Lessons that may or may not have been learned from the ~~17~~ 10 year USGS Groundwater Study of the Yakima basin

Tom Ring, Hydrogeologist
YN Water Res. Pgm
The Discovery Center, The Dalles, OR
March 15, 2011

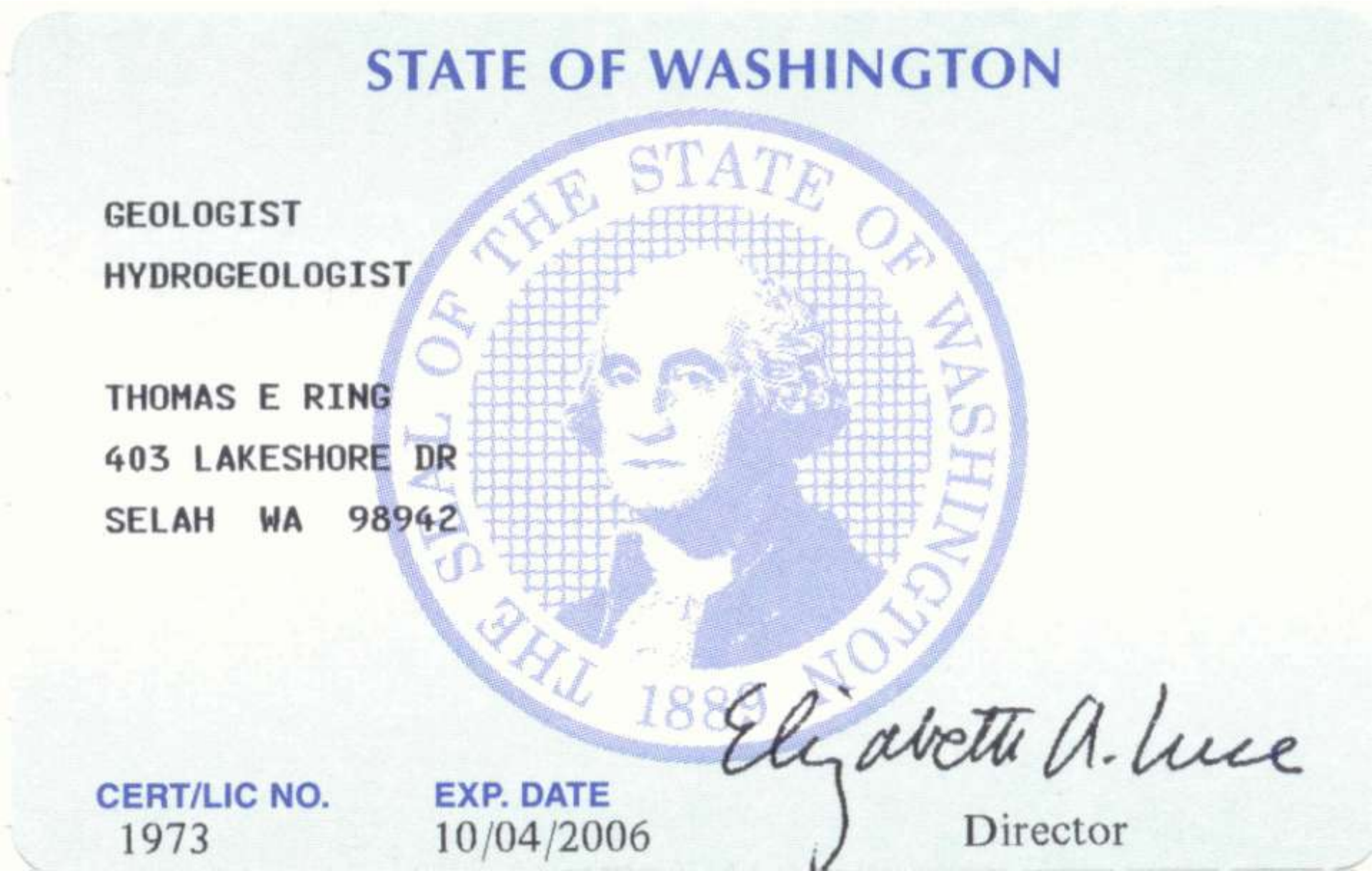
Standard Disclaimer Slide

Outline of talk

- Disclaimers - 20 minutes
- Talk - 4 minutes
- Questions - 1 minute

- The Obligatory Disclaimers
  - I am not the I am not the Yakama Nation
  - I work there, in the unsavory interface between the laws of nature and the laws of man
  - I do not speak for the Tribe, I am staff
  - No Treaty Rights were killed or injured in the making of this talk (or defined, diminished, impaired, abrogated……)

Papers Please



Hanging around the Yakima Basin since 1980

My Day Job

Discussing Water Rights, A Western Pastime

Mr. Ring goes to Yakima

- Attended meeting in May 1993 at Ecology CRO
- Ecology announced intention to issue hundreds of new groundwater permits for hundreds of cfs
- 17 years of my Iife later, this talk
- Lesson Learned: Don’t go to meetings on Tuesday nights at Ecology

Mr. Ring Reviews the Literature

REVIEW OF LITERATURE PERTINENT TO IMPACTS

OF FURTHER GROUNDWATER DEVELOPMENT

BLACK ROCK - MOXEE STUDY AREA, WASHINGTON

Prepared by Tom Ring, Hydrogeologist

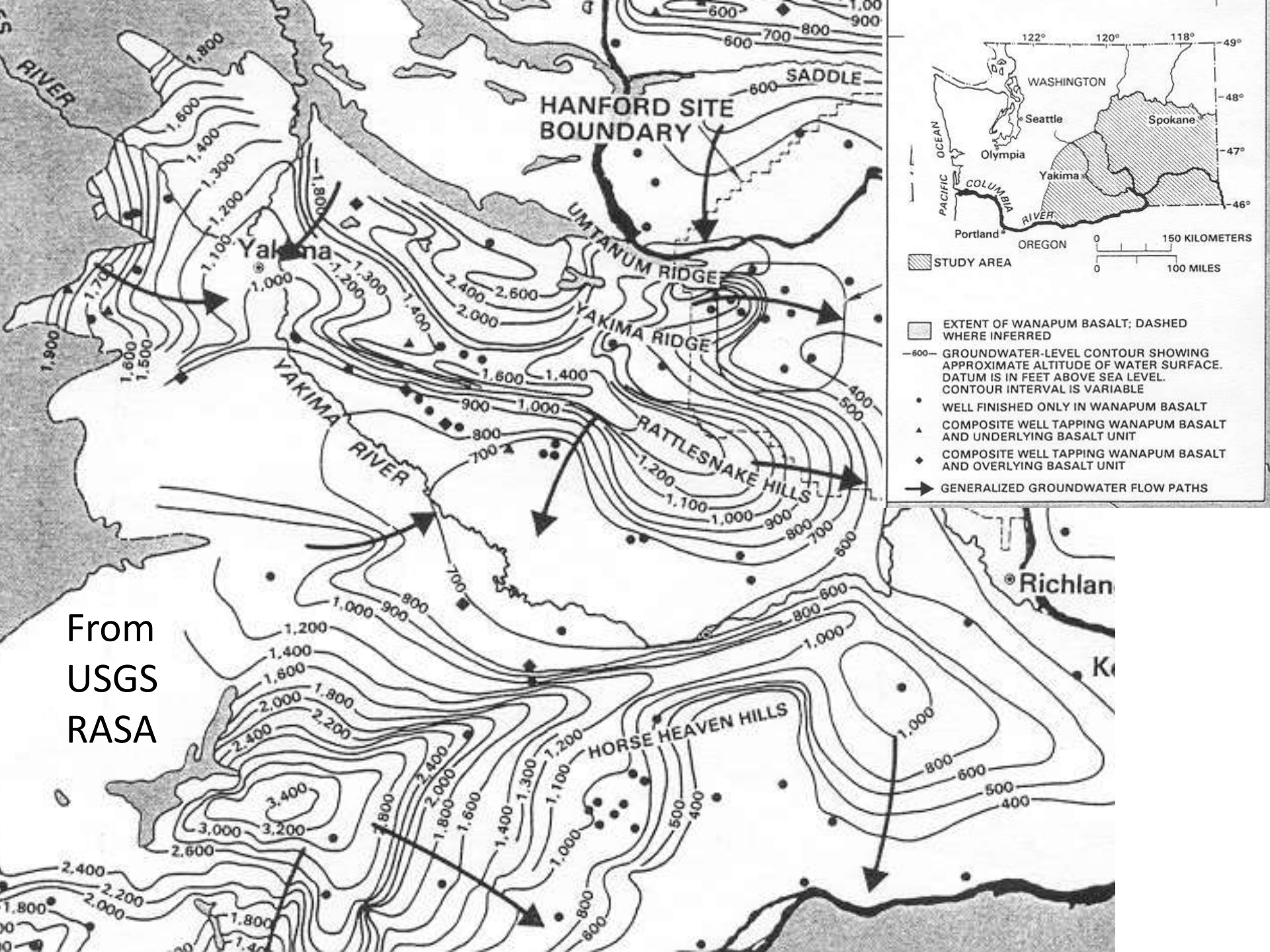
Yakima Indian Nation
Water Resources Planning Program

May 13, 1993

Revised June 2, 1993

and offers such remarkable insights as

- Inflow = outflow plus change in storage i.e. mass is conserved in the hydrologic cycle
- Groundwater flow down hydraulic gradient in accordance with Darcy's Law
- Groundwater in the basalts of the Moxee Valley is tributary to Yakima River
- Pumping will diminish flow, maybe soon



From USGS RASA

The Laws of Man
Washington Groundwater Law

- 1945 Groundwater Code
- Prior Appropriation
- Recognizes connection to surface water

  – The rights to appropriate the surface waters of the state and the rights acquired by the appropriation and use of surface waters shall not be affected or impaired by any of the provisions of this supplementary chapter and, **to the extent that any underground water is** part of or **tributary to** the source of **any surface stream** or lake, **or** that the **withdrawal of ground water may affect the flow of** any spring, water course, lake, or other body of **surface water**, the **right of** an appropriator and owner **of surface water shall be superior to any subsequent right** hereby authorized to be acquired in or to ground water (RCW 90.44.030, emphasis added)

The Laws of Nature
The Two Basic Laws

1. Groundwater flows under the force of gravity from high head (energy) to low head (Darcy's Law, most important thing to learn)
   - That allows us to know where it is coming from and going to (by measuring water levels)
2. Water is not being created or destroyed in the hydrologic cycle (the Continuity Equation)
   - Mass is conserved, we aren't making any more water, the water budget must add up to zero
   - Productive aquifers, producing wells – not!

