US Army Corps
of Engineers®
Portland District

WILLAMETTE VALLEY SYSTEM OPERATIONS AND MAINTENANCE

DRAFT PROGRAMMATIC ENVIRONMENTAL IMPACT STATEMENT

Appendix B: Hydrologic Processes Technical Information

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Resource Name: Hydrologic Processes
Preparer's Name: Jeff Ballantine, Josh Roach
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Appendix B – Hydrologic Processes Technical Information

1 INTRODUCTION

This technical appendix is designed to provide information on the development of the hydrologic model for the Willamette Valley System EIS. This includes technical details on the development of the input hydrologic dataset, the HEC-ResSim reservoir regulation model, related climate change analysis, and additional figures not included in the main report.

2 INFLOW DATASET

2.1 OVERVIEW

The HEC-ResSim model is used to simulate the period of record to assess hydrologic impacts across the WVS. However, the HEC-ResSim model needs to account for many hydrologic input datasets, including inflows, evaporation, and irrigation depletions. Prior datasets only extended to 2009. There have been several notable events since 2009, including an extreme dry year in 2015 and an unusually late flood in April 2019. As part of the hydrologic modeling for the WVS, the Corps selected a dataset for use up until 2009 and extended the dataset through water year 2019.

2.2 ASSUMPTIONS

Only daily average datasets are required. Datasets with a smaller time step (e.g. hourly) are useful for a model that is specifically focused on flood risk management (FRM), but the computational and data demands are much larger for a smaller time step. Since the Willamette EIS is a more general-purpose model where FRM is just one impact area among many, a daily average dataset is developed and applied.

Willamette Falls at Oregon City is the downstream end of the model. Salem is the furthest downstream point at which reservoirs actively operate to. The hydrologic inputs between Salem and Oregon City are included in the reservoir model, but they have no impact on the upstream reservoir operations.

2.3 EXISTING DATASETS AND INFORMATION

The Willamette Basin has been studied extensively through the years, and many inflow datasets already exist with inflow data.

2.3.1 Existing Inflow Datasets

The **Willamette Flood Insurance Study (FIS) dataset (USACE 2011a, USACE 2013)** was developed for the Willamette basin with the specific purpose of modeling flood conditions accurately. Inflows are developed at all locations required for reservoir operations. Daily average and hourly datasets are developed from 1935-2009. Significant QC efforts were taken for the winter season, while less scrutiny was given to the summer season. Irrigation and evaporation were not addressed consistently in this dataset. The datasets extends downstream to Salem.

The **2010 Modified Flows (BPA 2011)** was developed jointly by three federal agencies (Bonneville Power Administration, the Corps, and the Bureau of Reclamation) and builds on datasets developed roughly every decade for the whole Columbia Basin. The dataset spans September 1928 to October 2008 with daily average flow values downstream to Oregon City (Willamette Falls). The current level of irrigation in the 2010 modified flows is defined from the year 2008, which is the last year of the dataset. The adjustment includes estimates for evaporation and return flows as well. The Modified Flow dataset generally only includes estimates at dam sites and a few other key locations in the Willamette Basin, such as Salem and Albany. It does not include flow estimates at many other control points in the basin, such as Jasper, Mehama, and Jefferson. These control point locations are used during FRM operations at upstream reservoirs. Therefore, the 2010 Modified Flow dataset cannot be used directly to model FRM operations in the Willamette Valley. To summarize this flow set, the modified flows are defined as the historical streamflow that would have been observed without reservoir regulation and with all years adjusted to the same level of irrigation depletions (2008). Therefore, changes in irrigation practices have been accounted for across all years of the dataset. The only locations with irrigation depletions identified in the Willamette Valley are upstream of Fern Ridge, Albany, Salem, and Oregon City. After the EIS hydrologic dataset was developed, the 2020 Modified Flow Dataset was published. The 2020 Modified Flows were not used in the EIS.

The **2010 No Regulation, No Irrigation (NRNI) dataset (BPA 2017)** uses the base data from the 2010 Modified Flow work to produce a naturalized dataset without the effects of reservoir regulation and irrigation. The results for the Willamette Basin are very similar to the Modified Flow dataset—only the irrigation effects are removed.

Every year, Portland District helps provide a report to Congress showing the damages prevented by Willamette Valley Reservoirs. Part of that effort involves developing the **Annual Flood Damage Reduction (AFDR)** dataset for the largest flood event for the year. The AFDR analysis uses an automated process to calculate flows with and without reservoirs for the flood event. Whole water years are not available—only a short time window with the highest flow event.

As part of routine data collection, Portland District calculates inflows for projects using the measured outflow and change in reservoir storage, stored in **USACE Dataquery**. Prior to 2012, this database was known as the Columbia Database (CDB), and data could be accessed via

Dataquery 1.0. SHEF codes were used to identify the data. For instance, "QIDRXZZAZD" is a SHEF code for Cougar (CGR) reservoir inflow. This data source was used when constructing the 2010 modified flows and FIS flows. In 2012, Portland District transitioned to the Corps Water Management System (CWMS) to collect data. Data from CWMS is available via Dataquery 2.0 (also known as DBQuery). The calculation methods for project inflow were slightly modified at this time. CWMS pathnames are used to identify data in this database, such as "CGR.Flow-In.Ave.~1Day.1Day.CBT-REV".

2.3.2 Existing Evaporation Datasets

Evaporation data is most commonly reported in the form of pan evaporation rates. As is implied by the name, the reported values are measured evaporation from a pan in inches. Evaporation rates from a small pan are larger than those from a larger body of water due to an oasis effect. To estimate evaporation from lake surfaces, pan evaporation rates are typically multiplied by a constant of 0.70, but studies show that actual coefficients can range from 0.64 to 0.88 (NOAA, 1982). Evaporation is a function of several meteorological variables which may be difficult to measure, and so pan evaporation is considered one of the most direct methods for measuring evaporation rates. Evaporation volume from a reservoir is a function of evaporation rates and surface area, which varies with reservoir elevation.

WEST consultants estimated monthly average evaporation rates at Willamette Valley reservoirs in 2011 (WEST 2011). The data source used in the WEST report was pan evaporation measurements reported by the Western Regional Climate Center (WRCC) at Cottage Grove, Detroit, Dorena, Fern Ridge, and Lookout point reservoirs (WRCC, 2020). West multiplied pan evaporation rates by 0.75 to more closely estimate the evaporation from lake surfaces. For the reservoirs that did not have evaporation data, evaporation from the closest reservoir or the reservoir with the most similar climate was used. Precipitation data gathered from WRCC was then incorporated into net evaporation resulting in negative evaporation rates in some months (WEST, 2011). The values provided by WEST are currently used in several HEC- ResSim watersheds. These values are presented in Table 2-1.

Table 2-1.WEST monthly evaporation rates (inches)

Project	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
HCR (LOP)	-6.24	-3.03	-2.62	-0.77	1.29	3.77	7.09	5.96	2.81	-1.42	-5.65	-6.94
FAL (LOP)	-6.24	-3.03	-2.62	-0.77	1.29	3.77	7.09	5.96	2.81	-1.42	-5.65	-6.94
LOP	-6.24	-3.03	-2.62	-0.77	1.29	3.77	7.09	5.96	2.81	-1.42	-5.65	-6.94
DEX (DET)	-12.79	-8.83	-7.95	-4.66	-0.95	2.51	6.86	5.26	1.17	-4.87	-12.67	-14.14
GPR (DET)	-12.79	-8.83	-7.95	-4.66	-0.95	2.51	6.86	5.26	1.17	-4.87	-12.67	-14.14
FOS (DET)	-12.79	-8.83	-7.95	-4.66	-0.95	2.51	6.86	5.26	1.17	-4.87	-12.67	-14.14
DET	-12.79	-8.83	-7.95	-4.66	-0.95	2.51	6.86	5.26	1.17	-4.87	-12.67	-14.14
COT	-7.07	-4.55	-3.79	-1.49	0.53	2.53	5.3	4.2	1.83	-2.58	-6.61	-7.48
DOR	-6.67	-4.07	-3.28	-0.9	1.81	4.32	7.67	6.27	3.01	-1.77	-6.82	-7.32
FRN	-6.1	-4.19	-2.41	0.67	3.25	5.01	7.75	6.52	3.61	-0.89	-5.94	-6.91

Project	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
CGR (LOP)	-6.24	-3.03	-2.62	-0.77	1.29	3.77	7.09	5.96	2.81	-1.42	-5.65	-6.94
BLU (LOP)	-6.24	-3.03	-2.62	-0.77	1.29	3.77	7.09	5.96	2.81	-1.42	-5.65	-6.94

WRCC provided the Corps with the base data used to derive the evaporation coefficients listed on their website (WRCC, 2020), in the form of monthly cumulative values as shown in Table 2-2. While the Corps does have some evaporation data in the CWMS database, there are many more years of record available from WRCC than were found on the Corps CWMS database. Neither the WRCC data nor from the Corps CWMS database have documentation associated with it, so it is unclear how either was obtained. Table 2-3 indicates the period of record (POR) for the WRCC and Corps evaporation data. For time periods of overlapping data, the WRCC and CWMS estimates are quite similar, suggesting they may be based off the same pan evaporation site. Estimates are typically within a half-inch of each other. It is possible that one of the datasets underwent additional quality control, while the other dataset used more provisional data. There is not enough information to explain the differences, but they appear to be small.

Table 2-2. WRCC monthly pan evaporation rates (inches) multiplied by 0.70

Project	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
COTTAGE GROVE	0.00	0.89	1.51	2.15	3.19	3.92	5.43	4.69	3.13	1.44	0.57	0.00
DETROIT	0.13	0.81	1.18	1.76	3.07	4.13	5.38	4.65	2.97	1.44	0.62	0.32
DORENA	0.00	0.71	1.36	2.07	3.49	4.28	5.73	5.01	3.26	1.41	0.00	0.00
FERN RIDGE	0.27	0.55	1.34	2.22	3.52	4.35	5.68	4.96	3.33	1.55	0.47	0.24
LOOKOUT POINT	0.00	1.23	1.60	2.17	3.27	4.04	5.38	4.82	3.12	1.37	0.71	0.00

Table 2-3. Evaporation datasets period of record

Project	USACE (CWMS database)	WRCC
COT	1975-1978 1990-1994	1948-1978
DET	1974-1978 1990-1992	1955-1993
DOR	1975-1978 1990	1967-1978
FRN	1975-2005	1948-2007
LOP	1985-2006	1956-2006

The previously discussed evaporation datasets report average monthly evaporation rates. The volumetric evaporation from a reservoir in each month only varies based on reservoir elevation (and therefore surface area). Average monthly evaporation rates assume average monthly climate variables. In reality, the evaporation in a given month of a year is a function of many meteorologic variables including air temperature, solar radiation, wind, and humidity.

Figure 2-1 shows regressions of pan evaporation as a function of maximum daily temperatures averaged over the month at Salem at the reservoirs with available Corps pan evaporation data. There is insufficient data to perform regressions with other meteorologic variables. A strong correlation between monthly project evaporation and temperature at Salem is observed with correlation coefficients ranging between 0.58 and 0.77.

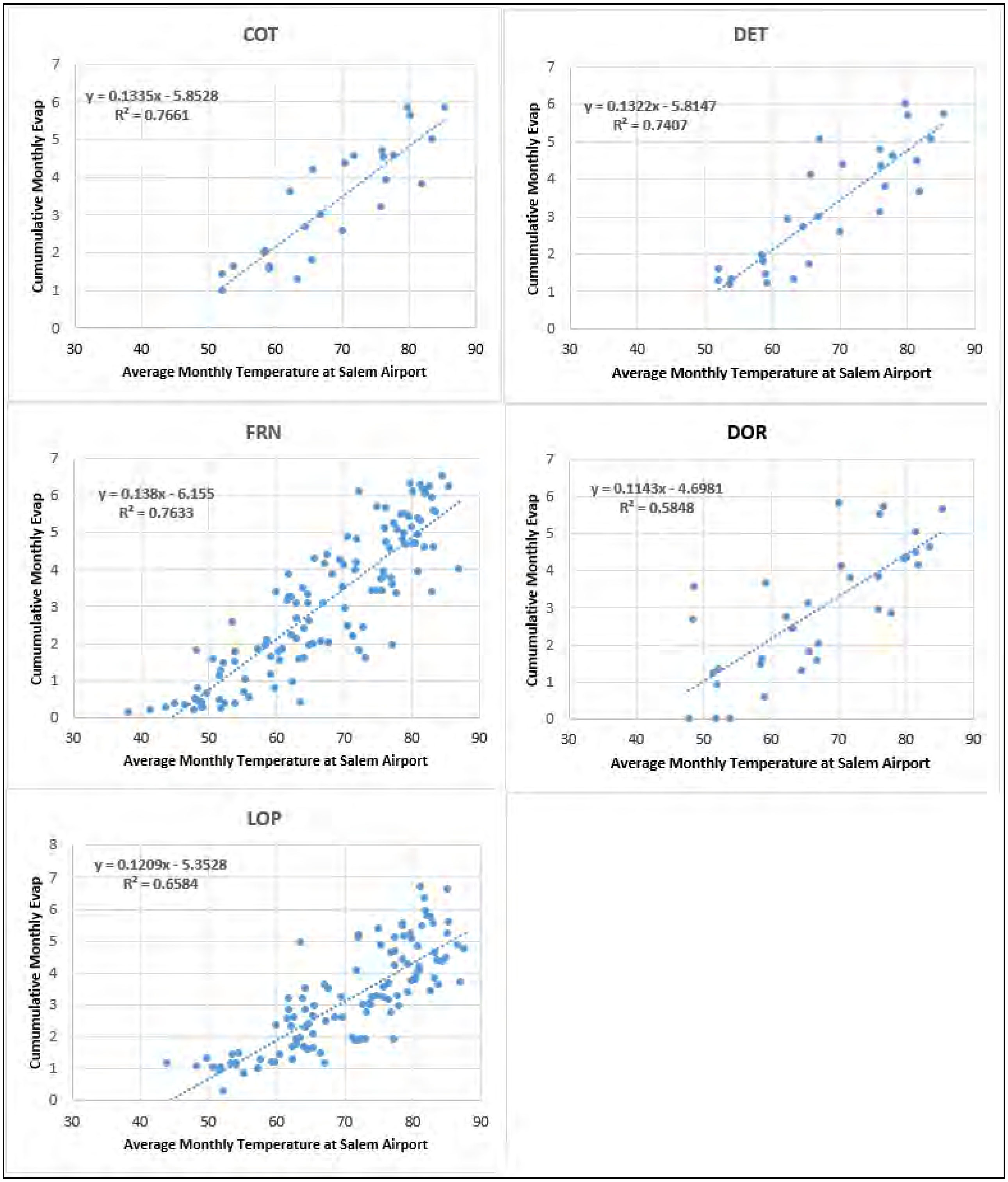


Figure 2-1. Monthly pan evaporation as a function of maximum daily temperatures averaged over the month at Salem.

Table 2-4 applies the WRCC pan evaporation rates corrected with the NOAA recommended constant of 0.7 and calculates the resulting evaporation volume assuming that reservoir elevations follow the congressionally mandated rule curves. For reservoirs without at-site pan evaporation measurements, evaporation rates from the reservoir with the most similar climate was used, consistent with the approach taken in Table 2-1 (WEST 2011). The resulting conservation season evaporation is compared with the storage at full conservation pool to identify the relative impact of evaporation on conservation storage. Fern Ridge exhibits the largest volume of evaporative losses in both relative and absolute terms, more than twice any other reservoir. Evaporative losses at Fern Ridge can exceed inflows in some months.

Table 2-4. Estimated conservation season evaporation

Reservoir	Maximum Conservation Storage (KAF)	Estimated June 1 - Sept 1 Evaporation (KAF)	% Conservation Storage Reduction	Average Daily June 1 - Sep 1 Evaporation (CFS)
Blue River	79	1.5	1.8%	6
Cottage Grove	29	1.6	5.6%	7
Cougar	137	1.9	1.4%	8
Detroit	281	5.0	1.8%	21
Dorena	65	2.5	3.8%	10
Fall Creek	107	2.6	2.4%	11
Fern Ridge	95	13.5	14.3%	56
Foster	25	1.8	7.2%	7
Green Peter	250	1.9	2.3%	23
Hills Creek	195	3.9	2.0%	16
Lookout Point	325	6.3	1.9%	26

The 2010 Modified Flow hydrologic dataset includes a coarse correction for evaporation, but this is only performed for Lookout Point and Fern Ridge. For both Fern Ridge and Lookout Point, the estimate of evaporation is a flat 10 cfs per day for the months of July through September. Negative 10 cfs is applied for evaporation in May for Fern Ridge, and negative 10 cfs is applied in April for Lookout Point. All other periods have no assumed evaporation. These estimates do not take into account changes in reservoir surface area or climate. The 2010 Modified Flow data set was created without consideration for what surface evaporation rates would be used in ResSim and other models. Estimated conservation season evaporation calculated from WRCC coefficients and guide curve project elevations presented in Table 2-4 suggests the 2010 Modified Flow dataset most significantly underestimates evaporation at Fern Ridge.

2.3.3 Existing Irrigation Datasets

Historic and current Irrigation withdrawals and return flows are not well documented in the Willamette Basin. The most rigorous investigation of irrigation withdrawals and return flows is believed to have been conducted while creating the 2010 Modified Flows dataset. This study concluded that most of the irrigation has historically and is currently located along the main stem of the Willamette River between Eugene and Oregon City. Estimates of historic crop acreage by type and irrigation methods used were compared with 2008 conditions and the difference between the two calculated for each year in the POR. These values were calculated for areas above Fern Ridge, Albany, Salem, and Oregon City in the Willamette Valley and are presented in Figure 2-2, Figure 2-3, and figure 2-4. Depletions for locations on the mainstem Willamette were assumed to be a percentage of total Willamette Valley estimates: 25% at Albany, 40% at Salem, and 93% at Oregon City. Figure 2-3 and Figure 2-4 show that irrigation levels at Salem and Albany are assumed to be about the same in the year 1970 and the year 2008. Depletions peaked around 1980. Agricultural water conservation from about 1980 to the present accounts for the change in irrigation depletions.

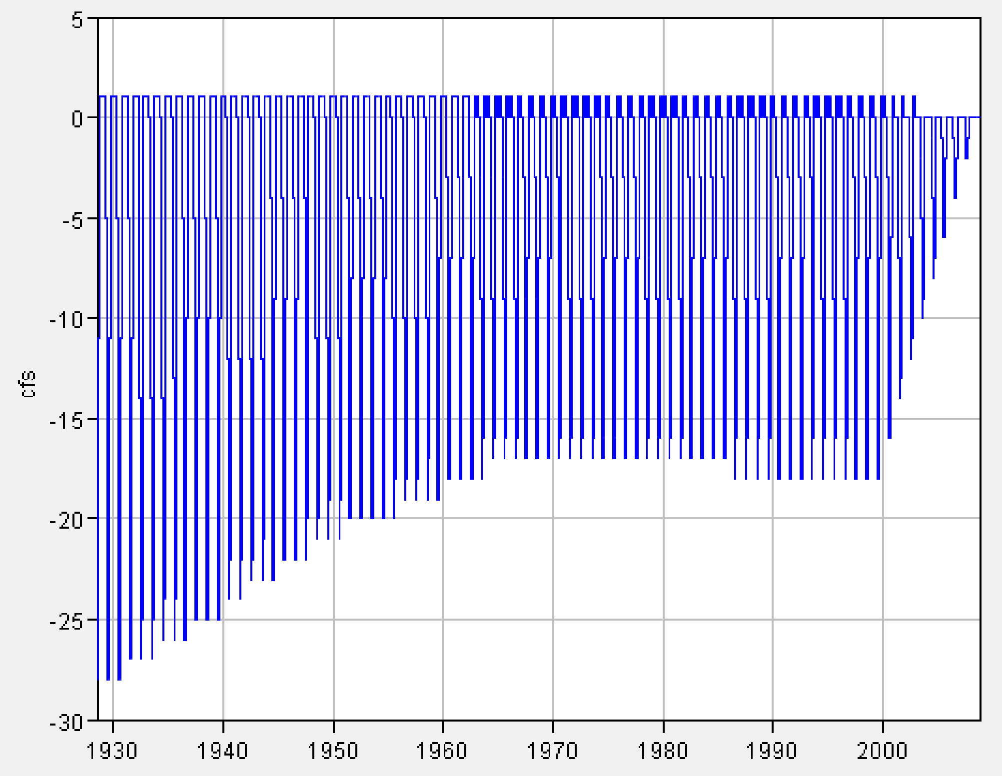


Figure 2-2. Historic minus 2008 irrigation withdrawals and return flows above Fern Ridge

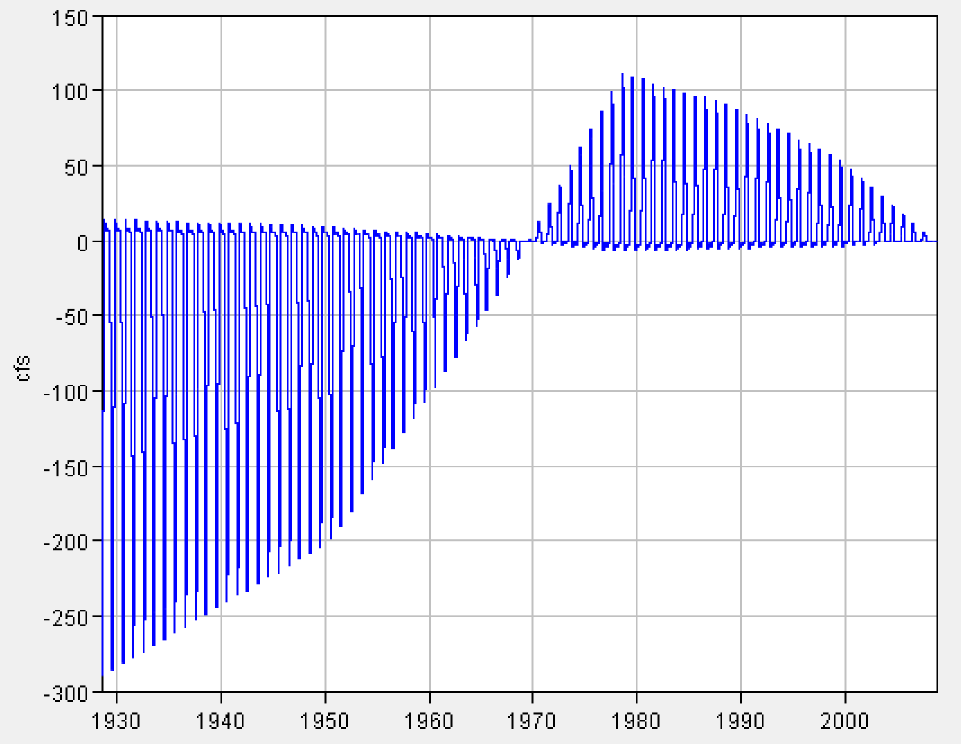


Figure 2-3. Historic minus 2008 irrigation withdrawals and return flows above Albany (not including above Fern Ridge)

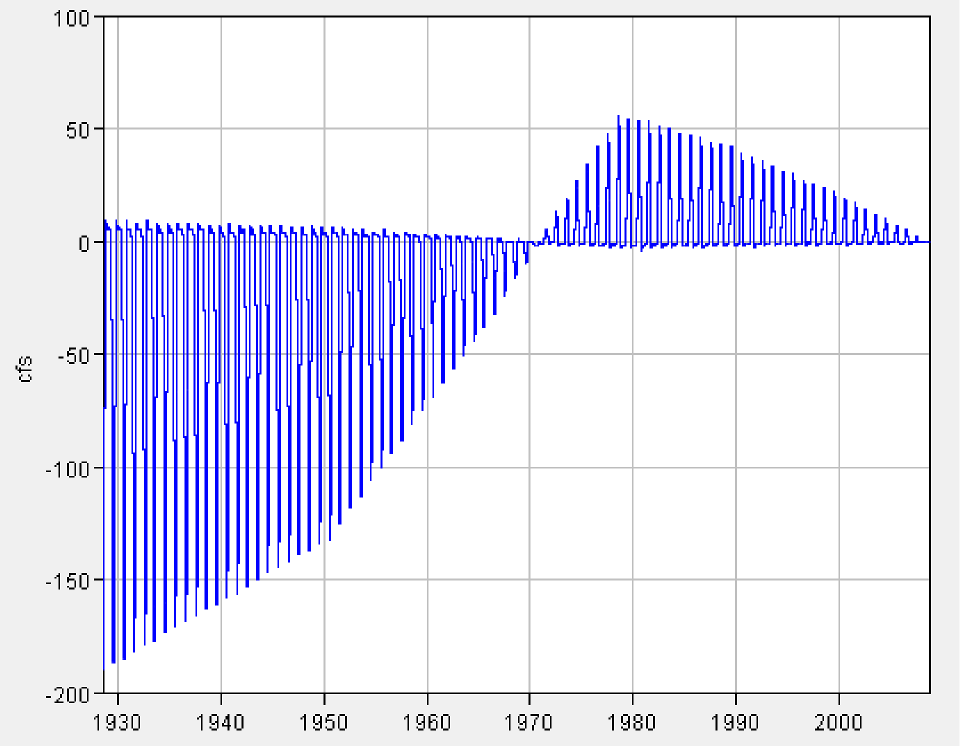


Figure 2-4. Historic minus 2008 irrigation withdrawals and return flows between Salem and Albany

2.4 METHODS

The WVS EIS requires a complete hydrologic dataset with homogenous irrigation and evaporation assumptions that extends through water year 2019. The inflow dataset is presented first, followed by the methods used to apply evaporation and irrigation to that basin-wide inflow.

2.4.1 Reservoir Inflows

Reservoir inflows are typically calculated values, not measured values. Only reservoir outflow and elevations are typically measured. The change in storage of the reservoir is calculated by applying the elevation change to the elevation-storage table. Then, inflow is calculated via conservation of mass using known outflow and change in storage. This method is typically used for periods after the reservoir was constructed and is termed the project inflow estimate. For periods before the reservoir was in place, inflow estimates are sourced from statistical relationships with nearby gages.

The 2010 Modified Flows report and the Willamette FIS use different methods to estimate the inflows during the pre-dam period. In general, the Willamette FIS used more rigor and QC when developing these estimates. Even after the reservoirs were constructed, the Willamette FIS and 2010 Modified Flows do not agree. The 2010 Modified Flows used the direct at-site project inflow estimate, which often yields negative inflow values in the summer since evaporation and depletions are embedded in the inflow estimate. The Willamette FIS dataset used two different methods for different seasons of the year (USACE 2011a). In the winter, the at-site project inflow estimate was typically used, with detailed quality control, since winter flooding was the primary focus of the study. In the summer, a variety of techniques were taken. In some locations, the at-site project inflow estimates were used directly. Other locations used a smoothing technique to eliminate negative inflows. Other locations used upstream gage records directly rather than using the information at the reservoir site. Table 2-5 shows how the winter and summer flows were derived in the Willamette FIS dataset. The most glaring issue with the Willamette FIS summer inflows is at Fern Ridge. The FIS dataset assumes inflows to Fern Ridge are solely from the upstream flow gage. While the FIS ResSim model implementation removes evaporation from these inflows, the significant irrigation depletions taken from Fern Ridge reservoir are ignored.

The Willamette FIS work was performed in 2011. At that time, the working database for at-site project inflows was Dataquery 1.0 (CDB). The FIS effort performed some QC on these inflow datasets, mostly to remove large spikes in data and fill in any isolated missing estimates. After the working USACE database was transitioned to CWMS in 2012, the inflow calculation methods changed slightly. Therefore, the exact inflow dataset used in the FIS work is no longer available in the CWMS database, and slightly different inflow estimates are used. For instance, at Cottage Grove, the FIS efforts used the “QIDPAZZ ZD” dataset from Dataquery 1.0 as a starting point for QC. The daily inflow pathname from the CWMS database is “MIXED-COMPUTED-REV”, and the inflow datasets do not match exactly for the period of overlapping data through 2012.

Table 2-5. Reservoir Inflow datasets and calculation methods in Willamette FIS

Project	DataQuery 1.0 (CDB) Inflow Code Used in 2011 FIS dataset	Current CWMS (DbQuery or Dataquery 2.0) Inflow Pathname (also shown with an F-part of "BEST" in CWMS)	Dataquery 1.0 data matches Dataquery 2.0 data?	Method for Summer Flows in FIS, 2000-2009 ("Summer" dates are variable by year)
Cottage Grove	QIDPAZZ ZD	COT.Flow-In.Ave.~1Day.1Day.MIXED-COMPUTED-REV	No	Dataquery 1.0 inflows used with negative flows removed or floored.
Dorena	QIDPAZZ ZD	DOR.Flow-In.Ave.~1Day.1Day.MIXED-COMPUTED-REV	No	Taken directly from USGS gage 14154500 (start and end date of "summer" changes by year). No drainage area adjustment applied to the USGS gage flow data.
Fern Ridge	QIDPAZZ ZD	FRN.Flow-In.Ave.~1Day.1Day.MIXED-COMPUTED-REV	No	Taken directly from USGS gage 14166500 (start and end date of "summer" changes by year). No drainage area adjustment applied to the USGS gage flow data.
Blue River	QIDPAZZ ZD	BLU.Flow-In.Ave.~1Day.1Day.MIXED-COMPUTED-REV	No	Before 2003, used USGS gage 14161100 (upstream on Blue River). After gage stopped operating in 2003, Datquery 1.0 inflows used with negative flows and extreme low flows removed or floored (e.g. September 2009.
Cougar	QIDRXZZAZD	CGR.Flow-In.Ave.~1Day.1Day.CBT-REV	Yes	Dataquery 1.0 inflows used with downward spikes in inflow removed or floored.
Fall Creek	QIDPAZZ ZD	FAL.Flow-In.Ave.~1Day.1Day.MIXED-COMPUTED-REV	No	Dataquery 1.0 inflows used. First, removed negative flow values via QC process. Then, took a 3-day centered moving average of the data.
Hills Creek	QIDRXZZAZD	HCR.Flow-In.Ave.~1Day.1Day.CBT-REV	Yes	Dataquery 1.0 inflows used with QC applied for downward spikes.
Detroit	QIDRXZZAZD	DET.Flow-In.Ave.~1Day.1Day.CBT-REV	Yes	Typically, summer flows used a 7-day average of the Dataquery 1.0 inflows, as evidenced by 2003-2006. 2007 FIS inflows do not match up with the CDB dataset or any known dataset. 2009 summer flows used North Santiam + Breitenbush (not Blowout Creek) USGS gages instead of Dataquery 1.0 inflows.
Green Peter	QIDRXZZAZD	GPR.Flow-In.Ave.~1Day.1Day.CBT-REV	Yes	Dataquery 1.0 inflows used. Negative/zero flows were floored to around 30 cfs.

The definition of what dates comprise the summer season were flexible in the Willamette FIS. Table shows the dates when the inflow calculation method switched at Fall Creek. It appears that the breakpoints were determined manually to ensure that any large storm events used the at-site project inflow estimates, rather than the more approximate summer techniques. This was appropriate, since the study was focused on flood risk management.

Table 2-6. Dates when inflow methods transitioned from winter to summer at Fall Creek in FIS dataset

Calendar Year	Begin Summer	End Summer	Notes
2002	1-May	31-Oct	
2003	1-Apr	31-Oct	
2004	1-Jun	31-Oct	
2005	1-Jun	30-Nov	
2006	1-May	31-Oct	
2007	1-May	30-Sep	Storm in October
2008	1-Mar	31-Oct	
2009	18-May	30-Sep	Minor storm in early May

For the Willamette EIS, both the FRM operations in the winter and the conservation season operations in the summer are of interest. To best suit the needs of the study, a composite approach is taken for the inflow dataset. The FIS dataset is used for the period of November-March, when high flood flows are most common. The FIS dataset has more detailed QC and gage extension methods for the winter season. The 2010 Modified Flows dataset (data type “A”) is used for the April-October period to ensure the at-site project inflow estimates are used. This dataset is then adjusted to provide consistent levels of irrigation and evaporation, as discussed in the following sections. For the period of 2009-2019, the at-site project inflow estimate from CWMS (Dataquery 2.0) is used for both the summer and winter, since evaporation and irrigation are already incorporated into these estimates and are assumed to be similar to 2008 levels of irrigation.

2.4.2 Local Inflows

Local flows are incremental flows that enter the system between upstream inflow points and the next downstream point. These types of flows are needed in the analyses at locations downstream of the dams so that all the water in the system is accounted for. The general process for calculating local flows is to route all known upstream flow hydrographs to the location of interest. These routed flows are then subtracted from the observed flow at this location. The difference is the incremental local flow between upstream inflow points and the location of the local flow. In general, USGS gages are operated just downstream of most Willamette Valley dams. In addition, outflow estimates are sometimes available from USACE as calculated values from known gate openings/hydropower generation. Outflows are calculated from rating tables. These calculated outflows are considered less reliable than USGS gages, which are calibrated regularly with measured flow data. Since the USGS gages are slightly downstream of dams, a slight drainage area ratio adjustment is often necessary to ensure all contributing drainage area is accounted for.

For the period until 2009, the local flows from the Willamette FIS dataset are used for the Willamette EIS. Unlike the reservoir inflows, there was no difference between summer and winter calculation methods for the Willamette FIS local inflows. These records were also used in the USGS regional volume-frequency study, since they were calculated based on USGS gage data. The drawback to the Willamette FIS dataset is that it contains no correction to the historic data for changing irrigation through time. The only local inflow points with irrigation depletion estimates from the 2010 Modified Flow report are Salem, Albany, and Oregon City. Therefore, rather than using the Salem, Albany, and Oregon City datasets directly from the existing FIS dataset, the irrigation depletions from the 2010 Modified Flow dataset are added to the FIS dataset at these locations to create a homogenous dataset.

To extend to the period 2009-2019, the same calculation methods from the Willamette FIS records from the USGS gages are used when available. Table B-2-7 shows the locations at which observed data is defined for the extension. USGS gages are used for all locations except for Green Peter outflows, Foster inflows, and Lookout Point inflows. In those cases, USGS gages are not available, and the flow estimates from Dataquery 2.0 are used.

Local flows between Salem and Oregon City are a special case, since inflows were not calculated in the FIS. For the period up to 2008, the 2010 Modified Flow dataset is used. For the period 2009-2019, local flows are calculated using the methods outlined by WEST, which are very similar to the 2010 Modified flow report (USACE 2018).

Table 2-7. Observed flow locations with DSS pathnames to calculate local flows

Location	A-Part	B-Part	C-Part	F-Part
Willamette_at Salem	WILLAMETTE RIVER	WILLAMETTE RIVER AT SALEM, OR (14191000)	FLOW	USGS
Willamette_at Harrisburg	WILLAMETTE RIVER	WILLAMETTE RIVER AT HARRISBURG, OR (14166000)	FLOW	USGS
Willamette_at Albany	WILLAMETTE RIVER	WILLAMETTE RIVER AT ALBANY, OR (14174000)	FLOW	USGS
So Santiam_nr Foster	SO SANTIAM NR FOSTER	14187200	FLOW	USGS
So Santiam_at Waterloo	SOUTH SANTIAM AT WATERLOO	14187500	FLOW	USGS
Santiam_at Jefferson	SANTIAM RIVER	SANTIAM RIVER AT JEFFERSON, OR (14189000)	FLOW	USGS
Row_nr Cottage Grove	DOR	14155500	FLOW	USGS
No Santiam_at Niagara	DET	14181500	FLOW	USGS
No Santiam_at Mehama	NORTH SANTIAM AT MEHAMA	14183000	FLOW	USGS
Mckenzie_at Vida	MCKENZIE RIVER NEAR VIDA	14162500	FLOW	USGS
McKenzie+SF McKenzie	CGR	14159500	FLOW	USGS
MF Willamette_nr Dexter	MF WILLAMETTE RIVER NR DEXTER	14150000	FLOW	USGS
MF Willamette_at Jasper	MIDDLE FORK WILLAMETTE AT JASPER	14152000	FLOW	USGS
MF Willamette_abv Salt Crk	HCR	14145500	FLOW	USGS
Long Tom_nr Alvadore	FRN	14169000	FLOW	USGS
Long Tom_at Monroe	LONG TOM RIVER	LONG TOM RIVER AT MONROE, OR (14170000)	FLOW	USGS
Green Peter_OUT		GPR	FLOW-OUT	BEST
Fall_btw Winberry Cr nr Fall Creek	FAL	14151000	FLOW	USGS
CF Willamette_nr Goshen	COAST FORK WILLAMETTE NEAR GOSHEN	14157500	FLOW	USGS
CF Willamette_blw Cottage Grove Dam	COT	14153500	FLOW	USGS
Blue_at Blue River	BLU	14162200	FLOW	USGS
Foster_IN		FOSTER	FLOW-IN	DATAQUERY-EDITED
Lookout Point_IN		LOOKOUT POINT	FLOW-IN	DATAQUERY-EDITED

2.4.2.1 Streamflow Routing

The Willamette FIS effort began from a District HEC-ResSim model from 2010. This model used SSARR (Streamflow Synthesis and Reservoir Routing) routing parameters, which had been in use historically. The Willamette FIS was more focused on short-duration flood routings and therefore revisited the channel routing methods and parameters. WEST consultants completed a report providing new routing methods and parameters focused on an hourly timestep (USACE 2011b). Some reaches were converted from SSARR routing to Muskingum-Cunge 8-point routing. These routing parameters were used when calculating the FIS local flows (USACE 2013). While these routings were applied in the HEC-ResSim model used for the FIS, the daily HEC-ResSim models used for other projects (e.g. Willamette Basin Review, COP, BiOp implementation) continued to use the original SSARR routing parameters. The AFDR HEC-ResSim model also uses the SSARR routing parameters. In 2018, WEST revisited the routing parameters between Salem and Willamette Falls to be used on an hourly timestep (USACE 2018). The proposed revision to routing still uses the SSARR method with adjusted the parameters to better match observed data on an hourly timestep.

The original SSARR parameters are used for the Willamette EIS local flows and HEC-ResSim model. Since a general purpose ResSim model is desired at a daily timestep, the finer level of detail afforded by the FIS routing methods or the new 2018 routing methods from Salem to Willamette Falls is not necessary. There are slight discrepancies on a daily timestep when calculating locals with the different routings. Therefore, the original SSARR parameters are used for the Willamette EIS local flows and HEC-ResSim model.

2.4.2.2 Computation Mechanics

To calculate local inflows for 2009-2019, there are a series of computational steps required. The District's Annual Flood Damage Reduction (AFDR) ResSim model is used to automate this calculation procedure (USACE 2015a).

Local flows for 2009-2019 are calculated using observed gage data with built-in AFDR model functionality. The observed flow datasets used to calculate local flows are summarized in Table B-2-7. After the AFDR model is used to calculate local flows, three sites need additional modifications to ensure they are aligned with the FIS processes. Jasper, Waterloo, and Mehama require manual post-processing: for more details, see section Local Flow Calculation Methods 2.6.

Local flows at Oregon City are a special case, because there has never been a gage in operation that estimates streamflow. Stage estimates are available at Willamette Falls, but not streamflow. The methods applied at Oregon City are also detailed section 2.6. In brief, the local flow is a sum of gaged flows on tributaries between Salem and Oregon City.

2.4.3 Evaporation

Reservoir inflows are calculated as a function of reservoir outflow and change in elevation over time periods when project data exists. Evaporation is inherent to this calculation because evaporation slightly lowers reservoir elevations. The effects of annual variation in reservoir elevations and climate are also embedded in these inflows. Insufficient data exists to reliably estimate evaporation as a function of annual climate variation. The remaining independent variables to model evaporation are average monthly surface evaporation rates and elevation, leaving the following two options for incorporating evaporation into the inflow dataset:

1. **Directly model evaporation in ResSim**. The volume of water lost to evaporation is a function of the surface area of the reservoir. Since the surface area of the reservoir depends on the pool elevation, evaporation losses could vary if reservoir operations were modified. For instance, if the pool is held at lower levels, the evaporative losses would be less. If the evaporative loss volumes are an important factor to capture for different alternatives, this approach should be taken.

2. **Embed evaporation into the inflow dataset.** This approach assumes the same volume of evaporative losses for each individual year irrespective of changes in reservoir surface area resulting from changes in reservoir operations.

The Willamette Valley reservoirs generally have low evaporative losses during the summer compared to their conservation storage volumes, as shown in Table 2-4. The exception is Fern Ridge, which has a large surface area relative to the volume of the reservoir. Evaporation was modeled directly in ResSim at Fern Ridge (Option 1) since it is relatively significant at that location and alternatives may significantly change Fern Ridge pool elevations in the summer. This was done by calculating the evaporative losses at Fern Ridge as a function of average monthly evaporation as reported in Table 2-2 and observed reservoir elevations. This estimated evaporation was added back into the inflow data set. Finally, ResSim was programmed to calculate evaporative losses as a function of evaporation rates and modeled elevation. At all other locations, evaporative losses inherent to the inflow dataset will remain (Option 2), and no evaporative losses are modeled in the HEC-ResSim model. Evaporation is considered negligible in the free-flowing river that existed pre-reservoir and so no correction is made to the inflow hydrology for the years prior to the construction of Fern Ridge.

2.4.4 Withdrawals

The withdrawals are used to adjust each year of record to provide a homogenous hydrologic dataset set to a consistent irrigation level. Ideally, irrigation depletions from the 2020 Modified Flow report would be applied to bring the dataset to 2018 levels. However, the 2020 report was not yet available, so the 2010-level depletions (water year 2008) were used as a starting point. The new data from 2009-2019 is assumed to have irrigation levels consistent with water year 2008. These depletions were directly incorporated into the inflow dataset. The 2020 Modified Flows study was released during development of the EIS inflow dataset. The increase in cumulative withdrawals at Willamette Falls between 2008-2018 is estimated to be at most 165 cfs, functionally all of which is to be withdrawn below Salem (Figure 2-5).

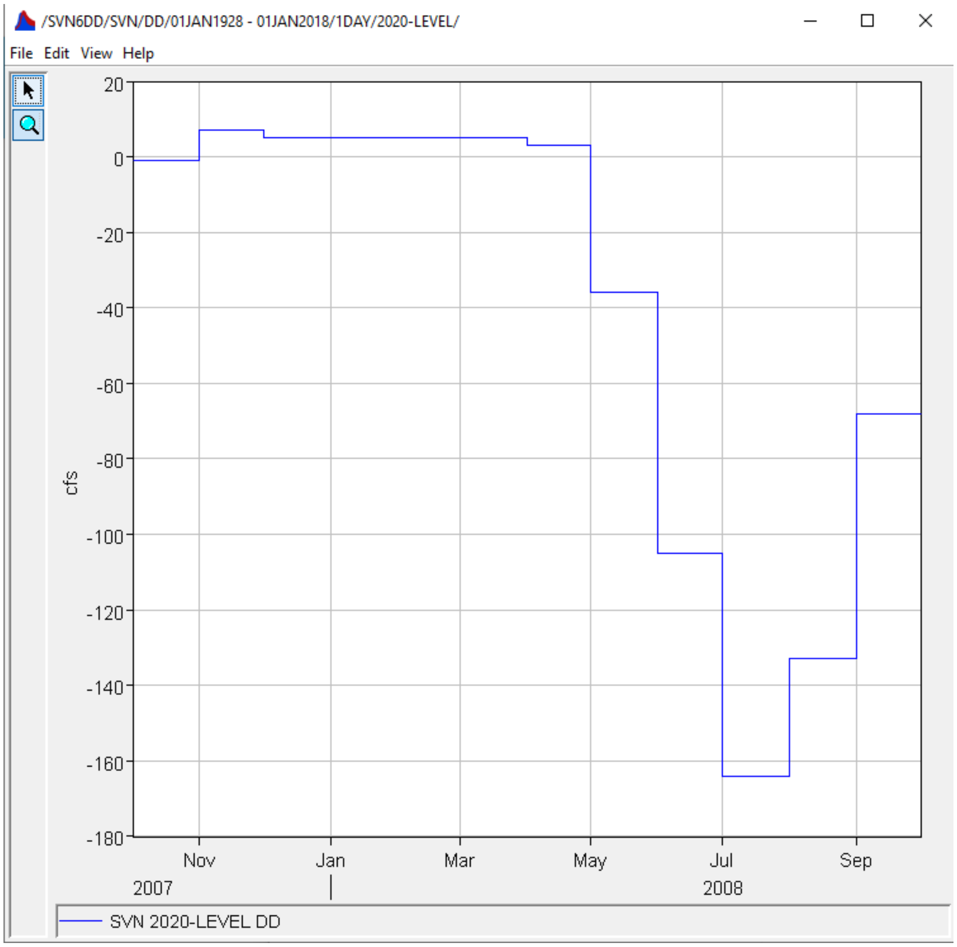


Figure 2-5. Increase in irrigation withdrawals between 2008-2018 at Oregon City Falls

2.5 RESULTS

This section provides validation results for the dataset extension from 2009-2019. Water year 2009 is an overlap year where both new flow extension results are available, as well as existing Willamette FIS dataset. Section 2.7 Water Year 2009 Validation Results includes plots for each flow location comparing the existing datasets and the flow extension performance for water year 2009. A brief discussion of the performance is provided in the following sections.

