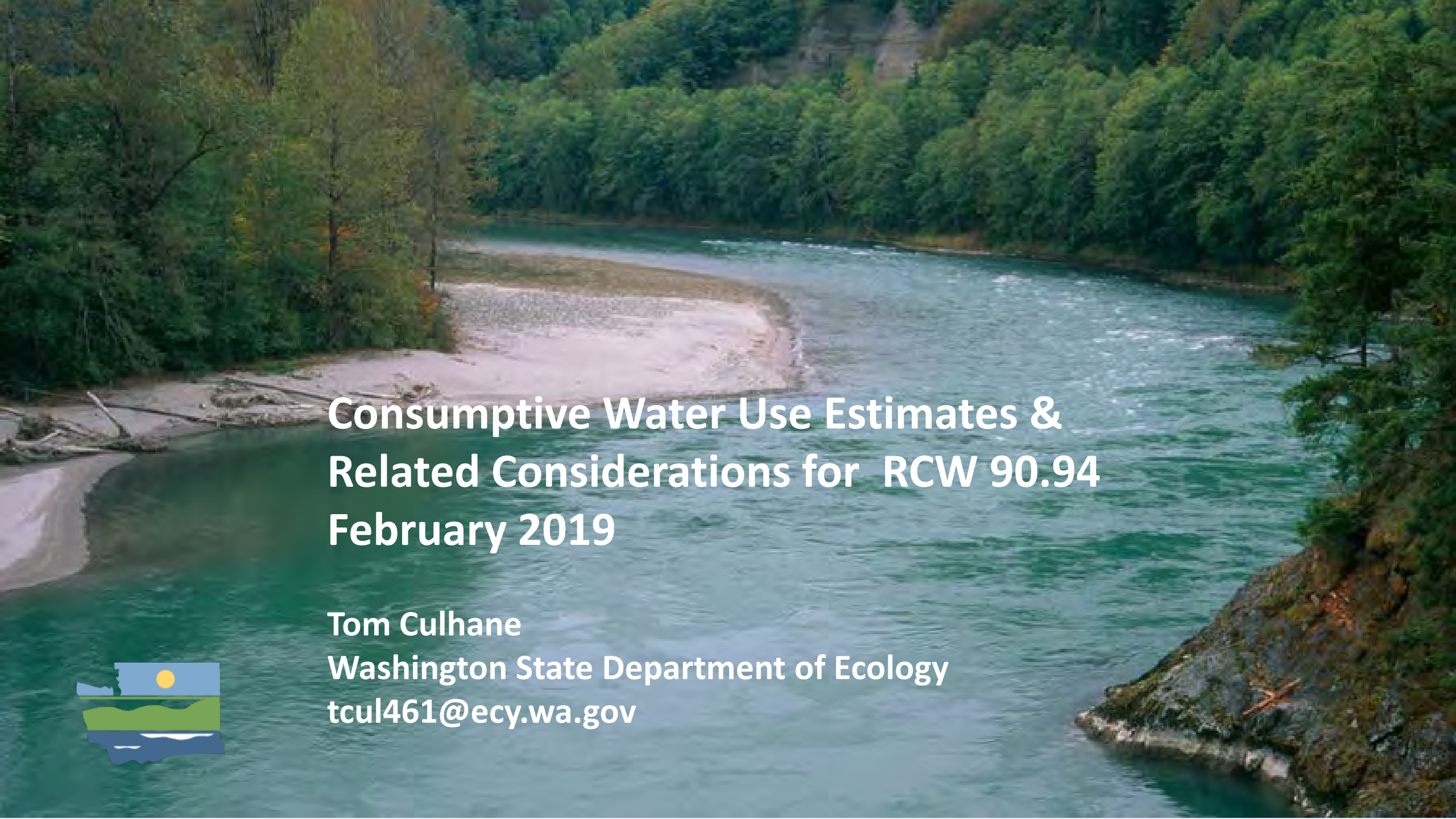


Consumptive Water Use Estimates & Related Considerations for RCW 90.94

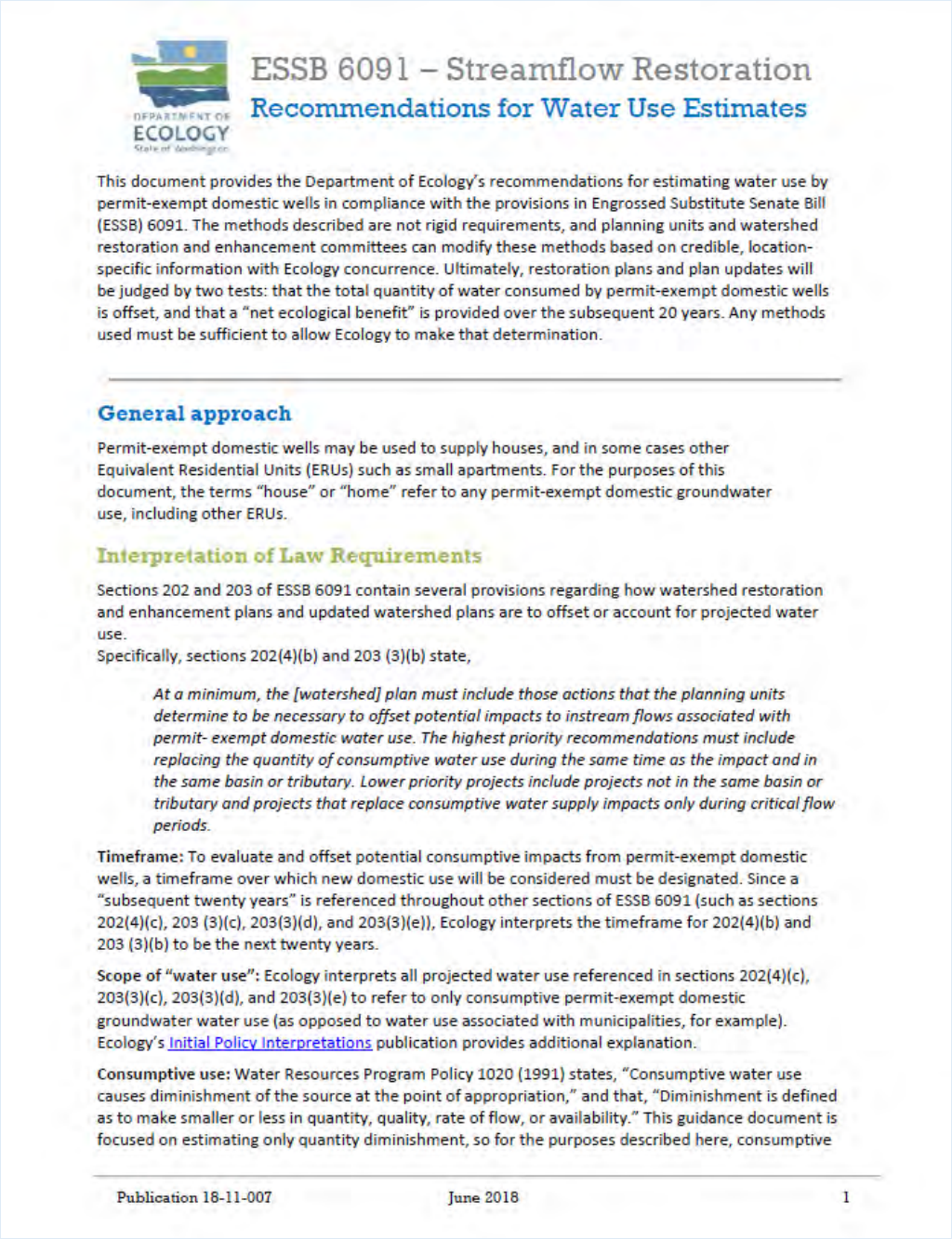
February 2019

Tom Culhane
Washington State Department of Ecology
tcul461@ecy.wa.gov

Ecology published recommendations for estimating water use by permit-exempt domestic wells in compliance with RCW 90.94.