Groundwater computer models are built from these two laws

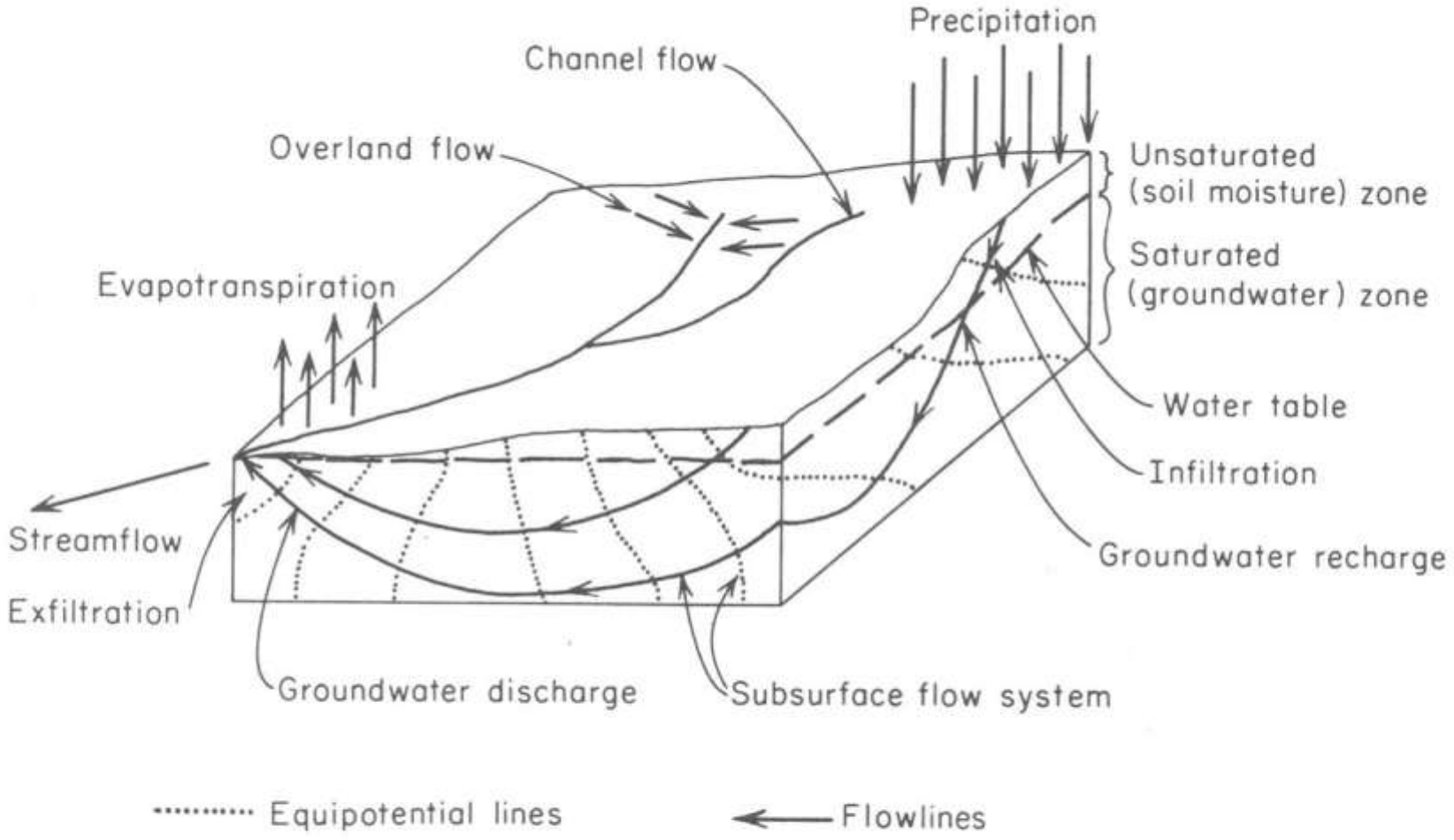


Figure 1.1 Schematic representation of the hydrologic cycle.
From Groundwater, Freeze and Cherry, 1979, Prentice Hall

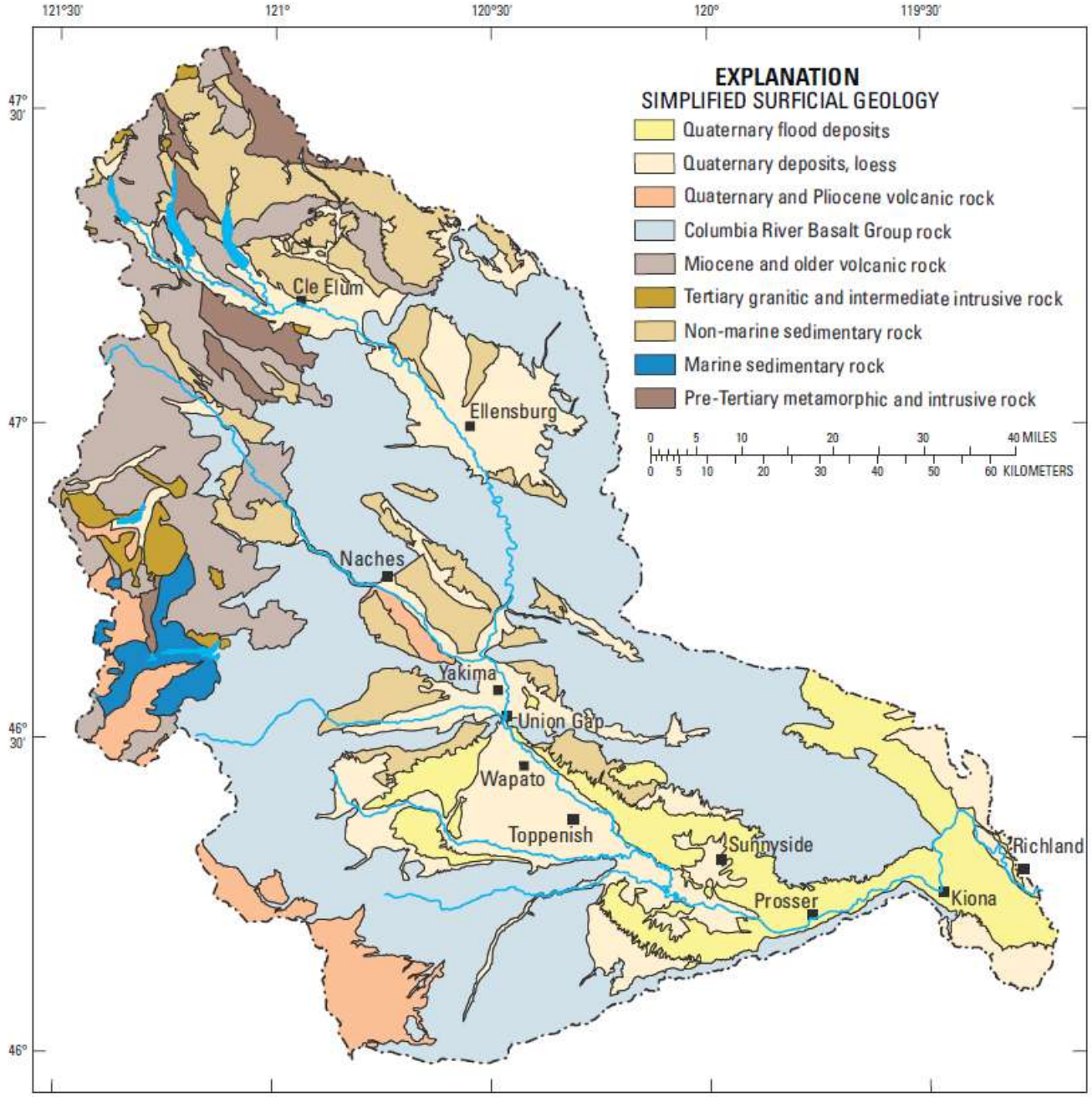
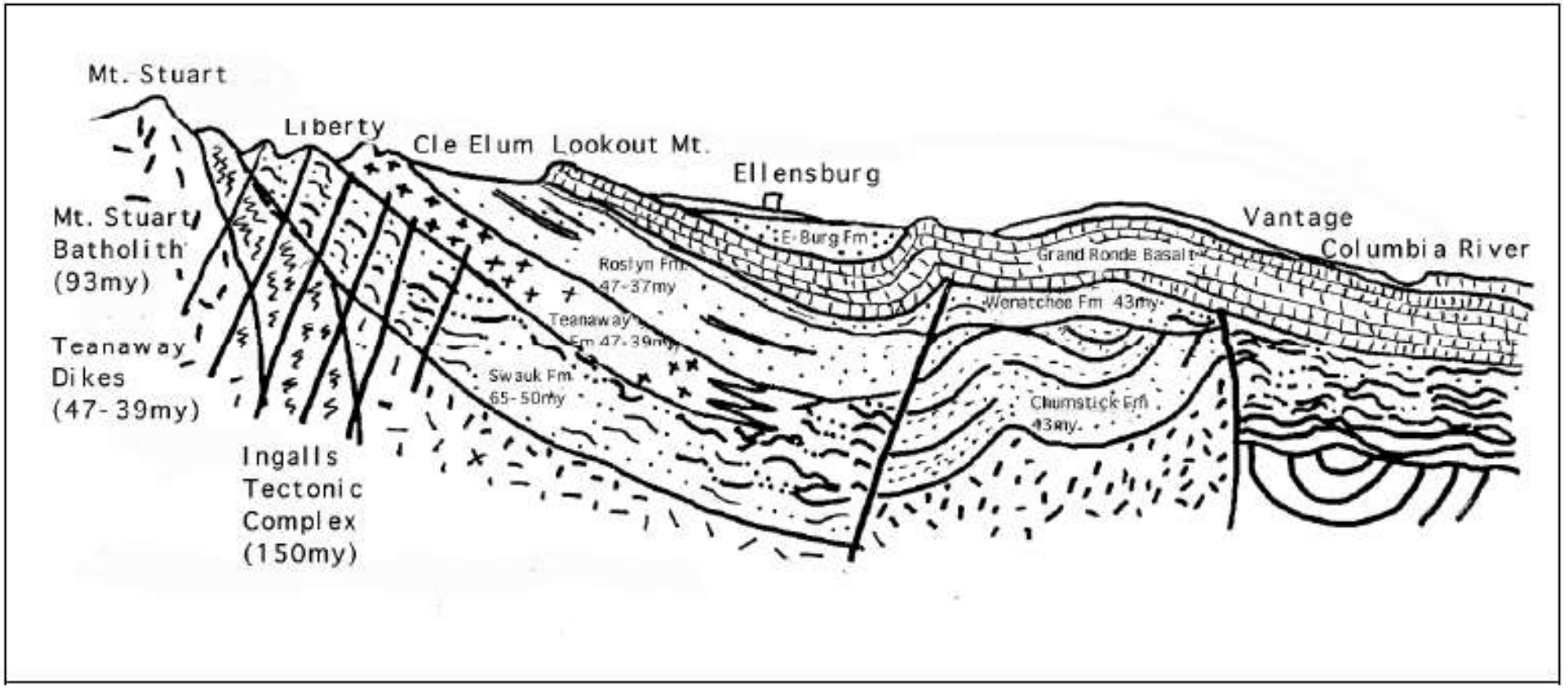


Figure 4. Simplified surficial geology of the Yakima River Basin, Washington. From Fuhrer and others, 1994.

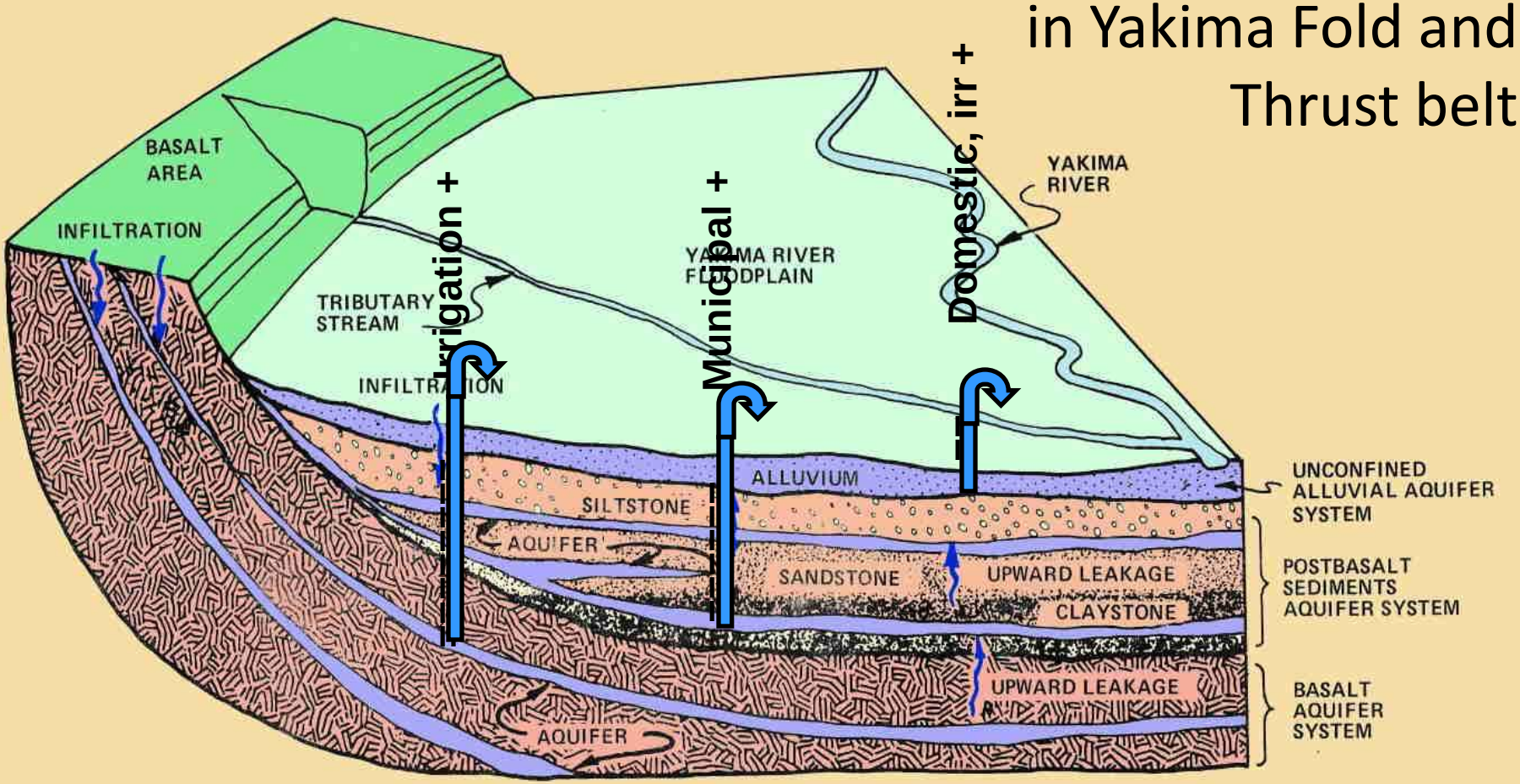
A Slice of Yakima



From: **Field Trip Guidebook to the Natural History of Kittitas County**
Jana Jones Mabry

http://sharepoint.snoqualmie.k12.wa.us/mshs/mabryj/Field%20trip%20Guide%20Book/mabry%20FieldTrip%20Guidebook.pdf