2.5.1 Reservoir Inflows

Reservoir inflows generally show fairly close agreement between the Willamette FIS dataset and the dataset extension. Differences are due to the change from Dataquery 1.0 (CDB) to Dataquery 2.0 (CWMS) in the winter. In the summer, difference at Dorena and Fern Ridge are notable, because the FIS used upstream USGS gage records, while the extended dataset uses the at-site project inflow estimate from Dataquery 2.0. The at-site project inflow record includes the effect of evaporation and depletions, leading to very low and sometimes negative net inflows.

2.5.2 Reservoir Inflows

The local flows calculated from the dataset extension match the FIS dataset well at all locations, except Salem. There are slight differences at other locations, stemming from different routing parameters. The differences at Salem are more exaggerated. It appears they are largely due from channel routing differences. While the local flows at Salem stand out as having the largest deviation, this is unlikely to affect reservoir operations significantly, since Salem locals are a very small portion of total inflows to the Willamette Basin.

The local flows at Oregon City from the dataset extension match the 2010 Modified Flows well for the comparison year of water year 2008. There are slight differences in volume, but they are relatively minor.

2.5.3 Evaporation

Figure 2-6 shows 3 years of estimated daily evaporation from Fern Ridge, calculated using monthly evaporation rates as reported in Table 2-2 and observed reservoir elevations. Calculated evaporation volumes are added to the Fern Ridge inflow for the POR to reflect a pre-reservoir condition. Evaporative losses were then calculated in ResSim as a function of monthly average evaporation rates and modeled reservoir surface area. This approach shows different evaporative effects for different operational alternatives.

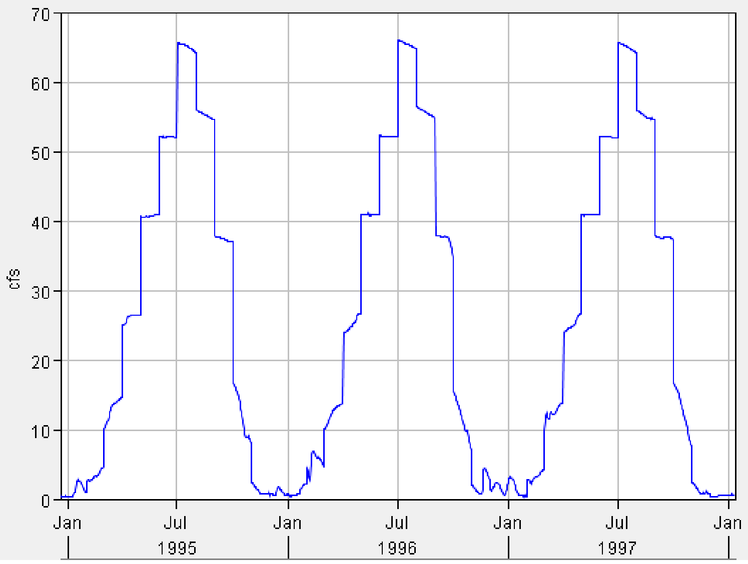


Figure 2-6. Fern Ridge daily evaporation in CFS

2.6 LOCAL FLOW CALCULATION METHODS

This section provides the routing methods that are used to calculate local flows for the dataset extension from 2009-2019. These routing diagrams were sourced from the Willamette FIS report. The same methods for calculating local flows applied in the Willamette FIS are applied here for the extension. The routing parameters used in the flow extension for the EIS are the SSARR routing parameters, while the FIS used a mix of SSARR routings and 8-point Muskingum-Cunge routings.

2.6.1 Mehama

Observed flow of USGS 14183000 minus routed flow of USGS 14181500 (Niagra) adjusted by DAR (1.091). The inflows between Detroit Dam and Big Cliff Dam are included in the Mehama local rather than in the Detroit inflow—that is the purpose of the drainage area ratio.

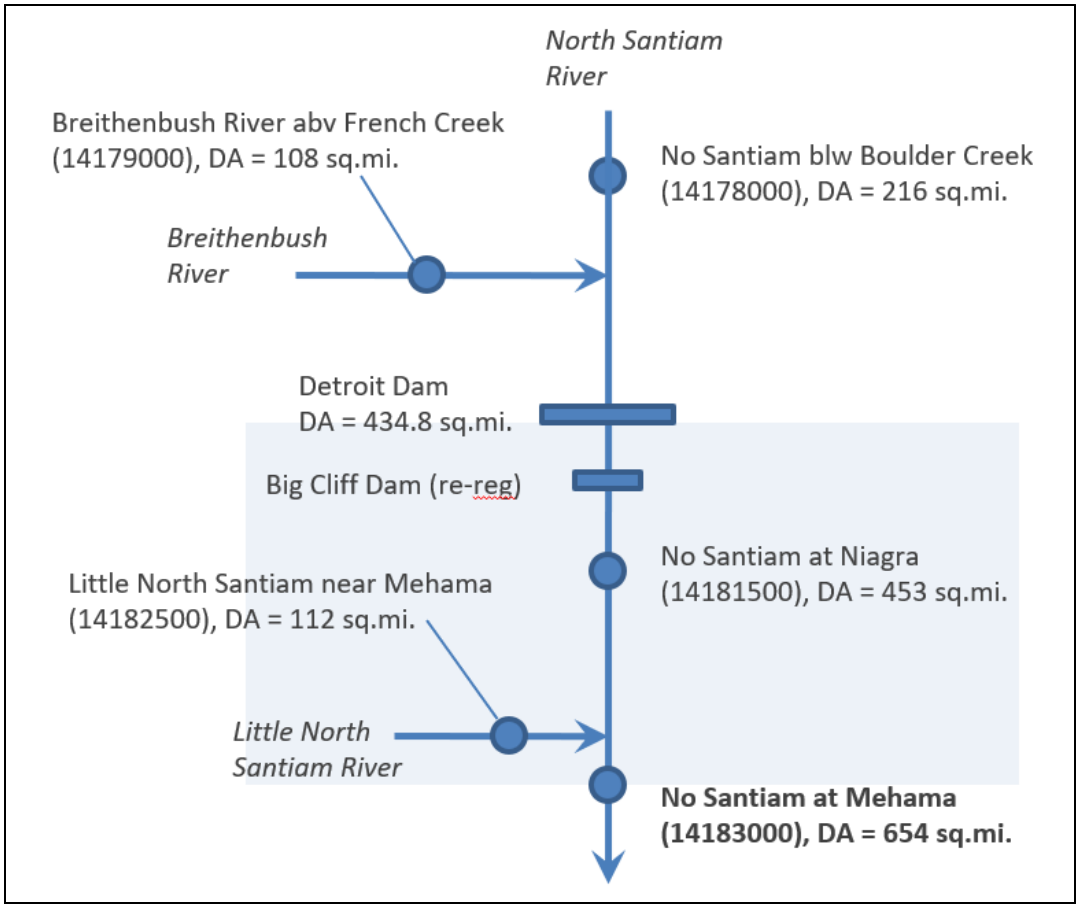


Figure 2-7. Mehama Routing Diagram

2.6.2 Foster

Observed Inflow at Foster from Dataquery minus routed releases of Green Peter from Dataquery.

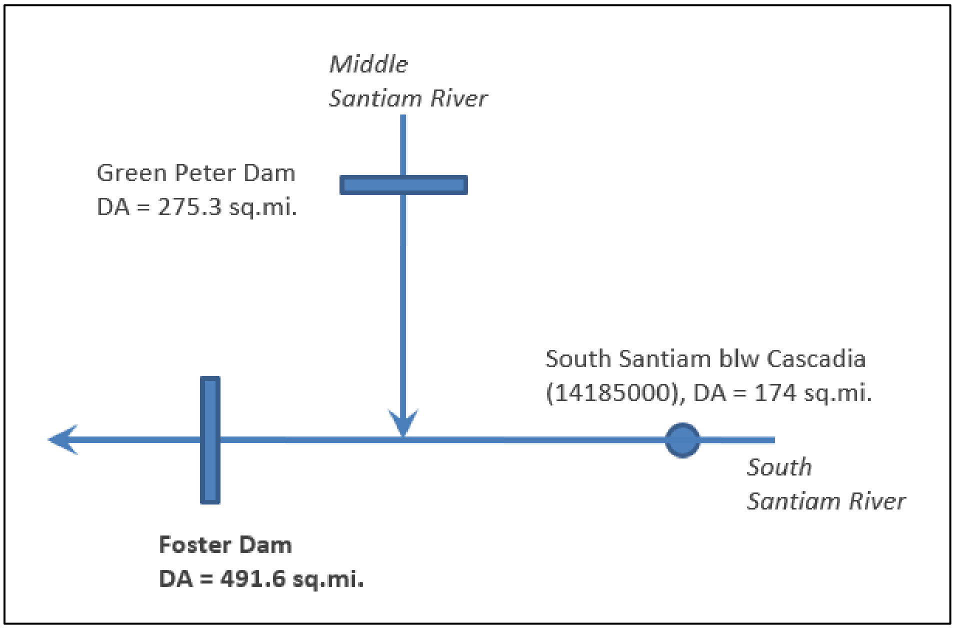


Figure 2-8. Foster Routing Diagram

2.6.3 Waterloo

Observed flow of USGS 14187500 (Waterloo) minus routed flow of USGS 14187200 (So Santiam nr Foster). Adjust this by Drainage Area Ratio of 1.164. Then, USGS 14187000 (Wiley Cr nr Foster).

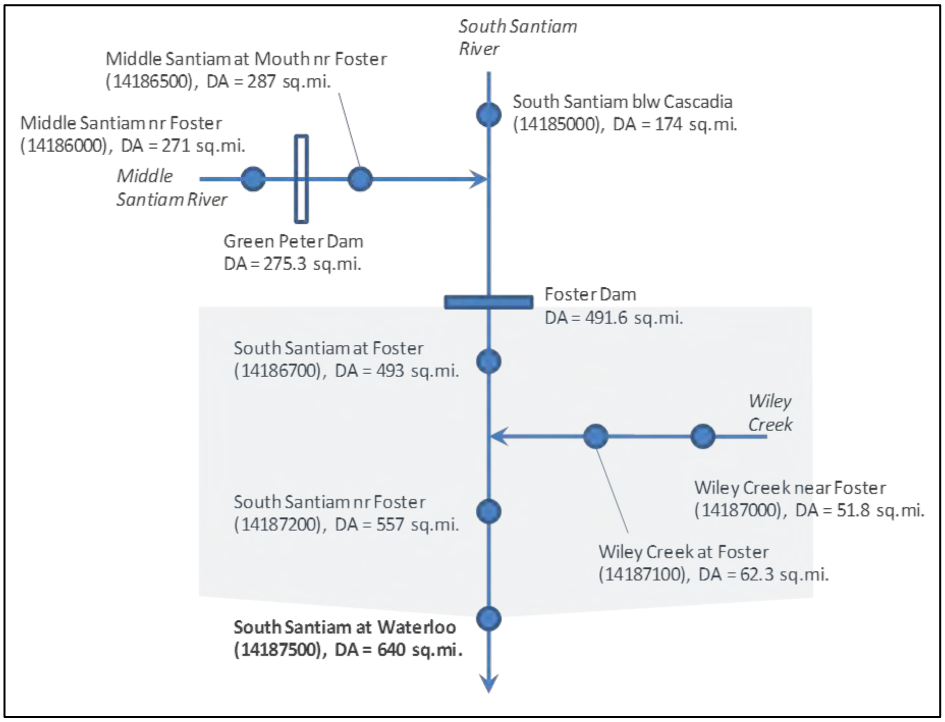


Figure 2-9. Waterloo Routing Diagram

2.6.4 Jefferson

Observed flow of USGS 14189000 (Jefferson) minus combined routed flows of USGS 14187500 (Waterloo) and 14183000 (Mehama)

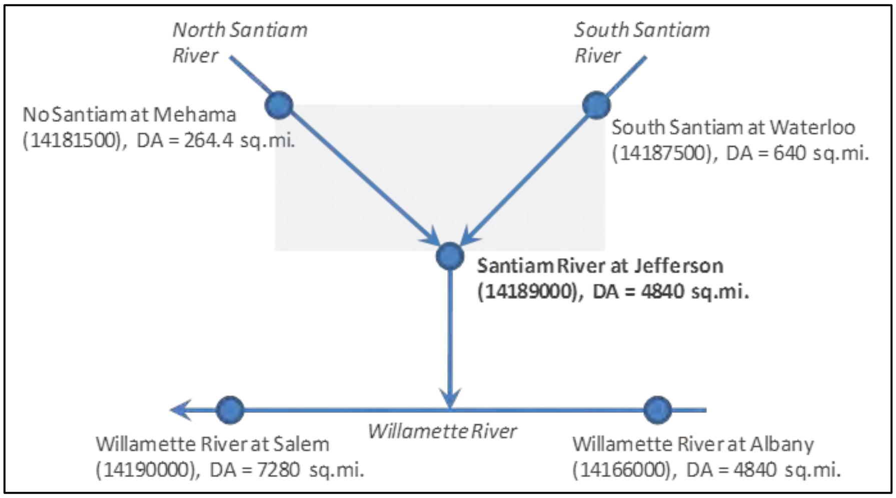


Figure 2-10. Jefferson Routing Diagram

2.6.5 Monroe

Observed flow of USGS 14170000 (Monroe) minus routed flows of USGS 14169000 (Alvadore).

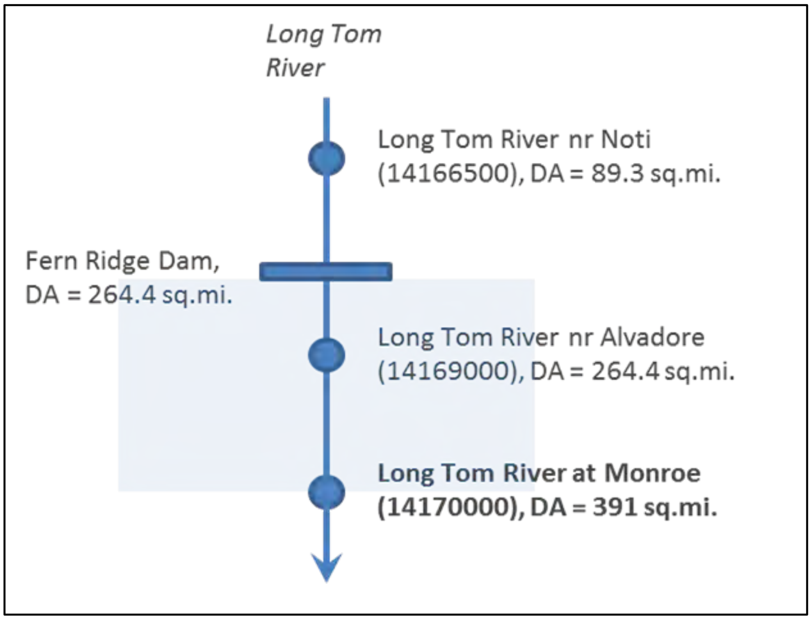


Figure 2-11. Monroe Routing Diagram

2.6.6 Vida

Observed flow of USGS 14162500 (Vida) minus combined routed flow of USGS 14162200 (Blue River at Blue River) and 14159500 (SF McKenzie).

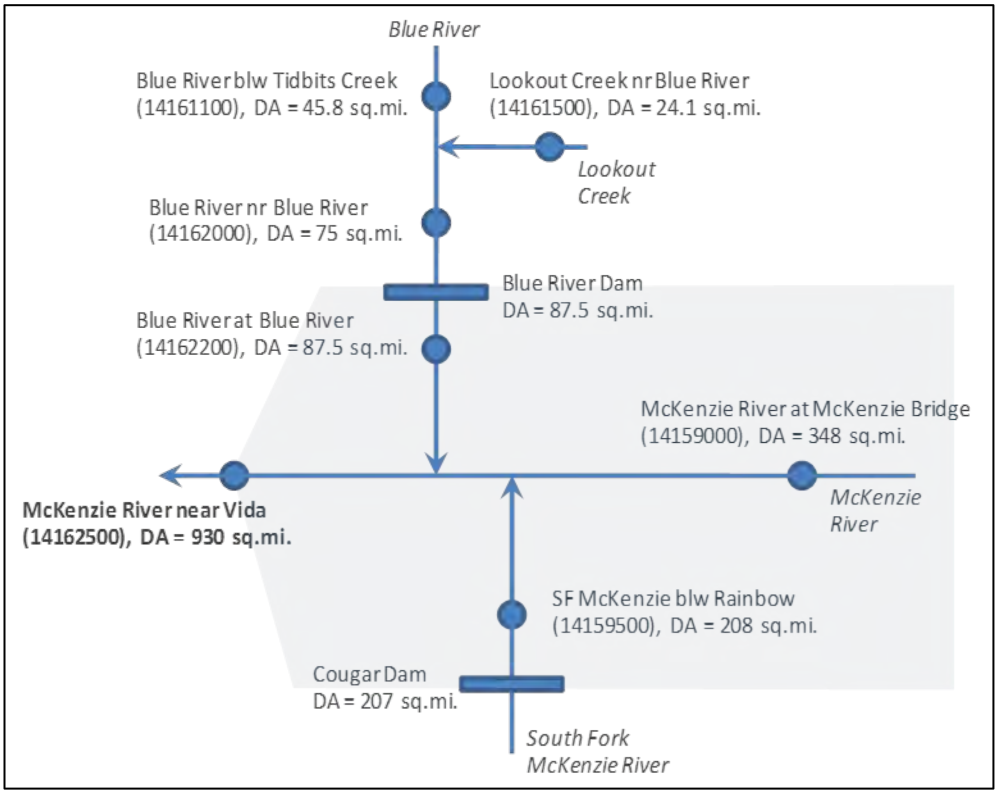


Figure 2-12. Vida Routing Diagram

2.6.7 Lookout Point

Observed inflow at Lookout Point from Dataquery minus routed flows of USGS 14145500 (MF Willamette River Above Salt Creek Near Oakridge).

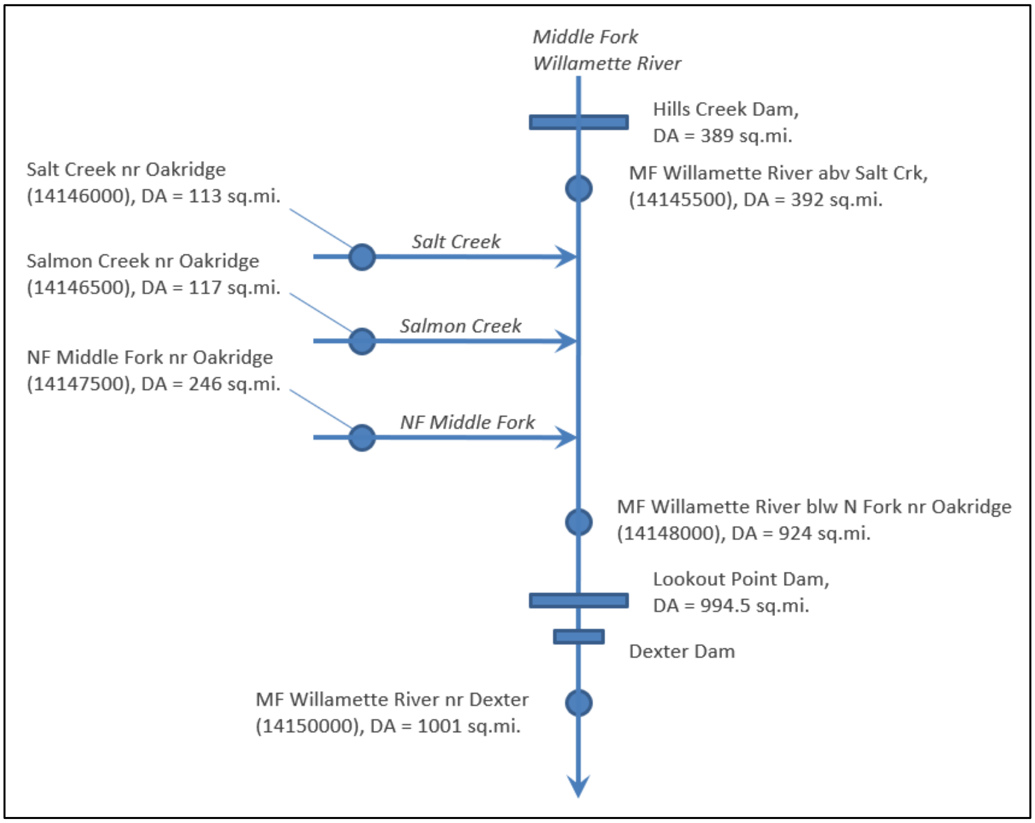


Figure 2-13. Lookout Point Routing Diagram

2.6.8 Jasper

Observed flow of USGS 14152000 (Jasper) minus combined routed flows of USGS 14150000 (Dexter) and 14151000 (Fall Creek). Then, multiply by the drainage area ratio (1.056) to capture area between the dam and the gage.

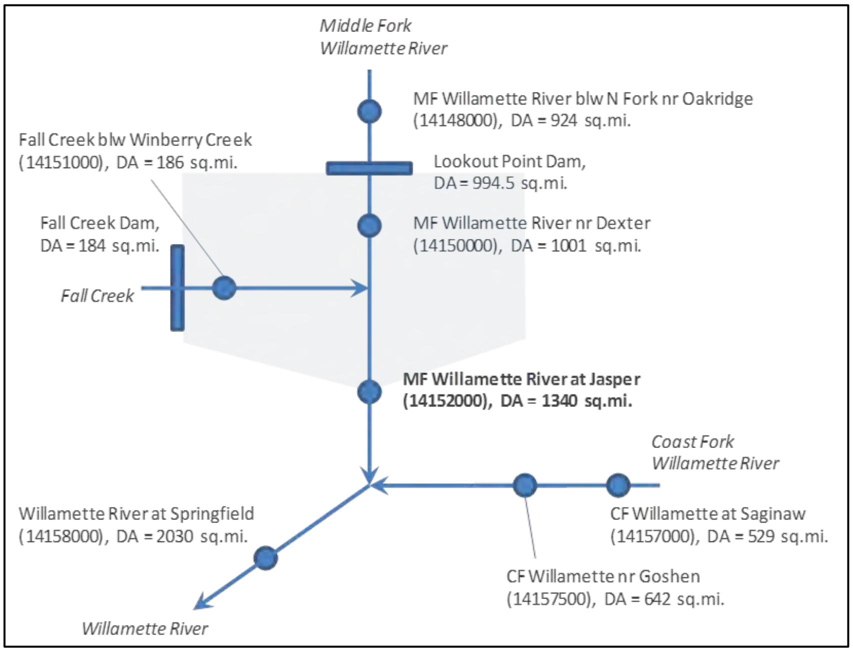


Figure 2-14. Jasper Routing Diagram

2.6.9 Goshen

Observed flow of USGS 14157500 (Goshen) minus combined routed flows of USGS 14153500 (CF Willamette bellow Cottage Grove) and 14155500 (Row River near Cottage Grove).

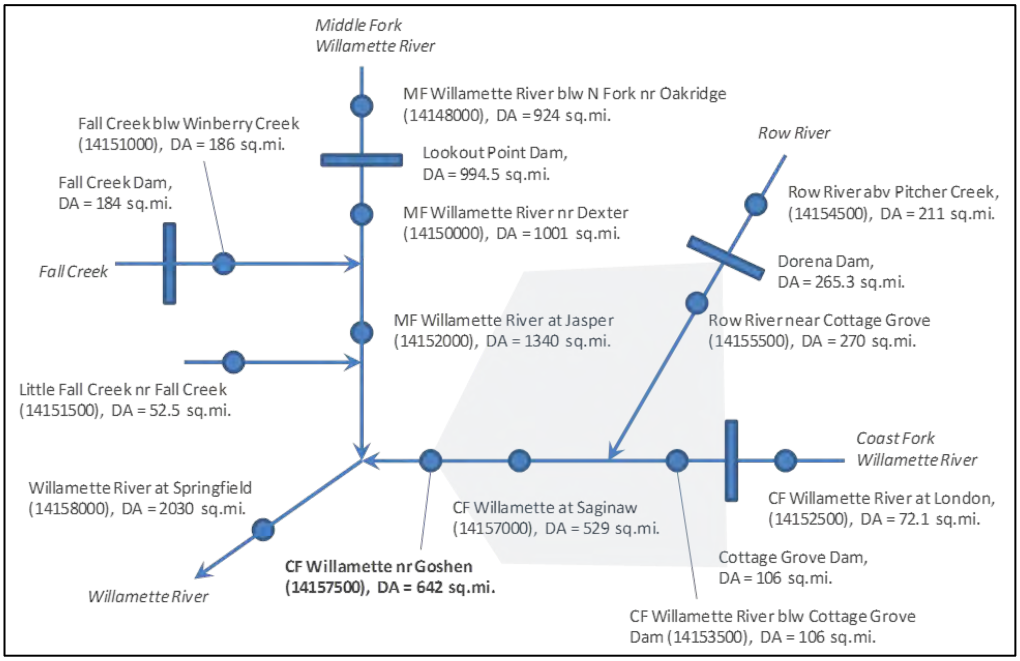


Figure 2-15. Goshen Routing Diagram

2.6.10 Harrisburg

Observed flow of USGS 14166000 (Harrisburg) minus combined routed flows of USGS 14157500 (Goshen), 14152000 (Jasper), and 14162500 (Vida).

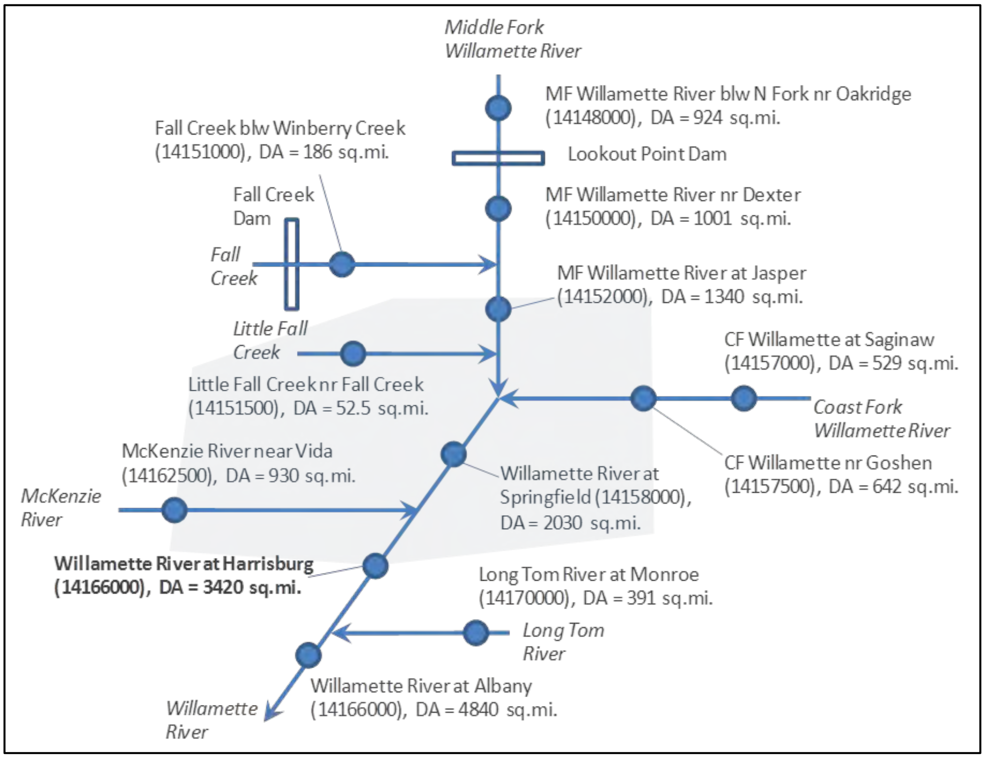


Figure 2-16. Harrisburg Routing Diagram

2.6.11 Albany

Observed flow of USGS 14187500 (Waterloo) minus routed flow of USGS 14187200 (So Santiam nr Foster). Adjust this by Drainage Area Ratio of 1.164. Then, USGS 14187000 (Wiley Cr nr Foster).

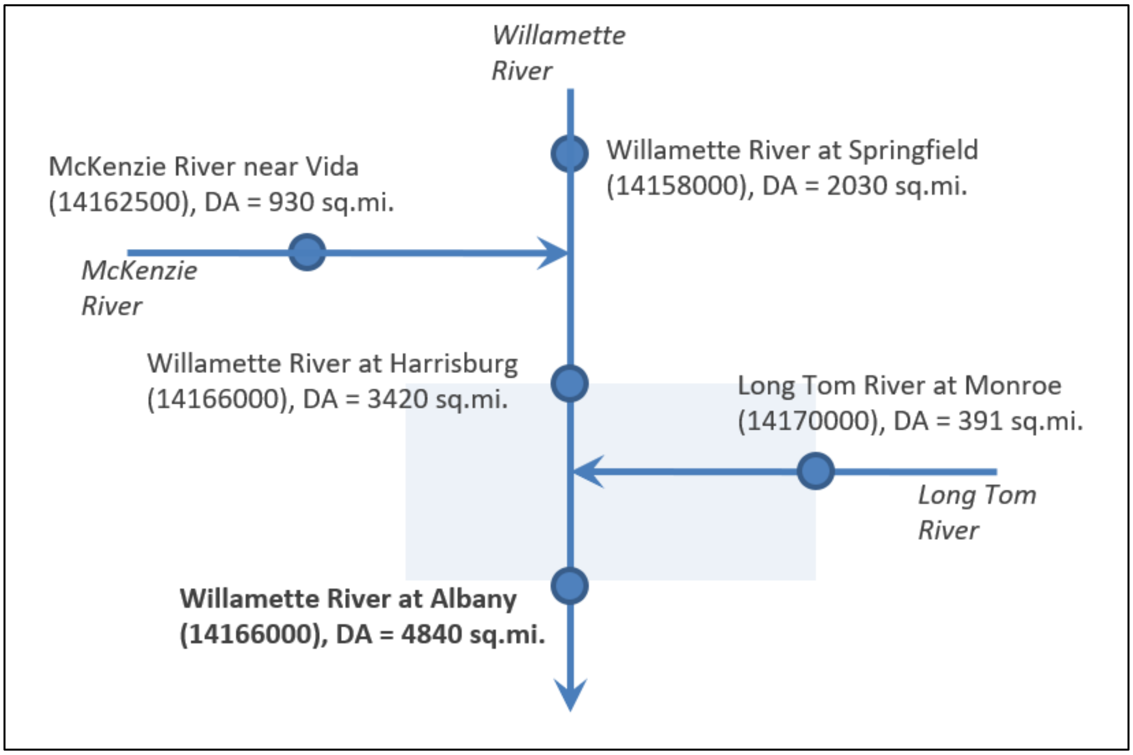


Figure 2-17. Albany Routing Diagram

2.6.12 Salem

Observed Flow at Salem (14191000) minus combined routed flows of Albany (14174000) and Jefferson (14189000).

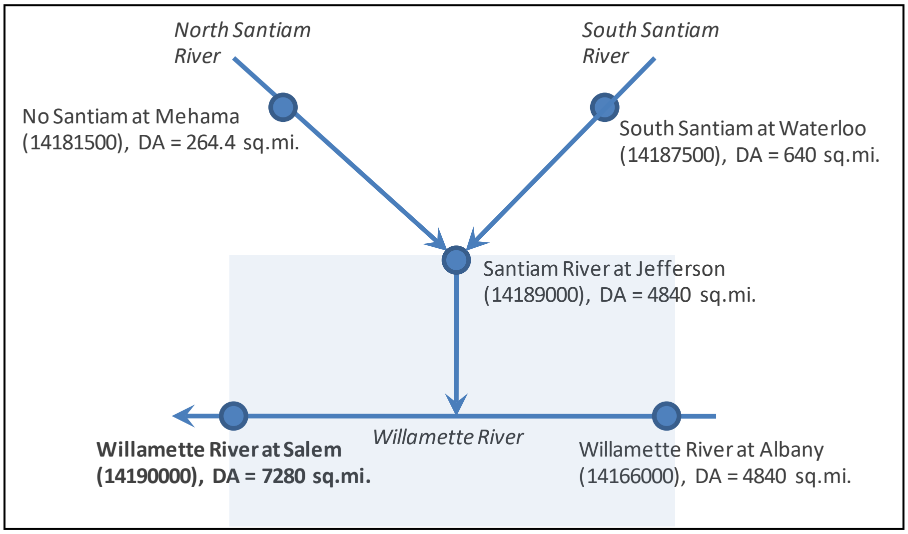


Figure 2-18. Salem Routing Diagram

2.6.13 Oregon City

Local flows at Oregon City help provide a complete dataset for the Willamette basin, but they do not have the same level of confidence as other local flows. There is no reliable rating curve at Oregon City, so gaged streamflow estimates are not available at this location. The 2010 Modified Flow Report calculates local flows at Oregon City by estimating total flows at Oregon City, then subtracting the routed observed flows from Salem. The estimated total flows at Oregon City are a simple sum of 7 components:

1. Observed flows at Salem
2. South Yamhill River (14194150)
3. North Yamhill River (14194300, not presently operated)
4. Molalla River (14200000)
5. Pudding River (14202000)
6. Tualatin River (14207500)
7. Ungaged Streamflow allowance

The 2010 Modified flow method uses the observed flows at Salem twice—once when estimating the total flows at Salem, and once when routing the observed flows from Salem to Willamette Falls using SSARR methods. For the 2009-2019 period, the method proposed by WEST (USACE 2018) is used. This method is very similar in concept to the 2010 Modified Flow method, but it is slightly simpler and easier to apply. The only major difference between the method is the accounting of the North Yamhill River. The 2010 Modified Flow method estimates the North Yamhill flows using a correlation to a gage on the Siletz River, while the

WEST method simply applies a ratio to the South Yamhill River gage. The 2010 Modified Flow report uses a factor of 1.5 applied to the Pudding River to estimate ungaged flows, while the WEST method uses 1.59, which is a fairly minimal difference.

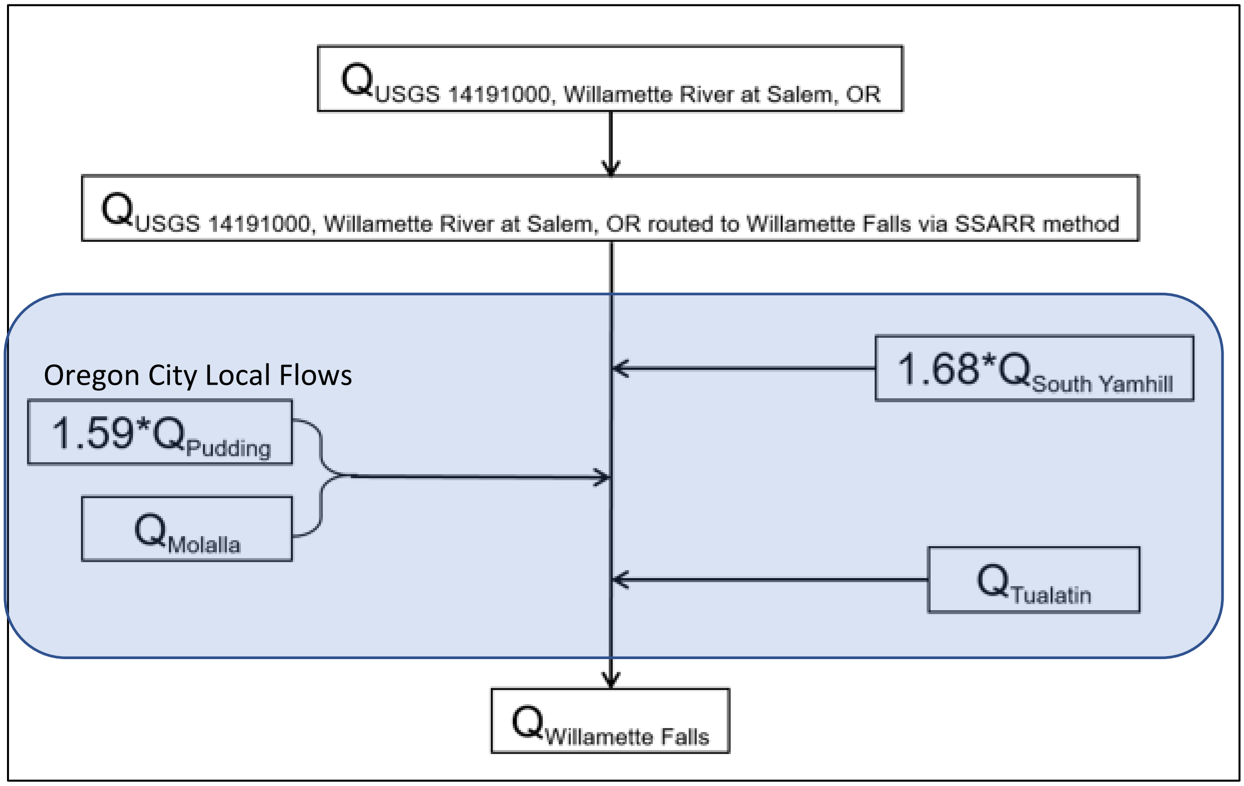


Figure 2-19. Oregon City Routing Diagram

2.7 WATER YEAR 2009 VALIDATION RESULTS

The dataset extension was performed for water years 2009-2019. Water year 2009 has data overlap with the Willamette FIS dataset. The results of the dataset extension were validated to the Willamette FIS existing data to ensure that the new methods were performing adequately.

2.7.1 Reservoir Inflows

The data from Dataquery 2.0 (CWMS) is used in the Willamette EIS for inflow estimates at reservoirs. The following plots compare this data source to the inflows used in the Willamette FIS study, which were Dataquery 1.0 (CDB) data for the winter. For the summer, different locations used different methods in the FIS, as previously discussed. The FIS dataset is shown in blue, and the extended dataset used for the EIS is shown in red.

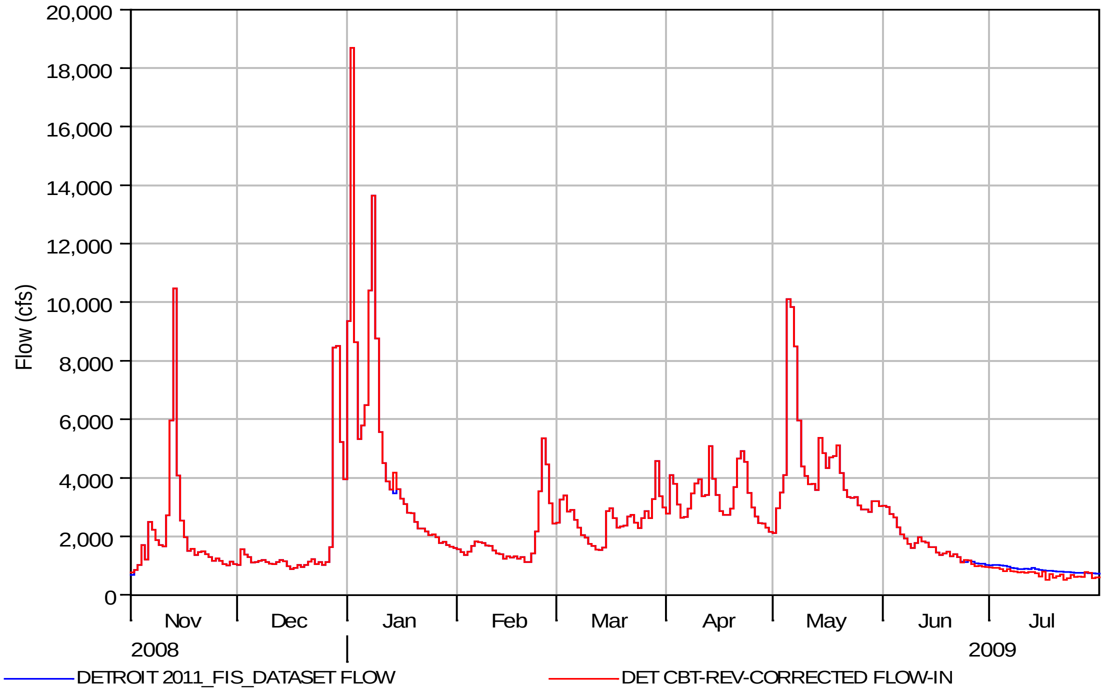


Figure 2-20. Water Year 2009 comparison at Detroit

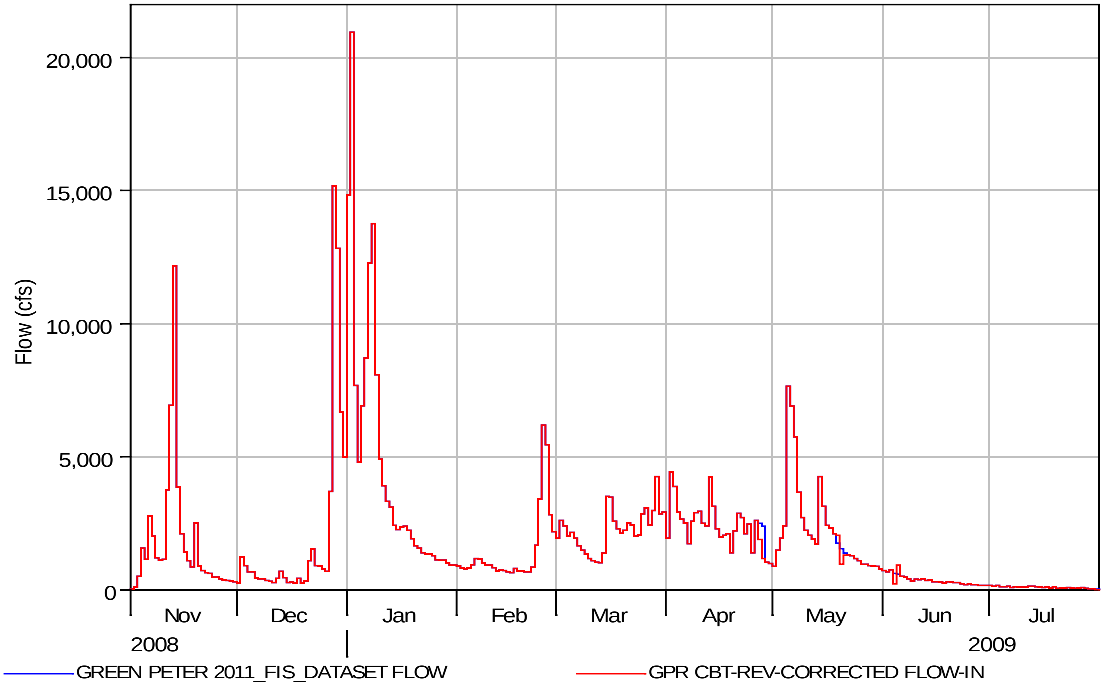


Figure 2-21. Water Year 2009 comparison at Green Peter

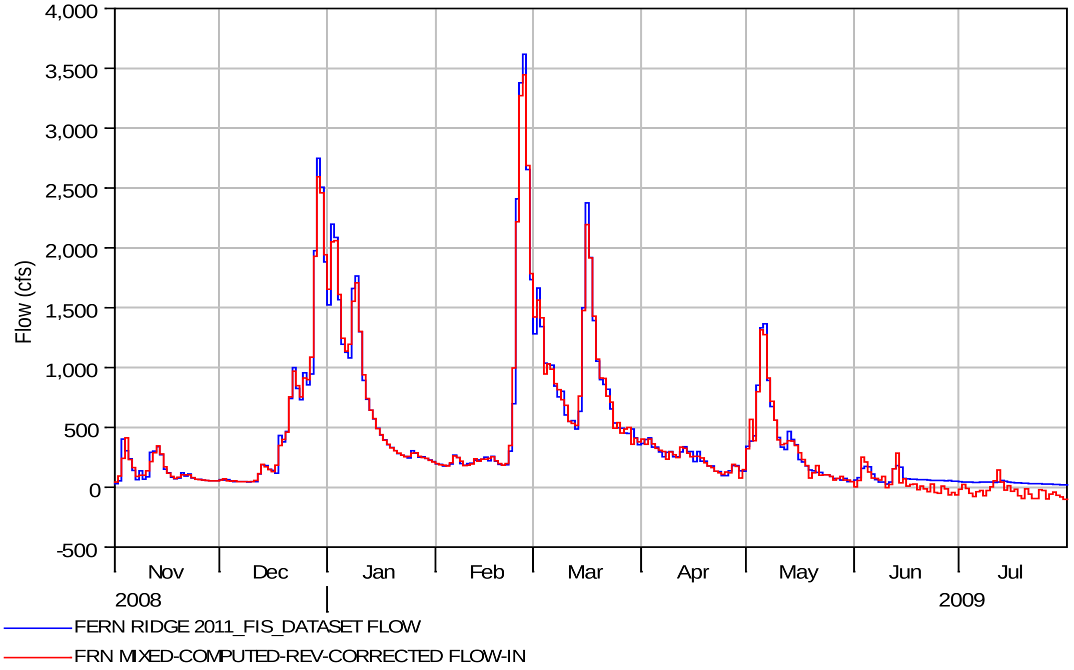


Figure 2-22. Water Year 2009 comparison at Fern Ridge

As previously noted, the FIS uses the upstream flow gage, while the dataset extension approach uses the at-site project inflow estimate.

