

Estimated Freshwater Withdrawals in Washington, 2010



Scientific Investigations Report 2015–5037

Cover: City of Spokane, called the “Queen of the Inland Empire,” looking east.
Photograph taken by Ron Reiring, April 6, 2009. Used with permission.

Estimated Freshwater Withdrawals in Washington, 2010

By R.C. Lane and Wendy B. Welch

Scientific Investigations Report 2015–5037

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

U.S. Department of the Interior
SALLY JEWELL, Secretary

U.S. Geological Survey
Suzette M. Kimball, Acting Director

U.S. Geological Survey, Reston, Virginia: 2015

For more information on the USGS—the Federal source for science about the Earth, its natural and living resources, natural hazards, and the environment, visit <http://www.usgs.gov> or call 1–888–ASK–USGS.

For an overview of USGS information products, including maps, imagery, and publications, visit <http://www.usgs.gov/pubprod>

To order this and other USGS information products, visit <http://store.usgs.gov>

Any use of trade, firm, or product names is for descriptive purposes only and does not imply endorsement by the U.S. Government.

Although this information product, for the most part, is in the public domain, it also may contain copyrighted materials as noted in the text. Permission to reproduce copyrighted items must be secured from the copyright owner.

Suggested citation:

Lane, R.C., and Welch, W.B., 2015, Estimated freshwater withdrawals in Washington, 2010: U.S. Geological Survey Scientific Investigations Report 2015-5037, 48 p., <http://dx.doi.org/10.3133/sir20155037>.

ISSN 2328-0328 (online)

Contents

Abstract.....	1
Introduction.....	1
Purpose and Scope	2
Description of Study Area	2
Freshwater Withdrawals.....	2
Public Supply	8
Domestic.....	14
Irrigation.....	20
Livestock.....	26
Aquaculture	31
Industrial	35
Mining	40
Thermoelectric Power	44
Summary.....	44
References Cited.....	45
Appendix A. Methods and Data Sources.....	46

Figures

1. Map showing total water withdrawals, Washington, 2010	4
2. Map showing total groundwater withdrawals, Washington, 2010.....	5
3. Map showing total surface-water withdrawals, Washington, 2010	6
4. Map showing total per capita water withdrawals, Washington, 2010	7
5. Map showing public-supply water withdrawals, Washington, 2010	10
6. Map showing public-supply groundwater withdrawals, Washington, 2010	11
7. Map showing public-supply surface-water withdrawals, Washington, 2010.....	12
8. Map showing public-supply per capita water withdrawals, Washington, 2010.....	13
9. Map showing domestic water withdrawals and deliveries, Washington, 2010.....	16
10. Map showing domestic self-supplied groundwater withdrawals, Washington, 2010....	17
11. Map showing domestic public-supplied water deliveries, Washington, 2010.....	18
12. Map showing domestic per capita water withdrawals, Washington, 2010.....	19
13. Map showing irrigation water withdrawals, Washington, 2010	22
14. Map showing irrigation groundwater withdrawals, Washington, 2010	23
15. Map showing irrigation surface-water withdrawals, Washington, 2010.....	24
16. Map showing irrigation water application rates, Washington, 2010	25

Figures—Continued

17. Map showing livestock water withdrawals, Washington, 2010	28
18. Map showing livestock groundwater withdrawals, Washington, 2010.....	29
19. Map showing livestock surface-water withdrawals, Washington, 2010	30
20. Map showing aquaculture water withdrawals, Washington, 2010.....	32
21. Map showing aquaculture groundwater withdrawals, Washington, 2010.....	33
22. Map showing aquaculture surface-water withdrawals, Washington, 2010	34
23. Map showing industrial self-supplied water withdrawals, Washington, 2010	37
24. Map showing industrial self-supplied groundwater withdrawals, Washington, 2010.....	38
25. Map showing industrial self-supplied surface-water withdrawals, Washington, 2010.....	39
26. Map showing mining water withdrawals, Washington, 2010	41
27. Map showing mining groundwater withdrawals, Washington, 2010.....	42
28. Map showing mining surface-water withdrawals, Washington, 2010	43

Tables

1. Total water withdrawals, Washington, 2010	3
2. Public-supply water withdrawals, Washington, 2010	9
3. Domestic water withdrawals and deliveries, Washington, 2010.....	15
4. Irrigation water withdrawals, Washington, 2010	21
5. Livestock and aquaculture water withdrawals, Washington, 2010	27
6. Industrial self-supplied and mining water withdrawals, Washington, 2010.....	36

Conversion Factors

[Inch/pound to International System of Units]

Multiply	By	To obtain
Length		
mile (mi)	5,280	foot (ft)
	1,609	meter (m)
	1.6093	kilometer (km)
Area		
acre	43,560	square foot (ft ²)
	4,047	square meter (m ²)
	0.001562	square mile (mi ²)
Flow rate		
foot per year (ft/yr)	0.3048	meter per year (m/yr)
gallon per day (gal/d)	3.785	liter per day (L/d)
million gallons per day (Mgal/d)	1.121	thousand acre-feet per year
	0.001547	thousand cubic feet per second
	0.6944	thousand gallons per minute
	0.003785	million cubic meters per day
	1.3815	million cubic meters per year
	1.3815	billion cubic meters per year
billion gallons per day (Bgal/d)	1.3815	billion cubic meters per year
inch per year (in/yr)	25.4	millimeter per year (mm/yr)
thousand acre-feet per year	0.8921	million gallons per day (Mgal/d)
	0.001380	thousand cubic feet per second
	0.6195	thousand gallons per minute
	0.003377	million cubic meters per day

Some water relations in inch/pound units are shown below:

1 gallon (gal)	=	8.34 pounds
1 million gallons (Mgal)	=	3.07 acre-feet
1 cubic foot (ft ³)	=	62.4 pounds
	=	7.48 gallons
1 acre-foot (acre-ft)	=	325,851 gallons
	=	43,560 cubic feet
1 inch of rain	=	17.4 million gallons per square mile
	=	27,200 gallons per acre
	=	100 tons per acre

Estimated Freshwater Withdrawals in Washington, 2010

By R.C. Lane and Wendy B. Welch

Abstract

Every 5 years since 1950, the U.S. Geological Survey (USGS) has compiled data on the amount of water used in homes, businesses, industries, and farms throughout the State. This water-use data, combined with other related USGS information, has facilitated a unique understanding of the effects of human activity on the State's water resources. As water availability continues to emerge as an important issue in the 21st century, the need for consistent, long-term water-use data will increase to support wise use of this essential natural resource.

The amount of public- and self-supplied water used for domestic, irrigation, livestock, aquaculture, industrial, mining, and thermoelectric power was estimated for state, county, and eastern and western regions of Washington during calendar year 2010. Withdrawals of freshwater for offstream uses were estimated to be about 4,885 million gallons per day. The total estimated freshwater withdrawals for 2010 was approximately 15 percent less than the 2005 estimate because of decreases in irrigation and thermoelectric power withdrawals.

Introduction

Water use in Washington has evolved during the past century from meager domestic and stock water needs to the current complex requirements of public-supply systems, domestic-water users, large irrigation projects, industrial plants, and numerous other uses such as fish habitat and recreational activities. Although advances have been made in the ability to control, divert, and develop water supplies, it has been difficult to keep accurate accounts of the actual amounts of water being withdrawn and used. With increasing competition for water (especially during periods of drought), water-use information is of considerable value in determining water availability and in making sound resource-management decisions. Although Washington State collects some water-use information, no statewide program currently requires the general reporting of water-use information to the State. Since 1950, the U.S. Geological Survey (USGS) has, at 5-year intervals, compiled and published state-level data on the amount of water used in homes, businesses, industries, and farms in the United States. These national reports, in turn, are backed up by numerous state and regional water-use reports.

Purpose and Scope

This report presents regional, county, and state-level estimates of freshwater withdrawn for public supply, domestic, irrigation, livestock, aquaculture, industrial, mining, and thermoelectric power uses in Washington State during calendar year 2010. Withdrawals and deliveries of saline water or of freshwater for any other purposes are not shown.

Description of Study Area

The north-south-trending Cascade Range and the prevailing wind patterns divide Washington State into two regions with distinctly different climates. Western Washington has a predominantly marine climate with cool, dry summers and mild, wet winters. Precipitation averages about 70 inches per year (in/yr), but ranges from less than 20 to about 200 in/yr. Potential evaporation ranges from 20 to 25 in/yr, and generally is less than precipitation. Eastern Washington has characteristics of both continental and marine climates, with hot, dry summers and cold, wet winters. Precipitation averages about 20 in/yr, but ranges from less than 7 to about 40 in/yr. Potential evaporation ranges from 25 to 45 in/yr, and generally exceeds precipitation (Dion, 1985; Williams, 1986).

Freshwater Withdrawals

Freshwater withdrawals in Washington in 2010 totaled 4,885 million gallons per day (Mgal/d), with estimated county withdrawals ranging from 0.69 to 1,070 Mgal/d. Groundwater accounted for 33 percent (1,600 Mgal/d) and surface water accounted for 67 percent (3,285 Mgal/d) of the state total. The per capita withdrawal rate for Washington was 726 gallons per day (gal/d), with estimated county rates ranging from 113 to 12,100 gal/d (table 1; figs. 1, 2, 3, and 4). The methods and data sources used to prepare these estimates are discussed in appendix A.

Freshwater withdrawals in Western Washington totaled 1,295 Mgal/d, with estimated county withdrawals ranging from 0.69 to 260 Mgal/d. Groundwater accounted for 40 percent (514 Mgal/d) and surface water accounted for 60 percent (779 Mgal/d) of the regional total. The per capita withdrawal rate for Western Washington was 247 gal/d, with estimated county rates ranging from 113 to 2,080 gal/d.

Freshwater withdrawals in Eastern Washington totaled 3,590 Mgal/d, with county withdrawals ranging from 3.03 to 1,070 Mgal/d. Groundwater accounted for 30 percent (1,085 Mgal/d) and surface water accounted for 70 percent (2,505 Mgal/d) of the estimated regional total. The per capita withdrawal rate for Eastern Washington was about 2,400 gal/d, with estimated county rates ranging from 199 to 12,100 gal/d.

Table 1. Total water withdrawals, Washington, 2010.

[Values may not sum to totals due to independent rounding]

Region	County	Population (thousands)	Withdrawals (million gallons per day)			Per capita (gallons per day)
			Groundwater	Surface water	Total water	
Western	Clallam	71.4	15.1	5.91	21.0	294
	Clark	425	97.5	36.6	134	315
	Cowlitz	102	10.9	135	146	1,430
	Grays Harbor	72.8	21.1	5.90	27.0	371
	Island	78.5	6.06	2.97	9.03	115
	Jefferson	29.9	2.94	2.65	5.59	187
	King	1,930	80.3	179	260	134
	Kitsap	251	25.3	6.86	32.1	128
	Lewis	75.5	18.1	6.28	24.4	519
	Mason	60.7	7.80	36.0	43.8	722
	Pacific	20.9	5.15	4.07	9.22	441
	Pierce	795	74.6	96.6	171	215
	San Juan	15.8	1.02	0.76	1.78	113
	Skagit	117	17.5	27.8	45.3	388
	Skamania	11.1	1.26	21.8	23.0	2,080
	Snohomish	713	34.1	168	202	283
	Thurston	252	44.2	8.16	52.3	207
	Wahkiakum	3.98	0.22	0.47	0.69	173
	Whatcom	201	50.9	33.8	84.7	425
Eastern	Adams	18.7	193	24.2	217	11,600
	Asotin	21.6	4.80	0.11	4.91	227
	Benton	175	89.4	305	395	2,370
	Chelan	72.4	11.6	56.9	68.6	947
	Columbia	4.08	1.44	6.91	8.35	2,050
	Douglas	38.4	14.7	20.4	35.2	915
	Ferry	7.55	4.03	2.29	6.32	837
	Franklin	78.2	94.0	385	479	6,130
	Garfield	2.27	0.88	2.15	3.03	1,340
	Grant	89.1	227	848	1,070	12,100
	Kittitas	40.9	11.8	120	132	3,230
	Klickitat	20.3	30.6	9.98	40.6	2,000
	Lincoln	10.6	26.0	6.29	32.3	3,060
	Okanogan	41.1	34.0	64.7	98.7	2,400
	Pend Oreille	13.0	2.60	1.40	4.00	308
	Spokane	471	152	32.7	185	393
	Stevens	43.5	12.8	16.6	29.3	688
	Walla Walla	58.8	32.5	128	160	2,720
	Whitman	44.8	7.37	1.54	8.91	199
Yakima	243	134	474	608	2,500	
Washington	6,725	1,600	3,285	4,885	726	
Western Washington	5,230	514	779	1,295	247	
Eastern Washington	1,495	1,085	2,505	3,590	2,400	
Change ¹ 2005–10, in percent						
Washington	7	7	-14	-8	-24	
Western Washington	7	-5	-1	-3	-11	
Eastern Washington	7	14	-18	-10	-24	

¹Negative values indicate decrease; unsigned values indicate increase.

4 Estimated Freshwater Withdrawals in Washington, 2010

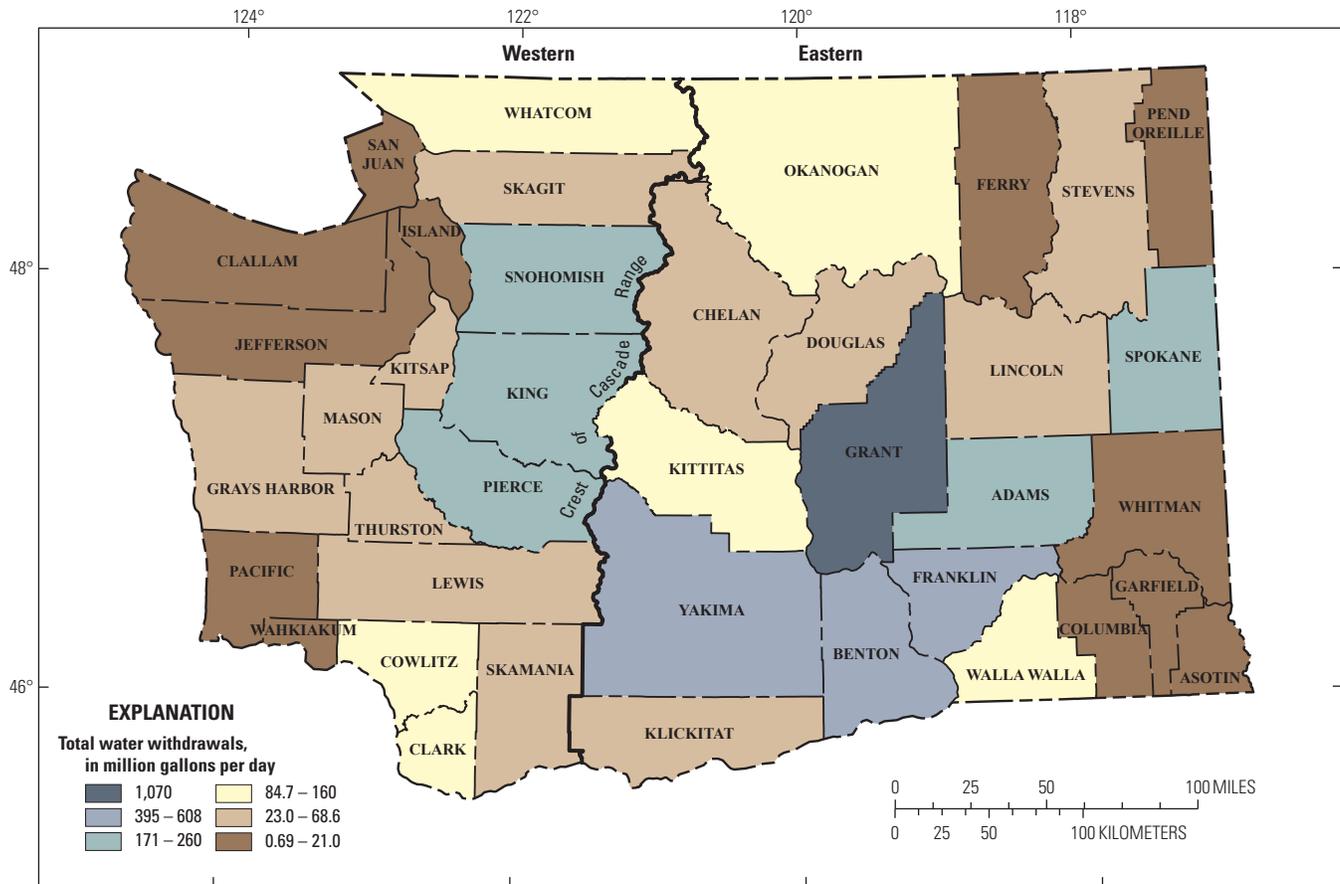


Figure 1. Total water withdrawals, Washington, 2010. Data ranges for each category reflect actual county values.

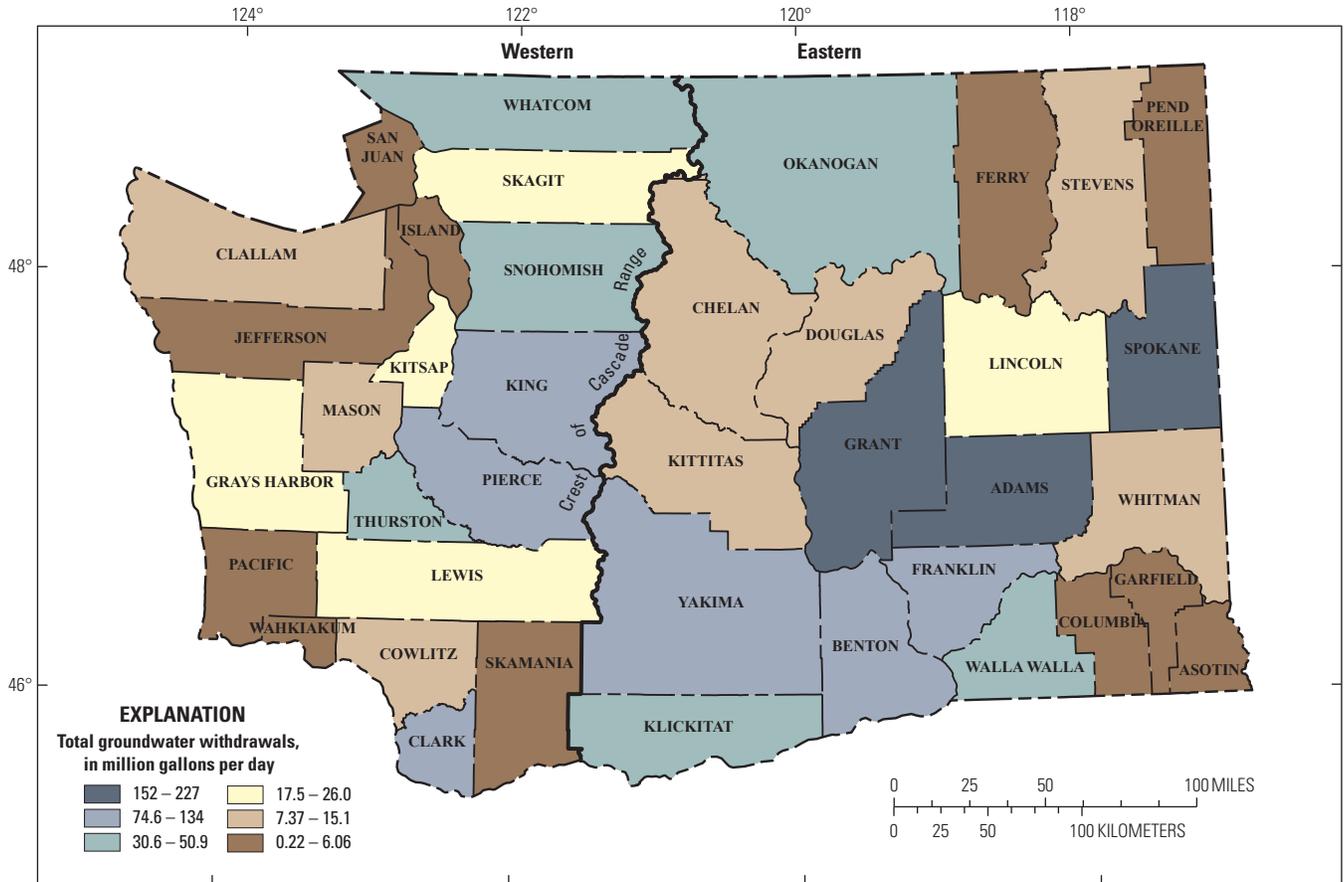


Figure 2. Total groundwater withdrawals, Washington, 2010. Data ranges for each category reflect actual county values.