Synclinal Basin in Yakima Fold and Thrust belt



Not rivers, but leaky sheets of folded layer cake geology
In basalts, interflow zones most permeable
Alluvial aquifer water young like me, basalts old

Figure 3. The Three Principal Aquifer Systems in the Yakima River Basin

From U.S. Army Corps of Engineers, 1978,
Yakima Valley Regional Water Management Study

Basalt Flow System

From USGS Columbia Plateau RASA

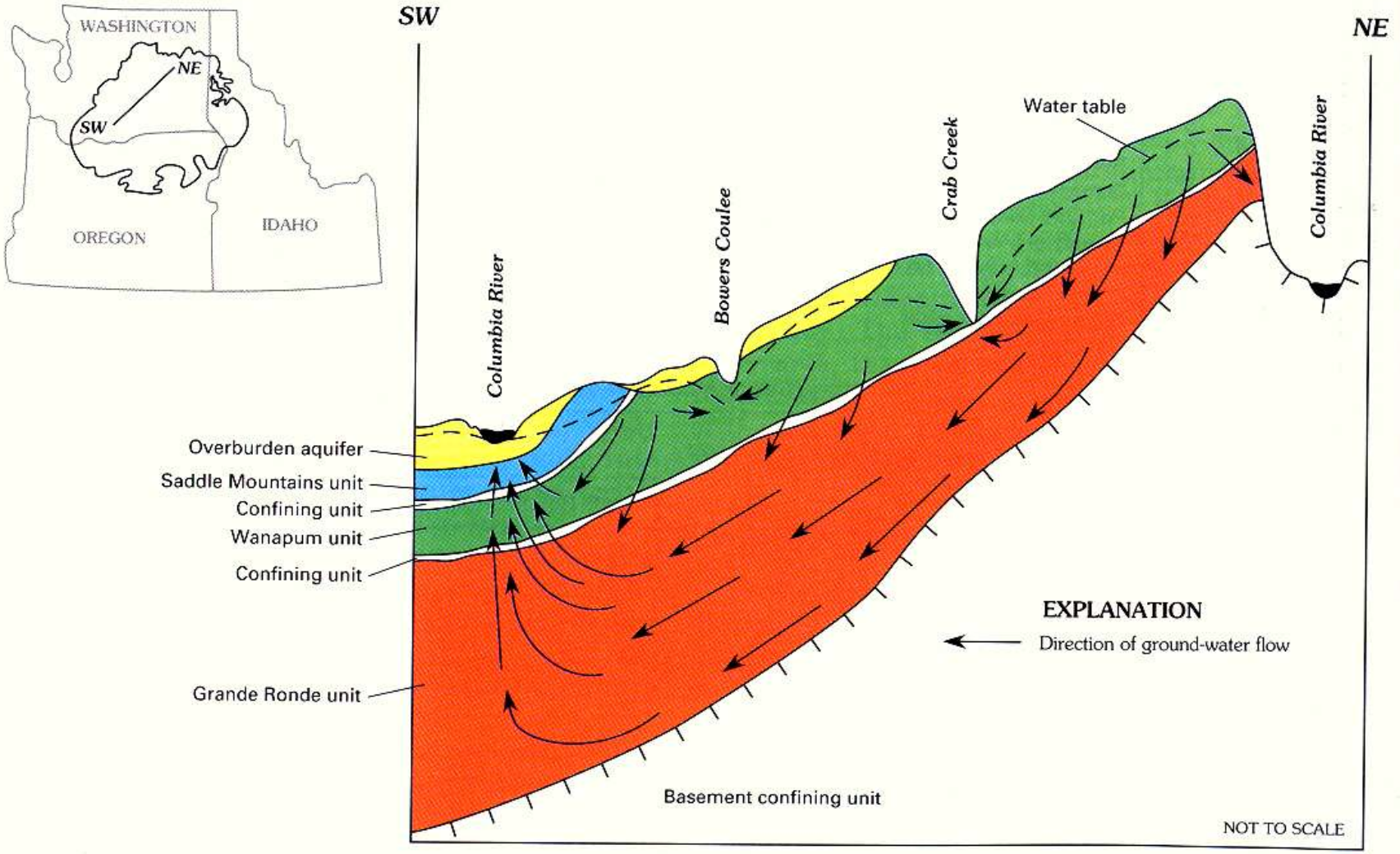
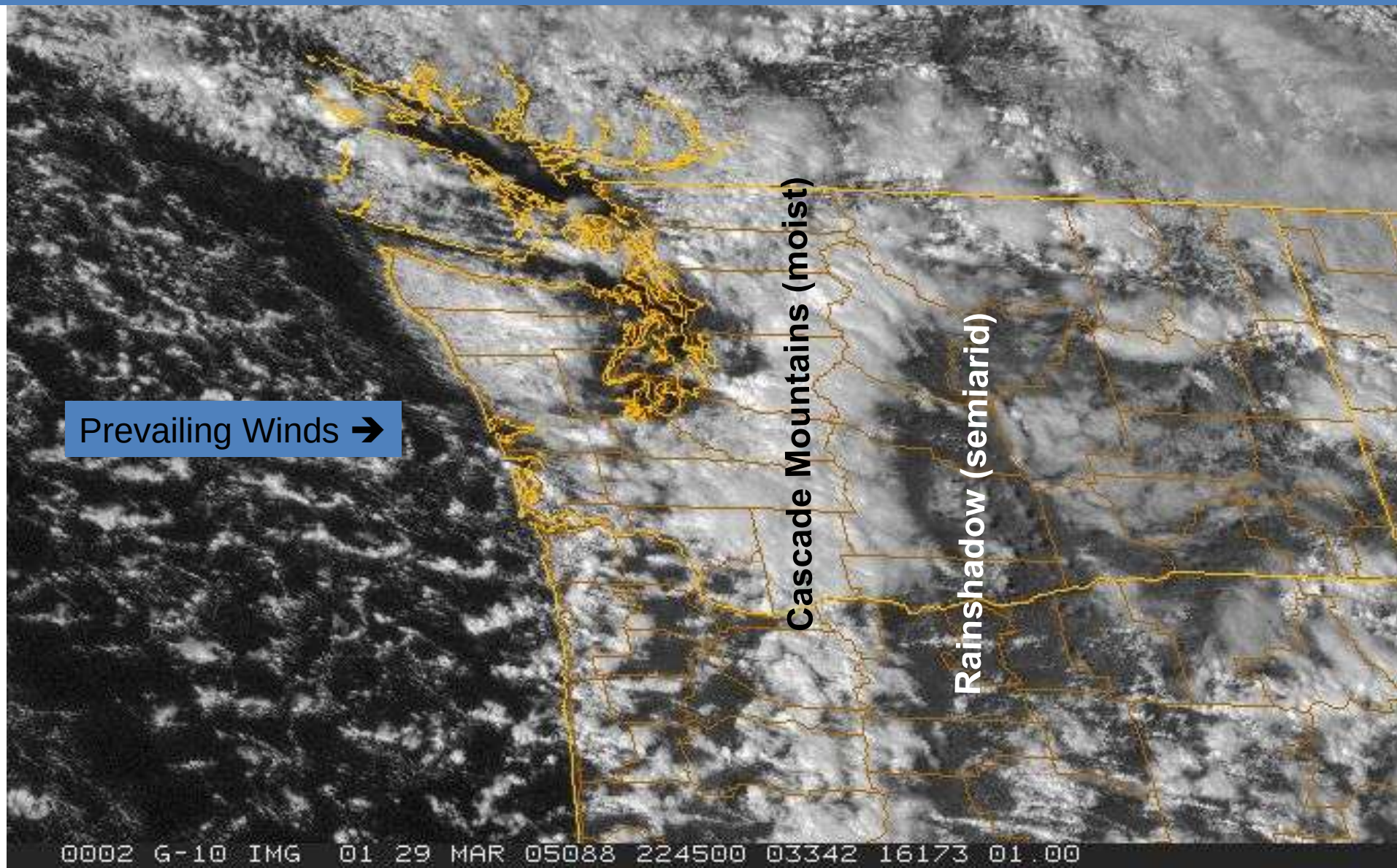


FIGURE 21.—Generalized ground-water-flow pattern in the Columbia Plateau aquifer system.

The Yakima Basin lies on the Dry side of the Cascade Mountains:
Snowmelt dominated streams drain the Cascades.
Cascades block flow of moisture from Pacific Ocean.
Streams flow east through semiarid lowlands and discharge to Columbia River.