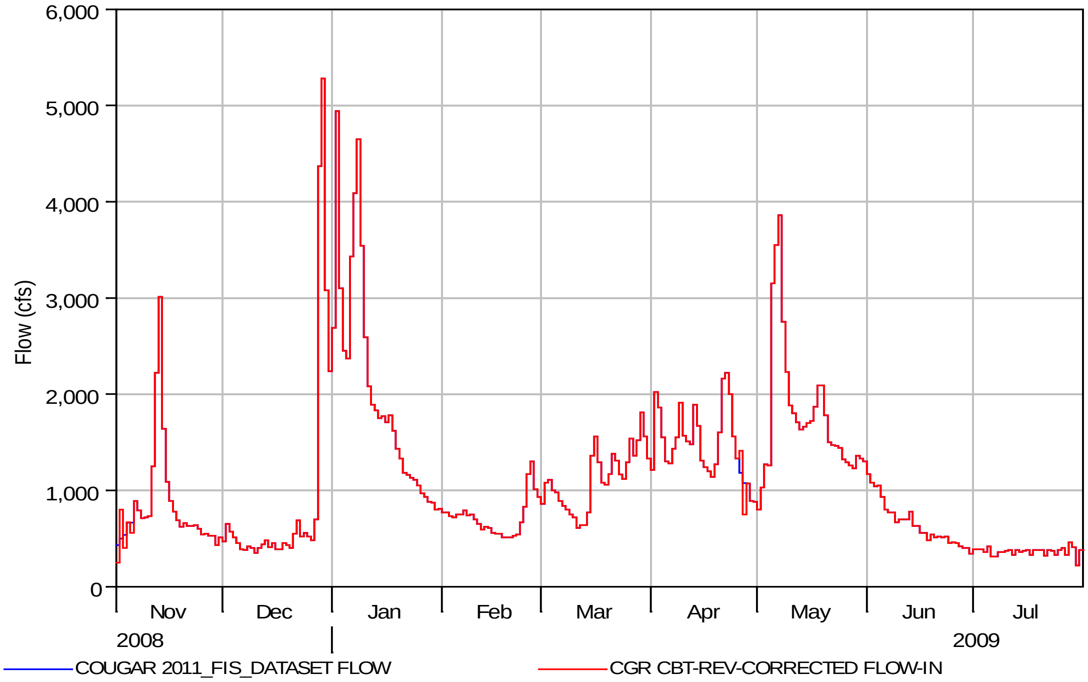


Figure 2-23. Water Year 2009 comparison at Cougar

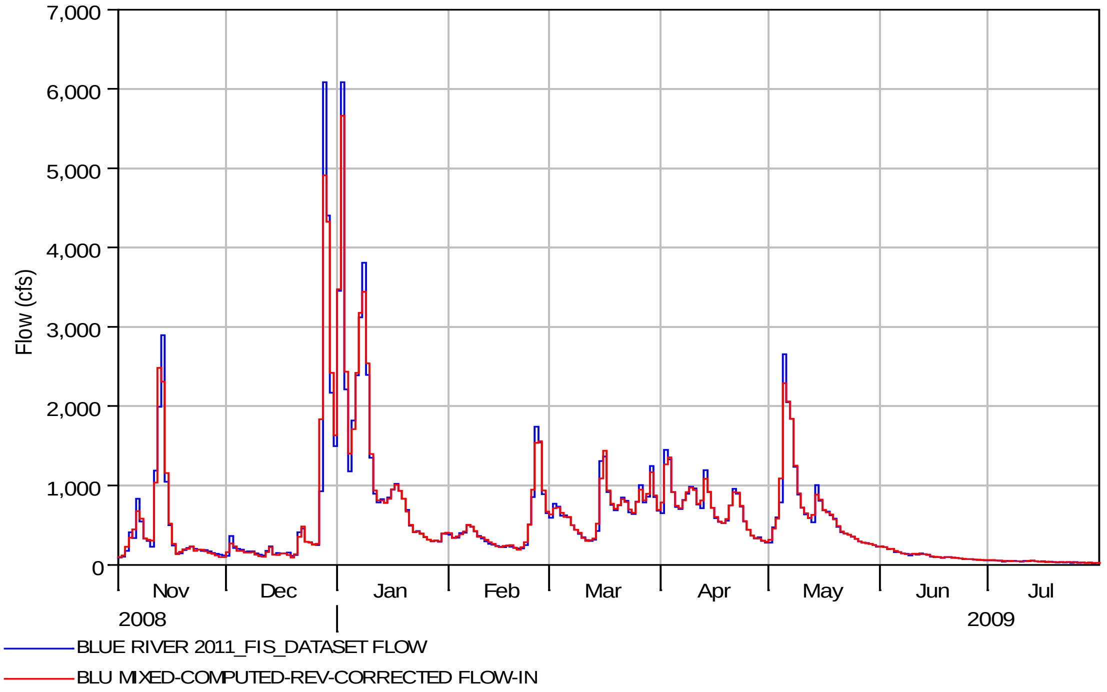


Figure 2-24. Water Year 2009 comparison at Blue River

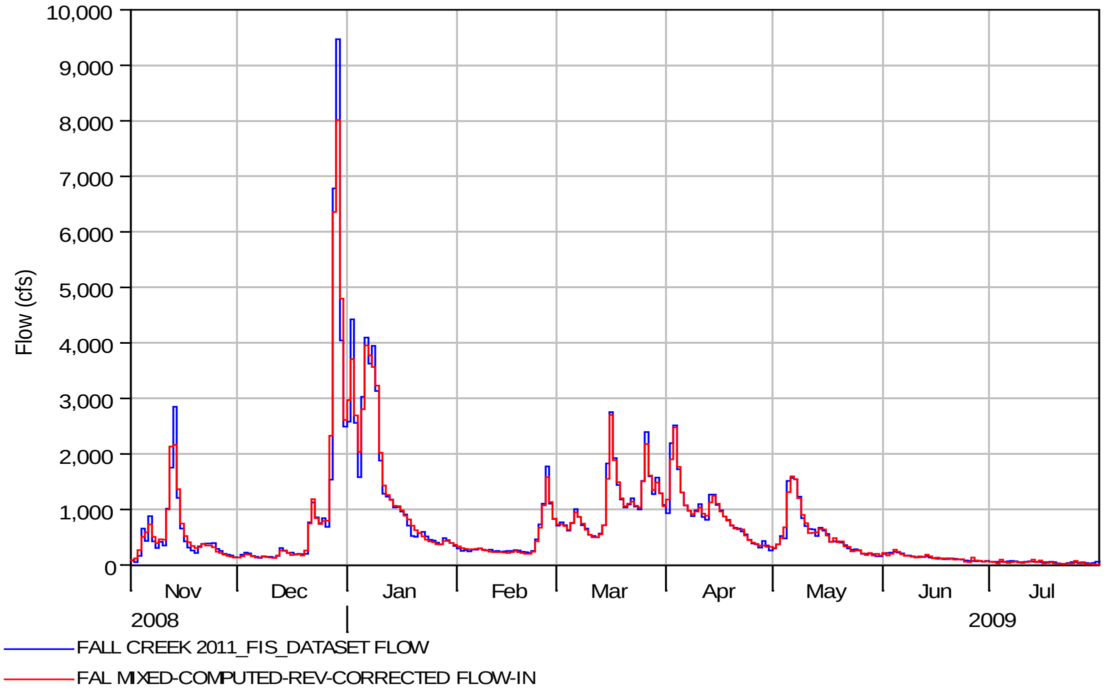


Figure 2-25. Water Year 2009 comparison at Fall Creek

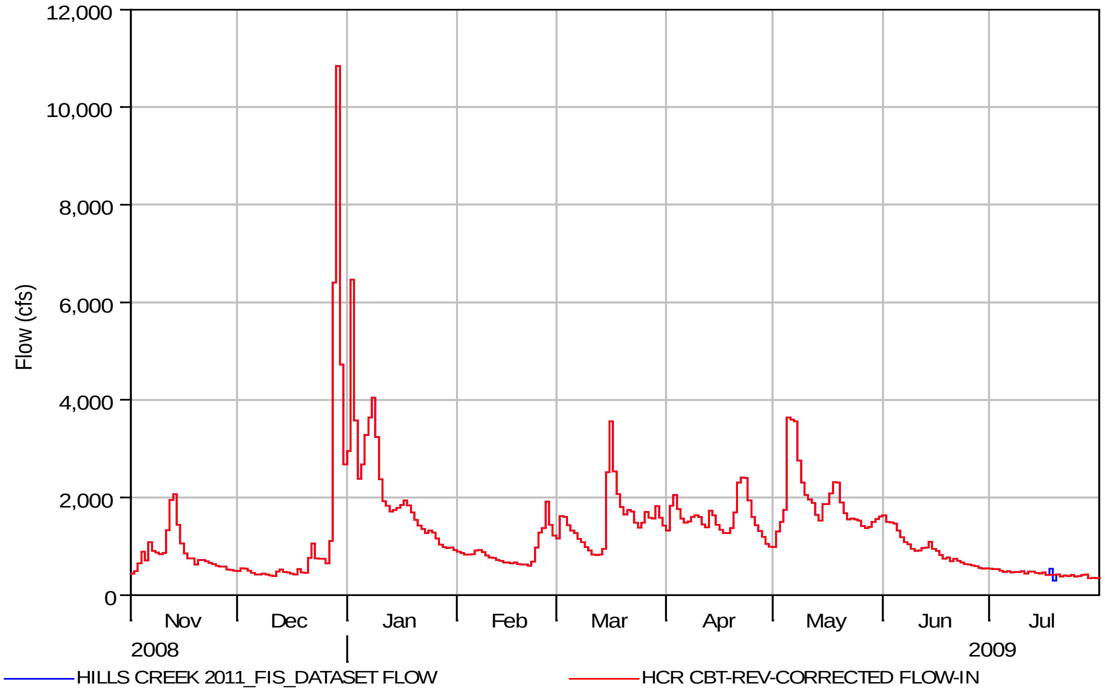


Figure 2-26. Water Year 2009 comparison at Hills Creek

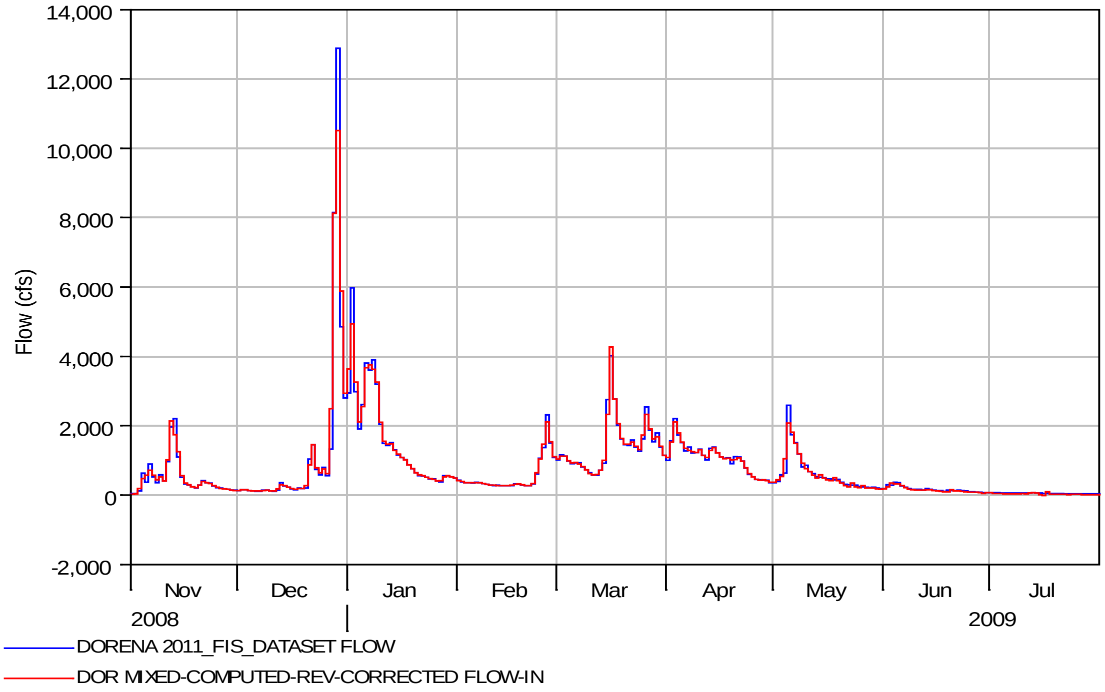


Figure 2-27. Water Year 2009 comparison at Dorena

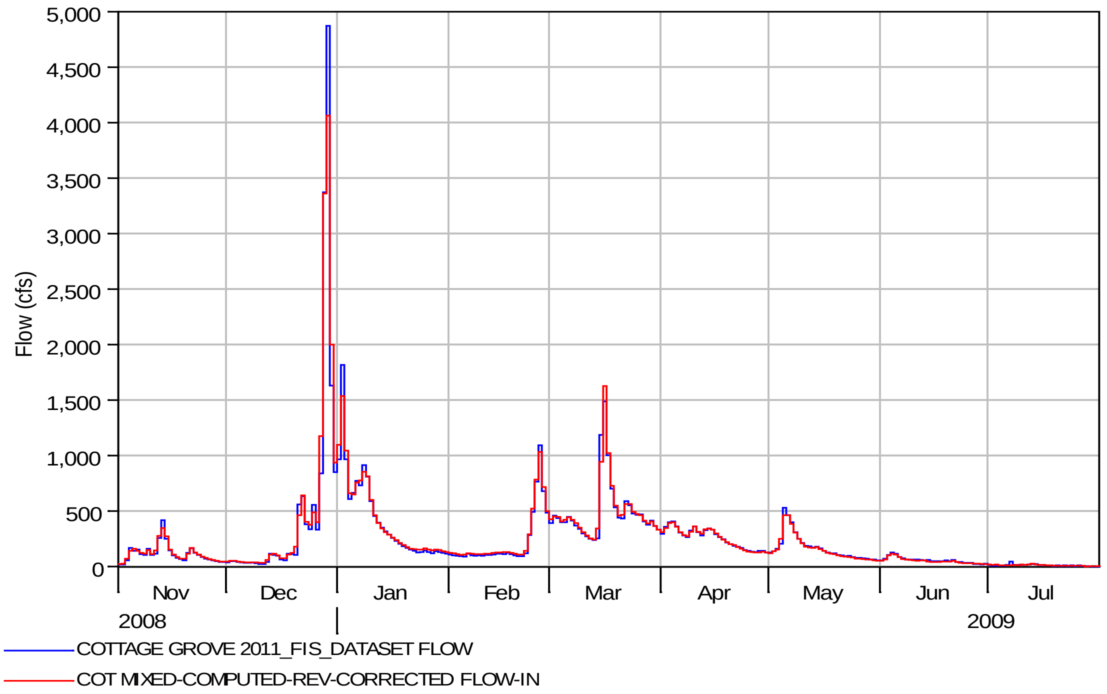


Figure 2-28. Water Year 2009 comparison at Cottage Grove

2.7.2 Local Inflows

The local flows from the Willamette FIS dataset are compared to the results from the flow extension in the below plots. The blue lines are the FIS data, and the green dashed lines are the new computed values.

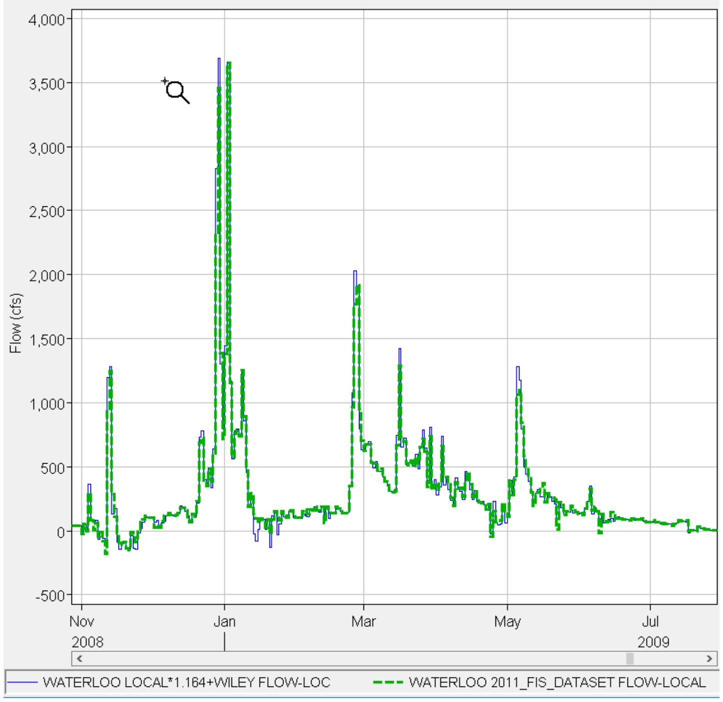


Figure 2-29. Water Year 2009 comparison at Mehama, OR

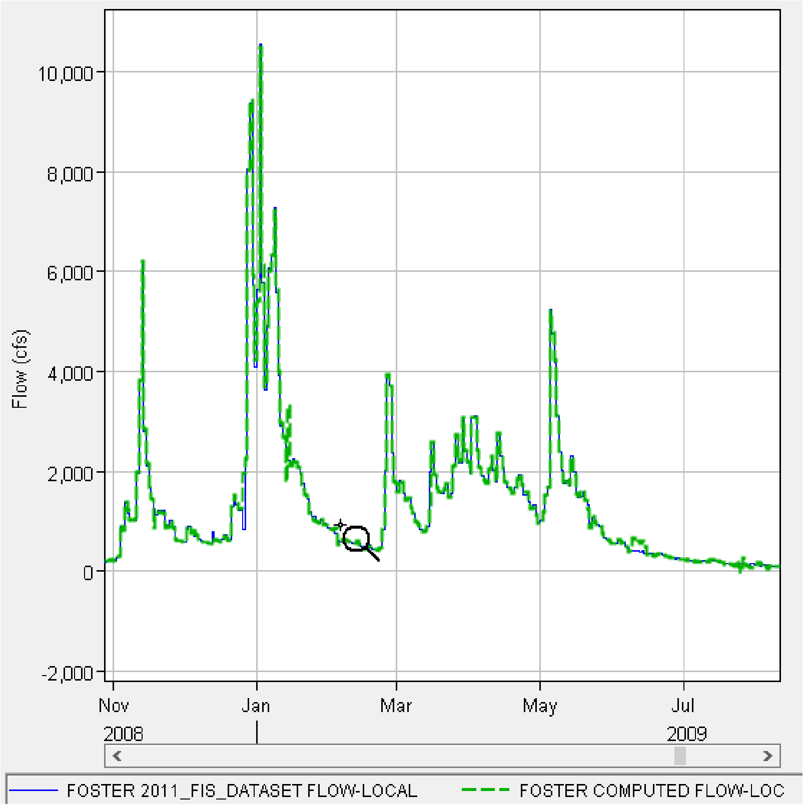


Figure 2-30. Water Year 2009 comparison at for local inflow at Foster

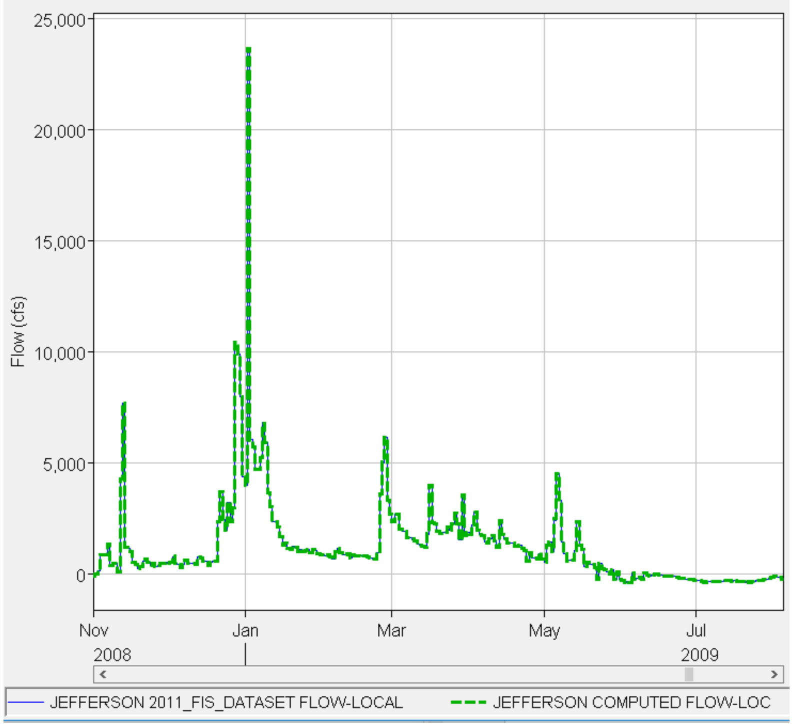


Figure 2-31. Water Year 2009 comparison at Jefferson, OR

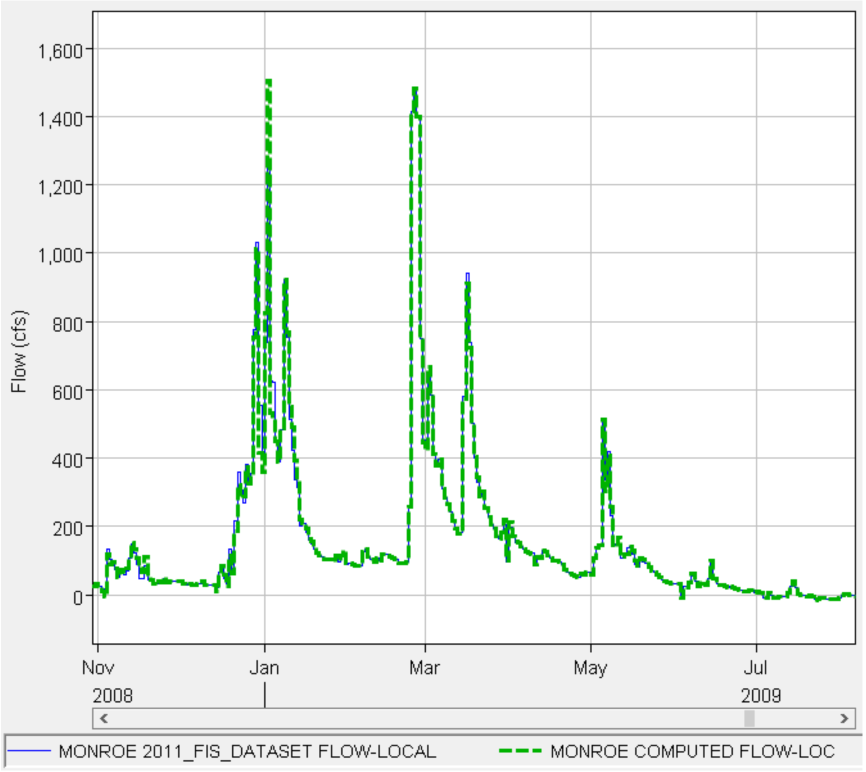


Figure 2-32. Water Year 2009 comparison at Monroe, OR

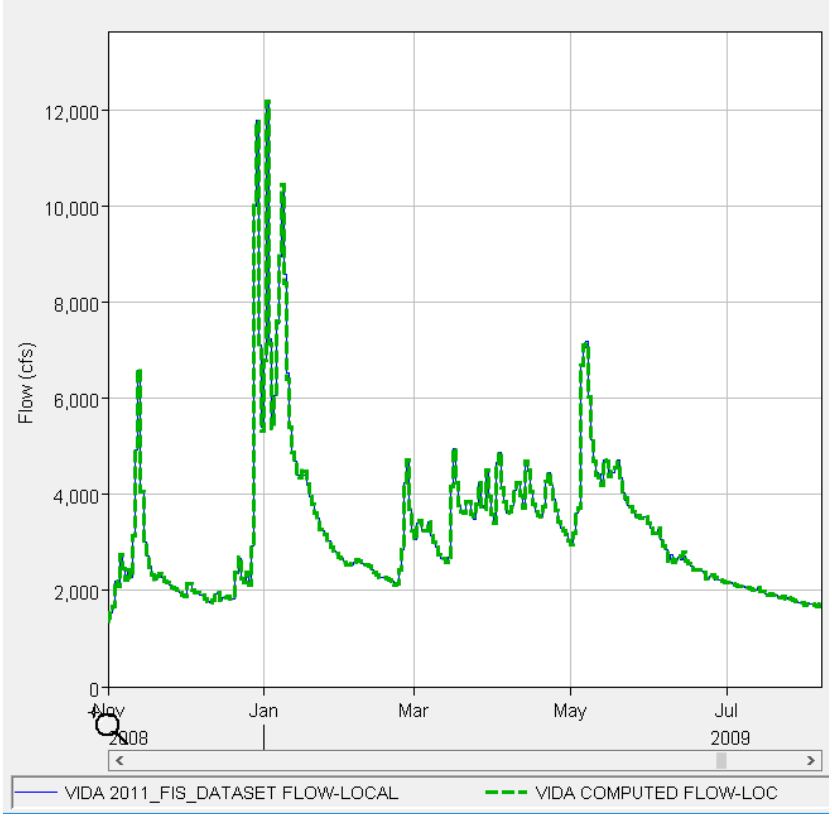


Figure 2-33. Water Year 2009 comparison at Vida, OR

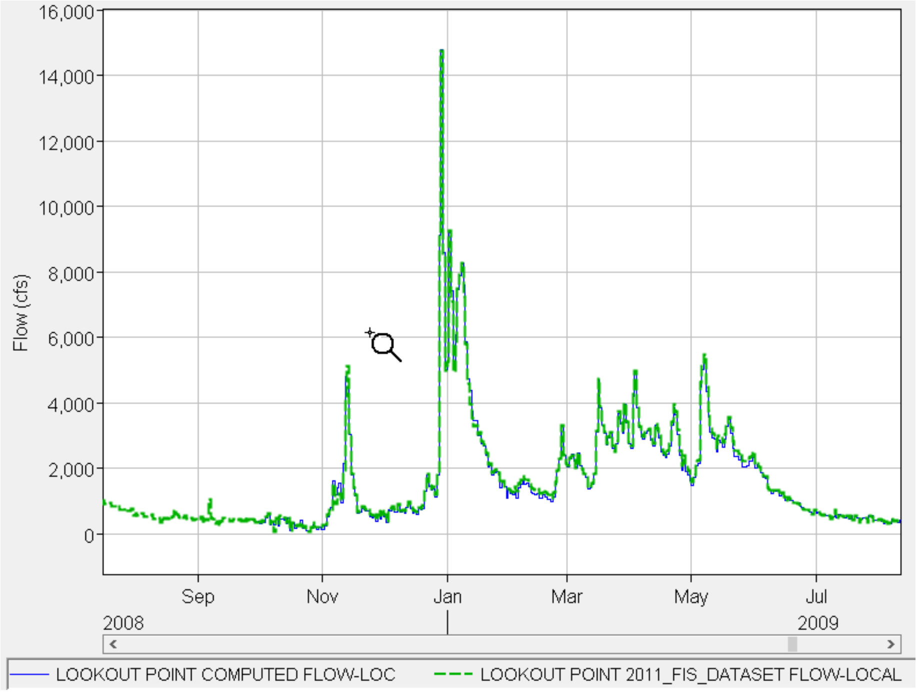


Figure 2-34. Water Year 2009 comparison at for local inflow at Lookout Point

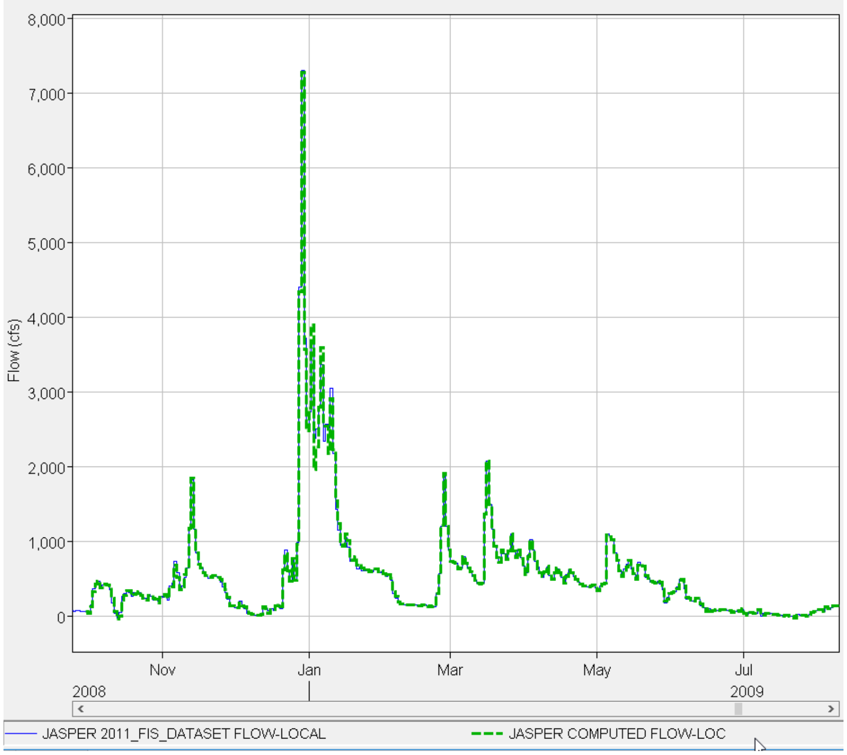


Figure 2-35. Water Year 2009 comparison at Jasper, OR

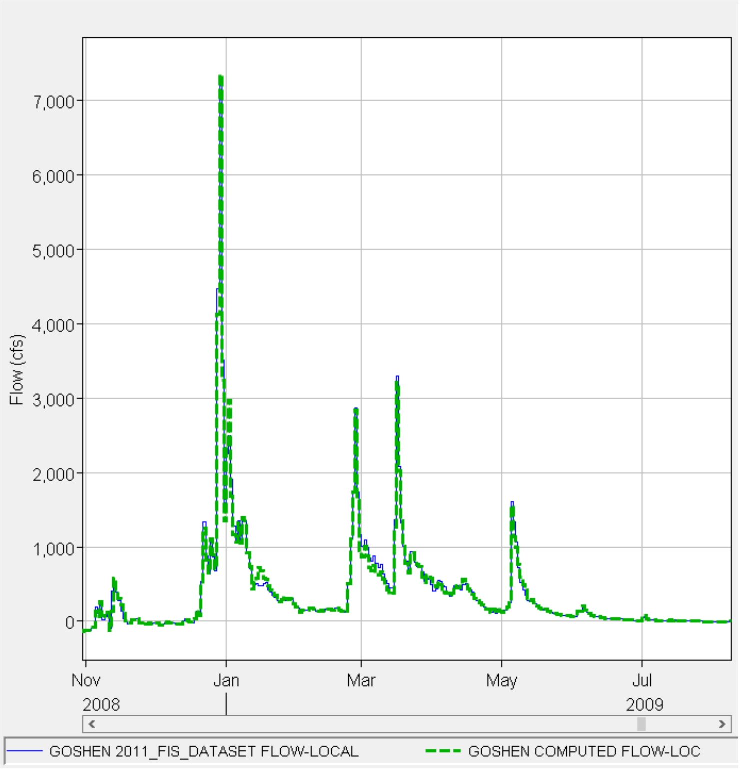


Figure 2-36. Water Year 2009 comparison at Goshen, OR

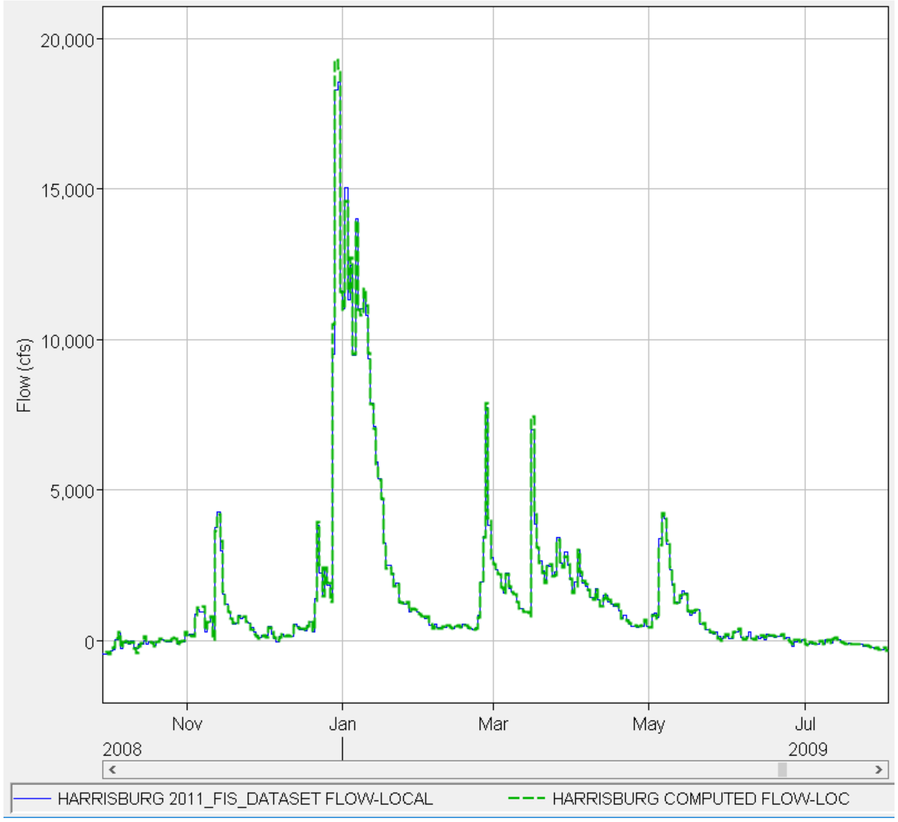


Figure 2-37. Water Year 2009 comparison at Harrisburg, OR

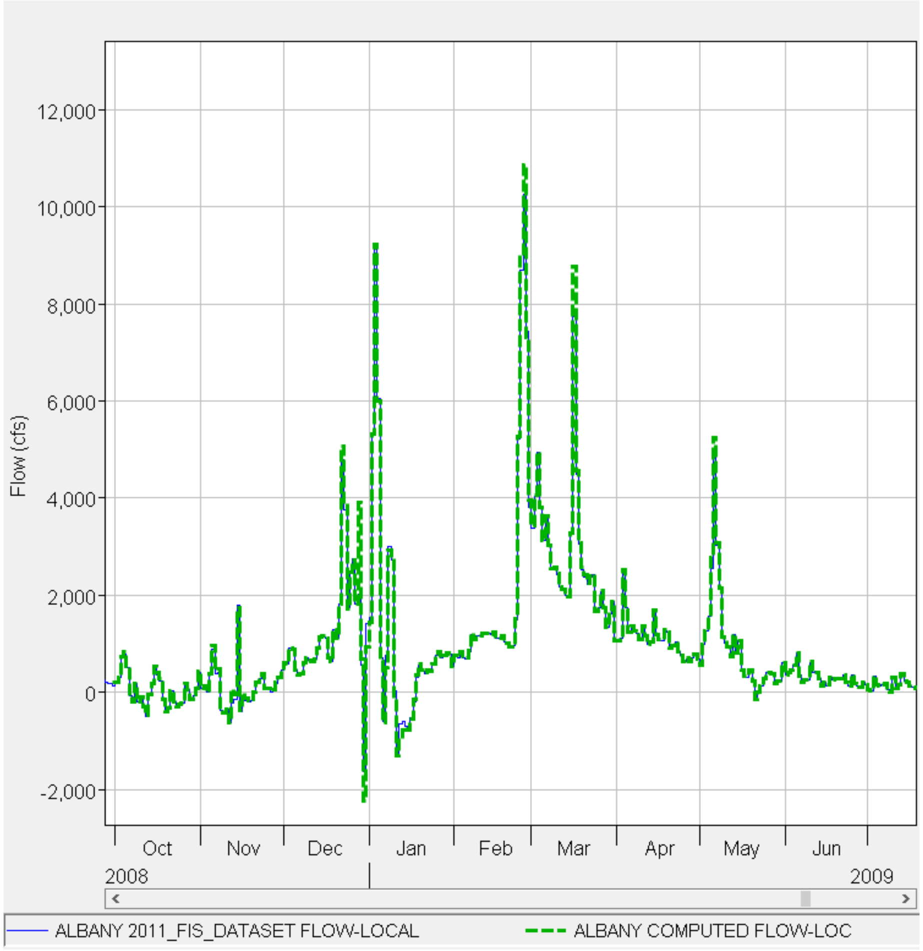


Figure 2-38. Water Year 2009 comparison at Albany, OR

The Salem location shows significant differences between the Willamette FIS and the computed flow extension. It is a bit unclear exactly how the FIS performed the calculation. From the FIS documentation: "Flow at Salem (14191000) and the upstream gages at Albany (14174000) and Jefferson (14189000). Direct locals are available with the gage on the Luckiamute River near Suver (14190500)." It is not clear exactly how the Luckiamute was treated specially in the Willamette FIS. The treatment of the Luckiamute may be one reason for the discrepancy, but another likely reason is the difference in routing parameters. Routing used in FIS dataset is 8-point Muskingum-Cunge. In the EIS ResSim model, SSARR routing is used from Jefferson and from Albany. In the EIS ResSim model, there is no routing from the confluence of the Santiam and Willamette to Salem.

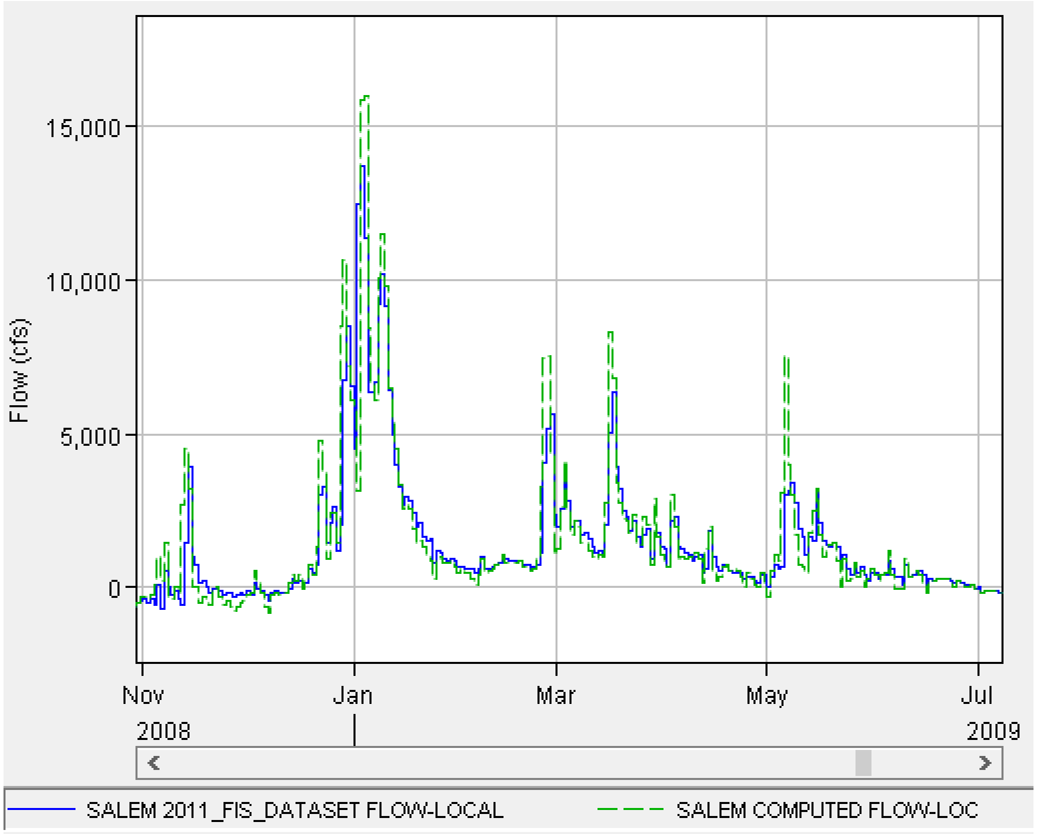


Figure 2-39. Water Year 2009 comparison at Salem, OR

At Oregon City, the comparison is between the 2010 Modified Flow dataset and the 2018 WEST method (USACE 2018). The overlap year is 2008, since the 2010 Modified Flow dataset only extends through Water Year 2008. The two methods are similar with the WEST method providing a slightly higher peak for the winter flood, but slightly lower volumes in the spring.

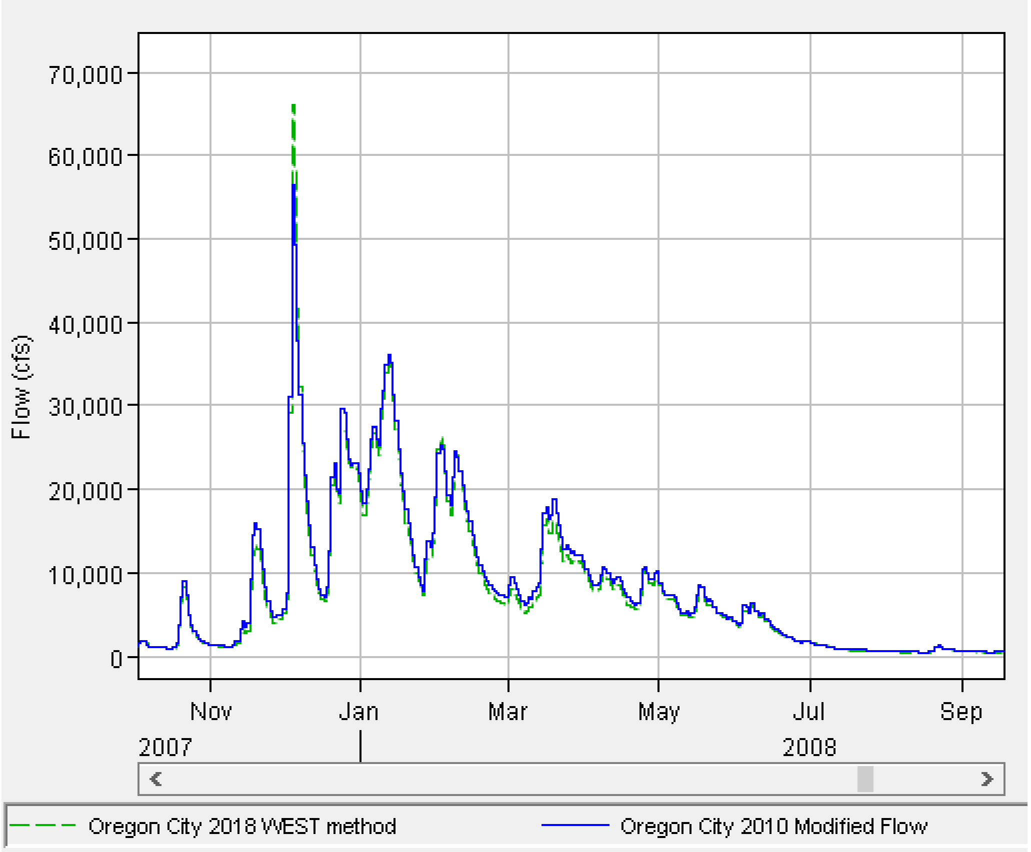


Figure 2-40. Water Year 2009 comparison at Oregon City, OR

3 NO ACTION ALTERNATIVE HEC-RESSIM MODEL

This section documents the HEC-ResSim simulation that is the No Action Alternative (NAA) model for the Willamette Valley System (WVS) Environmental Impact Statement (EIS). The NAA simulation is often referred to as the baseline model because the operation sets used in the simulation model and the operations anticipated for the foreseeable future if no other action is taken.

