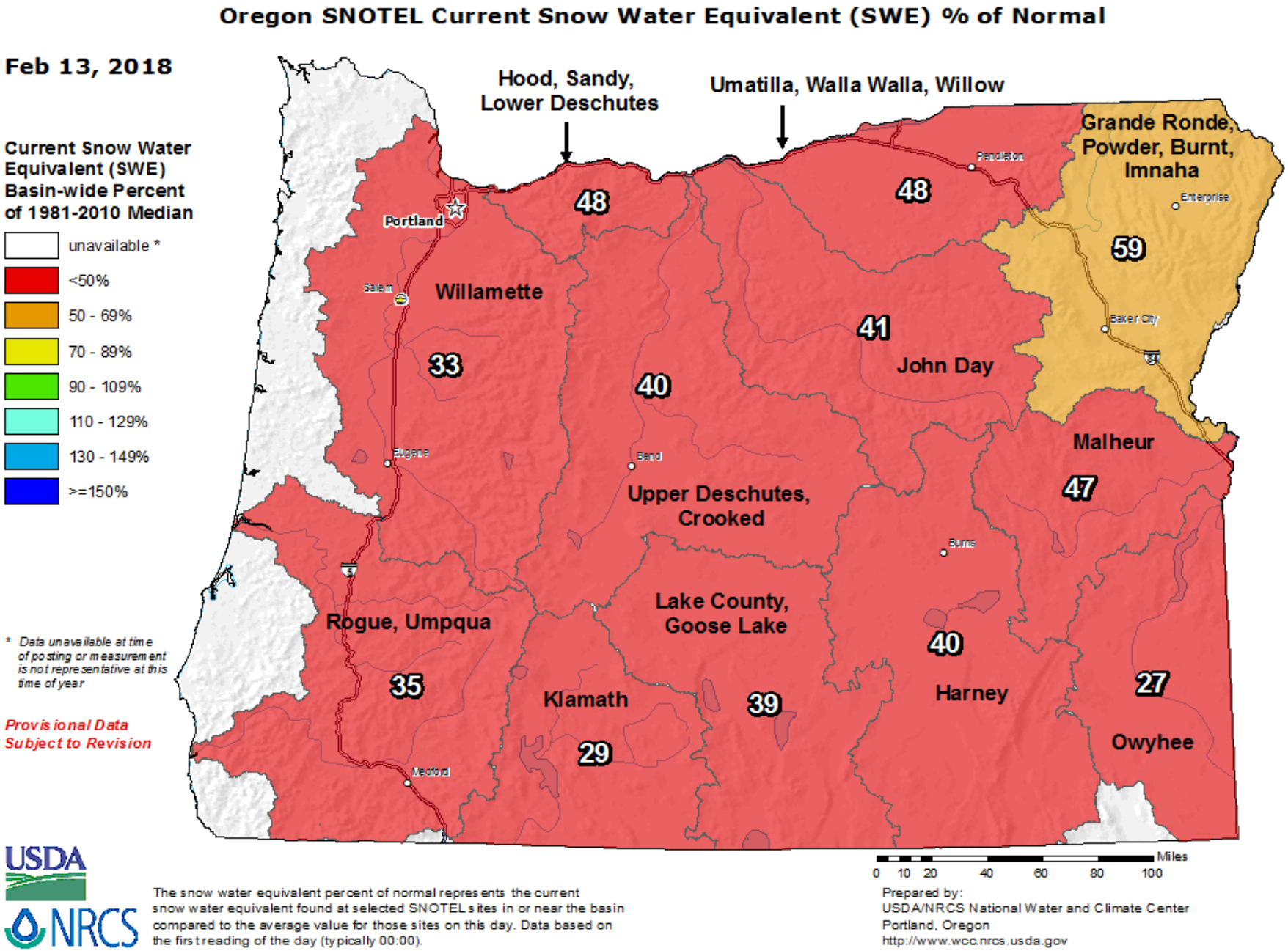
2018 Water Conditions Report

Drought Readiness Council

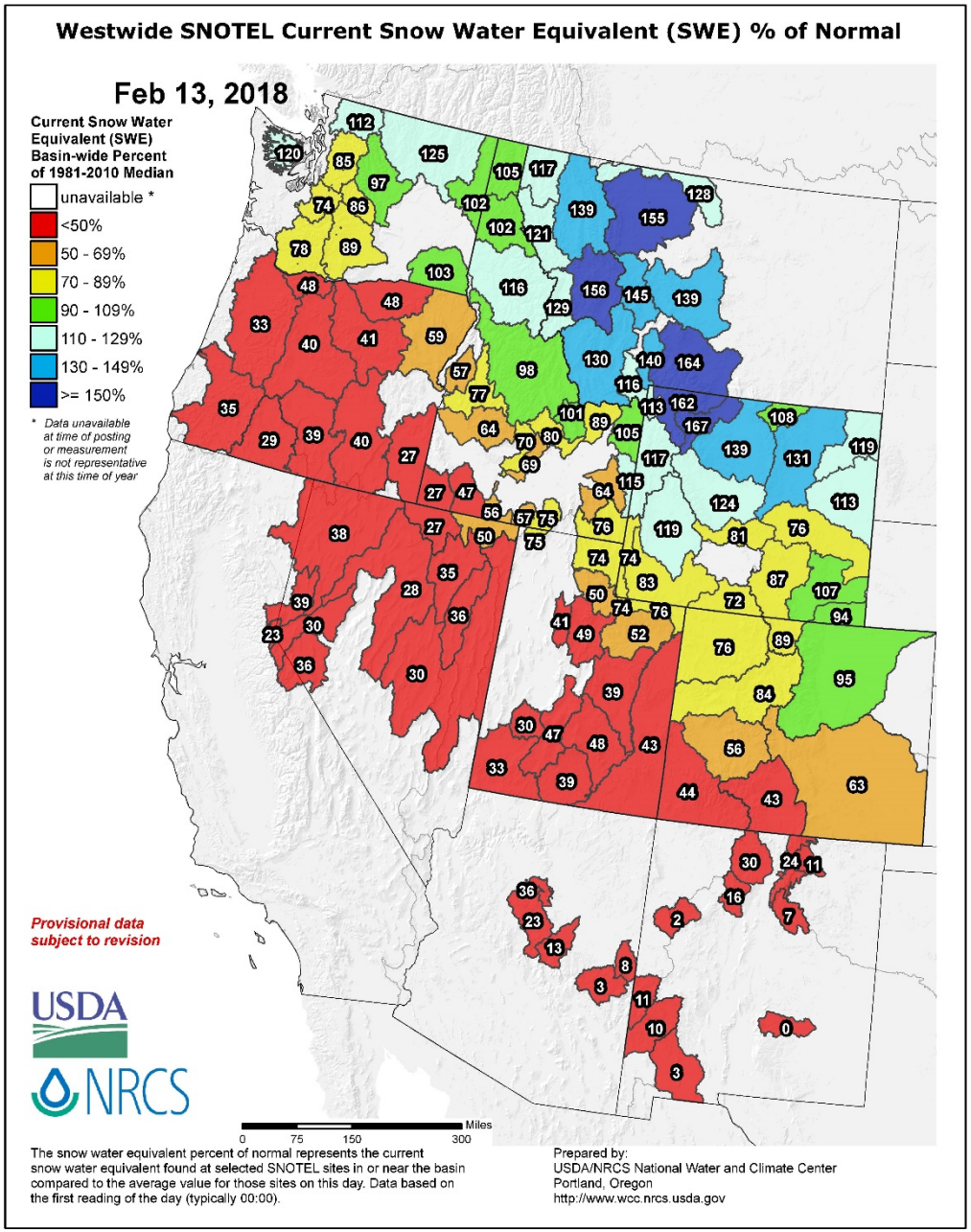
Ken Stahr, Chair,
Water Supply Availability Committee
Oregon Water Resources Dept.

February 15, 2018

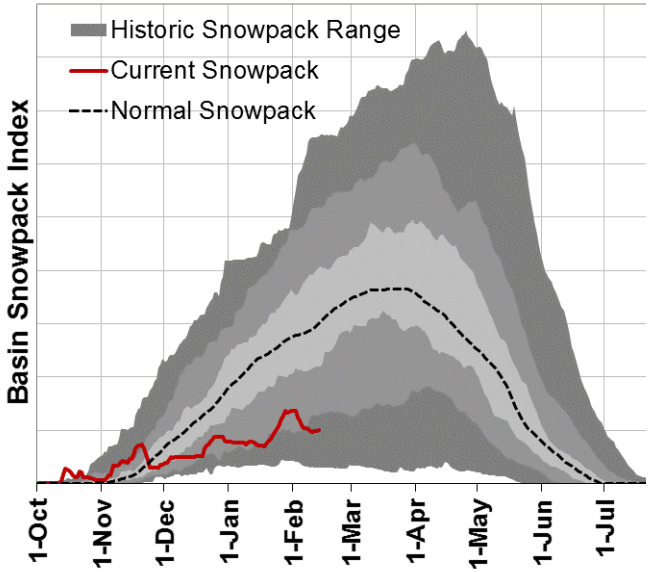
Statewide SNOTEL Snowpack is 39% of normal (25% of Normal In 2015)