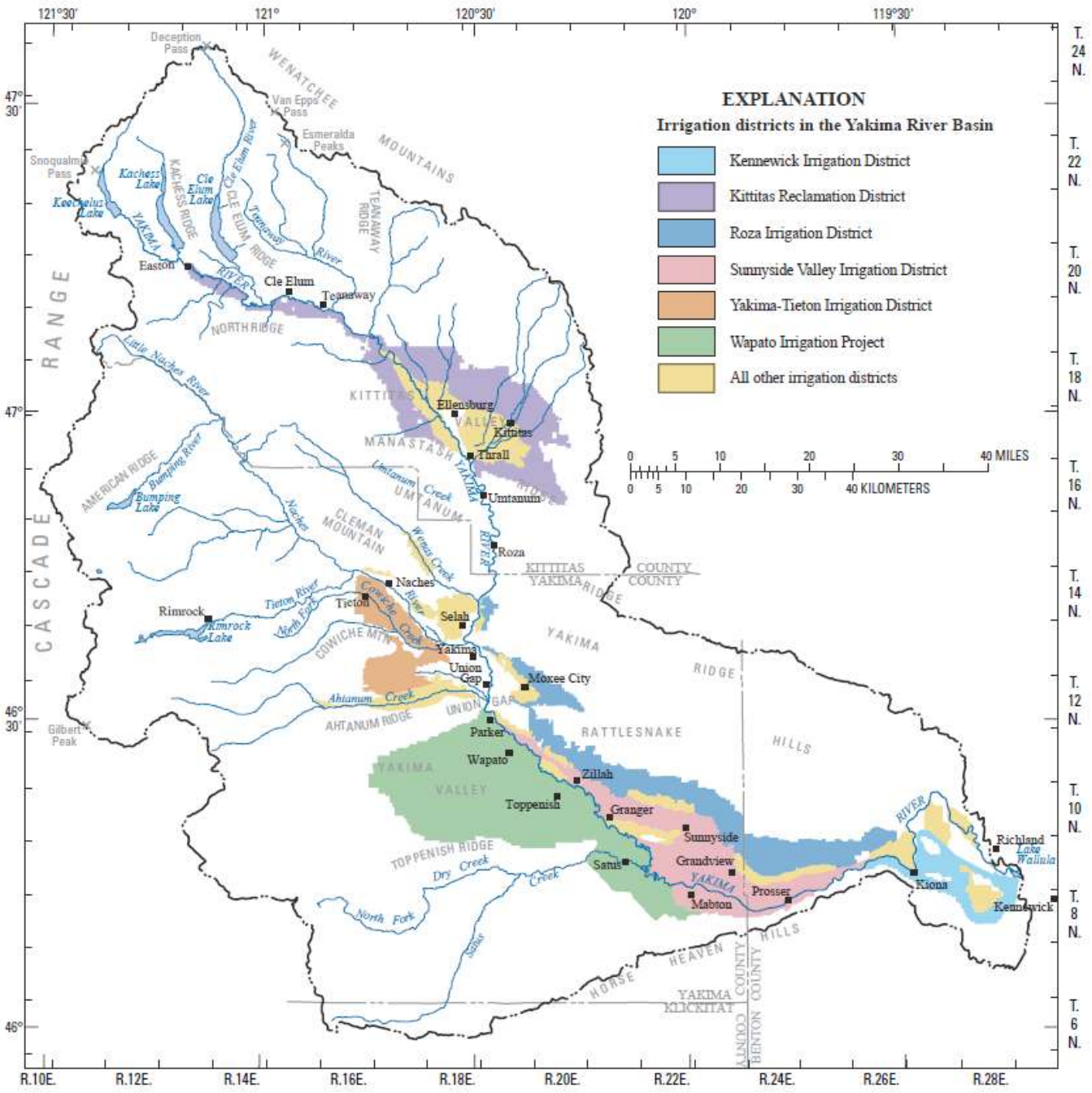
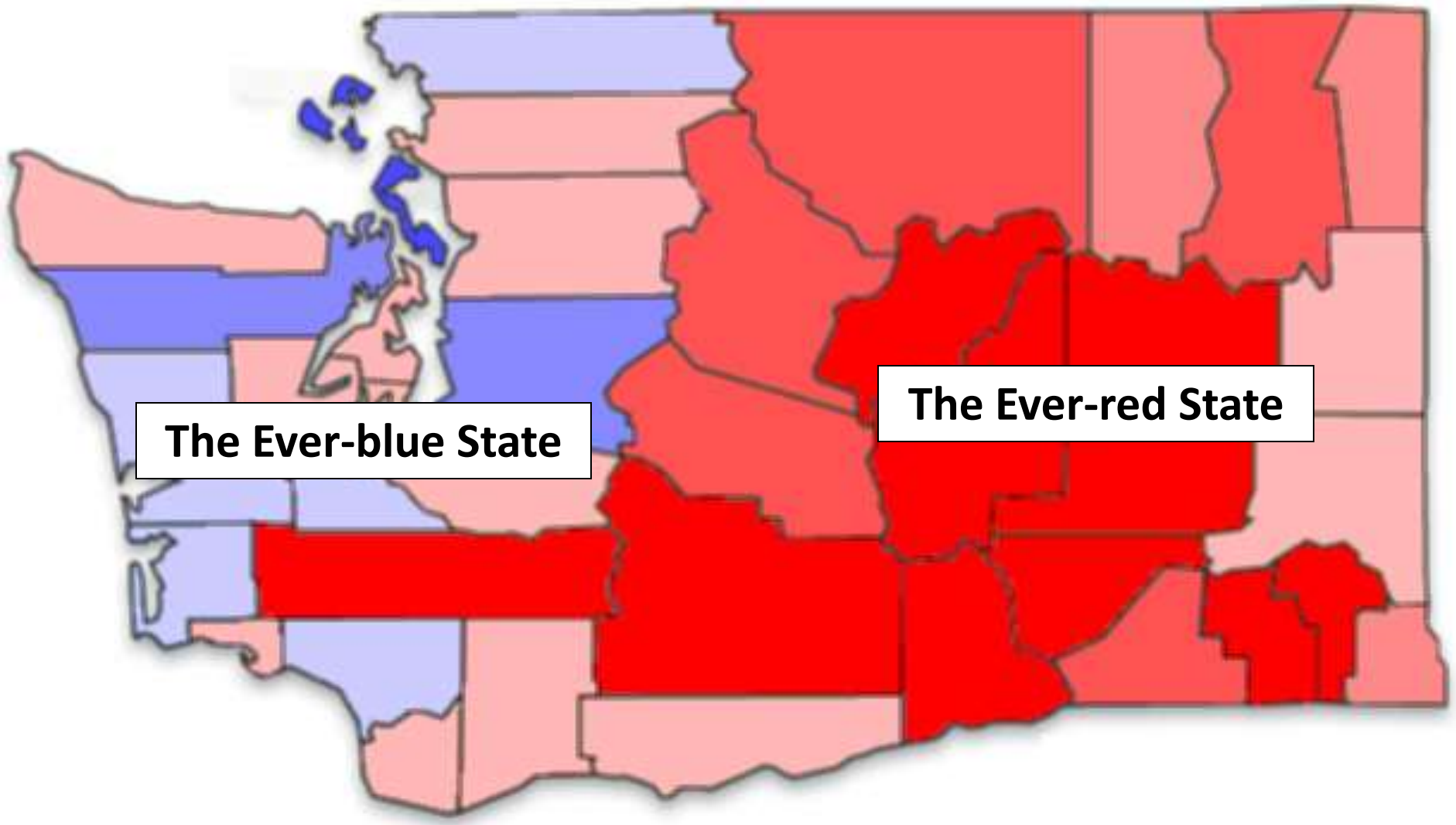


Figure 6. Surface-water irrigation districts, Yakima River Basin, Washington.

The Evergreen State




FEMINISTS
& TAXES
CONDENSATION
EVAPORATION
REPLENISH
"My name is America. And I am addicted to water."
- Stephen Colbert

So, who cares?
The effect on existing water users.

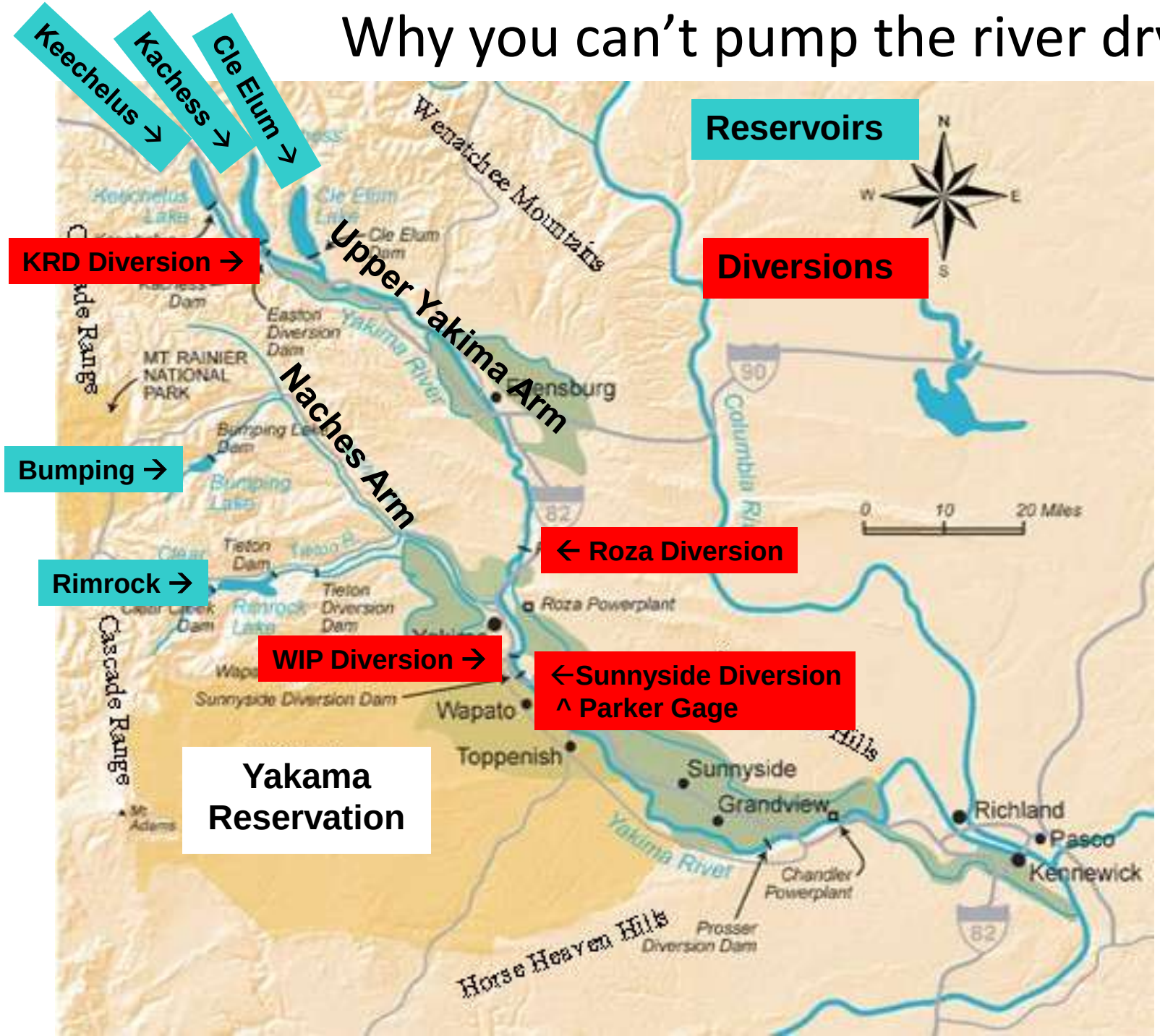
- The Yakima basin surface water rights are fully appropriated
- Every year during storage control all water released from reservoirs and flowing from other sources goes to meet an existing water right for
  - Irrigation
  - municipal supply
  - instream flow
- May 10th, 1905 rights are “prorated” during droughts

Can We Talk?

YN and Ecology staffs meet in Toppenish

- Shared the literature review
- Yeah, you're right, according to the "hypothetical hydrologic cycle"
- Maybe, but it would take hundreds or even thousands of years
- If your were right the Yakima River would be dry today.
  - Really, how much groundwater pumping is there?
  - I don't know, a lot

Why you can't pump the river dry



The Literature Review in 37tuplicate

Confederated Tribes and Bands
of the Yakima Indian Nation

Established by the
Treaty of June 9, 1855

June 4, 1993

Mr. Doug Clausing, Section Manager
Water Resources Program
Central Regional Office
Washington Department of Ecology
3601 W. Washington
Yakima, WA 98903-1164

