TESTIMONY OF STEPHEN E. NEMETH

My name is Stephen E. Nemeth. I am a professional Engineer, registered in California (License number C68192). I have over 15 years of experience in the Snow Surveys Section of the Department of Water Resources (DWR) and work in the Joint Operations Center in Sacramento, CA. My experience includes gathering precipitation, snowpack, reservoir storage, and full natural flow (FNF) data. Full natural flow represents the natural water production of a river basin, unaltered by upstream diversions, storage, or by export or import of water to or from other watersheds. My other responsibilities include calculating FNF values and producing reports outlining storage conditions, precipitation amounts, FNF rates, and snowpack conditions from snow sensors and courses. I also assist in making water supply forecasts for most major Sierra rivers. These forecasts are posted on the California Data Exchange Center (CDEC) website (http://cdec.water.ca.gov/snow/bulletin120/index.html) and are also published in DWR's monthly Bulletin 120 (B120) reports. A copy of my resume is attached as Prosecution Team Exhibit WR-18.

The purpose of my written testimony is to outline how DWR calculates its monthly and daily forecasts of full natural flow as reported in its B120 reports. My understanding is that the Division of Water Rights used DWR's forecasts from 2015 in its 2015 water supply availability analysis. See the written testimony of Brian Coats (WR-9) and Jeffrey Yeazell (WR-11).

Water Supply Forecasts

How ``wet'' or ``dry'' a year is predicted to be has many impacts. Public utilities need to determine what percentage of their electric energy generation will be hydro power. Good water years enable utilities to use more hydro power and, consequently, save oil. Conversely, in a dry year, the utilities must depend more on steam generation and therefore use more oil and coal. Agricultural interests use the information to determine crop planting patterns, ground water pumping needs, and irrigation schedules. Operators of flood control projects determine how much water can safely be stored in a reservoir while reserving space for predicted inflows.

Municipalities use the information to evaluate their water supply and determine whether (in a dry year) water rationing is needed.

The news media follows forecasts to inform the general public. Recreationists use the water conditions information to determine ski conditions in winter and rafting conditions year-round. Fish releases are also dependent on water supply forecasts. Businesses, such as banks and insurance companies, also follow the forecasts.

Some of the agencies and companies that use DWR's Bulletin 120 reports are the City of Bakersfield, East Bay Municipal Utility District, Kaweah Delta Water Conservation District, Kings River Water Association, Modesto Irrigation District, Turlock Irrigation District, the United States Bureau of Reclamation, the Metropolitan Water District, Southern California Edison Company, the US Department of Agriculture, the US Department of Commerce, and NASA. A full list can be found on page 2 of Exhibit WR-145 which is a hard copy version of DWR's B120 for May 1, 2015. The list is shown under the header "Cooperating Agencies".

Exhibits WR-180, WR-181, WR-182, and WR-183 are true and correct copies of DWR's B120 reports from February to May 2014 as posted online. Exhibits WR-60, WR-61, WR-62, and WR-63 are true and correct copies of DWR's B120 reports from February to May 2015 as posted online. Exhibits WR-64, WR-65, WR-66, and WR-67 are true and correct copies of updates to DWR's B120 reports from February through May 2015 as posted online.

The Cooperative Snow Survey section of DWR produces the Bulletin 120 (B120) report documenting the forecasts of the April-July and October-September FNF for major rivers in California. The publication is issued four times a year, in the second week of February, March, April, and May (http://cdec.water.ca.gov/snow/bulletin120/index.html). Updates to the first-of-month forecast are usually made each week into June. These seasonal forecasts are made using statistical models based on regression equations. A regression equation weighs and correlates several parameters, which are discussed below, in order to make a full natural flow forecast. Examples of parameters include the amount of snow expected on April 1, the October-March precipitation, the April-June precipitation, and the prior year's April-July runoff.

The equation helps one understand how the value being predicted, April-July runoff, changes when any of the parameter values change. The technique of correlating hydrologic parameters to the April-July FNF has been a DWR forecasting tool for about 45 years. Prior to the existence of computers and spreadsheets, the correlation was determined using hand-drawn charts.