This section documents the ResSim program inputs such as reach routing, physical limitations of projects, and the specific operation sets and rules at each of the Willamette projects used in the NAA. The modeled alternatives will compare against the NAA to identify changes for the WVS EIS.

3.1 OVERVIEW

The U.S. Army Corps of Engineers (USACE), Portland District owns and operates thirteen multi-purpose projects in the Willamette Valley which are operated as a system, not as independent entities. All projects in the basin share the various functions included in an overall water resources management plan designed to provide flood damage reduction, hydropower generation, irrigation, navigation, recreation, and water quality throughout the basin. This system of reservoirs is modeled in the program HEC-ResSim to define a baseline description of the system operation for the WVS EIS. The identification of a baseline is important when assessing alternatives within the EIS, as it provides a point of reference for comparison and for weighing potential benefits and impacts of those alternatives. This baseline in the WVS EIS is the NAA. The NAA describes conditions and operations that would likely continue for the foreseeable future if no other action were taken.

USACE developed a routing model of the Willamette Basin over many years across several projects, using the Reservoir System Simulation Program HEC-ResSim. This program was created by the USACE technical center Hydrologic Engineering Center – operated within the Institute for Water Resources. The ResSim software simulates reservoir operations as programmed by the user and is a powerful decision support tool for modelers performing reservoir project studies. The USACE office uses the ResSim program for many Willamette Basin studies, adapting the reservoir operation rule sets as needed for each particular study.

The purpose of the NAA simulation is to obtain quantitative results for reservoir operations and regulated streamflow using a formalized set of operational rules for each dam that is used as a proxy for real-time reservoir regulation decisions. Most importantly, the NAA is not meant to reproduce observed data, since the model does not take into account any of the special operations, repairs, or forecasting information available to the water management team in real-time. Furthermore, the model uses a flow dataset spanning more years than the dams have been in operation. The power of the NAA is that the same set of rules are applied without bias for each year of the flow dataset, providing a spread of regulated streamflow and reservoir levels that generally mimics what could have happened.

The results of the NAA simulation are used to analyze:

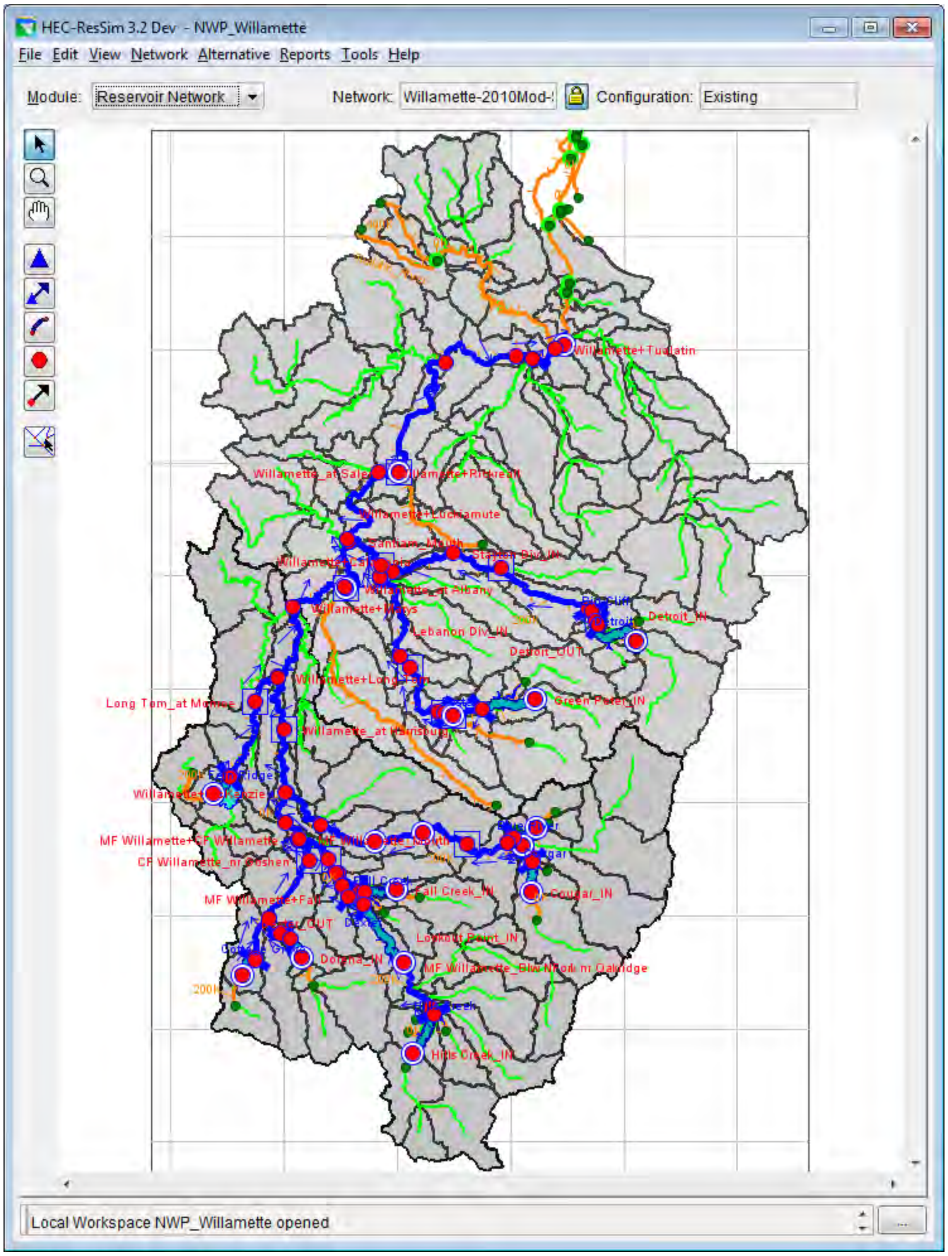
- Reservoir storage/elevations
- Reservoir outlet outflows
- Control point flows

These results are the point of reference for comparison to the simulations of all alternatives. This helps the EIS quantify changes that may result if those alternatives are implemented.

It is also important to understand what the NAA is not. The NAA is not a real-time water management tool, and does not use forecasts such as the availability of snow pack or inflow predictions from the weather service. In water management at the Portland District, each year has a unique conservation plan developed. In low water years, there are drought contingency plans developed with coordinating agencies. The NAA results will differ more from real-time regulation the drier the year, since the program models every day consecutively without the benefit of looking ahead for a whole season.

Figure B-3-1 shows the ResSim network for the WVS EIS NAA, defining the study area. The outlined gray area is the whole Willamette Basin. The major river of the basin is the Willamette

River, which flows northward from the southern end of the basin until it meets the Columbia River at its northern end. The ResSim model includes all thirteen of the Corps dams, all river reaches with Corps dams, and selected control points from the southern end of the basin to Oregon City above Willamette Falls (which is the upper-right most red dot outlined with a white circle). The flow dataset used for the analysis includes all of the surface water from the southern end of the basin to (and including) Oregon City above the Falls. The portion of the Willamette River flowing through Portland, Oregon, is downstream of Willamette Falls and is not included in the reservoir model, and neither is any flow coming into the river downstream of Willamette Falls (e.g., the Clackamas River). The Willamette River below the Falls has a tidal influence from the Columbia River that cannot be modeled in ResSim.



Module: Reservoir Network

Network: Willamette-2010Mod-

Configuration: Existing

Local Workspace NWP_Willamette opened

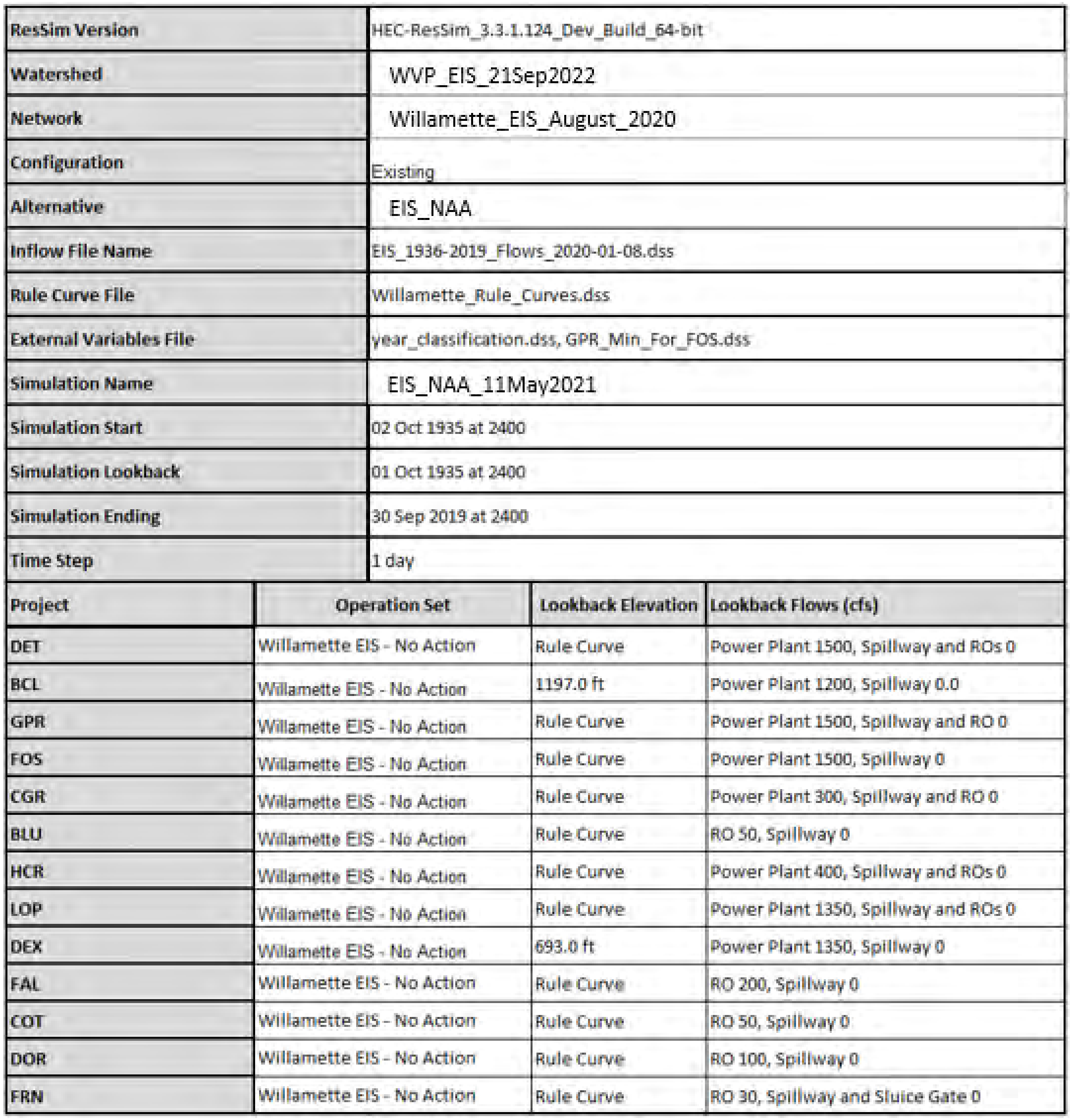
Figure 3-1. ResSim network for the NAA simulation.

In Figure B-3-1, the green and orange lines represent parts of the watershed, which are the fundamental building block of the reservoir model, outlining the streams in the smaller sub-basins (green) and the larger streambeds (orange). The green dots represent the calculation points within the watershed. The reservoir network is superimposed over the watershed. In the network image above, the dark blue lines are the river reaches that are analyzed in simulations, and these are superimposed on the orange streamlines of the watershed. Only the river reaches controlled by the USACE dams in the basin are modeled (shown in dark blue), leaving tributaries outside of any USACE control – for example, the Tualatin River and the Calapooia River – as orange lines. A river reach that isn't modeled means that there are no computation points for flow on that reach, though the inflows from those reaches are still included in the flow dataset. The modeled river reaches are connected at junction points (shown as red dots, which are superimposed over some of the green dots), with the red dots outlined by squares representing the control points. Junctions outlined with a white circle have a local inflow component specified in simulations, and junctions with a square around them indicate a location used for downstream flow control in rules. The thirteen Corps dams are input as reservoirs and shown as light blue, with the smallest reservoirs (Foster and Big Cliff) not visible at the scale of the figure.

Table B-3-1 lists the specifics of the NAA simulation described in this report. The alternative is made of the operation set used for each project, the initial conditions used (the lookback elevations and flows), and the specification of any time series to be used. The simulation is the specified starting and ending dates, the lookback date, the alternative used, and the time step used. Note that the project names in the table below are given by their three letter descriptions used in the Portland District Water Management (DET for Detroit, BCL for Big Cliff, GPR for Green Peter, FOS for Foster, CGR for Cougar, BLU for Blue River, HCR for Hills Creek, LOP for Lookout Point, DEX for Dexter, FAL for Fall Creek, COT for Cottage Grove, DOR for Dorena, and FRN for Fern Ridge).

The lookback flows coincide with the minimum tributary flow of each project for the beginning of October. The outlet for the release corresponds with the release allocation specified in Section 4. Lookback flows and elevations are only used when the simulation is initiated.

Table 3-1. Summary of the Specifics for the NAA Simulation.



ResSim Version	HEC-ResSim_3.3.1.124_Dev_Build_64-bit
Watershed	WVP_EIS_21Sep2022
Network	Willamette_EIS_August_2020
Configuration	Existing
Alternative	EIS_NAA
Inflow File Name	EIS_1936-2019_Flows_2020-01-08.dss
Rule Curve File	Willamette_Rule_Curves.dss
External Variables File	year_classification.dss, GPR_Min_For_FOS.dss
Simulation Name	EIS_NAA_11May2021
Simulation Start	02 Oct 1935 at 2400
Simulation Lookback	01 Oct 1935 at 2400
Simulation Ending	30 Sep 2019 at 2400
Time Step	1 day

Project	**Operation Set**	**Lookback Elevation**	**Lookback Flows (cfs)**
DET	Willamette EIS - No Action	Rule Curve	Power Plant 1500, Spillway and ROs 0
BCL	Willamette EIS - No Action	1197.0 ft	Power Plant 1200, Spillway 0.0
GPR	Willamette EIS - No Action	Rule Curve	Power Plant 1500, Spillway and RO 0
FOS	Willamette EIS - No Action	Rule Curve	Power Plant 1500, Spillway 0
CGR	Willamette EIS - No Action	Rule Curve	Power Plant 300, Spillway and RO 0
BLU	Willamette EIS - No Action	Rule Curve	RO 50, Spillway 0
HCR	Willamette EIS - No Action	Rule Curve	Power Plant 400, Spillway and ROs 0
LOP	Willamette EIS - No Action	Rule Curve	Power Plant 1350, Spillway and ROs 0
DEX	Willamette EIS - No Action	693.0 ft	Power Plant 1350, Spillway 0
FAL	Willamette EIS - No Action	Rule Curve	RO 200, Spillway 0
COT	Willamette EIS - No Action	Rule Curve	RO 50, Spillway 0
DOR	Willamette EIS - No Action	Rule Curve	RO 100, Spillway 0
FRN	Willamette EIS - No Action	Rule Curve	RO 30, Spillway and Sluice Gate 0

3.2 THE PERIOD OF RECORD IN THE RESSIM ANALYSIS

This section provides a brief discussion of the flow dataset as used in the model simulation and a discussion of the water year types in this Period of Record (POR), which are designations for wet through dry years made based on spring storage.

3.2.1 Reservoir Inflows

The hydrologic inflow dataset used in the WVS EIS adjusts historic inflows spanning 1935 - 2019 to reflect 2008 levels of depletion. A detailed description of the development of the inflow dataset is in Section Inflow Dataset.

3.2.2 Water Year Classification

The POR flows span 84 years, which encompass a variety of wet and dry water years. The 2008 BiOp designates four water year classifications that are used to determine the mainstem Willamette minimum flow targets for April through October. The four classifications are Abundant, Adequate, Insufficient, and Deficit. The Insufficient and Deficit water years have reduced minimum flow targets at Salem and Albany, with the Deficit year targets less than the Insufficient year targets during some, but not all, months. Table B-3-2 lists these mainstem targets by water year type.

Table 3-2. Mainstem BiOp Flow Targets for Salem and Albany.

Calendar Date	Albany Targets by Year Type (cfs)			Salem Targets by Year Type (cfs)		
	Abundant &Adequate	Insufficient	Deficit	Abundant &Adequate	Insufficient	Deficit
01 - 30 April	--	--	--	17,800	Salem targets are linearly interpolated between Adequate and Deficit targets based on Water Year designation.	15,000
01 -31 May	--	--	--	15,000		15,000
01 - 15 June	4,500	4,500	4,000	13,000		11,000
16 - 30 June	4,500	4,500	4,000	8,700		5,500
01 - 31 July	4,500	4,500	4,000	6,000		5,000
01 - 15 August	5,000	4,500	4,000	6,000		5,000
16 - 31 August	5,000	4,500	4,000	6,500		5,000
01 - 30 September	5,000	4,500	4,000	7,000		5,000
01 - 31 October	5,000	4,500	4,000	7,000		5,000

The year classification is based on the storage volume targets of the federal projects in the Willamette Basin for each day of May 10 through 20 of any year. The storage volume is determined by summing the conservation pool storage in all the reservoirs (not counting the reregulating dams of Big Cliff and Dexter). The peak composite system conservation storage occurring May 10 - 20 of each year is used to classify the water year type. Table B-3-3 has the water years type definitions and Figure B-3-2 shows how those definitions fit within the water management year in the Willamette basin. The maximum useable conservation storage is 1.59 million acre-feet (MAF).

Table 3-3. Definition of Water Year Types in the Willamette Basin.

Water Year Type	Total Willamette Conservation Storage between 10-20 May
Abundant	Greater than 1.48 Maf
Adequate	Between 1.20 and 1.48 Maf
Insufficient	Between 0.90 and 1.20 Maf
Deficit	Less than 0.90 Maf

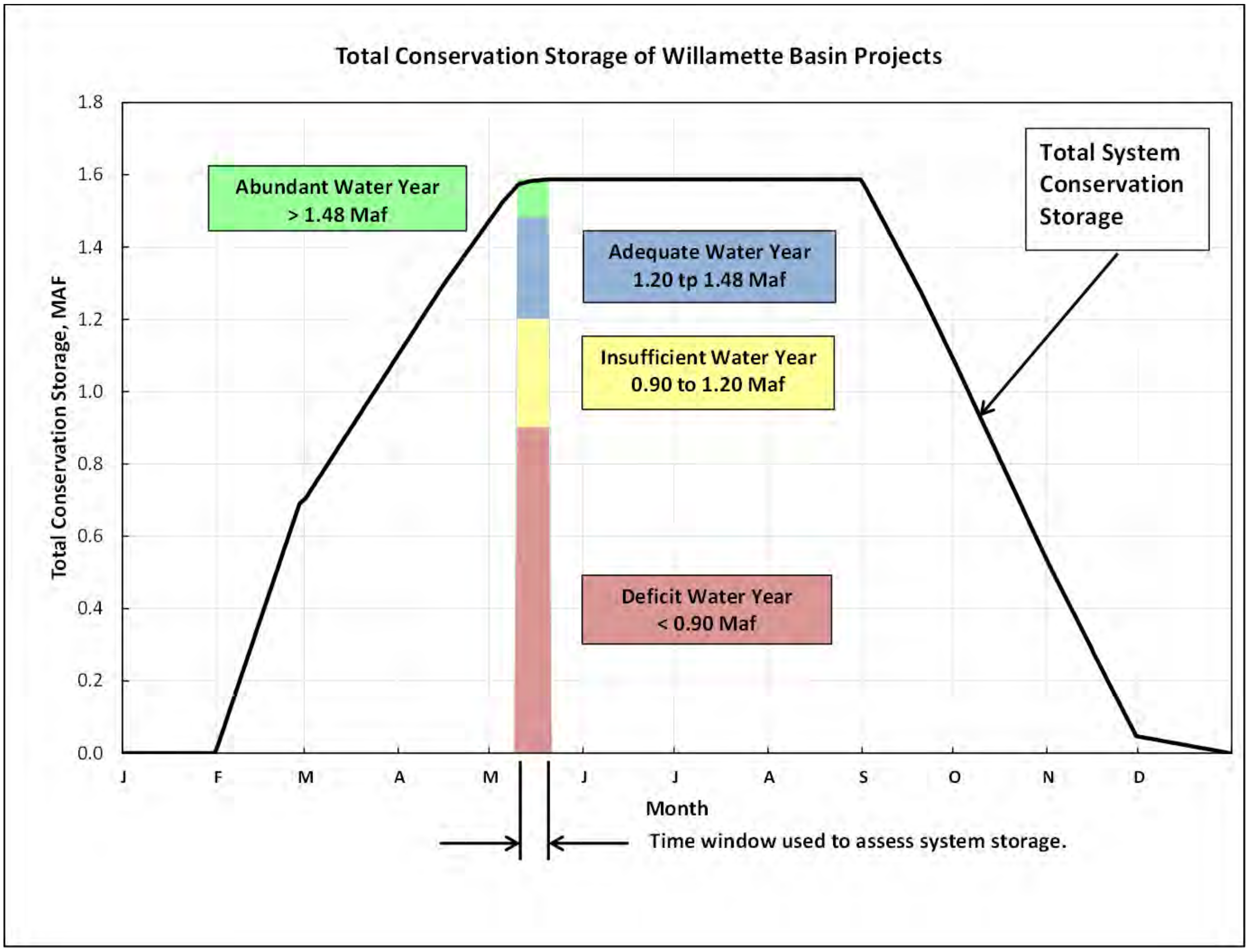


Figure 3-2. Total conservation storage in Willamette Basin USACE projects, by date, and graphical water year type definition.

The year types for the POR were determined by running a preliminary (first pass) simulation with water year designations used in the Willamette Basin Review (USACE, 2019) NAA and operations designated for the WVS EIS and then adjusting water year designations based on that simulation’s maximum storage for the period May 10-20.

A simulation was run with all projects using Salem minimum flow targets for the Abundant/Adequate year, and storage volumes for May 10-20 were calculated for each year.

These water year classifications are shown in Table B-3-4. The designation is only of use during the period of April through October and is not used during the fall and winter. The designation is by calendar year, not water year. October’s flow targets are based on the previous May storage volumes. The water year classifications shown in Table B-3-4 were entered into DSS as a time series and used in the model as an external variable for Salem and Albany minimum flow rules.

Table 3-4. Water Year Types for 1936 – 2019 and Maximum Conservation Storage Value for May 10-20, in Millions of Acre-Feet (Maf).

Year	Water Year	Storage	Year	Water Year	Storage	Year	Water Year	Storage
	Type Category	Maf		Type Category	Maf		Type Category	Maf
1936	Abundant	1.58	**1964**	Adequate	1.38	**1992**	Insufficient	0.96
1937	Abundant	1.59	**1965**	Insufficient	1.13	**1993**	Abundant	1.59
1938	Abundant	1.58	**1966**	Adequate	1.45	**1994**	Insufficient	0.93
1939	Adequate	1.35	**1967**	Insufficient	1.13	**1995**	Abundant	1.58
1940	Adequate	1.31	**1968**	Insufficient	0.95	**1996**	Abundant	1.59
1941	Deficit	0.36	**1969**	Abundant	1.58	**1997**	Abundant	1.58
1942	Deficit	0.74	**1970**	Adequate	1.40	**1998**	Adequate	1.44
1943	Abundant	1.58	**1971**	Abundant	1.59	**1999**	Abundant	1.59
1944	Insufficient	1.06	**1972**	Abundant	1.59	**2000**	Abundant	1.59
1945	Abundant	1.59	**1973**	Deficit	0.72	**2001**	Insufficient	0.92
1946	Adequate	1.47	**1974**	Abundant	1.58	**2002**	Adequate	1.44
1947	Adequate	1.40	**1975**	Abundant	1.58	**2003**	Abundant	1.57
1948	Abundant	1.59	**1976**	Abundant	1.58	**2004**	Adequate	1.28
1949	Abundant	1.57	**1977**	Deficit	0.89	**2005**	Adequate	1.22
1950	Abundant	1.59	**1978**	Insufficient	0.96	**2006**	Adequate	1.40
1951	Abundant	1.57	**1979**	Abundant	1.58	**2007**	Adequate	1.42
1952	Abundant	1.57	**1980**	Adequate	1.25	**2008**	Abundant	1.59
1953	Abundant	1.56	**1981**	Adequate	1.22	**2009**	Abundant	1.59
1954	Adequate	1.43	**1982**	Abundant	1.57	**2010**	Adequate	1.38
1955	Abundant	1.55	**1983**	Abundant	1.56	**2011**	Abundant	1.59
1956	Abundant	1.59	**1984**	Abundant	1.59	**2012**	Abundant	1.58
1957	Abundant	1.54	**1985**	Adequate	1.43	**2013**	Adequate	1.30
1958	Abundant	1.52	**1986**	Adequate	1.43	**2014**	Abundant	1.59
1959	Adequate	1.42	**1987**	Insufficient	0.96	**2015**	Deficit	0.56
1960	Abundant	1.59	**1988**	Abundant	1.57	**2016**	Adequate	1.36
1961	Abundant	1.56	**1989**	Abundant	1.52	**2017**	Abundant	1.59
1962	Abundant	1.58	**1990**	Adequate	1.41	**2018**	Adequate	1.33
1963	Abundant	1.58	**1991**	Abundant	1.53	**2019**	Adequate	1.45

3.3 RESSIM NETWORK AND DAM SPECIFICS

The reservoir simulation program HEC-ResSim requires input at the network level, which is information about the rivers, streams, and the physical parameters related to the dams that are modeled. This section describes the configuration, routing reaches, and dam physical parameters used in the NAA simulation for the WVP EIS.

3.3.1 Configuration in ResSim

The Configuration in ResSim is a specific physical arrangement of projects and computation points modeled in the Watershed. The Configuration used in the Willamette Basin model is called “Existing”, and it is the only configuration in the model.

3.3.2 Routing Reaches

The river reaches analyzed in the ResSim model (the dark blue lines in **Figure B-3-1**) have a routing associated with them, which the program uses to determine how fast the water will pass through that section of a river. A reach with “null” routing will pass the water through instantaneously, while a reach with routing will have a calculated flow change. The ResSim model is set to be as close to the routings used for the 2010 Modified Flow development as possible, which largely uses the Streamflow Synthesis and Reservoir Regulation (SSARR) routing method (see USACE, 1991). The SSARR routing was a method developed for the Pacific Northwest in the 1960’s for the HEC-5 model (a precursor to ResSim) for the Willamette Basin. The SSARR routing is based on a timing equation, TS = KTS/Q^n, where the time of storage in the reach is TS, Q is the flow, and KTS and n are parameters determined through hydrologic analyses. Note that the actual length of the reach is not in the equation – the travel time of water down a tributary stream can be applied to any single reach of the tributary, with the remaining reaches in the tributary given null routings. The schematic shown in **Figure B-3-3** illustrates the above description.

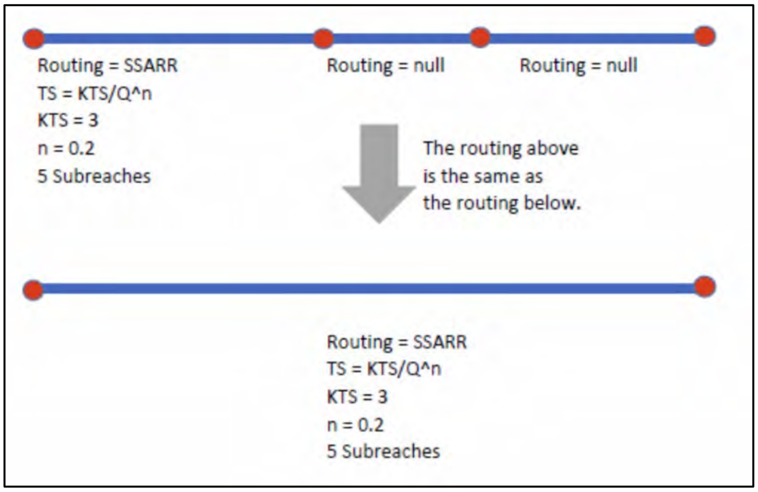


Figure 3-3. Schematic of SSARR routing applied to a portion of a stream

Most of the reaches in the ResSim network are given null routings, with those reaches not specified as “null” shown in Table B-3-5. The lower part of the table shows those reaches designated by interpolation rather than the KTS/Q^n equation.

Table 3-5. SSARR Routing Specifications

Reach Name	KTS	n	# Sub-reaches
CF Willamette+Row to CF Willamette_nr Goshen	10	0.2	4
Lebanon Div_IN to So Santiam_Mouth	5	0.2	5
Long Tom_nr Alvadore to Long Tom_at Monroe	5	0.2	5
MF Willamette+CF Willamette to Willamette_at Eugene	3	0.2	5
MF Willamette+Fall to MF Willamette_at Jasper	3	0.2	5
MF Willamette_abv Salt Cr nr Oakridge to MF Willamette_Blw NFork	1.5	0.1	2
McKenzie+Blue to McKenzie_at Vida	4	0.1	2
No Santiam_at Niagara to No Santiam_at Mehama	4	0.2	5
So Santiam_nr Foster to So Santiam_at Waterloo	3.5	0.2	5
Stayton Div_IN to Greens Bridge NR Jefferson	7	0.2	5
Willamette+McKenzie to Willamette_at Harrisburg	See Interpolation - A		7
Willamette+Long Tom to Willamette+Marys	See Interpolation - B		6
Willamette+Luckiamute to Willamette+Rickreall	See Interpolation - C		6
Willamette+Marys to Willamette+Calapooia	See Interpolation - D		5
Willamette+Mill to Willamette+Yamhill	See Interpolation - E		2

Interpolation A		Interpolation B		Interpolation C		Interpolation D		Interpolation E	
Outflow, cfs	Storage, hours	Outflow, cfs	Storage, hours	Outflow, cfs	Storage, hours	Outflow, cfs	Storage, hours	Outflow, cfs	Storage, hours
1	2.30	1	4.00	1000	3.33	1	2.94	1	0.40
1000	1.40	1000	3.33	10000	2.67	1000	2.40	50000	0.48
20000	0.57	10000	2.16	20000	2.17	3000	1.96	100000	0.71
30000	0.57	20000	1.83	30000	1.58	10000	1.40	150000	1.12
40000	0.71	30000	1.83	40000	1.42	20000	0.80	200000	1.54
50000	0.89	40000	2.08	50000	1.17	30000	0.60	250000	1.85
60000	1.14	50000	2.67	60000	1.28	40000	0.52	300000	2.10
80000	1.14	60000	3.34	80000	1.42	50000	0.52	350000	2.31
140000	0.83	70000	3.66	100000	2.26	60000	0.60	400000	2.50
180000	0.71	80000	3.58	120000	2.75	80000	0.70	500000	2.65
		100000	3.16	140000	3.00	100000	0.85		
		120000	2.80	170000	3.08	120000	1.00		
		180000	1.83	200000	2.84	150000	1.20		
				250000	2.16	200000	1.40		
				300000	1.83	300000	1.30		
				400000	1.75	400000	1.12		
				500000	1.66	500000	1.00		

3.3.3 ResSim Inputs for Physical Parameters of Each Dam

All thirteen USACE dams in the Willamette Basin are modeled in ResSim. The thirteen projects are comprised of eleven storage projects and two re-regulation projects. The projects are configured with a variety of outlet types, such as turbines, regulating outlets, and spillways, which can be either gated or uncontrolled. The physical parameters of individual outlets in ResSim for the NAA will remain the same for all alternatives evaluated. Rating curves for individual outlets are provided in each reservoir's respective USACE Water Control Manual (WCM).

The following is a list of the USACE projects in the Willamette Basin and their type:

Project	**Type of Reservoir**	**Abbreviation**
Big Cliff	Reregulation	BCL
Detroit	Storage	DET
Green Peter	Storage	GPR
Foster	Storage	FOS
Cougar	Storage	CGR
Blue River	Storage	BLU
Hills Creek	Storage	HCR
Lookout Point	Storage	LOP
Dexter	Reregulation	DEX
Fall Creek	Storage	FAL
Dorena	Storage	DOR
Cottage Grove	Storage	COT
Fern Ridge	Storage	FRN

Table B-3-6 shows the number of outlets that each dam has of each type. The table also lists the top of dam elevation in feet (in the NGVD29 datum) that is used in ResSim and the length of the dam that is used in ResSim.

Table 3-6. Summary of Outlets by Project

	Number of Outlets				Top of Dam Measures, in feet	
			Spillway			
Project	Turbines	Regulating Outlets	Gated Bays	Uncontrolled	Elevation	Length
Hills Creek	2	2	3	-	1548.0	2235.0
Lookout Point	3	4	5	-	941.0	2840.0
Dexter	1	-	7	-	235.0	2765.0
Fall Creek[1]	-	2	2	-	839.0	5100.0
Cottage Grove	-	3	-	1	808.0	1846.0
Dorena	-	5	-	1	865.7	2800.0
Cougar	2	2	2	-	1705.0	1500.0
Blue River	-	2	2	-	1362.0	1250.0
Fern Ridge[2]	-	5	6	-	379.5	6320.0
Green Peter	2	2	2	-	1020.0	1380.0
Foster	2	-	4	-	646.0	4800.0
Detroit[3]	2	4	6	-	1579.0	1523.2
Big Cliff	1	-	3	-	1210.0	295.0

[1] Fall Creek Dam has a special outflow structure collectively called the fish horns. ResSim models fish horn flow as going over the spillway.

[2] Fern Ridge Dam has four sliding gate regulating outlets and one sluice gate.

[3] Detroit Dam has two Upper Controlled Outlets and two Lower Controlled Outlets. The lower controlled outlets are not modeled because they are not used.

3.3.4 Water Withdrawals and Returns

The WVS EIS hydrologic inflow data set is adjusted to represent 2008 levels of irrigation using assumed irrigation demands predicted by the 2010 Modified Flows study discussed in Withdrawals. Withdrawals were added to account for increases in withdrawals between 2008 and 2050 (projected). These increases are documented in Appendix J.

3.4 RESSIM NETWORK AND DAM SPECIFICS

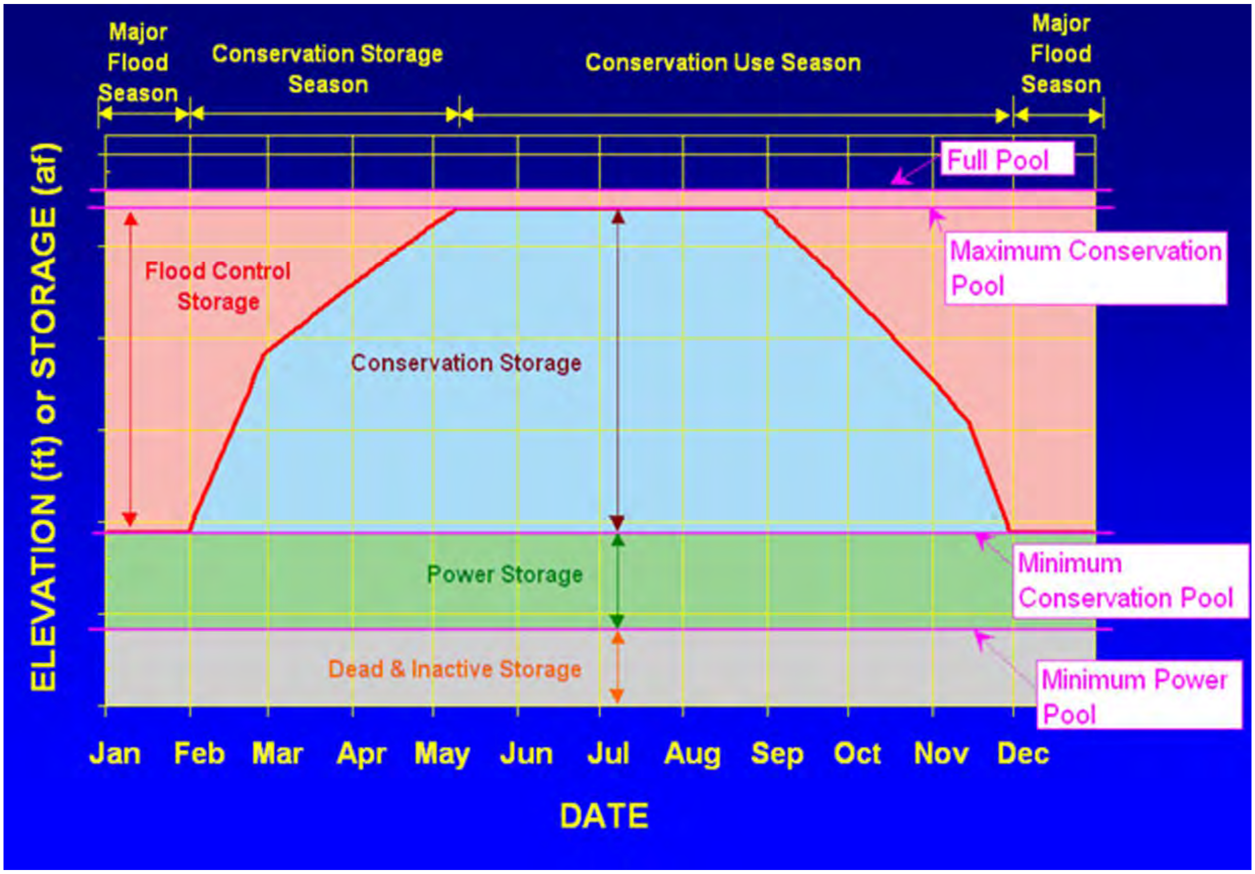


Figure 3-4. Generic storage graph of a Willamette project. Note the rule curve, the heavy red line, is shaped slightly differently for each project and refill and draft schedules also vary by project. Projects without a powerhouse do not have a power pool, shown in green in the graph here.

The NAA ResSim simulation for the flow dataset period of record contains an operation set of rules for each of the eleven storage projects that is intended to mimic the general way that reservoir regulation occurs in the Willamette Basin. The operation sets were not written to account for any forecasting or agency coordination efforts that occur in real time water management decisions, but rather seek to implement a consistent approach to the reservoir operations over all years of the record. This consistent approach means that the reservoirs store water when necessary for flood risk management, release stored water from flood events according to the water control manuals, refill according to the rule curves when inflows are high enough, supplement mainstem minimum flows, reduce releases to reserve water for later use in the season when pool levels are too far below rule curve, supply minimum tributary flows, and account for physical limitations of dam outlets.

The remainder of this section covers some of the basic operations and rules that are used at multiple projects in the NAA simulation, while the project specific rules are described individually in Sections 3.5 for each specific dam. Most of the particulars described in this section will also be part of the alternatives evaluated for the WVS EIS. Below is a brief outline of the information covered in this section and a note on how the WVS EIS alternatives would use this information:

- Reservoir zones and rule curves: the zones and guide curve to operate a project are defined in the operation set, and all alternatives in the WVS EIS analyses will have these zones, although target elevations defined by the rule curve may differ and additional zones may be added when modeling alternatives.
- Re-regulation dams (Big Cliff and Dexter): these dams are treated the same in all WVS EIS alternatives as they are in the NAA simulation. No operations are defined for these reservoirs. They pass flow from the reservoir above them on a daily timestep as is generally the case in actual operations.
- Release Allocations: the release allocation, which specifies the preferred order of outlet use for a dam, is part of the operation set. In general, the penstock is used first, followed by the regulating outlet when the penstock capacity is exceeded, and the spillway lastly when the combined penstock and regulating outlet capacity is exceeded. Spill operations to manage temperatures or encourage volitional fish passage requiring a different release allocation are modeled in ResSim at Foster and a spill allocation is post processed into results at Detroit in the NAA. Release allocations in other alternatives are modeled in ResSim when feasible and may otherwise be post processed outside of ResSim. ResSim modeling of minimum gate openings at low releases is coarse.
- RO capacities and minimum gate openings: All WVS EIS alternatives will adhere to the same physical outlet capacity constraints.
- Induced Surcharge Rules: these rules govern the release of water in special cases to prevent dam overtopping. These rules do not change among any of the operation sets for WVS EIS alternatives.
- Downstream Control Points, Maximum Flow Rules: Maximum flow rules are related to the flood risk management function of the dams. The same maximum flow rules for downstream control points apply to all WVS EIS alternatives.

- Downstream Control Point Minimum and maximum BiOp Flow Rules: BiOp Minimum and maximum flow rules on tributaries and on the mainstem of the Willamette River at Albany and Salem may change for an alternative to evaluate the effects of a possible change to these targets.
- Maximum and Minimum BiOp rates of flow changes are the same for all WVS EIS alternatives as they are in the NAA. These flow changes are also described as ramping rates.
- Interim Risk Reduction Measures (IRRMs)

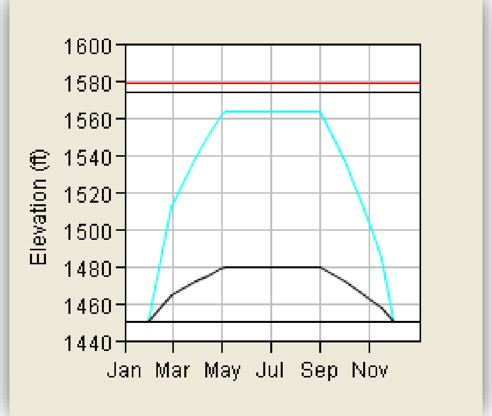
3.4.1 Reservoir Zones in ResSim and Rules Curves

The Willamette reservoirs are divided into zones where specific rules can be applied. The rules for a specific zone are applied when the modeled reservoir elevation is at, or below, that zone. Table B-3-7 and Figure B-3-5 identify and describes these zones.

Table 3-7. Zone types used in operation sets

Zone Name	Significance
Top of Dam	The physical top of dam where overtopping would occur.
Flood Control	Max pool available for flood control.
50% FC Pool*	Used to separate the flood control storage into different types of flood control operations at some projects: normal release rules and aggressive release rules which let out additional water when storage space becomes limited.
Primary Flood Control*	
Secondary Flood Control*	
Conservation	The "Guide Curve" which coincides with the project rule curve. (ResSim uses the zone defined as the Guide Curve as the preferential pool elevation for a project to be.)
Buffer	Acts like an interim draft limit to prevent the pool from drafting too rapidly and is used to help mimic reservoir regulation under drought conditions.
Inactive	The lowest zone in the operation set, and is a zone required by the program. No rules can be applied in this zone.

* Not used for all projects



Straight Red line – Top of Dam zone.

Straight Gray line – Flood Control zone.

Blue line – Below this line is the Conservation zone, and this line is the Rule Curve. The Rule Curve is always designated as the “Guide Curve” in ResSim, which means the preferred elevation of a pool.

Variable Black line – Below this line is the Buffer zone.

Figure 3-5. Typical Example Graph of Reservoir Zones

Inactive Zones. The ResSim program has a special zone required in each reservoir called the Inactive zone, with the program controlling even the name of this zone. This zone was programmed internally to ResSim to represent the pool elevation below which no water can leave the dam, or the elevation just below the lowest outlet, representing the dead storage of the project. The program does not allow any rules to be input to this zone, since it is supposed to be unable to let flow out.