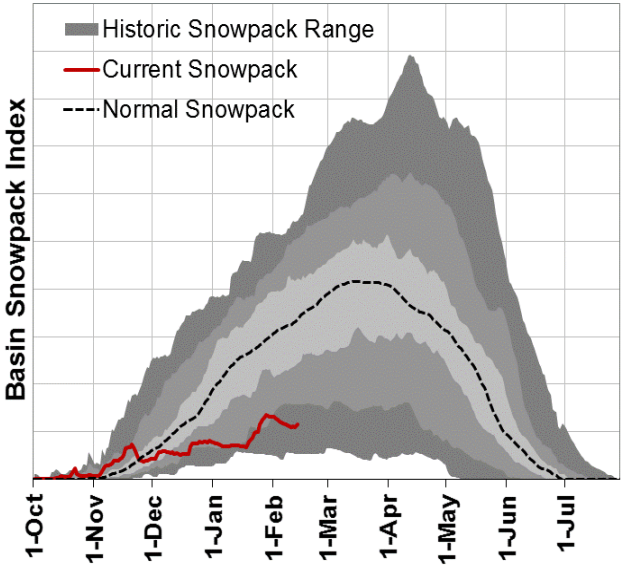
West-Wide Snowpack – February 13, 2018



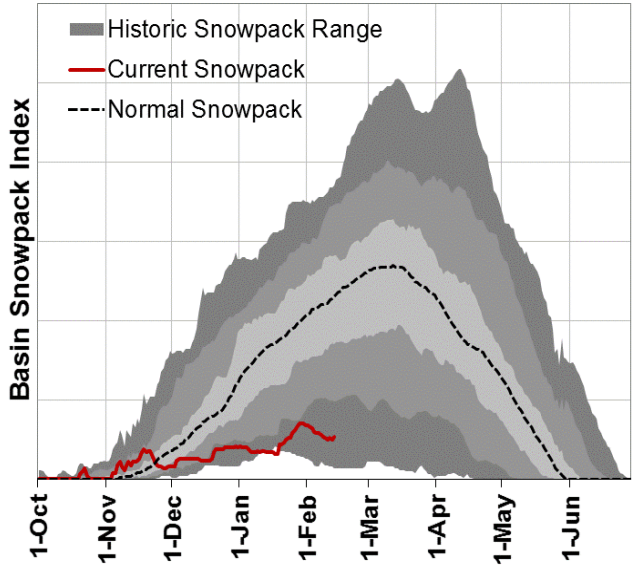
Willamette



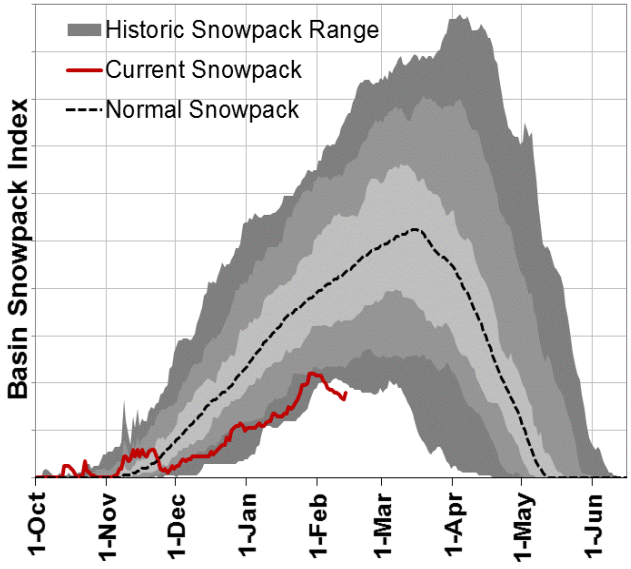
Rogue/Umpqua



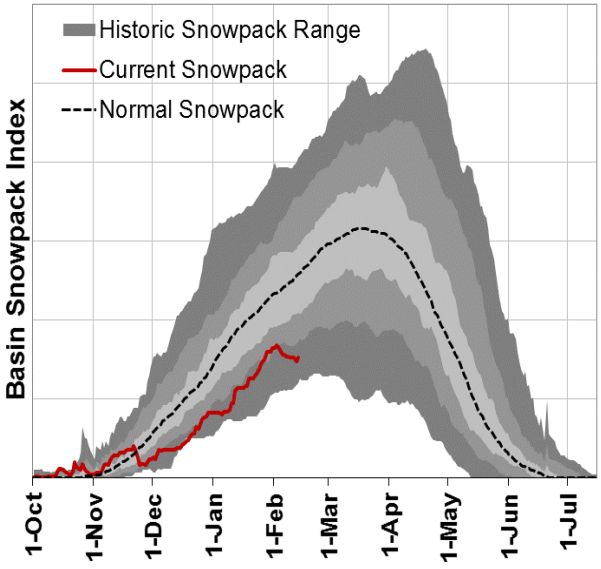
Klamath



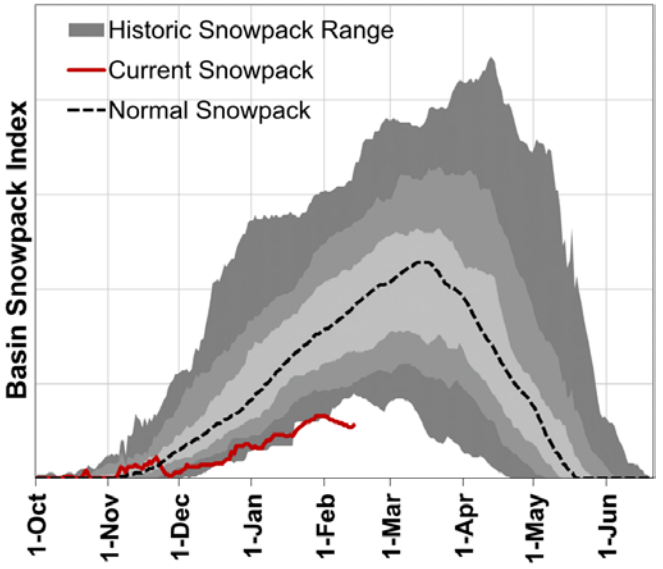
John Day



Grande Ronde/Powder/Burnt

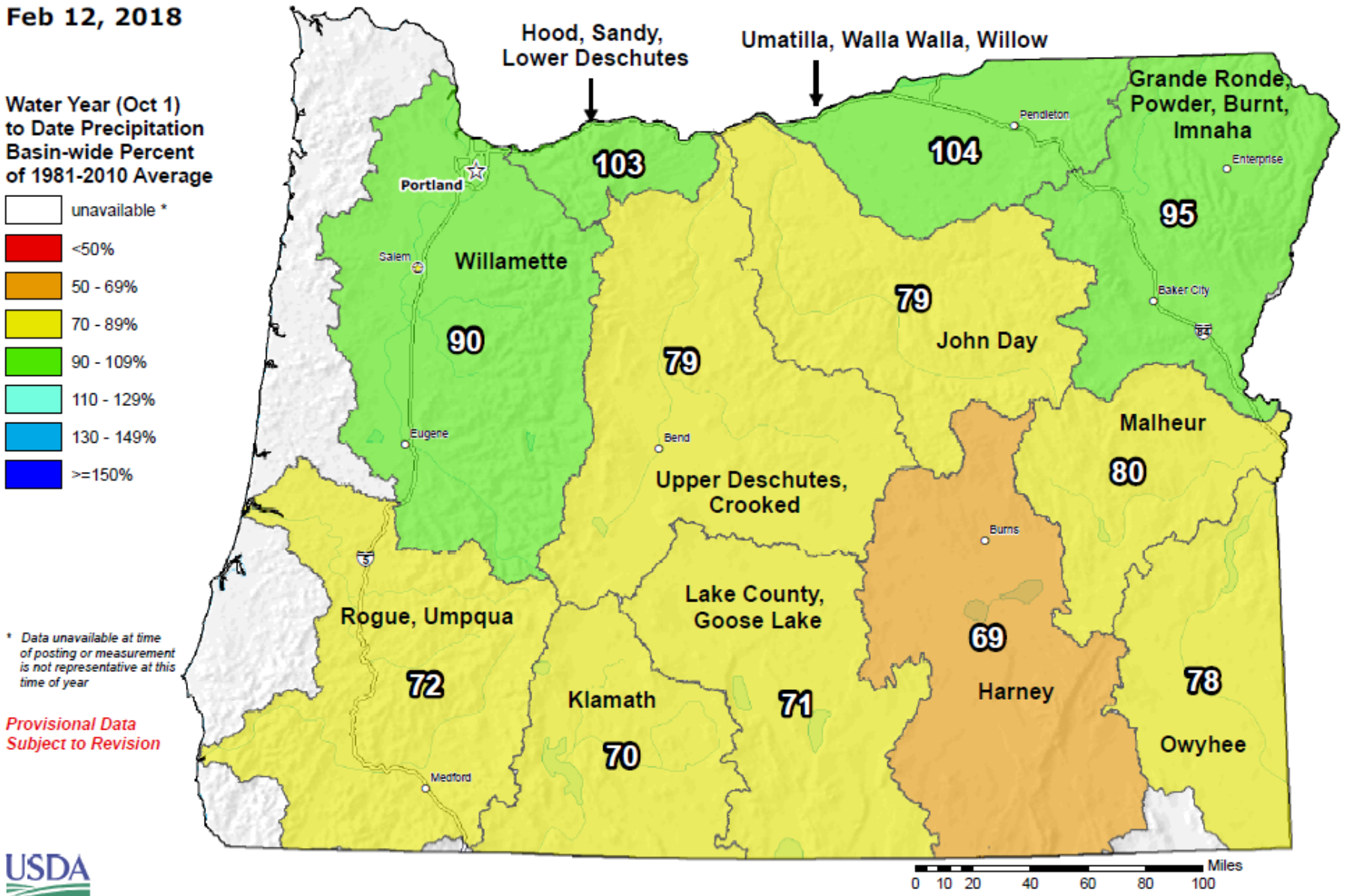


Owyhee/Malheur



Oregon SNOTEL Water Year (Oct 1) to Date Precipitation % of Normal

Feb 12, 2018

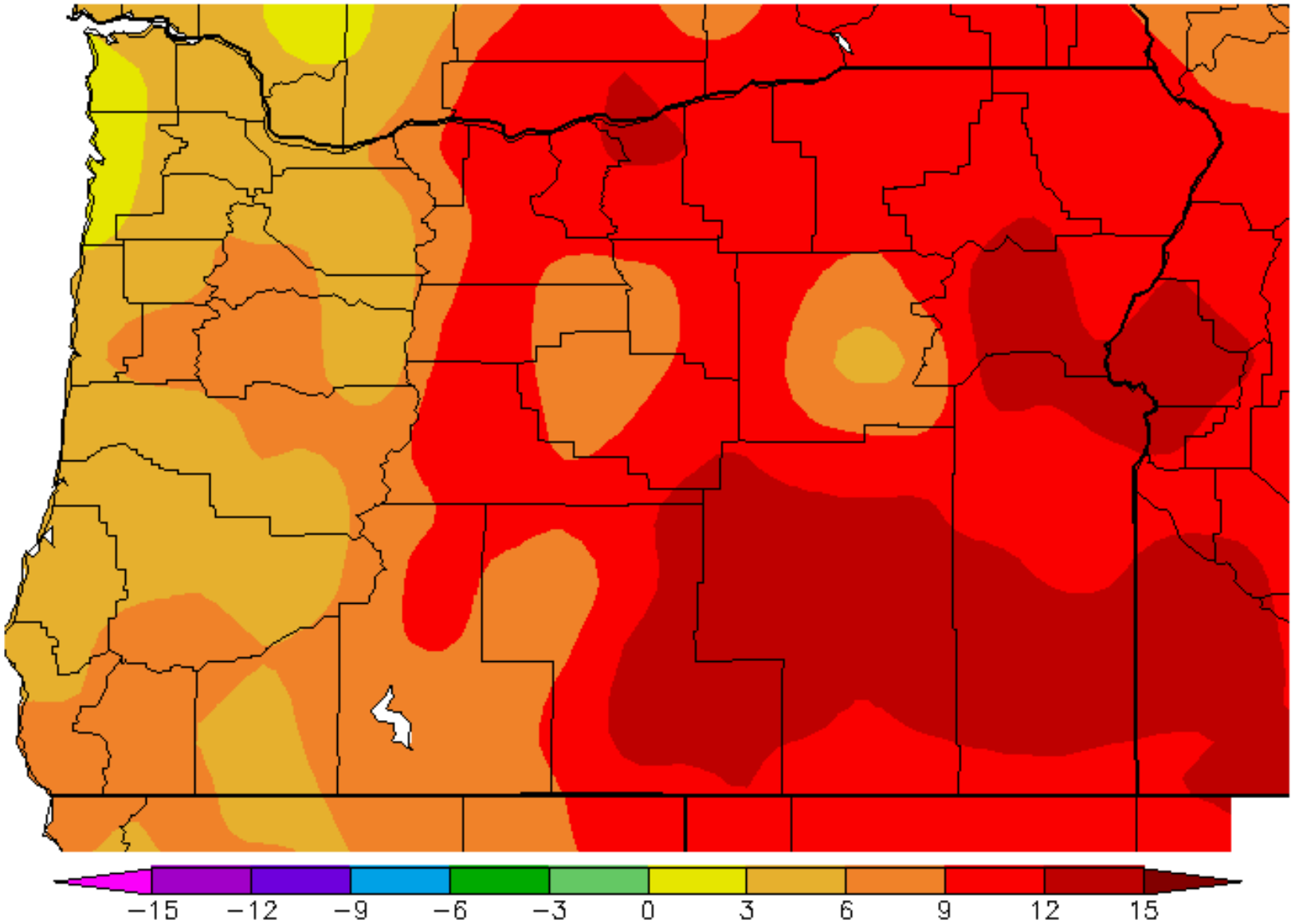


USDA NRCS

The water year to date precipitation percent of normal represents the accumulated precipitation found at selected SNOTEL sites in or near the basin compared to the average value for those sites on this day. Data based on the first reading of the day (typically 00:00).

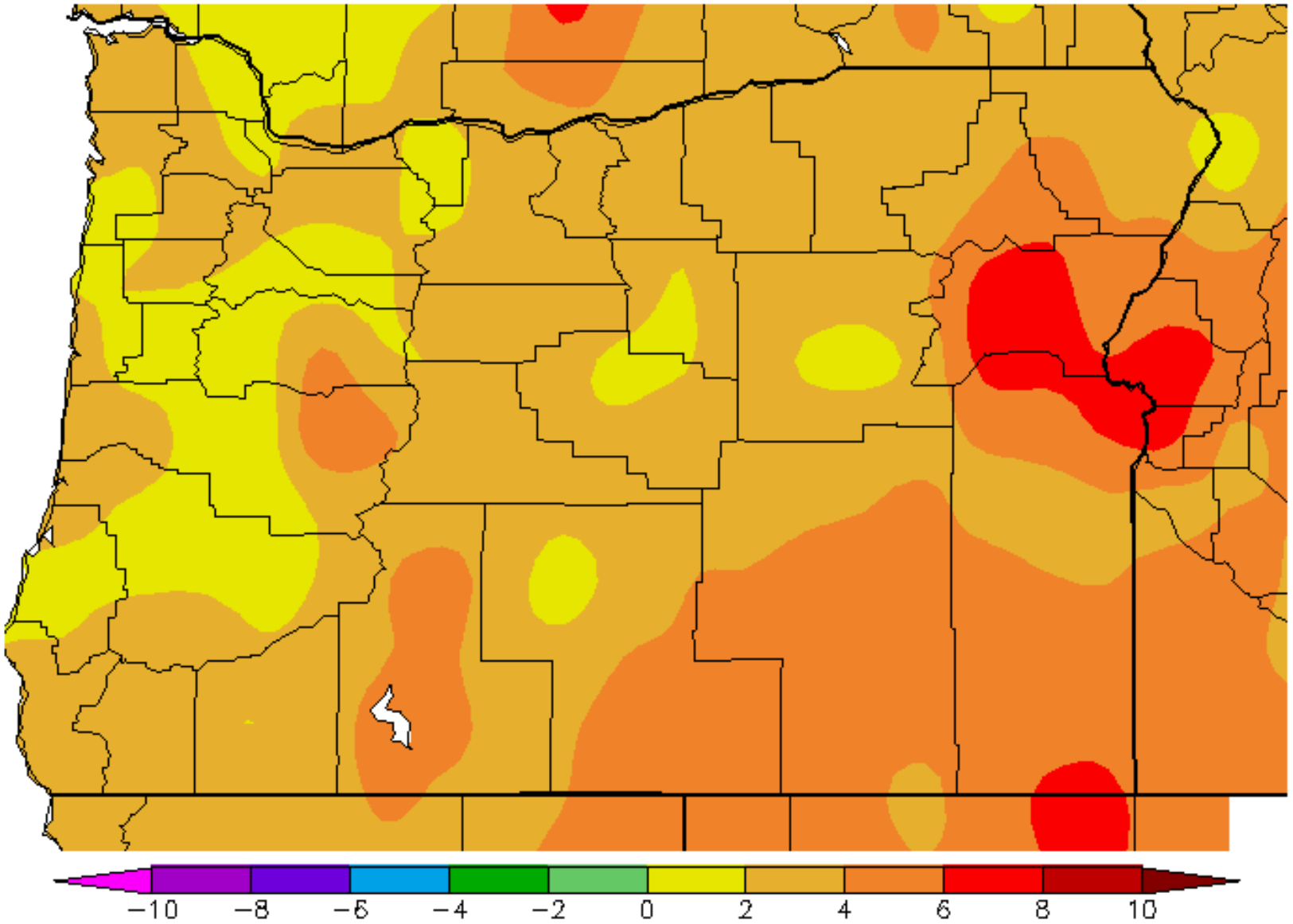
Prepared by:
USDA/NRCS National Water and Climate Center
Portland, Oregon
http://www.wcc.nrcs.usda.gov

Ave. Temperature dep from Ave (deg F)
1/28/2018 - 2/10/2018



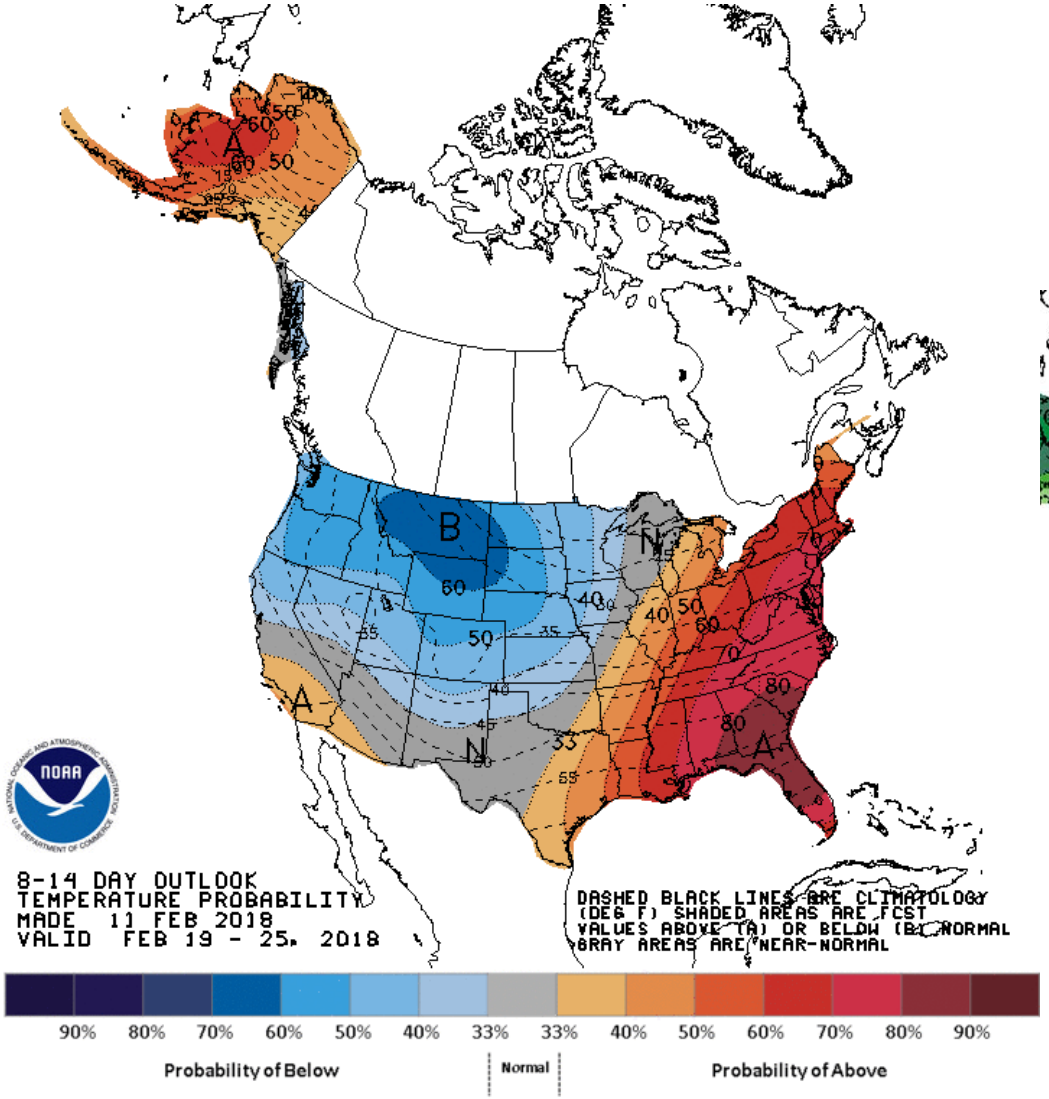
Generated 2/11/2018 at WRCC using provisional data.
NOAA Regional Climate Centers

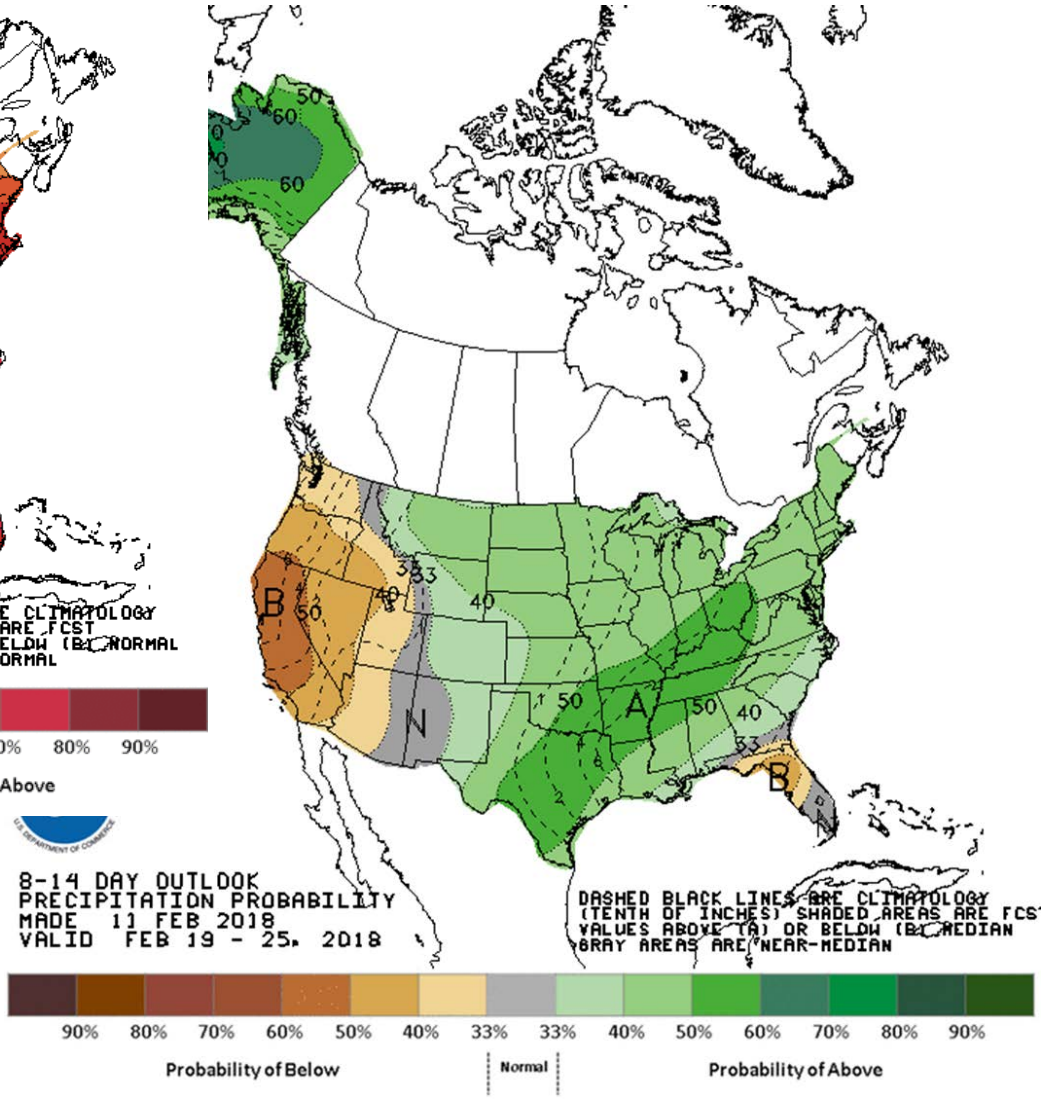
Ave. Temperature dep from Ave (deg F)
11/13/2017 – 2/10/2018



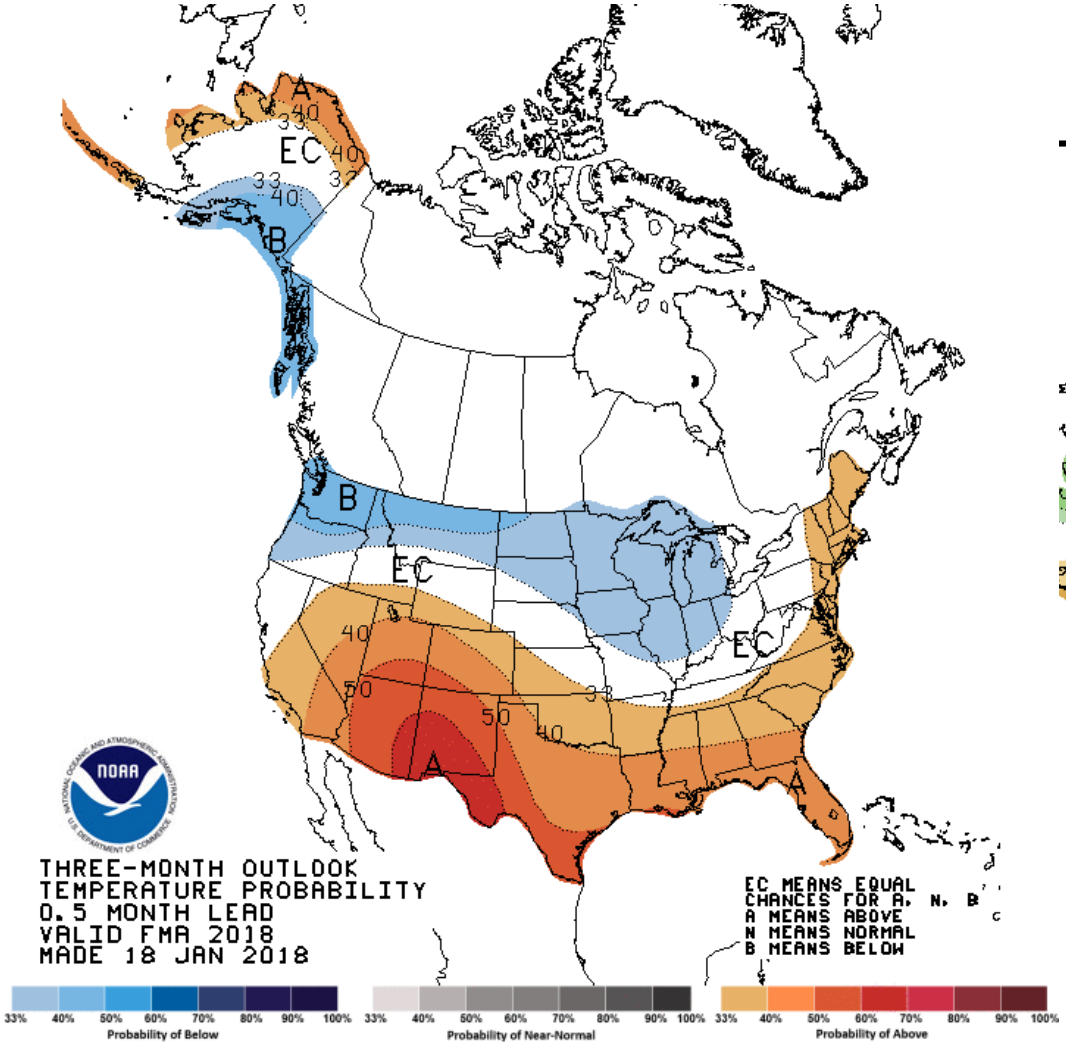
Generated 2/11/2018 at WRCC using provisional data.
NOAA Regional Climate Centers