In addition to providing FNF forecasts, the B120 report contains summaries of precipitation, snowpack, and reservoir storage. Shown below are pages 4 and 5 of the May 1, 2015 B120. Following these two pages from the May 1, 2015 B120 report are explanations of most columns and a description of the forecasting procedure for the San Joaquin River at Millerton Lake for the purpose of illustrating how the forecast calculations are performed.

MAY 1, 2015 FORECASTS
APRIL-JULY UNIMPAIRED RUNOFF

HYDROLOGIC REGION and Watershed	HISTORICAL: 50 Yr Avg (2)	Max of Record	Min of Record	FORECAST: Apr-Jul Forecasts	Pct of Avg	80 % Probability Range (1)
	Unimpaired Runoff in 1,000 Acre-Feet (1)					
North Coast						
Trinity River at Lewiston Lake	651	1,593	80	**110**	17%	85 - 200
SACRAMENTO RIVER						
Upper Sacramento River						
Sacramento River at Delta above Shasta Lake	302	751	39	65	22%	
McCloud River above Shasta Lake	392	850	185	160	41%	
Pit River near Montgomery Creek + Squaw Creek	1,046	2,098	480	460	44%	
Total Inflow to Shasta Lake	1,806	3,525	726	**710**	39%	600 - 860
Sacramento River above Bend Bridge, near Red Bluff	2,485	5,117	943	**970**	39%	800 - 1,140
Feather River						
Feather River at Lake Almanor near Prattville (3)	333	675	120	60	18%	
North Fork at Pulga (3)	1,028	2,416	243	210	20%	
Middle Fork near Clio (4)	86	518	4	15	17%	
South Fork at Ponderosa Dam (3)	110	267	13	20	18%	
Feather River at Oroville	1,758	4,676	392	**340**	19%	270 - 500
Yuba River						
North Yuba below Goodyears Bar	279	647	51	40	14%	
Inflow to Jackson Mdws and Bowman Reservoirs (3)	112	236	25	20	18%	
South Yuba at Langs Crossing (3)	233	481	57	40	17%	
Yuba River near Smartsville plus Deer Creek	996	2,424	200	**165**	17%	130 - 230
American River						
North Fork at North Fork Dam (3)	262	716	43	30	11%	
Middle Fork near Auburn (3)	522	1,406	100	70	13%	
Silver Creek Below Camino Diversion Dam (3)	173	386	37	30	17%	
American River below Folsom Lake	1,231	3,074	229	**175**	14%	145 - 250
SAN JOAQUIN RIVER						
Cosumnes River at Michigan Bar	128	446	8	**10**	8%	7 - 20
Mokelumne River						
North Fork near West Point (5)	437	829	104	70	16%	
Total Inflow to Pardee Reservoir	468	1,076	102	**75**	16%	60 - 100
Stanislaus River						
Middle Fork below Beardsley Dam (3)	334	702	64	50	15%	
North Fork Inflow to McKays Point Dam (3)	224	503	34	30	13%	
Stanislaus River below Goodwin Reservoir (9)	699	1,710	116	**95**	14%	70 - 160
Tuolumne River						
Cherry Creek & Eleanor Creek near Hetch Hetchy	315	727	97	70	22%	
Tuolumme River near Hetch Hetchy	604	1,392	153	140	23%	
Tuolumne River below La Grange Reservoir (9)	1,221	2,682	301	**240**	20%	190 - 300
Merced River						
Merced River at Pohono Bridge	372	888	80	60	16%	
Merced River below Merced Falls (9)	636	1,587	123	**85**	13%	65 - 140
San Joaquin River						
San Joaquin River at Mammoth Pool (7)	1,026	2,279	235	120	12%	
Big Creek below Huntington Lake (8)	91	264	11	10	11%	
South Fork near Florence Lake (7)	201	511	58	20	10%	
San Joaquin River inflow to Millerton Lake	1,258	3,355	262	**130**	10%	105 - 210
TULARE LAKE						
Kings River						
North Fork Kings River near Cliff Camp (3)	239	565	50	30	13%	
Kings River below Pine Flat Reservoir	1,236	3,113	274	**135**	11%	110 - 210
Kaweah River below Terminus Reservoir	290	814	62	**38**	13%	30 - 55
Tule River below Lake Success	64	259	2	**2**	3%	1 - 11
Kern River						
Kern River near Kernville	384	1,203	83	40	10%	
Kern River inflow to Lake Isabella	465	1,657	84	**45**	10%	35 - 90