6 Estimated Freshwater Withdrawals in Washington, 2010

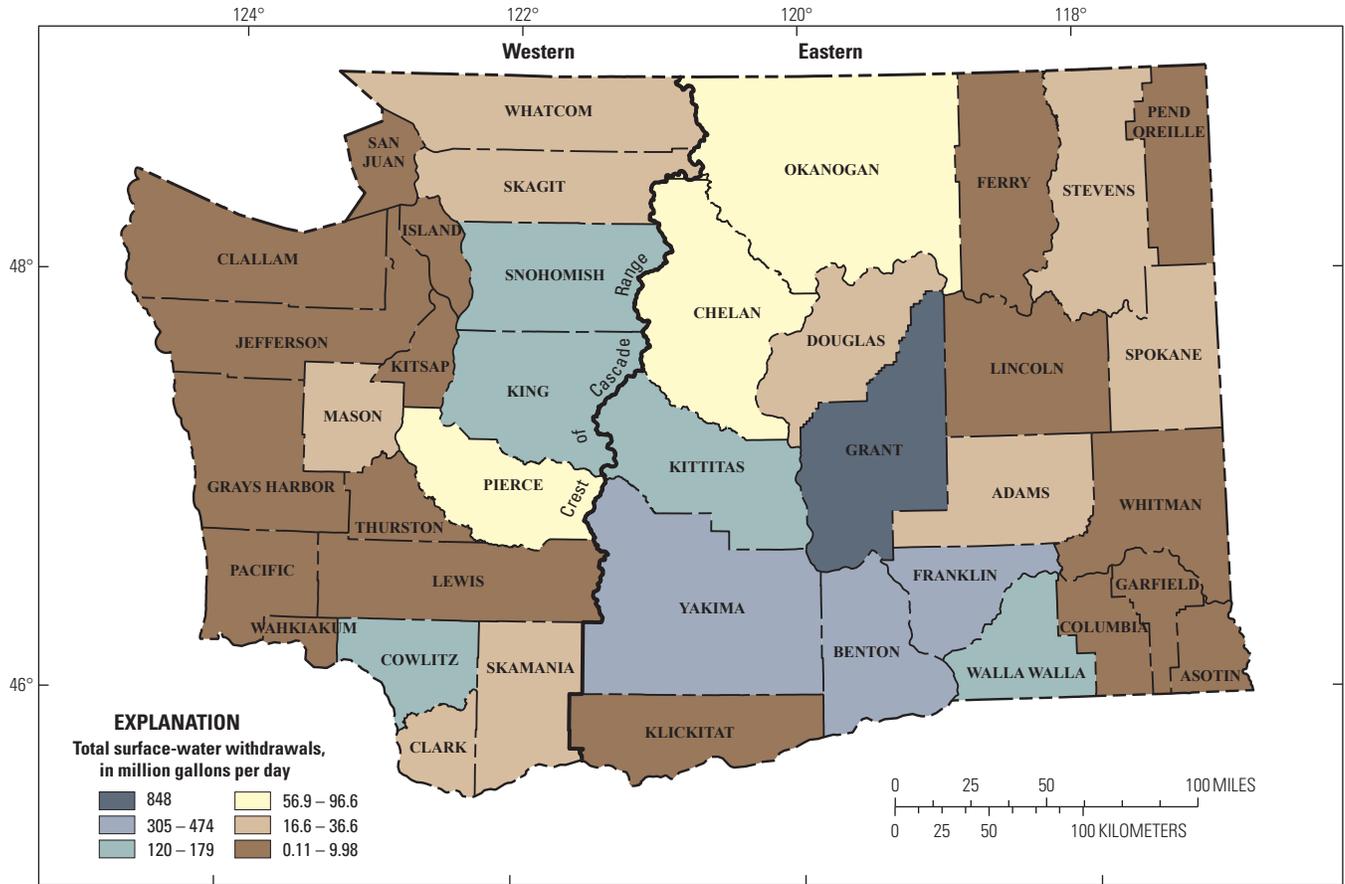


Figure 3. Total surface-water withdrawals, Washington, 2010. Data ranges for each category reflect actual county values.

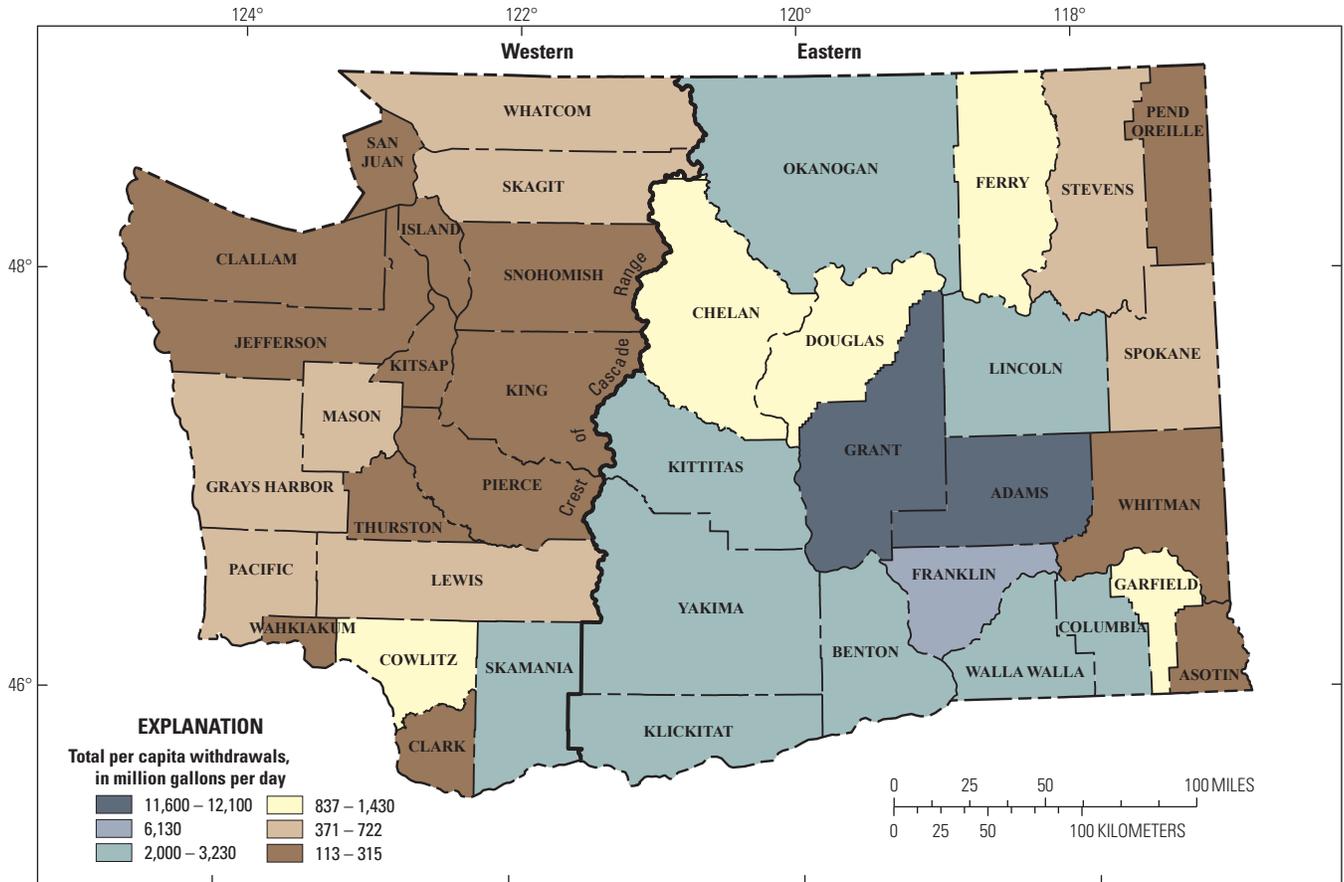


Figure 4. Total per capita water withdrawals, Washington, 2010. Data ranges for each category reflect actual county values.

Public Supply

Public-supply water withdrawals in Washington in 2010 totaled 910 Mgal/d, with estimated county withdrawals ranging from 0.42 to 234 Mgal/d. Groundwater accounted for 52 percent (471 Mgal/d) and surface water accounted for 48 percent (439 Mgal/d) of the state total. The public-supply per capita withdrawal rate for Washington was 159 gal/d, with estimated county rates ranging from about 88.7 to 446 gal/d (table 2; figs. 5, 6, 7, and 8).

Public-supply withdrawals in Western Washington totaled 625 Mgal/d, with estimated county withdrawals ranging from 0.42 to 234 Mgal/d. Groundwater accounted for 36 percent (227 Mgal/d) and surface water accounted for 64 percent (398 Mgal/d) of the regional total. The public-supply per capita withdrawal rate for Western Washington was 137 gal/d, with estimated county rates ranging from 88.7 to 247 gal/d.

Public-supply withdrawals in Eastern Washington totaled 285 Mgal/d, with estimated county withdrawals ranging from 0.49 to 118 Mgal/d. Groundwater accounted for 86 percent (244 Mgal/d) and surface water accounted for 14 percent

(about 41 Mgal/d) of the regional total. The public-supply per capita withdrawal rate for Eastern Washington was 247 gal/d, with estimated county rates ranging from 138 to 446 gal/d.



The Green River Headworks has been supplying water to the City of Tacoma since July 12, 1913. Undated picture courtesy of Tacoma Public Utilities, accessed February 25, 2015, at http://www.historylink.org/index.cfm?DisplayPage=output.cfm&file_id=5076.

Table 2. Public-supply water withdrawals, Washington, 2010.

[Values may not sum to totals due to independent rounding]

Region	County	Population (thousands)	Withdrawals (million gallons per day)			Per capita (gallons per day)
			Groundwater	Surface water	Total water	
Western	Clallam	53.9	6.24	0.63	6.87	127
	Clark	325	40.3	0	40.3	124
	Cowlitz	76.8	0.95	9.31	10.3	134
	Grays Harbor	54.7	4.19	3.62	7.81	143
	Island	69.0	3.60	2.52	6.12	88.7
	Jefferson	23.5	1.27	0.95	2.22	94.4
	King	1,885	61.7	172	234	124
	Kitsap	212	13.5	6.13	19.6	92.4
	Lewis	37.3	3.63	2.65	6.28	168
	Mason	37.9	4.19	0	4.19	111
	Pacific	17.8	0.71	2.15	2.86	160
	Pierce	740	48.4	51.1	99.5	134
	San Juan	8.81	0.26	0.65	0.91	103
	Skagit	93.1	0.73	22.2	23.0	247
	Skamania	6.56	0.64	0.49	1.13	172
	Snohomish	564	7.59	110	117	208
	Thurston	203	21.9	0	21.9	108
	Wahkiakum	3.28	0.08	0.34	0.42	128
Whatcom	156	6.68	13.1	19.8	127	
Eastern	Adams	12.7	5.66	0	5.66	446
	Asotin	20.9	4.39	0	4.39	210
	Benton	142	22.2	8.15	30.4	214
	Chelan	60.0	6.98	2.87	9.85	164
	Columbia	2.87	0.56	0	0.56	195
	Douglas	32.1	4.44	0	4.44	138
	Ferry	2.36	0.47	0.02	0.49	208
	Franklin	52.7	3.43	11.8	15.2	289
	Garfield	1.52	0.63	0	0.63	414
	Grant	60.3	21.6	0.54	22.2	368
	Kittitas	25.2	5.46	1.22	6.68	265
	Klickitat	14.9	3.49	0	3.49	234
	Lincoln	6.42	2.05	0	2.05	319
	Okanogan	20.3	4.84	0.42	5.26	259
	Pend Oreille	4.43	0.86	0.25	1.11	251
	Spokane	410	118	0	118	288
	Stevens	27.5	7.96	0	7.96	289
	Walla Walla	52.2	7.63	5.11	12.7	244
Whitman	38.2	5.62	0	5.62	147	
Yakima	168	17.7	10.3	28.1	167	
Washington	5,720	471	439	910	159	
Western Washington	4,565	227	398	625	137	
Eastern Washington	1,155	244	41	285	247	
Change ¹ 2005–10, in percent						
Washington	6	-13	-3	-8	-14	
Western Washington	6	-16	-2	-7	-13	
Eastern Washington	8	-9	-12	-10	-16	

¹Negative values indicate decrease; unsigned values indicate increase.

10 Estimated Freshwater Withdrawals in Washington, 2010

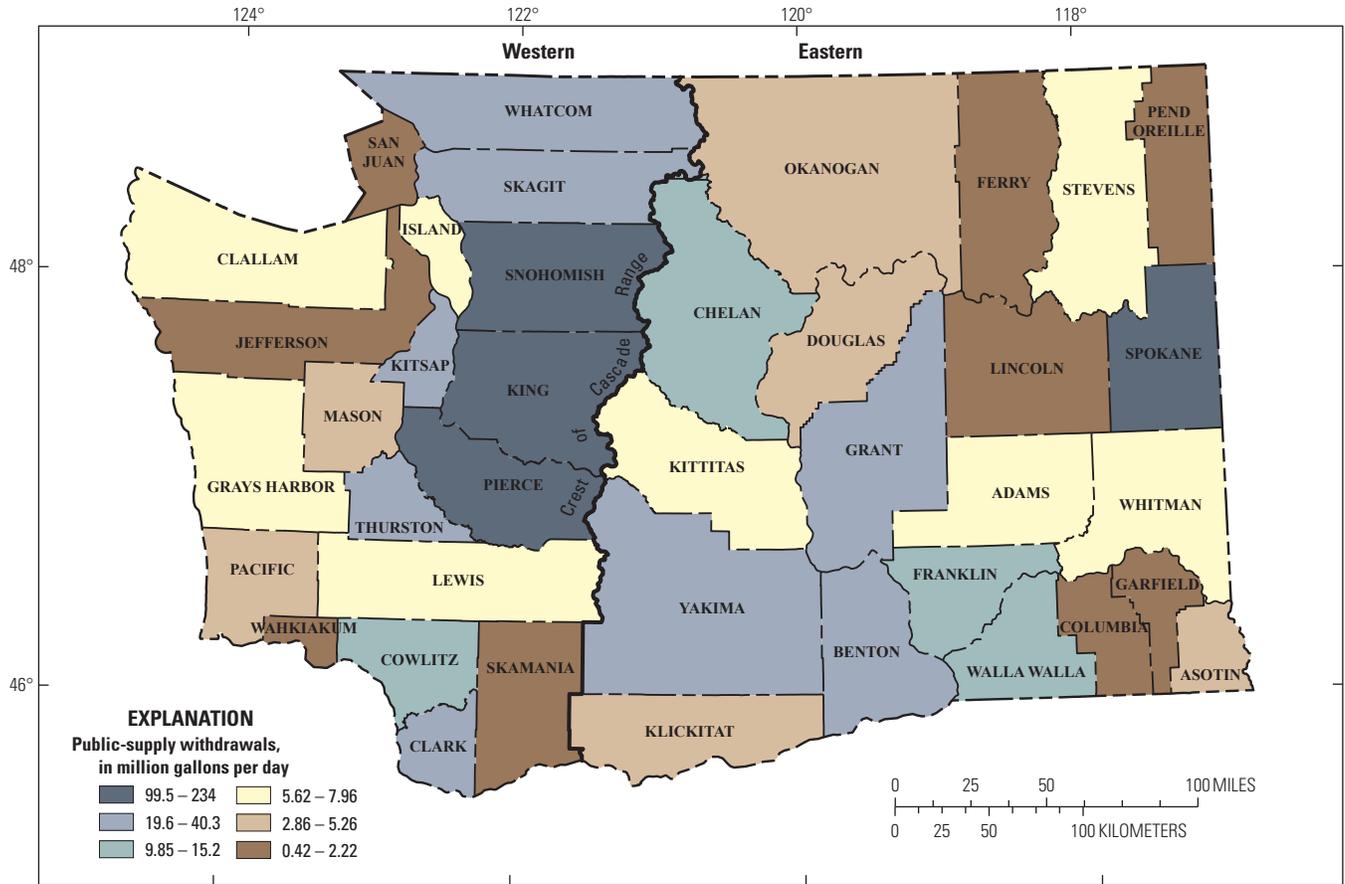


Figure 5. Public-supply water withdrawals, Washington, 2010. Data ranges for each category reflect actual county values.

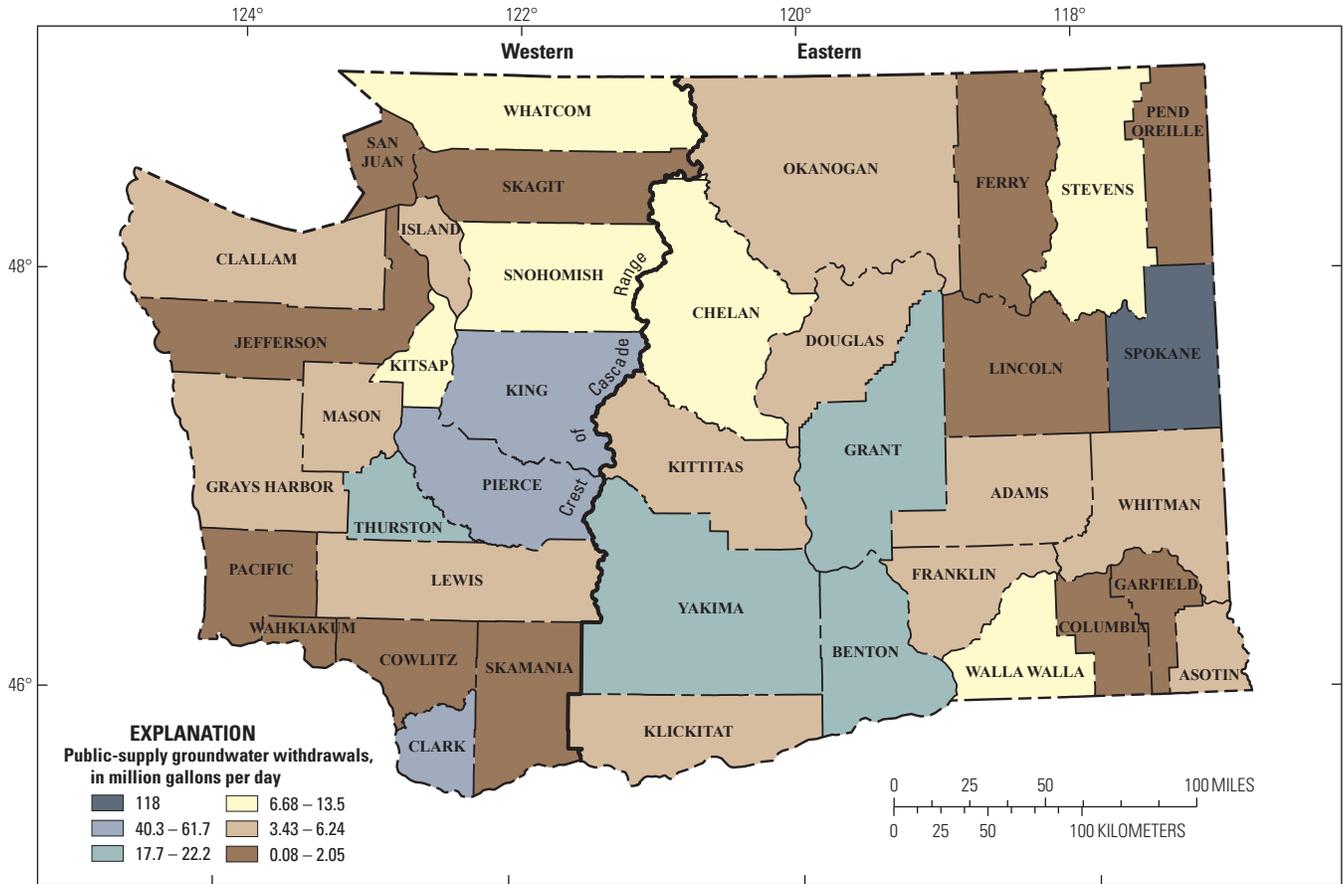


Figure 6. Public-supply groundwater withdrawals, Washington, 2010. Data ranges for each category reflect actual county values.

