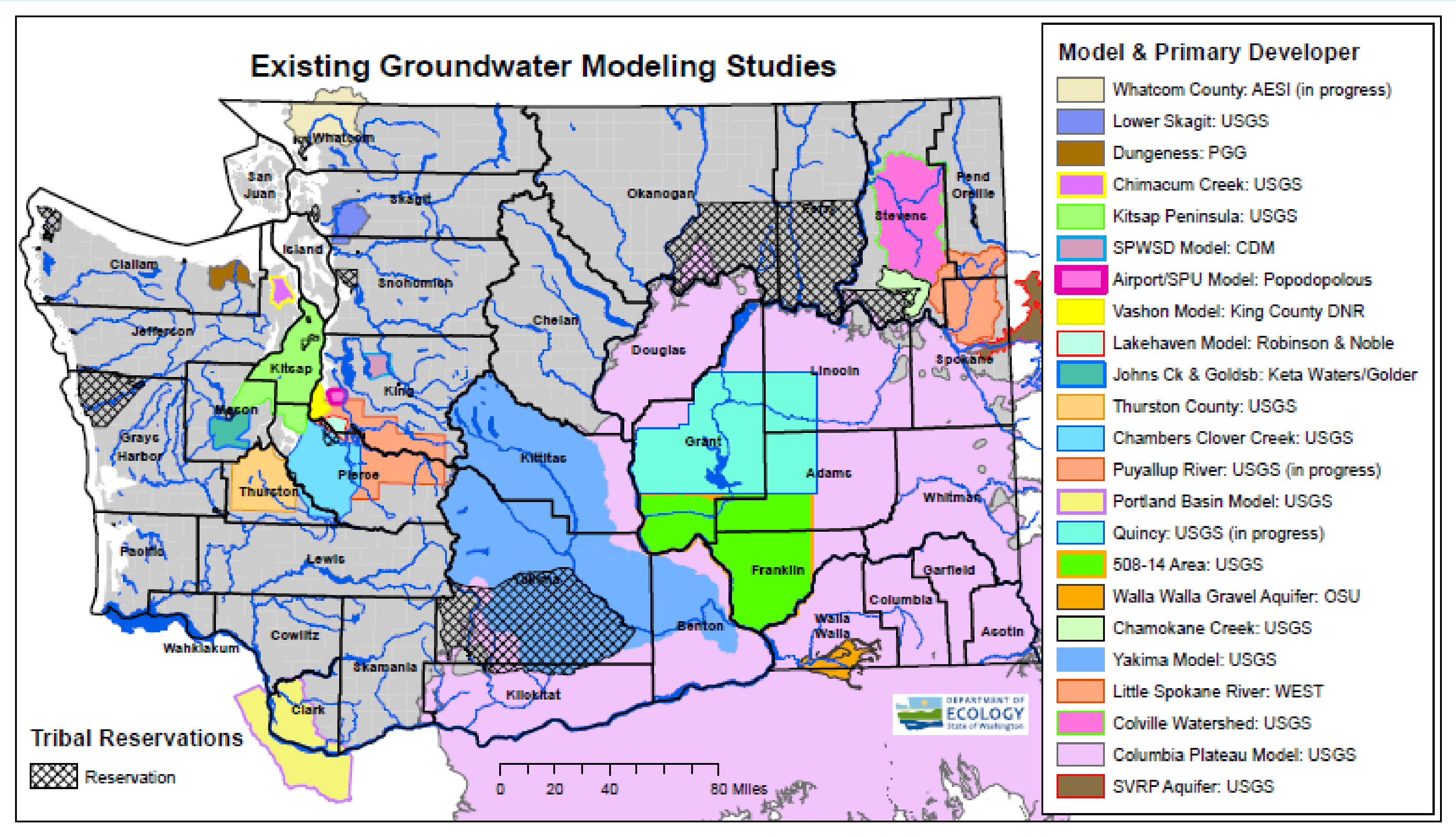
1. Assuming all houses discharge wastewater via septic systems
2. From Appendix A of the Washington Irrigation Guide (WAIG) (U.S. Department of Agriculture, 1997)

When & Where Consumptive Use Impacts Will Occur

- RCW 90.94 requires high priority offset projects to replace 20-year water use in-time and in same subbasin.
- Estimating timing of groundwater impacts on streams with precision is complicated due to lags between when a well is pumped and when those impacts propagate to a stream.