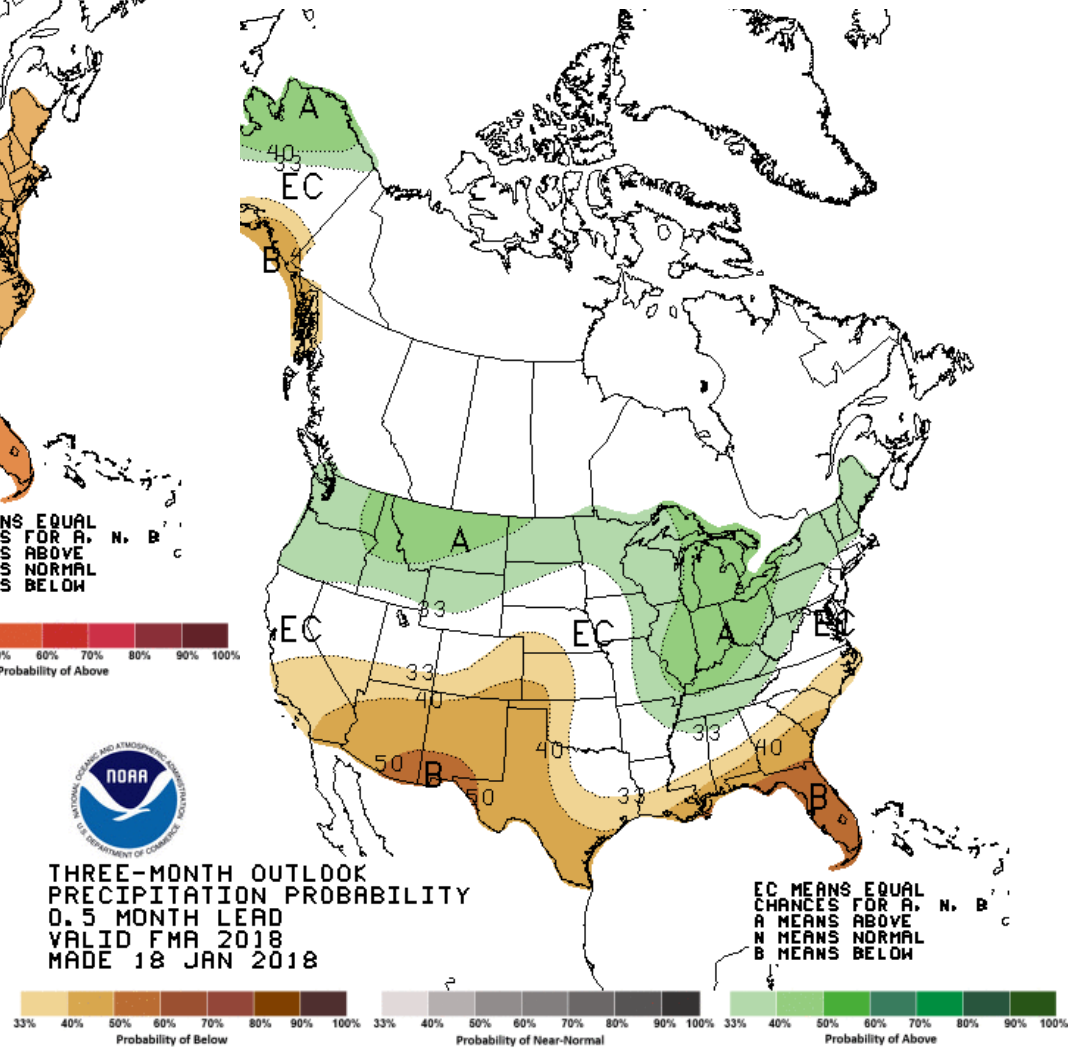
Short-Term Outlook



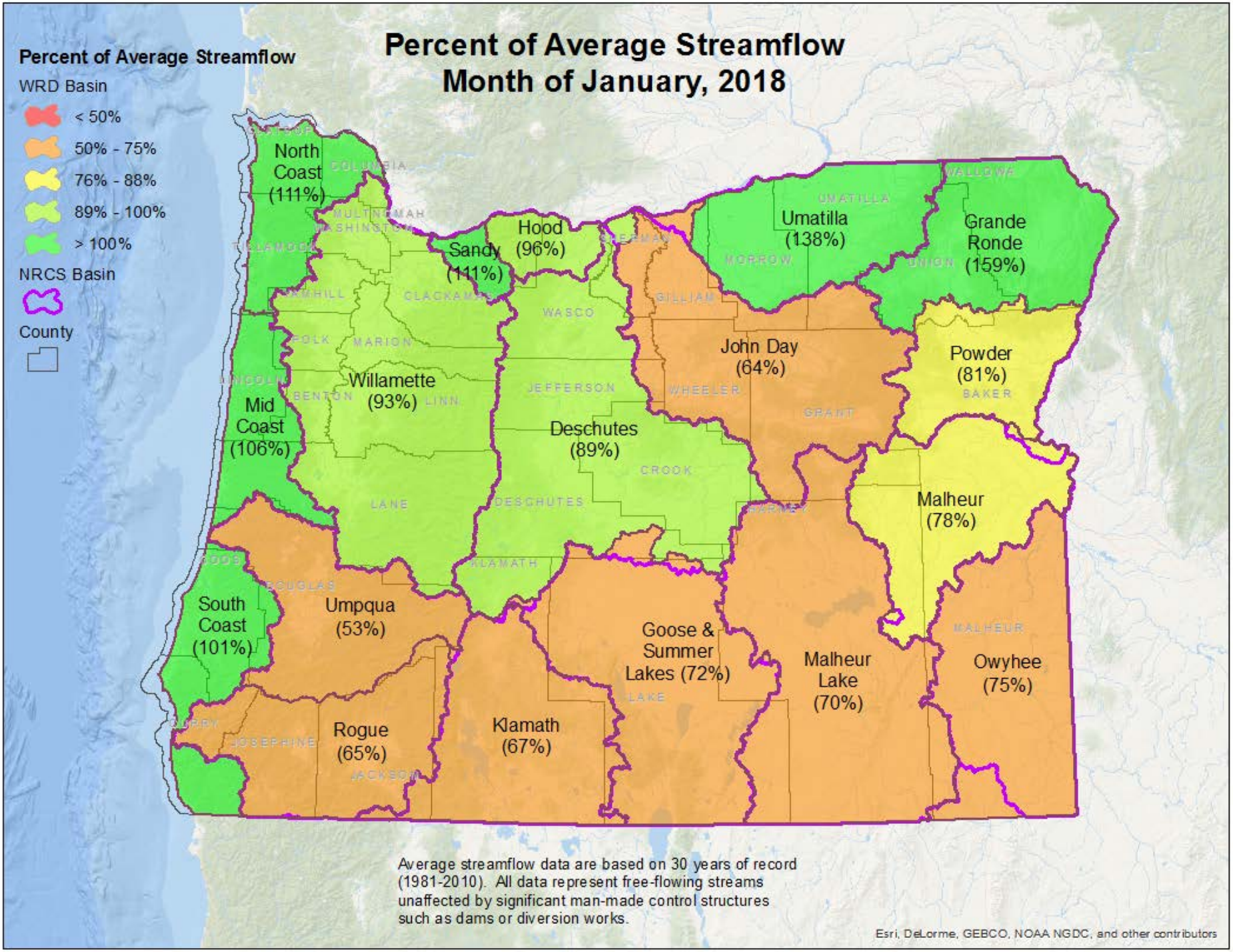


Three Month Outlook

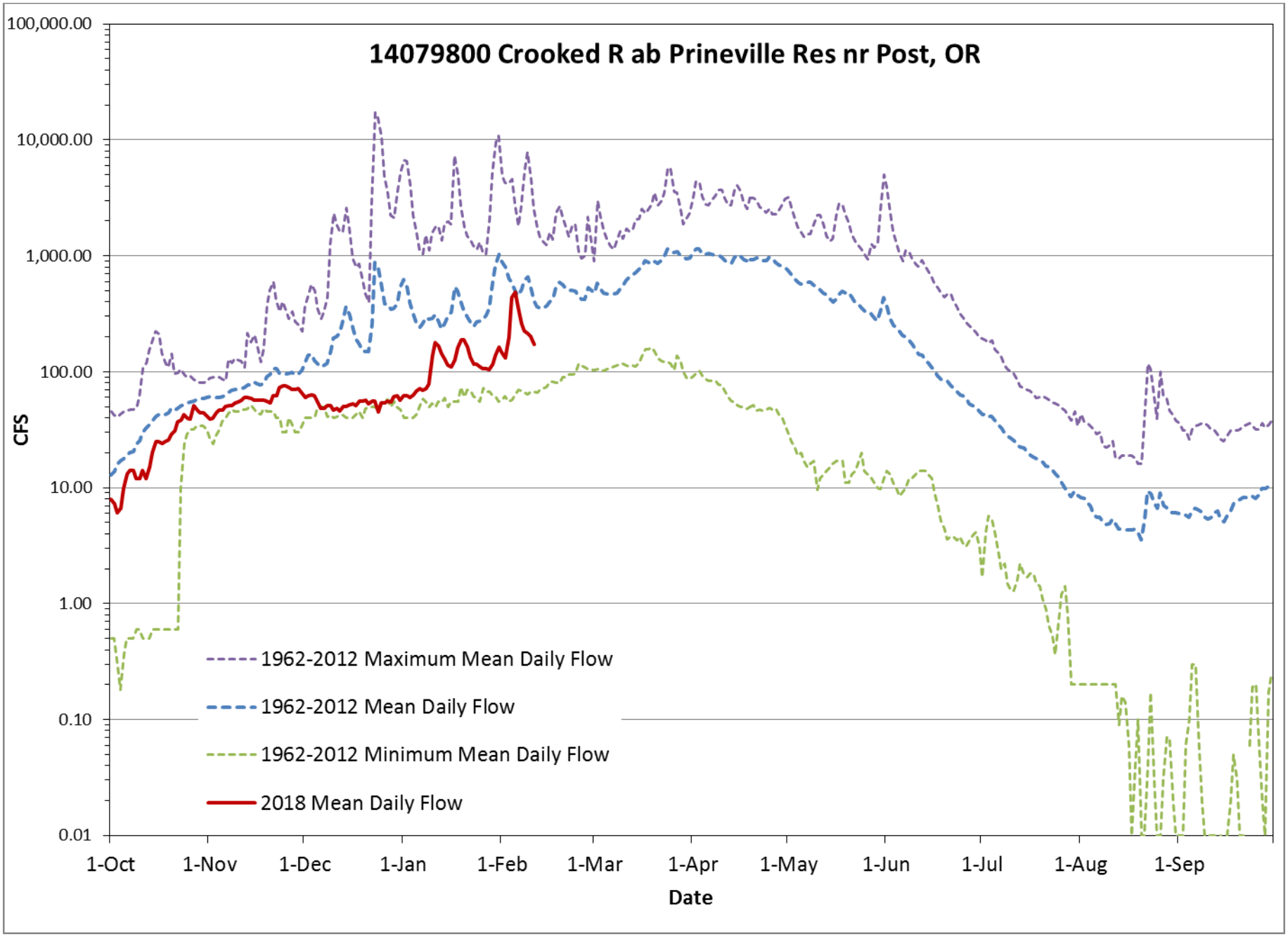


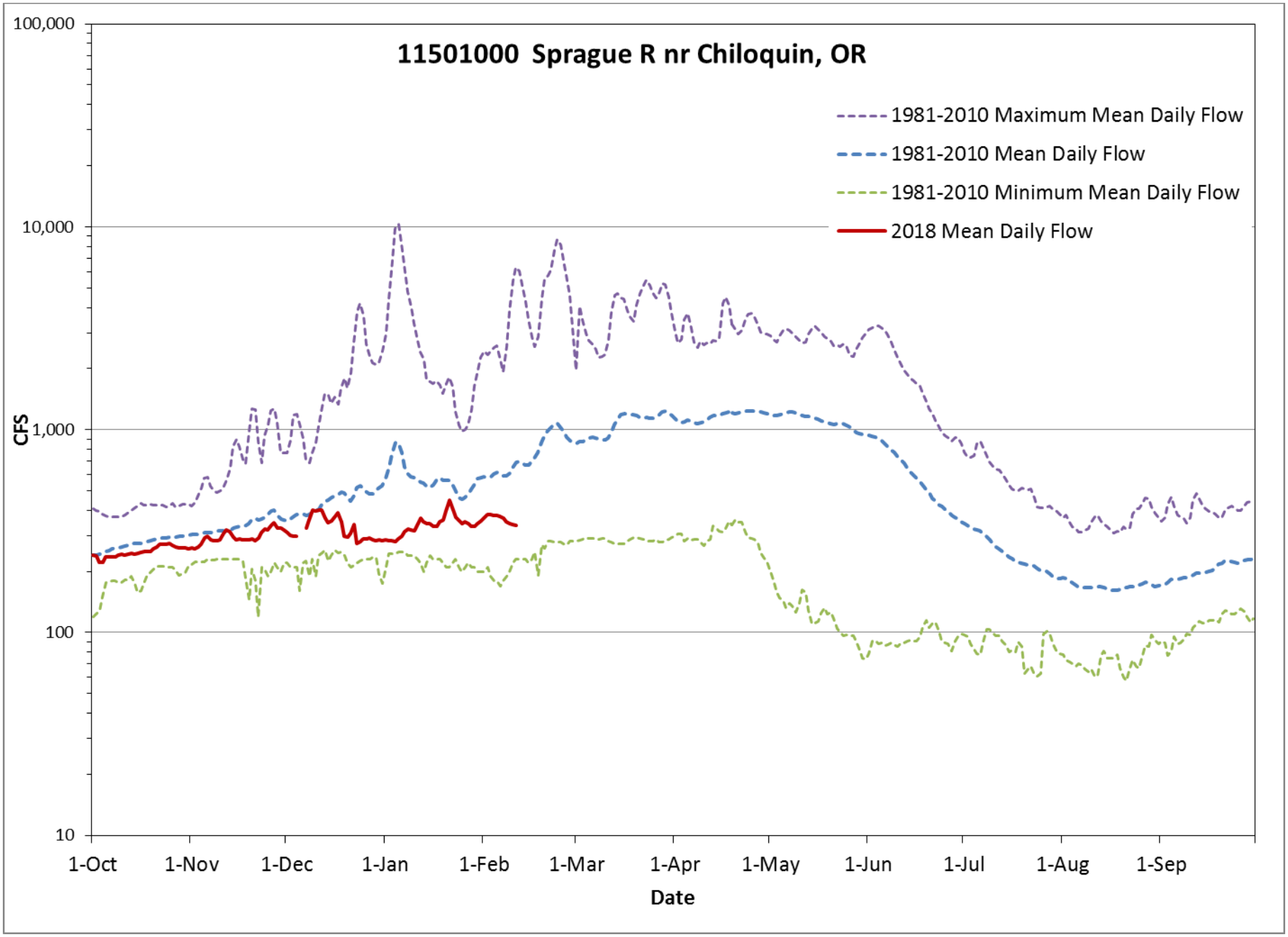


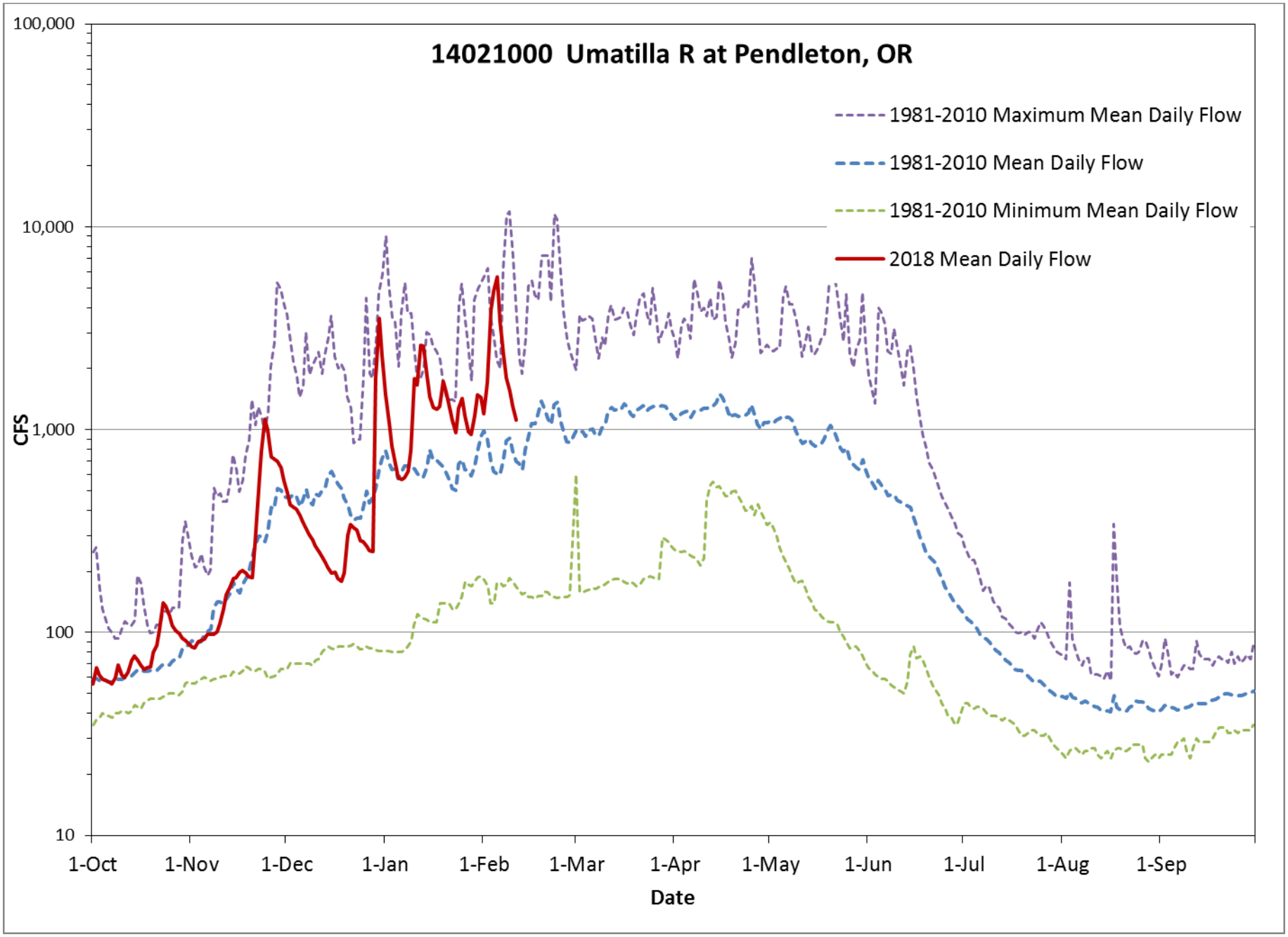
Percent of Average Streamflow
Month of January, 2018