In practice, a modeler can define the Inactive zone at any elevation, although no rules will be able to be applied and no zone can be defined below it. In the NAA model, the Inactive zone is specified as the elevation of the Minimum Conservation Pool because the Corps is generally not authorized to use the stored water below this level. At projects with power generation, water between this level and the Minimum Power Pool is reserved for use during power emergencies called by BPA in the NAA. During real time operations in very dry conditions with pool levels at the minimum conservation pool, the Corps and BPA will often agree to release water from these projects without a power emergency, dropping into the power pool rather than letting a river dry up.

The Inactive zone has another use within the program, which is to be the lower boundary for implicit storage calculations. Implicit storage is used for projects that operate for a downstream minimum flow so that the flow contribution or share of that target flow can be calculated.

When the program calculates that a reservoir pool level has dropped down to the elevation of the inactive zone, it will still release from the reservoir if an outlet has capacity at that elevation. The outlet chosen by the program is based on the release allocation and the physical capacity, but the flow level it calculates to pass is either the last minimum from the zone above or passing inflow, whichever is less. Once the inflow exceeds the last minimum outflow rule long enough to accumulate storage, the pool level raises to the zone above the inactive one, and then the program starts following that zone’s rule set.

3.4.2 Reregulating Dams

There are two dams in the Willamette Basin that are reregulation projects, Big Cliff and Dexter Dams. They are modeled in ResSim only with zones and no rules. Both have a Top of Dam, Flood Control, Conservation, Buffer, and Inactive zone, with the Conservation zone specified as the Guide Curve. All zones are given a constant elevation through the year because these two projects do not have rule curves. No rules are included. These dams have only a small amount of storage, and on a daily average, do not accumulate water or pass more than comes in. The NAA model data is being used to assess statistical data with a daily time step for 84 years, so more detailed modeling at these projects is not necessary for the results needed.

3.4.3 Release Allocations

Each operation set in ResSim has an associated release allocation which specifies the priority of use of each dam outlet. Table B-3-8 below shows the release outlet allocation used for each project, with the flow passing through turbines as first priority at power projects. Some projects have rules that adjust the chosen outlet for certain situations, but unless otherwise specified, the program follows the release order shown here in the NAA. Release allocations for other alternatives that differ from what is shown in Table B-3-8 will be modeled in ResSim when feasible, but complex flow reallocations will be post processed outside of ResSim.

Table 3-8. Sequential Release Allocation for all Model Runs

Project	Allocation Type and Order	Project	Allocation Type and Order
DET	Power Plant	HCR	Power Plant
	Upper Controlled Outlet		Regulated Outlet
	Spillway		Spillway
BCL	Power Plant	LOP	Power Plant
	Spillway		Regulated Outlet
GPR	Power Plant		Spillway
	Controlled Outlet	DEX	Power Plant
	Spillway		Spillway
FOS	Power Plant	FAL	Regulated Outlet
	Spillway		Spillway
CGR	Power Plant	DOR	Regulated Outlet
	Regulating Outlet		Uncontrolled Outlet
	Spillway	COT	Regulated Outlet
BLU	Regulating Outlet		Uncontrolled Outlet
	Spillway	FRN	Regulated Outlet
			Spillway
			Sluice Gate

*Detroit and Foster have modified release allocations to manage temperature in the NAA

3.4.4 Capacities and Minimum Gate Openings

Some of the Willamette projects with regulating outlets are operated with minimum gate opening – in other words, if a regulating outlet is going to be used, it must open a minimum amount. The flow out of an RO with a specific gate opening is a function of the pool elevation, as the amount of head affects the outflow. Many of the dams have controlled outlet physical parameter capacities with zeros for small gate openings in an attempt to model this gate opening restriction; however, in simulations, ResSim will interpolate between a zero outflow at one gate opening and the outflow it computes as necessary with the next higher gate opening, regardless of how small of an increment the gate opening specifications. If the smallest gate opening included in the capacity table is the minimum opening, the simulation can still interpolate to less than that.

The minimum gate opening rules do not apply to Detroit and Lookout Point because there are re-regulation dams just downstream of these projects. For example, in each day during real project operations, a Detroit dam RO might be opened the minimum amount for a few hours, then closed, and perhaps reopened the minimum amount more times. The average RO flow for the day at Detroit can be less than the minimum required, representing an open gate period for part of the day and a closed gate period for part of the day. The downstream reregulation dam, Big Cliff, will smooth the flows out over the day. Green Peter dam does not need the minimum gate opening rule either, since Foster also acts as a reregulation dam on a daily average. Note that Big Cliff, Dexter, and Foster dams do not have regulating outlets.

The dams Blue River, Cottage Grove, Dorena, Fall Creek, and Fern Ridge are not operated with minimum gate openings for the ROs. Two projects that are operated with minimum gate openings for the ROs are Cougar and Hills Creek, and both projects have these minimum RO gate openings modeled in the same way.

Cougar and Hills Creek each have an IF BLOCK to determine if the current time step has calculated RO flow at the project. If not, nothing changes, and no ELSE or ELSE IF is needed. If the current time step does have RO flow at the project, it is required to meet the minimum flow given in the rule within the IF BLOCK. The minimum RO flows listed in the rule are the one RO capacity by reservoir pool level for the minimum gate opening.

Dexter and Big Cliff have minimum flow requirements for their penstocks. These are accounted for in the minimum flow rules for the upstream project instead of a minimum gate opening. This works in the model because the penstock is the first outlet to release.

3.4.5 Induced Surcharge

Induced Surcharge Rules. The induced surcharge rule available in ResSim is one that specifies a total flow out of the project based on the pool elevation and the inflow to the reservoir. The purpose of this type of operation is to carefully control the rate of fill as the reservoir gets close to full to still reduce the regulated downstream peak, but also protect the project from overtopping. This type of operation is rare since the storage available at each project is usually sufficient to capture large inflow events in the flood season. The Willamette Valley storage reservoirs each have an induced surcharge operation described in their WCM.

The induced surcharge function is difficult to model for a daily time step. The special flood regulation curves shown in the project WCMs are smoothly varying functions of inflow, with the release changing as the inflow changes. With a daily time step, the inflow peak is flattened and widened, and the rule is either applied all day or not at all. Each project's induced surcharge rule is defined in the individual project sections. This rule is used because the flow dataset POR runs continuously from 01Oct1935 through to 30Sep 2019 and contains all the flood events in that record. The model configuration used is not suitable for assessing impacts to flood risk beyond a screening level analysis.

3.4.6 Downstream Control Points, Maximum Flow Rules

Flood risk management is the primary authorized purpose of the Willamette dams, and to accomplish this task, each dam in the Willamette regulates its outflow based on at least one control point downstream. This regulation is accomplished by the project storing inflows and reducing outflows either when the downstream control point flows are too high, or to assist in keeping the downstream flows as low as possible. The downstream control points and flow levels for regulation are illustrated in the schematic of Figure B-3-6.

The blue triangles in the schematic of Figure B-3-6 are the control points for reservoir regulation. Each control point has two key regulation thresholds: bankfull and flood stage, which are labeled as “BF” and “FS”, respectively, in the figure. Each of the control points has a stream gage that is used for reservoir regulation. Other gages in the basin provide additional information to regulators during real time operation, and these gages are shown in the figure as either circles or diamonds. For reservoir operation modeling for Willamette Basin studies, only the control points (the locations marked with the blue triangles) are included in ResSim.

Typically, projects are operated to maintain flows below bankfull level of a downstream control point whenever possible and when there is ample space in the reservoir to store inflows. Bankfull is considered a non-damaging level of flow at that location. In larger flood events, which have high local flow components, projects are operated to maintain control points below flood stage whenever possible. The goal of the reservoir regulation is to not make the flooding worse downstream. In all cases, each project must release its minimum required outflow, but increased releases from those minimums use the flow at the control points to guide the regulation.

These downstream control point flow level operations are modeled in ResSim as maximum downstream rules. A downstream maximum rule is used by ResSim to calculate a project outflow that does not exceed the maximum level specified in the rule.

The Willamette projects are operated as a system for flood control. All key control points on each tributary (Vida, Jasper, Goshen, Monroe, Waterloo, Mehama, and Jefferson) are regulated by the appropriate project upstream in the model. For mainstem control points, the southern projects are operated for a common bottleneck point, Harrisburg, and the northern Santiam projects are used to reduce flows at Salem. By reducing for Harrisburg, the southern projects also reduce Albany and Salem flows. Table B-3-9 summarizes which projects are used to reduce stages at each control point.

A project cannot always be operated to meet a bankfull goal at a control point. If the project is getting full, the downstream control point goal may be higher in order to slow the rate of fill. The goal then would be to not exceed flood stage, and these rules would be used at higher reservoir elevations than the bankfull rules. These two types of downstream maximum rules are summarized below by control point. Note that Hills Creek is modeled as a tandem operation with Lookout Point, rather than a specific downstream rule, so if Lookout Point stores for downstream control points, then Hills Creek adjusts to balance the storage between itself and Lookout Point, effectively reducing flows to help control downstream flows.

The downstream maximum rules are in effect year-round, but typically only govern the ResSim program decision making during a winter flood event. Smaller flood events may occur during the spring refill season or late in the drafting season as well and need some regulation to manage. **The WVS EIS ResSim watershed prioritizes model stability during the conservation season above accurate regulation of flood events which influences the choice of downstream regulation goals. The model results should not be used beyond screening level analysis to evaluate flood risk**.

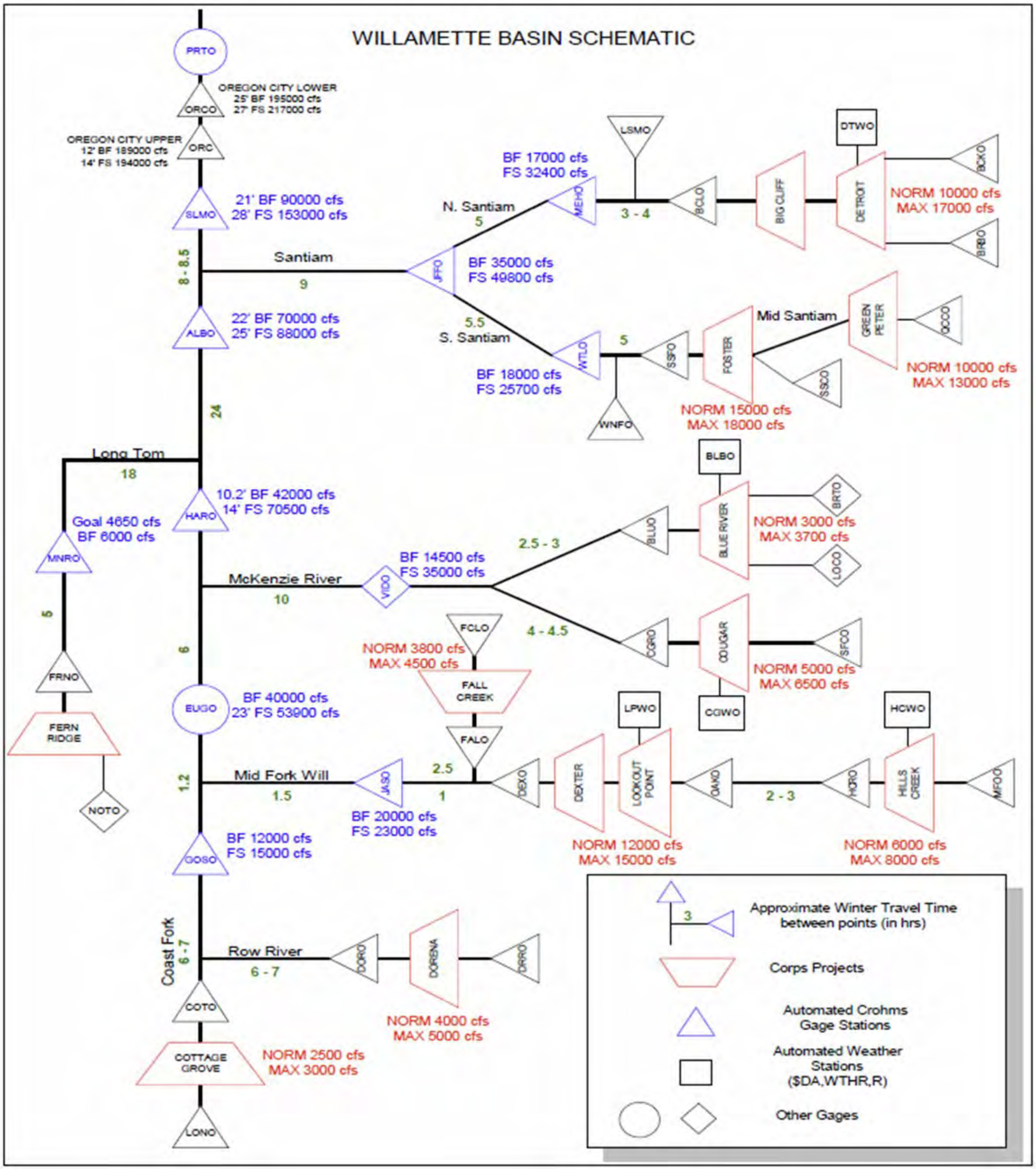


Figure 3-6. Willamette Basin Schematic

Table 3-9. Project Operation for Control Point Maximum Flows

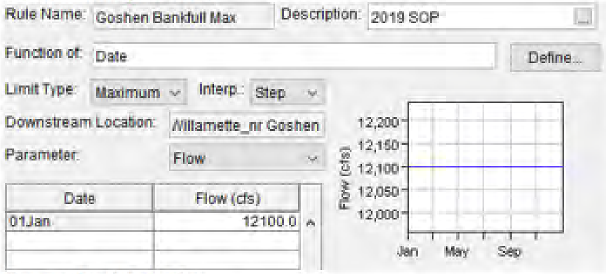
Control Point	Hills Creek	Lookout Point	Fall Creek	Cottage Grove	Dorena	Cougar	Blue River	Fern Ridge	Green Peter	Foster	Detroit
Jasper	x	**√**	**√**								
Goshen				**√**	**√**						
Vida						**√**	**√**				
Harrisburg	x	**√**	**√**	**√**	**√**	x	x				
Monroe								**√**			
Albany	x	x	x	x	x	x	x	x			
Waterloo									**√**	x	
Mehama											**√**
Jefferson									**√**	x	**√**
Salem	x	x	x	x	x	x	x	x	**√**	x	**√**

√ Project uses ResSim rules to reduce stages at the downstream control point.

x Project does not use a specific ResSim rule to reduce stages at the downstream control point, but reductions upstream do translate to reduced flows at these control points.

Screen shots of these downstream maximum rules are shown in Figure Figure B-3-7and Figure B-3-8.

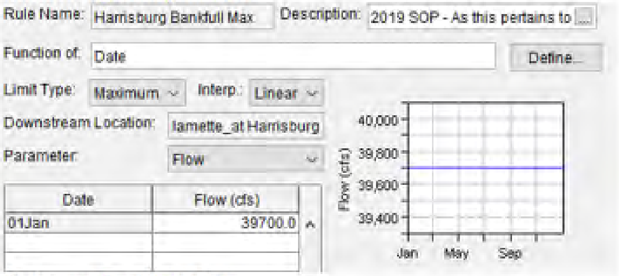
Goshen Bankfull Max



Rule Name: Goshen Bankfull Max
Description: 2019 SOP
Function of: Date
Limit Type: Maximum
Interp.: Step
Downstream Location: Willamette_nr Goshen
Parameter: Flow

Date	Flow (cfs)
01Jan	12100.0

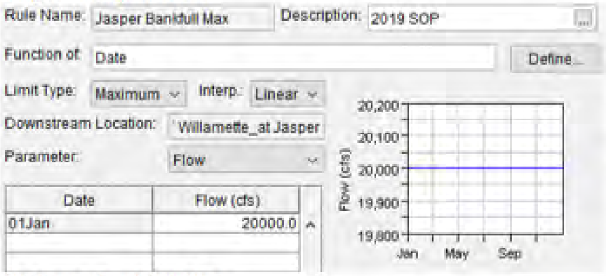
Harrisburg Bankfull Max



Rule Name: Harrisburg Bankfull Max
Description: 2019 SOP - As this pertains to
Function of: Date
Limit Type: Maximum
Interp.: Linear
Downstream Location: lamette_at Harrisburg
Parameter: Flow

Date	Flow (cfs)
01Jan	39700.0

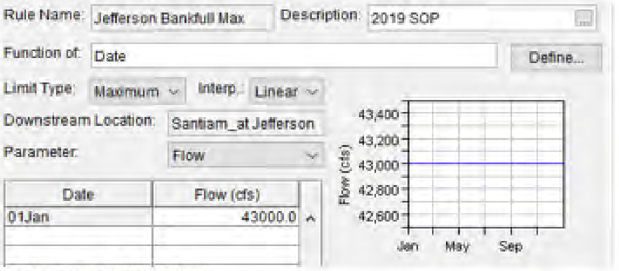
Jasper Bankfull Max



Rule Name: Jasper Bankfull Max
Description: 2019 SOP
Function of: Date
Limit Type: Maximum
Interp.: Linear
Downstream Location: Willamette_at Jasper
Parameter: Flow

Date	Flow (cfs)
01Jan	20000.0

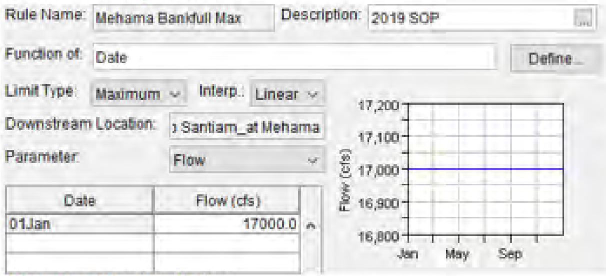
Jefferson Bankfull Max



Rule Name: Jefferson Bankfull Max
Description: 2019 SOP
Function of: Date
Limit Type: Maximum
Interp.: Linear
Downstream Location: Santiam_at Jefferson
Parameter: Flow

Date	Flow (cfs)
01Jan	43000.0

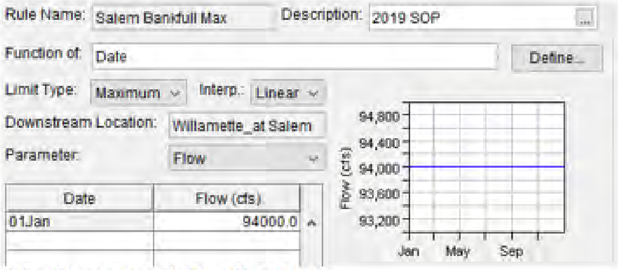
Mehama Bankfull Max



Rule Name: Mehama Bankfull Max
Description: 2019 SOP
Function of: Date
Limit Type: Maximum
Interp.: Linear
Downstream Location: Santiam_at Mehama
Parameter: Flow

Date	Flow (cfs)
01Jan	17000.0

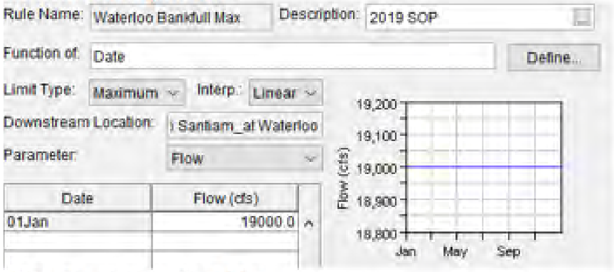
Salem Bankfull Max



Rule Name: Salem Bankfull Max
Description: 2019 SOP
Function of: Date
Limit Type: Maximum
Interp.: Linear
Downstream Location: Willamette_at Salem
Parameter: Flow

Date	Flow (cfs)
01Jan	94000.0

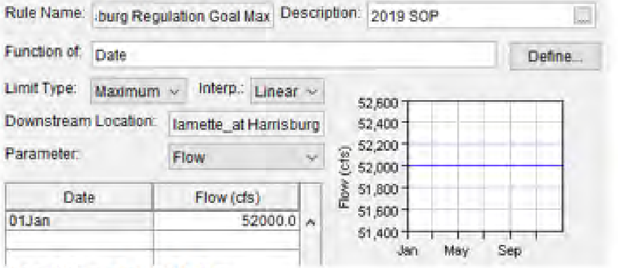
Waterloo Bankfull Max



Rule Name: Waterloo Bankfull Max
Description: 2019 SOP
Function of: Date
Limit Type: Maximum
Interp.: Linear
Downstream Location: Santiam_at Waterloo
Parameter: Flow

Date	Flow (cfs)
01Jan	19000.0

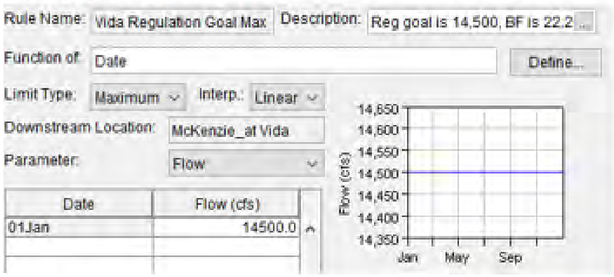
Harrisburg Regulation Goal Max



Rule Name: burg Regulation Goal Max
Description: 2019 SOP
Function of: Date
Limit Type: Maximum
Interp.: Linear
Downstream Location: lamette_at Harrisburg
Parameter: Flow

Date	Flow (cfs)
01Jan	52000.0

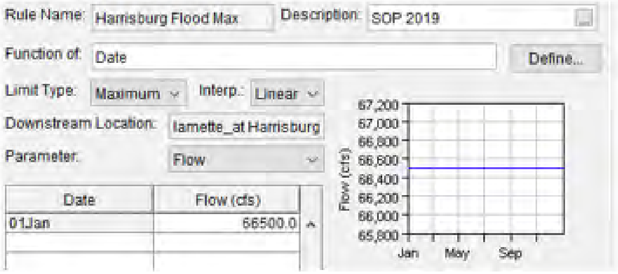
Vida Regulation Goal Max



Rule Name: Vida Regulation Goal Max
Description: Reg goal is 14,500, BF is 22.2
Function of: Date
Limit Type: Maximum
Interp.: Linear
Downstream Location: McKenzie_at Vida
Parameter: Flow

Date	Flow (cfs)
01Jan	14500.0

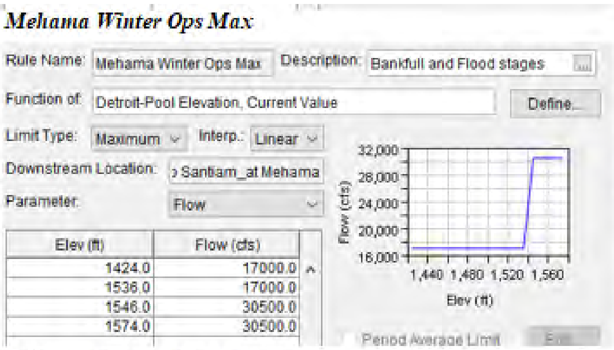
Harrisburg Flood Max



Rule Name: Harrisburg Flood Max
Description: SOP 2019
Function of: Date
Limit Type: Maximum
Interp.: Linear
Downstream Location: lamette_at Harrisburg
Parameter: Flow

Date	Flow (cfs)
01Jan	66500.0

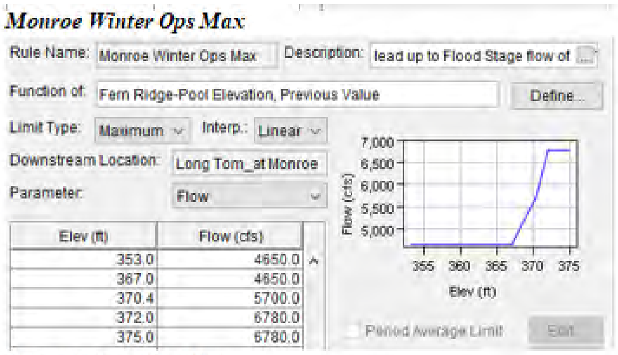
Figure 3-7. ResSim Screen Shots of Downstream Maximum Rules



Mehama Winter Ops Max

Rule Name: Mehama Winter Ops Max
Description: Bankfull and Flood stages
Function of: Detroit-Pool Elevation, Current Value
Limit Type: Maximum
Interp.: Linear
Downstream Location: ›Santiam_at Mehama
Parameter: Flow

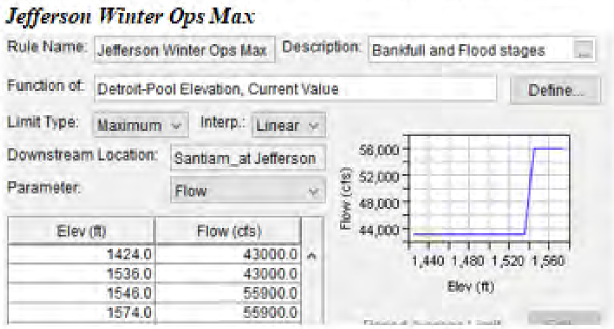
Elev (ft)	Flow (cfs)
1424.0	17000.0
1536.0	17000.0
1546.0	30500.0
1574.0	30500.0



Monroe Winter Ops Max

Rule Name: Monroe Winter Ops Max
Description: lead up to Flood Stage flow of
Function of: Fern Ridge-Pool Elevation, Previous Value
Limit Type: Maximum
Interp.: Linear
Downstream Location: Long Tom_at Monroe
Parameter: Flow

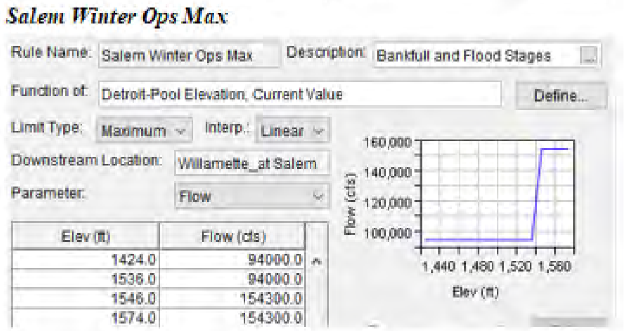
Elev (ft)	Flow (cfs)
353.0	4650.0
367.0	4650.0
370.4	5700.0
372.0	6780.0
375.0	6780.0



Jefferson Winter Ops Max

Rule Name: Jefferson Winter Ops Max
Description: Bankfull and Flood stages
Function of: Detroit-Pool Elevation, Current Value
Limit Type: Maximum
Interp.: Linear
Downstream Location: Santiam_at Jefferson
Parameter: Flow

Elev (ft)	Flow (cfs)
1424.0	43000.0
1536.0	43000.0
1546.0	55900.0
1574.0	55900.0



Salem Winter Ops Max

Rule Name: Salem Winter Ops Max
Description: Bankfull and Flood Stages
Function of: Detroit-Pool Elevation, Current Value
Limit Type: Maximum
Interp.: Linear
Downstream Location: Willamette_at Salem
Parameter: Flow

Elev (ft)	Flow (cfs)
1424.0	94000.0
1536.0	94000.0
1546.0	154300.0
1574.0	154300.0

Figure 3-8. ResSim Screen Shots of Downstream Maximum Rules Continued

3.4.7 Downstream Control Points, Minimum Flow Rules

Two control points on the Willamette River mainstem, Albany and Salem, are operated to minimum flows. Multiple projects are used to supplement the local flows to meet the target minimum flows, as shown in Table B-3-10.

The Salem and Albany minimum flows were set by the Willamette BiOp. These minimum flow targets are set by water year type (Abundant, Adequate, Insufficient, or Deficit) and by time of year. The targets are the same for Abundant and Adequate water years, and they are specific for each time period in the year. Water years defined as Insufficient have a minimum Salem flow that varies between that of Abundant/Adequate and Deficit on a sliding scale based on interpolation between the calculated storage volume and the storage values associated with Adequate and Deficit water years. The Albany minimum flows for Insufficient water years are specified rather than interpolated. These minimum flows were shown previously in Table B-3-2.

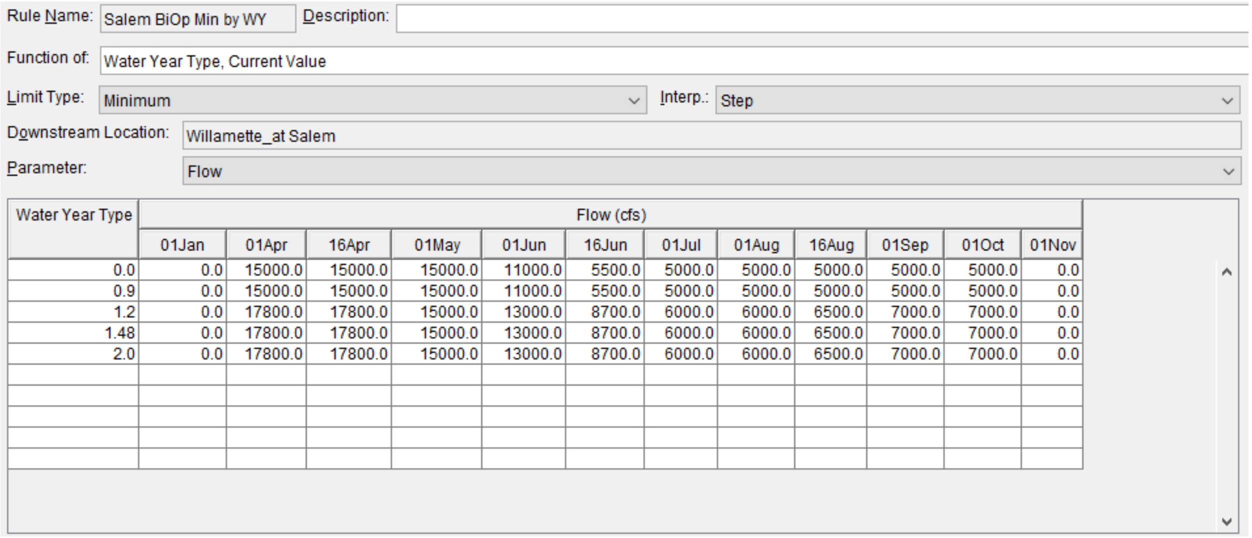
Both minimum flow rules use a two-way table, with time periods and a Water Year Type variable that is input as an external time series. The external variable is the computed water in storage, in kaf, described in Table B-3-4. The water year type is defined in a separate dss file. Within the .dss file, the Part B of the water year type variable is called “TOTAL STORAGE”, which corresponds to the storage volumes in Table B-3-2. The downstream Salem minimum rule is called “Salem BiOp Min by WY” and the downstream Albany minimum rule is “Albany BiOp Min by WY” Screen shots of these two rules are shown in Figure B-3-9 and Figure B-3-10, respectively.

Table 3-10. Project Operation for Control Point Minimum Flows

Control Point	Hills Creek	Lookout Point	Fall Creek	Cottage Grove	Dorena	Cougar	Blue River	Fern Ridge	Green Peter	Foster	Detroit
Salem	√	√	√	√	√	√	√	x	x	x	x
Albany	√	√	√	√	√	√	√	x			

√ Project storage is used by ResSim to meet minimum flow targets at downstream control point.

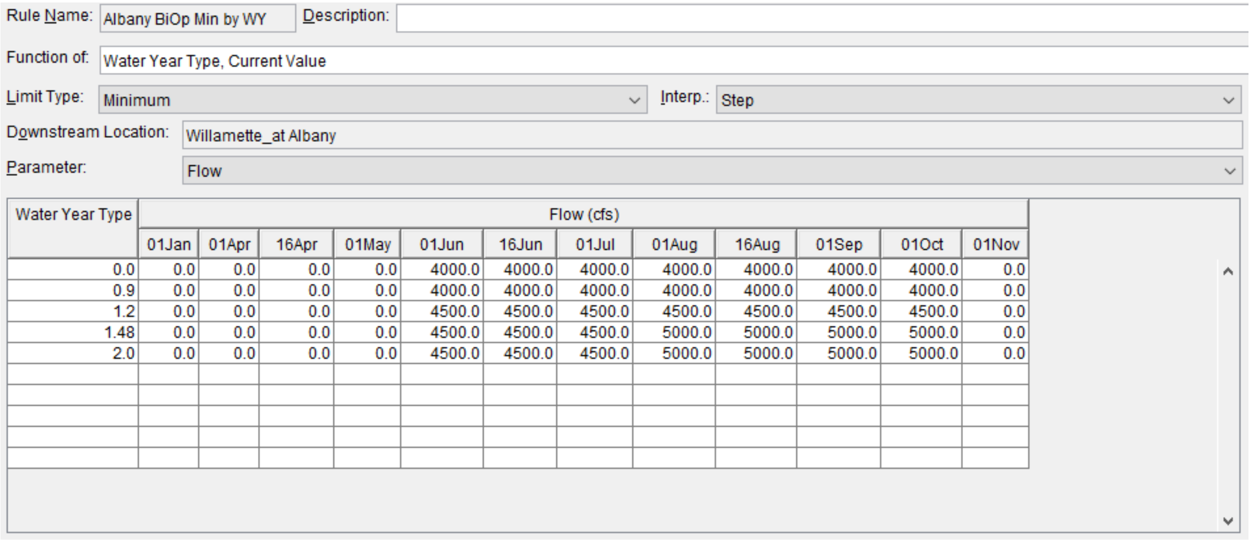
x Project does not use a specific ResSim rule to supplement flow at the downstream control point, but minimum project releases supplement flows at these control points.



Rule Name: Salem BiOp Min by WY
Description:
Function of: Water Year Type, Current Value
Limit Type: Minimum
Interp.: Step
Downstream Location: Willamette_at Salem
Parameter: Flow

Water Year Type	Flow (cfs)										
	01Jan	01Apr	16Apr	01May	01Jun	16Jun	01Jul	01Aug	16Aug	01Sep	01Oct	01Nov
0.0	0.0	15000.0	15000.0	15000.0	11000.0	5500.0	5000.0	5000.0	5000.0	5000.0	5000.0	0.0
0.9	0.0	15000.0	15000.0	15000.0	11000.0	5500.0	5000.0	5000.0	5000.0	5000.0	5000.0	0.0
1.2	0.0	17800.0	17800.0	15000.0	13000.0	8700.0	6000.0	6000.0	6500.0	7000.0	7000.0	0.0
1.48	0.0	17800.0	17800.0	15000.0	13000.0	8700.0	6000.0	6000.0	6500.0	7000.0	7000.0	0.0
2.0	0.0	17800.0	17800.0	15000.0	13000.0	8700.0	6000.0	6000.0	6500.0	7000.0	7000.0	0.0

Figure 3-9. ResSim Screen Shot of Min Flow – at Salem by Water Year Type rule.



Rule Name: Albany BiOp Min by WY
Description:
Function of: Water Year Type, Current Value
Limit Type: Minimum
Interp.: Step
Downstream Location: Willamette_at Albany
Parameter: Flow

Water Year Type	Flow (cfs)											
	01Jan	01Apr	16Apr	01May	01Jun	16Jun	01Jul	01Aug	16Aug	01Sep	01Oct	01Nov
0.0	0.0	0.0	0.0	0.0	4000.0	4000.0	4000.0	4000.0	4000.0	4000.0	4000.0	0.0
0.9	0.0	0.0	0.0	0.0	4000.0	4000.0	4000.0	4000.0	4000.0	4000.0	4000.0	0.0
1.2	0.0	0.0	0.0	0.0	4500.0	4500.0	4500.0	4500.0	4500.0	4500.0	4500.0	0.0
1.48	0.0	0.0	0.0	0.0	4500.0	4500.0	4500.0	5000.0	5000.0	5000.0	5000.0	0.0
2.0	0.0	0.0	0.0	0.0	4500.0	4500.0	4500.0	5000.0	5000.0	5000.0	5000.0	0.0

Figure 3-10. ResSim Screen Shot of Min Flow – at Albany by Water Year Type rule.

3.4.8 Rate of Flow Changes, Maximum and Minimum Flows

Each project has ramping rate rules for increasing and decreasing flows. The WCM for each project gives maximum rate of change (ramping rate) values for both filling and drafting, but the Willamette BiOp adjusted some of the rates to make for slower changes to flows.

All ramping rate rules at all projects will be the same in WVS EIS alternatives as they are in the NAA. See each project specific section for the ramping rate applied at each dam.

There are also maximum and minimum flow rules at each project. As with the ramping rates, the WCMs specify max and min outflows at each project, but the Willamette BiOp changed some of the flows. The maximum project outflows at every project will be at least as restrictive as the BiOp max in the NAA in all WVS EIS alternatives. Minimum project outflows will be varied in WVS EIS alternatives to evaluate effects. The WVS EIS NAA assumes projected 2050 withdrawals and returns and has minimum flow rules adjusted above the BiOp minimum flows to accommodate these withdrawals. See each project specific section for the max and min flows applied at each dam in the NAA.

3.4.9 Minimum Project Outflows

Minimum project outflows are accounted for in minimum flow rules. Physical minimum flows defined for specific outlets are used at projects when required.

3.4.10 E-Flows

The Sustainable Rivers Program (SRP) began in 2002 as a partnership between The Nature Conservancy (TNC) and the Corps with the objective of developing, implementing, and refining a framework for beneficial flows downstream of dams. SRP efforts in the Willamette River Basin focus on modifying dam releases within existing operational constraints to improve the overall downstream ecosystem health and resiliency by enhancing channel habitat, modifying channel features, and scouring and flushing of channels. The releases that provide these benefits are termed environmental flows (E-flows).

The E-flows are an opportunity driven operation that do not use the conservation storage of a reservoir during the summer months, nor are they predictable in timing. Therefore E-flow operations are not modeled in the NAA Simulation for the WVS EIS.

3.4.11 IRRM

Interim Risk Reduction Measures (IRRMs) are measures that are taken to mitigate temporary risks to dam safety until a permanent solution can be implemented. IRRMs currently implemented in the Willamette Basin include pool restrictions at Lookout Point, Hills Creek, and Detroit Reservoirs. These pool restrictions are not modeled as part of the NAA because they are temporary.

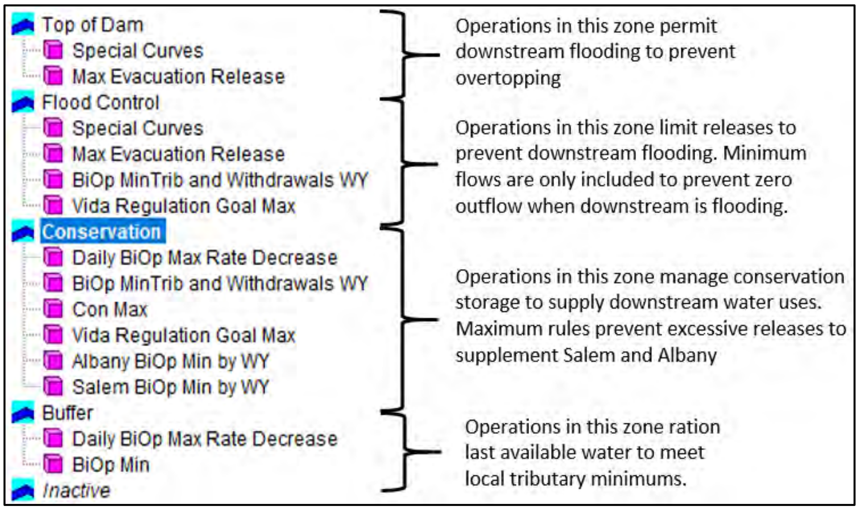
3.5 PROJECT SPECIFIED MODELED OPERATIONS

The following sub-sections detail the specific operations used in the NAA simulation at individual reservoirs. Big Cliff and Dexter are re-regulating reservoirs passing inflow from upstream reservoirs and do not have operations specified for them.

3.5.1 Blue River Modeled Operations

3.5.1.1 Blue River Operational Summary

A summary of reservoir zones, operations defined for each zone, and each zone's role in reservoir regulation is identified in Figure B-3-11. Operations only apply to the zone where they are located. The higher the location of an operation in a zone the higher the priority of that operation.



Operations in this zone permit downstream flooding to prevent overtopping

Operations in this zone limit releases to prevent downstream flooding. Minimum flows are only included to prevent zero outflow when downstream is flooding.

Operations in this zone manage conservation storage to supply downstream water uses. Maximum rules prevent excessive releases to supplement Salem and Albany

Operations in this zone ration last available water to meet local tributary minimums.

Figure 3-11. Blue River Operational Summary

3.5.1.2 Blue River ResSim Water Control Diagram

A water control diagram including all zones in ResSim is provided in Figure B-3-12. A table detailing seasonal zone elevations is provided in Table B-3-11. All zones are defined in the project's water control manual except for the buffer zone. The buffer zone is for modeling purposes intended to estimate likely conservation actions taken by regulators in extremely low storage situations when local tributary flows would be prioritized above withdrawals and mainstem flow targets.

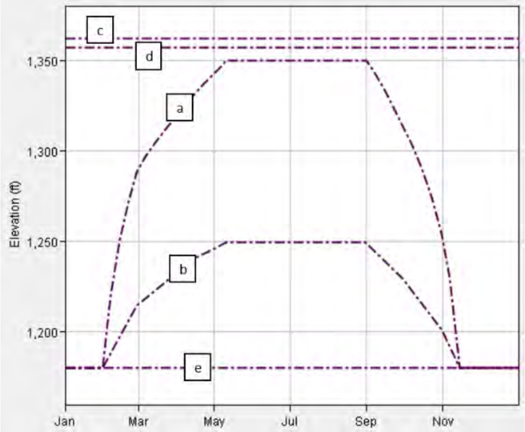


Figure 3-12. Blue River ResSim Water Control Diagram

Table 3-11. Blue River Reservoir Zone Elevations

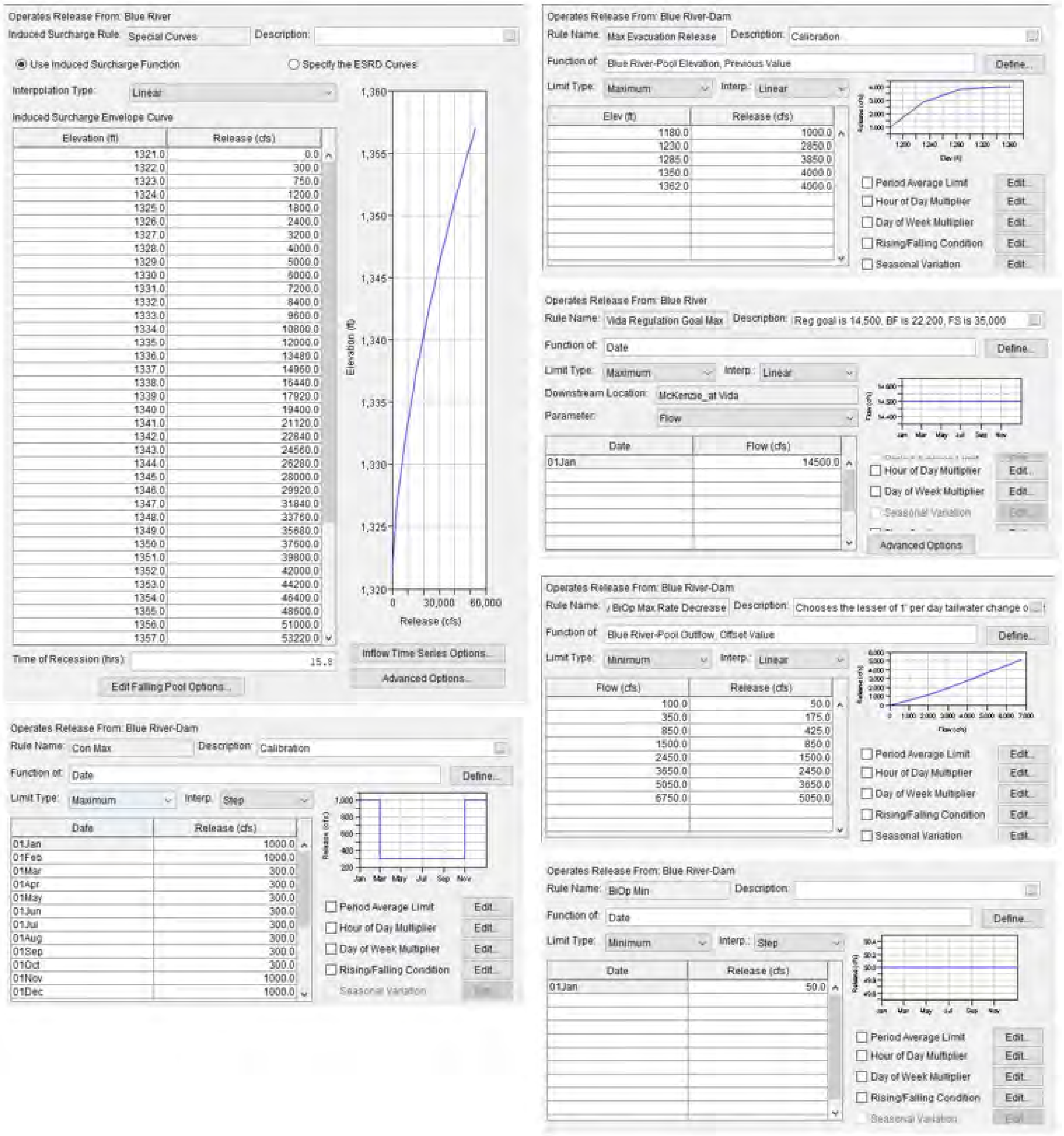
Conservation Zone (a)		Buffer Zone (b)	
Date	Elevation, feet	Date	Elevation, feet
1-Jan	1180.1	1-Jan	1180.0
31-Jan	1180.1	31-Jan	1180.0
7-Feb	1220.3	28-Feb	1214.8
14-Feb	1250.5	31-Mar	1232.6
21-Feb	1272.0	1-Apr	1233.2
28-Feb	1288.4	15-Apr	1240.6
7-Mar	1296.9	30-Apr	1245.6
15-Mar	1304.7	11-May	1249.3
23-Mar	1312.1	31-May	1249.3
31-Mar	1319.0	1-Jun	1249.3
7-Apr	1324.8	30-Jun	1249.3
15-Apr	1331.1	1-Jul	1249.3
22-Apr	1336.5	1-Aug	1249.3
30-Apr	1342.3	31-Aug	1249.3
7-May	1347.2	30-Sep	1229.4
11-May	1350.0	31-Oct	1201.4
1-Sep	1350.0	1-Nov	1200.4
7-Sep	1343.2	15-Nov	1180.0
15-Sep	1333.7	31-Dec	1180.0
22-Sep	1324.9		
30-Sep	1313.9		
7-Oct	1303.6		
15-Oct	1290.3	Top of Dam Zone (c)	
23-Oct	1274.5	All Year	1362
31-Oct	1253.9	Flood Control Zone (d)	
7-Nov	1229.4	All Year	1357
15-Nov	1180.1	Inactive Zone (e)	
22-Nov	1180.1	All Year	1180

3.5.1.3 Blue River Detailed Operational Descriptions

A description of each operation is provided below followed by detailed screenshots of each operation in Figure B-3-13 and Figure B-3-14.