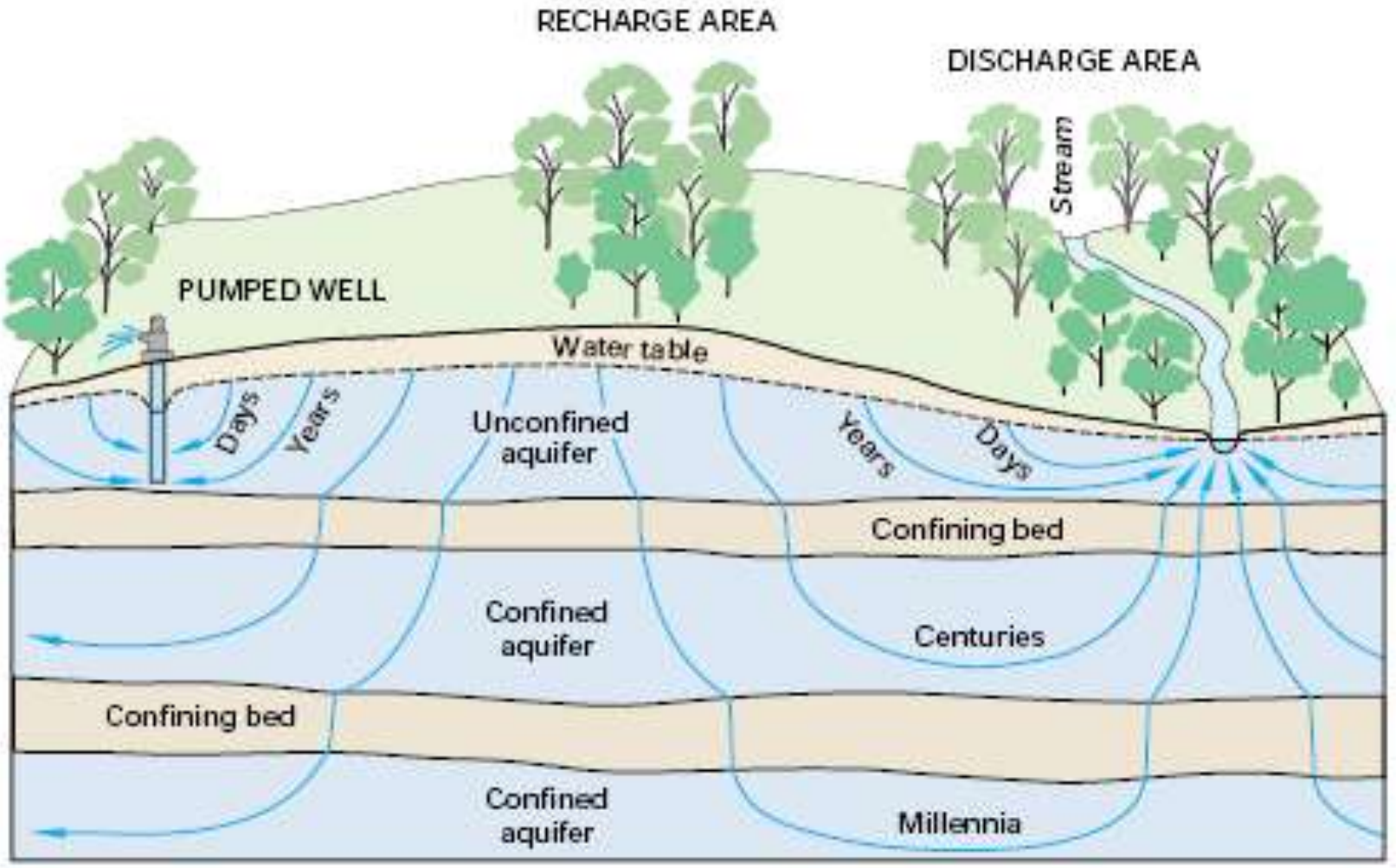
Regarding the following applications for permits for new groundwater development within the Black Rock - Moxee Study Area

G4-26446, G4-26563, G4-26562, G4-27812, G4-27851, G4-28341, G4-28555, G4-28653, G4-28665, G4-28670, G4-28674, G4-29138, G4-29179, G4-29307, G4-29359, G4-29472, G4-29482, G4-29573, G4-29653, G4-29657, G4-29667, G4-29893, G4-29919, G4-30246, G4-30418, G4-30752, G4-30770, G4-30767, G4-30864, G4-30942, G4-31348, G4-31350, G4-31351, G4-31364, G4-31407, G4-31681, G4-31684:

The 43 Decisions
Inferring the policy

- Direct vs. Indirect Hydraulic Continuity: a difference without a distinction
- Only permit deep wells except for some shallow ones
- No mining = no impact to surface water
- Supplemental ok, primary not ok, except where it is
- Hydrocooling and frost protection not in public interest
- Most recharge from irrigation water
- BR study dismisses capture concern
  - A well interference study, not a capture study

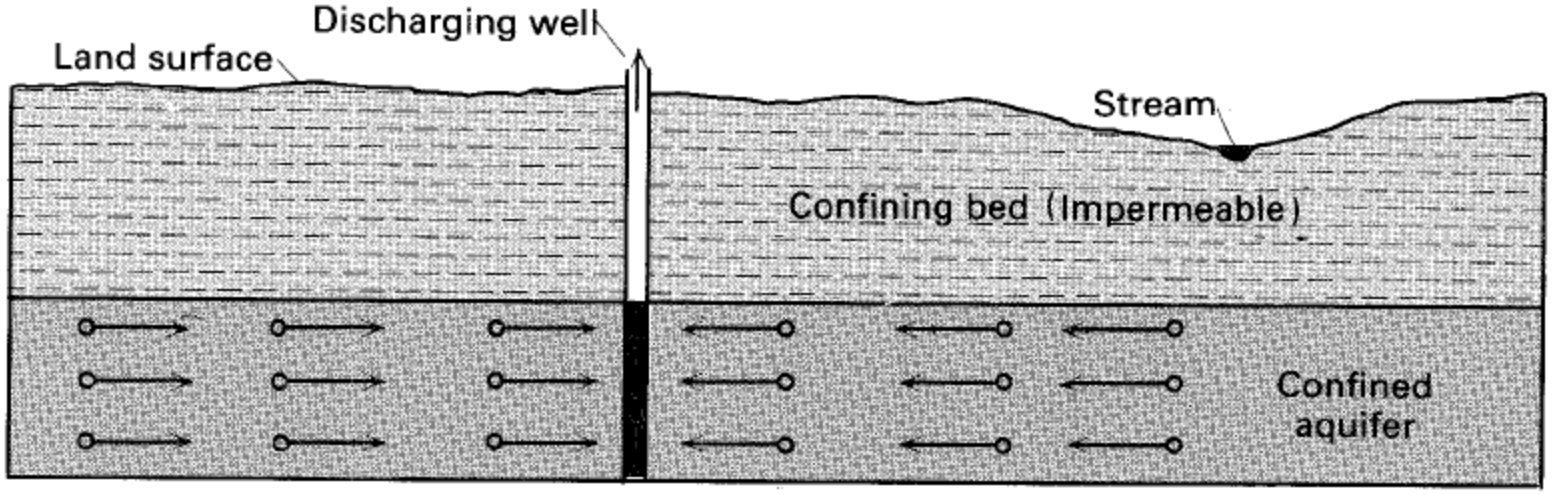
Three-Dimensional Groundwater Flow Through Multiple Hydrogeologic Units from Recharge Area to Discharge Area (from Winter et al., 1998)



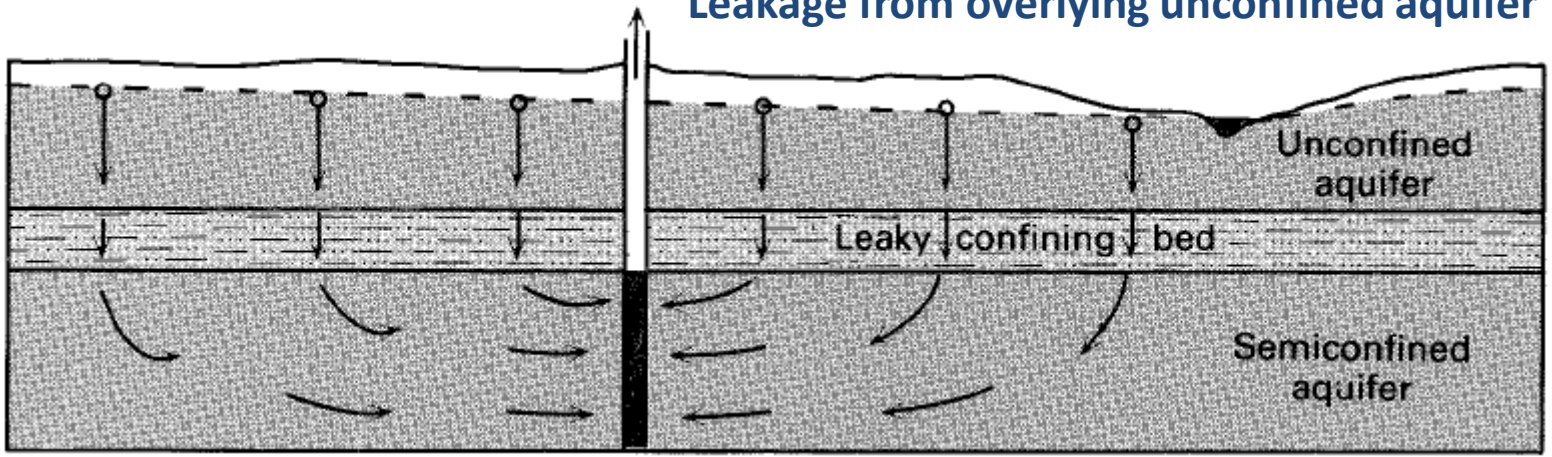
Suppose your (overlying) aquitard leaks into your confined aquifer

Heath, p. 50
USGS WSP 2220

Theis : Impermeable aquitard, no leakage



Hantush-Jacob: Permeable aquitard
Leakage from overlying unconfined aquifer



Not easy, but basic.

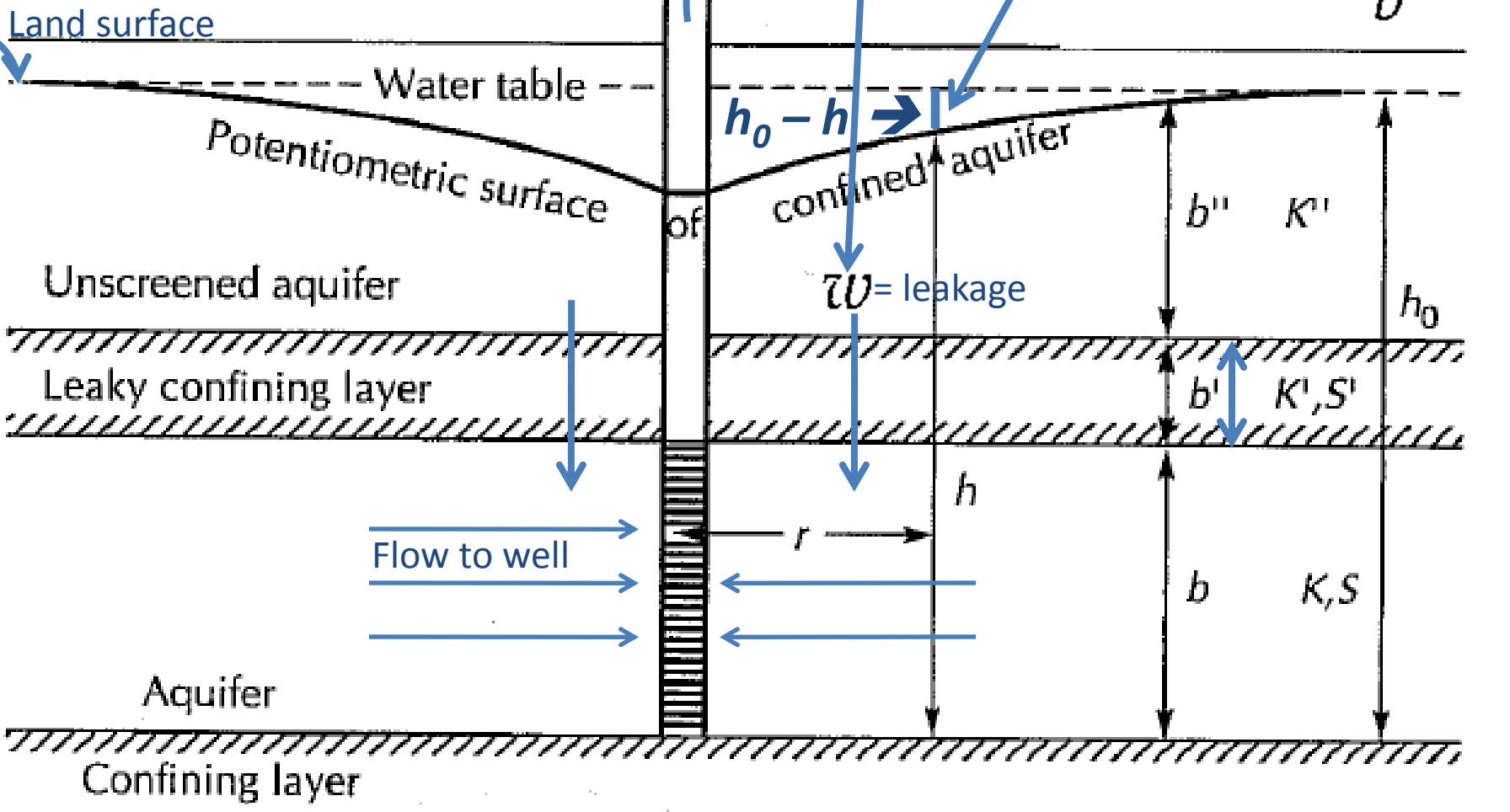
Pumpage affects vertical leakage

$$\frac{\partial^2 h}{\partial r^2} + \frac{1}{r}\frac{\partial h}{\partial r} - \frac{(h_0 - h)K'}{Tb'} = \frac{S}{T}\frac{\partial h}{\partial t}$$