The methods described here are described in that document.

https://fortress.wa.gov/ecy/publications/documents/1811007.pdf



ESSB 6091 – Streamflow Restoration

Recommendations for Water Use Estimates

This document provides the Department of Ecology's recommendations for estimating water use by permit-exempt domestic wells in compliance with the provisions in Engrossed Substitute Senate Bill (ESSB) 6091. The methods described are not rigid requirements, and planning units and watershed restoration and enhancement committees can modify these methods based on credible, location-specific information with Ecology concurrence. Ultimately, restoration plans and plan updates will be judged by two tests: that the total quantity of water consumed by permit-exempt domestic wells is offset, and that a "net ecological benefit" is provided over the subsequent 20 years. Any methods used must be sufficient to allow Ecology to make that determination.

General approach

Permit-exempt domestic wells may be used to supply houses, and in some cases other Equivalent Residential Units (ERUs) such as small apartments. For the purposes of this document, the terms "house" or "home" refer to any permit-exempt domestic groundwater use, including other ERUs.

Interpretation of Law Requirements

Sections 202 and 203 of ESSB 6091 contain several provisions regarding how watershed restoration and enhancement plans and updated watershed plans are to offset or account for projected water use.
Specifically, sections 202(4)(b) and 203 (3)(b) state,

> *At a minimum, the [watershed] plan must include those actions that the planning units determine to be necessary to offset potential impacts to instream flows associated with permit- exempt domestic water use. The highest priority recommendations must include replacing the quantity of consumptive water use during the same time as the impact and in the same basin or tributary. Lower priority projects include projects not in the same basin or tributary and projects that replace consumptive water supply impacts only during critical flow periods.*

Timeframe: To evaluate and offset potential consumptive impacts from permit-exempt domestic wells, a timeframe over which new domestic use will be considered must be designated. Since a "subsequent twenty years" is referenced throughout other sections of ESSB 6091 (such as sections 202(4)(c), 203 (3)(c), 203(3)(d), and 203(3)(e)), Ecology interprets the timeframe for 202(4)(b) and 203 (3)(b) to be the next twenty years.

Scope of "water use": Ecology interprets all projected water use referenced in sections 202(4)(c), 203(3)(c), 203(3)(d), and 203(3)(e) to refer to only consumptive permit-exempt domestic groundwater water use (as opposed to water use associated with municipalities, for example). Ecology's Initial Policy Interpretations publication provides additional explanation.

Consumptive use: Water Resources Program Policy 1020 (1991) states, "Consumptive water use causes diminishment of the source at the point of appropriation," and that, "Diminishment is defined as to make smaller or less in quantity, quality, rate of flow, or availability." This guidance document is focused on estimating only quantity diminishment, so for the purposes described here, consumptive

Why Estimate Consumptive Water Use?

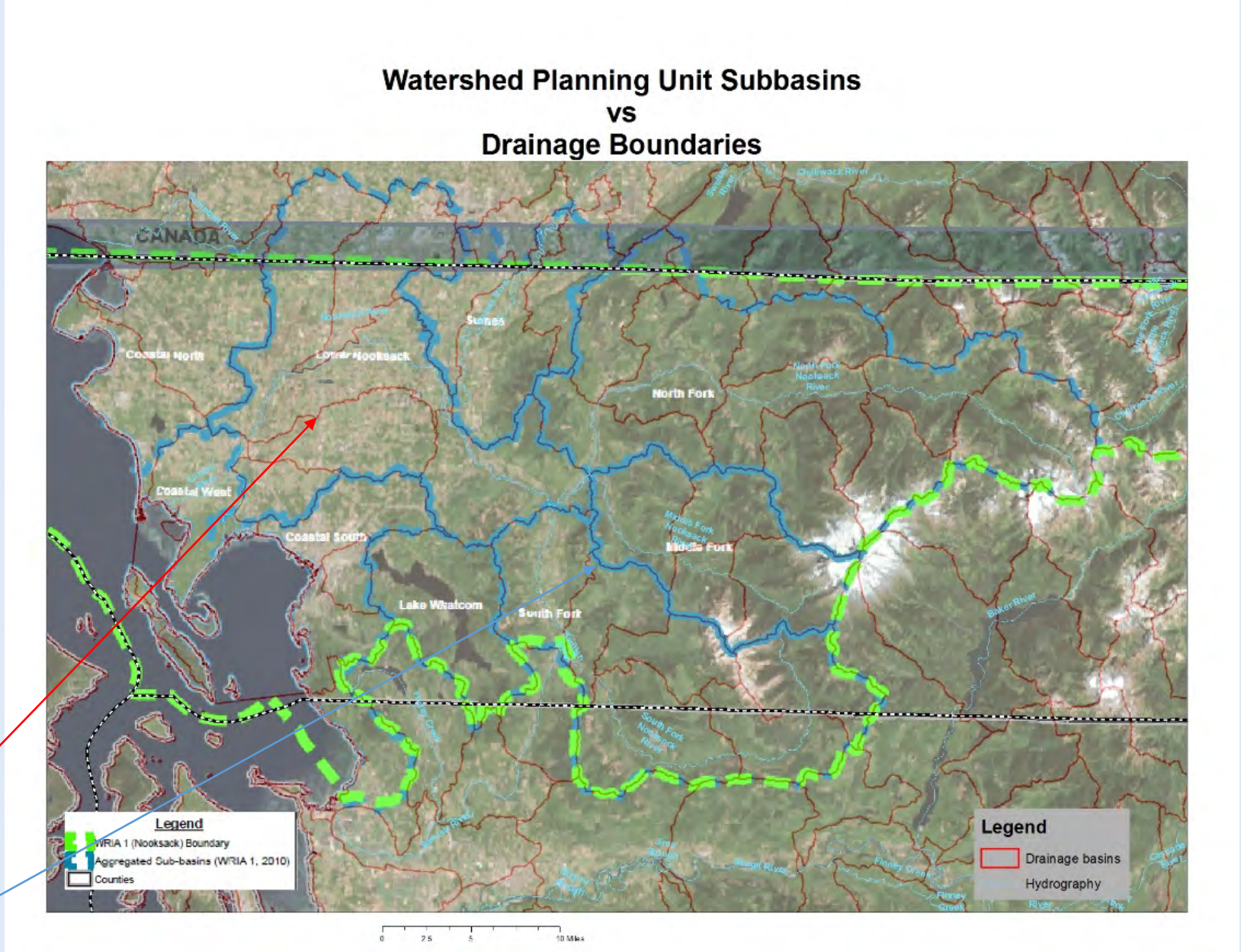
- Under RCW 90.94 permit-exempt domestic well water use must be estimated to establish amount of water use that watershed restoration plans and plan updates must address.
- Plans must estimate consumptive use associated with new domestic permit-exempt wells anticipated between January 19, 2018 and January 18, 2038.
- Ultimately, watershed plans will be judged by two tests:
  - total potential impacts of new permit-exempt domestic wells are offset
  - “net ecological benefit” (NEB) is provided by plan.

Subbasins

Planning groups must delineate suitably-sized subbasins within WRIAs.

Subbasins will not necessarily correspond with hydrologic basin delineations (i.e. watershed divides).

WRIA 01 has 49 USGS HUC12 subwatersheds and 9 Planning Unit subbasins



Considerations When Selecting Subbasins

Basic considerations:

- Where and to what extent number of new wells are expected to grow
- Where little well growth is expected
- Surface hydrology and/or hydrogeology

Other considerations:

- Too few of subbasins reduces understanding of relationships between where pumping effects will be and where benefits of offset projects will occur.
- Too many subbasins can make it unwieldly to evaluate all of the offset projects needed to achieve a net ecological benefit for the WRIA.