12 Estimated Freshwater Withdrawals in Washington, 2010

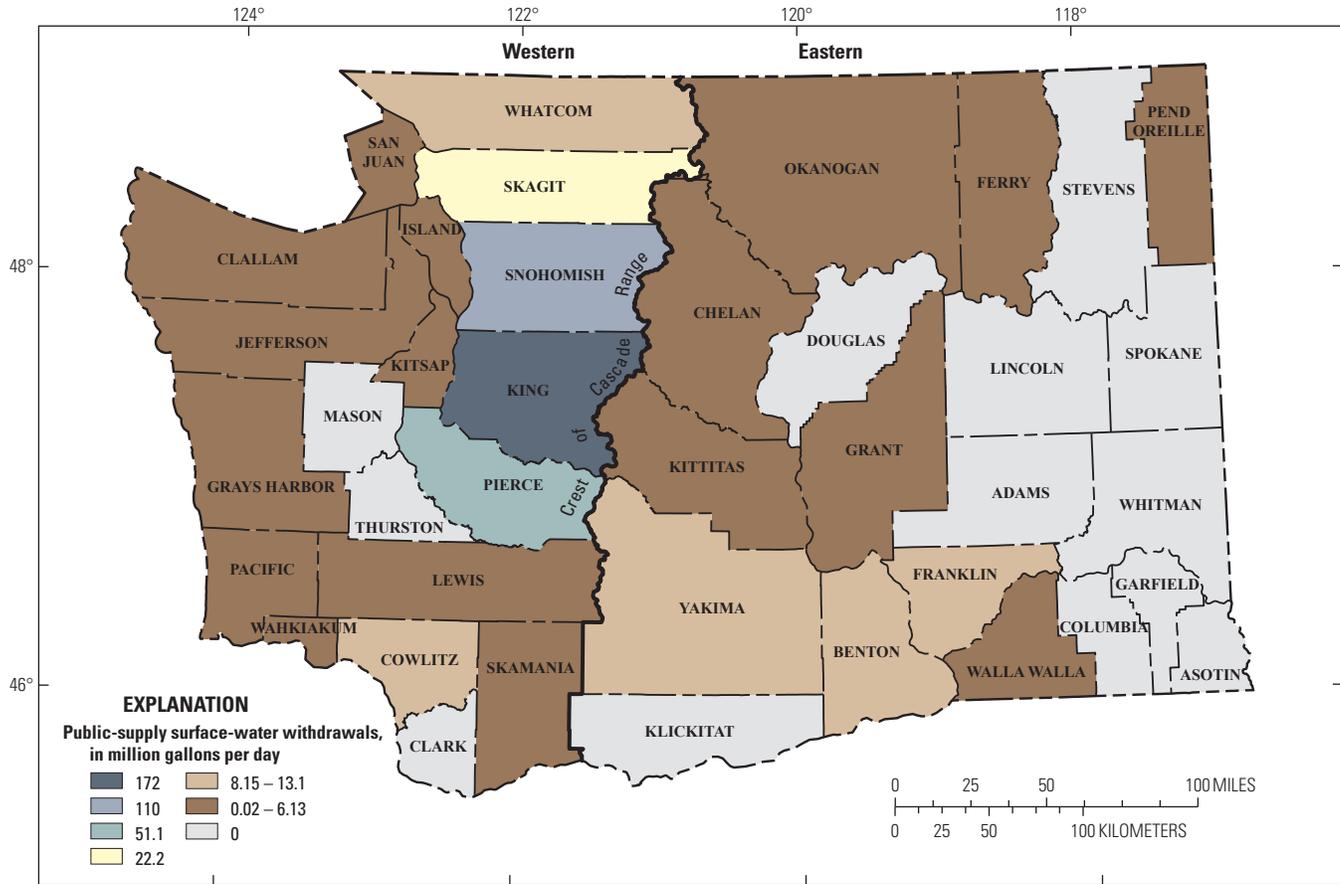


Figure 7. Public-supply surface-water withdrawals, Washington, 2010. Data ranges for each category reflect actual county values.

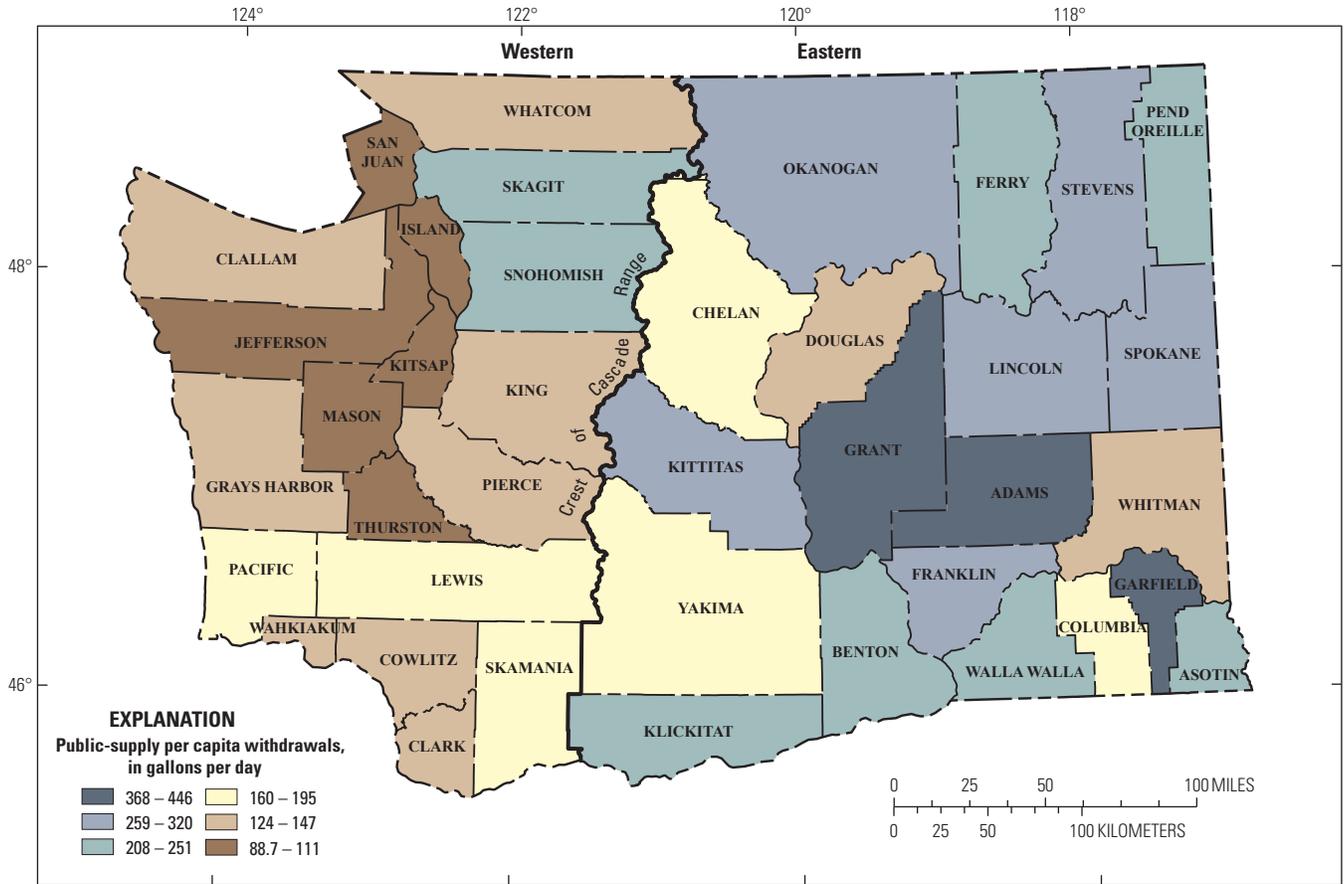


Figure 8. Public-supply per capita water withdrawals, Washington, 2010. Data ranges for each category reflect actual county values.

Domestic

Total domestic water withdrawals and deliveries in Washington for 2010 totaled 747 Mgal/d, with estimated county totals ranging from 0.24 to 213 Mgal/d. Self-supplied groundwater withdrawals accounted for 15 percent (113 Mgal/d) and public-supplied deliveries accounted for 85 percent (634 Mgal/d) of the state total. The total domestic per capita rate for Washington was 111 gal/d, with estimated county rates ranging from 60.3 to 234 gal/d (table 3; figs. 9, 10, 11, 12).

Domestic water withdrawals and deliveries in Western Washington totaled 520 Mgal/d, with estimated county totals ranging from 0.24 to 213. Self-supplied groundwater

accounted for 12 percent (63 Mgal/d) and public-supplied water accounted for 88 percent (458 Mgal/d) of the regional total. The total domestic per capita rate for Western Washington was 100 gal/d, with estimated county rates ranging from 60.3 to 117 gal/d.

Domestic water withdrawals and deliveries in Eastern Washington totaled 226 Mgal/d, with estimated county totals ranging from 0.31 to 87.2 Mgal/d. Self-supplied groundwater accounted for 22 percent (50 Mgal/d) and public-supplied water accounted for 78 percent (176 Mgal/d) of the regional total. The total domestic per capita rate for Eastern Washington was 151 gal/d, with estimated county rates ranging from 82.2 to 234 gal/d.



Urban farming is a growing market in many neighborhoods throughout the City of Spokane. Photograph from Ben Stuckart Blog, April 3, 2014, accessed February 24, 2015, at <https://beta.spokanecity.org/blog/2014/04/03/urban-farming-approved-in-city-of-spokane/>.

Table 3. Domestic water withdrawals and deliveries, Washington, 2010.

[Values may not sum to totals due to independent rounding. Mgal/d, million gallons per day; gal/d, gallon per day]

Region	County	Self-supplied			Public-supplied			Total domestic		
		Population (thousands)	Groundwater withdrawals (Mgal/d)	Per capita (gal/d)	Population (thousands)	Deliveries (Mgal/d)	Per capita (gal/d)	Population (thousands)	Withdrawals plus deliveries (Mgal/d)	Per capita (gal/d)
Western	Clallam	17.5	1.58	90.4	53.9	4.88	90.5	71.4	6.46	90.5
	Clark	101	10.3	102	325	33.0	102	425	43.3	102
	Cowlitz	25.6	2.56	99.8	76.8	7.66	99.8	102	10.2	100
	Grays Harbor	18.1	1.75	96.6	54.7	5.28	96.5	72.8	7.03	96.6
	Island	9.48	0.69	72.9	69.0	5.02	75.7	78.5	5.71	72.7
	Jefferson	6.36	0.54	84.9	23.5	1.99	84.6	29.9	2.53	84.7
	King	44.8	4.95	110	1,885	208	110	1,930	213	110
	Kitsap	39.2	3.28	83.6	212	17.7	83.5	251	21.0	83.6
	Lewis	38.1	3.75	98.4	37.3	3.67	98.3	75.5	7.42	98.3
	Mason	22.8	2.16	94.6	37.9	3.59	94.8	60.7	5.75	94.7
	Pacific	3.08	0.36	117	17.8	2.09	117	20.9	2.45	117
	Pierce	55.2	5.19	94.1	740	69.6	94.0	795	74.8	94.1
	San Juan	6.96	0.58	83.3	8.81	0.73	82.9	15.8	1.31	83.1
	Skagit	23.8	2.37	99.4	93.1	9.23	99.2	117	11.6	99.2
	Skamania	4.51	0.46	102	6.56	0.67	102	11.1	1.13	102
	Snohomish	150	13.6	91.1	564	51.4	91.2	713	65.0	91.2
	Thurston	49.4	4.04	81.7	203	16.6	81.8	252	20.6	81.7
	Wahkiakum	0.70	0.04	57.1	3.28	0.20	61.0	3.98	0.24	60.3
	Whatcom	45.4	4.61	102	156	15.8	101	201	20.4	101
Eastern	Adams	6.03	0.68	113	12.7	1.44	113	18.7	2.12	113
	Asotin	0.70	0.10	143	20.9	2.93	140	21.6	3.03	140
	Benton	33.4	4.60	138	142	19.5	138	175	24.1	138
	Chelan	12.4	1.75	140	60.0	8.41	140	72.4	10.2	140
	Columbia	1.21	0.17	140	2.87	0.40	139	4.08	0.57	140
	Douglas	6.37	0.71	111	32.1	3.59	112	38.4	4.30	112
	Ferry	5.19	0.73	144	2.36	0.34	144	7.55	1.09	144
	Franklin	25.4	3.12	123	52.7	6.47	123	78.2	9.59	123
	Garfield	0.75	0.10	133	1.52	0.21	138	2.27	0.31	137
	Grant	28.9	6.76	234	60.3	14.1	234	89.1	20.9	235
	Kittitas	15.7	2.02	129	25.2	3.25	129	40.9	5.27	127
	Klickitat	5.41	0.54	99.8	14.9	1.50	101	20.3	2.04	100
	Lincoln	4.15	0.71	171	6.42	1.09	170	10.6	1.80	170
	Okanogan	20.8	2.31	111	20.3	2.26	111	41.1	4.57	111
	Pend Oreille	8.57	1.53	179	4.43	0.79	178	13.0	2.32	178
	Spokane	61.6	11.4	185	410	75.8	185	471	87.2	185
	Stevens	16.0	2.26	141	27.5	3.89	141	43.5	6.15	141
	Walla Walla	6.54	0.83	127	52.2	6.63	127	58.8	7.46	127
	Whitman	6.61	0.54	81.8	38.2	3.14	82.3	44.8	3.68	82.2
Yakima	75.5	9.14	121	168	20.3	121	243	29.5	121	
Washington	1,005	113	113	5,720	634	111	6,725	747	111	
Western Washington	662	63	95	4,570	458	100	5,230	520	100	
Eastern Washington	341	50	147	1,155	176	153	1,495	226	151	
Change ¹ 2005–10, in percent										
Washington	11	31	18	6	13	6	7	15	8	
Western Washington	13	35	19	6	17	11	7	19	12	
Eastern Washington	7	27	18	8	2	-5	8	7	0.5	

¹Negative values indicate decrease; unsigned values indicate increase.

16 Estimated Freshwater Withdrawals in Washington, 2010

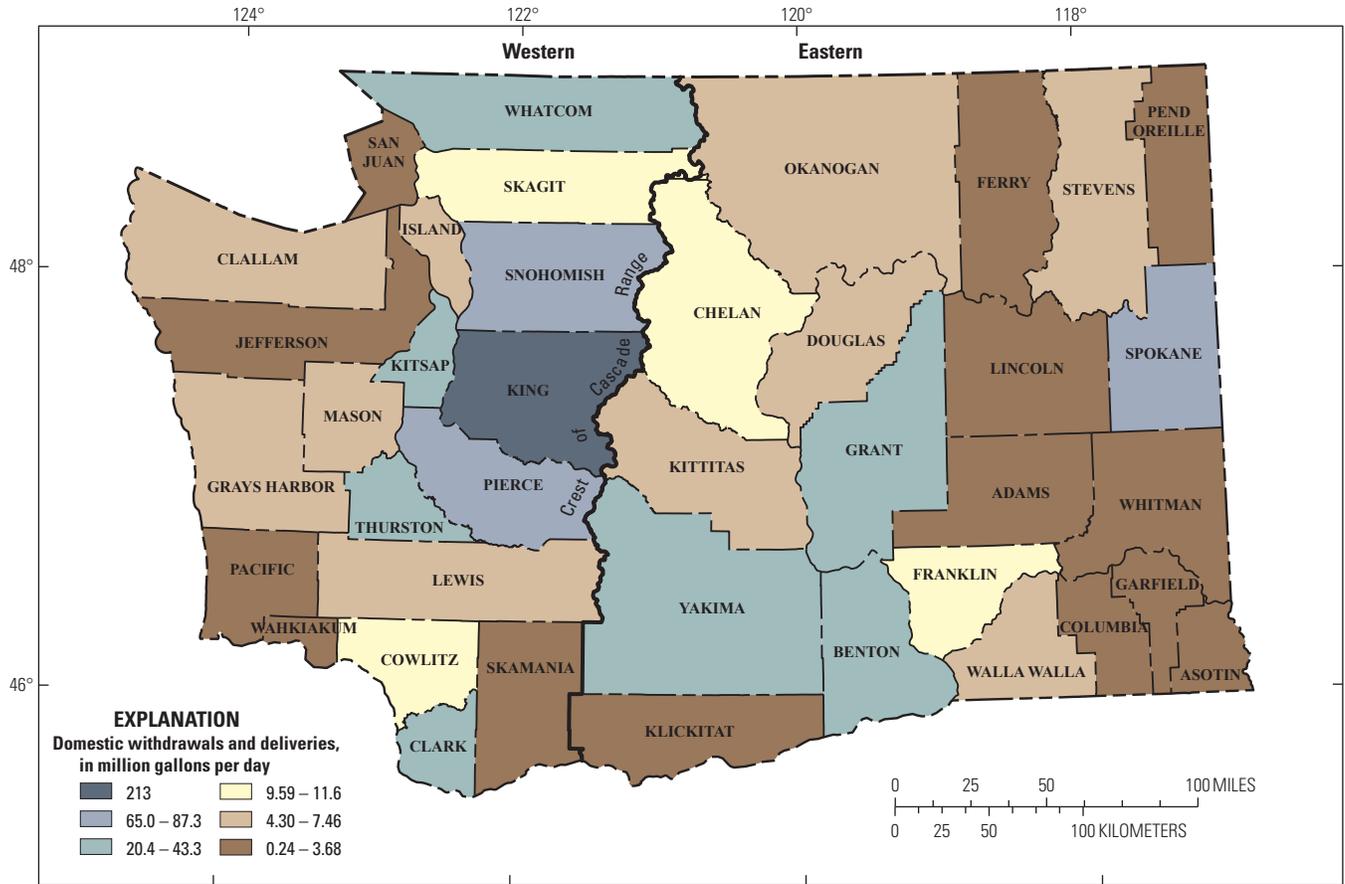


Figure 9. Domestic water withdrawals and deliveries, Washington, 2010. Data ranges for each category reflect actual county values.

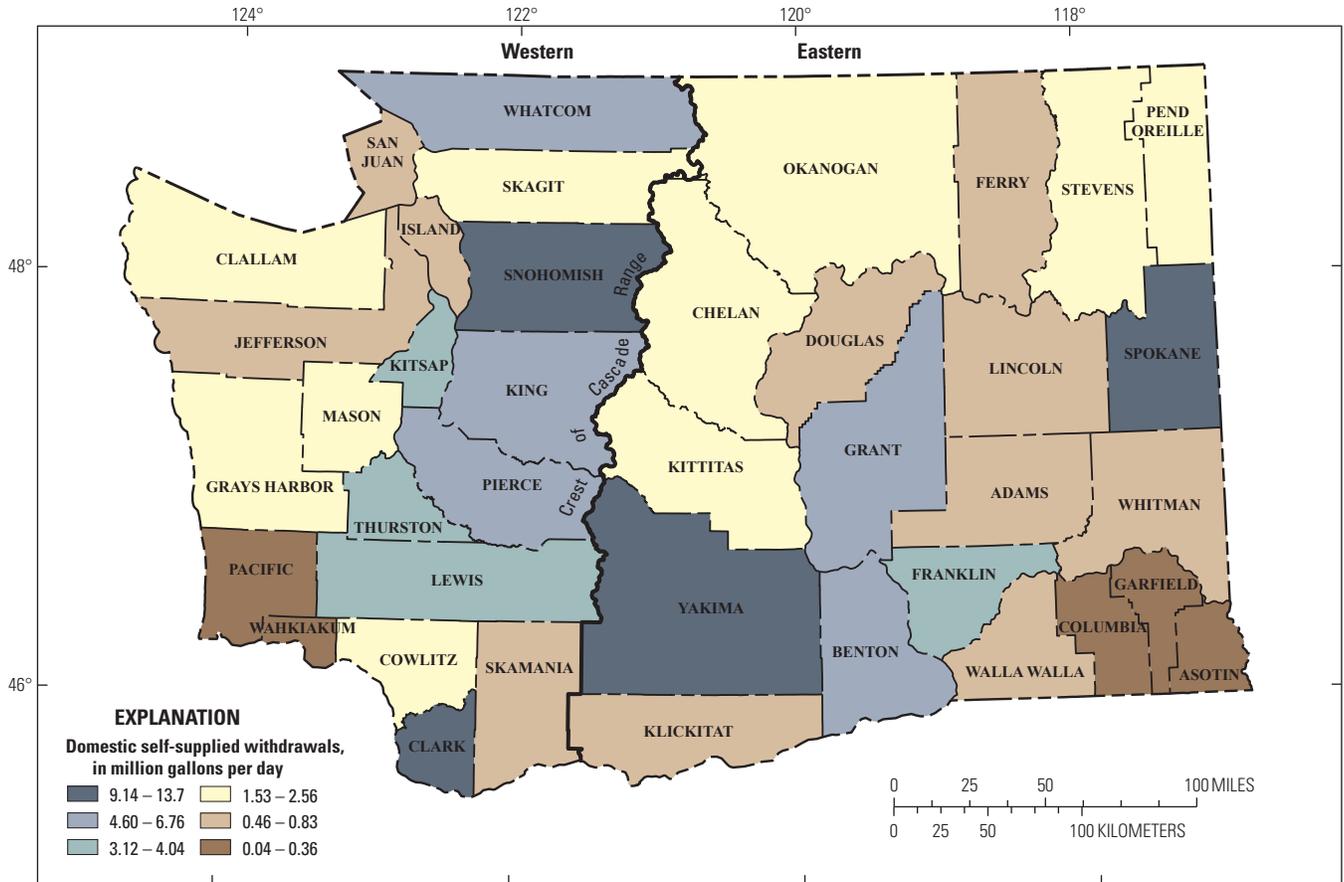


Figure 10. Domestic self-supplied groundwater withdrawals, Washington, 2010. Data ranges for each category reflect actual county values.