Pre-pumping water table = potentiometric surface

Why necessary?

$$w = K'\frac{h_0 - h}{b'}$$



A 4-year delay for timeliness
(or how I spent the 1990's)

- YN appeals (1993)
- Timeliness challenged
  - 3 answers, 4 years
  - 25 out of 43 spring back to life in 1997
- Meanwhile…
- Statewide cases
  - Ecology changes course
  - Court says, "Hydraulic continuity is a scientific fact"
- Hubbard
  - One molecule of impairment is impairment
- Changing of the Guard: Chain of command changed from permit writer to Governor
- Capture Committee

DRAFT

REPORT OF THE TECHNICAL ADVISORY COMMITTEE ON THE CAPTURE OF SURFACE WATER BY WELLS

Recommended Technical
Methods for Evaluating the Effects
of Ground-Water Withdrawals on Surface Water Quantity

AUGUST, 1998

Capture Analysis Should Be Based on Accepted Scientific Principles

The Committee agrees that the technical analysis of surface-water capture by wells should be rooted in broadly accepted, state-of-the-art, scientific principles governing ground-water and capture effects on surface-water flow, including the law of conservation of mass and Darcy's Law. Based upon these principles, the Committee agrees that, in the long run, any ground water withdrawal will reduce ("capture") surface water flow in one or more hydraulically connected water bodies, and may also affect other parts of the water cycle, such as the amount of water returned to the atmosphere through evapotranspiration. Questions that may require further analysis are: *how much* of a surface-water body's flow will be captured, *where* will water be captured (i.e., which surface-water bodies will be affected; *when* will the effect occur, and *how long* will the effect last.

Enter the 800 Pound Gorilla: Reclamation Rings In

- Hey, Buddy, that's my WSRF
- Affidavit
  - If continuity exists, and it appears to, then it's our water and you're impairing our contractors' rights and interfering with our duties to protect and enhance the river
- Amicus (denied)

Depositions & Summary Judgments

- You said it
- Pumping from wells will capture river flow over time
- Gw is cooler and cleaner; pumping will make river hotter and dirtier
- Every drop is important
- Denied

The 3 Sovereigns Agree to Agree

- Ecology letter to permittees
  - We've learned a thing or two
  - If we had it to do over again…
  - We won't defend the permits
- Settlements
  - Permittees to pay replacement cost for water into BOR water acquisition fund
- The MOA

Memorandum of Agreement
among the

Yakama Nation
and
United States Bureau of Reclamation
and
Washington State Department of Ecology

related to
Ground Water Management in the Yakima River Basin

I. INTRODUCTION

This Memorandum of Agreement (MOA) is entered into by the Yakama Nation (Yakama), United States Bureau of Reclamation (Reclamation) and Washington State Department of Ecology (Ecology) for the purposes stated below.

II. PURPOSE AND SCOPE

A. Purpose

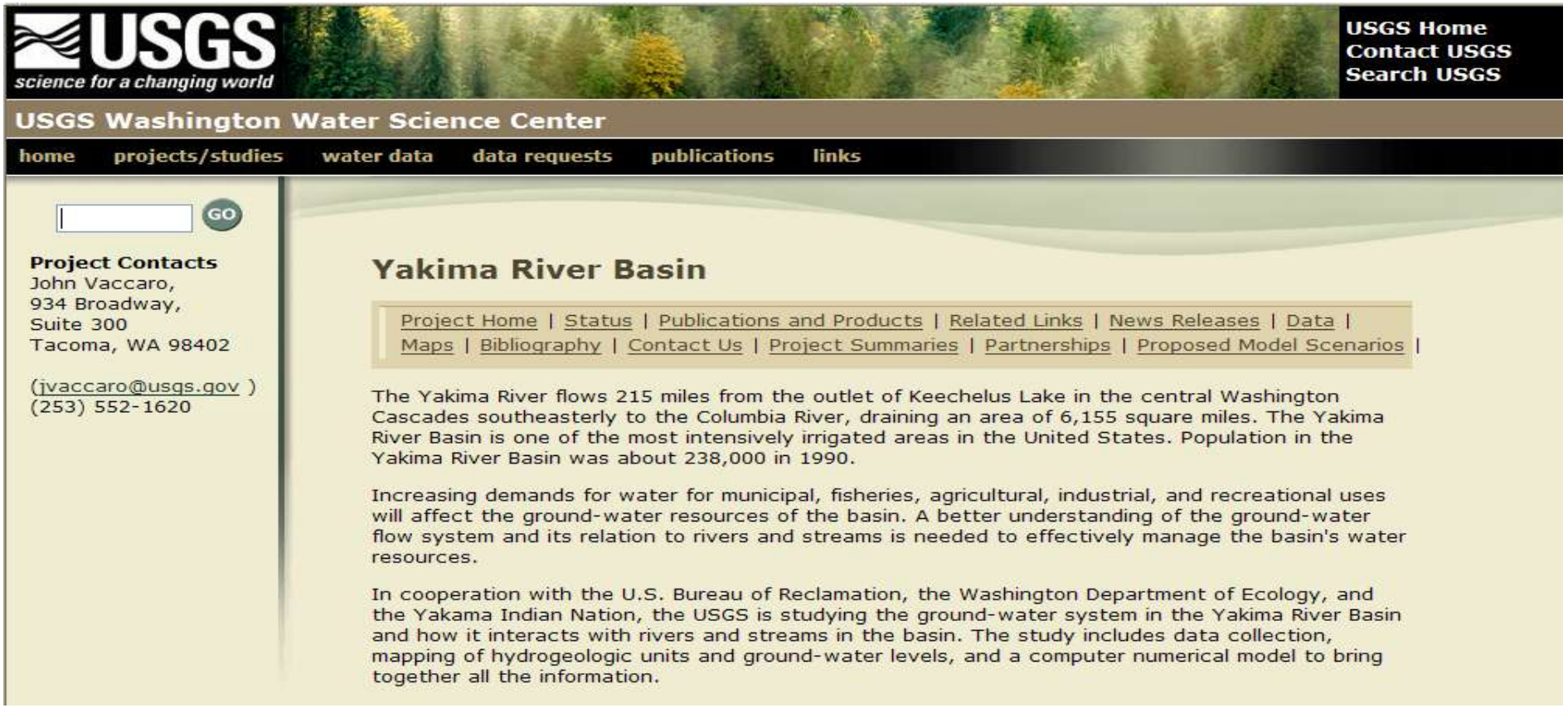
The Parties agree that there is a need to compile and synthesize existing information and to develop a common technical platform for making sound, efficient, and consistent water resource management decisions in the Yakima River Basin including future government management, allocation and mitigation decisions.

The MOA

- The 3 govs will contract USGS to develop a model to simulate effects of existing and proposed groundwater pumping
- Model will serve as technical platform for future decisions
- Study team (hg's from 3 govs) will draft scope and oversee project
- Ecology will not issue permits during study

The Study

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



Let's Get Ready to Model

Yakima River Basin

Publications and Products

Project Home | Status | Publications and Products | Related Links | News Releases | Data | Maps | Bibliography | Contact Us | Project Summaries | Partnerships | Proposed Model Scenarios |

Jones, M.A., and Julich, R.J., 2008, 3D hydrogeologic framework of basalt and interbed units, Yakima, Washington

Vaccaro, J.J., 2008, A thermal profile method for long river reaches to identify potential areas of ground-water discharge and preferred salmonid habitat and to document the longitudinal temperature regime, Symposium on Identifying, Protecting, and Restoring Thermal Refuges for Coldwater Fishes, A.F.S., May 4-8, 2008, Portland, Oregon

Bachmann, Matt, 2008, Approaches for assessing ground water availability under competing demands and climate change [poster]: American Geophysical Union Fall Meeting, San Francisco, California, December 15-19, 2008, PDF, 6.7 MB.

Jones, M.A., Vaccaro, J.J., and Watkins, A.M., 2006, Hydrogeologic Framework of Sedimentary Deposits in Six Structural Basins, Yakima River Basin, Washington: U.S. Geological Survey Scientific Investigations Report 2006-5116, 24 p.

Jones, M.A., and Vaccaro, J.J., 2008, Extent and Depth to Top of Basalt and Interbed Hydrogeologic Units, Yakima River Basin Aquifer System, Washington: U.S. Geological Survey Scientific Investigations Report 2008-5045, 22 p., 5 pls.

Keys, M.E., Vaccaro, J.J., Jones, M.A., and Julich, R.J., 2008, Hydrographs showing ground-water level trends for selected wells in the Yakima River basin aquifer system, Washington: U.S. Geological Survey Data Series 343

Magirl, C.S., Julich, R.J., Welch, W.B., Curran, C.R., Mastin, M.C., and Vaccaro, J.J., 2009, Summary of Seepage Investigations in the Yakima River Basin, Washington: U.S. Geological Survey Data Series 473

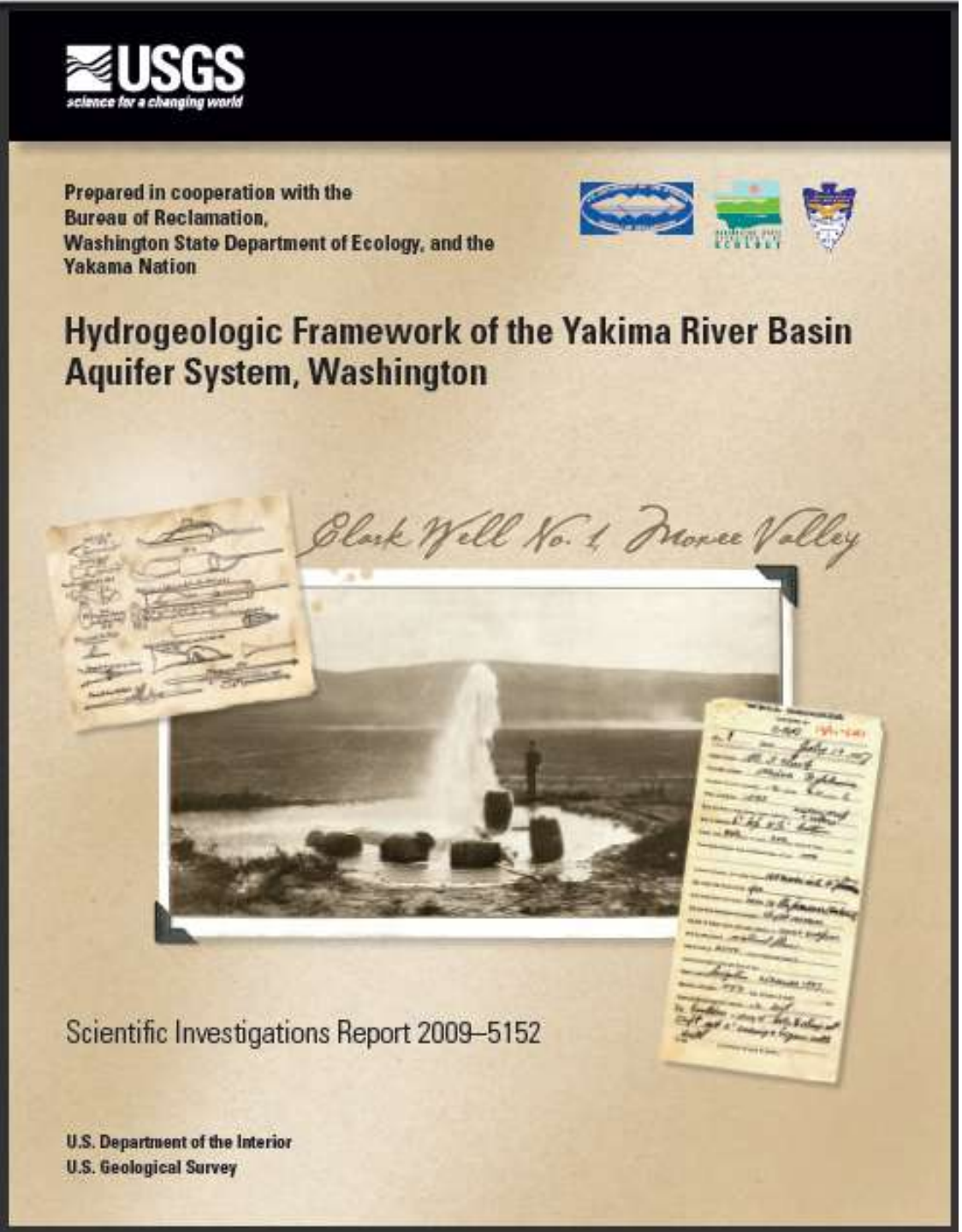
Ripich, M.A., 2003, Methods to estimate unmetered ground-water withdrawals in the Yakima River Basin, Washington (abs.): 4th Symposium on the Hydrogeology of Washington State, April 8-10, 2003, Tacoma, Washington, Program, p. 14.