Basin	Water Year % of average through January, 2018	% of average for January	% of average for 02/10/2018
North Coast	118%	111%	44%
Willamette	97%	93%	58%
Sandy	115%	111%	88%
Hood	106%	96%	89%
Deschutes	94%	89%	89%
John Day	74%	64%	77%
Umatilla	114%	138%	117%
Grande Ronde	130%	159%	224%
Powder	95%	81%	132%
Malheur	93%	78%	86%
Owyhee	84%	75%	67%
Malheur Lake	81%	70%	65%
Goose & Summer Lakes	83%	72%	83%
Klamath	77%	67%	59%
Rogue	74%	65%	59%
Umpqua	63%	53%	36%
South Coast	84%	101%	37%
Mid Coast	93%	106%	37%
West Side	**92%**	**91%**	**51%**
East Side	**94%**	**90%**	**99%**
State	**93%**	**90%**	**80%**

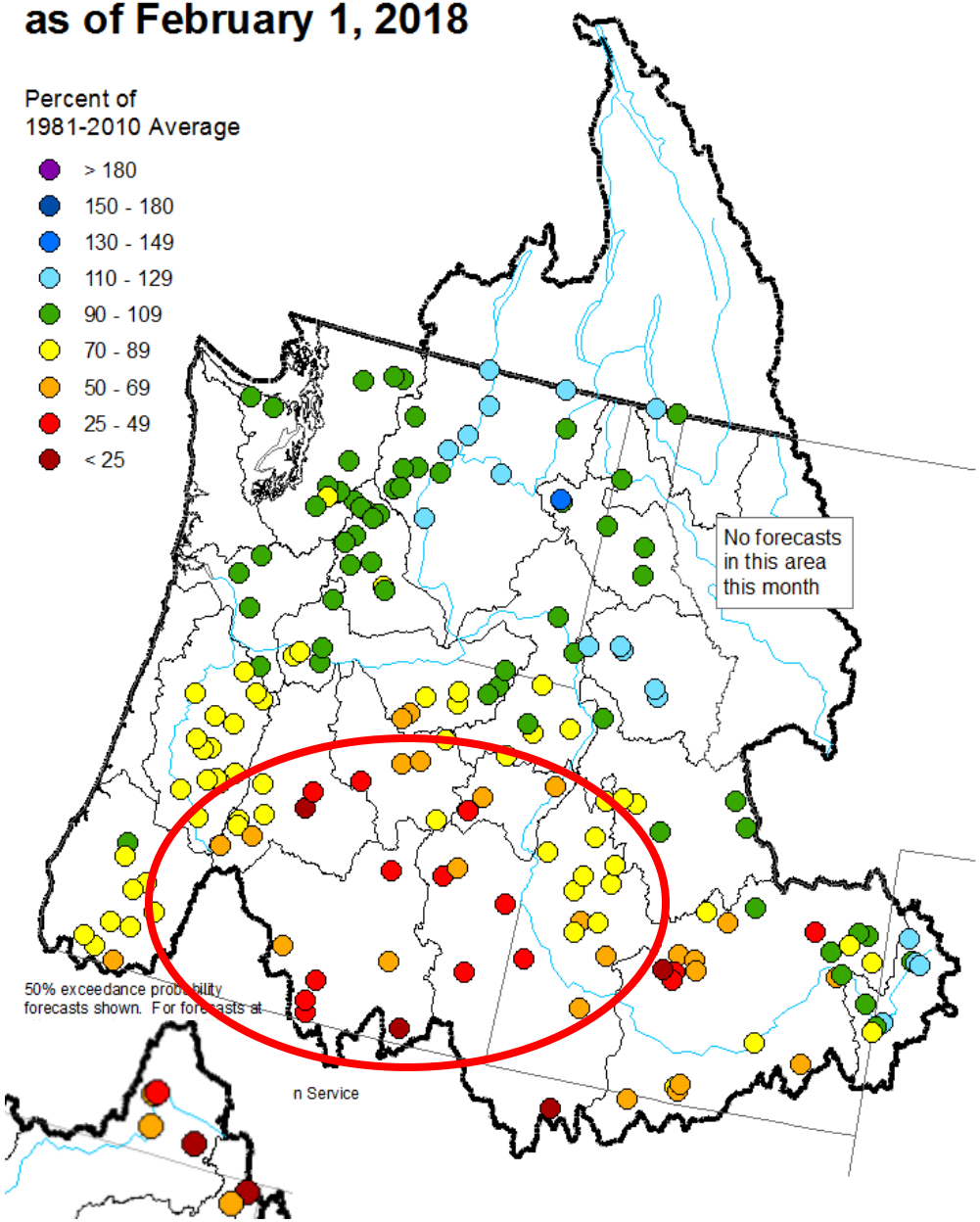

14079800 Crooked R ab Prineville Res nr Post, OR
100,000.00
10,000.00
1,000.00
100.00
10.00
1.00
0.10
0.01
CFS
1962-2012 Maximum Mean Daily Flow
1962-2012 Mean Daily Flow
1962-2012 Minimum Mean Daily Flow
2018 Mean Daily Flow
1-Oct
1-Nov
1-Dec
1-Jan
1-Feb
1-Mar
1-Apr
1-May
1-Jun
1-Jul
1-Aug
1-Sep
Date

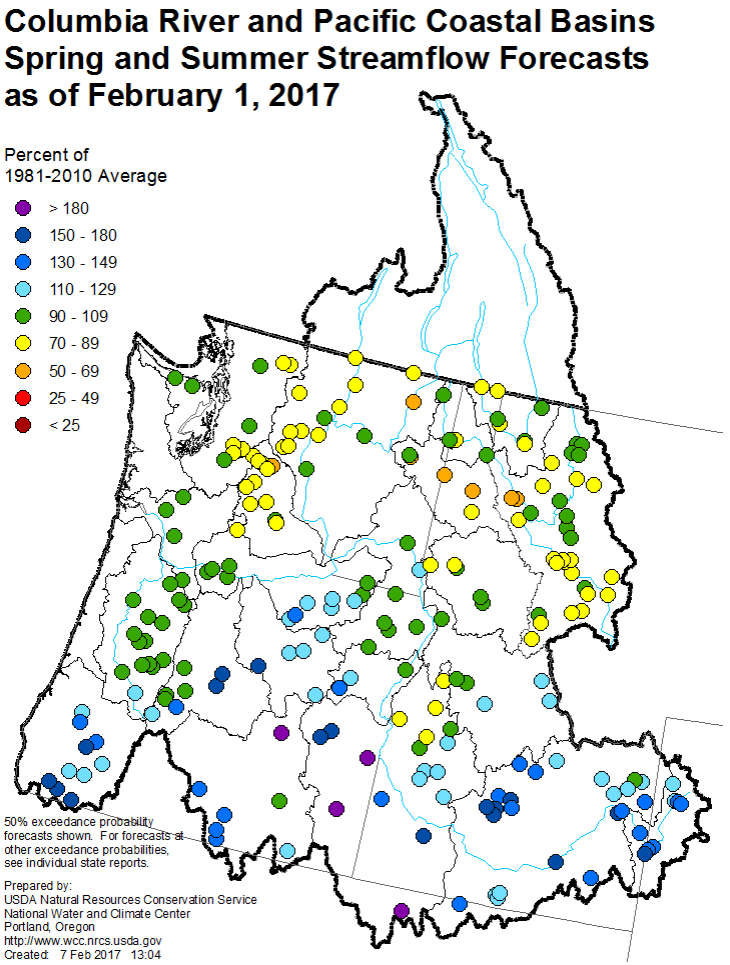

11501000 Sprague R nr Chiloquin, OR
1981-2010 Maximum Mean Daily Flow
1981-2010 Mean Daily Flow
1981-2010 Minimum Mean Daily Flow
2018 Mean Daily Flow
100,000
10,000
1,000
100
10
CFS
1-Oct
1-Nov
1-Dec
1-Jan
1-Feb
1-Mar
1-Apr
1-May
1-Jun
1-Jul
1-Aug
1-Sep
Date

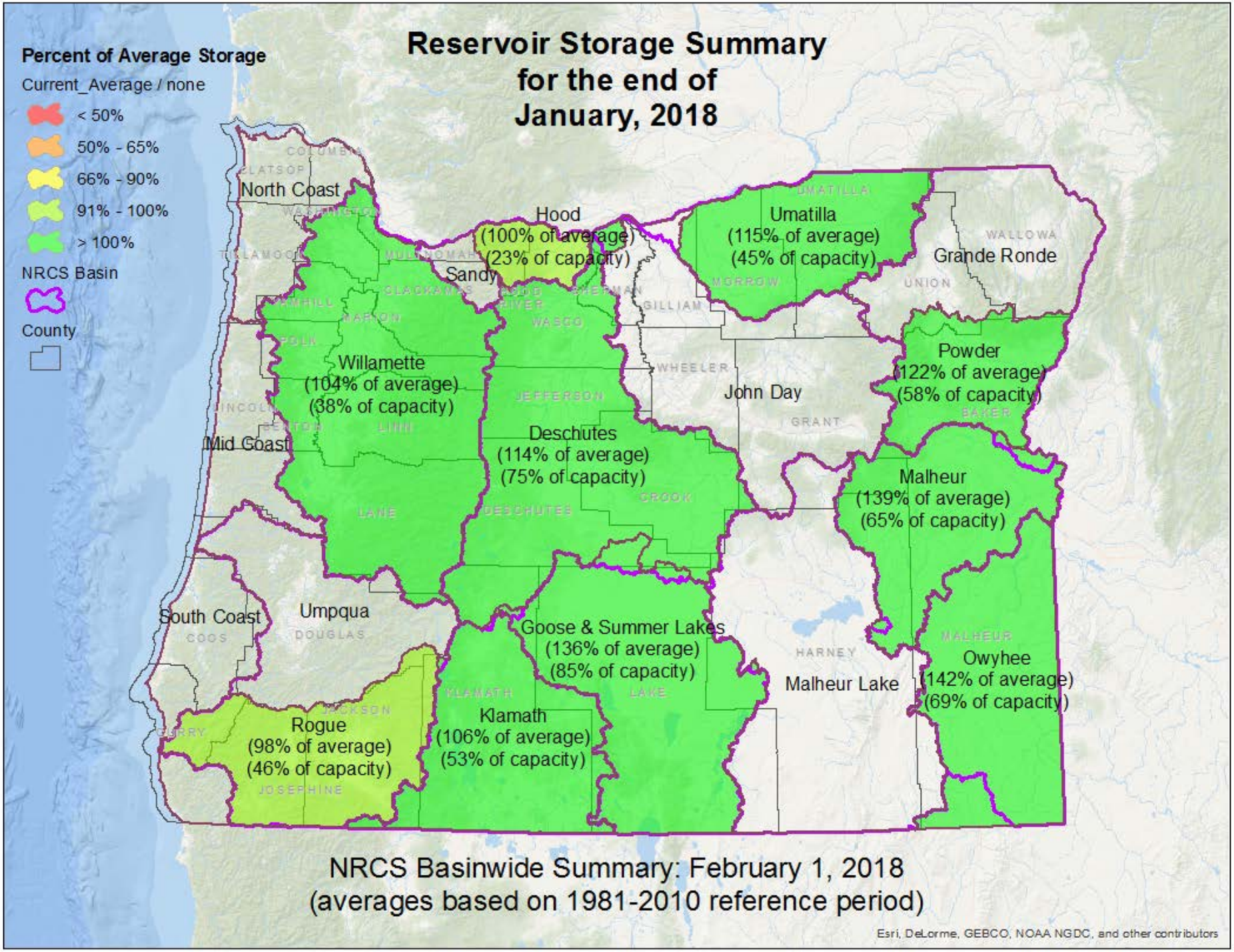

14021000 Umatilla R at Pendleton, OR
1981-2010 Maximum Mean Daily Flow
1981-2010 Mean Daily Flow
1981-2010 Minimum Mean Daily Flow
2018 Mean Daily Flow
100,000
10,000
1,000
100
10
CFS
1-Oct
1-Nov
1-Dec
1-Jan
1-Feb
1-Mar
1-Apr
1-May
1-Jun
1-Jul
1-Aug
1-Sep
Date

April thru September Streamflow Forecasts:

- Generally below normal to well below normal statewide
- Lack of Snowpack Driving Mechanism






Reservoir Storage Summary
for the end of
January, 2018
Percent of Average Storage
Current_Average / none
< 50%
50% - 65%
66% - 90%
91% - 100%
> 100%
NRCS Basin
County
North Coast
Hood
(100% of average)
(23% of capacity)
Sandy
Umatilla
(115% of average)
(45% of capacity)
Grande Ronde
Willamette
(104% of average)
(38% of capacity)
Mid Coast
Deschutes
(114% of average)
(75% of capacity)
John Day
Powder
(122% of average)
(58% of capacity)
Malheur
(139% of average)
(65% of capacity)
South Coast
Umpqua
Goose & Summer Lakes
(136% of average)
(85% of capacity)
Malheur Lake
Owyhee
(142% of average)
(69% of capacity)
Rogue
(98% of average)
(46% of capacity)
Klamath
(106% of average)
(53% of capacity)
NRCS Basinwide Summary: February 1, 2018
(averages based on 1981-2010 reference period)
Esri, DeLorme, GEBCO, NOAA NGDC, and other contributors


Questions?

OREGON DROUGHT READINESS COUNCIL
State Drought Declaration Process & Emergency Tools

State Drought Declaration Process

Requests for drought declarations typically go through a three-part process before securing a state drought declaration from the Governor. First, a county commission submits a request for a state drought declaration to the Drought Readiness Council, along with a description and observation of local drought impacts. Second, the Water Supply Availability Committee, chaired by the Water Resources Department, meets to discuss and report water supply conditions to the Drought Readiness Council. Finally, the Drought Readiness Council, co-chaired by the Water Resources Department and Office of Emergency Management, assesses the observed or projected drought impacts and makes recommendations to the Governor's Office about whether to declare drought in an area.

The Governor decides whether to issue an Executive Order declaring a drought emergency. State drought declarations are typically issued at a county scale. The primary benefits of state drought declarations from the Governor are that they create greater awareness of drought conditions, facilitate coordination between state agencies, and allow the Water Resources Department to provide existing water right holders with access to emergency water management tools. These tools are outlined below.

After a drought declaration, the Governor or the Oregon Water Resources Commission can also direct state agencies and political subdivisions to implement a water conservation plan or water curtailment plan.

Emergency Drought Tools for Water Right Holders

A state drought declaration allows the Water Resources Department to offer certain tools to water right holders in a drought-declared county. These tools have an expedited review process, reduced fee schedule, and are intended to be short-term emergency authorizations, not permanent solutions to deal with water supply challenges. Water right holders seeking long-term solutions should contact their watermaster to help identify what options may exist.

- **Temporary Emergency Water Use Permit**
  An approved emergency water use drought permit allows a water user to temporarily replace water normally available under an existing water right. The most common drought permit allows the use of groundwater as an alternative to an existing surface water right. A well-prepared application generally takes approximately ten business days to process. Emergency water use permits are issued through an expedited process and are valid for one year or the term of the drought declaration, whichever is shorter.

- **Temporary Transfer**
  A water user can apply to change the type of use, place of use, or the location of the diversion under an existing water right. A temporary drought transfer takes place under an expedited process, and is in effect for up to one year or the duration of the drought declaration, whichever is shorter.

- **Temporary Instream Lease**
  Once approved, a water user can convert all or a portion of a water right to an instream use for a period of one year or the term of the drought declaration, whichever is shorter.

- **Temporary Substitution**
  Any person holding both a primary right originating from a surface water source and a supplemental right from a groundwater source may apply to temporarily use the supplemental right instead.

- **Special Option Agreements**
  A water-right holder can provide water to another party, entering into an agreement that authorizes the use of water at locations, from points of diversion, and for uses other than those described in the water right. Typically, the agreement remains in place until terminated by the parties, and it provides additional water-supply options in times of drought.

- **Temporary Exchange of Water**
  The Water Resources Commission can approve a temporary exchange of existing rights, such as using stored-water instead of a direct-flow surface-water right.

- **Human Consumption or Stock Water Use Preference**
  The Water Resources Commission has authority to grant a temporary preference to water rights for human consumption and/or stock watering uses. The preference is given over other uses regardless of the priority date (seniority) of water rights associated with the other uses. In order for the preference to go into effect, the Water Resources Commission must approve temporary rules instituting the preference.

For More Information

The Water Resources Department maintains a webpage for Drought Information that provides the status of current water conditions and state drought declarations, as well as information on drought tools and what you can do to use water wisely.

Water Resources Department staff members are available to answer questions about emergency applications, the state declaration process, and general water supply conditions.