Preferred Methods for Estimating Number of Future Permit-Exempt Domestic Wells

1. Conducting GIS analysis of county building permits over time, zoning, and parcel information
2. Relying on population data available from WA Office of Financial Management (OFM)
3. Comprehensive plans

Use of Building Permit, Zoning, and Parcel Information

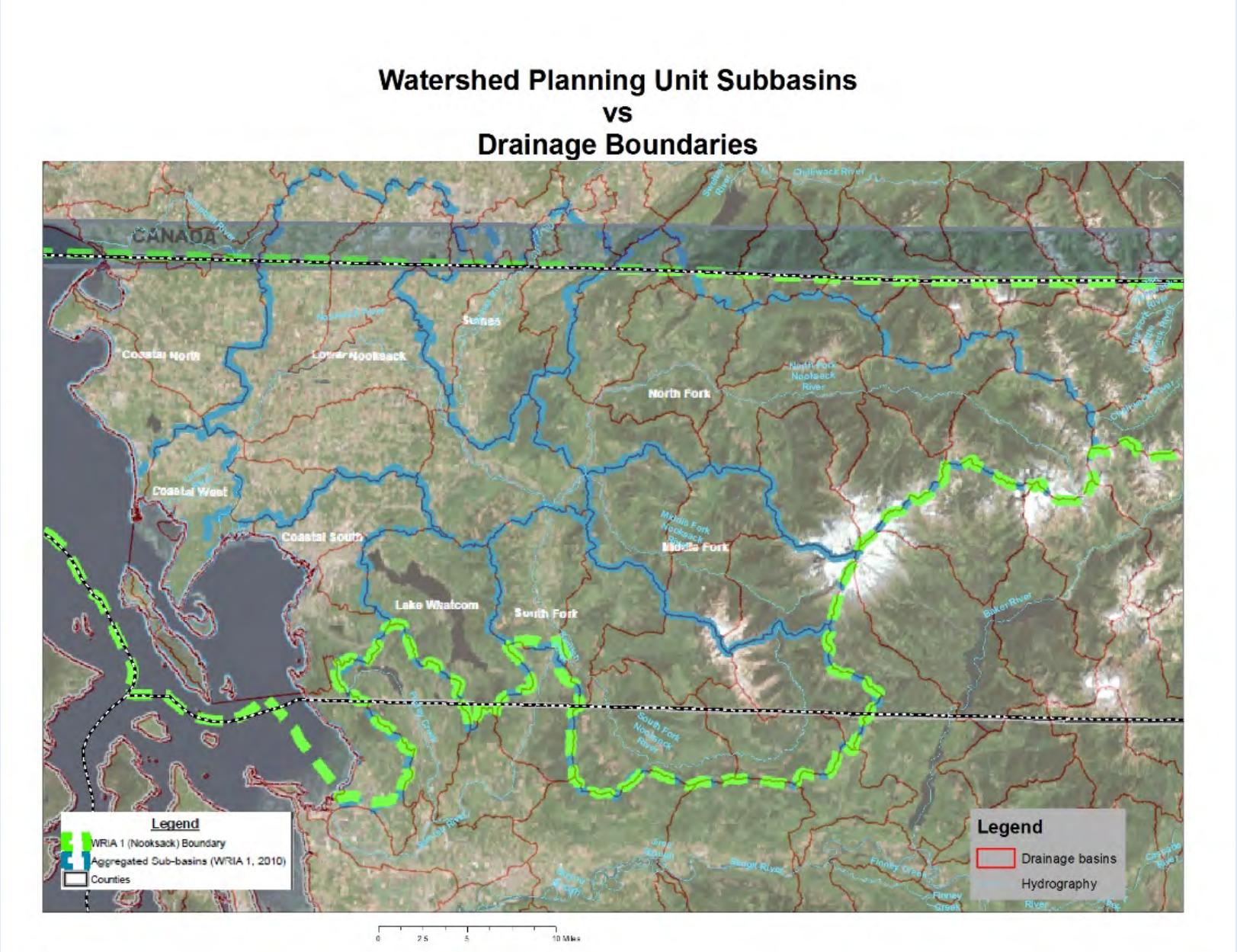
- Data can be segregated into subbasins, then evaluated to estimate number of building permits issued over some previous time period (e.g. past 10 years).
- Results can be used to predict permit-exempt domestic wells over subsequent 20-year period.
- Areas with municipal/community water systems must be removed.

Use of population data from WA Office of Financial Management (OFM)

- Option 1: look at populations for 2 different years (e.g. 2008 and 2018), then use rates of increase to predict future populations. **Upon request, OFM can prepare 2000-2017 small area estimates.**
- Option 2: rely on current population estimates, then increase those based on available population projections.
  - Requires subjectivity for WRIAs span two or more counties.
- For either method municipal/community water system populations must be removed and estimates must be divided by people per household.

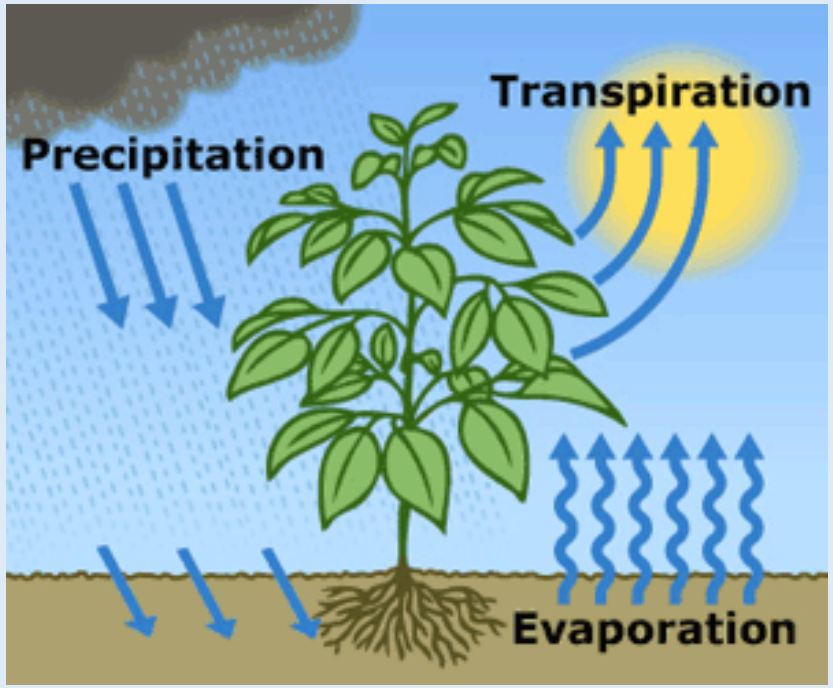
Outdoor Water Use Areas

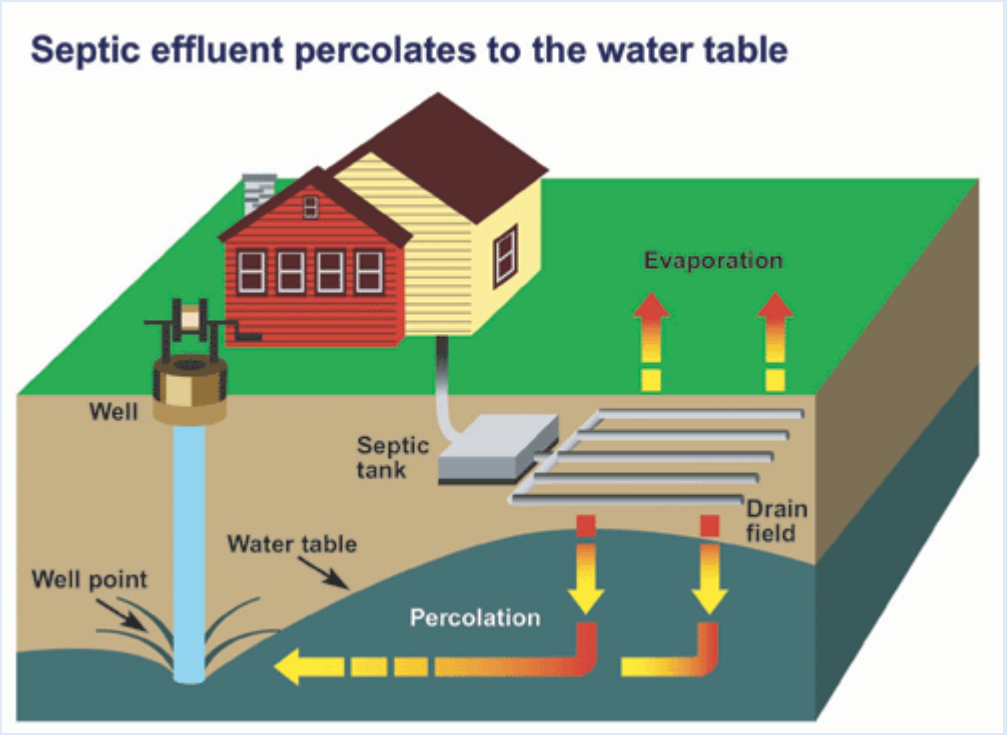
WRIA 1 calculated irrigated footprint of representative sample of domestic lots developed 2000 -2014 to estimate outside lawn and garden irrigation requirements by subbasin.