(1) See inside back cover for definition
(2) All 50 year averages are based on years 1961-2010 unless otherwise noted
(3) 50 year average based on years 1941-90
(4) 44 year average based on years 1936-79
(5) 36 year average based on years 1936-72
(6) 45 year average based on years 1936-81
(7) 50 year average based on years 1953-2002
(8) 50 year average based on years 1946-1995

MAY 1, 2015 FORECASTS
WATER YEAR UNIMPAIRED RUNOFF

Unimpaired Runoff in 1,000 Acre-Feet (1)

HISTORICAL			DISTRIBUTION									FORECAST		
50 Yr Avg (2)	Max of Record	Min of Record	Oct Thru Jan	Feb *	Mar *	Apr *	May	Jun	Jul	Aug	Sep	Water Year Forecasts	Pct of Avg	80 % Probability Range (1)
1376	2990	200	418	294	67	56	38	14	2	0	0	**889**	65%	864 - 985
876	1,965	165												
1,200	2,353	557												
3,082	5,150	1,484												
5,979	10,796	2,479	1,621	720	273	219	180	161	150	140	136	**3,600**	60%	3,435 - 3,810
8,727	17,180	3,294	2,652	1,068	348	306	265	221	178	155	162	**5,355**	61%	5,120 - 5,610
780	1,269	366												
2,417	4,400	666												
219	637	24												
291	562	32												
4,523	9,492	994	916	442	157	121	100	60	59	55	50	**1,960**	43%	1,850 - 2,140
564	1,056	102												
181	292	30												
379	565	98												
2,329	4,926	369	398	204	102	67	75	17	6	0	0	**869**	37%	835 - 950
616	1,234	66												
1,070	2,575	144												
318	705	59												
2,683	6,382	349	332	242	86	80	80	15	0	0	0	**835**	31%	805 - 910
385	1,253	20	22	38	9	7	3	0	0	0	0	**79**	21%	76 - 90
626	1,009	197												
763	1,848	129	43	65	30	30	42	3	0	0	0	**213**	28%	198 - 245
471	929	88												
1,167	2,952	155	64	92	37	37	47	11	0	0	0	**288**	25%	263 - 360
461	1,147	123												
770	1,661	258												
1,943	4,631	383	106	114	57	85	120	25	10	0	0	**517**	27%	467 - 585
461	1,020	92												
1,007	2,787	150	22	25	19	30	39	12	4	0	0	**151**	15%	131 - 210
1,337	2,964	308												
112	298	14												
248	653	71												
1,831	4,642	362	47	43	34	39	52	26	13	8	3	**265**	14%	237 - 355
284	607	58												
1,729	4,287	386	49	46	42	46	57	22	10	4	4	**280**	16%	254 - 365
456	1,402	94	15	17	13	10	20	6	2	1	1	**85**	19%	76 - 110
147	615	16	4	3	1	1	1	0	0	0	0	**10**	7%	9 - 20
558	1,577	163												
733	2,318	175	36	15	13	14	13	11	7	6	5	**120**	16%	106 - 175

(9) Forecast point names based on USGS gage names. Stanislaus below Goodwin also known as inflow to New Melones, Tuolumne River below La Grange also known as inflow to Don Pedro, Merced River below Merced Falls also known as inflow to McClure.
(10) Coordinated Forecast by National Weather Service California-Nevada River Forecast Center and Department of Water Resources, State of California
* Unimpaired runoff in months prior to forecast date are based on measured flows

Pages 4 and 5 of the B120 report show historical data, the April-July forecast, and the water year (October – September) forecast of FNF for rivers on the west side of the Sierra ridge. The two columns to the right of the "50 Yr Avg" column are the maximum and minimum values over the entire record not just the period over which the average is calculated. For the major rivers flowing into the Delta, the record of FNF begins before 1910. The "50 Yr Avg" column is updated every 5 years. The units for all of the flow information is thousands of acre-feet. An acre-foot is the volume needed to cover an acre with one foot of water. The "Apr-July forecasts" column represents the volume of FNF the DWR expects during those four months at the location described in the first column.