18 Estimated Freshwater Withdrawals in Washington, 2010

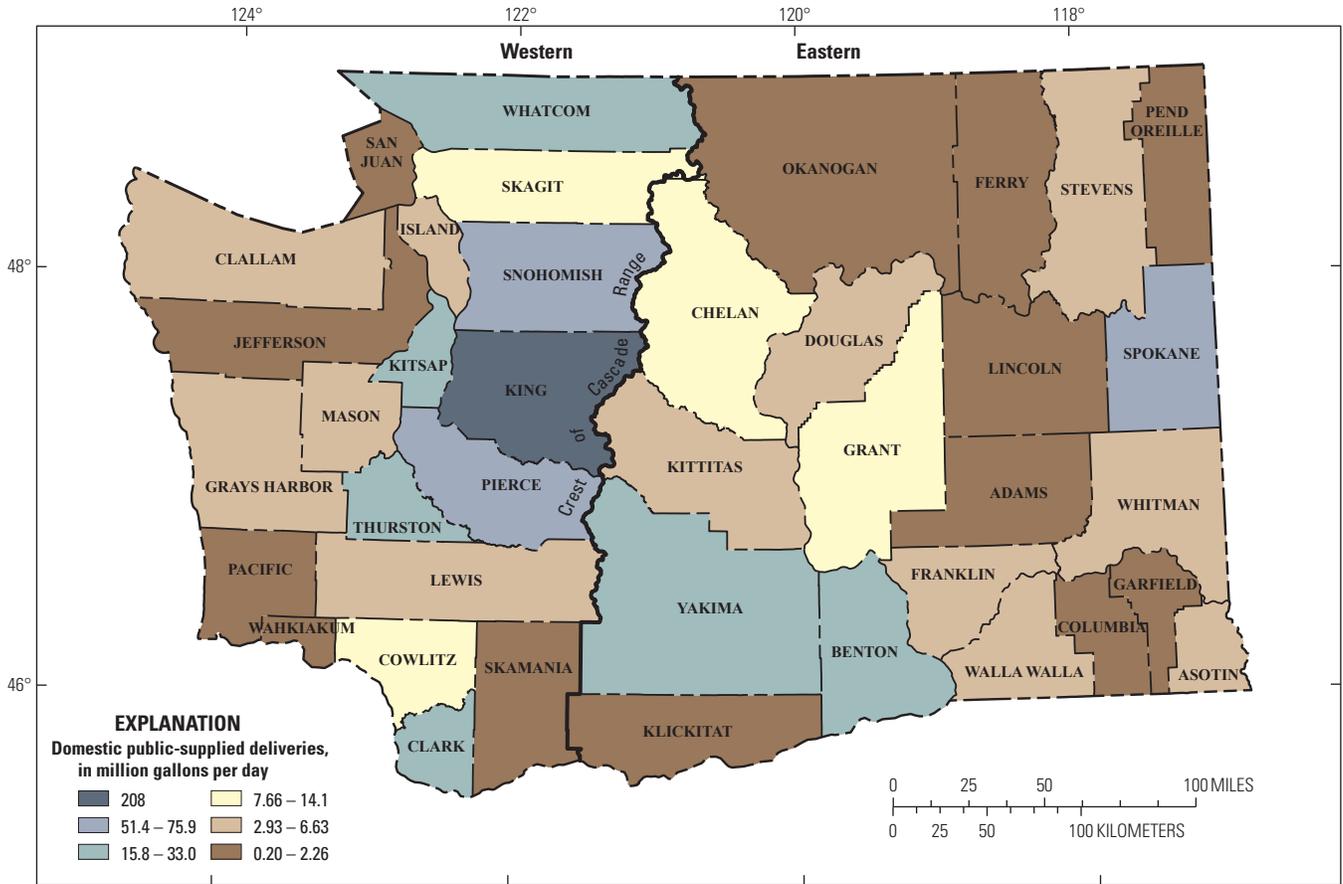


Figure 11. Domestic public-supplied water deliveries, Washington, 2010. Data ranges for each category reflect actual county values.

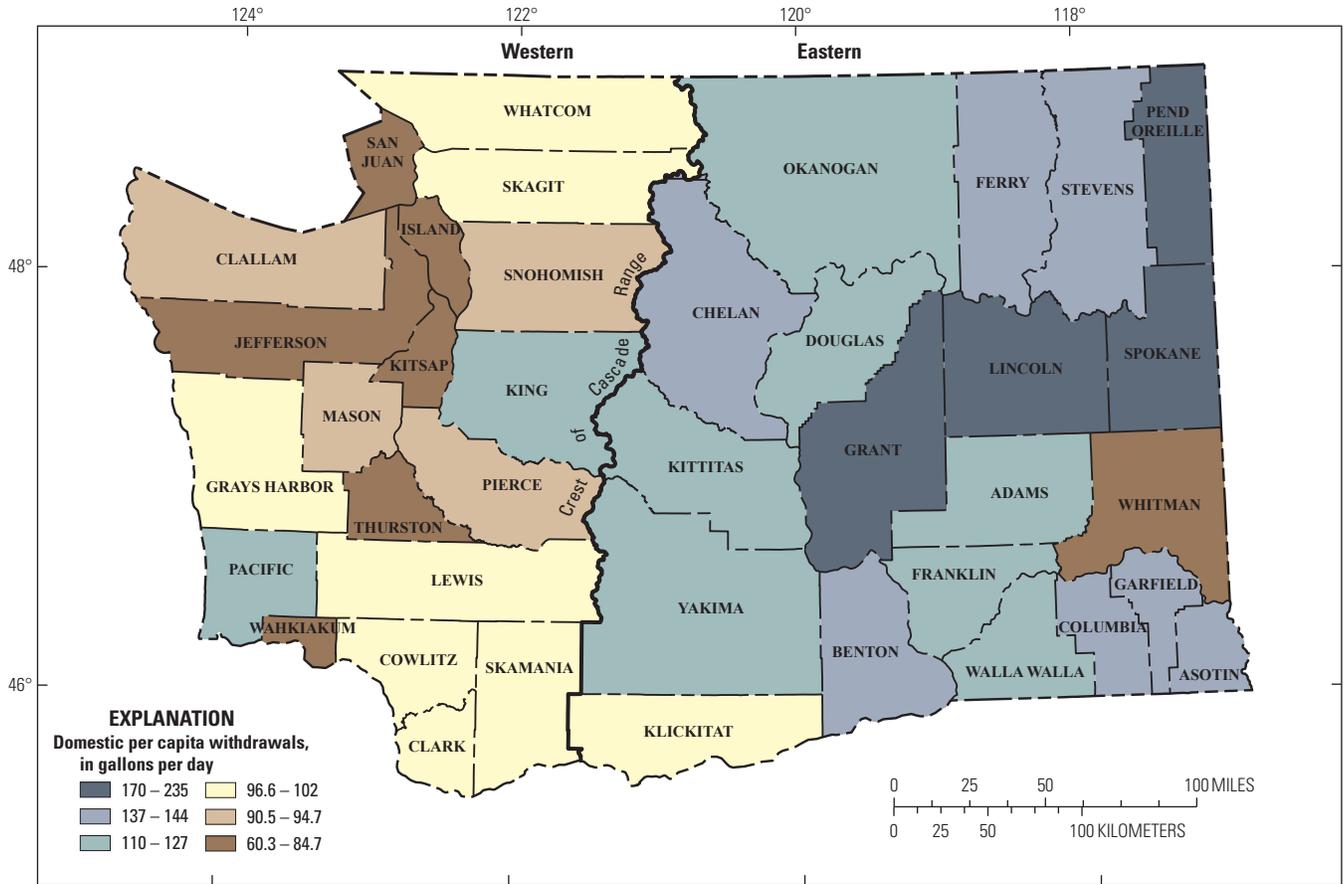


Figure 12. Domestic per capita water withdrawals, Washington, 2010. Data ranges for each category reflect actual county values.

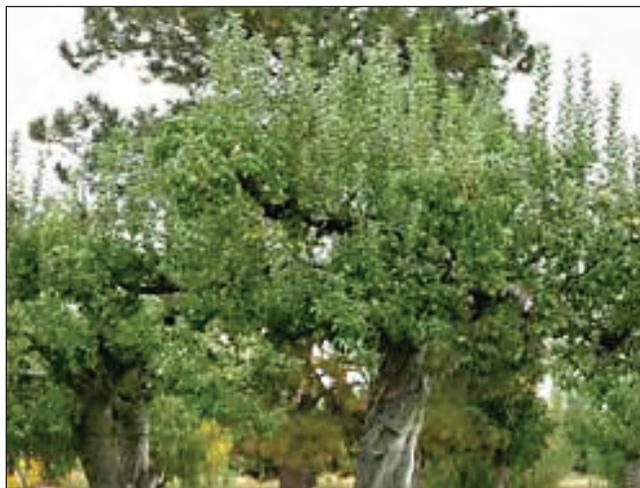
Irrigation

Irrigation water withdrawals in Washington for 2010 totaled 3,145 Mgal/d, or about 3,525 thousand acre-feet, with estimated county withdrawals ranging from 0.12 to 1,030 Mgal/d. Groundwater accounted for 25 percent (798 Mgal/d) and surface water accounted for 75 percent (2,350 Mgal/d) of the state total. The irrigation application rate for Washington was 2.24 feet per year (ft/yr), with county application rates ranging from 0.31 to 3.17 ft/yr (table 4; figs. 13, 14, 15, and 16). In terms of acres-irrigated, the five major crops in Washington in 2010 were alfalfa, orchards and vineyards, wheat, potatoes, and hay.

Irrigation withdrawals in Western Washington totaled 127 Mgal/d, or about 145 thousand acre-ft, with estimated county withdrawals ranging from 0.12 to 45.4 Mgal/d. Groundwater accounted for 66 percent (84 Mgal/d) and surface water accounted for 34 percent (43 Mgal/d) of the regional total. The irrigation application rate for Western Washington was 1.33 ft/yr, with estimated county rates ranging from 0.31 to 1.90 ft/yr.

Irrigation withdrawals in Eastern Washington totaled 3,020 Mgal/d, or about 3,380 thousand acre-ft, with estimated county withdrawals ranging from 0.24 to 1,030 Mgal/d. Groundwater accounted for 24 percent (713 Mgal/d) and surface water accounted for 76 percent (2,305 Mgal/d) of

the regional total. The irrigation application rate for Eastern Washington was 2.30 ft/yr, with county rates ranging from 0.63 to 3.17 ft/yr.



First irrigation ditch in the Yakima Valley was dug at the Saint Joseph Mission in 1852. These apple trees were planted at the Mission in 1867. Photograph taken by Paula Becker, October 2005, courtesy of History Link. org (Essay 5288, accessed February 25, 2015, at http://www.historylink.org/index.cfm?DisplayPage=output.cfm&file_id=5288).

Table 4. Irrigation water withdrawals, Washington, 2010.

[Values may not sum to totals due to independent rounding]

Region	County	Irrigated land (thousands acres)	Withdrawals (million gallons per day)			Withdrawals (thousand acre-feet per year)			Application rate (feet per year)
			Groundwater	Surface water	Total water	Groundwater	Surface water	Total water	
Western	Clallam	3.43	0.71	5.09	5.80	0.80	5.70	6.50	1.90
	Clark	4.45	5.07	1.74	6.81	5.68	1.95	7.63	1.71
	Cowlitz	2.81	0.49	2.80	3.29	0.55	3.14	3.69	1.31
	Grays Harbor	5.04	4.13	2.18	6.31	4.63	2.44	7.07	1.40
	Island	2.25	1.47	0.43	1.90	1.65	0.48	2.13	0.95
	Jefferson	0.80	0.83	0.33	1.16	0.93	0.37	1.30	1.62
	King	5.93	1.53	3.69	5.22	1.71	4.13	5.84	0.98
	Kitsap	1.76	1.34	0.62	1.96	1.50	0.69	2.19	1.24
	Lewis	5.63	3.90	3.24	7.14	4.37	3.63	8.00	1.42
	Mason	0.58	0.57	0.10	0.67	0.64	0.11	0.75	1.29
	Pacific	2.17	0.99	1.50	2.49	1.11	1.68	2.79	1.29
	Pierce	4.78	4.36	1.78	6.14	4.88	1.99	6.87	1.44
	San Juan	0.45	0.04	0.09	0.13	0.04	0.10	0.14	0.31
	Skagit	15.5	13.5	3.76	17.3	15.1	4.21	19.3	1.25
	Skamania	0.34	0.16	0.21	0.37	0.18	0.24	0.42	1.24
	Snohomish	6.23	2.43	2.94	5.37	2.72	3.29	6.01	0.96
	Thurston	6.67	7.34	2.05	9.39	8.22	2.30	10.5	1.58
	Wahkiakum	0.09	0.05	0.07	0.12	0.06	0.08	0.14	1.56
Whatcom	38.3	35.5	9.93	45.4	39.8	11.1	50.9	1.33	
Eastern	Adams	124	184	24.2	208	206	27.1	233	1.88
	Asotin	0.34	0.18	0.06	0.24	0.20	0.07	0.27	0.79
	Benton	166	50.2	238	288	56.2	266	322	1.94
	Chelan	21.4	2.89	35.6	38.5	3.24	39.9	43.1	2.02
	Columbia	4.43	0.55	5.41	5.96	0.62	6.06	6.68	1.51
	Douglas	18.9	4.00	20.4	24.4	4.48	22.9	27.4	1.45
	Ferry	2.47	0.56	2.10	2.66	0.63	2.35	2.98	1.21
	Franklin	204	81.0	373	454	90.7	418	509	2.50
	Garfield	0.36	0.07	0.23	0.30	0.08	0.26	0.34	0.94
	Grant	439	186	845	1,030	209	947	1,160	2.63
	Kittitas	43.0	2.90	119	122	3.25	133	136	3.17
	Klickitat	15.5	17.0	8.81	25.8	19.0	9.87	28.9	1.86
	Lincoln	29.9	23.0	6.22	29.3	25.8	6.97	32.8	1.10
	Okanogan	45.2	24.9	55.0	79.9	27.9	61.6	89.5	1.98
	Pend Oreille	0.59	0.15	0.18	0.33	0.17	0.20	0.37	0.63
	Spokane	13.8	13.4	1.98	15.4	15.1	2.22	17.3	1.25
	Stevens	8.81	2.03	7.47	9.50	2.27	8.37	10.6	1.21
	Walla Walla	87.7	22.8	104	127	25.5	117	143	1.62
Whitman	4.09	0.99	1.52	2.51	1.11	1.70	2.81	0.69	
Yakima	240	97.0	459	555	109	514	623	2.59	
Washington	1,575	798	2,350	3,145	895	2,630	3,525	2.24	
Western Washington	105	84	43	127	95	50	145	1.33	
Eastern Washington	1,470	713	2,305	3,020	800	2,580	3,380	2.30	
Change ¹ 2005–10, in percent									
Washington	-14	27	-19	-11	27	-19	-11	5	
Western Washington	-10	21	-18	4	21	-18	4	17	
Eastern Washington	-15	28	-19	-11	28	-19	-11	4	

¹Negative values indicate decrease; unsigned values indicate increase.

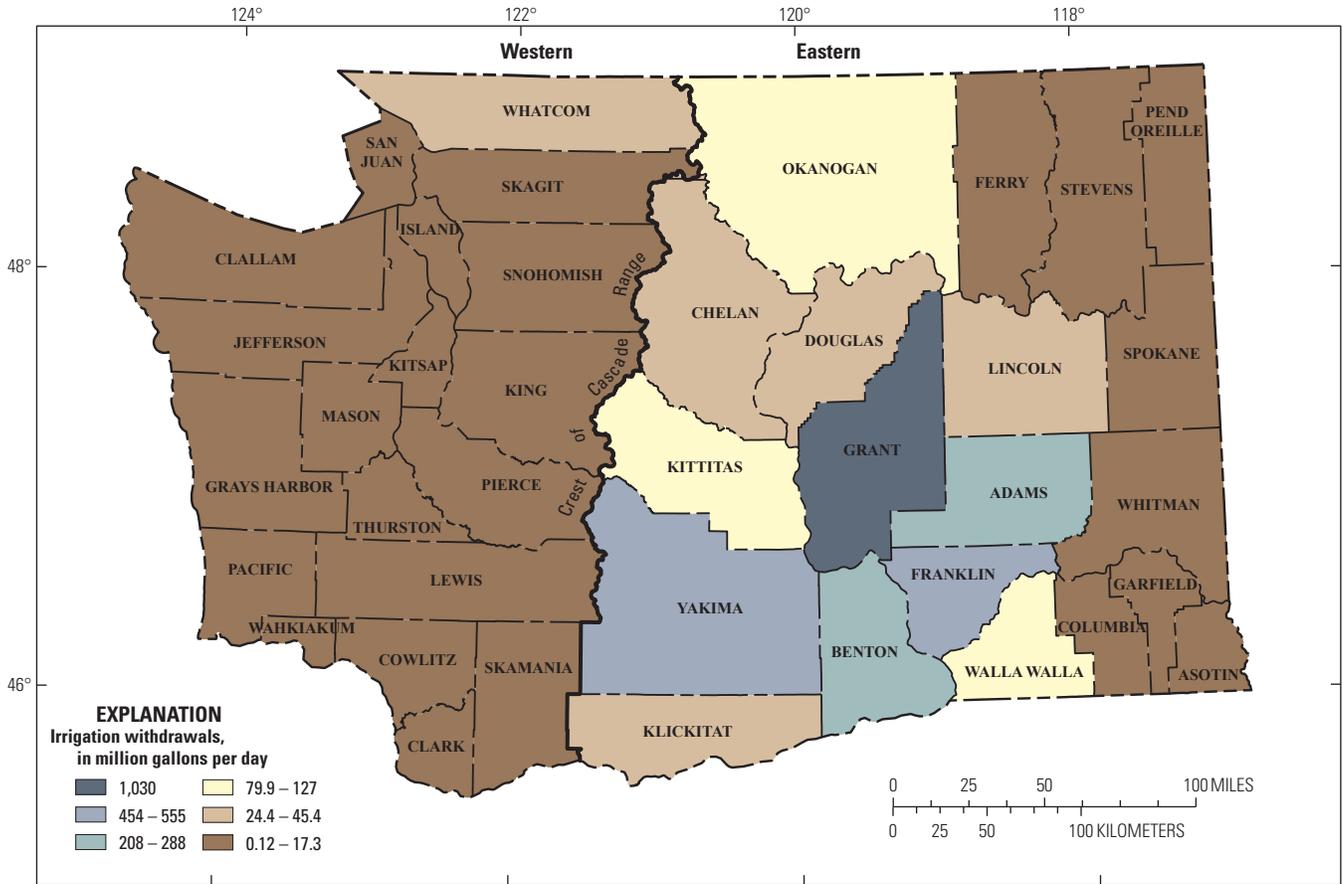


Figure 13. Irrigation water withdrawals, Washington, 2010. Data ranges for each category reflect actual county values.

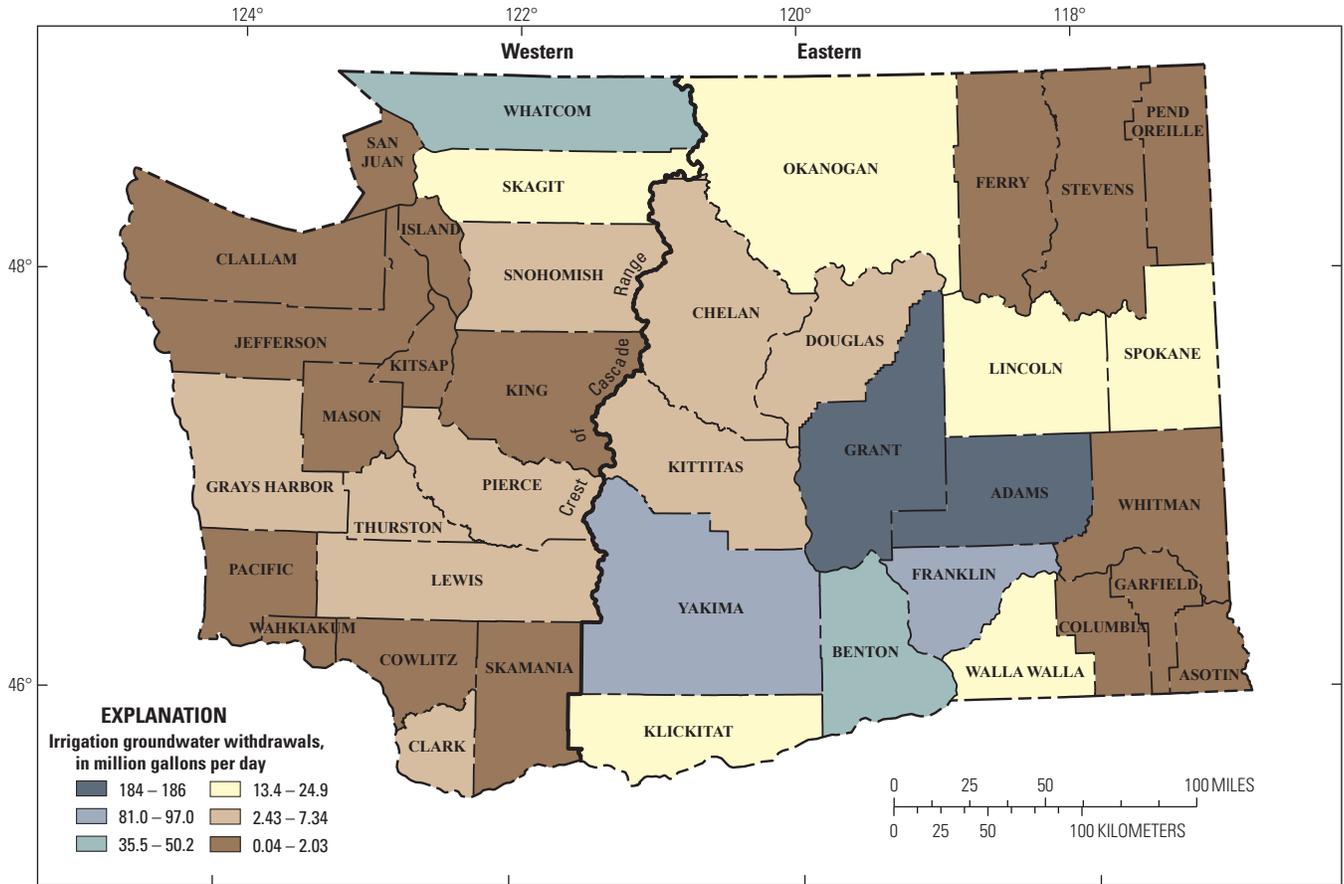


Figure 14. Irrigation groundwater withdrawals, Washington, 2010. Data ranges for each category reflect actual county values.