Contact: Ed Gosse 503-986-0801 / Edward.P.Gosse@oregon.gov

The Role of Groundwater in Governor-Declared Droughts

OREGON
WATER RESOURCES DEPARTMENT

Drought Readiness Council

February 15, 2018

Justin Iverson

Groundwater Manager, OWRD

OREGON WATER RESOURCES DEPARTMENT

Groundwater as an Alternate Supply

- Groundwater is commonly used as a supplemental supply during droughts
- Supplemental groundwater rights exist throughout the state
- Time-limited drought permits may be issued in the event of a governor-declared drought
- Ideally, supplemental groundwater use is episodic and impacts are mitigated by recharge during wet years

OREGON WATER RESOURCES DEPARTMENT

Supplemental Groundwater Pumping

- Use is limited to the acres and duty covered by the right
- Totalizing flow meters, where required, shall be installed prior to pumping
- Supplemental groundwater rights within the Klamath project area cover about 41,300 acres, equating to approximately 123,900 AF of potential groundwater pumping

OREGON WATER RESOURCES DEPARTMENT

2018 Drought Permits

- Emergency water use permit under OAR 690-019
- For use on lands in Oregon with underlying water rights (not for new irrigated acres)
- Duty (volume) will be limited to 1.5 acre feet per acre
- Totalizing flow meters will be required prior to issuing drought permits
- In the Klamath Project Area, will be available for wells where regional groundwater level declines are less than 20 feet since Y2K

OREGON WATER RESOURCES DEPARTMENT

Klamath County Case Study

- Droughts declared by governor approx. 46% of the time between 1992 and 2015, including 5 of 6 years between 2010 and 2015
- Majority of drought permits to date have been issued in Klamath County

Year	No. of Drought Permits	Acres Authorized by Drought Permits
2013	15	5,711
2014	41	18,760
2015	38	20,215

OREGON WATER RESOURCES DEPARTMENT

Klamath County Case Study

- BOR initiated several drought relief programs from the mid-2000s to 2015, including:
  - Land following program
  - Pay to pump program
  - Domestic well deepening program
- Water levels and groundwater use have been monitored by OWRD since 2010
- Annual reports prepared for BOR document groundwater response to drought relief programs

OREGON WATER RESOURCES DEPARTMENT

Klamath County Case Study

Some wells show a near-ideal response, for example:

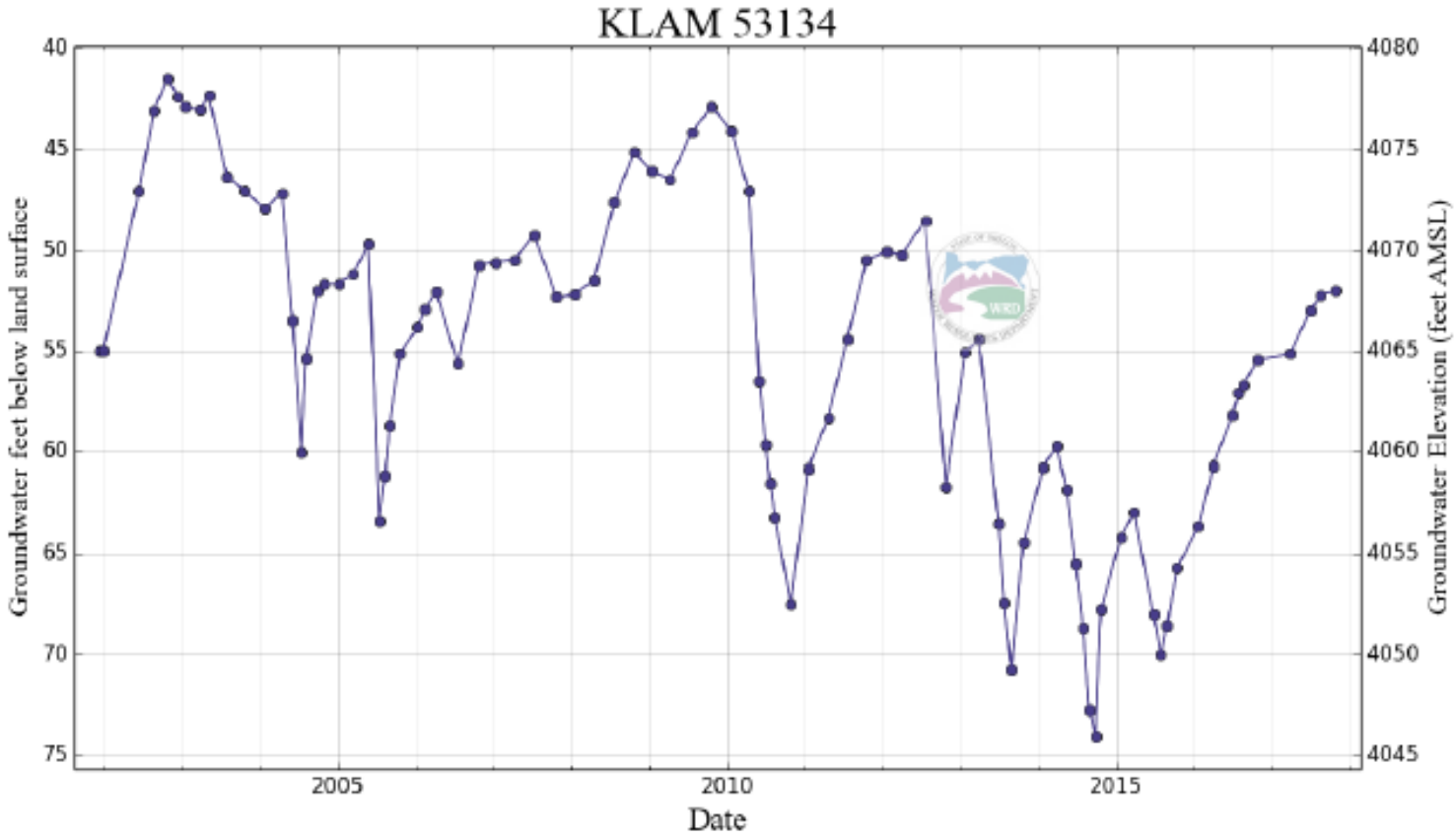


Figure 7. Hydrograph for well KLAM 53134 northwest of Stukel Mtn.

OREGON WATER RESOURCES DEPARTMENT

Klamath County Case Study

Most not so much…

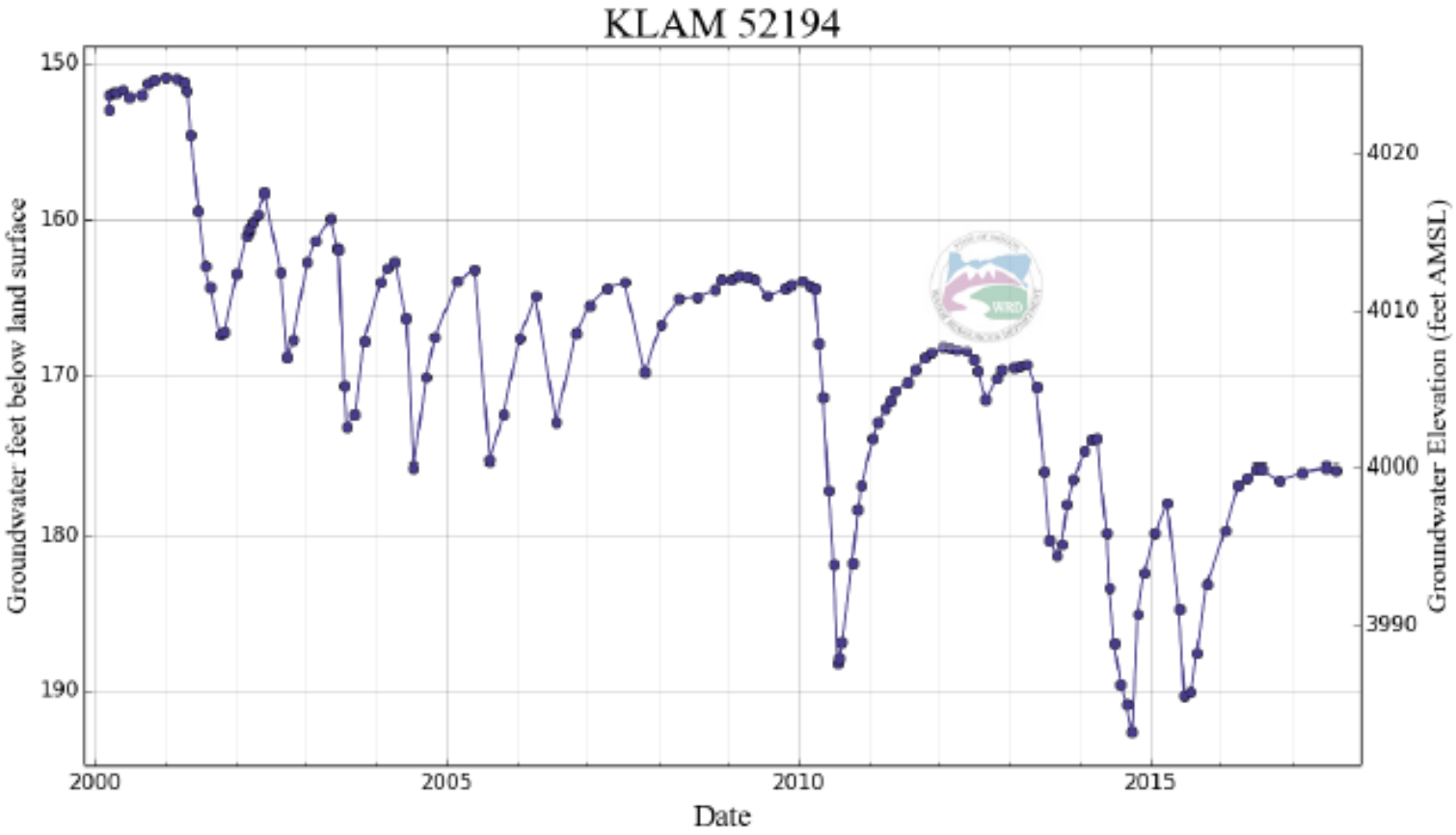


Figure 5. Hydrograph for well KLAM 52194 near Malin, OR

Annual Report regarding OWRD Technical Assistance for the U.S. Bureau of Reclamation Pilot Water Bank in the Upper Klamath Basin

2017 Irrigation Season

Mike Thoma, PhD, RG
Hydrogeologist

Justin Iverson, RG
Groundwater Section Manager

January 2018

Oregon Water Resources Department

Contents

Figures

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Appendices

Introduction

The Oregon Water Resources Department (OWRD) has been contracted to provide technical assistance to the U.S. Bureau of Reclamation (USBR) during Federal Fiscal Years (FFY) 2015-2019 under agreement R15AP00061. Technical assistance includes collection and assessment of groundwater use and groundwater level data from wells in Oregon associated with, and proximal to, the USBR's Klamath Project Area ("Project Area") in the Upper Klamath River Basin. This report summarizes water use data and groundwater level data for the 2017 irrigation season.

Background

Prior to 2015, the Klamath Water and Power Agency (KWAPA) managed water bank operations under the Water Use Mitigation Program (WUMP) under the guidance of the USBR. This program was used to augment diversion of surface water for the purpose of irrigation with additional groundwater pumping. Groundwater users with valid rights (which included single-year drought permits) were offered financial incentives to pump groundwater in lieu of surface water, either for land application or directly to USBR-operated canals, and to idle agricultural lands to conserve water. OWRD provided technical assistance and field presence for the groundwater use and water level monitoring component of WUMP since 2010. The primary purpose of this program was to enhance in-stream flows for fisheries during spring and summer.

A Governor's drought declaration in 2010 allowed OWRD to issue emergency drought permits for Oregon irrigators. Subsequently, during the 2010 irrigation season the USBR, KWAPA, and area irrigators relied extensively on supplemental groundwater to augment limited surface water supplies, pumping approximately 141,000 acre-feet of groundwater in Oregon and California. Drought emergency declarations and emergency drought water use permits were also issued in 2012, 2013, 2014, and 2015. KWAPA was dissolved in 2016 and the water bank program is no longer in effect. Consequently, groundwater pumping in the Project Area was lower in 2016 and 2017 (< 20,000 acre-feet) and primarily limited to irrigators with standard groundwater permits (not drought permits). In 2017 no drought declarations were made in Oregon.

Purpose of This Report

This report presents 2017 groundwater use data from metered production wells within and adjacent to the Oregon portion of the Project Area and groundwater level trends from representative wells in Oregon. Overall, 241 wells were visited in the Project Area between October 2017 and early January 2018 for the purpose of recording water use (this time-frame is referred to in this report as the "2017 Synoptic"), and 113 wells were measured in the Project Area by OWRD or USGS staff for water level data in WY 2017. This information was used to assess the impact of pumping on groundwater resources and to inform water management decisions. These monitoring data have been particularly important to state water resource managers due to the dry conditions experienced during recent years (between 2010 and 2015).

2017 Field Data Collection and Analysis

Data Collection

OWRD field staff mobilized to the Klamath Basin from the Salem, Bend, and Klamath Falls offices during the 2017 Synoptic to conduct the flow meter synoptic survey. During the synoptic survey OWRD staff visited 241 wells in and adjacent to the Project Area in Oregon to collect flow meter data. The visited wells are a subset of all permitted water supply wells in the Project Area for which current or historic permit conditions require water metering, or wells which have been voluntarily metered in the past. Figure 1 encompasses the area of interest and shows the location of permitted and visited wells. The size of the well location symbols correlates to calculated groundwater use in 2017.

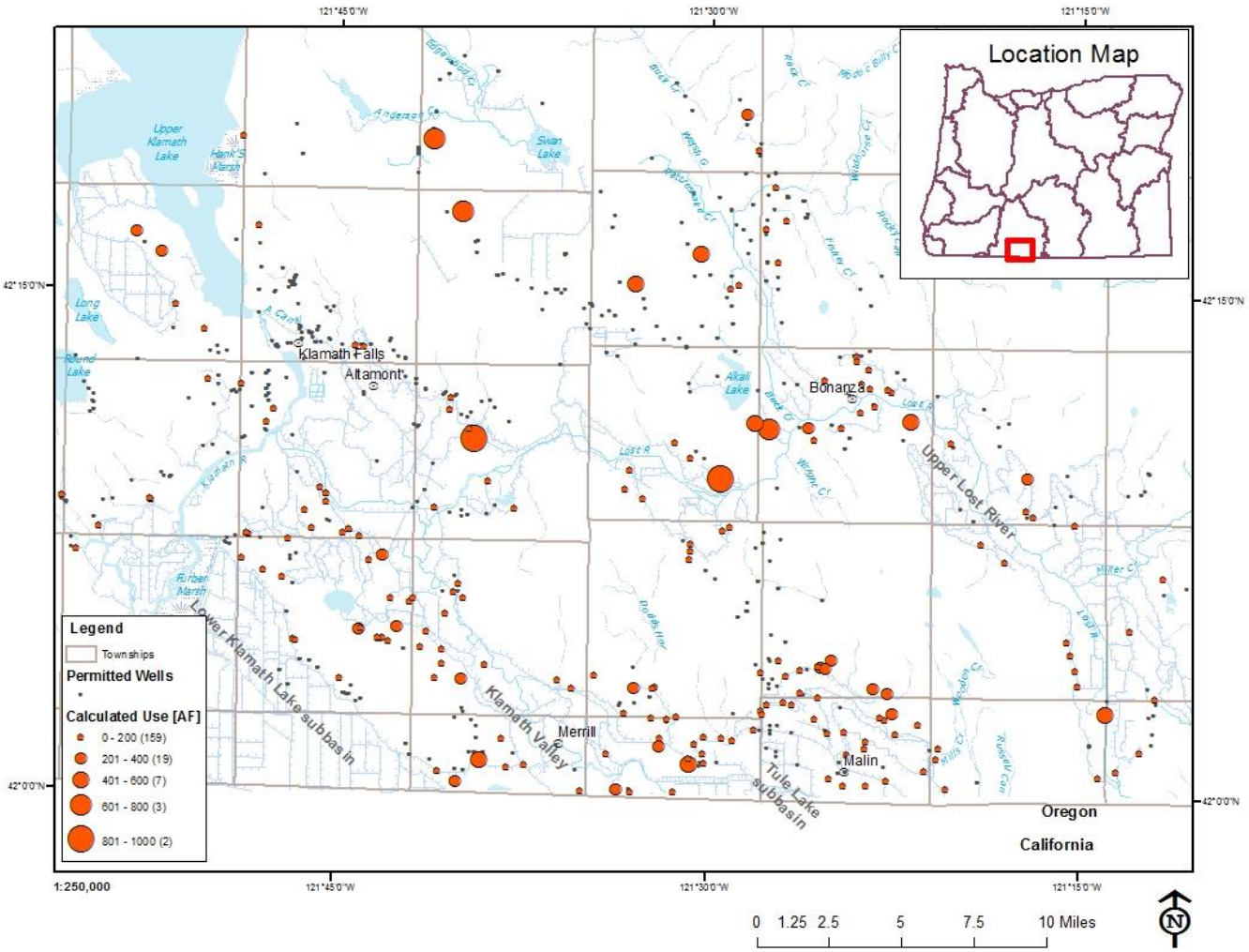

Figure 1. Map of 2017 permitted and visited wells within the Klamath Project and vicinity, Oregon

OWRD and USGS staff also collected water level data from 113 wells in the Project Area during 2017 (Figure 2). Groundwater level data are housed in the OWRD Groundwater Database and are available to the public at http://www.oregon.gov/owrd/pages/gw/well_data.aspx. A subset of this groundwater data can be accessed through a USGS-hosted web interface at http://or.water.usgs.gov/projs_dir/klamath_cooperative_monitoring/index.html

Appendix A lists all wells visited to collect water use data during the 2017 Synoptic survey or visited to collect water level data at any time during 2017.