Page 5 of the report shows the historical data on a water year basis and any observed flows for the water year. Included under the columns labeled "DISTRIBUTION" are the expected FNF values for the months after the forecast date. The remainder of my witness statement explains how the full natural flow forecast is made.

The last two columns of pages 4 and 5 depict the 80% Probability Range for the April-July and water year (October-September) forecasts. This range is comprised of the 10 and 90 percent exceedance level forecasts. These two values represent the "wet" and "dry" scenarios. For example, see pages 4 and 5 of Exhibit WR-145. The "80% Probability Range" shown on the right side of pages 4 and 5 of the B120 report, is bounded by the 90 and 10 percent exceedance level values. A 90 percent exceedance level April-July forecast is defined as the volume that has a 90 percent chance of being surpassed (or, there is only a 10 percent chance that the observed FNF will be less than this forecast). The forecast at the 90 percent exceedance level is considered the "dry" case scenario. The forecast is designed such that the final observed flow is expected to fall between the two values eight out of ten forecasts. So, for example, in looking at page 4 of the table, the 80 percent probability range for the first row shows a range of 85 to 200 thousand acre feet for Trinity River at Lewiston Lake. This means that the observed flow would be expected to fall between 85 and 200 thousand acre feet 8 out of 10 times. In summary, the expected flow volumes (the 50 percent exceedance forecast) for the April-July and water year periods are boldfaced while the "wet" and "dry" scenarios are shown under the header "80%

Probability Range". The boldfaced values are shown in the columns labeled "Apr-Jul Forecasts"on page 4 and "Water Year Forecasts" on page 5.

Forecasting by Regression Analysis

Earlier, reference was made to the regression process as being the main forecasting tool. To illustrate how the regression analysis is performed, the following example outlines the parameters used in the regression analysis for the San Joaquin River April-July FNF forecast.

Table 1 below shows the calculation method for three regression equations used for the San Joaquin River. The equations are read from top to bottom. By way of example, using equation 2, the index value for "High Snow" of 56 is multiplied by 4.44. The results of each parameter's input to the equation is tallied in the columns called "runoff" and their sum total equals the FNF forecast number in thousand acre feet.

The index column contains values that represent measurements that have been taken of various parameters. So, for example, the index value assigned to OMR (the Oct-Mar full natural flow) in the table below is 198 thousand acre feet. The index value assigned to the high elevation snow (HS) is 56 which means that the forecast assumes that the high elevation snow pack is expected to be about 56 percent of the historical April 1 average. In this case, the index is a percent of average. Continuing to use High Snow as an example, the result of 249 (56 times 4.44) is the contribution of the high elevation snow to the forecast value of 573 thousand acre feet shown in boldface. The example below is from the February 1, 2015 forecast.

Table 1:
San Joaquin River Inflow to Millerton Lake

Parameter	Index	Eq. 1 (10/88)	Runoff	Eq. 2 (3/82)	Runoff	Eq.3 (7/1/06)	Runoff
pre Apr-Jul runoff (PY)	375	.0546 x (PY)	20	.0382 x (PY)	14	.0419 x (PY)	16
O-M runoff (OMR)	198	-		.277 x (OMR)	55	0.1229 x (OMR)	24
High Snow (HS)	56	9.6603x (HS)	541	4.44 x (HS)	249	7.5365 x (HS)	420
Low Snow (LS)	45	-		3.15 x (LS)	141	3.1936 x (LS)	144
O-M precip (OMP)	66	.01752 x $(OMP)^2$	76	3.19 x (OMP)	210	.7957 x (OMP)	53
A-J precip (AJP)	84	2.738 x (AJP)	230	2.84 x (AJP)	237	3.1778 x (AJP)	267
Constant	-	-302.9	-303	-331	-331	-379.17	-379
Sum			**561**		**573**		**542**

The equations were made in 1982, 1988, and 2006.