- *Special Curves Normal* - Maximum outflow as a function of elevation and inflow designed to prevent the reservoir from overtopping.
- *Max Evacuation Release* - Designed to mimic typical flood season maximum releases at a given elevation.
- *BiOp MinTrib and Withdrawals by WY* - A composite minimum flow rule satisfying 2008 BiOp minimum flows and Projected 2050 withdrawals.
- *Vida Regulation Goal Max* - Regulation goal at Vida, 14,500 cfs.
- *Daily BiOp Max Rate of Decreases* - Designed to result in the lesser of 1' per day tailwater change or a 50% reduction in flow per the 2008 BiOp.

- *Con Max* - Maximum outflow during the conservation season limiting contribution to min flows at Salem and Albany.
- *Albany BiOp Min by WY* - 2008 BiOp min flow target at Albany.
- *Salem BiOp Min by WY* - 2008 BiOp min flow target at Salem.
- *BiOp Min* – 2008 BiOp minimum tributary flows.



Operates Release From: Blue River
Induced Surcharge Rule: Special Curves
Description:
● Use Induced Surcharge Function
○ Specify the ESRD Curves
Interpolation Type: Linear
Induced Surcharge Envelope Curve

Elevation (ft)	Release (cfs)
1321.0	0.0
1322.0	300.0
1323.0	750.0
1324.0	1200.0
1325.0	1800.0
1326.0	2400.0
1327.0	3200.0
1328.0	4000.0
1329.0	5000.0
1330.0	6000.0
1331.0	7200.0
1332.0	8400.0
1333.0	9600.0
1334.0	10800.0
1335.0	12000.0
1336.0	13480.0
1337.0	14960.0
1338.0	16440.0
1339.0	17920.0
1340.0	19400.0
1341.0	21120.0
1342.0	22840.0
1343.0	24560.0
1344.0	26280.0
1345.0	28000.0
1346.0	29920.0
1347.0	31840.0
1348.0	33760.0
1349.0	35680.0
1350.0	37600.0
1351.0	39800.0
1352.0	42000.0
1353.0	44200.0
1354.0	46400.0
1355.0	48600.0
1356.0	51000.0
1357.0	53220.0

Time of Recession (hrs): 15.8

Operates Release From: Blue River-Dam
Rule Name: Con Max
Description: Calibration
Function of: Date
Limit Type: Maximum
Interp.: Step

Date	Release (cfs)
01Jan	1000.0
01Feb	1000.0
01Mar	300.0
01Apr	300.0
01May	300.0
01Jun	300.0
01Jul	300.0
01Aug	300.0
01Sep	300.0
01Oct	300.0
01Nov	1000.0
01Dec	1000.0

☐ Period Average Limit
☐ Hour of Day Multiplier
☐ Day of Week Multiplier
☐ Rising/Falling Condition

Operates Release From: Blue River-Dam
Rule Name: Max Evacuation Release
Description: Calibration
Function of: Blue River-Pool Elevation, Previous Value
Limit Type: Maximum
Interp.: Linear

Elev (ft)	Release (cfs)
1180.0	1000.0
1230.0	2850.0
1285.0	3850.0
1350.0	4000.0
1362.0	4000.0

☐ Period Average Limit
☐ Hour of Day Multiplier
☐ Day of Week Multiplier
☐ Rising/Falling Condition
☐ Seasonal Variation

Operates Release From: Blue River
Rule Name: Vida Regulation Goal Max
Description: Reg goal is 14,500, BF is 22,200, FS is 35,000
Function of: Date
Limit Type: Maximum
Interp.: Linear
Downstream Location: McKenzie_at Vida
Parameter: Flow

Date	Flow (cfs)
01Jan	14500.0

☐ Hour of Day Multiplier
☐ Day of Week Multiplier

Operates Release From: Blue River-Dam
Rule Name: / BiOp Max Rate Decrease
Description: Chooses the lesser of 1' per day tailwater change o
Function of: Blue River-Pool Outflow, Offset Value
Limit Type: Minimum
Interp.: Linear

Flow (cfs)	Release (cfs)
100.0	50.0
350.0	175.0
850.0	425.0
1500.0	850.0
2450.0	1500.0
3650.0	2450.0
5050.0	3650.0
6750.0	5050.0

☐ Period Average Limit
☐ Hour of Day Multiplier
☐ Day of Week Multiplier
☐ Rising/Falling Condition
☐ Seasonal Variation

Operates Release From: Blue River-Dam
Rule Name: BiOp Min
Description:
Function of: Date
Limit Type: Minimum
Interp.: Step

Date	Release (cfs)
01Jan	50.0

☐ Period Average Limit
☐ Hour of Day Multiplier
☐ Day of Week Multiplier
☐ Rising/Falling Condition

Figure 3-13. Blue River NAA Operation Set Rules

Operates Release From: Blue River-Dam
Rule Name: nTrib and Withdrawals WY
Description:
Function of: Water Year Type, Current Value
Limit Type: Minimum
Interp.: Linear

Water Year Type	Release (cfs)											
	01Jan	01Feb	01Mar	01Apr	01May	01Jun	01Jul	01Aug	01Sep	01Oct	01Nov	01Dec
0.0	50.0	50.0	50.0	50.0	50.0	55.0	57.0	57.0	56.0	50.0	50.0	50.0
0.9	50.0	50.0	50.0	50.0	50.0	60.0	63.0	63.0	61.0	50.0	50.0	50.0
1.2	50.0	50.0	50.0	50.0	50.0	62.0	66.0	67.0	64.0	50.0	50.0	50.0
1.48	50.0	50.0	50.0	50.0	50.0	64.0	69.0	69.0	66.0	50.0	50.0	50.0
2.0	50.0	50.0	50.0	50.0	50.0	64.0	69.0	69.0	66.0	50.0	50.0	50.0

☐ Period Average Limit
☐ Hour of Day Multiplier
☐ Day of Week Multiplier
☐ Rising/Falling Condition
☑ Seasonal Variation

Operates Release From: Blue River
Rule Name: Salem BiOp Min by WY
Description:
Function of: Water Year Type, Current Value
Limit Type: Minimum
Interp.: Linear
Downstream Location: Willamette_at Salem
Parameter: Flow

Water Year Type	Flow (cfs)											
	01Jan	01Apr	16Apr	01May	01Jun	16Jun	01Jul	01Aug	16Aug	01Sep	01Oct	01Nov
0.0	0.0	15000.0	15000.0	15000.0	11000.0	5500.0	5000.0	5000.0	5000.0	5000.0	5000.0	0.0
0.9	0.0	15000.0	15000.0	15000.0	11000.0	5500.0	5000.0	5000.0	5000.0	5000.0	5000.0	0.0
1.2	0.0	17800.0	17800.0	15000.0	13000.0	8700.0	6000.0	6000.0	6500.0	7000.0	7000.0	0.0
1.48	0.0	17800.0	17800.0	15000.0	13000.0	8700.0	6000.0	6000.0	6500.0	7000.0	7000.0	0.0
2.0	0.0	17800.0	17800.0	15000.0	13000.0	8700.0	6000.0	6000.0	6500.0	7000.0	7000.0	0.0

Period Average Limit
☐ Hour of Day Multiplier
☐ Day of Week Multiplier
☑ Seasonal Variation
☐ Flow Contingency

Operates Release From: Blue River
Rule Name: Albany BiOp Min by WY
Description:
Function of: Water Year Type, Current Value
Limit Type: Minimum
Interp.: Linear
Downstream Location: Willamette_at Albany
Parameter: Flow

Water Year Type	Flow (cfs)											
	01Jan	01Apr	16Apr	01May	01Jun	16Jun	01Jul	01Aug	16Aug	01Sep	01Oct	01Nov
0.0	0.0	0.0	0.0	0.0	4000.0	4000.0	4000.0	4000.0	4000.0	4000.0	4000.0	0.0
0.9	0.0	0.0	0.0	0.0	4000.0	4000.0	4000.0	4000.0	4000.0	4000.0	4000.0	0.0
1.2	0.0	0.0	0.0	0.0	4500.0	4500.0	4500.0	4500.0	4500.0	4500.0	4500.0	0.0
1.48	0.0	0.0	0.0	0.0	4500.0	4500.0	4500.0	5000.0	5000.0	5000.0	5000.0	0.0
2.0	0.0	0.0	0.0	0.0	4500.0	4500.0	4500.0	5000.0	5000.0	5000.0	5000.0	0.0

Period Average Limit
☐ Hour of Day Multiplier
☐ Day of Week Multiplier
☑ Seasonal Variation
☐ Flow Contingency

Figure 3-14. Blue River NAA Operation Set Rules Continued

3.5.2 Cougar Modeled Operations

3.5.2.1 Cougar Operational Summary

A summary of reservoir zones, operations defined for each zone, and each zone's role in reservoir regulation is identified in Figure B-3-15. Operations only apply to the zone where they are located. The higher the location of an operation in a zone the higher the priority of that operation.

- Top of Dam
  - { } Make Sure RO Flow has Min Gate
    - IF (RO flow > 0)
      - Min RO Flow
  - updated max power release
  - Min Power Release
  - Special Curves Normal
  - Winter Max
- Flood Control
  - { } Make Sure RO Flow has Min Gate
    - IF (RO flow > 0)
      - Min RO Flow
  - updated max power release
  - Min Power Release
  - Special Curves Normal
  - Winter Max
  - BiOp MinTrib and Withdrawals by WY
  - Vida Regulation Goal Max
- Conservation
  - { } Make Sure RO Flow has Min Gate
    - IF (RO flow > 0)
      - Min RO Flow
  - updated max power release
  - Min Power Release
  - Revised Daily BiOp Max Rate of Decrease
  - Spawning Flow Max
  - Con Max
  - BiOp MinTrib and Withdrawals by WY
  - Vida Regulation Goal Max
  - Salem BiOp Min by WY
  - Albany BiOp Min by WY
- Buffer
  - { } Make Sure RO Flow has Min Gate
    - IF (RO flow > 0)
      - Min RO Flow
  - updated max power release
  - Min Power Release
  - Revised Daily BiOp Max Rate of Decrease
  - BiOp Min
- Bottom of Rules
  - Low Turbine Flows at Low Reservoir Elevations
  - Low RO Flows When Turbine Low
- *Inactive*

Operations in this zone permit downstream flooding to prevent overtopping.

Operations in this zone limit releases to prevent downstream flooding. Minimum flows are only included to prevent zero outflow when downstream is flooding.

Operations in this zone manage conservation storage to supply downstream water uses. Maximum rules prevent excessive releases to supplement Salem and Albany.

Operations in this zone ration last available water to meet local tributary minimums.

Operations in this zone balance flow through the regulating outlet and turbine when at the top of the power pool.

Figure 3-15. Cougar Operational Summary

3.5.2.2 Cougar ResSim Water Control Diagram

A water control diagram including all zones in ResSim is provided in Figure B-3-16. A table detailing seasonal zone elevations is provided in Table B-3-12. All zones are defined in the project’s water control manual except for the buffer zone and bottom of rules. The buffer zone is for modeling purposes intended to estimate likely conservation actions taken by regulators in extremely low storage situations when local tributary flows would be prioritized above withdrawals and mainstem flow targets. The bottom of rules zone balances turbine and regulating outlet flow when at the boundary of the inactive zone, which is also the top of the power pool.

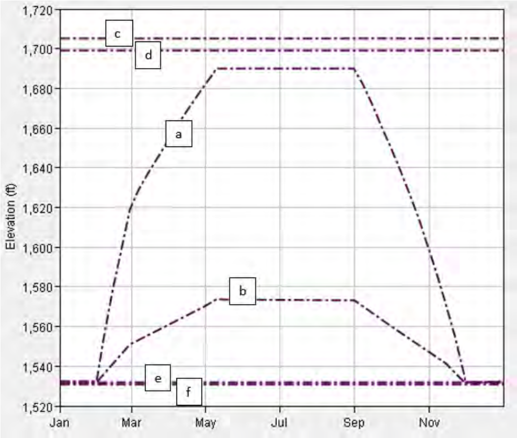


Figure 3-16. Cougar ResSim Water Control Diagram

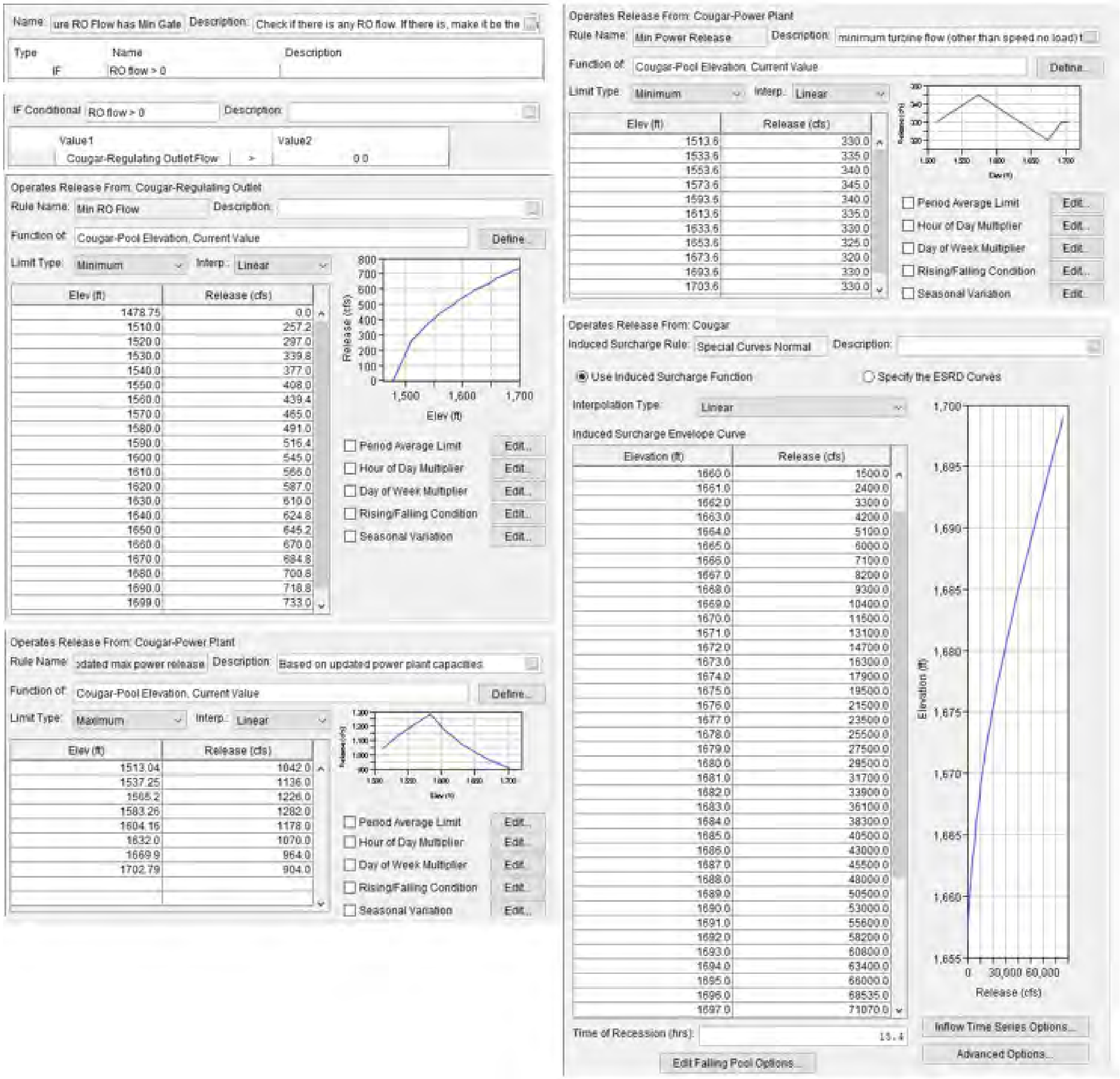
Table 3-12. Cougar Reservoir Zone Elevations

Conservation Zone (a)	Buffer Zone (b)	
Elevation, feet	Date	Elevation, feet
1532.1	1-Jan	1532.0
1532.1	31-Jan	1532.0
1555.9	28-Feb	1551.1
1579.5	30-Apr	1570.3
1600.2	10-May	1573.6
1618.9	1-Sep	1573.1
1629.1	30-Sep	1560.8
1637.7	15-Nov	1541.3
1645.9	30-Nov	1532.0
1653.8		
1660.5		
1667.9		
1674.3		
1681.4		
1687.4		
1690.0		
1690.0		
1682.4		
1671.9		
1662.4		
1651.1		
1640.8		
1628.3	Top of Dam Zone (c)	
1615.1	All Year	1705
1600.1	Flood Control Zone (d)	
1587.7	All Year	1699
1571.1	Bottom of Rules Zone (e)	
1555.3	All Year	1532
1534.7	Inactive Zone (f)	
1532.0	All Year	1531

3.5.2.3 Cougar Detailed Operational Descriptions

A description of each operation at Cougar is provided below followed by detailed screenshots of each operation in Figure B-3-17, Figure B-3-18, and Figure B-3-19.

- *Min RO Flow* - minimum flow from RO based on min gate opening
- *Updated max power release* - Max powerhouse release as a function of elevation
- *Min power release* - min flow through powerhouse with project elevation
- *Special Curves Normal* - induced surcharge function allowing for high releases to prevent overtopping
- *Winter Max* - Max release as a function of pool elevation. Designed to mimic flood season maximum releases
- *BiOp MinTrib and Withdrawals by WY* - Includes minimum flows to satisfy the 2008 BiOp and 2050 projected consumptive withdrawals.
- *Vida Regulation Goal Max* - Regulation goal at Vida is 14500 cfs
- *Spawning Flow Max* - 2008 BiOp max flow for spawning of 580 cfs
- *Con Max* - Normal maximum outflow during the conservation season as a function of date. Rule limits drafting to meet minimum flows at Salem and Albany.
- *Revised Daily BiOp Max Rate of Decrease* - Defines the next day’s minimum outflow as a function of current outflow. Designed to result in the lesser of 1' per day tailwater change or a 50% reduction in flow per the BiOp
- *Albany BiOp Min by WY* - 2008 BiOp min flow target at Albany
- *Salem BiOp Min by WY* - 2008 BiOp min flow target at Salem
- *BiOp Min* - 2008 BiOp minimum tributary flows
- *Low Turbine Flows at Low Reservoir Elevations* - specified low level releases through the turbine when flows out of project are less than the 400 cfs minimum. This low flow is either speed no load (100 cfs) or the approx. 300 cfs min. Is only used in the Bottom of Rules zone.
- *Low RO Flows When Turbine Low* - Balances RO and Turbine flows when reservoir elevations are very low.



Name: ure RO Flow has Min Gate
Description: Check if there is any RO flow. If there is, make it be the

Type	Name	Description
IF	RO flow > 0	

IF Conditional: RO flow > 0
Description:

Value1		Value2
Cougar-Regulating OutletFlow	>	0.0

Operates Release From: Cougar-Regulating Outlet
Rule Name: Min RO Flow
Description:
Function of: Cougar-Pool Elevation, Current Value
Limit Type: Minimum
Interp.: Linear

Elev (ft)	Release (cfs)
1478.75	0.0
1510.0	257.2
1520.0	297.0
1530.0	339.8
1540.0	377.0
1550.0	408.0
1560.0	439.4
1570.0	465.0
1580.0	491.0
1590.0	516.4
1600.0	545.0
1610.0	566.0
1620.0	587.0
1630.0	610.0
1640.0	624.8
1650.0	645.2
1660.0	670.0
1670.0	684.8
1680.0	700.8
1690.0	718.8
1699.0	733.0

☐ Period Average Limit
☐ Hour of Day Multiplier
☐ Day of Week Multiplier
☐ Rising/Falling Condition
☐ Seasonal Variation

Operates Release From: Cougar-Power Plant
Rule Name: :dated max power release
Description: Based on updated power plant capacities
Function of: Cougar-Pool Elevation, Current Value
Limit Type: Maximum
Interp.: Linear

Elev (ft)	Release (cfs)
1513.04	1042.0
1537.25	1136.0
1565.2	1226.0
1583.26	1282.0
1604.16	1178.0
1632.0	1070.0
1669.9	964.0
1702.79	904.0

☐ Period Average Limit
☐ Hour of Day Multiplier
☐ Day of Week Multiplier
☐ Rising/Falling Condition
☐ Seasonal Variation

Operates Release From: Cougar-Power Plant
Rule Name: Min Power Release
Description: minimum turbine flow (other than speed no load) t
Function of: Cougar-Pool Elevation, Current Value
Limit Type: Minimum
Interp.: Linear

Elev (ft)	Release (cfs)
1513.6	330.0
1533.6	335.0
1553.6	340.0
1573.6	345.0
1593.6	340.0
1613.6	335.0
1633.6	330.0
1653.6	325.0
1673.6	320.0
1693.6	330.0
1703.6	330.0

☐ Period Average Limit
☐ Hour of Day Multiplier
☐ Day of Week Multiplier
☐ Rising/Falling Condition
☐ Seasonal Variation

Operates Release From: Cougar
Induced Surcharge Rule: Special Curves Normal
Description:

● Use Induced Surcharge Function
○ Specify the ESRD Curves

Interpolation Type: Linear

Induced Surcharge Envelope Curve

Elevation (ft)	Release (cfs)
1660.0	1500.0
1661.0	2400.0
1662.0	3300.0
1663.0	4200.0
1664.0	5100.0
1665.0	6000.0
1666.0	7100.0
1667.0	8200.0
1668.0	9300.0
1669.0	10400.0
1670.0	11500.0
1671.0	13100.0
1672.0	14700.0
1673.0	16300.0
1674.0	17900.0
1675.0	19500.0
1676.0	21500.0
1677.0	23500.0
1678.0	25500.0
1679.0	27500.0
1680.0	29500.0
1681.0	31700.0
1682.0	33900.0
1683.0	36100.0
1684.0	38300.0
1685.0	40500.0
1686.0	43000.0
1687.0	45500.0
1688.0	48000.0
1689.0	50500.0
1690.0	53000.0
1691.0	55600.0
1692.0	58200.0
1693.0	60800.0
1694.0	63400.0
1695.0	66000.0
1696.0	68535.0
1697.0	71070.0

Time of Recession (hrs): 15.4

Figure 3-17. Cougar NAA Operation Set Rules

Operates Release From: Cougar

Rule Name: Winter Max

Description: Calibration

Function of: Cougar-Pool Elevation, Previous Value

Limit Type: Maximum

Interp.: Linear

Elev (ft)	Release (cfs)
1532.0	1200.0
1540.0	1200.0
1590.0	5000.0
1601.6	5270.0
1612.6	5520.0
1647.3	6320.0
1649.3	6370.0
1650.4	6390.0
1655.0	6500.0
1678.5	6500.0
1680.5	6500.0
1688.0	6500.0
1690.0	6500.0
1691.0	6500.0
1699.0	6500.0

☐ Period Average Limit
☐ Hour of Day Multiplier
☐ Day of Week Multiplier
☐ Rising/Falling Condition
☐ Seasonal Variation

Operates Release From: Cougar

Rule Name: Vida Regulation Goal Max

Description: Reg goal is 14,500, BF is 22,200, FS is 35,000

Function of: Date

Limit Type: Maximum

Interp.: Linear

Downstream Location: McKenzie_at Vida

Parameter: Flow

Date	Flow (cfs)
01Jan	14500.0

Period Average Limit
☐ Hour of Day Multiplier
☐ Day of Week Multiplier
Seasonal Variation
☐ Flow Contingency

Operates Release From: Cougar

Rule Name: BiOp Min

Description: BiOp calls for 300 cfs Jul-May and 400 cfs in June.

Function of: Date

Limit Type: Minimum

Interp.: Step

Date	Release (cfs)
01Jan	300.0
01Jun	400.0
01Jul	300.0

☐ Period Average Limit
☐ Hour of Day Multiplier
☐ Day of Week Multiplier
☐ Rising/Falling Condition
Seasonal Variation

Operates Release From: Cougar

Rule Name: Flows When Turbine Low

Description: Balances total flow out (power plus RO) with the tu

Function of: Cougar-Pool Net Inflow, Current Value

Limit Type: Specified

Interp.: Linear

Flow (cfs)	Release (cfs)
0.0	100.0
100.0	100.0
400.0	400.0
5000.0	400.0

☐ Period Average Limit
☐ Hour of Day Multiplier
☐ Day of Week Multiplier
☐ Rising/Falling Condition
☐ Seasonal Variation

Operates Release From: Cougar

Rule Name: Con Max

Description: Calibration

Function of: Date

Limit Type: Maximum

Interp.: Step

Date	Release (cfs)
01Jan	900.0
01Apr	900.0
01Aug	1000.0
01Sep	580.0
16Oct	900.0

☐ Period Average Limit
☐ Hour of Day Multiplier
☐ Day of Week Multiplier
☐ Rising/Falling Condition
Seasonal Variation

Operates Release From: Cougar

Rule Name: iOp Max Rate of Decrease

Description: Chooses the lesser of 1' per day tailwater change

Function of: Cougar-Pool Outflow, Offset Value

Limit Type: Minimum

Interp.: Linear

Flow (cfs)	Release (cfs)
100.0	50.0
800.0	400.0
1800.0	900.0
3400.0	1800.0
5600.0	3400.0
8200.0	5600.0
11300.0	8200.0
14900.0	11300.0

☐ Period Average Limit
☐ Hour of Day Multiplier
☐ Day of Week Multiplier
☐ Rising/Falling Condition
☐ Seasonal Variation

Operates Release From: Cougar

Rule Name: Spawning Flow Max

Description: WFOP Spawning season requirment of 3000cfs 0

Function of: Date

Limit Type: Maximum

Interp.: Step

Date	Release (cfs)
01Jan	999999.0
01Sep	580.0
16Oct	999999.0

☐ Period Average Limit
☐ Hour of Day Multiplier
☐ Day of Week Multiplier
☐ Rising/Falling Condition
Seasonal Variation

Operates Release From: Cougar-Power Plant

Rule Name: Low Reservoir Elevations

Description: Use this rule only near the minimum conservation

Function of: Cougar-Pool Net Inflow, Current Value

Limit Type: Specified

Interp.: Linear

Flow (cfs)	Release (cfs)
0.0	100.0
100.0	100.0
333.9	100.0
334.0	334.0
400.0	400.0
3000.0	400.0

☐ Period Average Limit
☐ Hour of Day Multiplier
☐ Day of Week Multiplier
☐ Rising/Falling Condition
☐ Seasonal Variation

Figure 3-18. Cougar NAA Operation Set Rules Continued

Operates Release From: Cougar-Dam

Rule Name: ib and Withdrawals by WY

Description:

Function of: Water Year Type, Current Value

Limit Type: Minimum

Interp.: Linear

Water Year Type	Release (cfs)											
	01Jan	01Feb	01Mar	01Apr	01May	01Jun	01Jul	01Aug	01Sep	01Oct	01Nov	01Dec
0.0	300.0	300.0	300.0	300.0	300.0	409.0	312.0	313.0	310.0	300.0	300.0	300.0
0.9	300.0	300.0	300.0	300.0	300.0	417.0	323.0	323.0	319.0	300.0	300.0	300.0
1.2	300.0	300.0	300.0	300.0	300.0	421.0	328.0	329.0	324.0	300.0	300.0	300.0
1.48	300.0	300.0	300.0	300.0	300.0	425.0	333.0	333.0	327.0	300.0	300.0	300.0
2.0	300.0	300.0	300.0	300.0	300.0	425.0	333.0	333.0	327.0	300.0	300.0	300.0

☐ Period Average Limit

☐ Hour of Day Multiplier

☐ Day of Week Multiplier

☐ Rising/Falling Condition

☑ Seasonal Variation

Operates Release From: Cougar

Rule Name: Salem BiOp Min by WY

Description:

Function of: Water Year Type, Current Value

Limit Type: Minimum

Interp.: Linear

Downstream Location: Willamette_at Salem

Parameter: Flow

Water Year Type	Flow (cfs)											
	01Jan	01Apr	16Apr	01May	01Jun	16Jun	01Jul	01Aug	16Aug	01Sep	01Oct	01Nov
0.0	0.0	15000.0	15000.0	15000.0	11000.0	5500.0	5000.0	5000.0	5000.0	5000.0	5000.0	0.0
0.9	0.0	15000.0	15000.0	15000.0	11000.0	5500.0	5000.0	5000.0	5000.0	5000.0	5000.0	0.0
1.2	0.0	17800.0	17800.0	15000.0	13000.0	8700.0	6000.0	6000.0	6500.0	7000.0	7000.0	0.0
1.48	0.0	17800.0	17800.0	15000.0	13000.0	8700.0	6000.0	6000.0	6500.0	7000.0	7000.0	0.0
2.0	0.0	17800.0	17800.0	15000.0	13000.0	8700.0	6000.0	6000.0	6500.0	7000.0	7000.0	0.0

Period Average Limit

☐ Hour of Day Multiplier

☐ Day of Week Multiplier

☑ Seasonal Variation

☐ Flow Contingency

Operates Release From: Cougar

Rule Name: Albany BiOp Min by WY

Description:

Function of: Water Year Type, Current Value

Limit Type: Minimum

Interp.: Linear

Downstream Location: Willamette_at Albany

Parameter: Flow

Water Year Type	Flow (cfs)											
	01Jan	01Apr	16Apr	01May	01Jun	16Jun	01Jul	01Aug	16Aug	01Sep	01Oct	01Nov
0.0	0.0	0.0	0.0	0.0	4000.0	4000.0	4000.0	4000.0	4000.0	4000.0	4000.0	0.0
0.9	0.0	0.0	0.0	0.0	4000.0	4000.0	4000.0	4000.0	4000.0	4000.0	4000.0	0.0
1.2	0.0	0.0	0.0	0.0	4500.0	4500.0	4500.0	4500.0	4500.0	4500.0	4500.0	0.0
1.48	0.0	0.0	0.0	0.0	4500.0	4500.0	4500.0	5000.0	5000.0	5000.0	5000.0	0.0
2.0	0.0	0.0	0.0	0.0	4500.0	4500.0	4500.0	5000.0	5000.0	5000.0	5000.0	0.0

Period Average Limit

☐ Hour of Day Multiplier

☐ Day of Week Multiplier

☑ Seasonal Variation

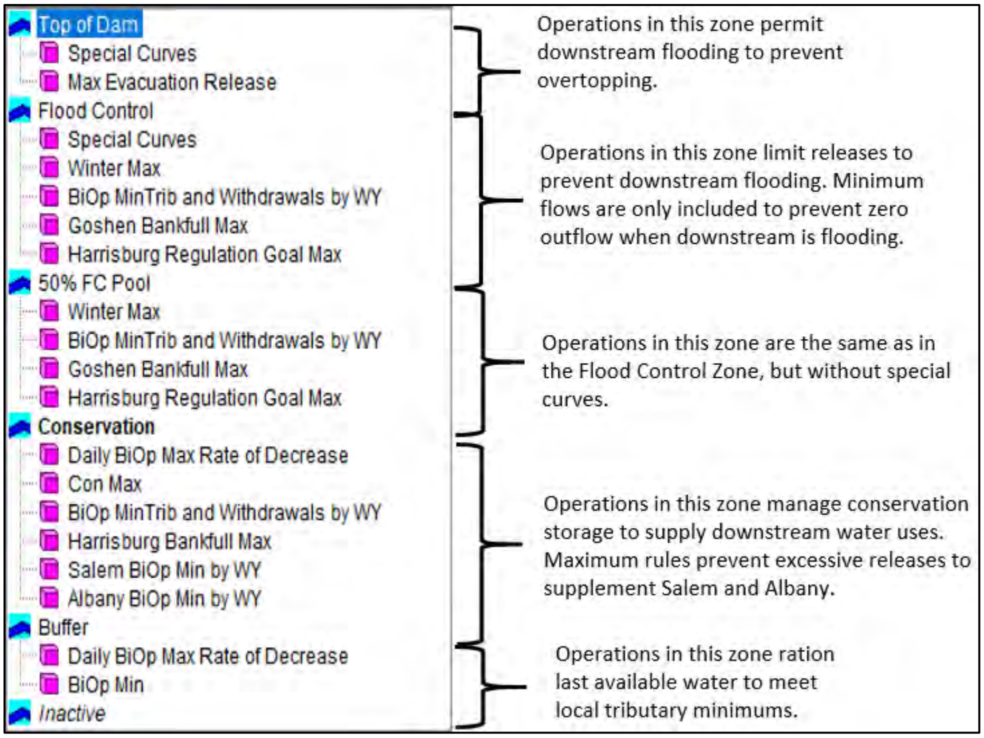
☐ Flow Contingency

Figure 3-19. Cougar NAA Operation Set Rules Continued

3.5.3 Dorena Modeled Operations

3.5.3.1 Dorena Operational Summary

A summary of reservoir zones, operations defined for each zone, and each zone's role in reservoir regulation is identified in Figure B-3-20. Operations only apply to the zone where they are located. The higher the location of an operation in a zone the higher the priority of that operation.



- Top of Dam
  - Special Curves
  - Max Evacuation Release
- Flood Control
  - Special Curves
  - Winter Max
  - BiOp MinTrib and Withdrawals by WY
  - Goshen Bankfull Max
  - Harrisburg Regulation Goal Max
- 50% FC Pool
  - Winter Max
  - BiOp MinTrib and Withdrawals by WY
  - Goshen Bankfull Max
  - Harrisburg Regulation Goal Max
- Conservation
  - Daily BiOp Max Rate of Decrease
  - Con Max
  - BiOp MinTrib and Withdrawals by WY
  - Harrisburg Bankfull Max
  - Salem BiOp Min by WY
  - Albany BiOp Min by WY
- Buffer
  - Daily BiOp Max Rate of Decrease
  - BiOp Min
- *Inactive*

Operations in this zone permit downstream flooding to prevent overtopping.

Operations in this zone limit releases to prevent downstream flooding. Minimum flows are only included to prevent zero outflow when downstream is flooding.

Operations in this zone are the same as in the Flood Control Zone, but without special curves.

Operations in this zone manage conservation storage to supply downstream water uses. Maximum rules prevent excessive releases to supplement Salem and Albany.

Operations in this zone ration last available water to meet local tributary minimums.

Figure 3-20. Dorena Operational Summary

3.5.3.2 Dorena ResSim Water Control Diagram

A water control diagram including all zones in ResSim is provided in Figure B-3-21. A table detailing seasonal zone elevations is provided in Table B-3-13. All zones are defined in the project's water control manual except for the buffer zone and 50% FC Pool. The 50% FC Pool allows for different flood control rules when at lower elevations in the flood zone. The buffer zone is for modeling purposes intended to estimate likely conservation actions taken by regulators in extremely low storage situations when local tributary flows would be prioritized above withdrawals and mainstem flow targets.

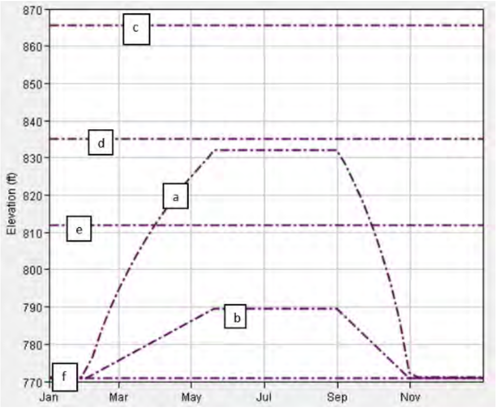


Figure 3-21. Dorena ResSim Water Control Diagram

Table 3-13. Dorena Reservoir Zone Elevations

Conservation Zone (a)		Buffer Zone (b)	
Date	Elevation, feet	Date	Elevation, feet
1-Jan	771.1	1-Jan	771.0
28-Jan	771.1	1-Feb	771.0
7-Feb	776.8	20-May	789.5
14-Feb	783.4	31-Aug	789.5
21-Feb	789.2	31-Oct	771.0
28-Feb	794.3		
7-Mar	798.9		
15-Mar	803.6		
23-Mar	808.0		
31-Mar	812.0		
7-Apr	815.3		
15-Apr	818.8		
22-Apr	821.7		
30-Apr	824.8		
7-May	827.4		
15-May	830.2		
20-May	832.0		
31-Aug	832.0		
7-Sep	828.4		
15-Sep	823.1	Top of Dam Zone (c)	
22-Sep	818.0	All Year	865.5
30-Sep	811.5	Flood Control Zone (d)	
7-Oct	805.0	All Year	835
15-Oct	796.6	50% FC Pool Zone (e)	
23-Oct	786.2	All Year	812
31-Oct	772.5	Inactive Zone (f)	
7-Nov	771.1	All Year	771

3.5.3.3 Dorena Detailed Operational Descriptions

A description of each operation at Dorena is provided below followed by detailed screenshots of each operation in Figure B-3-22 and Figure B-3-23.