Consumptive Use:

- water that is evaporated, transpired, consumed by humans, or otherwise removed from an immediate water environment due to use of permit-exempt domestic wells.





Total Water Use vs. Consumptive Water Use

- Estimates of water use by future permit-exempt domestic wells must account for portion of water consumptively used.
  - For indoor water use most houses with domestic wells are connected to septic systems, so it is reasonable to assume that only about 10% is lost from groundwater system.
  - For outdoor water use a good assumption is that about 80% is lost, mainly due to evapotranspiration.
- Planning groups can use assumptions other than 10% and 80% if justification is provided.

Method Example in Ecology Recommendations Document

Indoor Water Use

- Water Research Foundation (DeOreo, et al., 2016) evaluated water use in homes provided municipal water in 23 areas across U.S. and Canada. For indoor use:
  - Average use for all sampled homes was 59 gpd per capita.
  - Sampling of homes supplied by Tacoma Water averaged 51 gpd per capita.
- Homes supplied municipal water are more likely to be fitted with water saving appliances, so assumption of 60 gpd per capita is reasonable for indoor water use.

Household Consumptive Indoor Water Use

Average household size estimates are available from OFM.

Assuming 2.5 people per household, 60 gpd per capita water use, and 10% of indoor water use consumption, household consumptive indoor water use (HCIWU) equals :

60 gpd X 2.5 people/house X 365 days X 3.07 (10^{-6})AF/gal. X 10%

= 0.017 AF/YR

Outdoor Water Use

Irrigation requirements are available in Appendix A of the Washington Irrigation Guide (WAIG) (USDA, 1997).

Household Consumptive Outdoor Water Use

For example, if there is a 0.4 acre outdoor watering area:

Irrig. Req. (in.) = 11.11 in./12 in./ft. X 0.4 acres = 0.37 AF/YR

Assuming 75% efficiency for residential pop-up sprinkler system (to account for water lost during water application process):

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

Assuming 80% outdoor water use consumptive loss, total Household Consumptive Outdoor Water Use (HCOWU) per house would be:

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

WRIA 1 Results

WRIA 1 relied on comprehensive plan growth projections for rural growth outside of UGA's, then made adjustments for public water system capacity.

METHODS USED

RH2 used the population data provided by BERK to estimate the number of new DGWPE connections over the next 20 years. BERK identified that between 2018 and 2038, there will need to be sufficient new housing units to accommodate a population increase of 8,163 outside of the established Urban Growth Areas (UGAs) in Whatcom County, using the adopted comprehensive plan growth projection. The adopted growth projection distributes the future population between urban and rural areas by allocating specific shares of growth to urban areas (UGAs) and less to rural areas (non-UGAs) (84 percent urban and 16 percent rural). This

Table 3
Options for Total Projected New Housing Units (outside UGAs) by Aggregated Sub-Basin, 2018 through 2038, Served by DGWPE Wells

Aggregated Sub-Basin	Option 1 All Growth outside UGAs	Option 2 Considering Public Water System Service Areas	Option 3 Historic Ratio*	Option 4 Highest of Options 2 and 3	Option 5 Option 3 Plus 15 Percent
1 - Coastal North	1,017	594	563	594	647
2 - Coastal South	351	241	177	241	204
3 - Coastal West	328	290	276	290	317
4 - Lake Whatcom	205	13	145	145	167
5 - Lower Nooksack	915	495	561	561	645
6 - Middle Fork Nooksack	9	9	9	9	9
7 - North Fork Nooksack	212	126	78	126	90
8 - South Fork Nooksack	27	20	22	22	25
9 - Sumas	196	162	129	162	148
Total	**3,260**	**1,950**	**1,960**	**2,150**	**2,252**

* Historic ratio of non-UGA growth served by DGWPE wells vs. water systems.

WRIA 1 also calculated irrigated footprint of representative sample of domestic lots developed 2000 - 2014 to estimate outside lawn and garden irrigation requirements by subbasin.

Table 4
Irrigated Acreage Analysis on Whatcom County Single-Family Homes Served by DGWPE Wells; Building Permits Issued 2000 through 2014

Aggregated Sub-Basin	Building Permits	Analyzed for Irrigated Area	Percent Analyzed
1 - Coastal North	440	57	13%
2 - Coastal South	192	53	28%
3 - Coastal West	107	59	55%
4 - Lake Whatcom	135	67	50%
5 - Lower Nooksack	672	63	9%
6 - Middle Fork Nooksack	9	9	100%
7 - North Fork Nooksack	148	66	45%
8 - South Fork Nooksack	29	29	100%
9 - Sumas	106	62	58%
Total	**1,838**	**465**	**25%**

The aerial photo used in this analysis was from July 2017 (summer, when irrigation is expected most), and the area irrigated was calculated by creating polygons around the areas believed to be irrigated. Irrigated areas were identified as either those areas that appeared to have actively growing vegetation (a green color) or as gardens. Google Earth Pro was used to create the polygons, and ESRI's ArcMAP was used to calculate the area and correlate the areas to the aggregated sub-basins.

Table 5
Irrigated Acreage Analysis Results for Whatcom County Single-Family Homes Served by DGWPE Wells for Building Permits Issued from 2000 through 2014

Aggregated Sub-Basin	Permits	Analyzed for Irrigated Area	No Irrigation		Irrigation from 0 to ½ Acre		Irrigation of Over ½ Acre		Median	Mean		Modified Mean	
			No.	%	No.	%	No.	%	Ac.	Ac.	+/-	Ac.	+/-
1 - Coastal North	148	57	20	35%	27	47%	10	18%	0.20	0.30	0.40	0.21	0.21
2 - Coastal South	192	53	22	42%	28	53%	3	6%	0.02	0.12	0.18	0.12	0.16
3 - Coastal West	107	59	12	20%	16	27%	31	53%	0.53	0.59	0.55	0.32	0.21
4 - Lake Whatcom	135	67	24	36%	41	61%	2	3%	0.03	0.11	0.15	0.11	0.14
5 - Lower Nooksack	672	63	15	24%	25	40%	23	37%	0.16	0.40	0.45	0.25	0.22
6 - Middle Fork Nooksack	9	9	7	78%	1	11%	1	11%	0.00	0.13	0.35	0.06	0.16
7 - North Fork Nooksack	148	66	28	42%	32	49%	6	9%	0.02	0.20	0.39	0.14	0.18
8 - South Fork Nooksack	29	29	8	28%	17	58%	4	14%	0.11	0.20	0.29	0.16	0.18
9 - Sumas	106	62	24	39%	26	42%	12	19%	0.08	0.33	0.60	0.18	0.20
Total	**1,838**	**465**	**160**	**34%**	**213**	**46%**	**92**	**20%**	-	-	-	-	-

No. = Number

Ac. = Acres

+/- = Standard deviation

Median = Median of all analyzed irrigated acre data

Mean = Mean of all analyzed irrigated acre data

Modified Mean = For individual housing units with irrigation of over 1/2 acre calculated, that acreage was reduced to 1/2 acre before inclusion in the Modified Mean Irrigated Acres calculation.