Vaccaro, J.J., 2005, Thermal profiling of long river reaches to characterize ground-water discharge and preferred salmonid habitat: Presentation by the U.S. Geological Survey at the 5th Washington Hydrogeology Symposium, Tacoma, Washington, April 12-14, 2005, 25 p. (PDF, 2.76 MB)

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

Vaccaro, J.J., 2007, Yakima River Basin Ground-Water Investigation--An update: Presentation by U.S. Geological Survey at Yakima River Basin public update, Yakima, Washington, February 28, 2007, 85 p. (PDF, 8 MB)

Vaccaro, J.J., Jones, M.A., Ely, D.M., Keys, M.E., Olsen, T.D., Welch, W.B., and Cox, S.E., 2009, Hydrogeologic framework of the Yakima River basin aquifer system, Washington: U.S. Geological Survey Scientific Investigations Report 2009-5152, 106 p.



One Stop Shopping

Framework Report compiles task reports and synthesizes

- Geology: Stratigraphy and Structure
- Hydrogeologic Units
  - Hydraulic Characteristics
    - Lateral and Vertical Hydraulic Conductivities
      - Necessary to calculate horizontal and vertical groundwater flow (Darcy's Law)
    - Storage Coefficients
      - Necessary for transient simulations of pumping
- Hydrochemistry
- Groundwater
  - Recharge
  - Water levels
  - Flow System
  - Pumpage
    - Turns out "a lot" is about 312,284 acre-ft (about 430 ft3/s) (in 2000)
- Water Budget

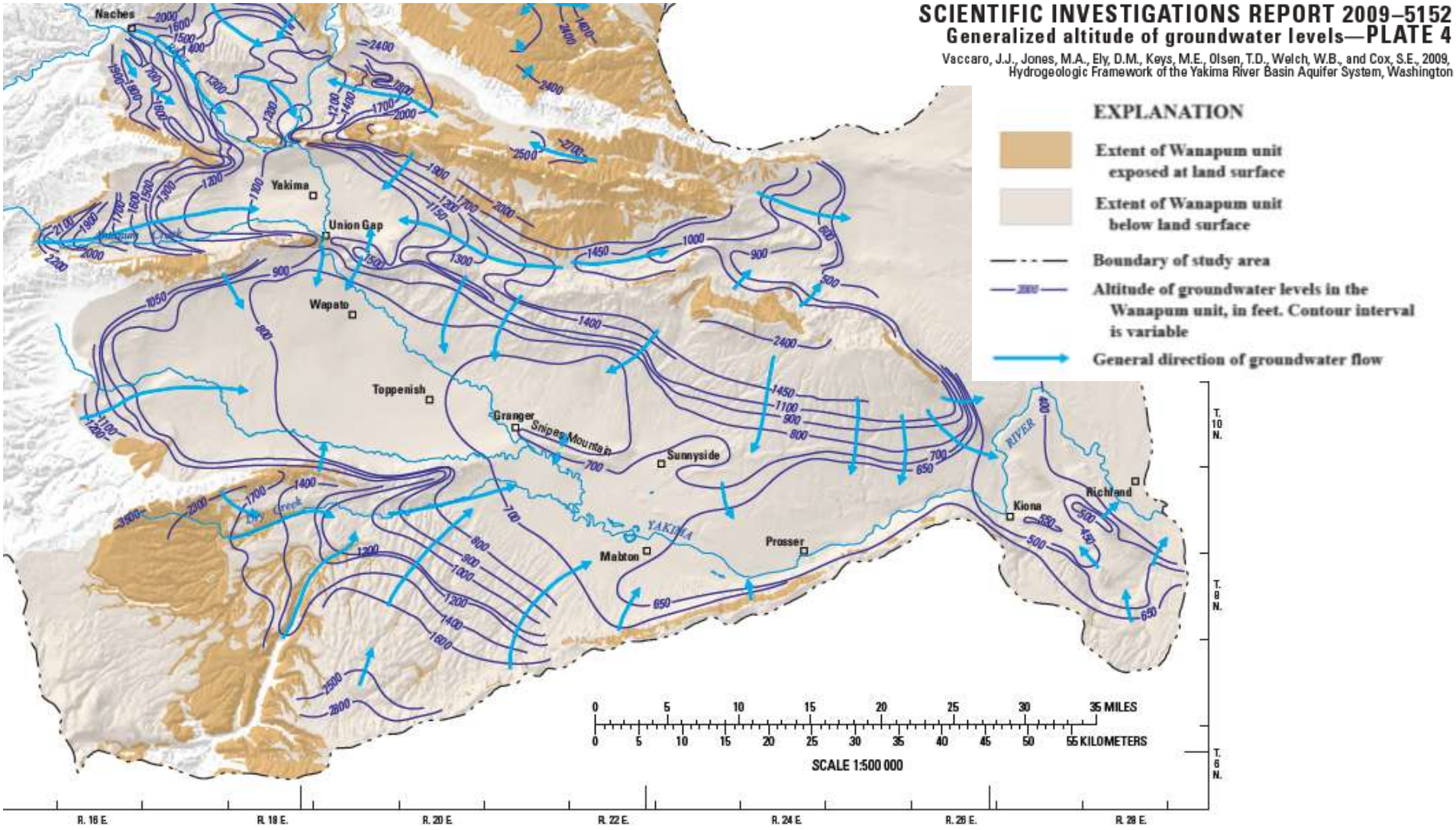
Hydrogeologic Framework of the Yakima River Basin Aquifer System, Washington

- Conclusions
- Hydraulic conductivities range widely
  - Vertical K's are lower then lateral (as usual)
- Groundwater residence time range from a few tens to many thousands of years
- Irrigation has increased recharge
- Groundwater moves from topographic highs in the uplands to topographic low areas along the streams
- Regional groundwater flow discharges to surface drainage features in the lowlands in the structural basins and to the Columbia River
  - The ridges (anticlines) compartalize flow into local systems
  - Groundwater (including all but the deepest basalts) discharges to surface water at the downgradient end of the structural basins
  - Flow from one structural basin to another is via surface water

Lesson: Deep waters still run

or

Even Basalt Aquifers follow the laws of physics

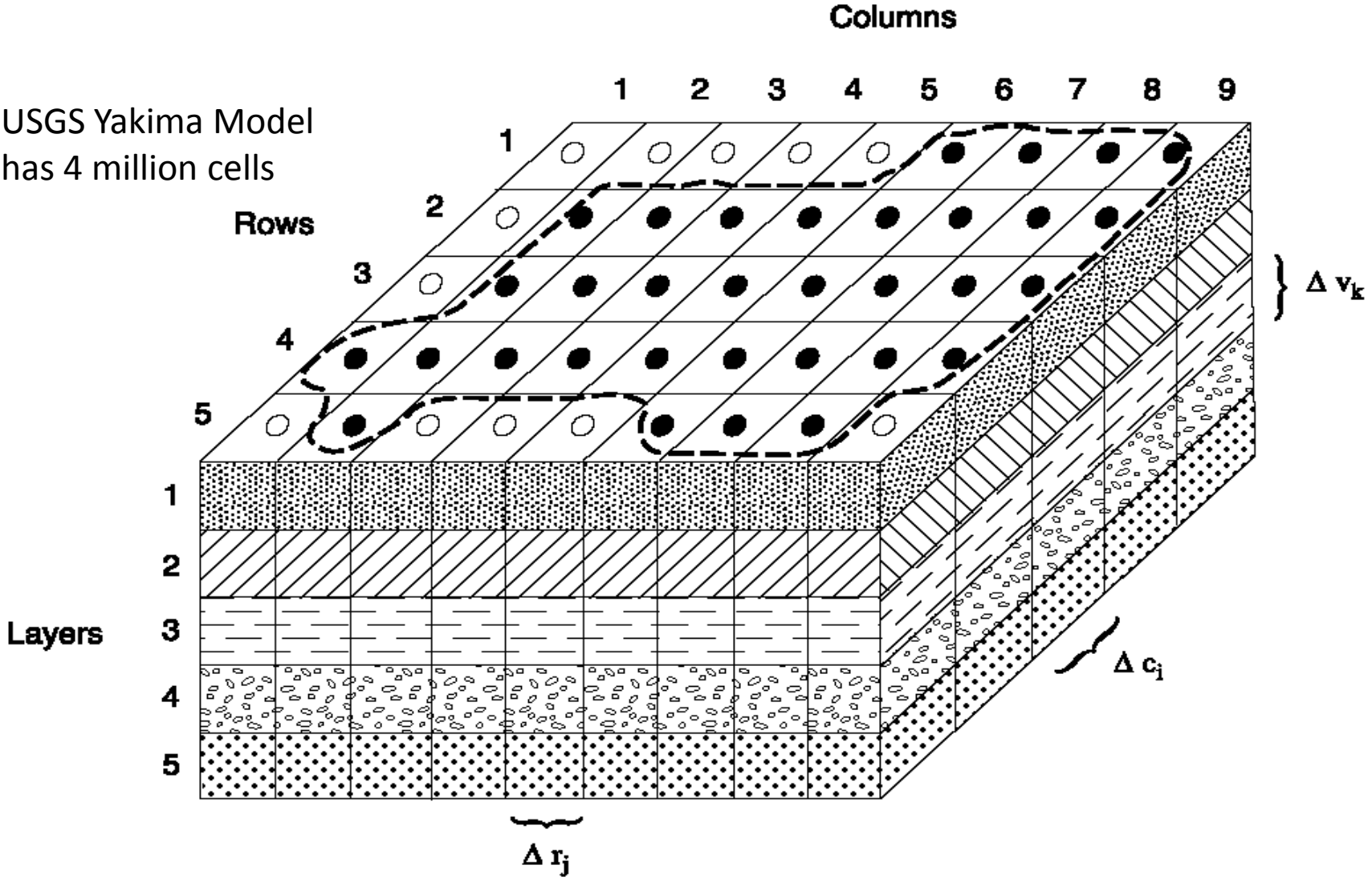


Prediction is very difficult, especially about the future.