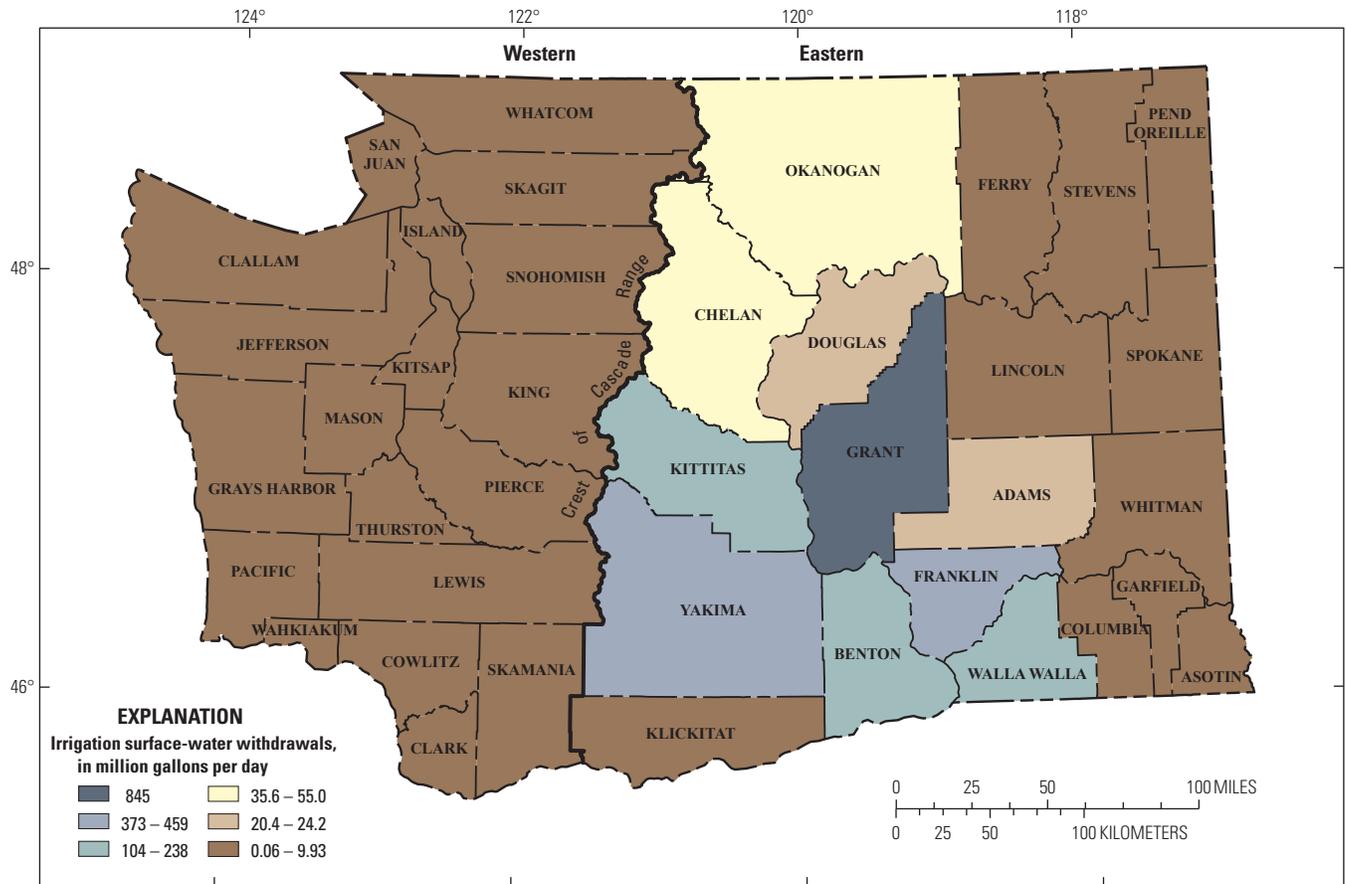


Figure 15. Irrigation surface-water withdrawals, Washington, 2010. Data ranges for each category reflect actual county values.

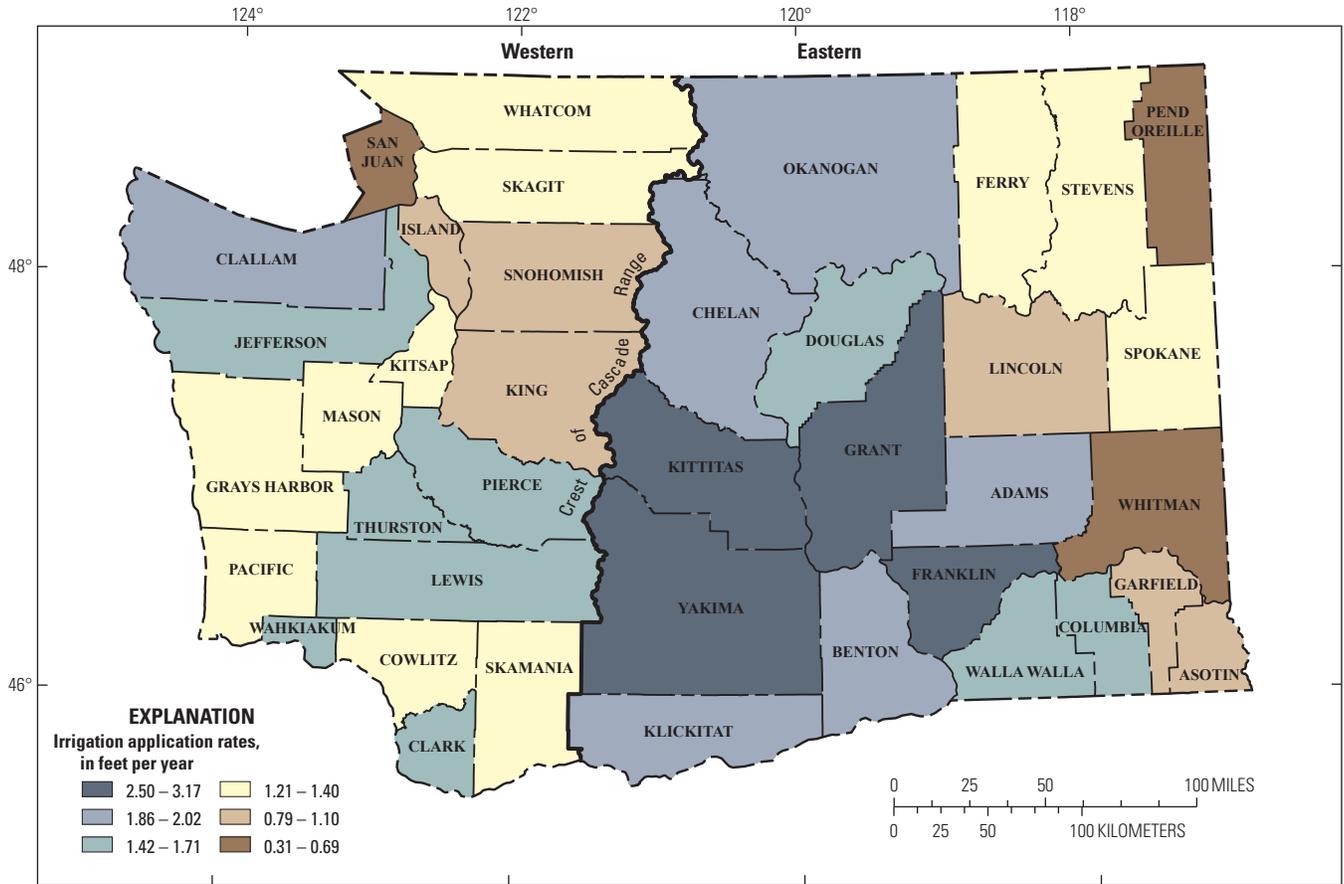


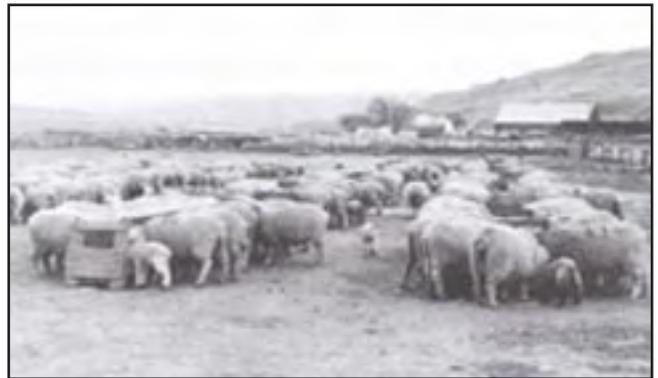
Figure 16. Irrigation water application rates, Washington, 2010. Data ranges for each category reflect actual county values.

Livestock

Livestock water withdrawals in Washington for 2010 totaled 28 Mgal/d, with estimated county withdrawals ranging from 0.01 to 7.30 Mgal/d. Groundwater accounted for 68 percent (19 Mgal/d) and surface water accounted for 32 percent (9 Mgal/d) of the State total (table 5; figs. 17, 18, and 19). Almost all livestock water use in Washington was for dairy and beef cattle, although most other farm animal groups were represented in the State.

Livestock withdrawals in Western Washington totaled 10 Mgal/d, with estimated county withdrawals ranging from 0.01 to 3.71 Mgal/d. Groundwater accounted for 60 percent (6 Mgal/d) and surface water accounted for 40 percent (4 Mgal/d) of the regional total.

Livestock withdrawals in Eastern Washington totaled 17 Mgal/d, with county withdrawals ranging from 0.01 to 7.30 Mgal/d. Groundwater accounted for 72 percent (13 Mgal/d) and surface water accounted for 28 percent (5 Mgal/d) of the region total.



Sheep ranching in Eastern Washington, circa 1930s. Photographs courtesy of Milan DeRuwe (History Link.org, Essay 8971, accessed February 25, 2015, at http://www.historylink.org/index.cfm?DisplayPage=output.cfm&file_id=8971).

Table 5. Livestock and aquaculture water withdrawals, Washington, 2010.

[All values in million gallons per day. Values may not sum to totals due to independent rounding]

Region	County	Livestock			Aquaculture		
		Groundwater	Surface water	Total water	Groundwater	Surface water	Total water
Western	Clallam	0.09	0.05	0.14	6.40	0	6.40
	Clark	0.37	0.10	0.47	2.16	0	2.16
	Cowlitz	0.10	0.03	0.13	6.71	0	6.71
	Grays Harbor	0.10	0.10	0.20	9.55	0	9.55
	Island	0.12	0.02	0.14	0	0	0
	Jefferson	0.04	0	0.04	0	1.37	1.37
	King	0.86	0.07	0.93	6.73	0	6.73
	Kitsap	0.03	0.03	0.06	6.92	0	6.92
	Lewis	0.57	0.26	0.83	3.37	0	3.37
	Mason	0.02	0.02	0.04	0	27	27
	Pacific	0.12	0.08	0.20	2.71	0	2.71
	Pierce	0.33	0.03	0.36	0	38.7	38.6
	San Juan	0.02	0.02	0.04	0	0	0
	Skagit	0.61	0.60	1.21	0	1.12	1.12
	Skamania	0	0.01	0.01	0	15.4	15.4
	Snohomish	0.56	0.54	1.10	6.63	0.04	6.67
	Thurston	0.38	0.26	0.64	6.10	5.59	11.7
Wahkiakum	0.03	0.03	0.06	0.02	0.03	0.05	
Whatcom	2.14	1.57	3.71	1.46	1.46	2.92	
Eastern	Adams	0.94	0.01	0.95	0	0	0
	Asotin	0.08	0.04	0.12	0	0	0
	Benton	0.57	0.06	0.63	2.66	1.57	4.23
	Chelan	0.01	0.04	0.05	0	8.34	8.34
	Columbia	0.06	0.02	0.08	0	1.47	1.47
	Douglas	0.11	0.04	0.15	3.09	0	3.09
	Ferry	0.06	0.02	0.08	1.98	0	1.98
	Franklin	1.09	0.28	1.37	3.23	0	3.23
	Garfield	0.07	0.02	0.09	0	1.90	1.90
	Grant	2.97	0.33	3.30	6.43	1.61	8.04
	Kittitas	0.21	0.20	0.41	0	0	0
	Klickitat	0.21	0.15	0.36	9.18	0	9.18
	Lincoln	0.17	0.06	0.23	0	0	0
	Okanogan	0.53	0.10	0.63	0	9.18	9.18
	Pend Oreille	0.04	0.03	0.07	0	0	0
	Spokane	0.44	0.01	0.45	1.07	1.07	2.14
	Stevens	0.22	0.17	0.39	0	8.67	8.67
Walla Walla	0.34	0.20	0.54	0	0	0	
Whitman	0.22	0.02	0.24	0	0	0	
Yakima	4.37	2.93	7.30	0.03	1.79	1.82	
Washington		19	9	28	86	127	213
Western Washington		6	4	10	59	91	150
Eastern Washington		13	5	17	28	36	63
Change ¹ 2005–10, in percent							
Washington		-8	-13	-10	-3	22	12
Western Washington		-26	-27	-26	-9	25	11
Eastern Washington		5	3	4	9	16	13

¹Negative values indicate decrease; unsigned values indicate increase.

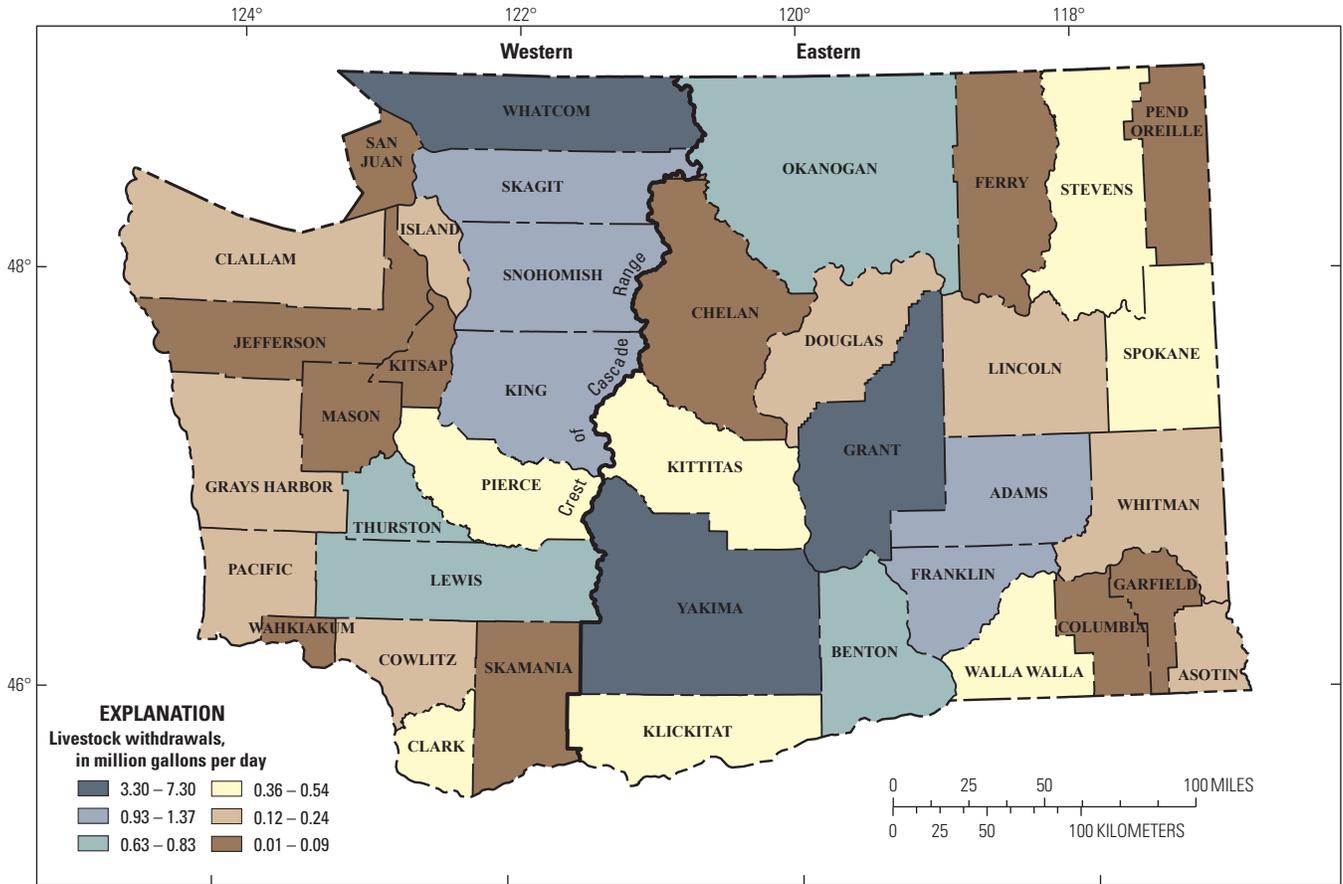


Figure 17. Livestock water withdrawals, Washington, 2010. Data ranges for each category reflect actual county values.

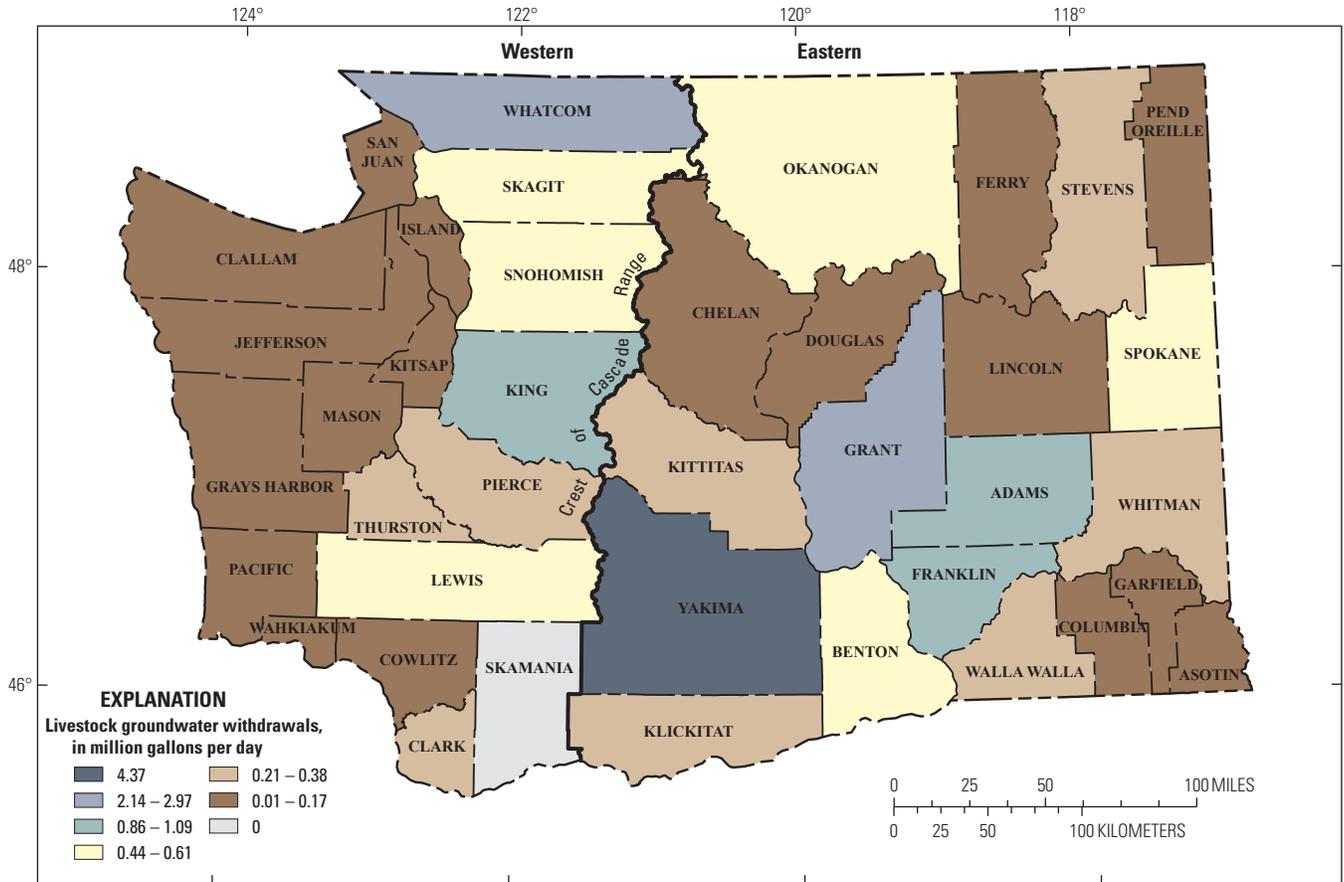


Figure 18. Livestock groundwater withdrawals, Washington, 2010. Data ranges for each category reflect actual county values.