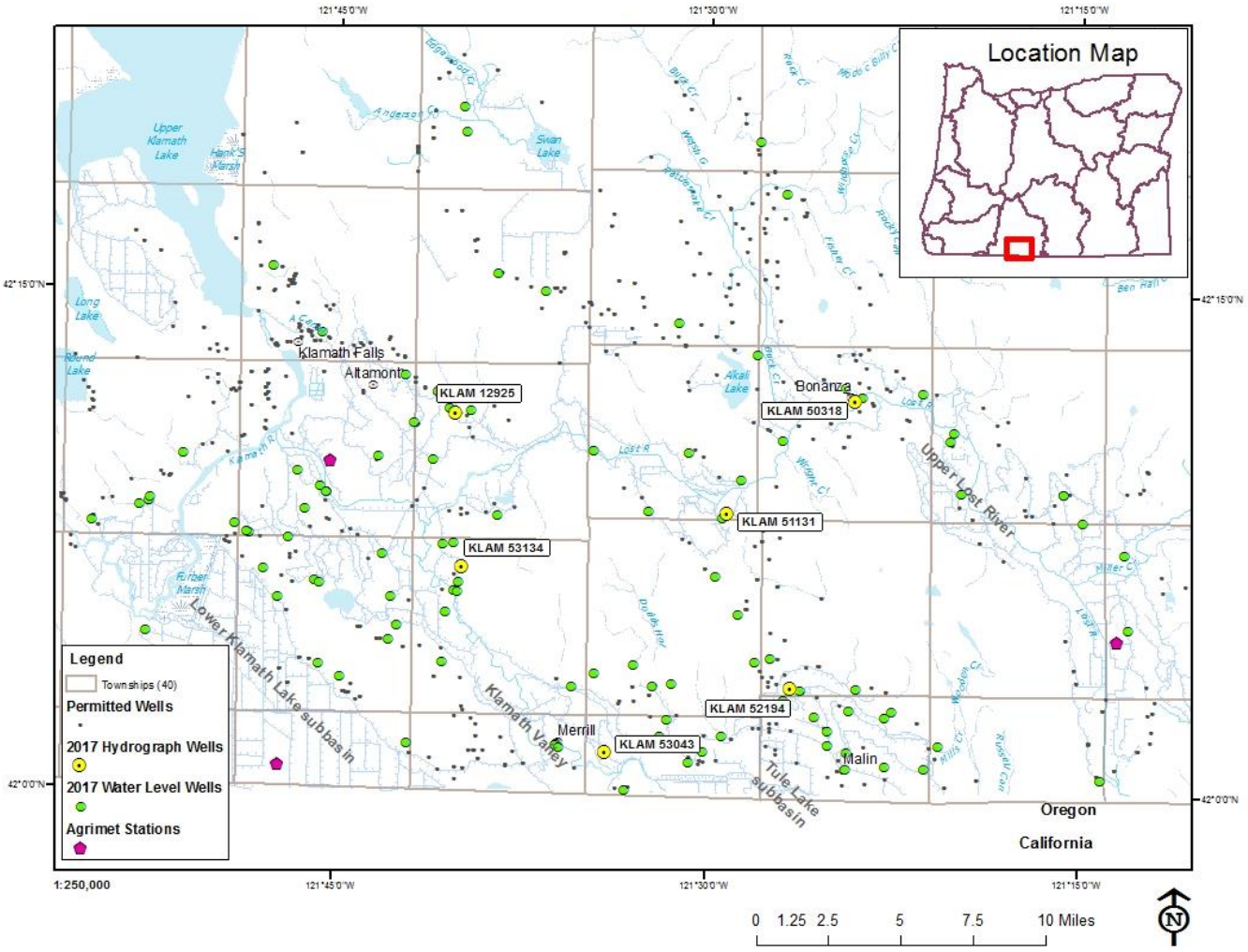

Figure 2. Map of wells with measured water levels in 2017, Klamath Project and vicinity, Oregon

2017 Metered Groundwater Use in the Oregon portion of the Klamath Project

Flow meter readings collected during the 2017 Synoptic were compared to readings from previous years to calculate metered groundwater use in the study area. Of the 241 wells visited during this survey, slightly over three-quarters had working flow meters installed which allowed OWRD to calculate water use directly (Table 1). Indirect methods of estimating groundwater use based on power consumption or other data are sometimes available but were not included as part of this analysis.

Table 1. Summary of 2017 metered groundwater use in the Klamath Project and vicinity, Oregon

		# Records	% Wells Visited	Groundwater Use (AF)
All Wells Visited by OWRD in the Area of Interest		241		
Visited Wells with Operable Flow Meters		183	76 %	17,358
Permitted Wells Visited during Flow Meter Synoptic		237	98 %	
2017 Flow Meter Status*	No Fm	39	16 %	
	New Fm	1	< 1%	
	Fm Broken	7	3 %	
	Fm Fixed	0	0 %	
	No Access	10	4 %	
	Shared Fm	1	< 1 %	
Wells with Flowmeter Readings and Water Level Measurements in 2017		46	20 %	

* Refer to Appendix A for details regarding flow meter status definitions

Metered irrigation water use calculated from 183 wells in the Project Area totaled 17,359 AF in 2017, which is approximately 10% less than 19,409 AF metered in 2016. There are nearly 600 authorized groundwater points of appropriation (POAs) that exist in the area and many are associated with older water rights that do not require totalizing flowmeters to be installed. Therefore, groundwater use volume listed in Table 1 represents only a small portion of groundwater extracted in the area during 2017. However, the number of metered wells is similar from year to year and relative changes in volumetric groundwater extraction in the area can be estimated by comparing annual data.

A direct comparison of 109 wells that have both 2016 and 2017 water-use data identifies 62 % of wells reporting a change in use between -50 AF (less use) and +50 AF (more use) with a median

value -0.1 AF with (Figure 3). 0 summarizes groundwater use from metered wells measured by OWRD during synoptic surveys conducted since 2010.

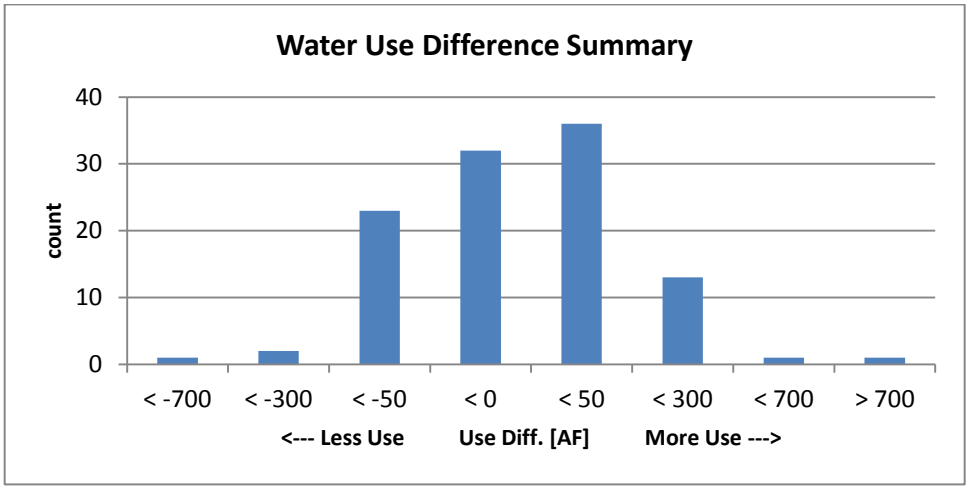

Figure 3. Distribution of changes in water use between fall 2016 and fall 2017

Table 2. Metered groundwater use from 2010 to 2017 in the Klamath Project and vicinity, Oregon

Year	Number of visited wells with flow meters in Oregon	Metered Groundwater Withdrawal in Oregon (acre-feet)	USBR total water bank pumping in Oregon and California (acre-feet)
2010	204	78,920	128,740
2011	209	18,377	0
2012	223	35,864	30,363
2013	233	58,048	64,688
2014	249	72,574	83,456
2015	238	61,645	37,800
2016	173	19,409	N/A
2017	190	17,358	N/A

Water Level Response to Groundwater Pumping

A comparison of fall water level data between 2016 and 2017 shows that approximately 77% of wells reported higher water levels in 2017 and an additional 17% reported water level declines of < 1 ft (Figure 4Figure 3). Groundwater level hydrographs from representative wells within the Klamath Project Area in Oregon (Figure 2) are presented in Figure 5 through Figure 10. These records generally show a response to variations in annual precipitation and supplemental groundwater pumping that has occurred due to curtailed surface water availability during dry years since 2001. Water levels in recent years where groundwater pumping has been less severe show much smaller summer declines and relatively flat trends but, as yet, no evidence of water levels increasing. Recharge from canal leakage has been documented in the Project Area by the USGS (Pischel and Gannett, 2015) and can influence water levels in proximal wells. Aquifer response assessments were conducted within the hydrogeologic framework of the area most recently described by the USGS (Gannett and others, 2007 and 2012).

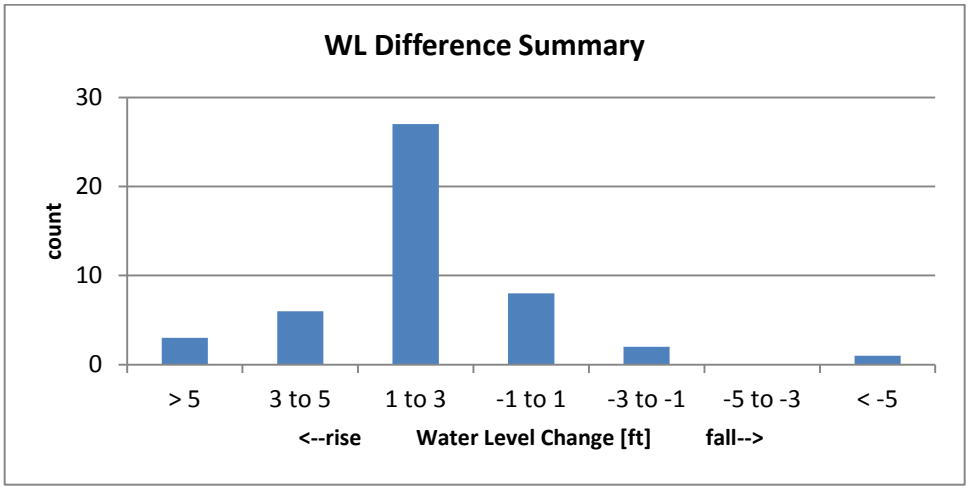

Figure 4. Distribution of changes in water levels between fall 2016 and fall 2017

Table 3 presents water bank pumping from wells in both Oregon and California since the program began in 2001 through 2015 when the program ended. Annual precipitation records from three Agrimet stations in Oregon are also shown. Water bank pumping is a subset of total pumping in the Project Area, but relative changes in total volumetric groundwater extraction may be inferred by comparing water bank pumping from year to year. Although there was no water bank program since

2015, precipitation data show that 2016 and 2017 were comparable to 2015 in terms of total water-year precipitation and above the average of the past several years.

Table 3. Water bank pumping volumes and water-year precipitation since 2002

Year	Total Water Bank Pumping, OR and CA[1] (acre-feet)	Total Water Year Precipitation – Agrimet Stations[2] (inches)		
		Klamath Falls, OR	Worden, OR	Lorella, OR
2002	18,569	10.63	8.24	8.42
2003	55,667	11.97	10.12	10.64
2004	73,870	11.54	8.42	7.68
2005	65,710	10.92	10.95	12.85
2006	32,740	15.58	13.47	17.62
2007	47,621	11.25	8.21	10.51
2008	–	10.70	8.17	8.98
2009	–	10.78	7.41	7.95
2010	128,740	8.10	9.32	9.49
2011	–	13.00	12.64	13.56
2012	30,363	9.21	8.05	8.58
2013	64,688	9.55	10.89	12.06
2014	83,456	10.16	8.13	9.45
2015	37,742	12.71	15.56	12.29
2016	N/A	13.66	13.01	12.21
2017	N/A	14.93	12.22	18.26

[1]Pumping data for 2001–2007 collected by USBR, data for 2010–2015 collected by KWAPA, water bank program not operational during 2008 and 2009 while transitioning from USBR to KWAPA administration.

[2]Refer to Figure 2 for Agrimet station locations.

The historic water bank pumping record and absence of the program since 2015 correlates to observed groundwater level trends as follows:

- A period of increased supplemental irrigation pumping beginning in 2001 correlates with a trend of declining groundwater levels. Wells that are strongly influenced by surface waters, such as leaky canals, experienced recovery after the 2001 groundwater irrigation season (see Figure 7 as

an example), while wells utilizing deep regional aquifers experienced persistent water level declines after 2001.

- The water bank program did not operate during 2008 and 2009 while administration of the program was transferred from USBR to KWAPA. The reduction in supplemental pumping appears to have resulted in relatively constant water levels or minor water level recovery in area wells, especially in those wells with water levels influenced by canal leakage.
- A sharp increase in supplemental pumping during 2010 and continued pumping from 2012 through 2015 has resulted in declining spring water levels in most wells.
- 2016 marked the first year without the water bank program and, along with 2017, a continuation of more typical precipitation amounts. Hydrographs reflect the reduced stress with similar or slightly higher spring water levels in 2016 and 2017 compared to 2015 and far less seasonal drawdown than previous years.

Hydrographs of representative wells presented in the following pages illustrate the distribution of groundwater pumping effects and water level response across the Klamath Project Area and vicinity in Oregon (Figure 2 shows well locations).

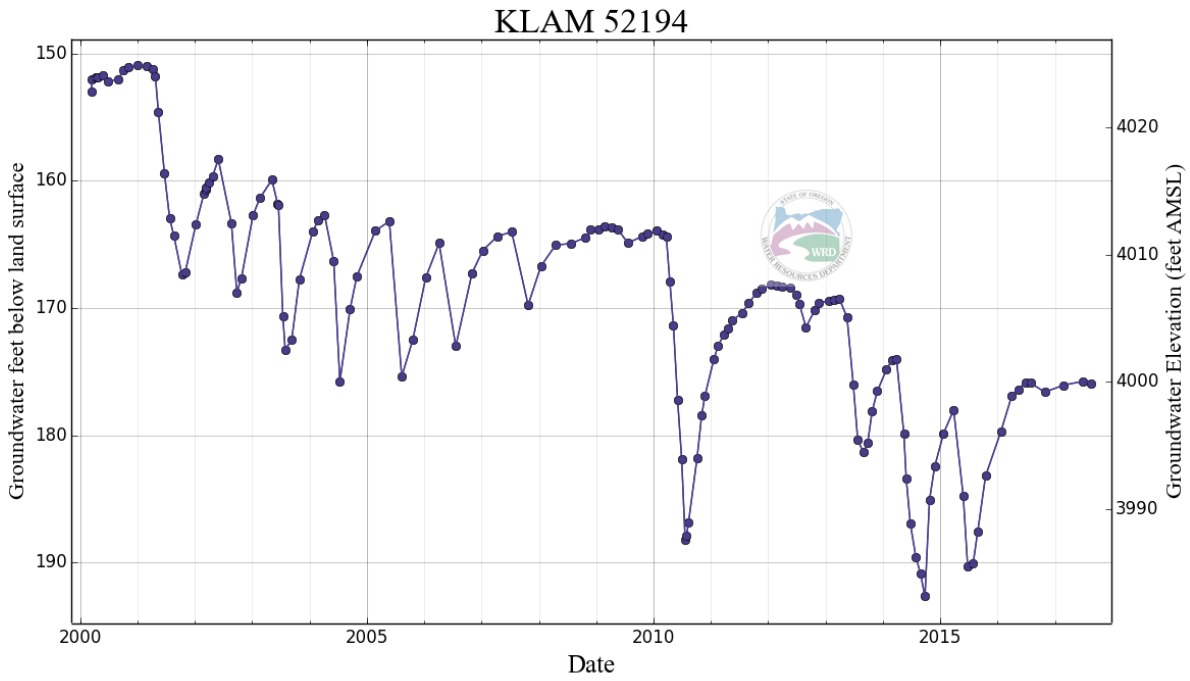

Figure 5. Hydrograph for well KLAM 52194 near Malin, OR

KLAM 52194 is an observation well installed by OWRD about 3.8 miles north of the state line near Malin, OR within the boundaries of the Shasta View Irrigation District. Seasonal fluctuations in the hydrograph (Figure 5) are a response to groundwater pumping in the area. The hydrograph shows groundwater level declines of nearly 30 feet from spring 2001 through spring 2017. Pumping during the 2010, 2014, and 2015 irrigation seasons resulted in a 24 ft, 20 ft, and 12 ft seasonal decline, respectively, at this well. The seasonal fluctuation was substantially reduced in 2008, 2009, 2016 and 2017, which are years that the water bank program was not operating (i.e., years in which groundwater pumping was not subsidized by the water bank program).

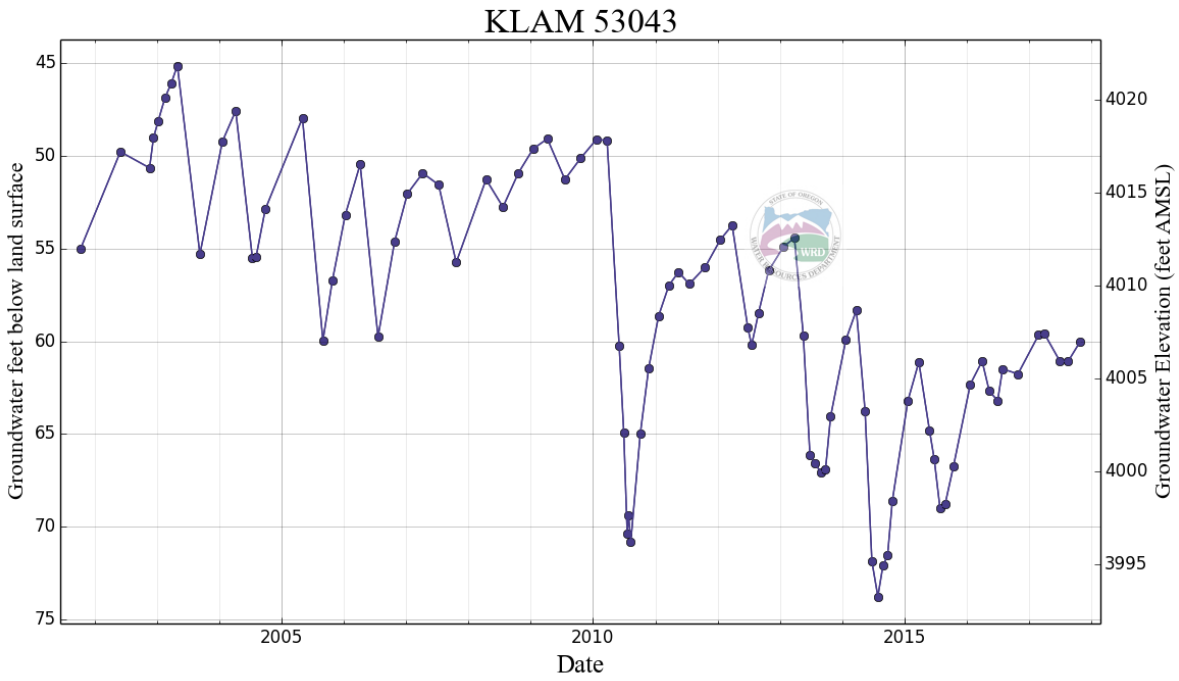

Figure 6. Hydrograph for well KLAM 53043 east of Merrill, OR

KLAM 53043 is an irrigation well drilled in 2001 about 1.5 miles east of Merrill, OR and just over one mile north of the Oregon-California state line. This well is subject to drawdown interference from the Tulelake Irrigation District wellfield located in California along the state line. The hydrograph from this well (Figure 6) displays water-level declines from 2002 through 2007 followed by partial recovery coincident with reduced groundwater pumping in 2008 and 2009. The 2010 irrigation season resulted in a 20 ft seasonal decline. Spring groundwater levels have dropped approximately 13 ft since the spring of 2003 but were stable between spring 2015 and spring 2016 and slightly higher in 2017.