ESSB 6091 WRIA 1 (Whatcom and Skagit County) Future Use (2018 through 2038) Scenarios and Calculated Total Consumptive Water Use

New DGWPE Served Home Options	Aggregated Subbasins									
	1 - Coastal North	2 - Coastal South	3 - Coastal West	4 - Lake Whatcom	5 - Lower Nooksack	6 - Middle Fork Nooksack	7 - North Fork Nooksack	8 - South Fork Nooksack	9 - Sumas	Total Homes
Option 1: Total Homes Outside UGA - BERK data	1,017	351	328	205	915	9	212	27	196	3,260
Option 2: All Water Districts and avail. Water Assoc. provide water	594	241	290	13	495	9	126	20	162	1,950
Option 3: Historic (2000-2014) Ratio	563	177	276	145	561	9	78	22	129	1,960
Option 4: Take the larger number from Options 2 & 3	594	241	290	145	561	9	126	22	162	2,150
Option 5: Take Option 3 and apply buffer/ factor of safety (15%)	647	204	317	167	645	9	90	25	148	2,252

Scenario	Square Feet Irrigated	Acres Irrigated	Option	Aggregated Subbasin Household Total Consumptive Water Use (acre-feet per year)									Total (acre-feet per year)
1	0	0.000	1	17.50	6.04	5.64	3.53	15.74	0.15	3.65	0.46	3.37	56.09
			2	10.22	4.15	4.99	0.22	8.52	0.15	2.17	0.34	2.79	33.55
			3	9.69	3.05	4.75	2.49	9.65	0.15	1.34	0.38	2.22	33.72
			4	10.22	4.15	4.99	2.49	9.65	0.15	2.17	0.38	2.79	36.99
			5	11.13	3.51	5.45	2.87	11.10	0.15	1.55	0.43	2.55	38.75
2	2,500	0.057	1	98.80	32.57	32.69	18.18	85.26	0.78	18.47	2.35	17.07	306.18
			2	57.71	22.36	28.90	1.15	46.12	0.78	10.98	1.74	14.11	183.87
			3	54.70	16.43	27.51	12.86	52.27	0.78	6.80	1.92	11.24	184.49
			4	57.71	22.36	28.90	12.86	52.27	0.78	10.98	1.92	14.11	201.90
			5	62.86	18.93	31.59	14.81	60.10	0.78	7.84	2.18	12.89	211.99
3	5,625	0.129	1	200.44	65.74	66.49	36.50	172.15	1.57	36.99	4.71	34.20	618.79
			2	117.07	45.14	58.79	2.31	93.13	1.57	21.99	3.49	28.27	371.76
			3	110.96	33.15	55.95	25.81	105.54	1.57	13.61	3.84	22.51	372.95
			4	117.07	45.14	58.79	25.81	105.54	1.57	21.99	3.84	28.27	408.02
			5	127.51	38.21	64.26	29.73	121.35	1.57	15.71	4.36	25.83	428.53
4	Variable by Subbasin	See Below	1	316.27	59.88	157.24	31.82	315.74	0.86	38.75	5.77	45.94	972.27
			2	184.73	41.11	139.02	2.02	170.81	0.86	23.03	4.27	37.97	603.82
			3	175.09	30.19	132.31	22.50	193.59	0.86	14.26	4.70	30.24	603.73
			4	184.73	41.11	139.02	22.50	193.59	0.86	23.03	4.70	37.97	647.51
			5	201.21	34.80	151.96	25.92	222.57	0.86	16.45	5.34	34.69	693.80
5A	21,780 & excess at ~68% consumptive using 3,000 gpd	0.500	1	2,339.43	800.92	757.75	463.84	2,089.40	20.29	478.03	60.88	441.95	7,452.50
			2	1,366.39	549.92	669.96	29.41	1,130.33	20.29	284.11	45.10	365.29	4,460.81
			3	1,295.08	403.88	637.62	328.08	1,281.04	20.29	175.88	49.61	290.88	4,482.37
			4	1,366.39	549.92	669.96	328.08	1,281.04	20.29	284.11	49.61	365.29	4,914.70
			5	1,488.31	465.49	732.34	377.86	1,472.85	20.29	202.94	56.37	333.72	5,150.18
5B	21,780	0.500	1	725.83	237.20	241.26	131.18	621.33	5.64	132.77	16.91	122.75	2,234.85
			2	423.94	162.86	213.31	8.32	336.13	5.64	78.91	12.53	101.45	1,343.08
			3	401.81	119.61	203.01	92.79	380.95	5.64	48.85	13.78	80.79	1,347.22
			4	423.94	162.86	213.31	92.79	380.95	5.64	78.91	13.78	101.45	1,473.61
			5	461.76	137.86	233.17	106.87	437.99	5.64	56.36	15.66	92.69	1,547.98
6	21,780 & excess at ~68% consumptive using 5,000 gpd	0.500	1	3,899.04	1,334.87	1,262.92	773.07	3,482.33	33.82	796.72	101.47	736.59	12,420.83
			2	2,277.32	916.53	1,116.61	49.02	1,883.88	33.82	473.52	75.16	608.81	7,434.68
			3	2,158.47	673.14	1,062.70	546.81	2,135.07	33.82	293.13	82.68	484.79	7,470.61
			4	2,277.32	916.53	1,116.61	546.81	2,135.07	33.82	473.52	82.68	608.81	8,191.16
			5	2,480.51	775.82	1,220.57	629.77	2,454.76	33.82	338.23	93.95	556.20	8,583.63

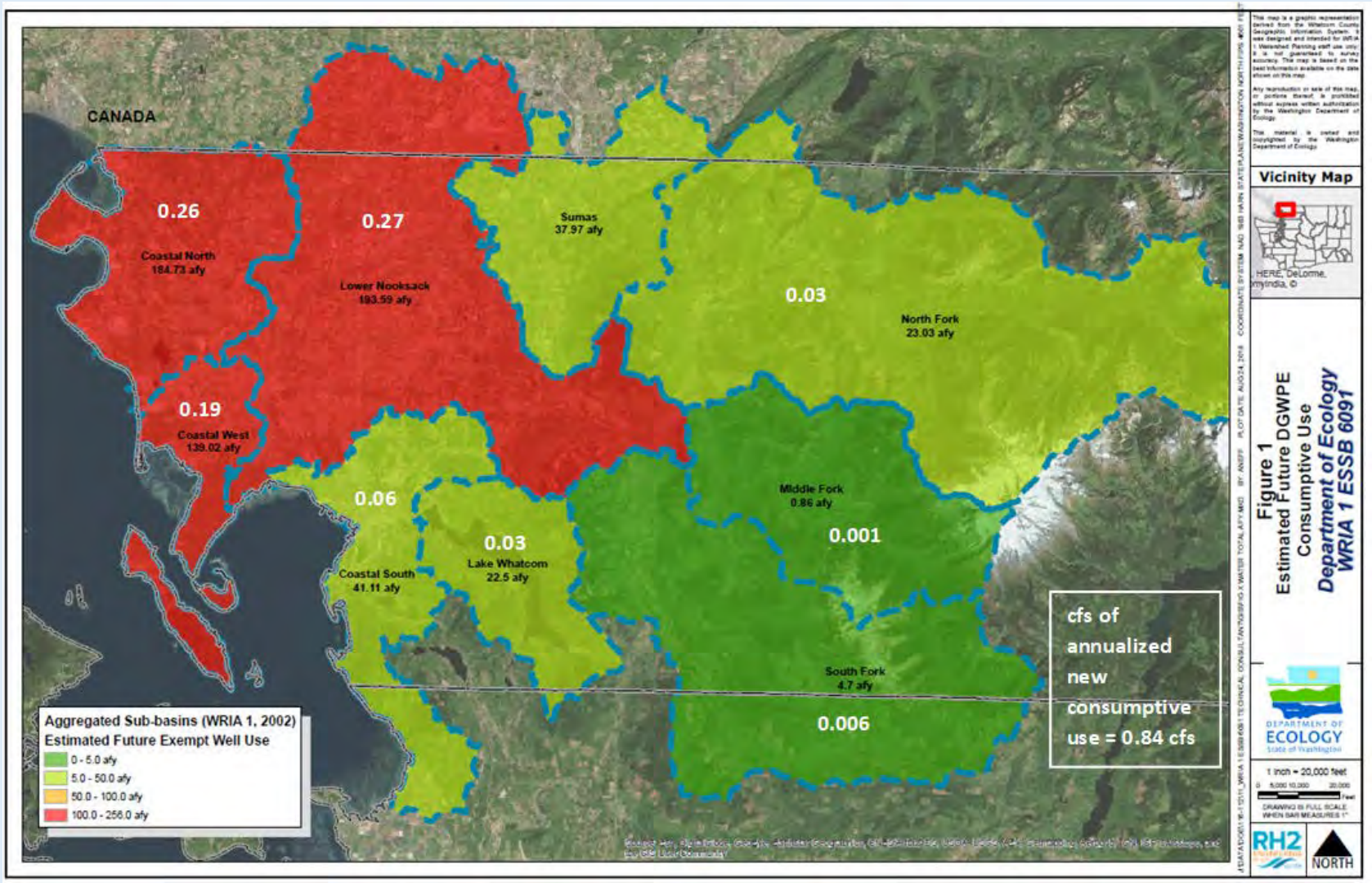
Scenario 4	Acres Irrigated by Subbasin	0.211	0.116	0.322	0.111	0.248	0.064	0.136	0.161	0.178

Scenario Descriptions:

Scenario 1	One home and no outdoor irrigation
Scenario 2	One home and 50'x50' outdoor irrigation
Scenario 3	One home and 75'x75' outdoor irrigation
Scenario 4	One home and results of irrigated acreage analysis by aggregated subbasin (modified mean)
Scenario 5A	3,000 gpd used for one home and 1/2 acre (66'x330') outdoor irrigation, using WST and PU recommend
Scenario 5B	One home and 1/2 acre of outdoor irrigation, using strictly Ecology guidance for consumptive use
Scenario 6	5,000 gpd used for one home and 1/2 acre (66'x330') outdoor irrigation, using WST and PU recommend

WRIA 1 then calculated suite of potential outcomes based on matrix of possible scenarios.