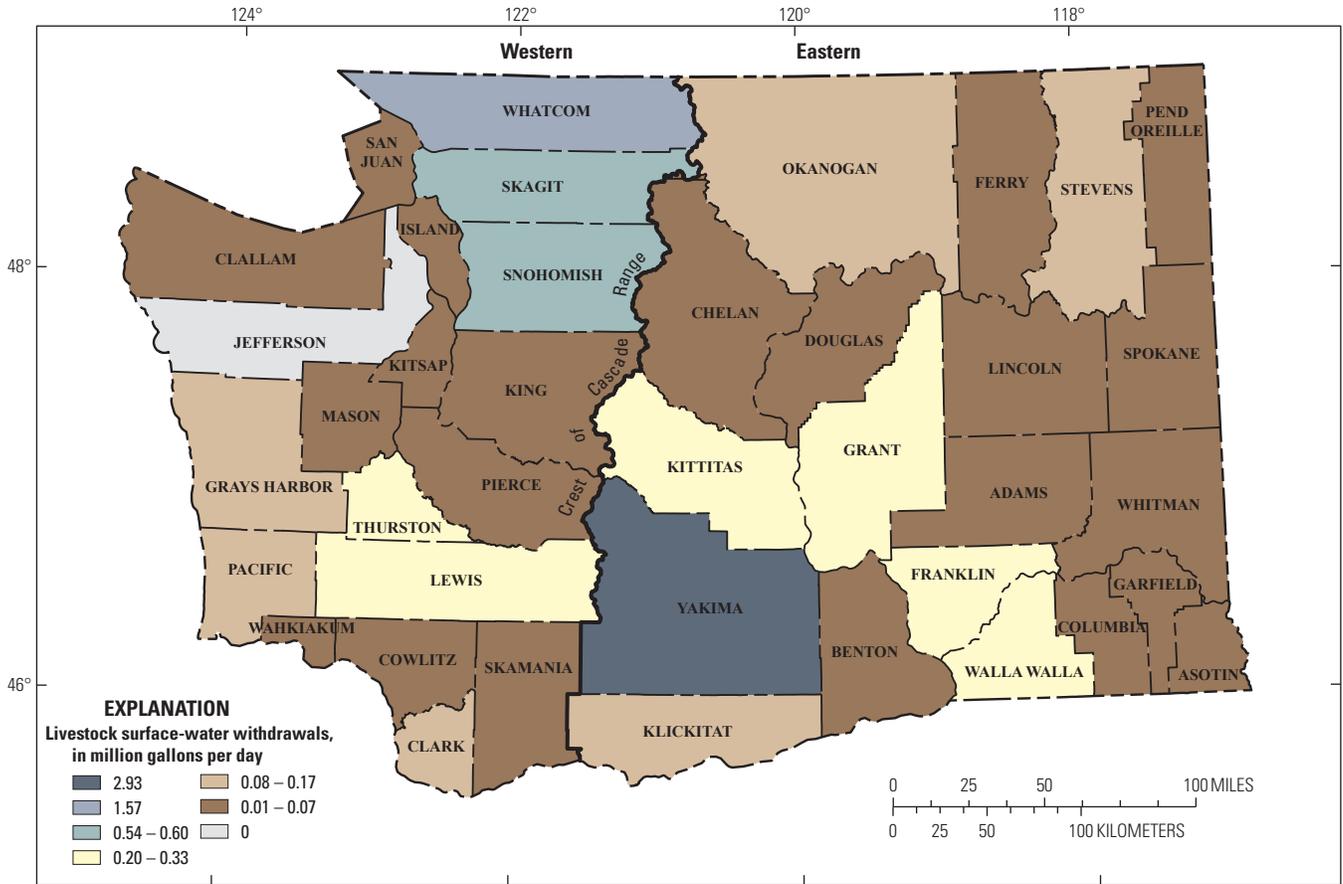


Figure 19. Livestock surface-water withdrawals, Washington, 2010. Data ranges for each category reflect actual county values.

Aquaculture

Aquaculture water withdrawals in Washington for 2010 totaled 213 Mgal/d, with estimated county withdrawals ranging from 0 to 38.6 Mgal/d. Groundwater accounted for 40 percent (86 Mgal/d) and surface water accounted for 60 percent (127 Mgal/d) of the state total (table 5; figs. 20, 21, and 22). Most water used for aquaculture in Washington during 2010 was for rearing salmon and trout in fish hatcheries.

Aquaculture withdrawals in Western Washington totaled 150 Mgal/d, with estimated county withdrawals ranging from 0 to 38.6 Mgal/d. Groundwater accounted for 39 percent (59 Mgal/d) and surface water accounted for 61 percent (91 Mgal/d) of the regional total.

Aquaculture withdrawals in Eastern Washington totaled 63 Mgal/d, with estimated county withdrawals ranging from 0 to 9.18 Mgal/d. Groundwater accounted for 44 percent (28 Mgal/d) and surface water accounted for 56 percent (36 Mgal/d) of the regional total.



Anglers trolling the Columbia River on opening day of fishing season. Photograph from Washington Department of Fish and Wildlife (accessed February 25, 2015, at http://www.wdfw.wa.gov/gallery/index.php/fish/album05/mvc_338f).

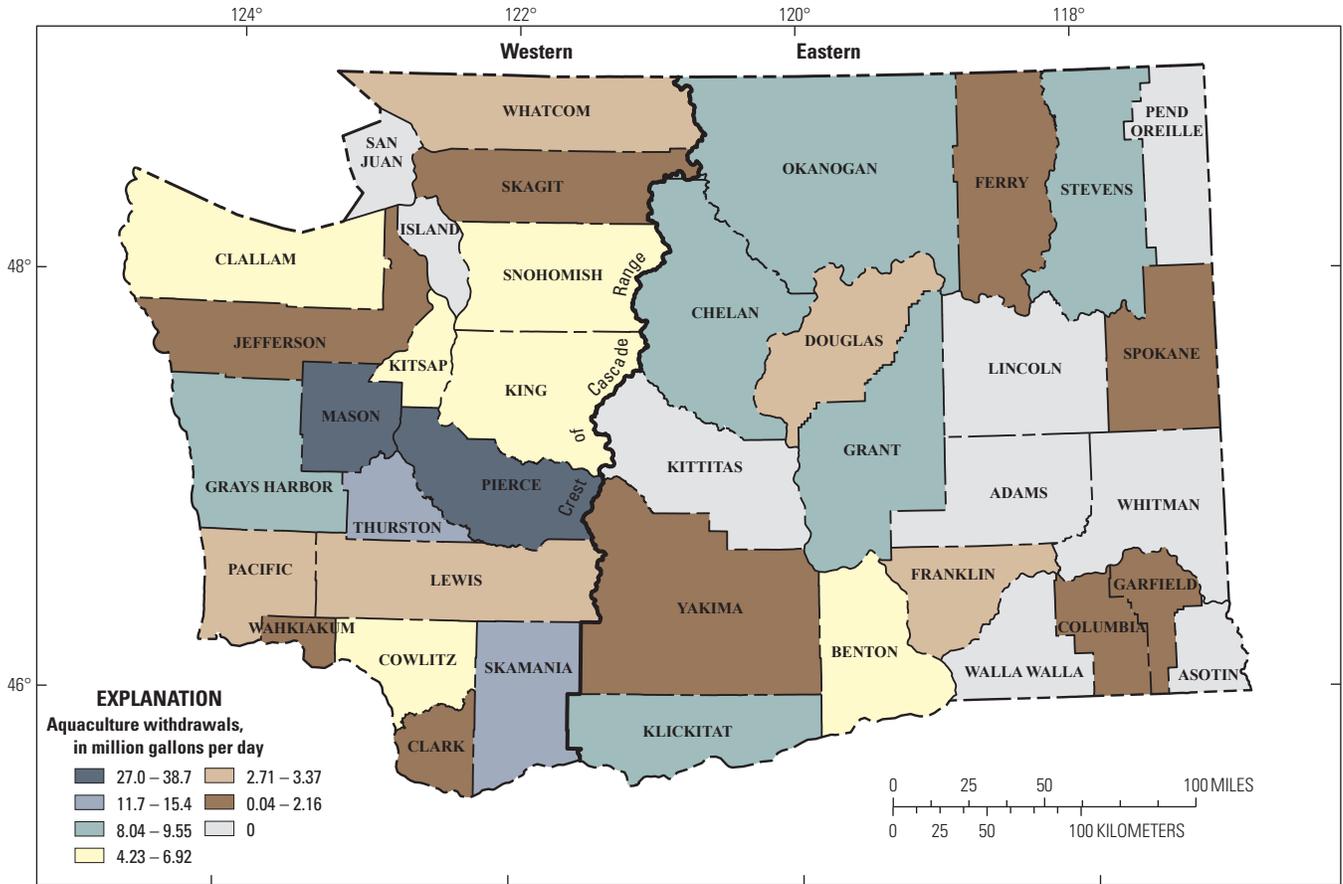


Figure 20. Aquaculture water withdrawals, Washington, 2010. Data ranges for each category reflect actual county values.

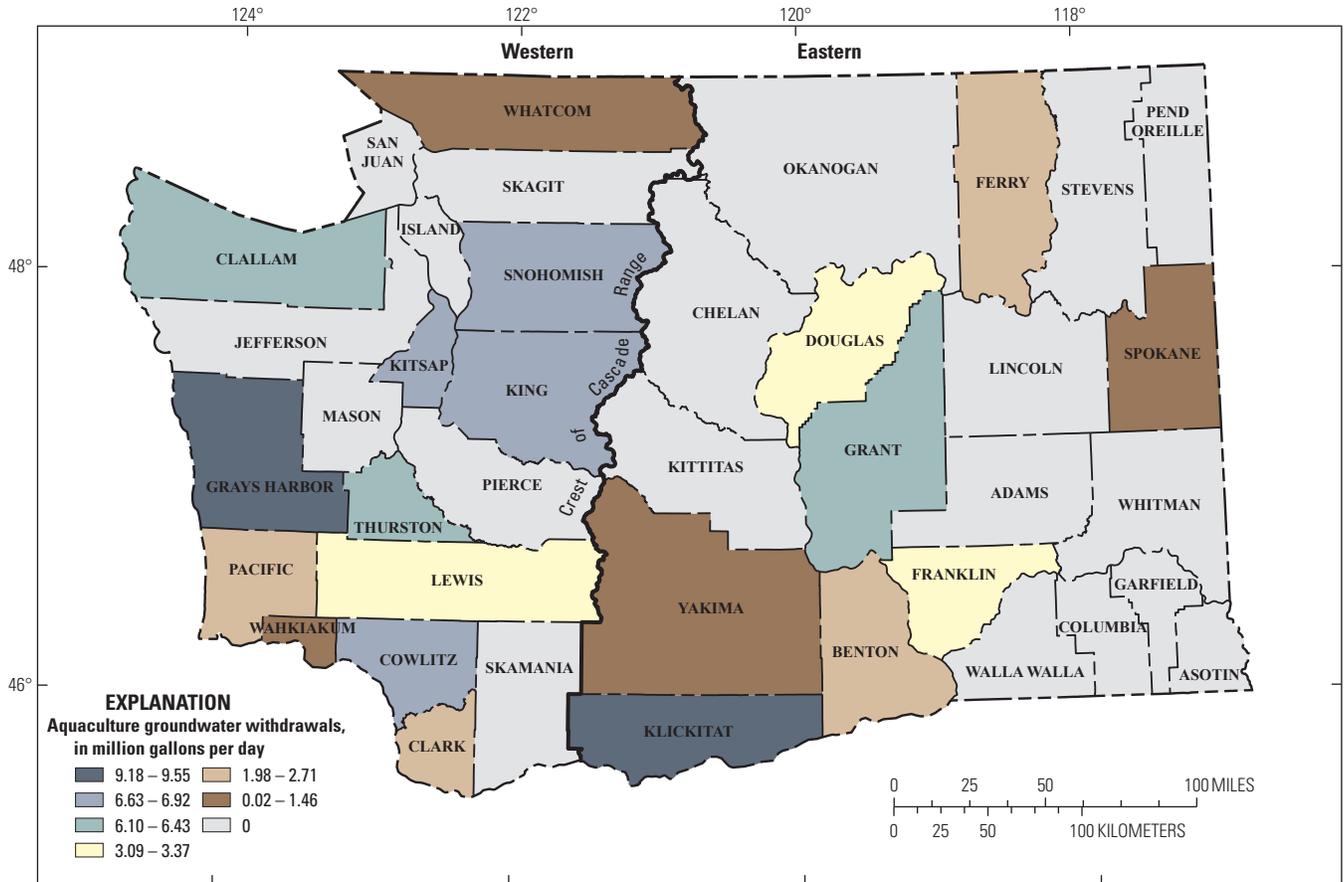


Figure 21. Aquaculture groundwater withdrawals, Washington, 2010. Data ranges for each category reflect actual county values.

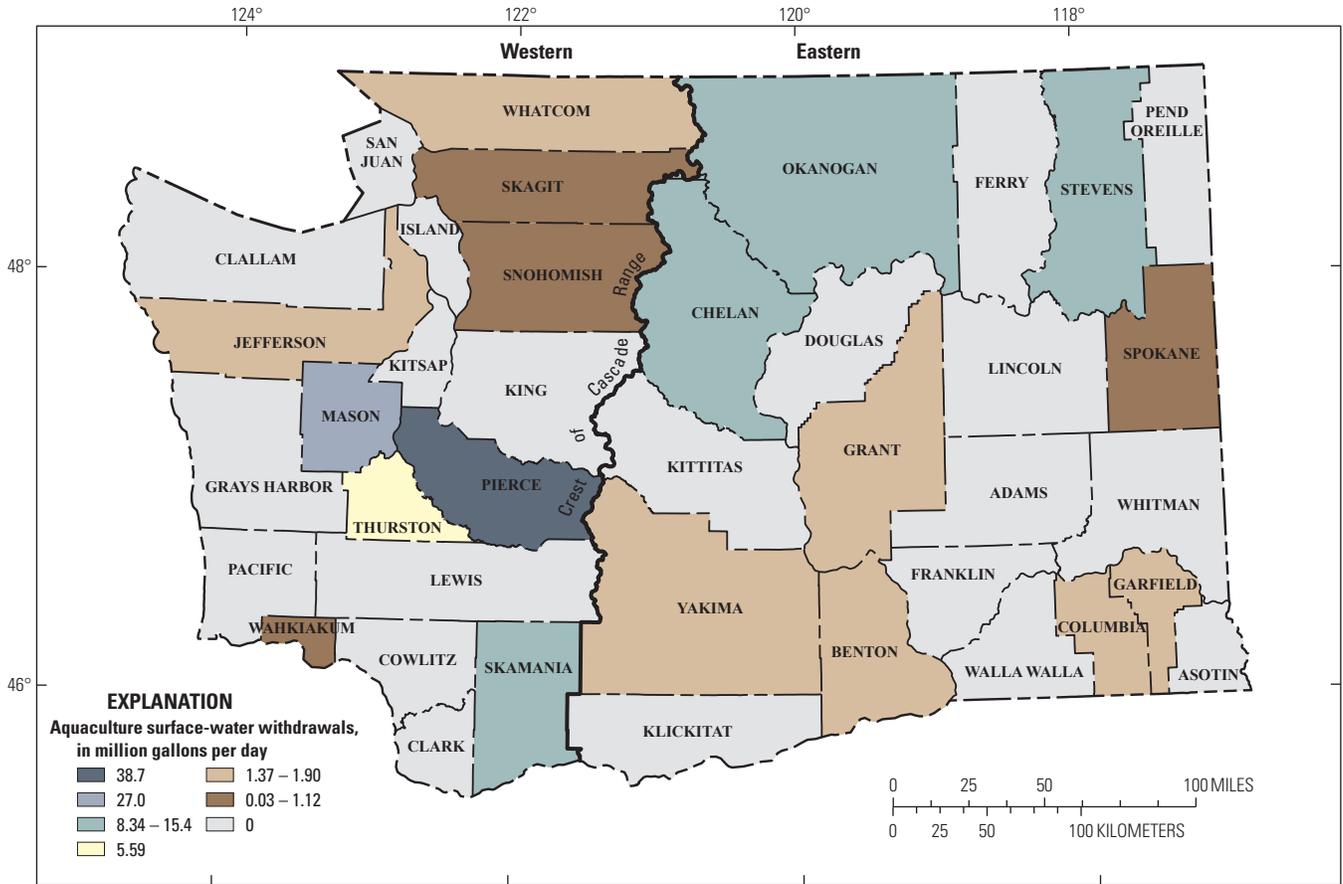


Figure 22. Aquaculture surface-water withdrawals, Washington, 2010. Data ranges for each category reflect actual county values.

Industrial

Industrial self-supplied freshwater withdrawals in Washington for 2010 totaled 458 Mgal/d, with estimated county withdrawals ranging from 0 to 123 Mgal/d. Groundwater accounted for 22 percent (99 Mgal/d) and surface water accounted for 78 percent (358 Mgal/d) of the state total (table 6; figs. 23, 24, and 25). In terms of production hours worked, the major industrial groups in Washington in 2010 were manufacturing of transportation equipment, wood products and paper, computer and electrical products, and fabricating various metallic and non-metallic products.

Industrial self-supplied withdrawals in Western Washington totaled 306 Mgal/d, with estimated county withdrawals ranging from 0 to 123 Mgal/d. Groundwater accounted for 21 percent (65 Mgal/d) and surface water accounted for 79 percent (241 Mgal/d) of the regional total.

Industrial self-supplied withdrawals in Eastern Washington totaled 152 Mgal/d, with estimated county withdrawals ranging from 0 to 66.5 Mgal/d. Groundwater accounted for 22 percent (34 Mgal/d) and surface water accounted for 78 percent (118 Mgal/d), of the regional total.



Aircraft assemble building, Boeing Factory Everett, Washington. The building is the largest building in the world by volume (Glenday, 2013). Photograph by Maurice King taken March 9, 2008. Used with permission.

36 Estimated Freshwater Withdrawals in Washington, 2010
Table 6. Industrial self-supplied and mining water withdrawals, Washington, 2010.

[All values in million gallons per day. Values may not sum to totals due to independent rounding]

Region	County	Industrial			Mining		
		Groundwater	Surface water	Total water	Groundwater	Surface water	Total water
Western	Clallam	0	0	0	0.09	0.14	0.23
	Clark	38.7	34.3	73.1	0.62	0.46	1.08
	Cowlitz	0	123	123	0.12	0.04	0.16
	Grays Harbor	1.19	0	1.19	0.20	0	0.20
	Island	0	0	0	0.18	0	0.18
	Jefferson	0	0	0	0.26	0	0.26
	King	3.11	3.10	6.21	1.44	0.07	1.51
	Kitsap	0.02	0.08	0.10	0.23	0	0.23
	Lewis	2.55	0	2.55	0.31	0.13	0.44
	Mason	0.35	8.49	8.84	0.51	0	0.51
	Pacific	0.21	0.29	0.50	0.05	0.05	0.10
	Pierce	13.2	4.83	18.0	3.17	0.26	3.43
	San Juan	0.10	0	0.10	0.02	0	0.02
	Skagit	0	0	0	0.30	0.08	0.38
	Skamania	0	5.64	5.64	0	0	0
	Snohomish	2.24	53.8	56.0	0.98	0.73	1.71
	Thurston	3.78	0	3.78	0.57	0.26	0.83
	Wahkiakum	0	0	0	0	0	0
	Whatcom	0	7.67	7.67	0.50	0.11	0.61
Eastern	Adams	2.22	0	2.22	0	0	0
	Asotin	0	0	0	0.05	0.01	0.06
	Benton	8.64	57.9	66.5	0.47	0.08	0.55
	Chelan	0	10.0	10.0	0.01	0.03	0.04
	Columbia	0.05	0	0.05	0.05	0.01	0.06
	Douglas	2.05	0	2.05	0.30	0	0.30
	Ferry	0.10	0	0.10	0.13	0.13	0.26
	Franklin	1.67	0	1.67	0.44	0	0.44
	Garfield	0	0	0	0.01	0	0.01
	Grant	3.02	0	3.02	0.22	0	0.22
	Kittitas	1.10	0	1.10	0.11	0.11	0.22
	Klickitat	0	0.92	0.92	0.23	0.10	0.33
	Lincoln	0	0	0	0.04	0.01	0.05
	Okanogan	1.33	0	1.33	0.12	0.02	0.14
	Pend Oreille	0	0.94	0.94	0.02	0	0.02
	Spokane	6.94	29.6	36.5	0.89	0.10	0.99
	Stevens	0	0.10	0.10	0.30	0.15	0.45
	Walla Walla	0.96	18.3	19.2	0	0	0
	Whitman	0	0	0	0	0	0
Yakima	5.85	0	5.85	0.41	0.28	0.69	
Washington	99	359	458	13	3	17	
Western Washington	65	241	306	10	2	12	
Eastern Washington	34	118	152	4	1	5	
Change ¹ 2005–10, in percent							
Washington	-7	3	1	-40	-19	-37	
Western Washington	-8	2	0	-40	-23	-37	
Eastern Washington	-6	6	3	-42	-6	-37	

¹Negative values indicate decrease; unsigned values indicate increase.