The constant listed in the parameter column (the row identifying -302.9, -331, -379.17 for each equation) is calculated when the regression equation is derived, or when the relationship between the parameters is determined. Mathematically, it is the location where the line correlating the parameters with the April-July forecast crosses the Y-axis.

The six parameters for each equation are discussed below, and include the following:

1. The previous year's April-July FNF.

2. The October-March FNF from the current water year.

3. The high elevation snow water content (SWC). The most important type of snow data used to evaluate hydrologic conditions and to make a water supply forecast is not the depth of snow but the SWC. The SWC data used in the first of month B120 forecasts are from manual measurements at snow courses. For April 1, about 245 courses are measured. The data from each site includes the SWC and depth of snow at each sampling point which allows one to make a calculation of the density (SWC/depth). The density is used as a check of the SWC data since an approximate density can be made for a given time of the season in a given region and compared to the density from a specific course.

The high elevation snow index is measured using 11 snow courses ranging from 8400 to 11450 feet in elevation. The snow course data is used to calculate an index which is the average of the usual April 1 SWC. For forecasts made before April 1, the historical median increase in snow between the measurement date and April 1 is added to the measured amount to estimate the SWC that would exist on April 1. This number is entered into the regression equation.

4. The low elevation snow water content. Evaluating this parameter uses snow courses ranging from 6800 to 8300 feet in elevation. The index calculation method is the same as that for the high elevation courses.

Regression equations require that the SWC data be for the first of the month. Because a course may not be measured on the first of the month, an adjustment is made to the measured SWC value. The SWC value is adjusted according to a precipitation gauge nearby. The gauge is used to determine the precipitation amount, if any, that occurred between the date the course was measured and the first of the month. Because the gauge may not accumulate precipitation at the same rate as the course, a factor is applied to the precipitation value. The factor is the approximate ratio between the historical precipitation at the gage and at the course.

5. The October-March precipitation. Precipitation data includes the amount of liquid water in both rain and snow. This data is from telemetered or manually measured gauges. Some of the values received are visually inspected by the National Weather Service before they are received by CDEC. The data from approximately 80 precipitation stations are entered in the equations used to make water supply runoff forecasts. The precipitation data is checked by comparing data from individual stations to other nearby stations in the same basin for a chosen month. Each station's percent-of-average for a month is the compared statistic.

The index calculated uses 8 gages. The index approximates the percent of average for the October-March period. The precipitation of each month is weighted differently in the calculation. October is weighted 0.5 and March is weighted a 1.0 because early months in the season are treated as relatively minor contributors to the April-July runoff. So, 5 inches in October do not increase the forecast as much as 5 inches in March.

6. The April-June precipitation. This index is calculated using the same method as the Oct-Mar precipitation index.

When all six predictors have been determined, they are entered into the three regression equations shown earlier. The results of the equations are the first estimates of expected median (50 percent exceedance level) April-July FNF. The DWR uses the same regression equations for the February, March, April, and May forecasts. For some forecast dates, the data to calculate an index is not available. In these cases, median conditions after the forecast date are used to estimate the missing data. Using a May 1 forecast as an example, the precipitation for May and June are missing in the Apr-Jun precipitation calculation. In this case, median precipitation is assumed for May and June.

Because the soil type in a basin has an affect on the release rate of water from the soil into a river, for some rivers such as the Sacramento River at Bend Bridge, Yuba, American, Mokelumne, Tuolumne, Merced, and San Joaquin, the FNF volumes from prior (antecedent) years are used in the April-July FNF forecast equations. Usually the volume is the prior year's April-July FNF. In the basin above the Sacramento River at Bend Bridge, where volcanic soils are prevalent, the antecedent period is longer because the volcanic soils can release water from the season two years before the year in which the forecast is being made.