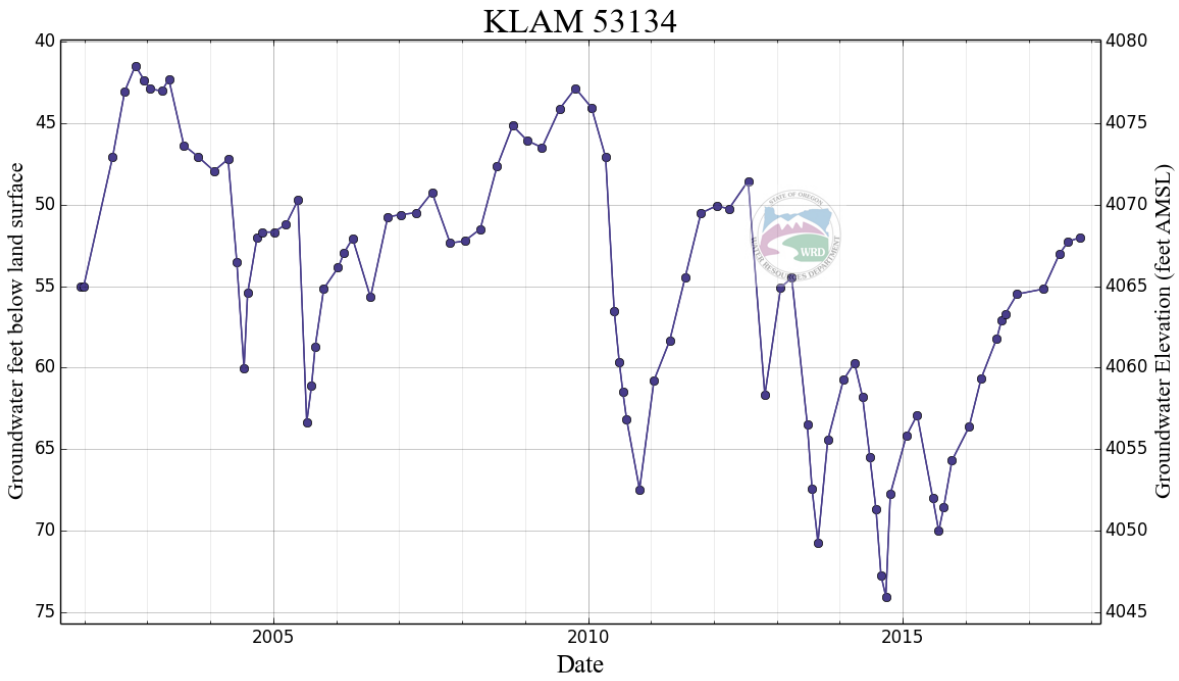

Figure 7. Hydrograph for well KLAM 53134 northwest of Stukel Mtn.

KLAM 53134 is a domestic well located about two miles southeast of Henley, OR in the eastern portion of the Klamath Valley. Historically, this area has been the source of multiple complaints from local well owners about declining groundwater levels and well-to-well interference. KLAM 53134 develops water from sediments overlying the primary volcanic aquifer, but responds to pumping of the deeper aquifer. Water levels at this well (Figure 7) are affected by recharge to the sedimentary aquifer by canal leakage. The hydrograph shows water levels declining from 2002 to 2006, recovering between 2006 and 2010, declining again since the 2010 pumping season, and recovering strongly in 2016 and 2017. Water levels have declined approximately 20 ft between spring 2010 and spring 2015 but have recovered almost 10 ft by spring 2017.

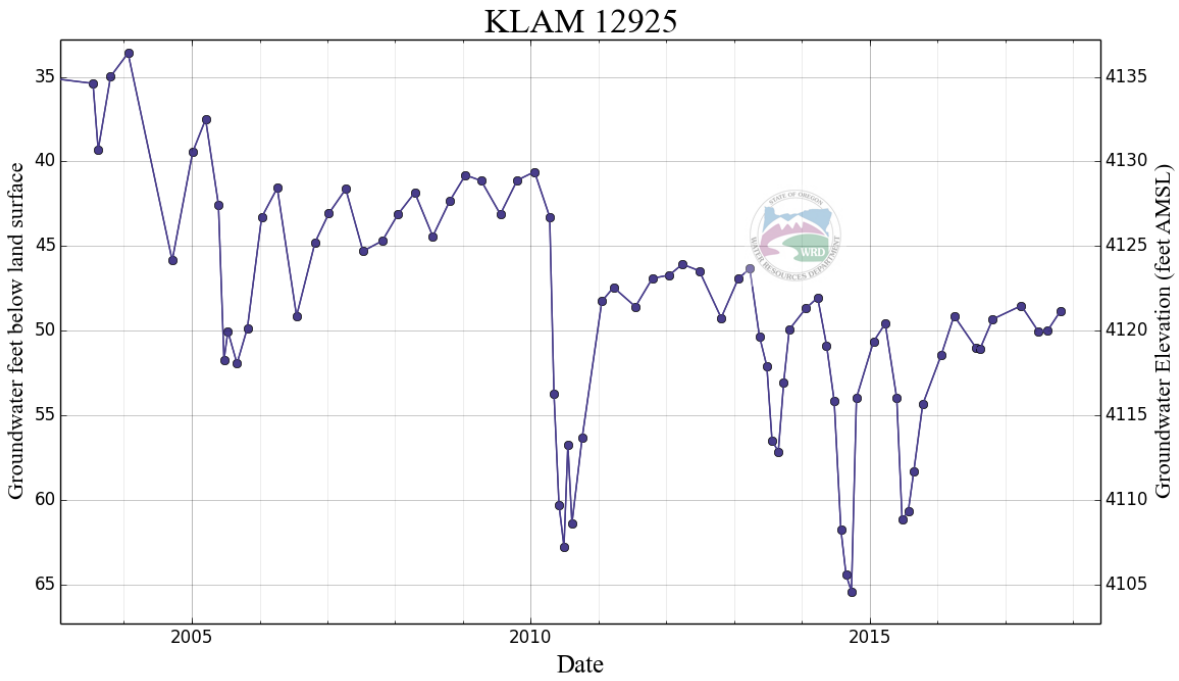

Figure 8. Hydrograph for well KLAM 12925 in the Pine Grove area

KLAM 12925 is a domestic and stock well located in the Pine Grove area southeast of Klamath Falls, OR where groundwater levels in the volcanic aquifer and the overlying sediments are strongly influenced by supplemental groundwater pumping. The hydrograph for this well (Figure 8) displays a trend similar to that observed in wells located along the state line and in the Klamath Valley. Water levels have declined approximately 10 ft at this well since the spring of 2010 with no additional decline, but no significant recovery, between 2015 and 2017.

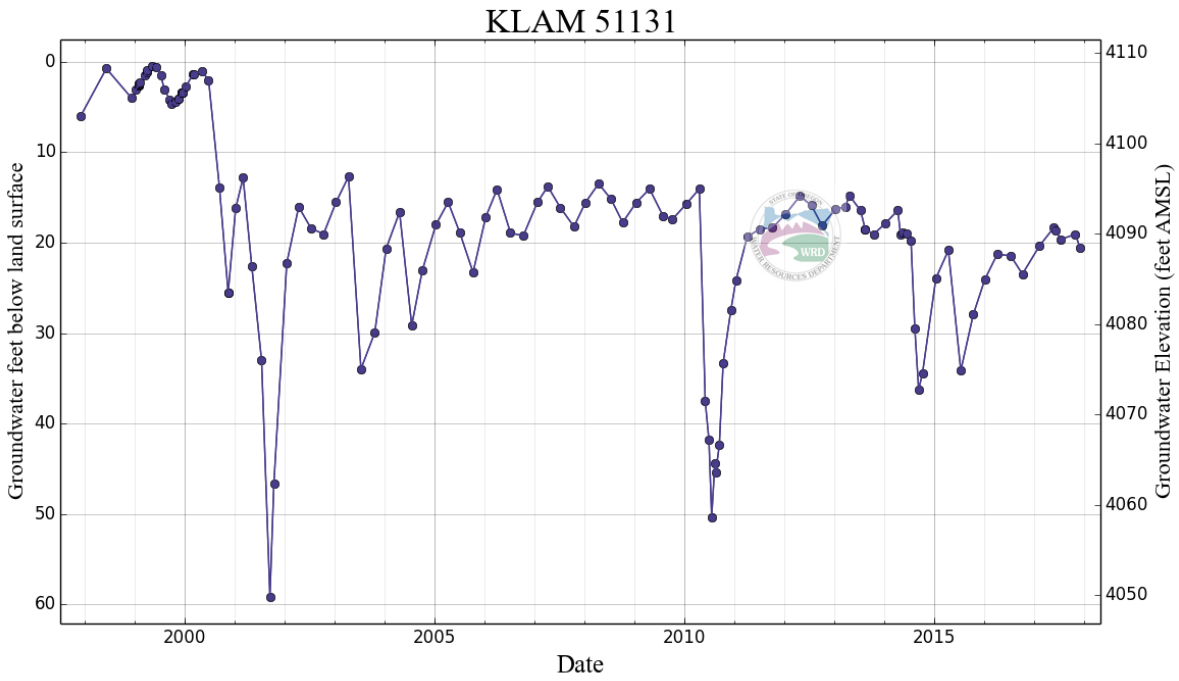

Figure 9. Hydrograph for well KLAM 51131 South Poe Valley

KLAM 51131 is an irrigation well located in South Poe Valley approximately 2000 ft from a channel of the Lost River. The well develops water from both the sedimentary and basalt aquifers and receives recharge from numerous surrounding surface water features including irrigation canals, lakes, and the Lost River. The hydrograph (Figure 9) displays a more stable, but still declining, water level trend than wells in other areas following the extensive groundwater pumping in 2010. Regulation of unauthorized groundwater pumping in the area and availability of surface water resulted in a significant reduction in groundwater use in mid-season 2010, which likely supported this trend. However, water levels have still declined approximately 7 ft between spring of 2010 and spring 2017, with increasingly large seasonal drops since 2013. 2016 water levels appear consistent with the gentle decline since 2010 but 2017 water levels show slight recovery.

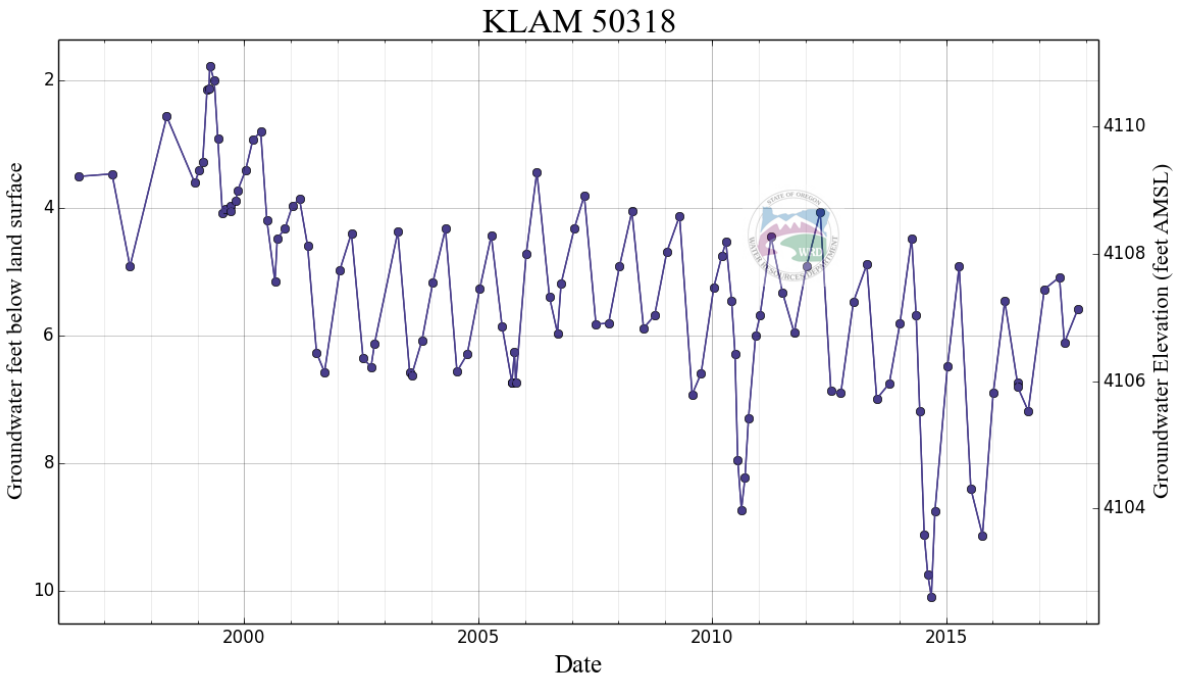

Figure 10. Hydrographs for well KLAM 50318

KLAM 50318 is a shallow unused well located in a groundwater discharge area adjacent to the Lost River and near Bonanza Big Springs. The groundwater hydrograph (Figure 10) shows a seasonal response to pumping with year-to-year spring high water level trends that are relatively steady and appear to reflect climate fluctuations (refer to Table 3 for annual total precipitation values since 2001). The seasonal drawdown of groundwater levels is larger during the 2010, 2014, and 2015 irrigation seasons as a result of increased groundwater pumping in the area. Seasonal drawdown in 2016 is similar to previous years and 2017 shows only approximately 1 ft of seasonal drawdown.

The water level in KLAM 50318 is representative of the head in the aquifer driving flow to Bonanza Big Springs. Lower groundwater levels at this well are coincident with lower discharge at spring outflow locations adjacent to the river. Groundwater levels generally observe a smooth annual cycle (rising through the fall, lowering through the summer) while river stage often show large spikes (times of rapid increase then decrease in stage). Stage elevation at this location is partly controlled by a diversion structure on the Lost River downstream of the gaging station (Harpold dam, equipped with removable boards). Groundwater elevation is above river stage elevation for most of the fall, winter, and spring. When the river stage elevation exceeds the groundwater level elevation, primarily in summer months, the hydraulic gradient is reversed and surface water can flow into the aquifer via Bonanza Big

Springs and potentially contaminate nearby water wells. For all of 2017 groundwater levels in KLAM 50318 were above Lost River stage and it was only a brief period in late August – early September when water levels were within a few tenths of a foot. This is in contrast to most summers when groundwater elevation drops below river stage for several days.

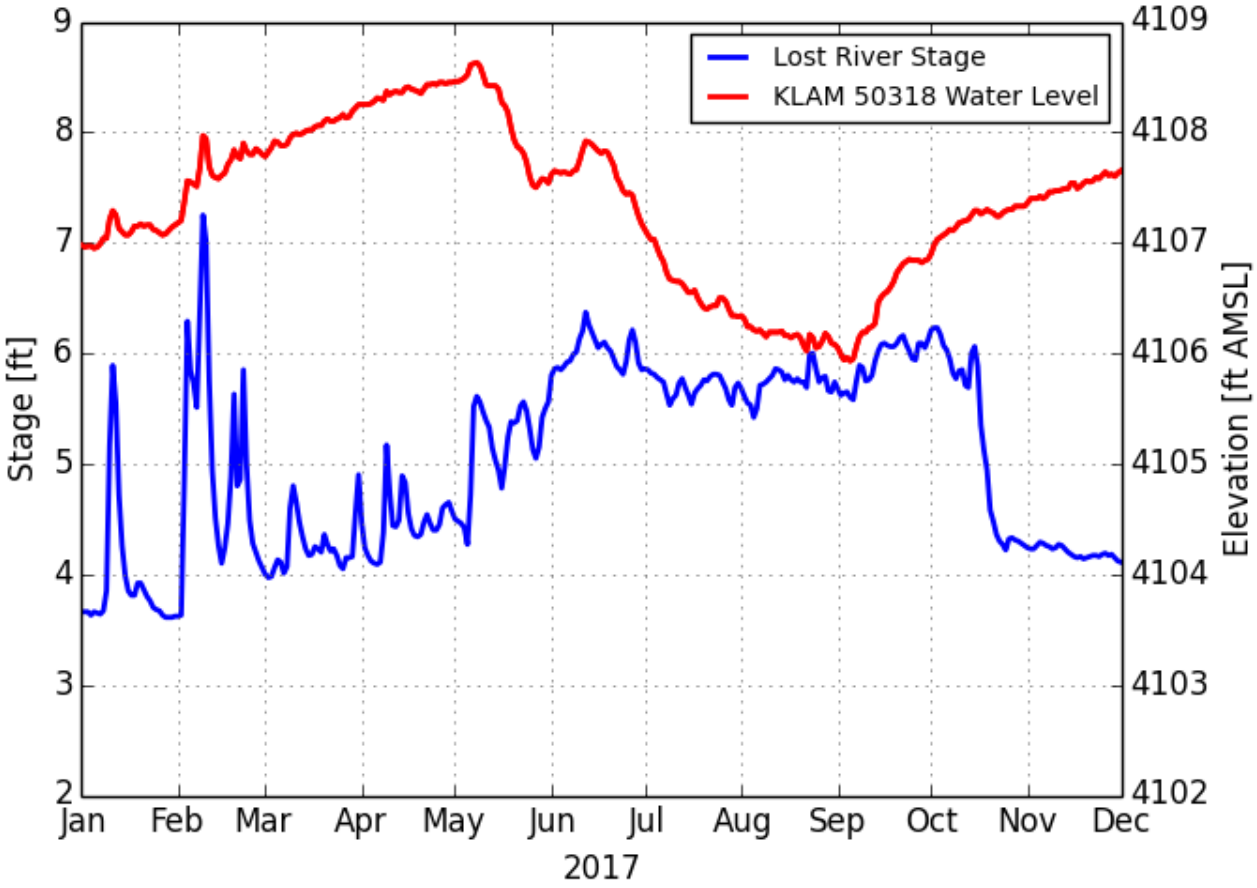

Figure 11. Hydrograph for well KLAM 50318 and the Lost River during 2017

Impacts of Groundwater Pumping

Groundwater pumping can cause hydraulic interference with other groundwater users, seasonal water-level declines, and long-term (persistent) water-level declines, all of which result in greater pumping costs for area groundwater users and in some cases require deepening of wells. Hydraulic interference is a local effect that occurs when the cone of depression from a pumping well lowers the water level in a nearby well. Hydraulic interference generally occurs within hundreds to thousands of feet from a pumping well, builds up quickly when pumping begins, and dissipates quickly when pumping ends. Alternatively, seasonal declines are the general lowering of the water table caused by the overlap of the cones of depression of multiple pumping wells over a widespread area (up to several square miles). These effects build up during the irrigation season and recover, to a large degree, during the following winter. Long-term declines are the cumulative lowering of the water table over multiple years due to a combination of drought (reduced recharge) and groundwater pumping (increased withdrawal), and reflect a diminishment of groundwater storage in the area. Reductions in groundwater storage are an indication of unsustainable groundwater extraction.