- *Special Curves Normal* – induced surcharge function, a function of elevation and inflow. Designed for flood events that present risk of dam overtopping
- *Max Evacuation Release* – Max release as a function of pool elevation. Designed to mimic flood season maximum releases
- *BiOp MinTrib and Withdrawals by WY* – Includes minimum flows to satisfy the 2008 BiOp and 2050 projected consumptive withdrawals.
- *Winter Max* - Max release as a function of the previous pool elevation. Designed to mimic flood season maximum releases
- *Goshen Bankfull Max* – Bankfull at Goshen is 12,100 cfs

- *Harrisburg Regulation Goal Max* – Regulation goal at Harrisburg is 52,000 cfs
- *Daily BiOp Max Rate of Decrease* – Defines the next day's minimum outflow as a function of current outflow. Designed to result in the lesser of 1' per day tailwater change or a 50% reduction in flow per the BiOp
- *Con Max* - Normal maximum outflow during the conservation season as a function of date. Rule limits drafting to meet minimum flows at Salem and Albany.
- *Harrisburg Bankfull Max* – Bankfull at Harrisburg is 39,700 cfs
- *Albany BiOp Min by WY* - 2008 BiOp min flow target at Albany
- *Salem BiOp Min by WY* - 2008 BiOp min flow target at Salem
- *BiOp Min* – 2008 BiOp minimum tributary flows

Operates Release From: Dorena
Induced Surcharge Rule: Special Curves
Description:
● Use Induced Surcharge Function ○ Specify the ESRD Curves
Interpolation Type: Linear
Induced Surcharge Envelope Curve

Elevation (ft)	Release (cfs)
847.3	0.0
851.7	8.0
852.5	160.0
853.3	400.1
854.4	800.1
856.0	1600.2
857.0	2286.0
857.5	2667.0
858.1	3200.4
858.7	4000.5
859.0	4445.0
859.3	5000.6
859.6	5715.0
859.8	6667.5
859.9	7273.6
860.0	97500.0

Time of Recession (hrs): 26.8

Operates Release From: Dorena
Rule Name: Goshen Bankfull Max
Description: 2019 SOP
Function of: Date
Limit Type: Maximum
Interp.: Step
Downstream Location: CF Willamette_nr Goshen
Parameter: Flow

Date	Flow (cfs)
01Jan	12100.0

Operates Release From: Dorena
Rule Name: burg Regulation Goal Max
Description: 2019 SOP
Function of: Date
Limit Type: Maximum
Interp.: Linear
Downstream Location: Willamette_at Harrisburg
Parameter: Flow

Date	Flow (cfs)
01Jan	52000.0

Operates Release From: Dorena-Dam
Rule Name: Max Evacuation Release
Description:
Function of: Dorena-Pool Elevation, Previous Value
Limit Type: Maximum
Interp.: Linear

Elev (ft)	Release (cfs)
770.5	1500.0
790.0	3500.0
820.0	6000.0

Operates Release From: Dorena-Dam
Rule Name: iOp Max Rate of Decrease
Description: Chooses the lesser of 1' per day tailwater change o...
Function of: Dorena-Pool Outflow, Offset Value
Limit Type: Minimum
Interp.: Linear

Flow (cfs)	Release (cfs)
150.0	75.0
600.0	300.0
1150.0	600.0
1850.0	1150.0
2750.0	1850.0
3700.0	2750.0
4800.0	3700.0
6050.0	4800.0
7300.0	6050.0
8750.0	7300.0
10300.0	8750.0

Operates Release From: Dorena-Dam
Rule Name: Winter Max
Description: Calibration
Function of: Dorena-Pool Elevation, Previous Value
Limit Type: Maximum
Interp.: Linear

Elev (ft)	Release (cfs)
770.5	1500.0
812.0	4000.0
835.0	5000.0

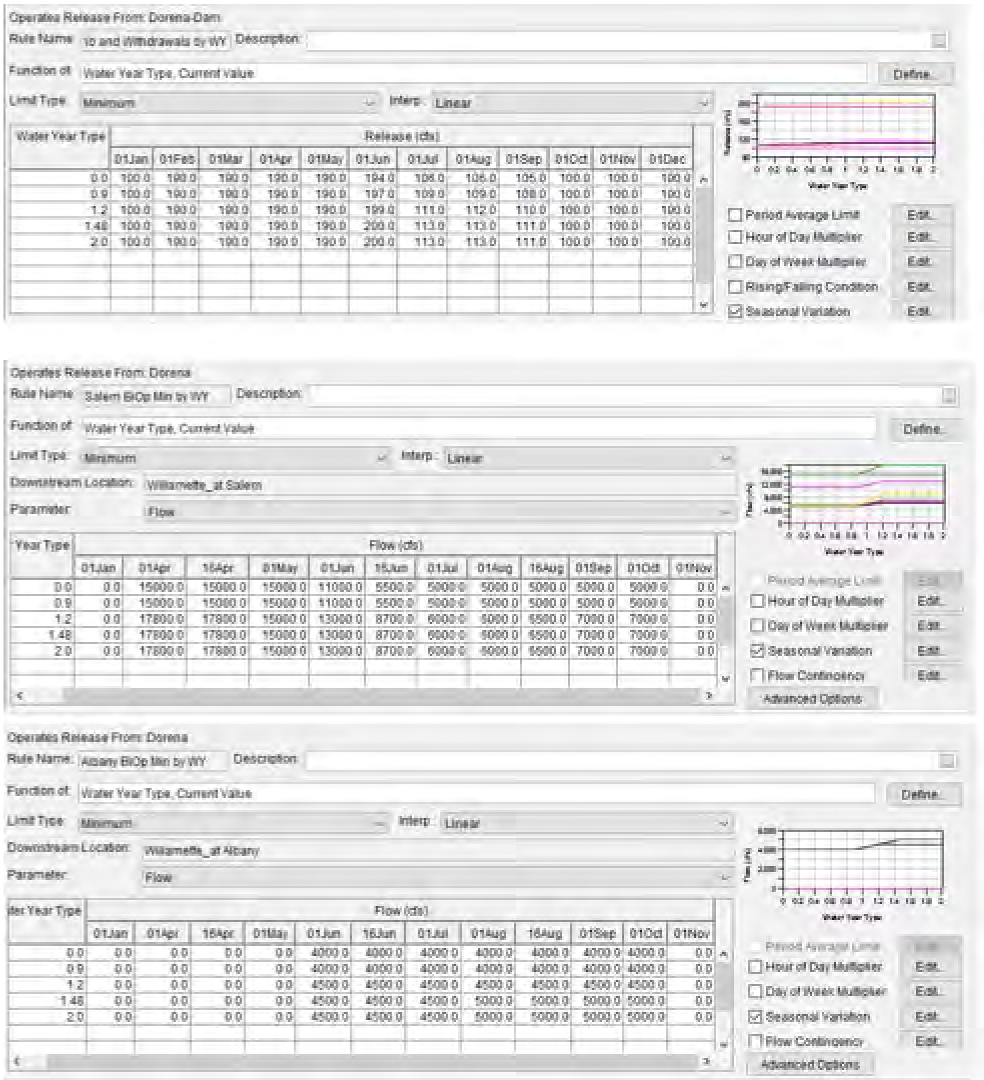
Operates Release From: Dorena-Dam
Rule Name: BiOp Min
Description: BiOp
Function of: Date
Limit Type: Minimum
Interp.: Step

Date	Release (cfs)
01Jan	100.0
01Feb	190.0
01Mar	190.0
01Apr	190.0
01May	190.0
01Jun	190.0
01Jul	100.0
01Aug	100.0
01Sep	100.0
01Oct	100.0
01Nov	100.0
01Dec	100.0

Operates Release From: Dorena-Dam
Rule Name: Con Max
Description:
Function of: Date
Limit Type: Maximum
Interp.: Step

Date	Release (cfs)
01Jan	1500.0
01Feb	1500.0
01Mar	900.0
01Apr	400.0
01May	400.0
01Jun	400.0
01Jul	200.0
01Aug	200.0
01Sep	200.0
01Oct	200.0
01Nov	1500.0
01Dec	1500.0

Figure 3-22. Dorena NAA Operation Set Rules



Operates Release From: Dorena-Dam
Rule Name: 10 and Withdrawals by WY
Description:
Function of: Water Year Type, Current Value
Limit Type: Minimum
Interp.: Linear

Water Year Type	Release (cfs)											
	01Jan	01Feb	01Mar	01Apr	01May	01Jun	01Jul	01Aug	01Sep	01Oct	01Nov	01Dec
0.0	100.0	190.0	190.0	190.0	190.0	194.0	106.0	106.0	105.0	100.0	100.0	100.0
0.9	100.0	190.0	190.0	190.0	190.0	197.0	109.0	109.0	108.0	100.0	100.0	100.0
1.2	100.0	190.0	190.0	190.0	190.0	199.0	111.0	112.0	110.0	100.0	100.0	100.0
1.48	100.0	190.0	190.0	190.0	190.0	200.0	113.0	113.0	111.0	100.0	100.0	100.0
2.0	100.0	190.0	190.0	190.0	190.0	200.0	113.0	113.0	111.0	100.0	100.0	100.0

☐ Period Average Limit
☐ Hour of Day Multiplier
☐ Day of Week Multiplier
☐ Rising/Falling Condition
☑ Seasonal Variation

Operates Release From: Dorena
Rule Name: Salem BiOp Min by WY
Description:
Function of: Water Year Type, Current Value
Limit Type: Minimum
Interp.: Linear
Downstream Location: Willamette_at Salem
Parameter: Flow

Year Type	Flow (cfs)											
	01Jan	01Apr	16Apr	01May	01Jun	15Jun	01Jul	01Aug	16Aug	01Sep	01Oct	01Nov
0.0	0.0	15000.0	15000.0	15000.0	11000.0	5500.0	5000.0	5000.0	5000.0	5000.0	5000.0	0.0
0.9	0.0	15000.0	15000.0	15000.0	11000.0	5500.0	5000.0	5000.0	5000.0	5000.0	5000.0	0.0
1.2	0.0	17800.0	17800.0	15000.0	13000.0	8700.0	6000.0	6000.0	6500.0	7000.0	7000.0	0.0
1.48	0.0	17800.0	17800.0	15000.0	13000.0	8700.0	6000.0	6000.0	6500.0	7000.0	7000.0	0.0
2.0	0.0	17800.0	17800.0	15000.0	13000.0	8700.0	6000.0	6000.0	6500.0	7000.0	7000.0	0.0

Period Average Limit
☐ Hour of Day Multiplier
☐ Day of Week Multiplier
☑ Seasonal Variation
☐ Flow Contingency

Operates Release From: Dorena
Rule Name: Albany BiOp Min by WY
Description:
Function of: Water Year Type, Current Value
Limit Type: Minimum
Interp.: Linear
Downstream Location: Willamette_at Albany
Parameter: Flow

ter Year Type	Flow (cfs)											
	01Jan	01Apr	16Apr	01May	01Jun	16Jun	01Jul	01Aug	16Aug	01Sep	01Oct	01Nov
0.0	0.0	0.0	0.0	0.0	4000.0	4000.0	4000.0	4000.0	4000.0	4000.0	4000.0	0.0
0.9	0.0	0.0	0.0	0.0	4000.0	4000.0	4000.0	4000.0	4000.0	4000.0	4000.0	0.0
1.2	0.0	0.0	0.0	0.0	4500.0	4500.0	4500.0	4500.0	4500.0	4500.0	4500.0	0.0
1.48	0.0	0.0	0.0	0.0	4500.0	4500.0	4500.0	5000.0	5000.0	5000.0	5000.0	0.0
2.0	0.0	0.0	0.0	0.0	4500.0	4500.0	4500.0	5000.0	5000.0	5000.0	5000.0	0.0

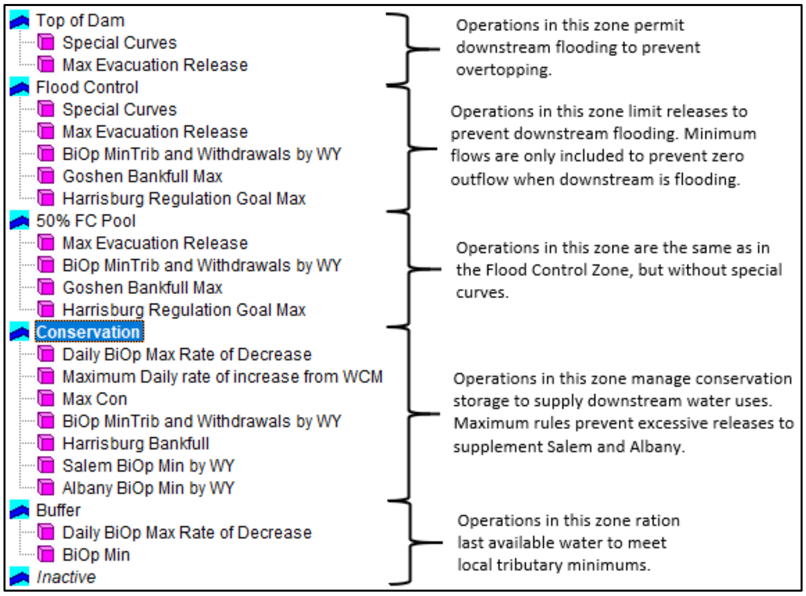
Period Average Limit
☐ Hour of Day Multiplier
☐ Day of Week Multiplier
☑ Seasonal Variation
☐ Flow Contingency

Figure 3-23. Dorena NAA Operation Set Rules Continued

3.5.4 Cottage Grove Modeled Operations

3.5.4.1 Cottage Grove Operational Summary

A summary of reservoir zones, operations defined for each zone, and each zone’s role in reservoir regulation is identified in Figure B-3-24. Operations only apply to the zone where they are located. The higher the location of an operation in a zone the higher the priority of that operation.



- Top of Dam
  - Special Curves
  - Max Evacuation Release
- Flood Control
  - Special Curves
  - Max Evacuation Release
  - BiOp MinTrib and Withdrawals by WY
  - Goshen Bankfull Max
  - Harrisburg Regulation Goal Max
- 50% FC Pool
  - Max Evacuation Release
  - BiOp MinTrib and Withdrawals by WY
  - Goshen Bankfull Max
  - Harrisburg Regulation Goal Max
- Conservation
  - Daily BiOp Max Rate of Decrease
  - Maximum Daily rate of increase from WCM
  - Max Con
  - BiOp MinTrib and Withdrawals by WY
  - Harrisburg Bankfull
  - Salem BiOp Min by WY
  - Albany BiOp Min by WY
- Buffer
  - Daily BiOp Max Rate of Decrease
  - BiOp Min
- *Inactive*

Operations in this zone permit downstream flooding to prevent overtopping.

Operations in this zone limit releases to prevent downstream flooding. Minimum flows are only included to prevent zero outflow when downstream is flooding.

Operations in this zone are the same as in the Flood Control Zone, but without special curves.

Operations in this zone manage conservation storage to supply downstream water uses. Maximum rules prevent excessive releases to supplement Salem and Albany.

Operations in this zone ration last available water to meet local tributary minimums.

Figure 3-24. Cottage Grove Operational Summary

3.5.4.2 Cottage Grove ResSim Water Control Diagram

A water control diagram including all zones in ResSim is provided in Figure B-3-25. A table detailing seasonal zone elevations is provided in Table B-3-14. All zones are defined in the project's water control manual except for the buffer zone and 50% FC Pool. The 50% FC Pool allows for different flood control rules when at lower elevations in the flood zone. The buffer zone is for modeling purposes intended to estimate likely conservation actions taken by regulators in extremely low storage situations when local tributary flows would be prioritized above withdrawals and mainstem flow targets.

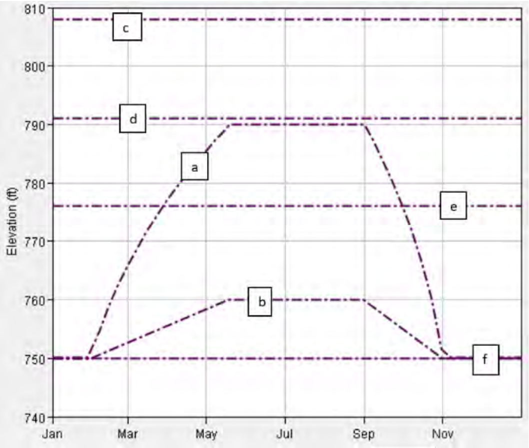


Figure 3-25. Cottage Grove ResSim Water Control Diagram

Table 3-14. Cottage Grove Reservoir Zone Elevations

Conservation Zone (a)		Buffer Zone (b)	
Date	Elevation, feet	Date	Elevation, feet
1-Jan	750.1	1-Jan	750.0
28-Jan	750.1	31-Jan	750.0
7-Feb	754.7	18-May	760.0
14-Feb	758.9	31-Aug	760.0
21-Feb	762.5	1-Nov	750.0
28-Feb	765.6		
7-Mar	768.5		
15-Mar	771.6		
23-Mar	774.3		
31-Mar	776.9		
7-Apr	779.0		
15-Apr	781.3		
22-Apr	783.2		
30-Apr	785.3		
7-May	787.1		
15-May	789.0		
19-May	790.0		
1-Sep	790.0		
7-Sep	787.5		
15-Sep	783.9	Top of Dam Zone (c)	
22-Sep	780.5	All Year	808
30-Sep	776.3	Flood Control Zone (d)	
7-Oct	772.2	All Year	791
15-Oct	766.8	50% FC Pool Zone (e)	
23-Oct	760.4	All Year	776
31-Oct	751.5	Inactive Zone (f)	
7-Nov	750.1	All Year	750

3.5.4.3 Cottage Grove Detailed Operational Descriptions

A description of each operation at Cottage Grove is provided below followed by detailed screenshots of each operation in Figure B-3-26 and Figure B-3-27.

- *Special Curves* - Induced surcharge function, a function of elevation and inflow. Designed for flood events that present risk of dam overtopping
- *Max Evacuation Release* - Max release as a function of pool elevation. Designed to mimic flood season maximum releases
- *BiOp MinTrib and Withdawals by WY* - Includes minimum flows to satisfy the 2008 BiOp and 2050 projected consumptive withdrawals.
- *Goshen Bankfull Max* - Bankfull at Goshen is 12,100 cfs

- *Harrisburg Regulation Goal Max* - Regulation goal at Harrisburg is 52,000 cfs
- *Daily BiOp Max Rate of Decrease* - Defines the next day's minimum outflow as a function of current outflow. Designed to result in the lesser of 1' per day tailwater change or a 50% reduction in flow per the BiOp
- *Maximum Daily rate of increase from WCM* - Maximum release ramping rate from water control manual.
- *Con Max* - Normal maximum outflow during the conservation season as a function of date. Rule limits drafting to meet minimum flows at Salem and Albany.
- *Harrisburg Bankfull Max* – Harrisburg bankfull max is 39,700 cfs
- *Albany BiOp Min by WY* - 2008 BiOp min flow target at Albany
- *Salem BiOp Min by WY* - 2008 BiOp min flow target at Salem
- *BiOp Min* - 2008 BiOp minimum tributary flows

Operates Release From: Cottage Grove
Induced Surcharge Rule: Special Curves
Description:
● Use Induced Surcharge Function
○ Specify the ESRD Curves
Interpolation Type: Linear
Induced Surcharge Envelope Curve

Elevation (ft)	Release (cfs)
794.9	0.0
798.9	2.0
799.3	40.0
799.6	100.1
800.1	200.1
800.8	400.2
801.3	571.7
801.5	667.0
801.7	800.4
802.0	1000.5
802.2	1111.7
802.3	1250.6
802.4	1429.3
802.5	1667.5
802.6	72700.0

Time of Recession (hrs): 30

Operates Release From: Cottage Grove-Dam
Rule Name: Max Evacuation Release
Description: Calibration
Function of: Cottage Grove-Pool Elevation, Previous Value
Limit Type: Maximum
Interp.: Linear

Elev (ft)	Release (cfs)
750.0	1000.0
760.0	2500.0
790.0	3400.0

☐ Period Average Limit
☐ Hour of Day Multiplier
☐ Day of Week Multiplier
☐ Rising/Falling Condition
☐ Seasonal Variation

Operates Release From: Cottage Grove-Dam
Rule Name: BiOp Min
Description: BiOp
Function of: Date
Limit Type: Minimum
Interp.: Step

Date	Release (cfs)
01Jan	50.0
01Feb	75.0
01Jun	75.0
01Jul	50.0

☐ Period Average Limit
☐ Hour of Day Multiplier
☐ Day of Week Multiplier
☐ Rising/Falling Condition

Operates Release From: Cottage Grove-Dam
Rule Name: iOp Max Rate of Decrease
Description: Chooses the lesser of 1' per day tailwater cl...
Function of: Cottage Grove-Pool Outflow, Offset Value
Limit Type: Minimum
Interp.: Linear

Flow (cfs)	Release (cfs)
100.0	50.0
330.0	165.0
760.0	380.0
1300.0	760.0
1900.0	1300.0
2500.0	1900.0
3300.0	2500.0
4100.0	3300.0
5100.0	4100.0
6100.0	5100.0

☐ Period Average Limit
☐ Hour of Day Multiplier
☐ Day of Week Multiplier
☐ Rising/Falling Condition
☐ Seasonal Variation

Operates Release From: Cottage Grove-Dam
Rule Name: Con Max
Description: Calibration
Function of: Date
Limit Type: Maximum
Interp.: Step

Date	Release (cfs)
01Jan	1000.0
01Feb	1000.0
01Mar	600.0
01Apr	100.0
01Nov	1000.0

☐ Period Average Limit
☐ Hour of Day Multiplier
☐ Day of Week Multiplier
☐ Rising/Falling Condition

Operates Release From: Cottage Grove
Rule Name: Goshen Bankfull Max
Description: 2019 SOP
Function of: Date
Limit Type: Maximum
Interp.: Step
Downstream Location: CF Willamette_nr Goshen
Parameter: Flow

Date	Flow (cfs)
01Jan	12100.0

☐ Hour of Day Multiplier
☐ Day of Week Multiplier

Operates Release From: Cottage Grove
Rule Name: burg Regulation Goal Max
Description: 2019 SOP
Function of: Date
Limit Type: Maximum
Interp.: Linear
Downstream Location: Willamette_at Harrisburg
Parameter: Flow

Date	Flow (cfs)
01Jan	52000.0

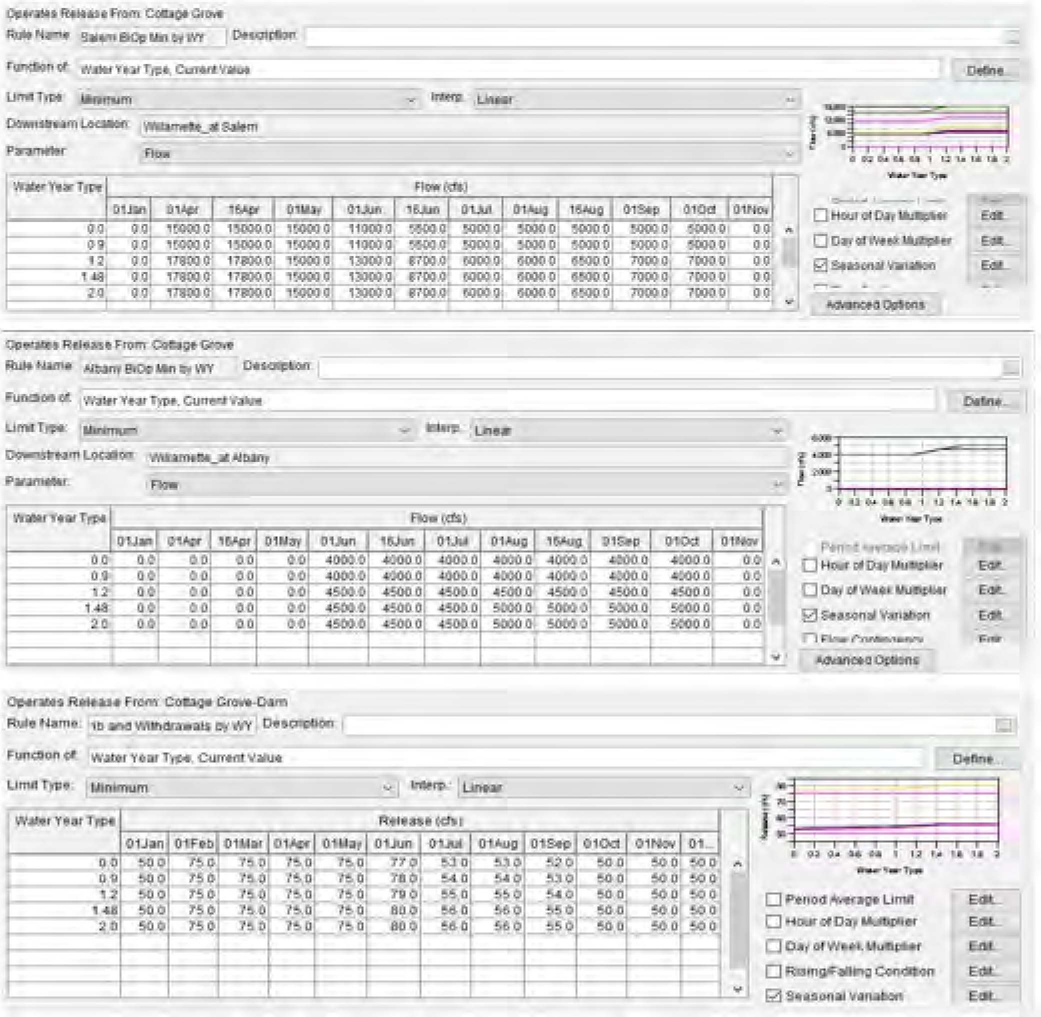
☐ Hour of Day Multiplier
☐ Day of Week Multiplier
☐ Flow Contingency

Operates Release From: Cottage Grove-Dam
Rule Name: rate of increase from WCM
Description:
Function of: Cottage Grove-Pool Outflow, Offset Value
Limit Type: Maximum
Interp.: Linear

Flow (cfs)	Release (cfs)
0.0	300.0
50.0	350.0
100.0	400.0
1000.0	1300.0
2000.0	2300.0
2700.0	3000.0
2701.0	3000.0
3000.0	3000.0

☐ Period Average Limit
☐ Hour of Day Multiplier
☐ Day of Week Multiplier
☐ Rising/Falling Condition
☐ Seasonal Variation

Figure 3-26. Cottage Grove NAA Operation Set Rules



Operates Release From: Cottage Grove
Rule Name: Salem BiOp Min by WY
Description:
Function of: Water Year Type, Current Value
Limit Type: Minimum
Interp.: Linear
Downstream Location: Willamette_at Salem
Parameter: Flow

Water Year Type	Flow (cfs)											
	01Jan	01Apr	16Apr	01May	01Jun	16Jun	01Jul	01Aug	16Aug	01Sep	01Oct	01Nov
0.0	0.0	15000.0	15000.0	15000.0	11000.0	5500.0	5000.0	5000.0	5000.0	5000.0	5000.0	0.0
0.9	0.0	15000.0	15000.0	15000.0	11000.0	5500.0	5000.0	5000.0	5000.0	5000.0	5000.0	0.0
1.2	0.0	17800.0	17800.0	15000.0	13000.0	8700.0	6000.0	6000.0	6500.0	7000.0	7000.0	0.0
1.48	0.0	17800.0	17800.0	15000.0	13000.0	8700.0	6000.0	6000.0	6500.0	7000.0	7000.0	0.0
2.0	0.0	17800.0	17800.0	15000.0	13000.0	8700.0	6000.0	6000.0	6500.0	7000.0	7000.0	0.0

☐ Hour of Day Multiplier
☐ Day of Week Multiplier
☑ Seasonal Variation

Operates Release From: Cottage Grove
Rule Name: Albany BiOp Min by WY
Description:
Function of: Water Year Type, Current Value
Limit Type: Minimum
Interp.: Linear
Downstream Location: Willamette_at Albany
Parameter: Flow

Water Year Type	Flow (cfs)											
	01Jan	01Apr	16Apr	01May	01Jun	16Jun	01Jul	01Aug	16Aug	01Sep	01Oct	01Nov
0.0	0.0	0.0	0.0	0.0	4000.0	4000.0	4000.0	4000.0	4000.0	4000.0	4000.0	0.0
0.9	0.0	0.0	0.0	0.0	4000.0	4000.0	4000.0	4000.0	4000.0	4000.0	4000.0	0.0
1.2	0.0	0.0	0.0	0.0	4500.0	4500.0	4500.0	4500.0	4500.0	4500.0	4500.0	0.0
1.48	0.0	0.0	0.0	0.0	4500.0	4500.0	4500.0	5000.0	5000.0	5000.0	5000.0	0.0
2.0	0.0	0.0	0.0	0.0	4500.0	4500.0	4500.0	5000.0	5000.0	5000.0	5000.0	0.0

☐ Hour of Day Multiplier
☐ Day of Week Multiplier
☑ Seasonal Variation
☐ Flow Contingency

Operates Release From: Cottage Grove-Dam
Rule Name: 1b and Withdrawals by WY
Description:
Function of: Water Year Type, Current Value
Limit Type: Minimum
Interp.: Linear

Water Year Type	Release (cfs)											
	01Jan	01Feb	01Mar	01Apr	01May	01Jun	01Jul	01Aug	01Sep	01Oct	01Nov	01...
0.0	50.0	75.0	75.0	75.0	75.0	77.0	53.0	53.0	52.0	50.0	50.0	50.0
0.9	50.0	75.0	75.0	75.0	75.0	78.0	54.0	54.0	53.0	50.0	50.0	50.0
1.2	50.0	75.0	75.0	75.0	75.0	79.0	55.0	55.0	54.0	50.0	50.0	50.0
1.48	50.0	75.0	75.0	75.0	75.0	80.0	56.0	56.0	55.0	50.0	50.0	50.0
2.0	50.0	75.0	75.0	75.0	75.0	80.0	56.0	56.0	55.0	50.0	50.0	50.0

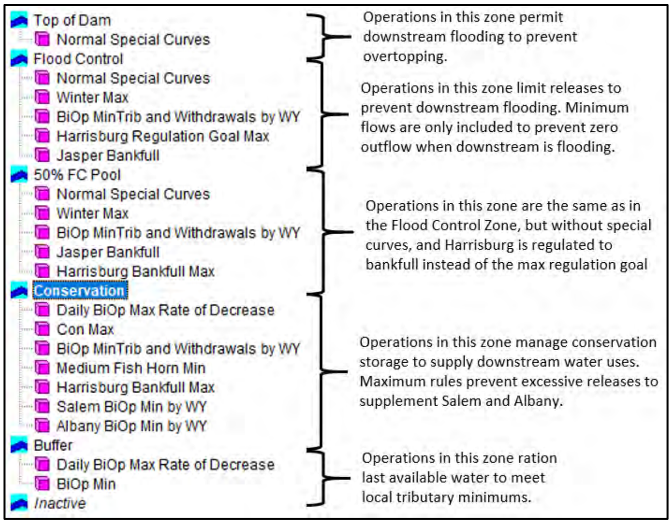
☐ Period Average Limit
☐ Hour of Day Multiplier
☐ Day of Week Multiplier
☐ Rising/Falling Condition
☑ Seasonal Variation

Figure 3-27. Cottage Grove NAA Operation Set Rules Continued

3.5.5 Fall Creek Modeled Operations

3.5.5.1 Fall Creek Operational Summary

A summary of reservoir zones, operations defined for each zone, and each zone's role in reservoir regulation is identified in Figure B-3-28. Operations only apply to the zone where they are located. The higher the location of an operation in a zone the higher the priority of that operation.



- Top of Dam
  - Normal Special Curves
- Flood Control
  - Normal Special Curves
  - Winter Max
  - BiOp MinTrib and Withdrawals by WY
  - Harrisburg Regulation Goal Max
  - Jasper Bankfull
- 50% FC Pool
  - Normal Special Curves
  - Winter Max
  - BiOp MinTrib and Withdrawals by WY
  - Jasper Bankfull
  - Harrisburg Bankfull Max
- Conservation
  - Daily BiOp Max Rate of Decrease
  - Con Max
  - BiOp MinTrib and Withdrawals by WY
  - Medium Fish Horn Min
  - Harrisburg Bankfull Max
  - Salem BiOp Min by WY
  - Albany BiOp Min by WY
- Buffer
  - Daily BiOp Max Rate of Decrease
  - BiOp Min
- *Inactive*

Operations in this zone permit downstream flooding to prevent overtopping.

Operations in this zone limit releases to prevent downstream flooding. Minimum flows are only included to prevent zero outflow when downstream is flooding.

Operations in this zone are the same as in the Flood Control Zone, but without special curves, and Harrisburg is regulated to bankfull instead of the max regulation goal

Operations in this zone manage conservation storage to supply downstream water uses. Maximum rules prevent excessive releases to supplement Salem and Albany.

Operations in this zone ration last available water to meet local tributary minimums.

Figure 3-28. Fall Creek Operational Summary

3.5.5.2 Fall Creek ResSim Water Control Diagram

A water control diagram including all zones in ResSim is provided in Figure B-3-29. A table detailing seasonal zone elevations is provided in Table B-3-15. All zones are defined in the project's water control manual except for the buffer zone and 50% FC Pool. The 50% FC Pool allows for different flood control rules when at lower elevations in the flood zone. The buffer zone is for modeling purposes intended to estimate likely conservation actions taken by regulators in extremely low storage situations when local tributary flows would be prioritized above withdrawals and mainstem flow targets.

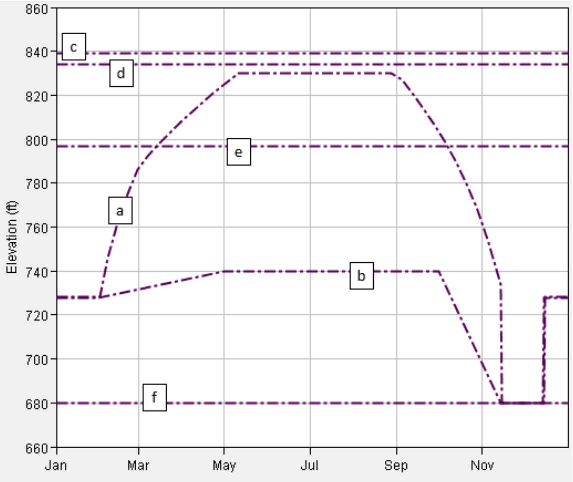


Figure 3-29. Fall Creek ResSim Water Control Diagram

Table 3-15. Fall Creek Reservoir Zone Elevations

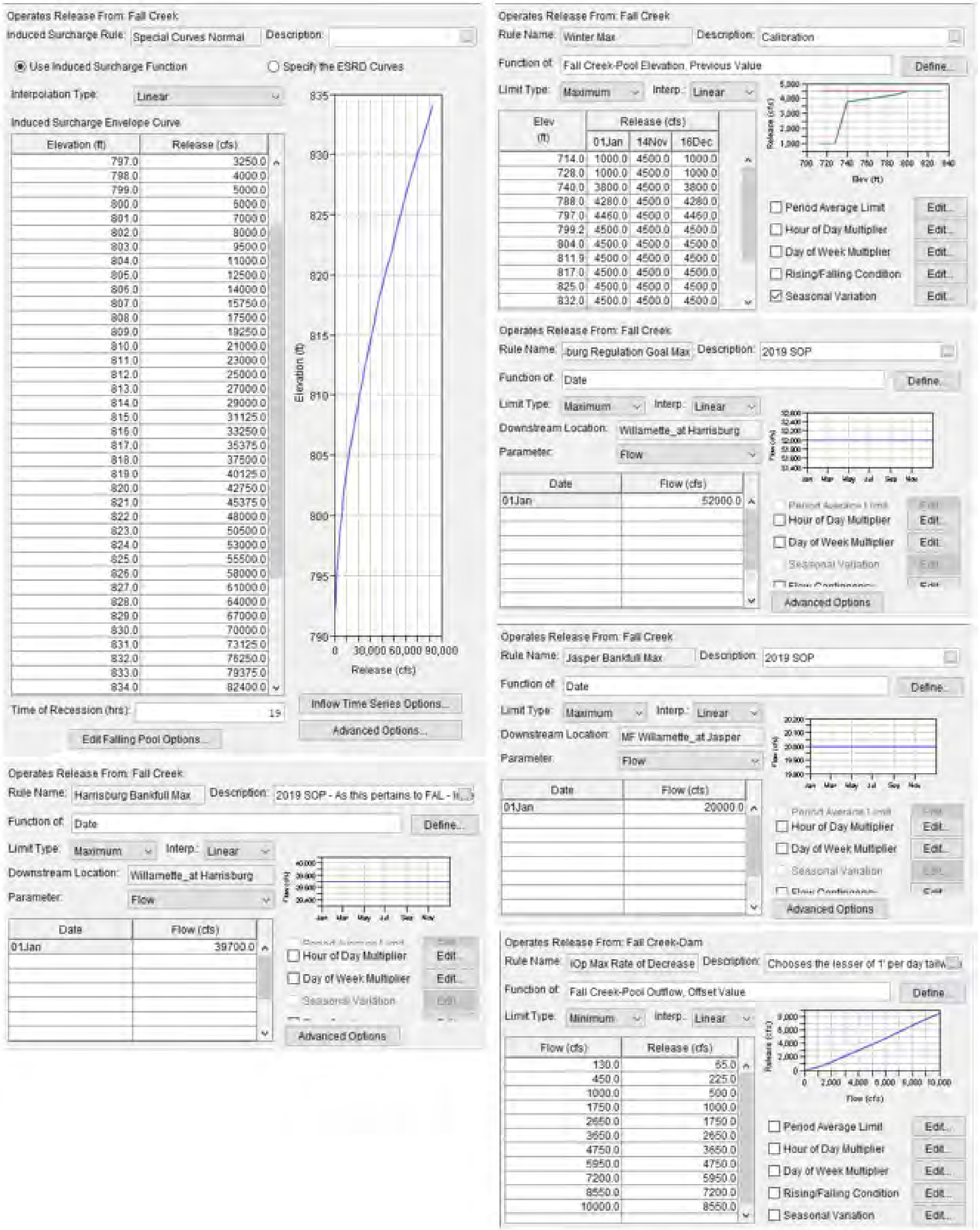
Conservation Zone (a)		Buffer Zone (b)	
Date	Elevation, feet	Date	Elevation, feet
1-Jan	728.1	1-Jan	728.00
28-Jan	728.1	31-Jan	728.00
1-Feb	728.1	1-May	740.00
7-Feb	745.8	1-Oct	740.00
14-Feb	761.9	14-Nov	680.00
21-Feb	775.0	14-Dec	680.00
28-Feb	786.2	15-Dec	728.00
7-Mar	792.1		
15-Mar	797.8		
23-Mar	803.1		
31-Mar	808.0		
7-Apr	812.1		
15-Apr	816.6		
22-Apr	820.4		
30-Apr	824.5		
7-May	828.0		
11-May	830.0		
22-Aug	830.0		
28-Aug	830.0		
5-Sep	826.8		
12-Sep	821.0		
20-Sep	814.0		
27-Sep	807.4		
5-Oct	799.1		
13-Oct	790.0	Top of dam Zone (c)	
21-Oct	779.5	All Year	839
28-Oct	768.9	Flood Control Zone (d)	
5-Nov	754.5	All Year	834
14-Nov	733.8	50% Flood Control Pool (e)	
15-Nov	680.1	All Year	834
15-Dec	680.1	Inactive Zone (f)	
16-Dec	728.1	All Year	680

3.5.5.3 Fall Creek Detailed Operational Descriptions

A description of each operation at Fall Creek is provided below followed by detailed screenshots of each operation in Figure B-3-30 and Figure B-3-31.

- *Normal Special Curves* - Induced surcharge function, a function of elevation and inflow. Designed for flood events that present risk of dam overtopping
- *Winter Max* - Max release as a function of pool elevation. Designed to mimic flood season maximum releases
- *BiOp MinTrib and Withdrawals by WY* - Includes minimum flows to satisfy the 2008 BiOp and 2050 projected consumptive withdrawals.
- *Harrisburg Regulation Goal Max* - Regulation goal at Harrisburg is 52,000 cfs
- *Jasper bankfull Max* - Jasper bankfull is 20,000 cfs

- *Harrisburg Bankfull Max* - Harrisburg bankfull max is 39,700 cfs
- *Daily BiOp Max Rate of Decrease* - Defines the next day's minimum outflow as a function of current outflow. Designed to result in the lesser of 1' per day tailwater change or a 50% reduction in flow per the BiOp
- *Con Max* - Normal maximum outflow during the conservation season as a function of date. Rule limits drafting to meet minimum flows at Salem and Albany.
- *Medium Fish Horn Min* - Typical minimum fish horn flow
- *Albany BiOp Min by WY* - 2008 BiOp min flow target at Albany
- *Salem BiOp Min by WY* - 2008 BiOp min flow target at Salem
- *BiOp Min* - 2008 BiOp minimum tributary flows



Operates Release From: Fall Creek

Induced Surcharge Rule: Special Curves Normal

Description:

● Use Induced Surcharge Function ○ Specify the ESRD Curves

Interpolation Type: Linear

Induced Surcharge Envelope Curve

Elevation (ft)	Release (cfs)
797.0	3250.0
798.0	4000.0
799.0	5000.0
800.0	6000.0
801.0	7000.0
802.0	8000.0
803.0	9500.0
804.0	11000.0
805.0	12500.0
806.0	14000.0
807.0	15750.0
808.0	17500.0
809.0	19250.0
810.0	21000.0
811.0	23000.0
812.0	25000.0
813.0	27000.0
814.0	29000.0
815.0	31125.0
816.0	33250.0
817.0	35375.0
818.0	37500.0
819.0	40125.0
820.0	42750.0
821.0	45375.0
822.0	48000.0
823.0	50500.0
824.0	53000.0
825.0	55500.0
826.0	58000.0
827.0	61000.0
828.0	64000.0
829.0	67000.0
830.0	70000.0
831.0	73125.0
832.0	76250.0
833.0	79375.0
834.0	82400.0

Time of Recession (hrs): 19

Operates Release From: Fall Creek

Rule Name: Harrisburg Bankfull Max

Description: 2019 SOP - As this pertains to FAL - I

Function of: Date

Limit Type: Maximum

Interp.: Linear

Downstream Location: Willamette_at Harrisburg

Parameter: Flow

Date	Flow (cfs)
01Jan	39700.0

☐ Hour of Day Multiplier

☐ Day of Week Multiplier

Operates Release From: Fall Creek

Rule Name: Winter Max

Description: Calibration

Function of: Fall Creek-Pool Elevation, Previous Value

Limit Type: Maximum

Interp.: Linear

Elev (ft)	Release (cfs)		
	01Jan	14Nov	16Dec
714.0	1000.0	4500.0	1000.0
728.0	1000.0	4500.0	1000.0
740.0	3800.0	4500.0	3800.0
788.0	4280.0	4500.0	4280.0
797.0	4460.0	4500.0	4460.0
799.2	4500.0	4500.0	4500.0
804.0	4500.0	4500.0	4500.0
811.9	4500.0	4500.0	4500.0
817.0	4500.0	4500.0	4500.0
825.0	4500.0	4500.0	4500.0
832.0	4500.0	4500.0	4500.0

☐ Period Average Limit

☐ Hour of Day Multiplier

☐ Day of Week Multiplier

☐ Rising/Falling Condition

☑ Seasonal Variation

Operates Release From: Fall Creek

Rule Name: burg Regulation Goal Max

Description: 2019 SOP

Function of: Date

Limit Type: Maximum

Interp.: Linear

Downstream Location: Willamette_at Harrisburg

Parameter: Flow

Date	Flow (cfs)
01Jan	52000.0

☐ Hour of Day Multiplier

☐ Day of Week Multiplier

Operates Release From: Fall Creek

Rule Name: Jasper Bankfull Max

Description: 2019 SOP

Function of: Date

Limit Type: Maximum

Interp.: Linear

Downstream Location: MF Willamette_at Jasper

Parameter: Flow

Date	Flow (cfs)
01Jan	20000.0

☐ Hour of Day Multiplier

☐ Day of Week Multiplier

Operates Release From: Fall Creek-Dam

Rule Name: iOp Max Rate of Decrease

Description: Chooses the lesser of 1' per day tailw

Function of: Fall Creek-Pool Outflow, Offset Value

Limit Type: Minimum

Interp.: Linear

Flow (cfs)	Release (cfs)
130.0	65.0
450.0	225.0
1000.0	500.0
1750.0	1000.0
2650.0	1750.0
3650.0	2650.0
4750.0	3650.0
5950.0	4750.0
7200.0	5950.0
8550.0	7200.0
10000.0	8550.0

☐ Period Average Limit

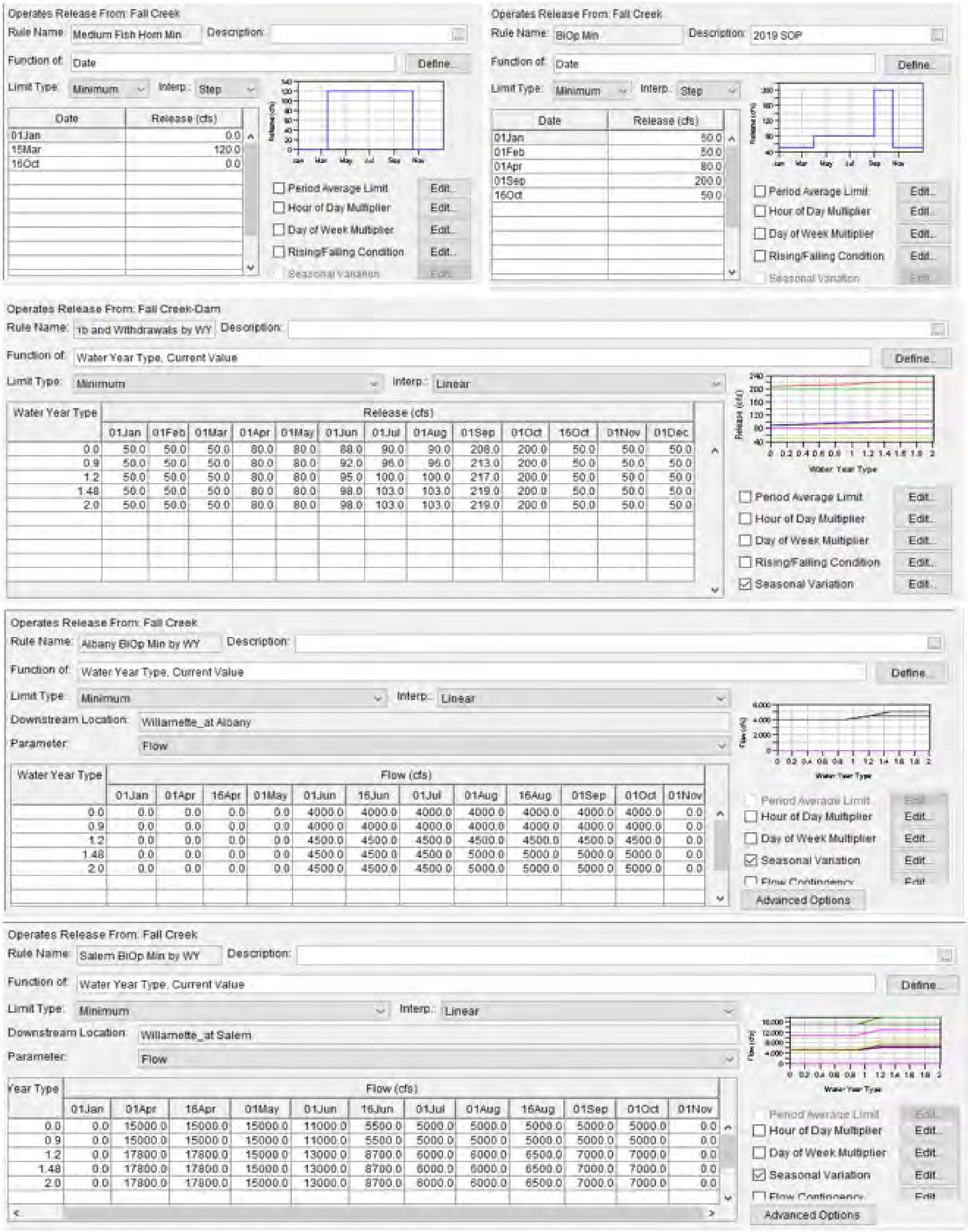
☐ Hour of Day Multiplier

☐ Day of Week Multiplier

☐ Rising/Falling Condition

☐ Seasonal Variation

Figure 3-30. Fall Creek NAA Operation Set Rules


Operates Release From: Fall Creek

Rule Name: Medium Fish Horn Min

Description:

Function of: Date

Limit Type: Minimum

Interp.: Step

Date	Release (cfs)
01Jan	0.0
15Mar	120.0
16Oct	0.0

☐ Period Average Limit

☐ Hour of Day Multiplier

☐ Day of Week Multiplier

☐ Rising/Falling Condition

Seasonal Variation

Operates Release From: Fall Creek

Rule Name: BiOp Min

Description: 2019 SOP

Function of: Date

Limit Type: Minimum

Interp.: Step

Date	Release (cfs)
01Jan	50.0
01Feb	50.0
01Apr	80.0
01Sep	200.0
16Oct	50.0

☐ Period Average Limit

☐ Hour of Day Multiplier

☐ Day of Week Multiplier

☐ Rising/Falling Condition

Seasonal Variation

Operates Release From: Fall Creek-Dam

Rule Name: ib and Withdrawals by WY

Description:

Function of: Water Year Type, Current Value

Limit Type: Minimum

Interp.: Linear

Water Year Type	Release (cfs)												
	01Jan	01Feb	01Mar	01Apr	01May	01Jun	01Jul	01Aug	01Sep	01Oct	16Oct	01Nov	01Dec
0.0	50.0	50.0	50.0	80.0	80.0	88.0	90.0	90.0	208.0	200.0	50.0	50.0	50.0
0.9	50.0	50.0	50.0	80.0	80.0	92.0	96.0	96.0	213.0	200.0	50.0	50.0	50.0
1.2	50.0	50.0	50.0	80.0	80.0	95.0	100.0	100.0	217.0	200.0	50.0	50.0	50.0
1.48	50.0	50.0	50.0	80.0	80.0	98.0	103.0	103.0	219.0	200.0	50.0	50.0	50.0
2.0	50.0	50.0	50.0	80.0	80.0	98.0	103.0	103.0	219.0	200.0	50.0	50.0	50.0

☐ Period Average Limit

☐ Hour of Day Multiplier

☐ Day of Week Multiplier

☐ Rising/Falling Condition

☑ Seasonal Variation

Operates Release From: Fall Creek

Rule Name: Albany BiOp Min by WY

Description:

Function of: Water Year Type, Current Value

Limit Type: Minimum

Interp.: Linear

Downstream Location: Willamette_at Albany

Parameter: Flow

Water Year Type	Flow (cfs)											
	01Jan	01Apr	16Apr	01May	01Jun	16Jun	01Jul	01Aug	16Aug	01Sep	01Oct	01Nov
0.0	0.0	0.0	0.0	0.0	4000.0	4000.0	4000.0	4000.0	4000.0	4000.0	4000.0	0.0
0.9	0.0	0.0	0.0	0.0	4000.0	4000.0	4000.0	4000.0	4000.0	4000.0	4000.0	0.0
1.2	0.0	0.0	0.0	0.0	4500.0	4500.0	4500.0	4500.0	4500.0	4500.0	4500.0	0.0
1.48	0.0	0.0	0.0	0.0	4500.0	4500.0	4500.0	5000.0	5000.0	5000.0	5000.0	0.0
2.0	0.0	0.0	0.0	0.0	4500.0	4500.0	4500.0	5000.0	5000.0	5000.0	5000.0	0.0

Period Average Limit

☐ Hour of Day Multiplier

☐ Day of Week Multiplier

☑ Seasonal Variation

☐ Flow Contingency

Operates Release From: Fall Creek

Rule Name: Salem BiOp Min by WY

Description:

Function of: Water Year Type, Current Value

Limit Type: Minimum

Interp.: Linear

Downstream Location: Willamette_at Salem

Parameter: Flow

Year Type	Flow (cfs)											
	01Jan	01Apr	16Apr	01May	01Jun	16Jun	01Jul	01Aug	16Aug	01Sep	01Oct	01Nov
0.0	0.0	15000.0	15000.0	15000.0	11000.0	5500.0	5000.0	5000.0	5000.0	5000.0	5000.0	0.0
0.9	0.0	15000.0	15000.0	15000.0	11000.0	5500.0	5000.0	5000.0	5000.0	5000.0	5000.0	0.0
1.2	0.0	17800.0	17800.0	15000.0	13000.0	8700.0	6000.0	6000.0	6500.0	7000.0	7000.0	0.0
1.48	0.0	17800.0	17800.0	15000.0	13000.0	8700.0	6000.0	6000.0	6500.0	7000.0	7000.0	0.0
2.0	0.0	17800.0	17800.0	15000.0	13000.0	8700.0	6000.0	6000.0	6500.0	7000.0	7000.0	0.0

Period Average Limit

☐ Hour of Day Multiplier

☐ Day of Week Multiplier

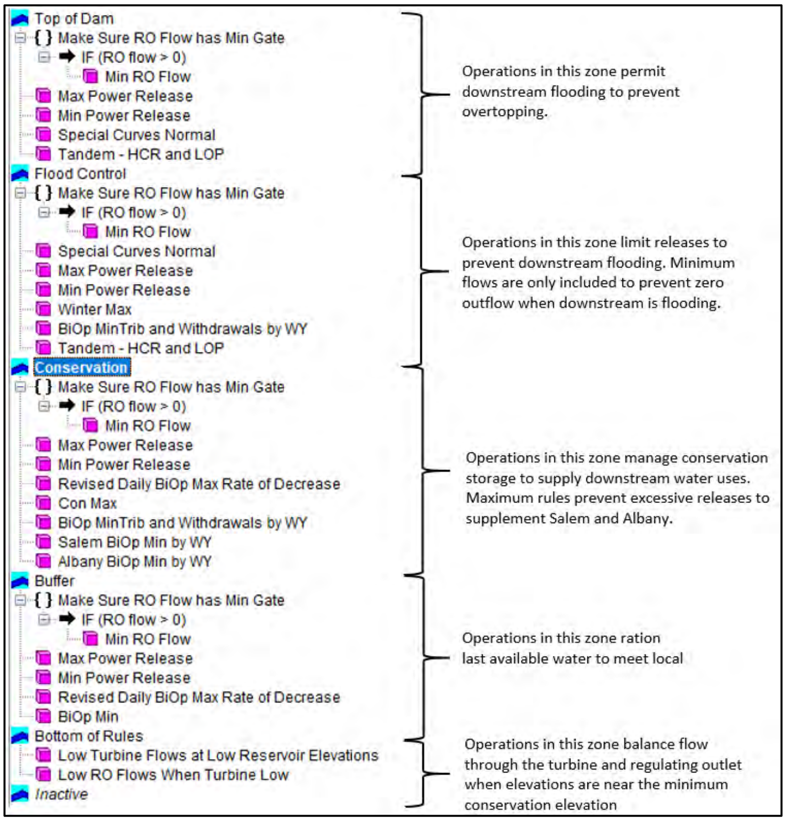
☑ Seasonal Variation

☐ Flow Contingency

Figure 3-31. Fall Creek NAA Operation Set Rules ContinuedHills Creek Modeled Operations

3.5.5.4 Hills Creek Operational Summary

A summary of reservoir zones, operations defined for each zone, and each zone's role in reservoir regulation is identified in Figure B-3-32. Operations only apply to the zone where they are located. The higher the location of an operation in a zone the higher the priority of that operation.