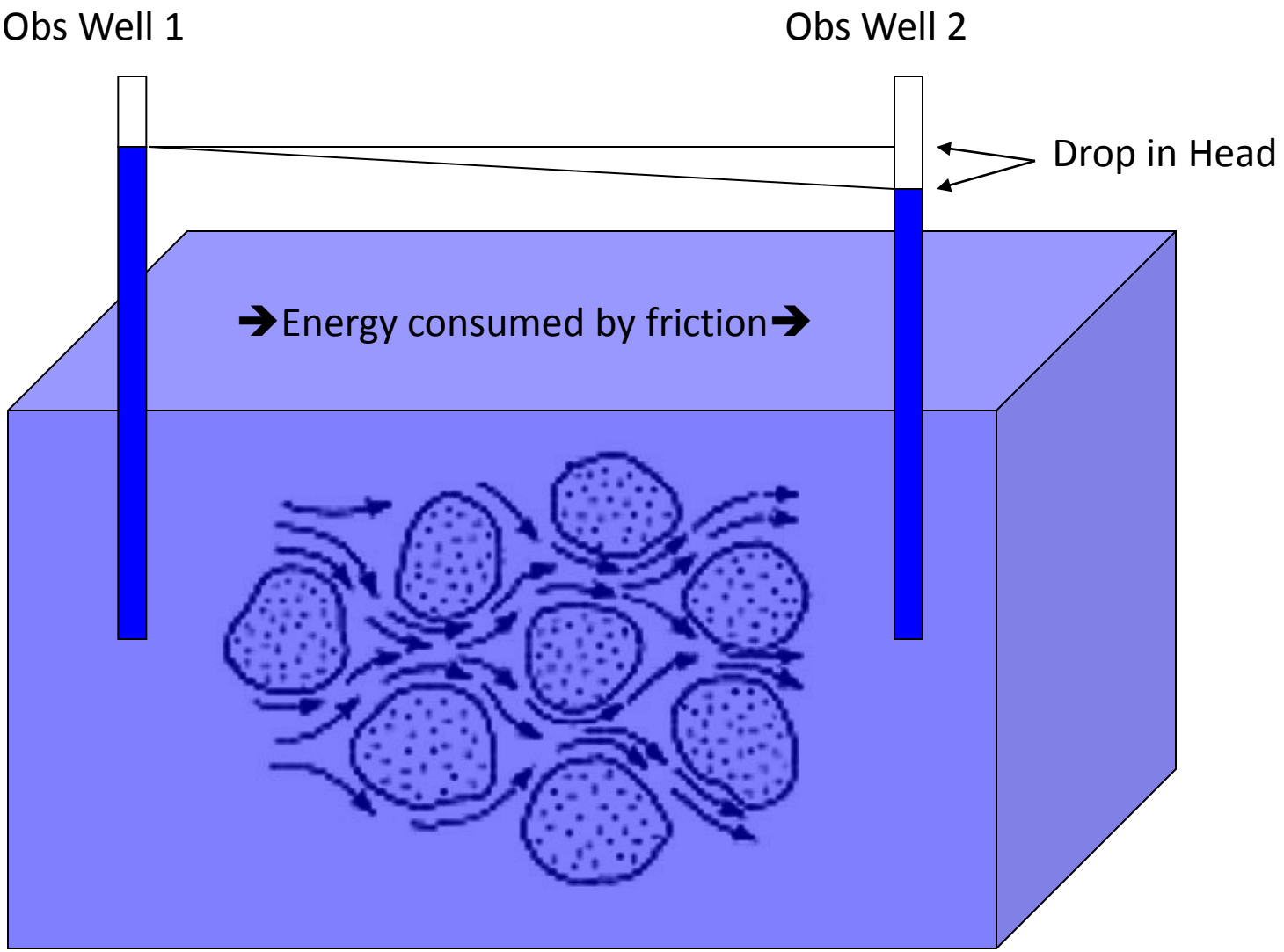
(Niels Bohr)

America's Next Top Model MODFLOW, e.g.

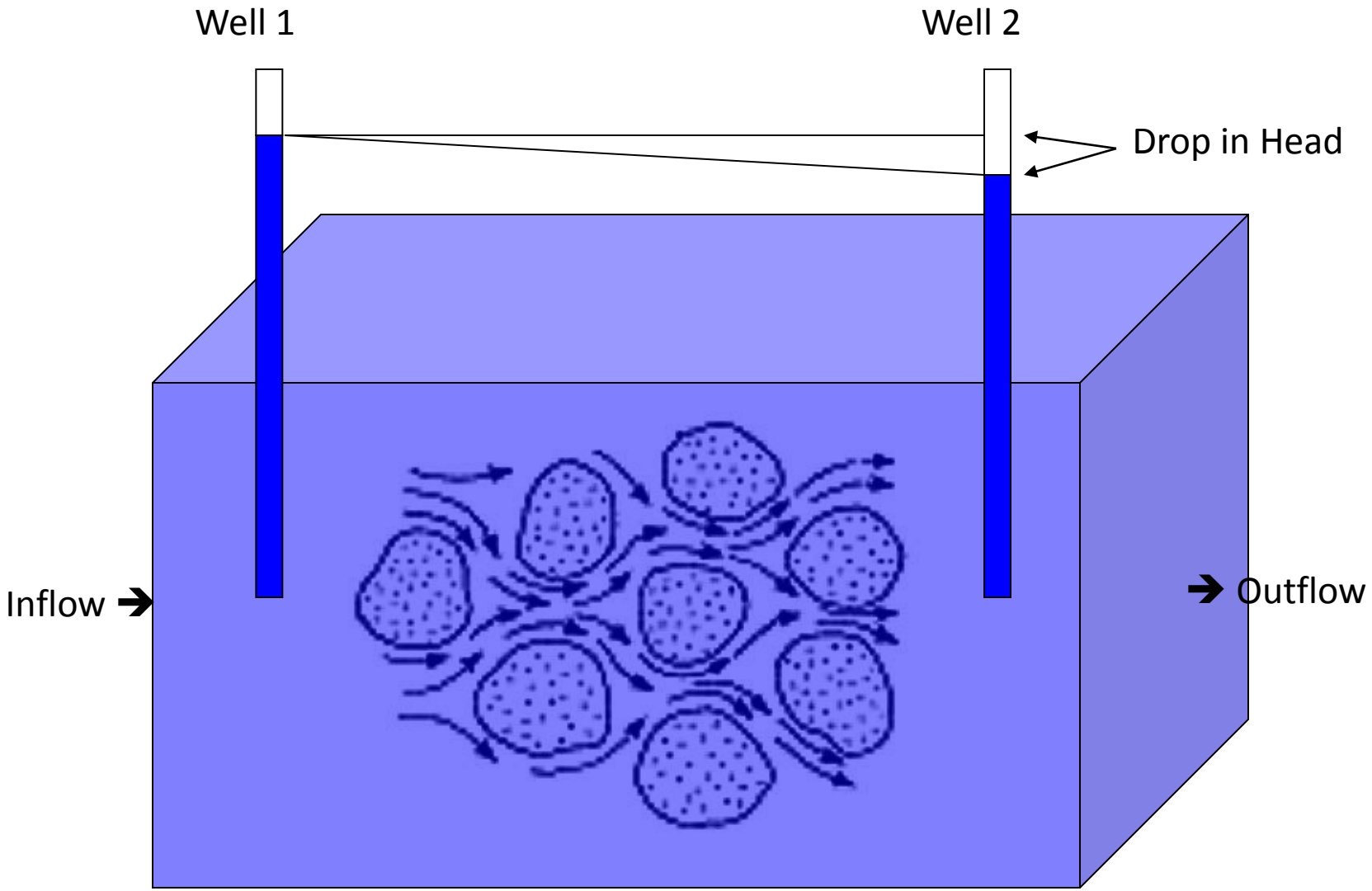
USGS Yakima Model has 4 million cells



Work Needed


Obs Well 1
Obs Well 2
Drop in Head
➔Energy consumed by friction➔

Oh yeah, did I tell you mass is conserved? Think model grid cell.



Water Budget Components

Model allows calculation of components and changes caused by e.g. wells, irrigation, etc.

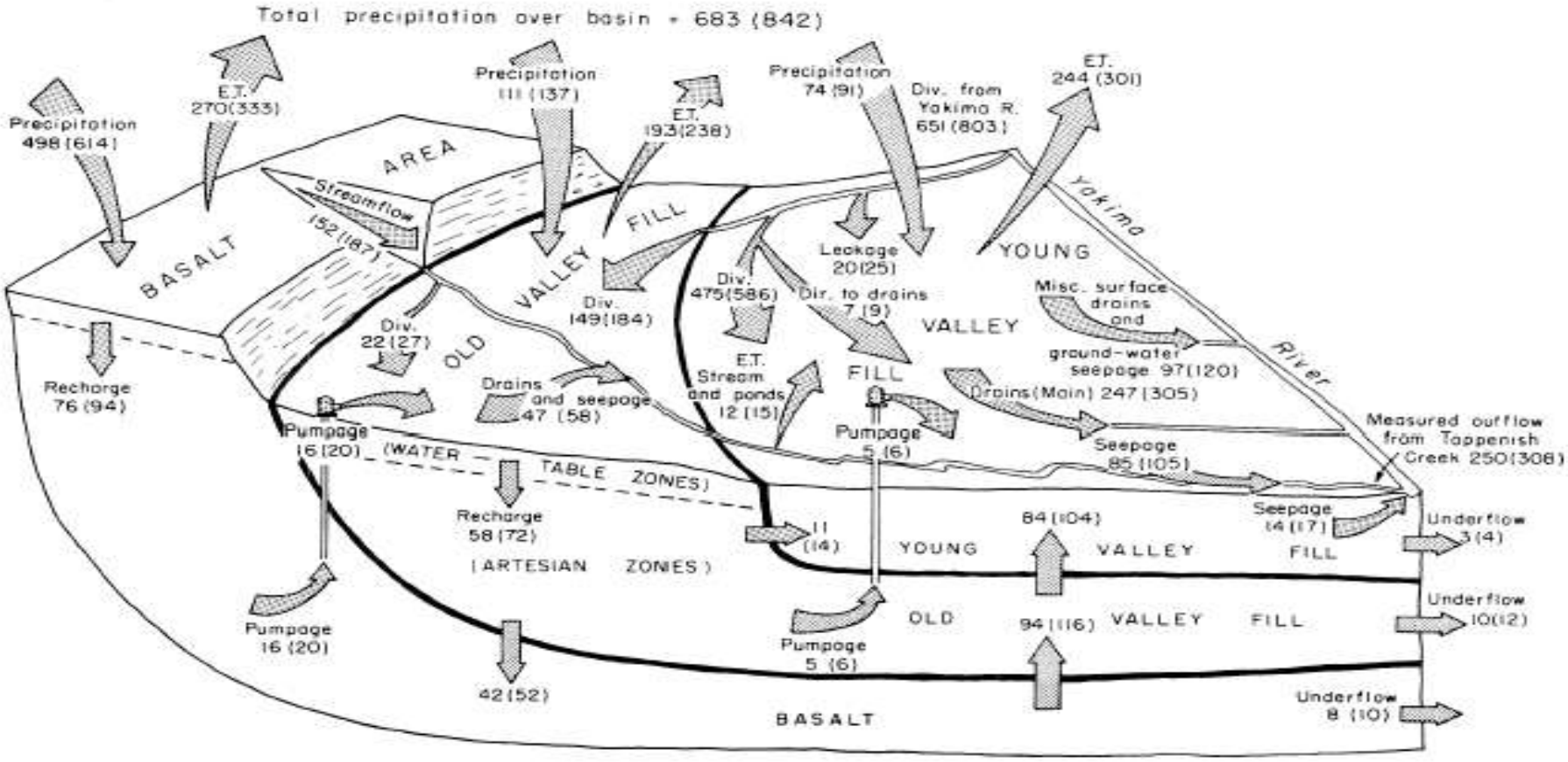


FIGURE 32.--Schematic budget of the hydrologic system in the Toppenish Creek basin. Values are in thousands of acre-feet per year. Values in parentheses are in millions of cubic metres per year.

Preliminary Model Results

(from my notes)

- Unusual for USGS to release preliminary results
  - Did so because of urgency of ongoing processes
- Existing rates of groundwater use will result in about 200 cfs reduction in surface water budget (at equilibrium)
  - About 30 cfs from exempt pumpage (may change)
  - Effects increase as increased pumpage is modeled
    - Pending applications would take 70cfs more
- Effects felt almost instantaneously
  - About 50% of pumpage shows up annually in SW budget
  - Some effects take 10 years
- Basalt response is complex
  - Pressure effects propagate
  - Effects from basalt pumpage attenuated in space and time

Lesson Learned: Lessons hard learned are easily forgotten

or

Why this talk is not a victory lap

or

Every Day is Groundhog Day
in Water Resources

- The return of “indirect hydraulic continuity”
- Black Friday
  - Only ….. are in likely in hydraulic continuity
- Come back in 2028 for “Lessons learned from 34 year study of groundwater in the Yakima basin”.
- Lesson Learned: Never quit paying attention