Need to Simplify

Due to hydrogeologic variability, uncertainty regarding new well locations, limited money, and limited time, planning groups will not be able to model pumping effects in detail.

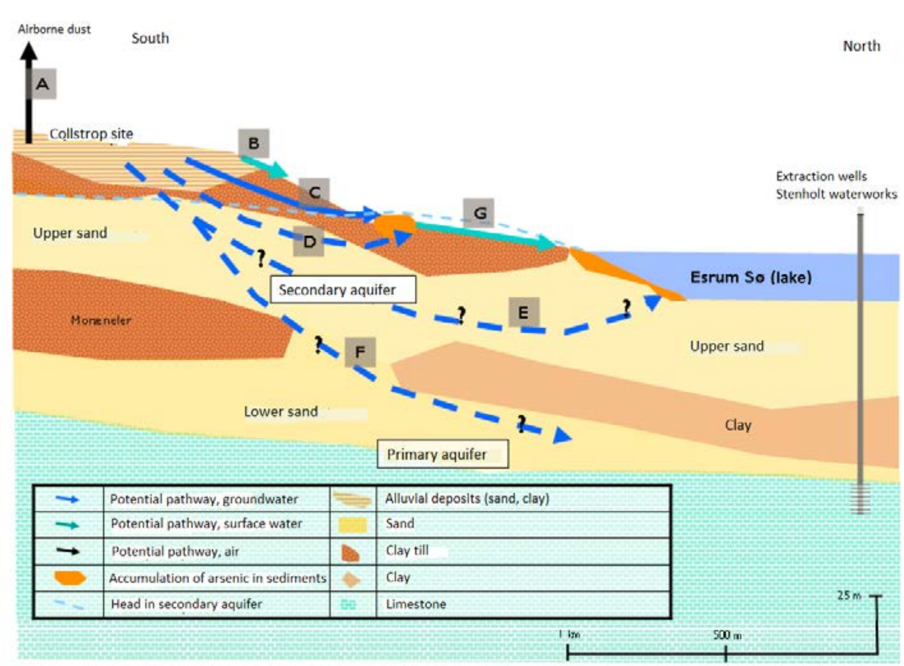


Conceptual Groundwater Understanding

Conceptual groundwater models provide overall hydrogeologic understanding.