Probability Ranges: The 10, 50, and 90 Percent Exceedance Forecasts

On page 4 of the May 1, 2015 B120 report, attached as Exhibit WR-145, the 90 and 10 percent exceedance level forecasts for the Feather River at Oroville are shown under the column header "80% Probability Range" as 270 and 500 thousand acre feet, respectively. The value of 270 means that there is a 90 percent chance that the final flows will be greater than 270 thousand acre feet. The value of 500 means that there is a 10 percent chance that the final flows will be greater than 500 thousand acre feet. The 50 percent (median) exceedance level forecast of 340 is shown in boldface under the column header "Apr-Jul Forecasts". The April-July 10% and 90% exceedance level forecasts are computed by adding a probability range to the median forecast. Therefore, these exceedance level forecasts are not calculated using a regression equation. The 90% and 10% exceedance levels are calculated by using the historical forecasts which are those that have been made over about the last 45 years. Because the observed April-July FNF is known for each year during this period, the forecasted value and the observed numbers can be compared. The difference between these two numbers is the forecast error. The errors are ranked (listed smallest to largest) and the various exceedance levels are determined from the ranked list. The 80% probability range becomes smaller through the forecast season because weather uncertainty diminishes as the end of July approaches.

Further Analysis and Peer Review

Producing forecast values from the three main equations is the beginning of the forecasting process. The forecasting process involves 3-5 people. Each person gathers data[1] and makes their analysis using, in part, the output from the general equations described earlier before the group meets to finalize the forecast. The group, for example, discusses whether the outlook is for a particularly dry or wet year. During this process, the group's findings are discussed and a final forecast is determined.

The equation output can be adjusted to reflect hydrological conditions not accounted for by the analytical methods. An example of such a condition is the situation where an unusual runoff pattern exists due to one extremely wet month followed by a very dry month. Most of the

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[1] The information for these forecasts and reports is gathered from the following entities: the United States Corps of Engineers, United States Bureau of Reclamation, California State Water Project, United States Geological Survey, Contra Costa Water District, East Bay Municipal Utility District, Eldorado Irrigation District, Santa Clara Valley Water District, Monterey County, Nevada Irrigation District, Truckee Water Master, Modesto Irrigation District, San Luis Opisbo County, Turlock Irrigation District, Metropolitan Water District, City of San Diego, Southern District of the California Department of Water Resources, California Department of Water Resources Oroville Field Division, Pacific Gas and Electric, Placer County Water Agency, City of Napa, Southern California Edison, City of San Francisco, Yolo County Flood Control and Water Conservation District, Merced Irrigation District, Georgetown Public Utilities District, South Sutter Water District, Humboldt Bay Municipal Water District, and the City of Bakersfield.

equations were made using data from a large group of years (30 to 50) yet a small number of those years are similar to the extraordinary conditions of the 2012-15 drought. Some additional equations developed by the DWR were derived using years that were considered "dry". These equations were made in 2008. An example of a "dry" year equation for the Feather River is shown in table 2.

Table 2: Dry year equation

Criteria to determine if the "dry" year definition is met… ↓ Criteria 1: index is less than	↓ or Criteria 2: index is less than	Parameter	February 1, 2015 "Dry year" equation for the Feather River	Index value	Contribution and forecast
97	77	Apr 1 High Snow (HS)	7.85 times (HS)	**44**	345
94	75	Apr 1 Low Snow (LS)	2.03 times (LS)	**9**	18
99	79	Oct-Mar Precip (OMP)	1.64 times (OMP)	**84**	138
99	80	Apr-Jun Precip (AJP)	4.54 times (AJP)	**87**	395
2470		Oct-Mar FNF (OMRO)	0.14 times (OMRO)	**1816**	254
1845		Prior Yr Apr-Jul FNF (PYAJ)	0.003 times (PYAJ)	**569**	2
		Constant		**-269**	**883**

The main difference between this "dry" year equation and the first three equations is that this equation uses data from a smaller sample of years. Data from wet years are not included. This equation was used while making the 2015 water supply forecasts.

Some of the other tools and techniques used to refine the output of the raw equations are:

● calculation of the average month-to-month change (recedence) after the date of forecast for similar years

● calculation of the monthly FNF values after the forecast date assuming they will be at the same exceedance level as the most recent complete month. If, for example, March of 2015 is the most recent complete month, one would list all the historical March FNF values from smallest to largest. In that list is the March 2015 number. If there are 100 years of data on the list and the March 2015 value is 20th in the list, the exceedance value for March 2015 is 80 percent.