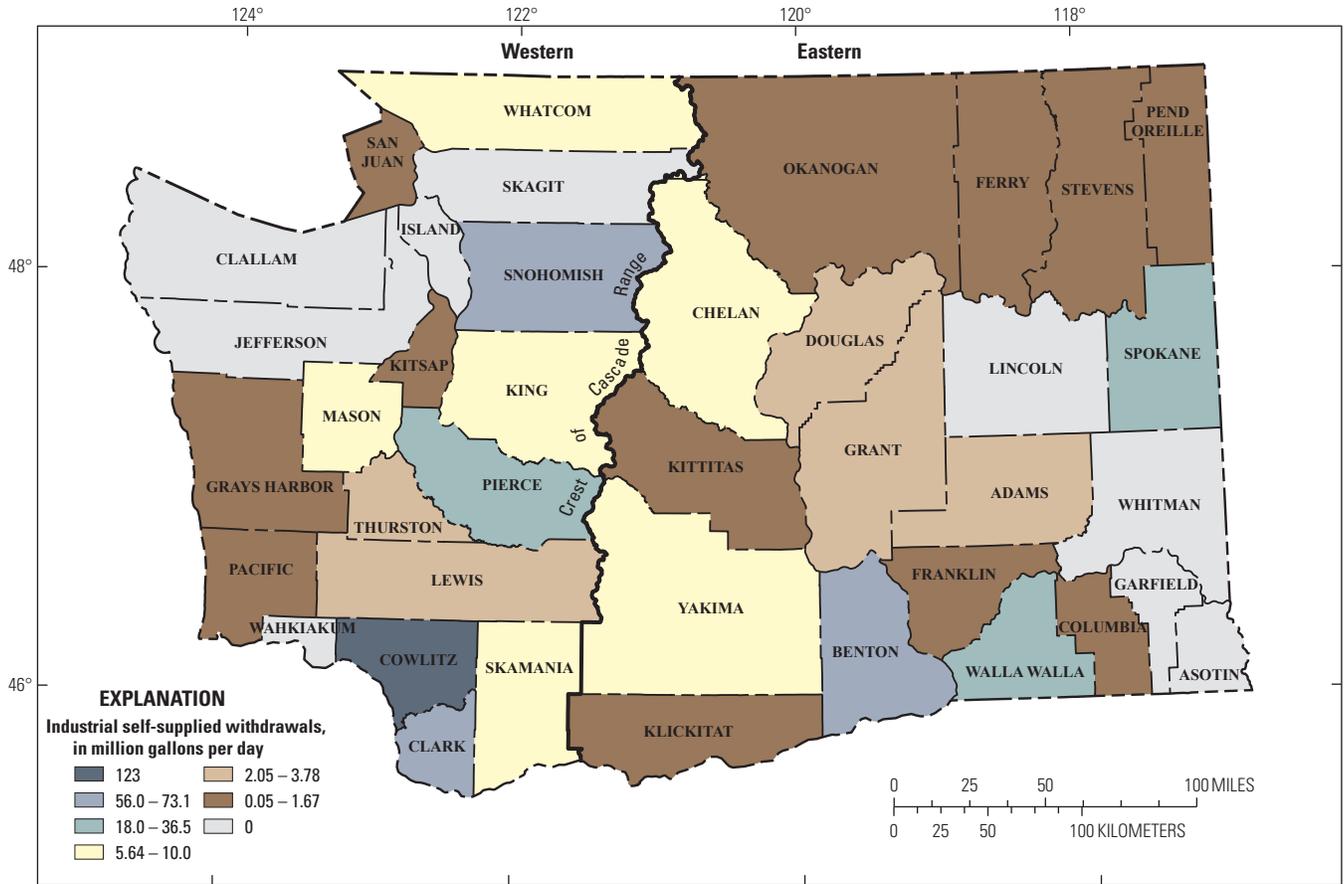


Figure 23. Industrial self-supplied water withdrawals, Washington, 2010. Data ranges for each category reflect actual county values.

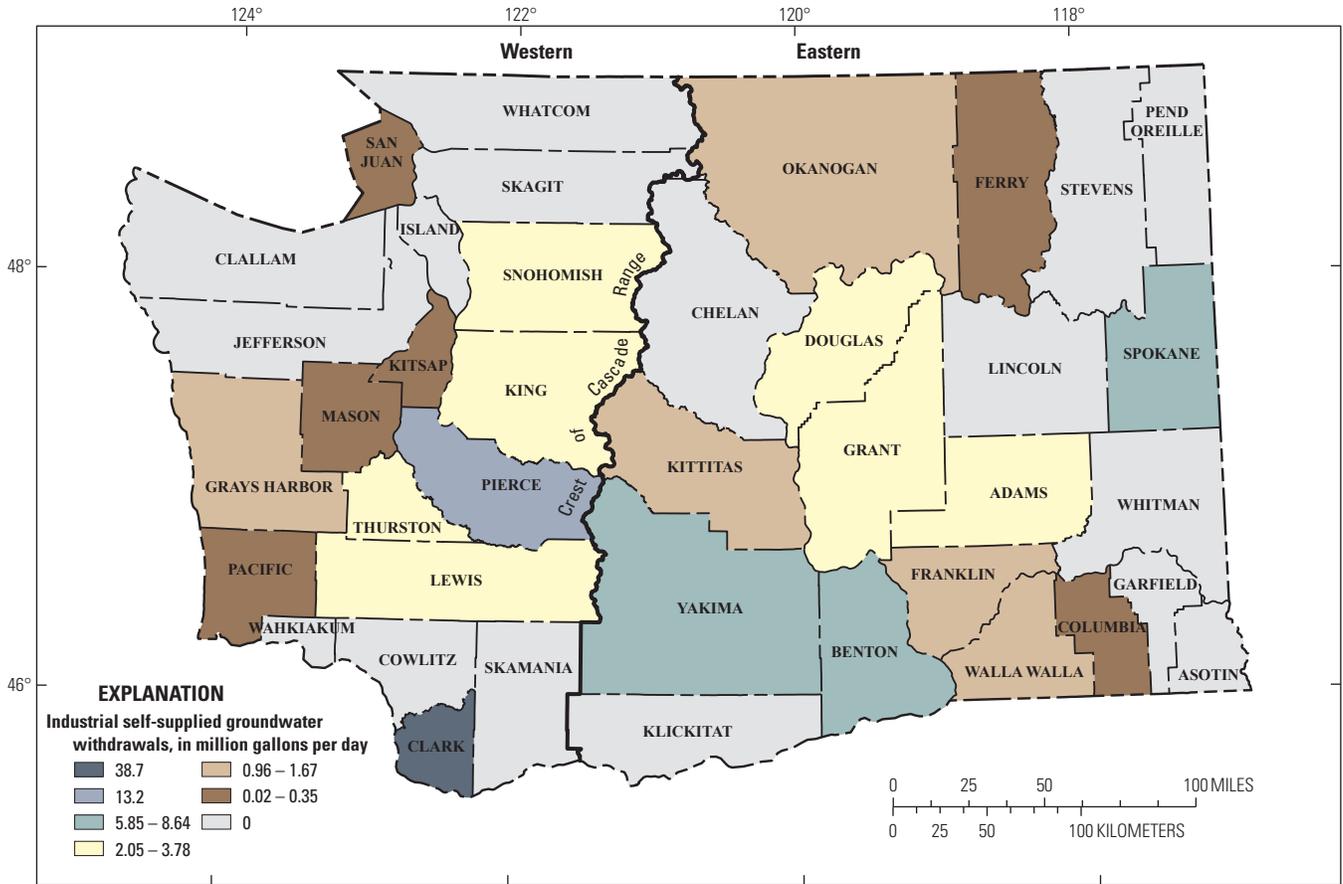


Figure 24. Industrial self-supplied groundwater withdrawals, Washington, 2010. Data ranges for each category reflect actual county values.

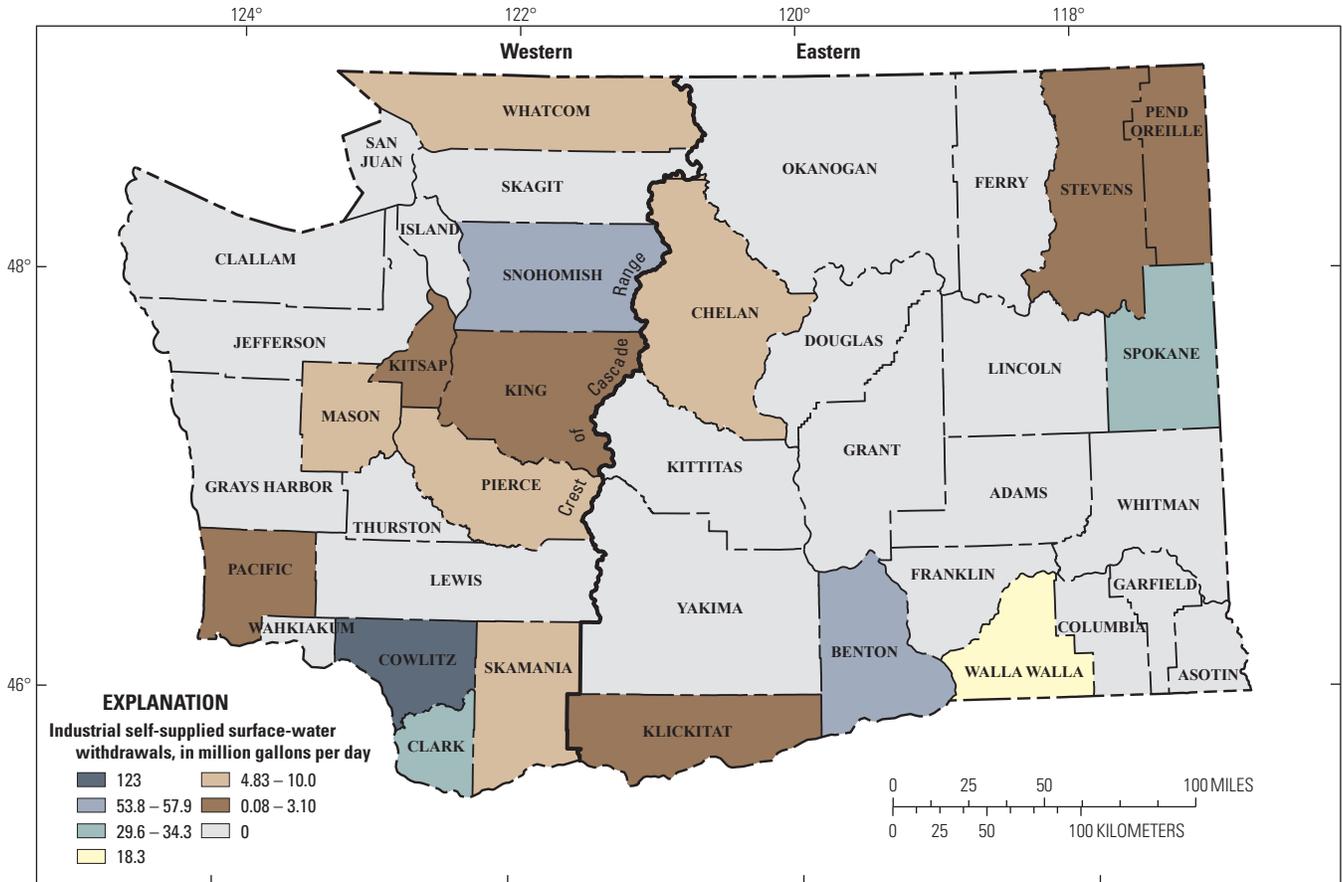


Figure 25. Industrial self-supplied surface-water withdrawals, Washington, 2010. Data ranges for each category reflect actual county values.

Mining

Mining water withdrawals in Washington for 2010 totaled 17 Mgal/d, with estimated county withdrawals ranging from 0 to 3.43 Mgal/d. Groundwater accounted for 82 percent (13 Mgal/d) and surface water accounted for 18 percent (3 Mgal/d) of the state total (table 6; figs. 26, 27, and 28). Nearly all of the mining water withdrawals in Washington were for the mining and quarrying of sand, gravel, stone, and other non-metallic minerals.

Mining withdrawals in Western Washington for 2010 totaled 12 Mgal/d; with estimated county withdrawals ranging from 0 to 3.43 Mgal/d. Groundwater accounted for 83 percent (10 Mgal/d) and surface water accounted for 17 percent (2 Mgal/d) of the regional total.

Mining withdrawals in Eastern Washington for 2010 totaled 5 Mgal/d, with estimated county withdrawals ranging from 0 to 0.99 Mgal/d (fig. 12). Groundwater accounted for 75 percent (4 Mgal/d) and surface water accounted for 25 percent (1 Mgal/d) of the regional total.



ICON Materials Baydo aggregate processing plant, south Auburn, Washington. The plant is one to the largest mines in the state. Photograph courtesy of Rian Skov, Washington State Department of Natural Resources. (accessed February 25, 2015, at http://www.dnr.wa.gov/ResearchScience/Topics/EarthResources/Pages/geology_mining_minerals.aspx).

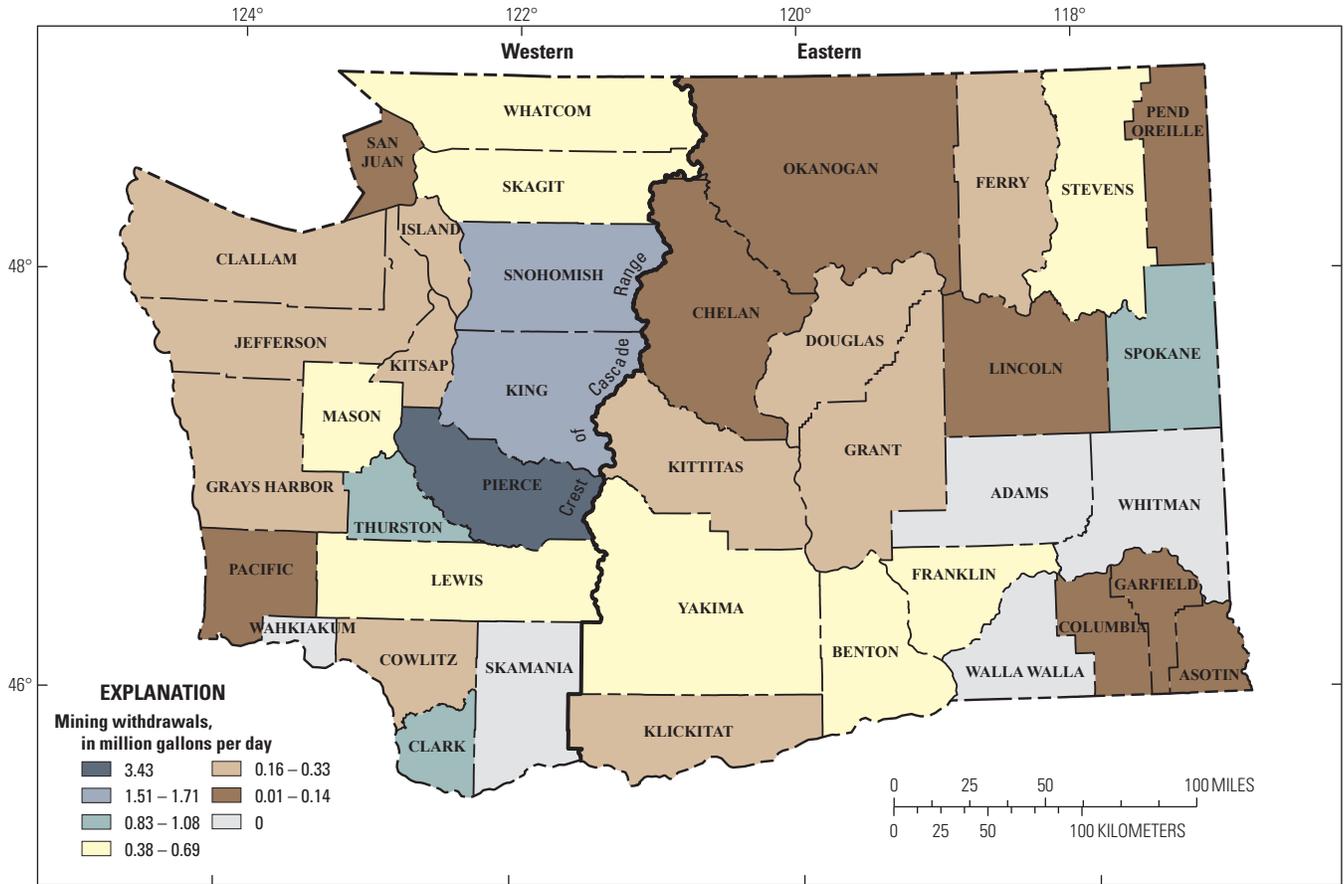


Figure 26. Mining water withdrawals, Washington, 2010. Data ranges for each category reflect actual county values.

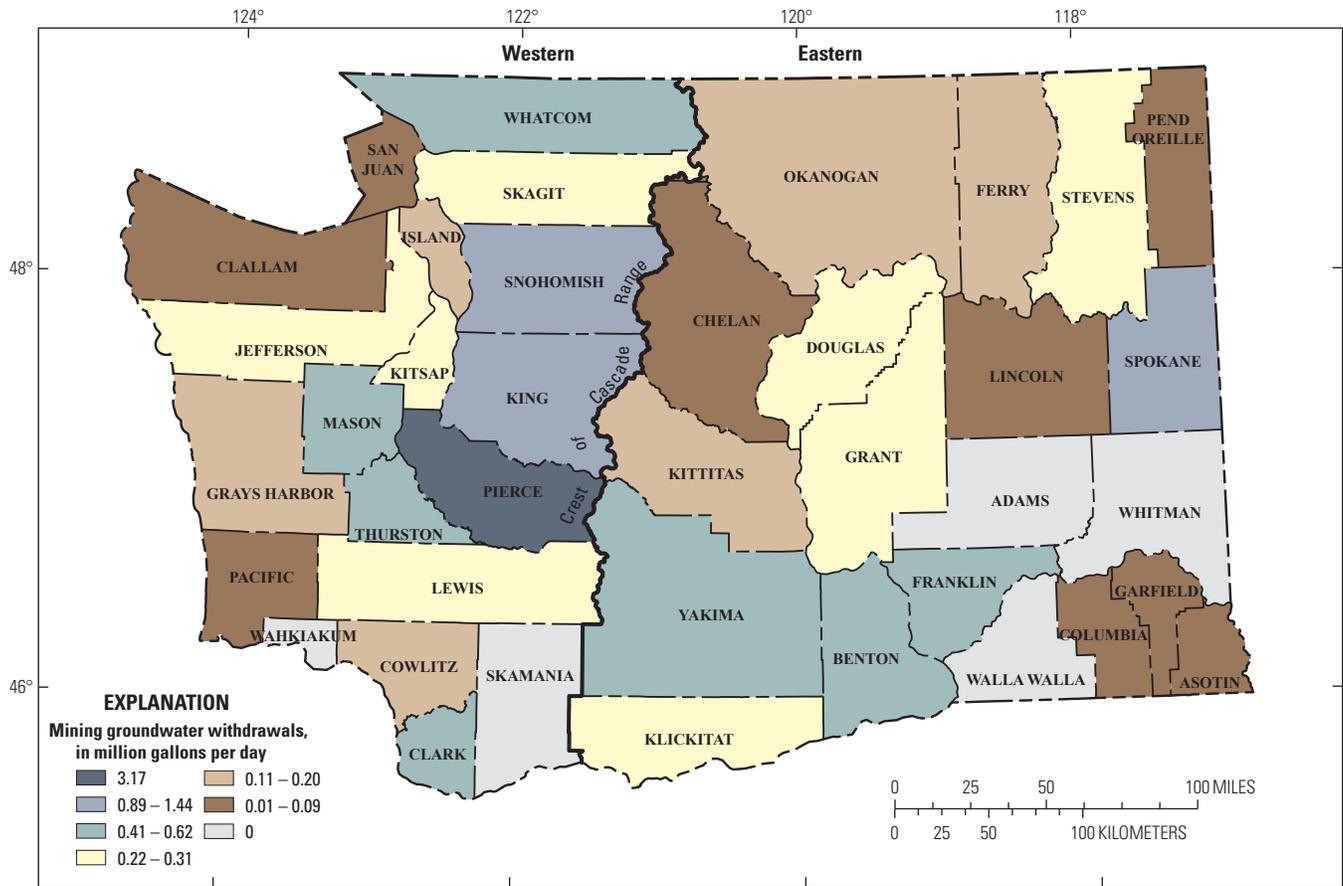


Figure 27. Mining groundwater withdrawals, Washington, 2010. Data ranges for each category reflect actual county values.