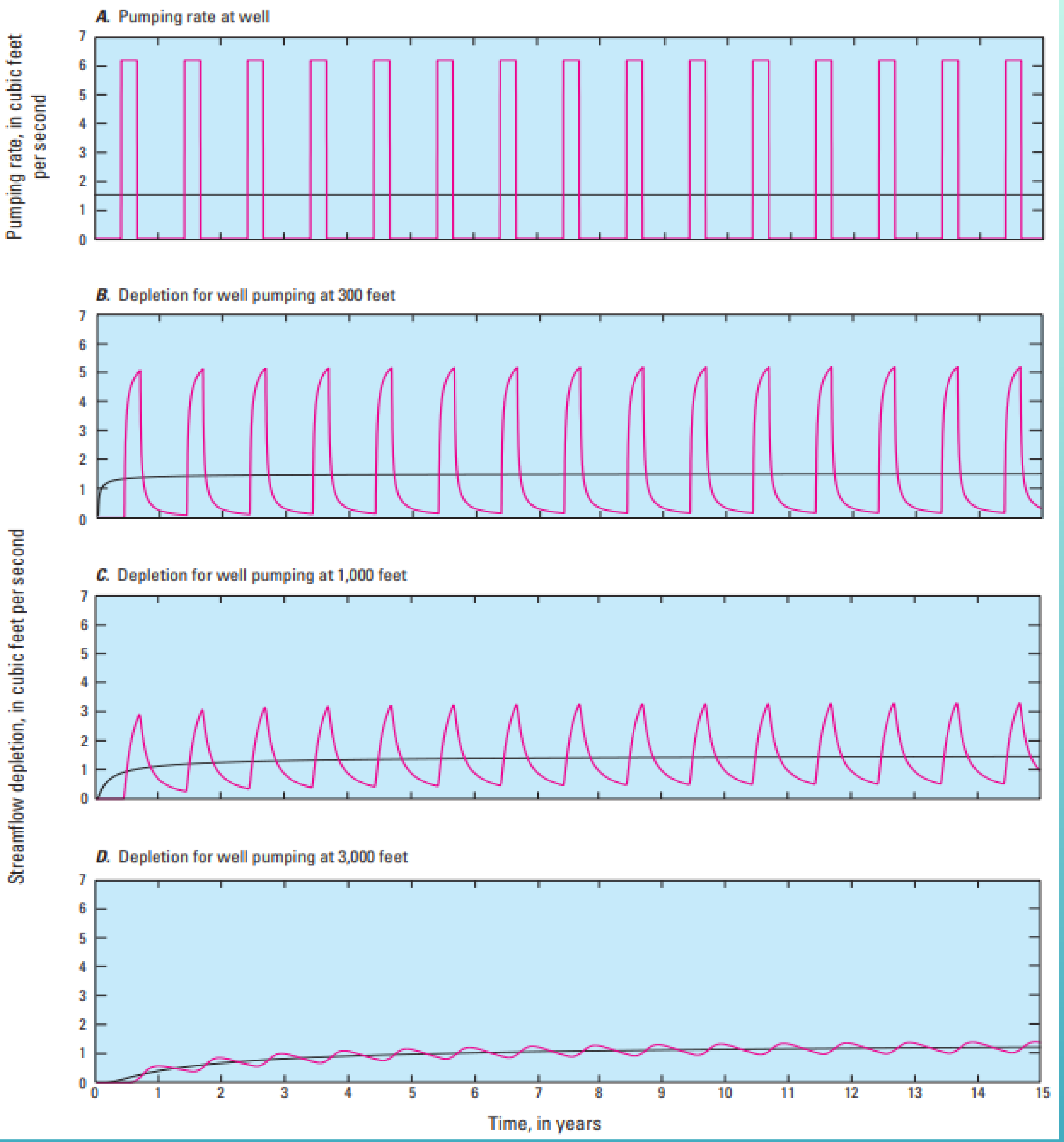
In water resources terms this generally considers:

- spatial delineations of recharge and discharge areas
- identification of pathways from unsaturated zones through saturated zones to groundwater receptors
- analyses and estimates of time scales of flow and effects of groundwater pumping



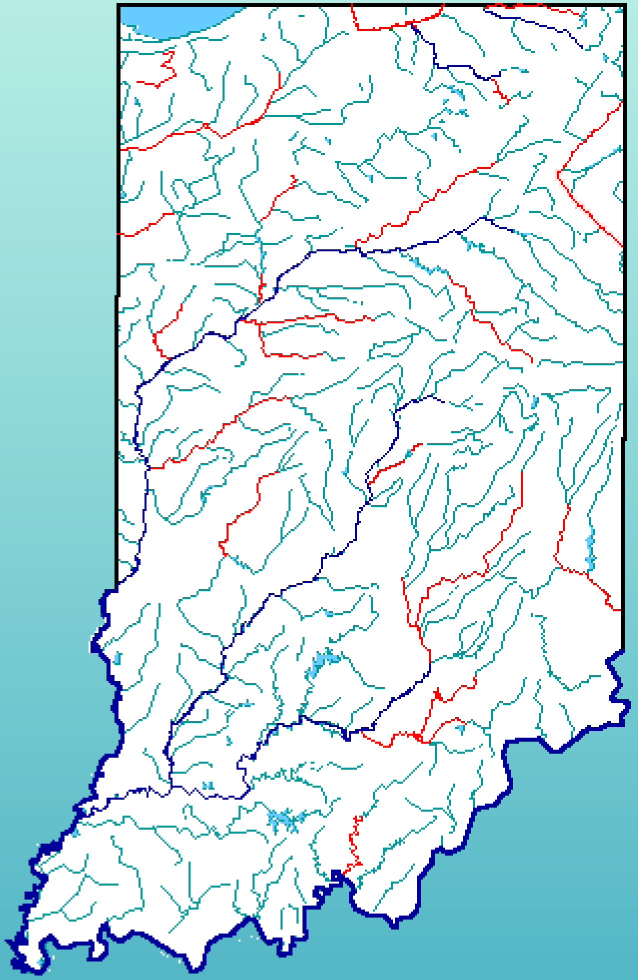
Seasonal vs. Steady State

- Magnitudes of aquifer pumping pulses decay over distance and time as effects spread out.
- In this example water-level changes range from a distinct pump-on – pump-off pattern, to a relatively constant impact.
- In most instances in western Washington it is reasonable to assume streamflow depletion will essentially be steady state - especially beyond distance of few thousand feet.