● use the plotted trace of observed daily FNF values, defined and discussed in more detail below, to estimate the FNF for the remainder of the April-July period

● consider the month-to-month trend in the equation output

● consider equations (other than the three main equations) that were made for certain year types

● compare the snowpack on April 1 to similar years and note the April-July runoff that followed

● calculate the recedence considering the possibility that the recedence pattern is ahead or behind the historical pattern

● refer to calculations that show the historical error in two of the three main equations. The errors were determined in seven different year types and are used to make adjustments to the equation results.

Daily Full Natural Flow

As stated earlier, FNF represents the natural water production of a river basin, unaltered by upstream diversions, storage, or by export or import of water to or from other watersheds. Daily FNF values are posted by snow surveys on CDEC (http://cdec.water.ca.gov/cgi-progs/reports/FNF). (WR-185) Snow Surveys does not calculate the daily or monthly FNF values for all of the rivers referred to on the reports. Daily FNF values are calculated by Snow Surveys for the Sacramento River at Bend Bridge, Feather River at Oroville, American River at Folsom, and the Stanislaus River at Goodwin. For other rivers, the values of daily and monthly FNF are received from the United States Bureau of Reclamation, the United States Corps of Engineers, the Merced Irrigation District, the East Bay Municipal Utility District, Pacific Gas and Electric, the United States Geological Survey, and the Turlock Irrigation District.

Where DWR calculates daily FNF, the process involves gathering data describing the volume of water being removed from the river, the volume being added to the river from another river, and the storage changes in reservoirs above the calculation location. As an example, there is only one daily FNF equation for the Sacramento River at Bend Bridge. The process of determining the daily FNF for the Sacramento River at Bend Bridge starts with the measured flow of the river at Bend Bridge. Added to this volume are the estimated value of irrigation and consumption, the evaporation from Lake Shasta, the storage change in Lake Shasta and the storage change in Whiskeytown Lake. Then, the daily volume through the Judge Francis Carr Powerhouse is subtracted.

Exhibit WR-148 contains the link to data posted to CDEC for the station known as Sacramento River at Bend Bridge which is the location where DWR collects flow data for the river. If one clicks on “daily” in the row titled “FULL NATURAL FLOW, cfs” the link leads to the link contained in Exhibit WR-149.

Exhibit WR-149 shows the mean daily flow, FNF, and the irrigation and consumption value on a daily basis. The difference between mean daily flow and FNF is that the mean daily flow is the volume of water that one would see if they were physically at the site and could measure the flow volume for a day. This volume is measured by a gauge. The FNF is the calculated full natural flow which means it accounts for upstream accretions, depletions, and storage changes. The irrigation and consumption is the estimated volume of water removed from the river for the purpose of irrigation and consumption.

Verification of the calculated daily FNF values is made by comparing the flow rates in adjacent rivers. When data is entered into CDEC, the interface allows viewing of past entries. Consequently, the previously entered data can be checked and compared to the most recent entry. The format of the report showing the daily full natural flows is shown at: http://cdec.water.ca.gov/cgi-progs/reports/FNF. (WR-185) A general site regarding full natural flow is: http://cdec.water.ca.gov/snow/current/flow/index2.html. (WR-186)

Authentication of Other Exhibits

- Exhibit WR-73 is a true and correct copy of the Sacramento River Water Year Forecast Breakdown, dated May 1, 2015 (available at http://cdec.water.ca.gov/cgi-progs/products/20150501SRWSI.pdf)

- Exhibit WR-74 is a true and correct copy of the San Joaquin River Water Year Forecast Breakdown, May 1, 2015 (available at: http://cdec.water.ca.gov/cgi-progs/products/20150501SJWSI.pdf)
- Exhibit WR-109 is a true and correct copy of the Sacramento River Water Year Forecast Breakdown, dated April 1 and May 1, 2015, and the San Joaquin River Water Year Forecast Breakdown, dated April 1 and May 1, 2015.