WRIA 1 concluded consumptive use from new domestic uses over 20-year horizon will likely be about 647 AF/year (equal to about 0.9 cfs), apportioned out by subbasin based on expected new well locations.

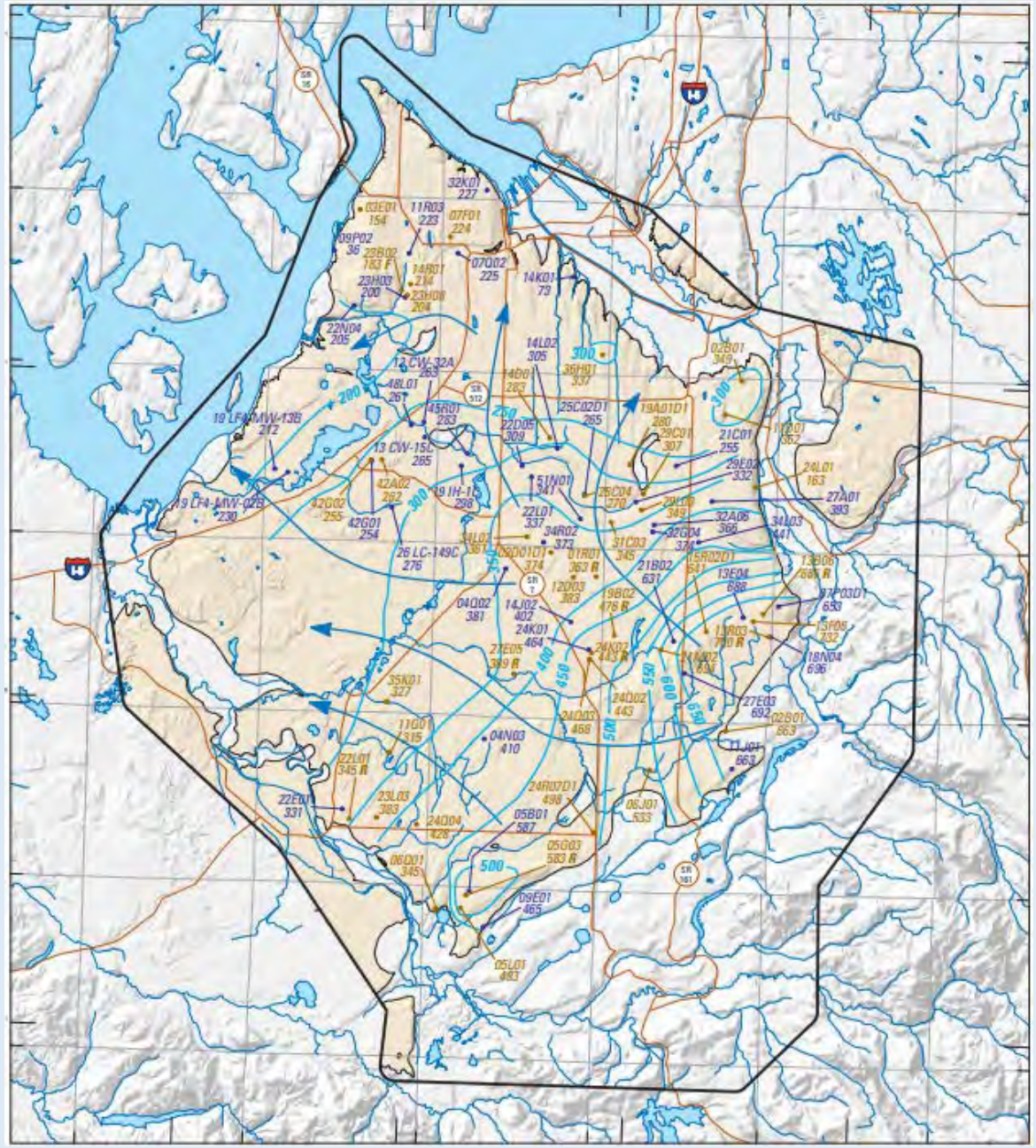


Related Considerations

When & Where Consumptive Use Impacts Will Occur

- ESSB 6091 requires high priority offset projects to replace 20-year water use in-time and in same subbasin.
- Estimating timing of groundwater impacts on streams is complicated due to lags between when a well is pumped and when those impacts propagate to a stream.
- If shallow well pumps an unconfined aquifer adjacent to a stream, pumping effects can be almost instantaneous. However, if well pumps aquifer further from stream, smaller effects can occur over longer periods.

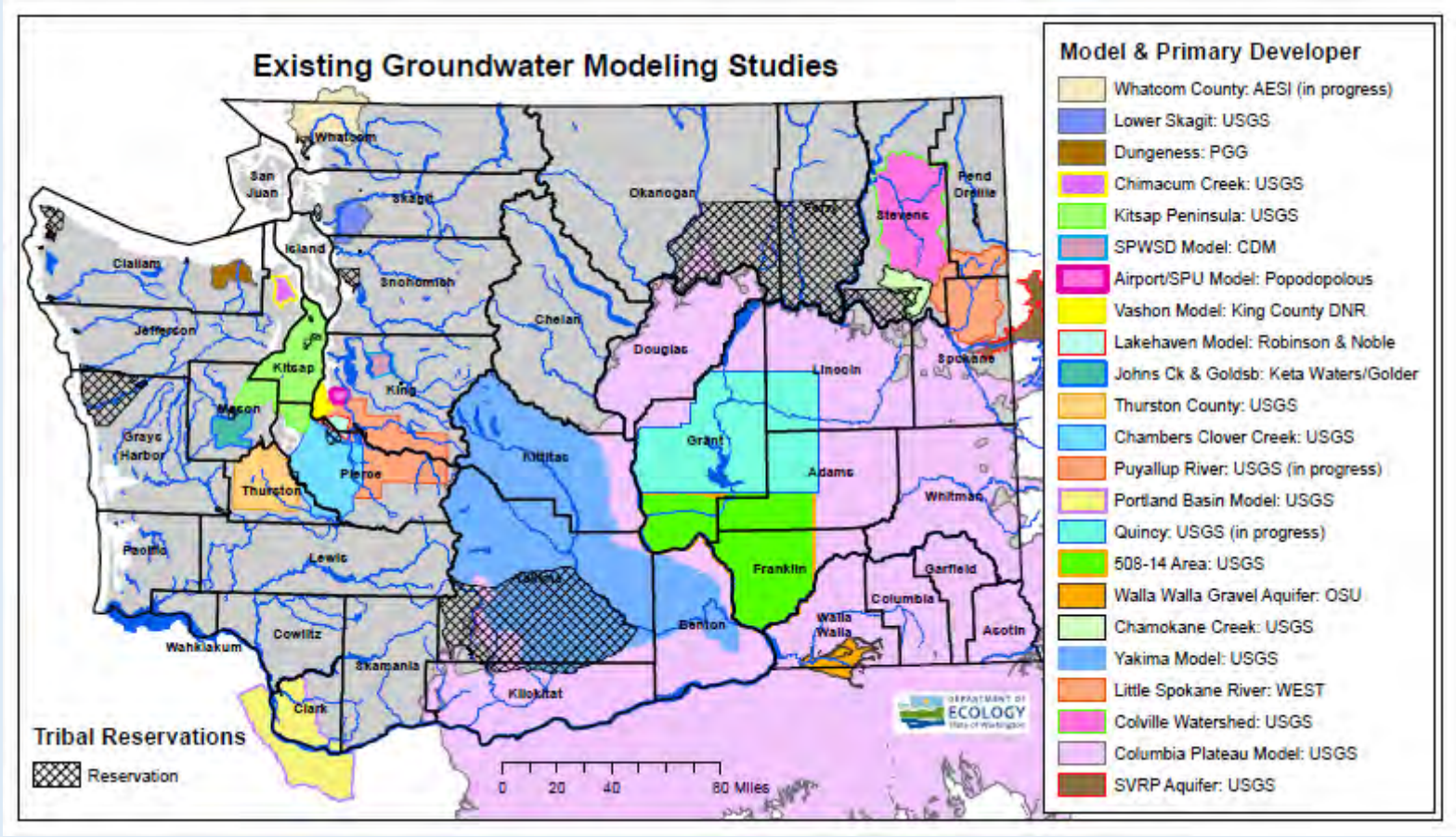
In the real world, groundwater and surface water interconnections are complicated by precipitation patterns, topography, geology, aquifer parameters, impervious surfaces, water use, and many other considerations.