USGS Circular 1376

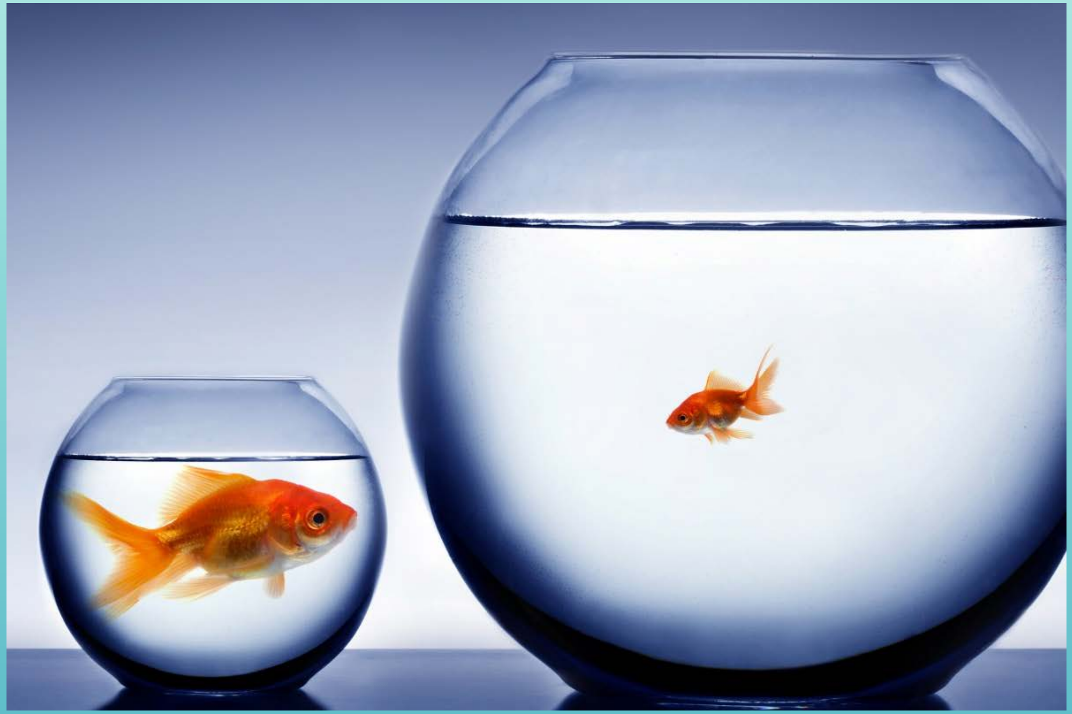
Spatial Considerations



- Even when planning groups assume steady state conditions, they will need to consider how steady state pumping effects are distributed spatially.
- Conceptually, one option is to assume all pumping effects will remain within a subbasin and be distributed evenly to all surface water bodies.
- In those instances where most future wells are likely to be shallow and congregated near a stream particularly important to fish, another option would be to conservatively assume depletion impacts are entirely attributed to streams closest to pumping well.

Significance of Scale

When evaluating the hydrologic impacts of new permit-exempt domestic wells or water offset projects on surface water an important consideration is what the magnitude of impacts or benefits will be relative to size of the water bodies.



Context of RCW 90.94

- Structure of mitigation under RCW 90.94 is fundamentally different then mitigation for groundwater permits.
- Typically water right permits require offsetting impacts of groundwater pumping in-time and in place.
- RCW 90.94 allows mitigation for permit-exempt domestic wells to occur anywhere within a WRIA, provided watershed plans achieve a Net Ecological Benefit (NEB).
- Per RCW 90.94 when Ecology reviews plan addendums it will be looking for:
  (1) "actions that the planning unit determines to be necessary to offset potential consumptive impacts to instream flows associated with permit-exempt domestic water use."
  (2) actions that "will result in a net ecological benefit to instream resources within the water resource inventory area."
- This means placing offset projects in places most beneficial to fish is probably more important than understanding specific impacts from permit-exempt domestic well pumping.

Questions?

Tom Culhane
Washington Department of Ecology
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