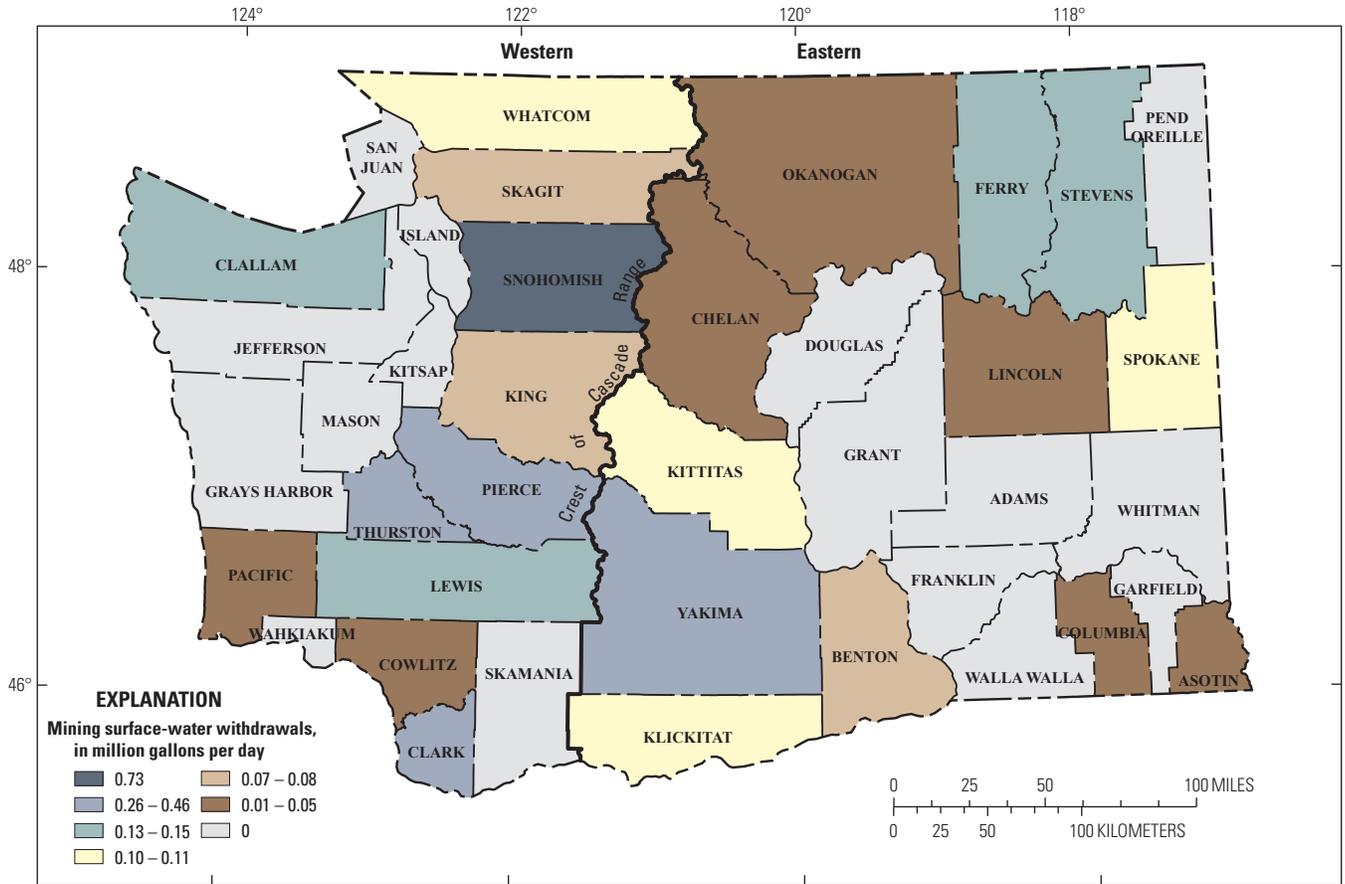


Figure 28. Mining surface-water withdrawals, Washington, 2010. Data ranges for each category reflect actual county values.

Thermoelectric Power

Thermoelectric-power water withdrawals in Washington for 2010 totaled 40 Mgal/d. Self-supplied groundwater accounted for 4 percent (2 Mgal/d), self-supplied surface water accounted for 91 percent (36 Mgal/d), and public-supply deliveries for 5 percent (2 Mgal/d) of the thermoelectric-power withdrawals of the estimated state total withdrawal. Regional and county-level data are not included in this report due to privacy considerations.

In the 2005 estimates of thermoelectric-power withdrawals, one power-generation facility was misidentified as having once-through cooling rather than closed-loop cooling, which lead to a published withdrawal estimate of 456 Mgal/d (Kenney, 2009; Lane, 2009). When corrected for this error, the 2005 withdrawals were 50 Mgal/d.

Summary

This report presents estimates of public- and self-supplied freshwater withdrawn and delivered for domestic, irrigation, livestock, aquaculture, industrial, mining, and thermoelectric power purposes in Washington during calendar year 2010. Freshwater withdrawals in Washington for 2010 totaled 4,885 million gallons per day (Mgal/d), with a per capita withdrawal rate of 726 gallons per day (gal/d). Groundwater accounted for 33 percent (1,600 Mgal/d) and surface water accounted for 67 percent (3,285 Mgal/d) of the estimated state total.

- Withdrawals in Western Washington totaled 1,295 Mgal/d, with a per capita withdrawal rate of 247 gal/d. Groundwater accounted for 40 percent (514 Mgal/d) and surface water accounted for 60 percent (779 Mgal/d) of the estimated regional total.
- Withdrawals in Eastern Washington totaled 3,590 Mgal/d, with a per capita withdrawal rate of 2,400 gal/d. Groundwater accounted for 30 percent (1,085 Mgal/d) and surface water accounted for 70 percent (2,505 Mgal/d) of the estimated regional total.

Public-supply withdrawals in Washington for 2010 totaled 910 Mgal/d, with a per capita withdrawal rate of 159 gal/d. Groundwater accounted for 52 percent (471 Mgal/d) and surface water accounted for 48 percent (439 Mgal/d) of the estimated state total.

- Public-supply withdrawals in Western Washington totaled 625 Mgal/d, with a per capita withdrawal rate of 137 gal/d. Groundwater accounted for 36 percent (227 Mgal/d) and surface water accounted for 64 percent (398 Mgal/d) of the estimated regional total.

- Public-supply withdrawals in Eastern Washington totaled 285 Mgal/d, with a per capita withdrawal rate of 247 gal/d. Groundwater accounted for 86 percent (244 Mgal/d) and surface water accounted for 14 percent (41 Mgal/d) of the estimated regional total.

Domestic water withdrawals and deliveries in Washington for 2010 totaled 747 Mgal/d, with a per capita withdrawal rate of 111 gal/d. Self-supplied groundwater accounted for 15 percent (113 Mgal/d) and public-supplied deliveries accounted for 85 percent (634 Mgal/d) of the estimated state domestic withdrawals.

- Domestic water withdrawals in Western Washington totaled to 520 Mgal/d, with a per capita withdrawal rate of 100 gal/d. Self-supplied groundwater accounted for 12 percent (63 Mgal/d) and public-supplied deliveries accounted for 88 percent (458 Mgal/d) of the estimated regional domestic withdrawals.
- Domestic water withdrawals in Eastern Washington totaled to 226 Mgal/d, with a per capita withdrawal rate of 151 gal/d. Self-supplied groundwater accounted for 22 percent (50 Mgal/d) and public-supplied water accounted for 78 percent (176 Mgal/d) of the estimated regional total domestic withdrawals.

Irrigation water withdrawals in Washington for 2010 totaled 3,145 Mgal/d, with an application rate of 2.24 feet per year (ft/yr). Groundwater accounted for 25 percent (798 Mgal/d) and surface water accounted for 75 percent (2,350 Mgal/d) of the estimated state total.

- Irrigation withdrawals in Western Washington totaled to 127 Mgal/d, with an application rate of 1.33 ft/yr. Groundwater accounted for 66 percent (84 Mgal/d) and surface water accounted for 43 percent (45 Mgal/d) of the estimated regional total.
- Irrigation withdrawals in Eastern Washington totaled to 3,020 Mgal/d, with an application rate of 2.30 ft/yr. Groundwater accounted for 24 percent (713 Mgal/d) and surface water accounted for 76 percent (2,305 Mgal/d) of the estimated regional total.

Livestock water withdrawals in Washington for 2010 totaled 28 Mgal/d, with groundwater accounting for 68 percent (19 Mgal/d) and surface water accounting for 32 percent (9 Mgal/d) of the estimated state total.

- Livestock withdrawals in Western Washington totaled 10 Mgal/d, with groundwater accounting for 60 percent (6 Mgal/d) and surface water accounting for 40 percent (4 Mgal/d) of the estimated regional total.

- Livestock withdrawals in Eastern Washington totaled 17 Mgal/d, with groundwater accounting for 72 percent (13 Mgal/d) and surface water accounting for 28 percent (5 Mgal/d) of the estimated regional total.

Aquaculture water withdrawals in Washington for 2010 totaled to 213 Mgal/d, with groundwater accounting for 40 percent (86 Mgal/d) and surface water accounting for 60 percent (127 Mgal/d) of the estimated state total.

- Aquaculture withdrawals in Western Washington totaled 150 Mgal/d, with groundwater accounting for 39 percent (59 Mgal/d) and surface water accounting for 61 percent (91 Mgal/d) of the estimated regional total.
- Aquaculture withdrawals in Eastern Washington totaled to 63 Mgal/d, with groundwater accounting for 44 percent (28 Mgal/d) and surface water accounting for 56 percent (36 Mgal/d) of the estimated regional total.

Industrial self-supplied water withdrawals in Washington for 2010 totaled 458 Mgal/d, with groundwater accounting for 22 percent (99 Mgal/d) and surface water accounting for 78 percent (358 Mgal/d) of the estimated state total.

- Industrial withdrawals in Western Washington totaled 306 Mgal/d, with groundwater accounting for 21 percent (65 Mgal/d) and surface water accounting for 79 percent (241 Mgal/d) and of the estimated regional total.
- Industrial withdrawals in Eastern Washington totaled 152 Mgal/d, with groundwater accounting for 22 percent (34 Mgal/d) and surface water accounting for 78 percent (118 Mgal/d) of the estimated regional total.

Mining withdrawals in Washington for 2010 totaled 17 Mgal/d, with groundwater accounting for 82 percent (13 Mgal/d) and surface water accounting for 18 percent (3 Mgal/d) of estimated state total.

- Mining withdrawals in Western Washington totaled 12 Mgal/d, with groundwater accounting for 83 percent (10 Mgal/d) and surface water accounting for 17 percent (2 Mgal/d) of the estimated regional total.
- Mining withdrawals in Eastern Washington totaled 5 Mgal/d, with groundwater accounting for 75 percent (4 Mgal/d) and surface water accounting for 25 percent (1 Mgal/d) of the estimated regional total.

Thermoelectric-power withdrawals in Washington for 2010 totaled 40 Mgal/d, with self-supplied groundwater accounting for 4 percent (2 Mgal/d), self-supplied surface water accounting for 91 percent (36 Mgal/d), and public-supplied water for 5 percent (2 Mgal/d), of the estimated state total. Regional and county data are not included in this report due to privacy considerations.

References Cited

- Dion, N.P., 1985, Washington ground-water resources, *in* U.S. Geological Survey, National water summary 1984—Hydrologic events, selected water-quality trends, and ground-water resources: U.S. Geological Survey Water-Supply Paper 2275, p. 433–438. [Also available at <http://pubs.er.usgs.gov/publication/wsp2275>.]
- Glenday, Craig, ed., 2013, Guinness world records, 2013: New York, Bantam Books, 606 p.
- Kenny, J.F., Barber, N.L., Huston, S.S., Linsey, K.S., Lovelace, J.K., and Maupin, M.A., 2009, Estimated use of water in the United States in 2005: U.S. Geological Survey Circular 1344, 52 p. [Also available at <http://pubs.usgs.gov/circ/1344/>.]
- Lane, R.C., 2009, Estimated water use in Washington, 2005: U.S. Geological Survey Scientific Investigations Report 2009-5128, 30 p. [Also available at <http://pubs.usgs.gov/sir/2009/5128/>.]
- Williams, J.R., 1986, Washington surface-water resources, *in* Moody, D.E., Chase, E.B., and Aronson, D.A., National water summary 1985—Hydrologic events and surface-water resources: U.S. Geological Survey Water-Supply Paper 2300, p. 473–478.

Appendix A. Methods and Data Sources

Public Supply

Estimates of public-supply freshwater withdrawals were based on data from the Washington State Department of Health (WDOH). A list of all registered Group A public water-supply systems in Washington was obtained from the WDOH on-line database (Washington State Department of Health, 2010). The database contains the names, locations, service or resident populations, and other data for all water-systems registered with the WDOH, as well as withdrawal and water-use data for about 76 percent of the listed sites. These data were used to estimate withdrawals for the non-reporting systems.

Based on water-system characteristics, reporting systems in each county were subdivided into urban, residential, and “other” groups.

- Urban systems deliver water for various purposes including residential, commercial, and industrial use (for example, cities and towns).
- Residential systems deliver water primarily for residential or domestic use (for example, single-family homes with yards).
- Other systems are residential systems that serve mobile home parks and apartments, which tend to have a lower per capita use because of smaller lots and yards.

Withdrawal and delivery data from the reporting systems in each group were used to calculate raw per capita rates as follows:

Total population served: Sum of the reported resident service populations.

Withdrawal per capita: Total water withdrawn
/ total population served.

Delivery per capita: Water delivered to residential users
/ total population served.

Losses per capita: Reported losses / total population served.

To eliminate outliers resulting from abnormal circumstances or questionable data, the largest and smallest 10 percent of the raw per capita rates were not included in these calculations.

Missing (non-reported) total withdrawals, domestic withdrawals, and losses were estimated as follows.

Urban Systems

Withdrawals: Reported service population
× urban withdrawal per capita.

Domestic withdrawals: Reported service population
× residential withdrawal per capita.

Losses and other uses: Withdrawals – domestic withdrawals.

Residential Systems

Withdrawals: Reported service population
× residential withdrawal per capita.

Delivery: Reported service population
× residential delivery per capita.

Note: For residential systems, all deliveries are assumed to be domestic withdrawals only.

Losses = Withdrawals – deliveries.

Other Systems

Withdrawals: Reported service population
× residential delivery per capita.

Because of the size and compact nature of these systems, losses were not calculated for the non-reporting systems.

Domestic

Self-supplied domestic withdrawals were estimated for each county by using the trimmed residential delivery per capita from the public supply estimates and the self-supplied

population of each county calculated as the difference between total county population and the public-supplied resident population. State and county population data from the U.S. Census Bureau were provided by the USGS National Water Use Information Office (written commun., December 1, 2011). For the purposes of this report, the public-supplied domestic-use category included only those people who were served by a Group A public water-supply system. The self-supplied domestic-use category includes those who are self-supplied and those who are served by a Group B public water-supply system. All domestic self-supplied water was assumed to be groundwater except for the 0.02 million gallons per day (Mgal/d) of surface water used in Ferry County.

Irrigation

Irrigation water withdrawals were estimated as the sum of crop-irrigation water use and golf-course-irrigation water use. Crop-irrigation acreage and application data for Washington State were not available for the 2010 growing season; therefore, state and county data for the 2002 and 2007 growing season (National Agricultural Statistics Service 2004a, 2004b, 2009a, 2009b) were used to estimate the 2010 growing season. Golf-course irrigation estimates were prepared by combining the county golf-course acreage data for 2005 (Lane, 2009) with the crop irrigation application rates for 2010.

Livestock

Estimates of livestock water withdrawals were prepared by John Lovelace (USGS) using livestock population estimates from the 2007 Census of Agriculture (National Agricultural Statistics Service, 2009a), state-level per animal water-use coefficients, and the methods documented in Lovelace (2009a). The USGS Washington Water Science Center (WAWSC) reviewed and accepted these estimates without change.

Aquaculture

Estimates of aquaculture water withdrawals were prepared by John Loveless (USGS) using aquaculture data from the 2002 and 2007 Census of Agriculture (National Agricultural Statistics Services, 2004a, 2009a), additional unpublished and proprietary data obtained from the National Agricultural Statistics Service, and the methods documented in Loveless (2009b). The USGS Washington Water Science Center (WAWSC) reviewed and accepted the estimates without change.

Industrial

Estimates of industrial water use were based on similar data from Lane (2009) and the change (by county) in the total industrial hours worked from the 2002 and 2007 reports (U.S. Department of Commerce, 2007) using the following equation:

$$\text{Water.2010} = \text{Water.2005} \times (\text{Industrial.hours.2010} / \text{industrial.hours.2005}).$$

Mining

Estimates of mining water withdrawals were prepared by John Lovelace (USGS) using data from various sources and the methods documented Lovelace (2009c). The USGS Washington Water Science Center (WAWSC) reviewed and accepted these estimates without change.

Thermoelectric Power

Estimates of water withdrawals for thermoelectric power generation were prepared for each power-generation facility in Washington with a nameplate rating of 10 megawatts or more. These estimates were prepared using the following equation:

$$\text{Water.2010} = \text{Water.2005} \times (\text{power.2010} / \text{power.2005}).$$

The 2010 thermoelectric power-generation data were provided by the National Water Use Information Program (Melissa Harris, U.S. Geological Survey, written commun, April 10, 2013).

References Cited

- Lane, R.C., 2009, Estimated water use in Washington, 2005: U.S. Geological Survey Scientific Investigations Report 2009-5128, 30 p. [Also available at <http://pubs.usgs.gov/sir/2009/5128/>.]
- Lovelace, J.K., 2009a, Method for estimating water withdrawals for livestock in the United States, 2005: U.S. Geological Survey Scientific Investigations Report 2009-5041, 7 p.
- Lovelace, J.K., 2009b, Methods for estimating water withdrawals for aquaculture in the United States, 2005: U.S. Geological Survey Scientific Investigations Report 2009-5042, 13 p.

Lovelace, J.K., 2009c, Method for estimating water withdrawals for mining in the United States, 2005: U.S. Geological Survey Scientific Investigations Report 2009-5041, 7 p. [Also available at <http://pubs.usgs.gov/sir/2009/5041/>.]

National Agricultural Statistics Service, 2004a, 2002 census of agriculture—Volume 1, geographic area series, part 47 AC-02-A-47, Washington State and county data: U.S. Department of Agriculture, 483 p. [Also available at: http://www.agcensus.usda.gov/Publications/2002/Volume_1,_Chapter_1_State_Level/Washington/.]

National Agricultural Statistics Service, 2004b, 2002 census of agriculture, farm and ranch irrigation survey (2003)—Volume 3, special studies part 1 AC-02-SS-1: U.S. Department of Agriculture, 216 p. [Also available at: <http://www.agcensus.usda.gov/Publications/2002/FRIS/index.asp>.]

National Agricultural Statistics Service, 2009a, 2007 census of agriculture—Volume 1, geographic area series, part 47 AC-07-A-47, Washington State and county data, updated December 2009: U.S. Department of Agriculture, 551 p. [Also available at: http://www.agcensus.usda.gov/Publications/2007/Full_Report/Volume_1,_Chapter_2_County_Level/Washington/.]

National Agricultural Statistics Service, 2009b, 2007 census of agriculture—Volume 3, farm and ranch irrigation survey (2008), special studies part 1, AC-07-SS-1, updated July 2010: U.S. Department of Agriculture, 268 p. [Also available at http://www.agcensus.usda.gov/Publications/2007/Online_Highlights/Farm_and_Ranch_Irrigation_Survey/index.php.]

U.S. Department of Commerce, 2007, Economic census—Manufacturing—Geographic area series—Industry statistics for the states, metropolitan and micropolitan statistical areas, counties, and places: U.S. Department of Commerce, EC0731A1, accessed January 2015, at <http://factfinder.census.gov/faces/nav/jsf/pages/searchresults.xhtml?refresh=t>.

Washington State Department of Health, 2010, Public water systems database: Washington State Department of Health, accessed January 2011, at <https://fortress.wa.gov/doh/eh/portal/odw/si/Intro.aspx>.

Publishing support provided by the U.S. Geological Survey
Science Publishing Network, Tacoma Publishing Service Center

For more information concerning the research in this report, contact the
Director, Washington Water Science Center
U.S. Geological Survey
934 Broadway, Suite 300
Tacoma, Washington 98402
<http://wa.water.usgs.gov>