Summary and Conclusion

Significant reliance on supplemental groundwater since 2001 has resulted in steady groundwater declines in and near the Klamath Project in Oregon. Spring 2016 and spring 2017 water levels measured at many wells in the area were similar to, or slightly higher than, spring 2015 levels but most hydrographs did not show drastic seasonal summer drawdowns in 2016 and 2017 – primarily due to lesser amounts of supplemental groundwater withdrawal and absence of a water bank program. Long-term water-level declines from pre-2001 levels remain at 10-20 ft over a broad area and exceed 30 ft in some wells. Most wells are beginning to show stable or slightly increasing groundwater levels since 2015.

It is clear that large supplemental groundwater withdrawals have resulted in large seasonal declines at some wells and persistent groundwater level declines at most wells. These groundwater level declines result in reduced groundwater discharge to, and in some cases induced recharge from, streams, springs, and drains, which exacerbates already stressed surface water supplies. Seasonal and long-term water level declines also result in increased pumping costs incurred by groundwater users. These impacts are not limited to the Klamath Project Area or to those that use water for agricultural purposes. Impacts extend to off-project users and those reliant on groundwater as a domestic supply. Therefore, supplemental groundwater pumping should remain a periodic emergency supply in times of extreme surface water shortage and should not be considered a long-term, renewable source of irrigation or mitigation water.

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KLAM0002289	42.32651167	-121.6885219	Yes		Yes	Yes	
KLAM0002340	42.31154813	-121.45773	Yes	No Access		Yes	
KLAM0002373	42.33554415	-121.4772746	Yes	Broken		Yes	
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KLAM0010139	42.19701785	-121.674454	Yes		Yes	Yes	
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KLAM0050366	42.27787394	-121.8876785	Yes		Yes	Yes	
KLAM0050445	42.33139766	-121.6886538	Yes	Broken?		Yes	
KLAM0050464	42.08161	-121.7328	Yes		Yes	Yes	
KLAM0050623	42.12556686	-121.512315	Yes		Yes	Yes	
KLAM0050763	42.00422848	-121.3396093	Yes		Yes	Yes	
KLAM0051034	42.28296511	-121.463835	Yes		Yes	Yes	
KLAM0051131	42.1401223	-121.4869345				Yes	Yes
KLAM0051179	42.30413	-121.4577	Yes		Yes	Yes	
KLAM0051231	42.1275795	-121.8092415	Yes		Yes	Yes	Yes
KLAM0051602	42.05193959	-121.4376369	Yes		Yes	Yes	Yes
KLAM0051611	42.03168768	-121.4185139	Yes		Yes	Yes	Yes
KLAM0051612	42.0138915	-121.3803157	Yes			Yes	Yes
KLAM0051675	42.20279634	-121.8158943	Yes		Yes	Yes	
KLAM0051920	42.17677627	-121.3374117	Yes		Yes	Yes	Yes
KLAM0052633	42.19499165	-121.3891917	Yes	Broken?	Yes	Yes	
KLAM0052646	42.03853371	-121.5374857	Yes		Yes	Yes	
KLAM0052647	42.07144203	-121.6784699	Yes		Yes	Yes	
KLAM0052650	42.07693	-121.71848	Yes		Yes	Yes	
KLAM0052651	42.07681	-121.72156	Yes		Yes	Yes	
KLAM0052686	42.22193692	-121.733575	Yes		Yes	Yes	
KLAM0052697	42.100044	-121.67088	Yes		Yes	Yes	Yes
KLAM0052703	42.18216	-121.66176	Yes		Yes	Yes	
KLAM0052706	42.041009	-121.4631258	Yes		Yes	Yes	Yes
KLAM0052711	42.05683992	-121.6654889	Yes		Yes	Yes	
KLAM0052724	42.14435077	-121.7571859	Yes		Yes	Yes	
KLAM0052759	42.04244411	-121.4633977	Yes		Yes	Yes	Yes
KLAM0052761	42.0285305	-121.5315293	Yes		Yes	Yes	Yes
KLAM0052765	42.04957997	-121.4254537	Yes		Yes	Yes	
KLAM0052776	42.15175618	-121.7616123	Yes		Yes	Yes	Yes
KLAM0052778	42.15278	-121.55685	Yes		Yes	Yes	

OWRD Log ID	Latitude	Longitude	Flowmeter Well	Flowmeter Status	Flowmeter Analyzed	Permitted Well	2017 WL Well
KLAM0052787	42.1308239	-121.910175	Yes		Yes	Yes	
KLAM0052790	42.05363331	-121.5346824	Yes		Yes	Yes	
KLAM0052795	42.015141	-121.512356	Yes		Yes	Yes	Yes
KLAM0052797	42.082561	-121.709375	Yes		Yes	Yes	Yes
KLAM0052806	42.17599	-121.52341	Yes		Yes	Yes	
KLAM0052816	42.1421	-121.68459	Yes		Yes	Yes	
KLAM0052817	42.115529	-121.7277002	Yes		Yes	Yes	
KLAM0052818	42.15557	-121.64922	Yes		Yes	Yes	
KLAM0052824	42.096912	-121.7135654	Yes		Yes	Yes	Yes
KLAM0052825	42.118396	-121.719536	Yes		Yes	Yes	Yes
KLAM0052830	42.09536852	-121.7006413	Yes		Yes	Yes	
KLAM0052831	42.127257	-121.734701	Yes		Yes	Yes	
KLAM0052835	42.22249615	-121.7394236	Yes		Yes	Yes	
KLAM0052840	42.02410784	-121.3937197	Yes		Yes	Yes	
KLAM0052869	42.06401806	-121.6496396	Yes		Yes	Yes	
KLAM0052910	42.05940542	-121.575613	Yes		Yes	Yes	Yes
KLAM0052911	42.16206	-121.55358	Yes		Yes	Yes	
KLAM0052916	42.1065	-121.78603	Yes		Yes	Yes	
KLAM0052918	42.121868	-121.512076	Yes		Yes	Yes	
KLAM0052923	42.07535831	-121.7148688	Yes		Yes	Yes	Yes
KLAM0052925	42.12925347	-121.7463043	Yes		Yes	Yes	
KLAM0052932	42.05698765	-121.6004806	Yes		Yes	Yes	
KLAM0052935	42.00588916	-121.3932686	Yes		Yes	Yes	
KLAM0052941	42.13115	-121.74225	Yes		Yes	Yes	
KLAM0052942	42.03994177	-121.3841899	Yes	No Fm	Yes	Yes	
KLAM0052964	42.00830733	-121.3793331	Yes		Yes	Yes	
KLAM0052970	42.10981	-121.79943	Yes		Yes	Yes	Yes
KLAM0052972	42.0239438	-121.5320299	Yes		Yes	Yes	
KLAM0052973	42.10447674	-121.667747	Yes		Yes	Yes	Yes
KLAM0053023	42.0755	-121.77812	Yes	No Fm	Yes	Yes	
KLAM0053043	42.020463	-121.567589	Yes		Yes	Yes	Yes
KLAM0053049	42.32084886	-121.6985086	Yes	No Access		Yes	
KLAM0053080	42.11794043	-121.5125965	Yes		Yes	Yes	
KLAM0053125	42.07524	-121.77668	Yes	No Fm	Yes	Yes	
KLAM0053137	42.08116	-121.73418	Yes		Yes	Yes	
KLAM0053142	42.1489354	-121.7573287	Yes		Yes	Yes	Yes
KLAM0053188	42.15916606	-121.7771847	Yes			Yes	Yes
KLAM0053201	42.0183	-121.51177	Yes		Yes	Yes	
KLAM0053234	42.14040573	-121.7717979	Yes		Yes	Yes	Yes
KLAM0053250	42.00540236	-121.4081472	Yes		Yes	Yes	
KLAM0053269	42.02059791	-121.5026313	Yes		Yes	Yes	Yes
KLAM0053270	42.268002	-121.871034	Yes		Yes	Yes	
KLAM0053320	42.144848	-121.875705	Yes		Yes	Yes	Yes
KLAM0053340	42.01900812	-121.346375	Yes		Yes	Yes	
KLAM0053571	42.14446113	-121.8749748	Yes		Yes	Yes	
KLAM0053581	42.13227	-121.49426	Yes	No Fm	Yes	Yes	
KLAM0053717	42.05301845	-121.5908619	Yes		Yes	Yes	Yes
KLAM0053732	42.14872494	-121.7574006	Yes	No Fm	Yes	Yes	Yes

OWRD Log ID	Latitude	Longitude	Flowmeter Well	Flowmeter Status	Flowmeter Analyzed	Permitted Well	2017 WL Well
KLAM0053736	42.13388	-121.4862	Yes		Yes	Yes	
KLAM0053737	42.14247725	-121.6309298	Yes		Yes	Yes	
KLAM0053738	42.03145	-121.37374	Yes		Yes	Yes	
KLAM0053747	42.04069703	-121.5558284	Yes		Yes	Yes	
KLAM0053755	42.191298	-121.675246	Yes		Yes	Yes	Yes
KLAM0053757	42.03214515	-121.4077702	Yes		Yes	Yes	
KLAM0053758	42.028477	-121.490057	Yes		Yes	Yes	Yes
KLAM0053778	42.07815315	-121.8777643	Yes		Yes	Yes	Yes
KLAM0053779	42.16845109	-121.513119	Yes		Yes	Yes	
KLAM0053792	42.04593	-121.46021	Yes		Yes	Yes	
KLAM0053936	42.07231151	-121.6925747	Yes		Yes	Yes	
KLAM0053940	42.12601404	-121.7826528	Yes		Yes	Yes	Yes
KLAM0054078	42.17725308	-121.6590972	Yes		Yes	Yes	
KLAM0054305	42.13239	-121.49103	Yes		Yes	Yes	
KLAM0054337	42.23019002	-121.8617238	Yes	No Fm	Yes	Yes	
KLAM0054561	42.09700785	-121.697917	Yes		Yes	Yes	
KLAM0054829	42.0803041	-121.688706	Yes		Yes	Yes	
KLAM0055522	42.23001129	-121.8413157	Yes		Yes	Yes	
KLAM0055767	42.0022455	-121.5607101	Yes		Yes	Yes	
KLAM0056125	42.09706602	-121.6641853	Yes		Yes	Yes	
KLAM0056425	42.02915013	-121.5015753	Yes		Yes	Yes	
KLAM0056426	42.02755392	-121.4824049	Yes		Yes	Yes	
KLAM0056490	42.13135446	-121.7668339	Yes		Yes	Yes	
KLAM0056562	42.01141043	-121.6630383	Yes	No Access		Yes	
KLAM0057323	42.016221	-121.652758	Yes		Yes	Yes	
KLAM0057326	42.28948614	-121.4367881	Yes	No Fm		Yes	
KLAM0057366	42.01654	-121.49259	Yes		Yes	Yes	
KLAM0057367	42.1478	-121.54483	Yes	Broken?	Yes	Yes	
KLAM0057371	42.03295645	-121.4682703	Yes		Yes	Yes	
KLAM0057372	42.04586209	-121.4430354	Yes		Yes	Yes	
KLAM0057387	42.00173	-121.52201	Yes		Yes	Yes	
KLAM0057403	42.02579	-121.50804	Yes		Yes	Yes	
KLAM0057409	42.06301	-121.43782	Yes		Yes	Yes	
KLAM0057410	42.00167	-121.58431	Yes		Yes	Yes	
KLAM0057431	42.03778	-121.52647	Yes		Yes	Yes	
KLAM0057532	42.14104	-121.54083				Yes	Yes
KLAM0057552	42.2574993	-121.4628253	Yes	No Access		Yes	
KLAM0057566	42.26619607	-121.4623441	Yes	No Fm	Yes	Yes	
KLAM0057660	42.07136586	-121.2564354	Yes		Yes	Yes	
KLAM0058135	42.11565	-121.8137	Yes		Yes	Yes	
KLAM0058142	42.02765077	-121.3936096	Yes		Yes	Yes	
KLAM0058146	42.03628	-121.3583	Yes		Yes		
KLAM0058293	42.00138692	-121.5512489	Yes		Yes	Yes	
KLAM0058432	42.326438	-121.816319	Yes		Yes	Yes	
KLAM0058533	42.02744164	-121.6374188	Yes		Yes	Yes	
KLAM0058839	42.10996245	-121.1941452	Yes		Yes		
LAKE0051215	42.08969706	-121.6761037	Yes		Yes		Yes
KLAM0010699	42.1263947	-121.3169183	Yes		Yes	Yes	

OWRD Log ID	Latitude	Longitude	Flowmeter Well	Flowmeter Status	Flowmeter Analyzed	Permitted Well	2017 WL Well
KLAM0014124	42.19347964	-121.9153055	Yes	No Fm		Yes	
KLAM0012487	42.2078098	-121.7053818				Yes	Yes
KLAM0013719	42.11923237	-121.9251613	Yes		Yes	Yes	
KLAM0014959	42.02363498	-121.6017057				Yes	Yes
KLAM0015096	42.01273727	-121.4065291				Yes	Yes
KLAM0050493	42.2587953	-121.6438126				Yes	Yes
KLAM0050854	42.18678117	-121.8111095	Yes	No Access		Yes	
KLAM0052681	42.14320293	-121.9094997	Yes	No Fm		Yes	
KLAM0058594	42.01599751	-121.5019679	Yes		Yes	Yes	
KLAM0051922	42.19834415	-121.3969723					Yes
KLAM0014746	42.08948	-121.47983				Yes	Yes
KLAM0014731	42.10870681	-121.4948347				Yes	Yes
KLAM0010814	42.18117315	-121.3357208					Yes
KLAM0050318	42.19678157	-121.4011608					Yes
KLAM0010159	42.13761118	-121.4912235					Yes
KLAM0010574	42.0081908	-121.2357299					Yes
KLAM0014966	42.02212117	-121.5993084					Yes
KLAM0014918	42.02438775	-121.6007001				Yes	Yes
KLAM0014563	42.06308698	-121.761149					Yes
KLAM0013800	42.0641717	-121.8509002					Yes
KLAM0051795	42.06593318	-121.4678627					Yes
KLAM0014829	42.0675277	-121.4578849				Yes	Yes
KLAM0014889	42.0829916	-121.2171923					Yes
KLAM0051130	42.1036473	-121.7617556					Yes
KLAM0014525	42.10445837	-121.7643502					Yes
KLAM0053531	42.1487826	-121.7573204					Yes
KLAM0050228	42.00341388	-121.889395					Yes
KLAM0013812	42.04587679	-121.9050771					Yes
KLAM0014781	42.0548382	-121.5238632					Yes
KLAM0053771	42.09584428	-121.7893733					Yes
KLAM0011059	42.1231508	-121.678907					Yes
KLAM0011211	42.13259318	-121.818528					Yes
KLAM0010253	42.1329779	-121.9150682					Yes
KLAM0010362	42.13663985	-121.248076					Yes
KLAM0052096	42.15067816	-121.2614517					Yes
KLAM0052204	42.15067816	-121.2614517					Yes
KLAM0013582	42.1511299	-121.3302969					Yes
KLAM0010252	42.15698585	-121.4780849				Yes	Yes
KLAM0050325	42.165647	-121.6855166					Yes
KLAM0050392	42.16692539	-121.8538414					Yes
KLAM0013491	42.1702877	-121.5138608					Yes
KLAM0016807	42.1706009	-121.5775147					Yes
KLAM0010258	42.1768023	-121.4508019					Yes
KLAM0010948	42.18378815	-121.6991117					Yes
KLAM0011950	42.22862549	-121.7619474					Yes
KLAM0013353	42.20327996	-121.408991					Yes
KLAM0013456	42.21954245	-121.4681033					Yes
KLAM0011139	42.2353246	-121.5210406					Yes

OWRD Log ID	Latitude	Longitude	Flowmeter Well	Flowmeter Status	Flowmeter Analyzed	Permitted Well	2017 WL Well
KLAM0012221	42.2505318	-121.6113786				Yes	Yes
KLAM0011656	42.2613827	-121.7950383					Yes
KLAM0050934	42.3000856	-121.4492272					Yes
KLAM0002277	42.3417099	-121.66779					Yes
KLAM0053134	42.112017	-121.664615					Yes
KLAM0053108	42.123883	-121.671803					Yes
KLAM0014764	42.063754	-121.549473				Yes	Yes
KLAM0015072	42.024384	-121.418758					Yes
KLAM0012893	42.190214	-121.661058				Yes	Yes
KLAM0053045	42.00128	-121.554918					Yes
KLAM0015051	42.041883	-121.404585					Yes
KLAM0052103	42.141463	-121.883274					Yes
KLAM0052864	42.14303	-121.876573					Yes
KLAM0054088	42.166895	-121.722358					Yes
KLAM0054529	42.138175	-121.6424					Yes
KLAM0053209	42.099826	-121.66826					Yes
KLAM0012925	42.189206	-121.670425					Yes
KLAM0012847	42.19955	-121.68315					Yes
KLAM0002286	42.32957	-121.66566					Yes
KLAM0002374	42.32603	-121.46735				Yes	Yes

*** Flowmeter Status:**

Broken?	Flowmeter was determined to, or suspected be not recording correctly
New	A new flowmeter had been installed since the last visit - no previous readings
No Access	Flowmeter was not accessable by OWRD staff or access was not given
No FM	No flowmeter was found
Shared	Flowmeter is used to measure multiple wells or points of diversion