USGS SIR 2010-5055

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.

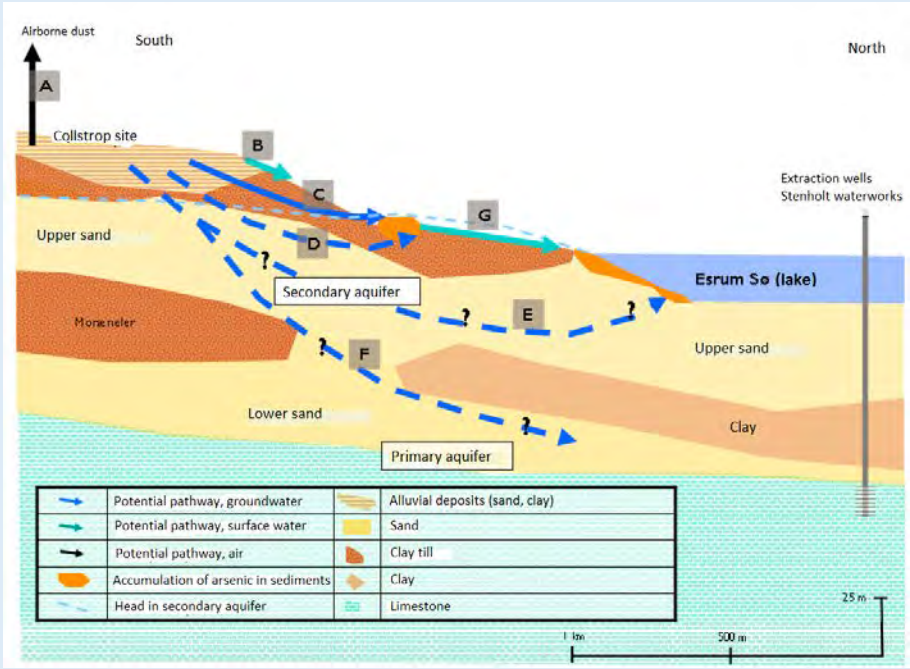


Conceptual Groundwater Understanding

Conceptual groundwater models provide overall hydrogeologic understanding.

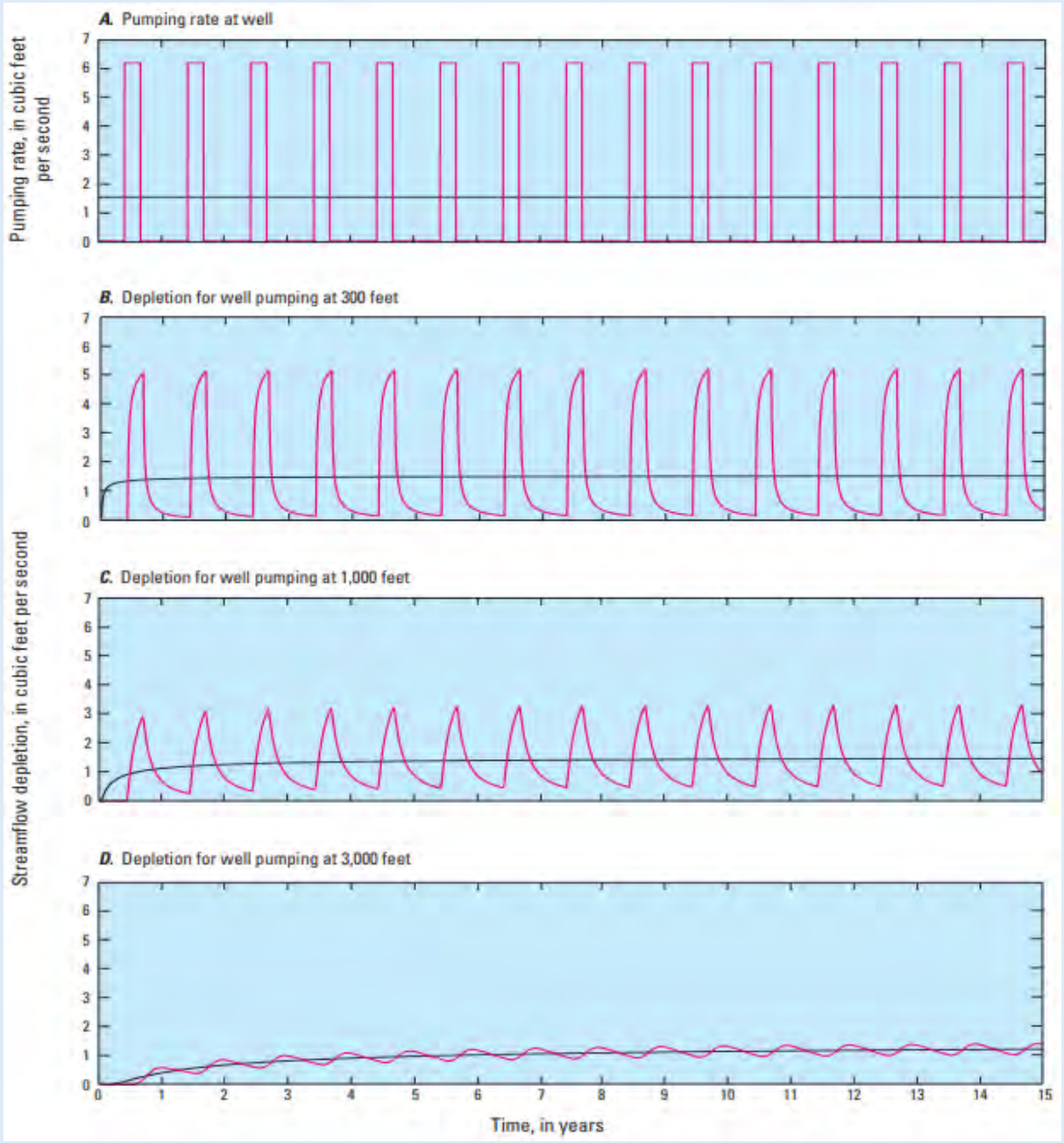
In water resources terms this generally considers:

- 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



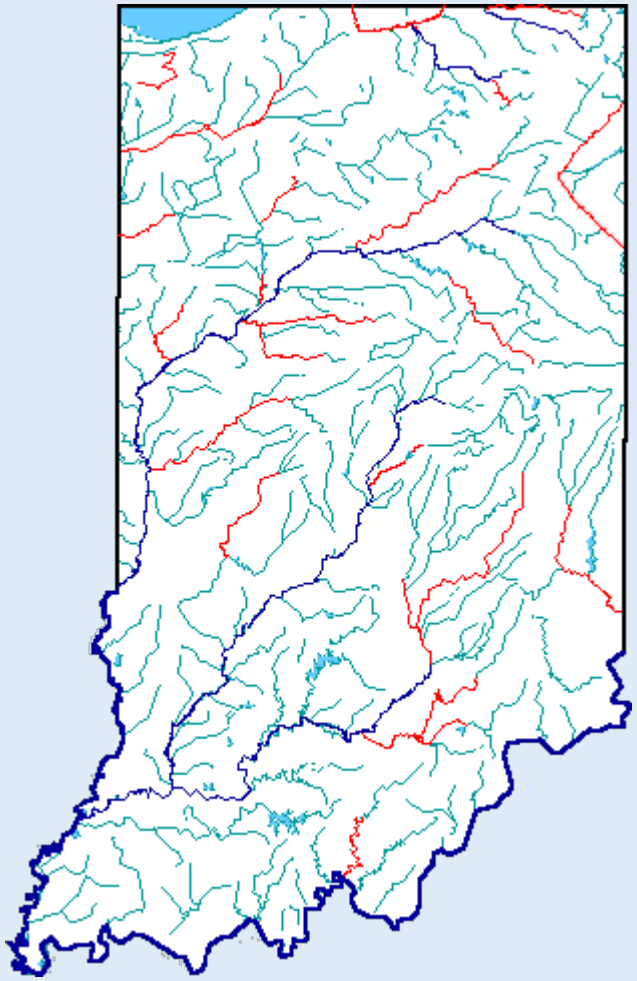
Seasonal vs. Steady State

- 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

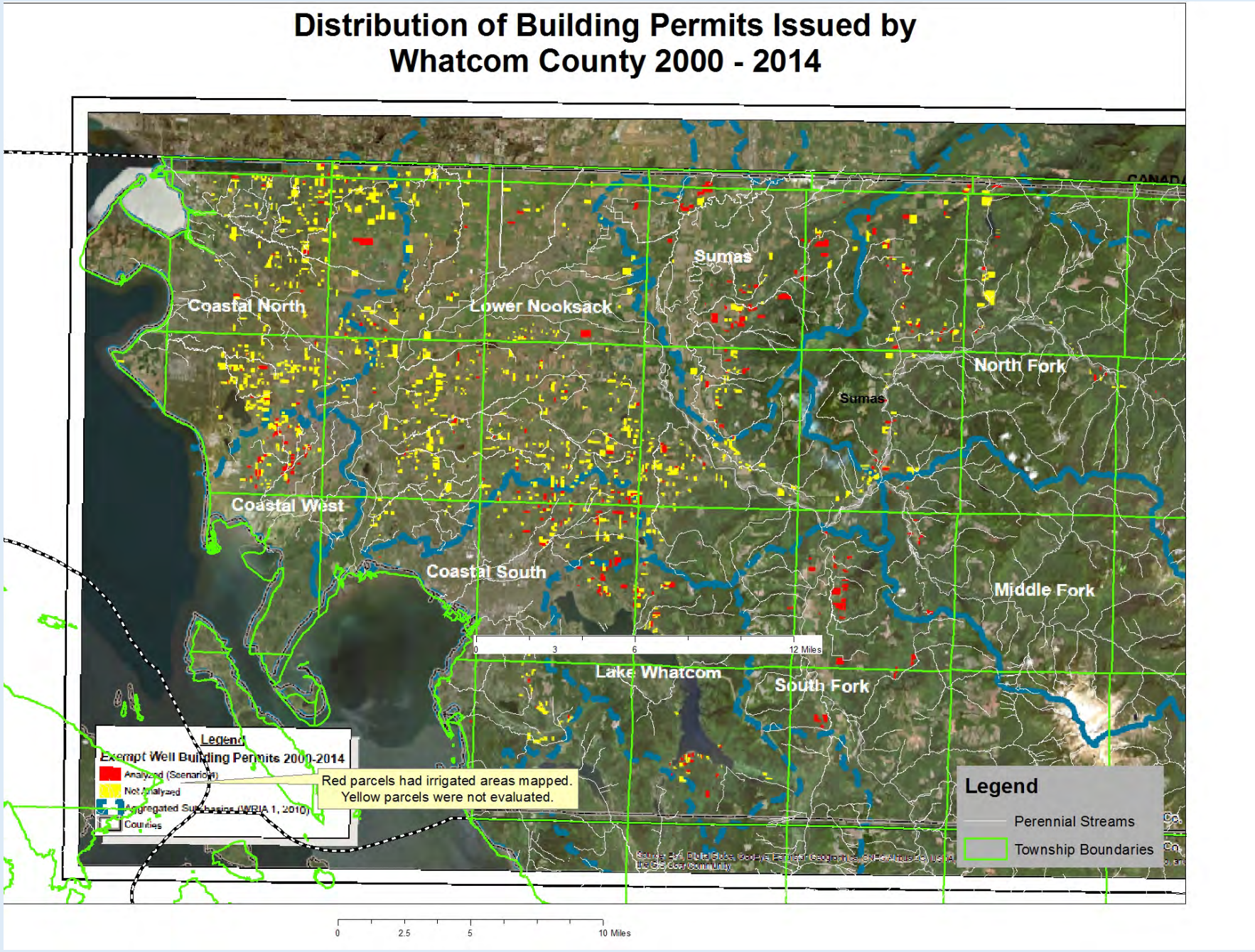
Spatial Considerations



- Even when planning groups assume steady state conditions, they will need to consider how 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 an important fish-bearing stream, another option is to conservatively assume depletion impacts are entirely attributed to streams closest to pumping. However, this likely would be a rare instance.

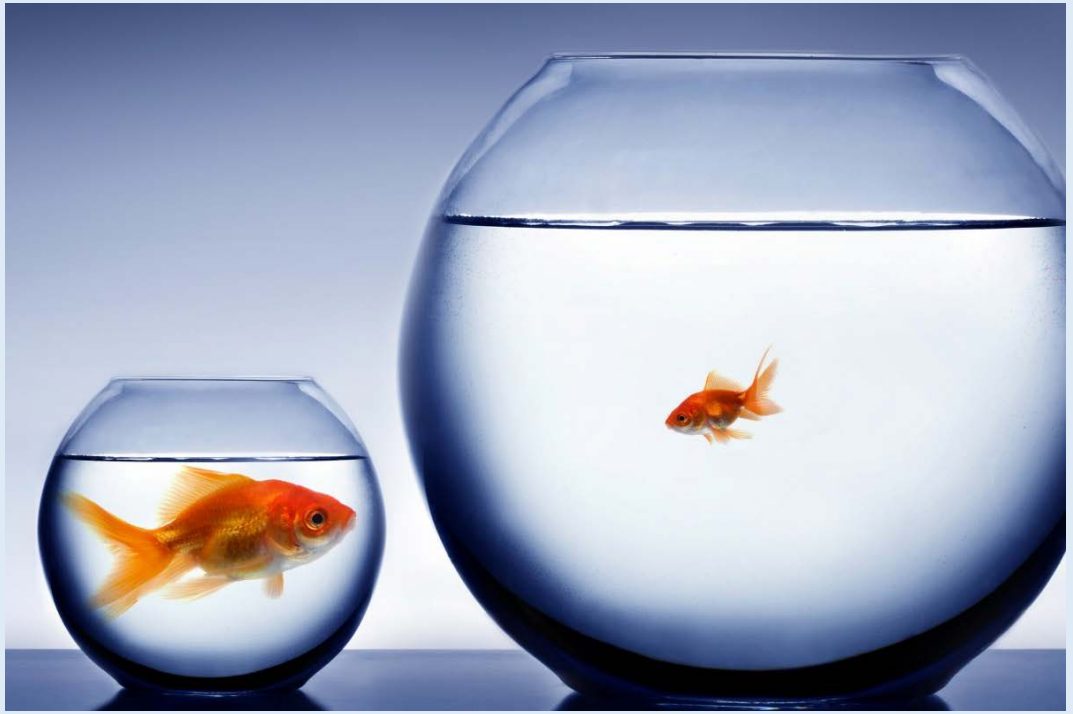
Most of permit exempt wells drilled in WRIA 1 2000-2014 were not located adjacent to perennial streams (both yellow and red parcels).

Steady-state depletion impacts are reasonable.



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
tcul461@ecy.wa.gov