Top of Dam
- { } Make Sure RO Flow has Min Gate
  - IF (RO flow > 0)
    - Min RO Flow
- Max Power Release
- Min Power Release
- Special Curves Normal
- Tandem - HCR and LOP

Flood Control
- { } Make Sure RO Flow has Min Gate
  - IF (RO flow > 0)
    - Min RO Flow
- Special Curves Normal
- Max Power Release
- Min Power Release
- Winter Max
- BiOp MinTrib and Withdrawals by WY
- Tandem - HCR and LOP

Conservation
- { } Make Sure RO Flow has Min Gate
  - IF (RO flow > 0)
    - Min RO Flow
- Max Power Release
- Min Power Release
- Revised Daily BiOp Max Rate of Decrease
- Con Max
- BiOp MinTrib and Withdrawals by WY
- Salem BiOp Min by WY
- Albany BiOp Min by WY

Buffer
- { } Make Sure RO Flow has Min Gate
  - IF (RO flow > 0)
    - Min RO Flow
- Max Power Release
- Min Power Release
- Revised Daily BiOp Max Rate of Decrease
- BiOp Min

Bottom of Rules
- Low Turbine Flows at Low Reservoir Elevations
- Low RO Flows When Turbine Low

Inactive

Operations in this zone permit downstream flooding to prevent overtopping.

Operations in this zone limit releases to prevent downstream flooding. Minimum flows are only included to prevent zero outflow when downstream is flooding.

Operations in this zone manage conservation storage to supply downstream water uses. Maximum rules prevent excessive releases to supplement Salem and Albany.

Operations in this zone ration last available water to meet local

Operations in this zone balance flow through the turbine and regulating outlet when elevations are near the minimum conservation elevation

Figure 3-32. Hills Creek Operational Summary

3.5.5.5 Hills Creek ResSim Water Control Diagram

A water control diagram including all zones in ResSim is provided in Figure B-3-33. A table detailing seasonal zone elevations is provided in Table B-3-16. Hills Creek currently (August 2020) has an Interim Risk Reduction Measure (IRRM) pool restriction, but this pool restriction is not in the NAA because it is interim. All zones are defined in the project's water control manual except for the buffer zone and 50% FC Pool. The 50% FC Pool allows for different flood control rules when at lower elevations in the flood zone. The buffer zone is for modeling purposes intended to estimate likely conservation actions taken by regulators in extremely low storage situations when local tributary flows would be prioritized above withdrawals and mainstem flow targets.

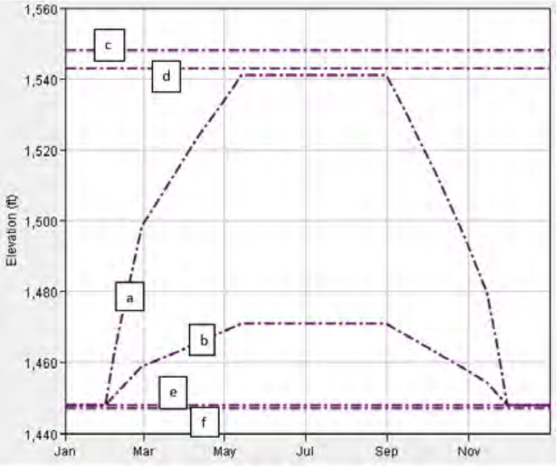


Figure 3-33. Hills Creek ResSim Water Control Diagram

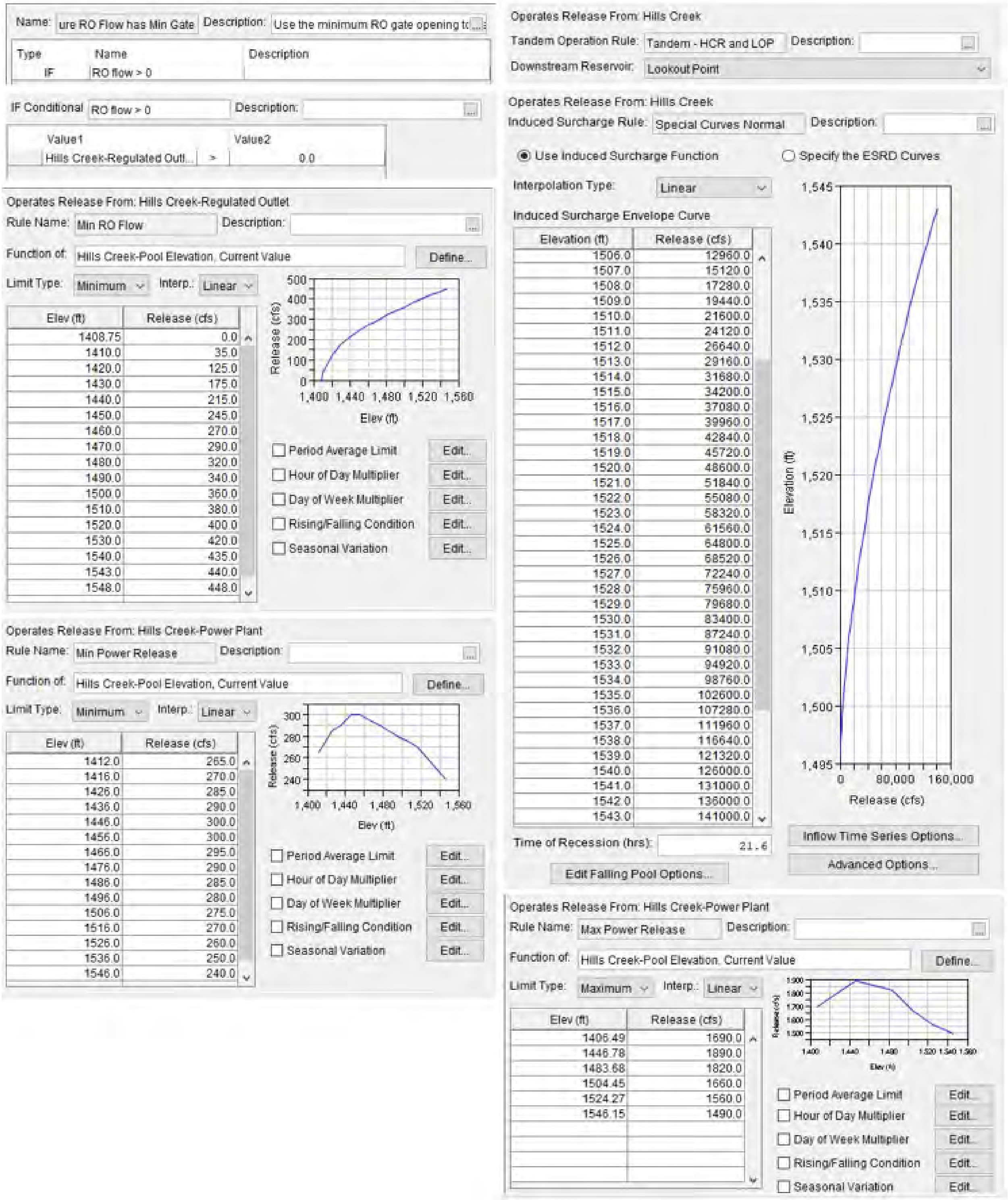
Table 3-16. Hills Creek Reservoir Zone Elevations

Conservation Zone (a)		Buffer Zone (b)	
Date	Elevation, feet	Date	Elevation, feet
1-Jan	1448.1	1-Jan	1448.0
31-Jan	1448.1	31-Jan	1448.0
7-Feb	1462.2	28-Feb	1458.9
14-Feb	1475.2	31-Mar	1463.8
21-Feb	1487.2	1-Apr	1464.0
28-Feb	1498.4	14-May	1470.8
7-Mar	1502.7	31-Aug	1470.8
15-Mar	1507.6	31-Oct	1457.7
23-Mar	1512.4	15-Nov	1454.5
31-Mar	1517.1	30-Nov	1448.0
7-Apr	1521.1	31-Dec	1448.0
15-Apr	1525.6		
22-Apr	1529.4		
30-Apr	1533.7		
7-May	1537.4		
14-May	1541.0		
31-Aug	1541.0		
7-Sep	1536.1		
15-Sep	1530.3		
22-Sep	1525.1		
30-Sep	1519.0		
7-Oct	1513.5	Top of Dam Zone (c)	
15-Oct	1507.0	All Year	1548
23-Oct	1500.4	Flood Control Zone (d)	
31-Oct	1493.4	All Year	1543
7-Nov	1487.2	Bottom of Rules Zone (e)	
15-Nov	1479.7	All Year	1448
22-Nov	1465.7	Inactvie Zone (f)	
30-Nov	1448.1	All Year	1447.0

3.5.5.6 Hills Creek Detailed Operational Descriptions

A description of each operation at Hills Creek is provided below followed by detailed screenshots of each operation in Figure B-3-34 and Figure B-3-31.

- *Min RO Flow* - Minimum flow from RO based on min gate opening
- *Max Power Release* - Max flow through powerhouse
- *Min Power Release* - Min flow through powerhouse, but different than speed no load
- *Special Curves Normal* - induced surcharge function, a function of elevation and inflow. Designed for flood events that present risk of dam overtopping
- *Tandem - HCR and LOP* - Helps Hills Creek and Lookout Point balance storage
- *Winter Max* - Max release as a function of pool elevation. Designed to mimic flood season maximum releases
- *BiOp MinTrib and Withdrawals by WY* - Includes minimum flows to satisfy the 2008 BiOp and 2050 projected consumptive withdrawals.
- *Revised Daily BiOp Max Rate of Decrease* - Defines the next day’s minimum outflow as a function of current outflow. Designed to result in the lesser of 1' per day tailwater change or a 50% reduction in flow per the BiOp
- *Con Max* - Maximum outflow during the conservation season as a function of date. Rule limits drafting to meet minimum flows at Salem and Albany.
- *Salem BiOp Min by WY* - 2008 BiOp min flow target at Salem
- *Albany BiOp Min by WY* - 2008 BiOp min flow target at Albany
- *BiOp Min* - 2008 BiOp minimum tributary flow
- *Low Turbine Flows at Low Reservoir Elevations* - Balances flow through the turbine and regulating outlet when pool elevations are very low
- *Low RO Flows When Turbine Low* - Balances flow through the turbine and regulating outlet when pool elevations are very low



Name: ure RO Flow has Min Gate Description: Use the minimum RO gate opening t

Type	Name	Description
IF	RO flow > 0	

IF Conditional: RO flow > 0 Description:

Value1		Value2
Hills Creek-Regulated Outl...	>	0.0

Operates Release From: Hills Creek-Regulated Outlet
Rule Name: Min RO Flow Description:
Function of: Hills Creek-Pool Elevation, Current Value
Limit Type: Minimum Interp.: Linear

Elev (ft)	Release (cfs)
1408.75	0.0
1410.0	35.0
1420.0	125.0
1430.0	175.0
1440.0	215.0
1450.0	245.0
1460.0	270.0
1470.0	290.0
1480.0	320.0
1490.0	340.0
1500.0	360.0
1510.0	380.0
1520.0	400.0
1530.0	420.0
1540.0	435.0
1543.0	440.0
1548.0	448.0

☐ Period Average Limit
☐ Hour of Day Multiplier
☐ Day of Week Multiplier
☐ Rising/Falling Condition
☐ Seasonal Variation

Operates Release From: Hills Creek-Power Plant
Rule Name: Min Power Release Description:
Function of: Hills Creek-Pool Elevation, Current Value
Limit Type: Minimum Interp.: Linear

Elev (ft)	Release (cfs)
1412.0	265.0
1416.0	270.0
1426.0	285.0
1436.0	290.0
1446.0	300.0
1456.0	300.0
1466.0	295.0
1476.0	290.0
1486.0	285.0
1496.0	280.0
1506.0	275.0
1516.0	270.0
1526.0	260.0
1536.0	250.0
1546.0	240.0

☐ Period Average Limit
☐ Hour of Day Multiplier
☐ Day of Week Multiplier
☐ Rising/Falling Condition
☐ Seasonal Variation

Operates Release From: Hills Creek
Tandem Operation Rule: Tandem - HCR and LOP Description:
Downstream Reservoir: Lookout Point

Operates Release From: Hills Creek
Induced Surcharge Rule: Special Curves Normal Description:
● Use Induced Surcharge Function ○ Specify the ESRD Curves
Interpolation Type: Linear

Induced Surcharge Envelope Curve

Elevation (ft)	Release (cfs)
1506.0	12960.0
1507.0	15120.0
1508.0	17280.0
1509.0	19440.0
1510.0	21600.0
1511.0	24120.0
1512.0	26640.0
1513.0	29160.0
1514.0	31680.0
1515.0	34200.0
1516.0	37080.0
1517.0	39960.0
1518.0	42840.0
1519.0	45720.0
1520.0	48600.0
1521.0	51840.0
1522.0	55080.0
1523.0	58320.0
1524.0	61560.0
1525.0	64800.0
1526.0	68520.0
1527.0	72240.0
1528.0	75960.0
1529.0	79680.0
1530.0	83400.0
1531.0	87240.0
1532.0	91080.0
1533.0	94920.0
1534.0	98760.0
1535.0	102600.0
1536.0	107280.0
1537.0	111960.0
1538.0	116640.0
1539.0	121320.0
1540.0	126000.0
1541.0	131000.0
1542.0	136000.0
1543.0	141000.0

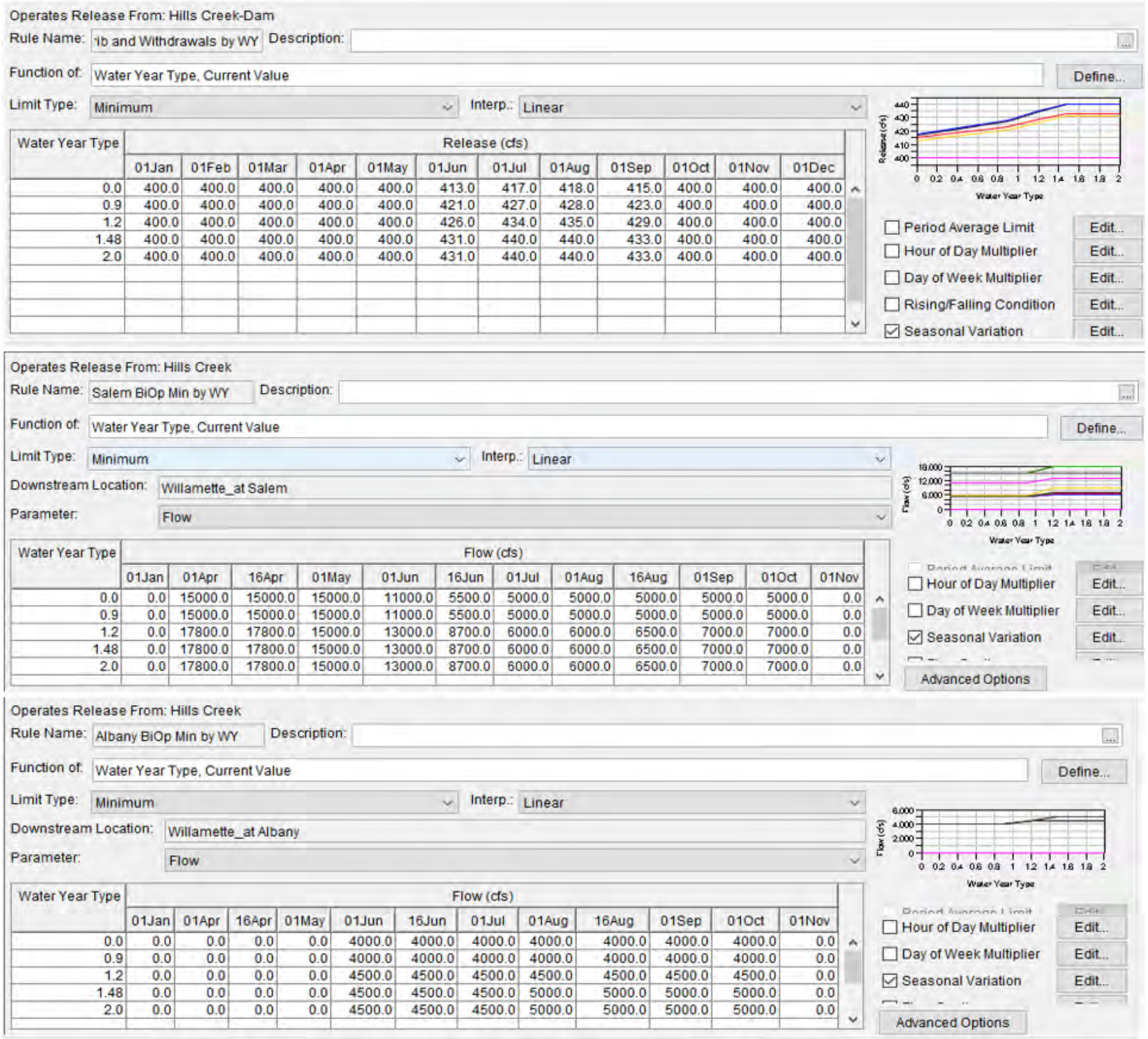
Time of Recession (hrs): 21.6

Operates Release From: Hills Creek-Power Plant
Rule Name: Max Power Release Description:
Function of: Hills Creek-Pool Elevation, Current Value
Limit Type: Maximum Interp.: Linear

Elev (ft)	Release (cfs)
1406.49	1690.0
1446.78	1890.0
1483.68	1820.0
1504.45	1660.0
1524.27	1560.0
1546.15	1490.0

☐ Period Average Limit
☐ Hour of Day Multiplier
☐ Day of Week Multiplier
☐ Rising/Falling Condition
☐ Seasonal Variation

Figure 3-34. Hills Creek NAA Operation Set Rules



Operates Release From: Hills Creek-Dam

Rule Name: ·ib and Withdrawals by WY

Description:

Function of: Water Year Type, Current Value

Limit Type: Minimum

Interp.: Linear

Water Year Type	Release (cfs)											
	01Jan	01Feb	01Mar	01Apr	01May	01Jun	01Jul	01Aug	01Sep	01Oct	01Nov	01Dec
0.0	400.0	400.0	400.0	400.0	400.0	413.0	417.0	418.0	415.0	400.0	400.0	400.0
0.9	400.0	400.0	400.0	400.0	400.0	421.0	427.0	428.0	423.0	400.0	400.0	400.0
1.2	400.0	400.0	400.0	400.0	400.0	426.0	434.0	435.0	429.0	400.0	400.0	400.0
1.48	400.0	400.0	400.0	400.0	400.0	431.0	440.0	440.0	433.0	400.0	400.0	400.0
2.0	400.0	400.0	400.0	400.0	400.0	431.0	440.0	440.0	433.0	400.0	400.0	400.0

☐ Period Average Limit
☐ Hour of Day Multiplier
☐ Day of Week Multiplier
☐ Rising/Falling Condition
☑ Seasonal Variation

Operates Release From: Hills Creek

Rule Name: Salem BiOp Min by WY

Description:

Function of: Water Year Type, Current Value

Limit Type: Minimum

Interp.: Linear

Downstream Location: Willamette_at Salem

Parameter: Flow

Water Year Type	Flow (cfs)											
	01Jan	01Apr	16Apr	01May	01Jun	16Jun	01Jul	01Aug	16Aug	01Sep	01Oct	01Nov
0.0	0.0	15000.0	15000.0	15000.0	11000.0	5500.0	5000.0	5000.0	5000.0	5000.0	5000.0	0.0
0.9	0.0	15000.0	15000.0	15000.0	11000.0	5500.0	5000.0	5000.0	5000.0	5000.0	5000.0	0.0
1.2	0.0	17800.0	17800.0	15000.0	13000.0	8700.0	6000.0	6000.0	6500.0	7000.0	7000.0	0.0
1.48	0.0	17800.0	17800.0	15000.0	13000.0	8700.0	6000.0	6000.0	6500.0	7000.0	7000.0	0.0
2.0	0.0	17800.0	17800.0	15000.0	13000.0	8700.0	6000.0	6000.0	6500.0	7000.0	7000.0	0.0

☐ Hour of Day Multiplier
☐ Day of Week Multiplier
☑ Seasonal Variation

Operates Release From: Hills Creek

Rule Name: Albany BiOp Min by WY

Description:

Function of: Water Year Type, Current Value

Limit Type: Minimum

Interp.: Linear

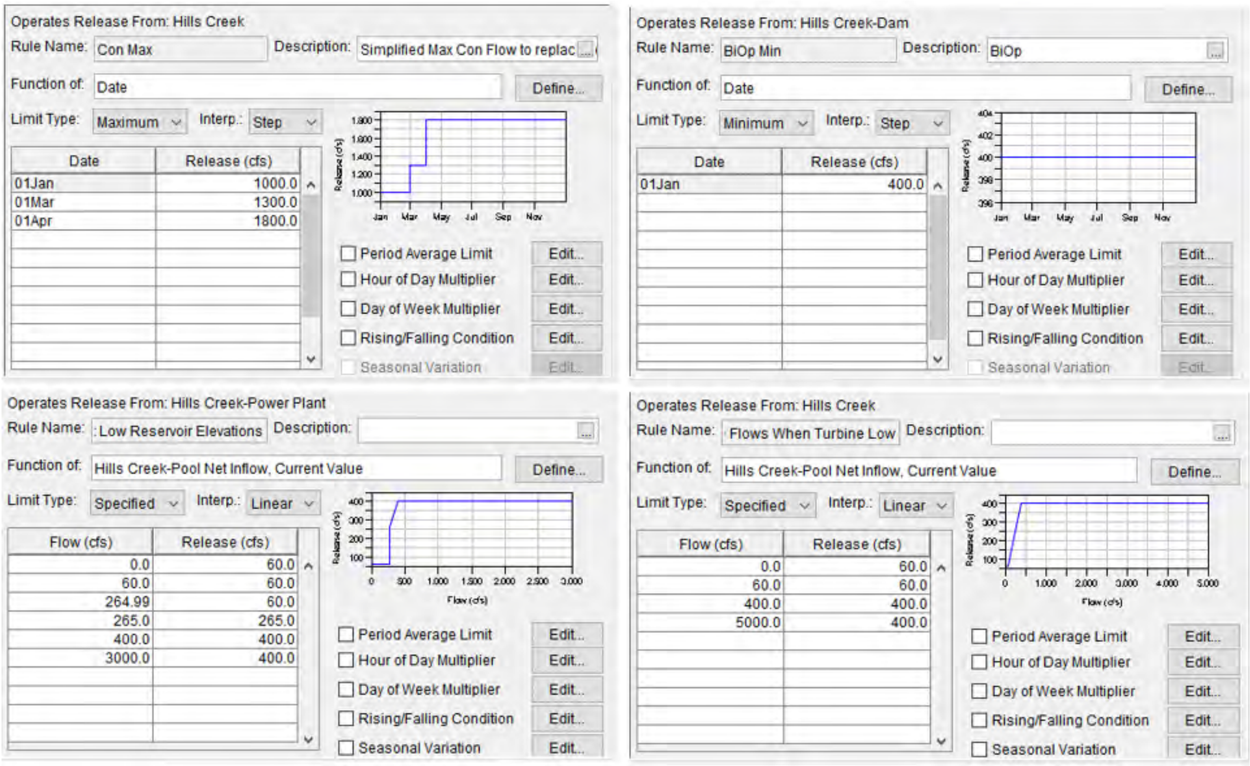
Downstream Location: Willamette_at Albany

Parameter: Flow

Water Year Type	Flow (cfs)											
	01Jan	01Apr	16Apr	01May	01Jun	16Jun	01Jul	01Aug	16Aug	01Sep	01Oct	01Nov
0.0	0.0	0.0	0.0	0.0	4000.0	4000.0	4000.0	4000.0	4000.0	4000.0	4000.0	0.0
0.9	0.0	0.0	0.0	0.0	4000.0	4000.0	4000.0	4000.0	4000.0	4000.0	4000.0	0.0
1.2	0.0	0.0	0.0	0.0	4500.0	4500.0	4500.0	4500.0	4500.0	4500.0	4500.0	0.0
1.48	0.0	0.0	0.0	0.0	4500.0	4500.0	4500.0	5000.0	5000.0	5000.0	5000.0	0.0
2.0	0.0	0.0	0.0	0.0	4500.0	4500.0	4500.0	5000.0	5000.0	5000.0	5000.0	0.0

☐ Hour of Day Multiplier
☐ Day of Week Multiplier
☑ Seasonal Variation

Figure 3-35. Hills Creek NAA Operation Set Rules Continued


Operates Release From: Hills Creek
Rule Name: Con Max
Description: Simplified Max Con Flow to replac
Function of: Date
Limit Type: Maximum
Interp.: Step

Date	Release (cfs)
01Jan	1000.0
01Mar	1300.0
01Apr	1800.0

☐ Period Average Limit
☐ Hour of Day Multiplier
☐ Day of Week Multiplier
☐ Rising/Falling Condition
☐ Seasonal Variation

Operates Release From: Hills Creek-Dam
Rule Name: BiOp Min
Description: BiOp
Function of: Date
Limit Type: Minimum
Interp.: Step

Date	Release (cfs)
01Jan	400.0

☐ Period Average Limit
☐ Hour of Day Multiplier
☐ Day of Week Multiplier
☐ Rising/Falling Condition
☐ Seasonal Variation

Operates Release From: Hills Creek-Power Plant
Rule Name: Low Reservoir Elevations
Description:
Function of: Hills Creek-Pool Net Inflow, Current Value
Limit Type: Specified
Interp.: Linear

Flow (cfs)	Release (cfs)
0.0	60.0
60.0	60.0
264.99	60.0
265.0	265.0
400.0	400.0
3000.0	400.0

☐ Period Average Limit
☐ Hour of Day Multiplier
☐ Day of Week Multiplier
☐ Rising/Falling Condition
☐ Seasonal Variation

Operates Release From: Hills Creek
Rule Name: Flows When Turbine Low
Description:
Function of: Hills Creek-Pool Net Inflow, Current Value
Limit Type: Specified
Interp.: Linear

Flow (cfs)	Release (cfs)
0.0	60.0
60.0	60.0
400.0	400.0
5000.0	400.0

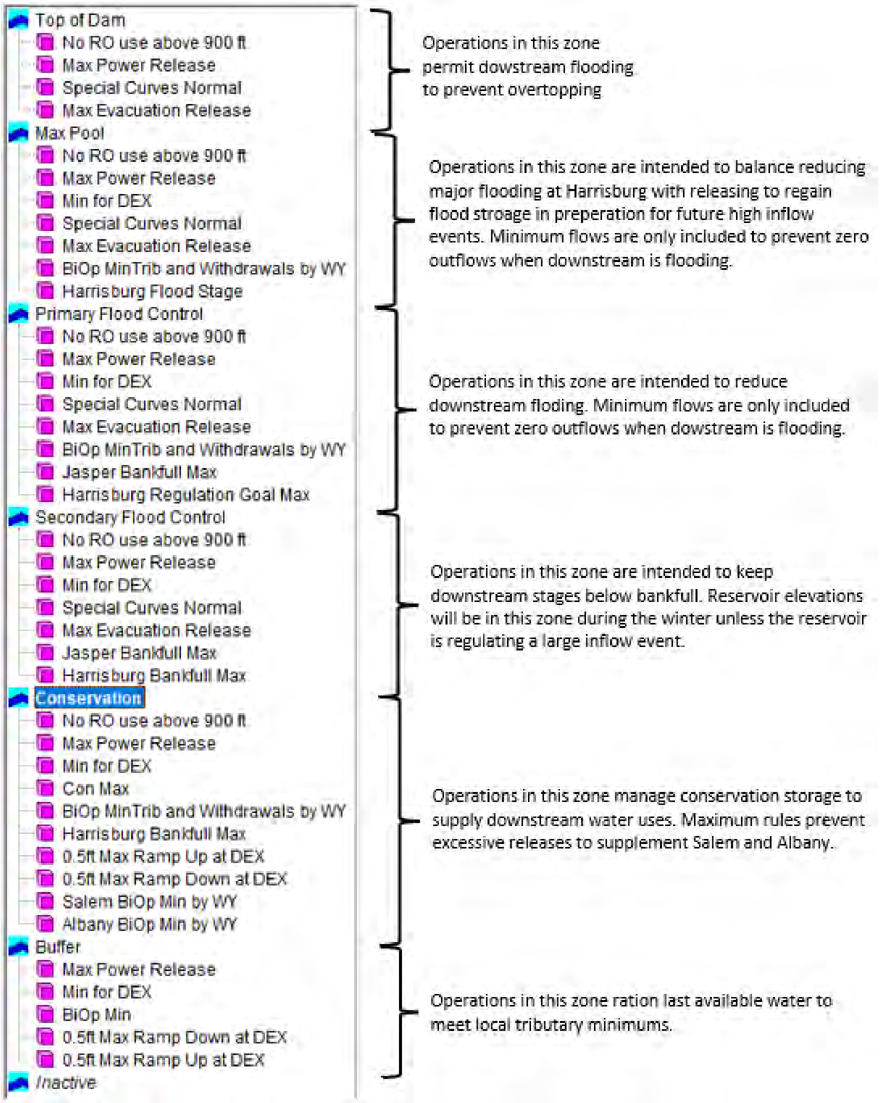
☐ Period Average Limit
☐ Hour of Day Multiplier
☐ Day of Week Multiplier
☐ Rising/Falling Condition
☐ Seasonal Variation

Figure 3-36. Hills Creek NAA Operation Set Rules Continued

3.5.6 Lookout Point Modeled Operations

3.5.6.1 Lookout Point Operational Summary

A summary of reservoir zones, operations defined for each zone, and each zone's role in reservoir regulation is identified in Figure B-3-37. Operations only apply to the zone where they are located. The higher the location of an operation in a zone the higher the priority of that operation.



- Top of Dam
  - No RO use above 900 ft
  - Max Power Release
  - Special Curves Normal
  - Max Evacuation Release
- Max Pool
  - No RO use above 900 ft
  - Max Power Release
  - Min for DEX
  - Special Curves Normal
  - Max Evacuation Release
  - BiOp MinTrib and Withdrawals by WY
  - Harrisburg Flood Stage
- Primary Flood Control
  - No RO use above 900 ft
  - Max Power Release
  - Min for DEX
  - Special Curves Normal
  - Max Evacuation Release
  - BiOp MinTrib and Withdrawals by WY
  - Jasper Bankfull Max
  - Harrisburg Regulation Goal Max
- Secondary Flood Control
  - No RO use above 900 ft
  - Max Power Release
  - Min for DEX
  - Special Curves Normal
  - Max Evacuation Release
  - Jasper Bankfull Max
  - Harrisburg Bankfull Max
- Conservation
  - No RO use above 900 ft
  - Max Power Release
  - Min for DEX
  - Con Max
  - BiOp MinTrib and Withdrawals by WY
  - Harrisburg Bankfull Max
  - 0.5ft Max Ramp Up at DEX
  - 0.5ft Max Ramp Down at DEX
  - Salem BiOp Min by WY
  - Albany BiOp Min by WY
- Buffer
  - Max Power Release
  - Min for DEX
  - BiOp Min
  - 0.5ft Max Ramp Down at DEX
  - 0.5ft Max Ramp Up at DEX
- *Inactive*

Operations in this zone permit dowstream flooding to prevent overtopping

Operations in this zone are intended to balance reducing major flooding at Harrisburg with releasing to regain flood stroage in preperation for future high inflow events. Minimum flows are only included to prevent zero outflows when downstream is flooding.

Operations in this zone are intended to reduce downstream floding. Minimum flows are only included to prevent zero outflows when dowstream is flooding.

Operations in this zone are intended to keep downstream stages below bankfull. Reservoir elevations will be in this zone during the winter unless the reservoir is regulating a large inflow event.

Operations in this zone manage conservation storage to supply downstream water uses. Maximum rules prevent excessive releases to supplement Salem and Albany.

Operations in this zone ration last available water to meet local tributary minimums.

Figure 3-37. Lookout Point Operational Summary

3.5.6.2 Lookout Point ResSim Water Control Diagram

A water control diagram including all zones in ResSim for Lookout is provided in figure Figure B-3-38. A table detailing seasonal zone elevations is provided in Table B-3-17. Lookout Point currently (August 2020) has an Interim Risk Reduction Measure (IRRM) pool restriction, but this pool restriction is not in the NAA because it is interim. All zones are defined in the project's water control manual except for the buffer zone and bottom of rules. The buffer zone is for modeling purposes intended to estimate likely conservation actions taken by regulators in extremely low storage situations when local tributary flows would be prioritized above withdrawals and mainstem flow targets. The bottom of rules zone balances turbine and regulating outlet flow when at the boundary of the inactive zone, which is also the top of the power pool. Dexter dam and reservoir re-regulates Lookout Point outflows. Average daily outflow from Dexter is the same as the average daily outflow from Lookout Point. In ResSim, which is a daily model, Dexter has no defined operations and passes inflow from Lookout Point.

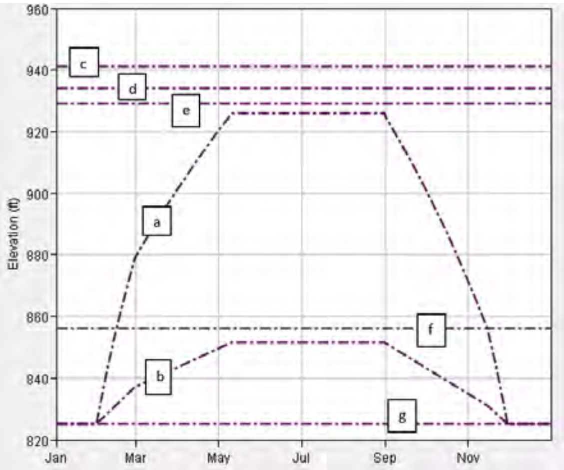


Figure 3-38. Lookout Point ResSim Water Control Diagram

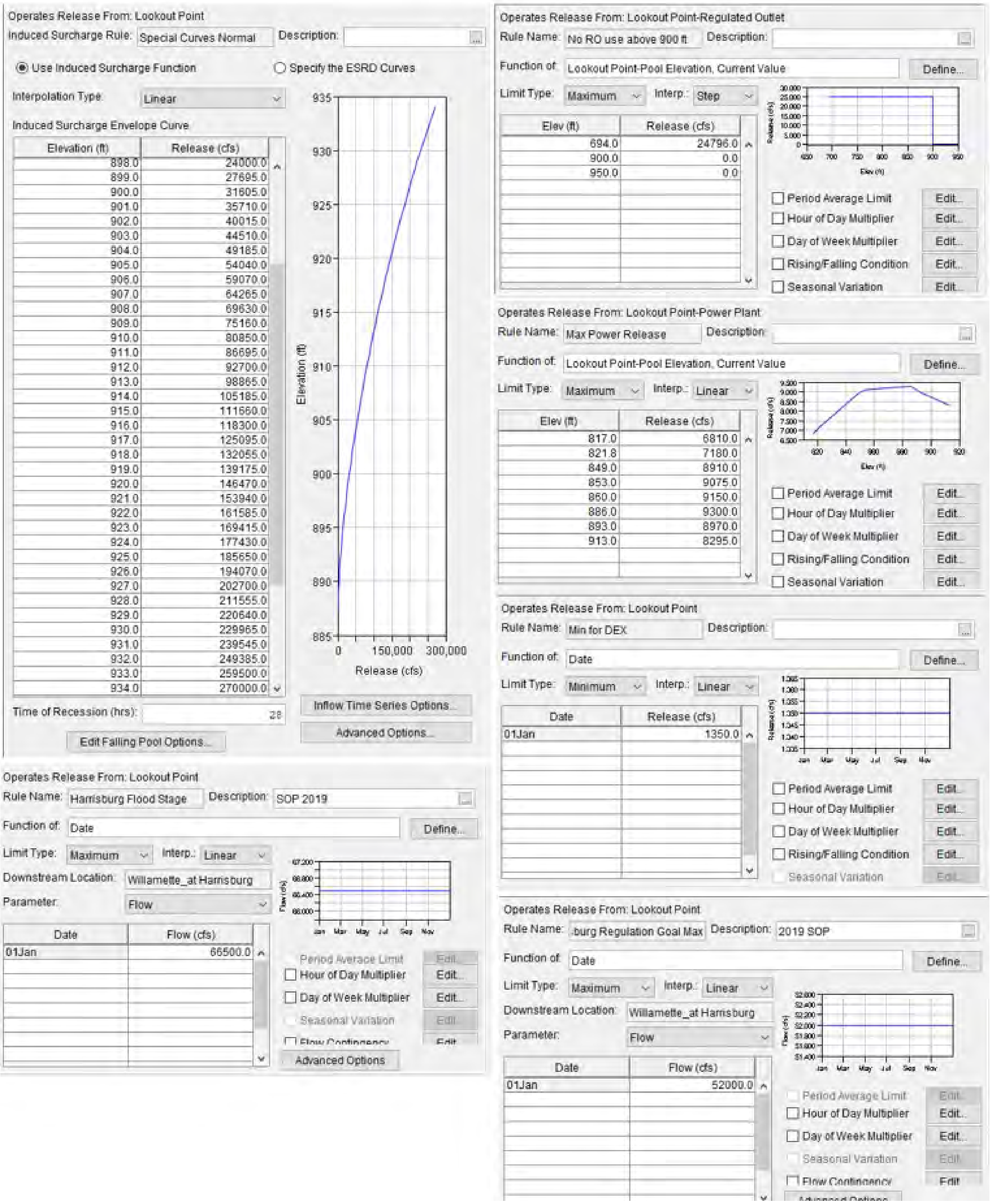
Table 3-17. Lookout Point Reservoir Zone Elevations

Conservation Zone (a)		Buffer Zone (b)	
Date	Elevation, feet	Date	Elevation, feet
1-Jan	825.1	1-Jan	825.0
31-Jan	825.1	31-Jan	825.0
7-Feb	841.1	28-Feb	837.0
14-Feb	855.2	10-May	851.6
21-Feb	867.6	31-Aug	851.6
28-Feb	879.0	30-Sep	843.5
7-Mar	884.3	15-Nov	831.2
15-Mar	890.0	30-Nov	825.0
23-Mar	895.6		
31-Mar	901.0		
7-Apr	905.6		
15-Apr	910.7		
22-Apr	915.0		
30-Apr	920.0		
7-May	924.0		
10-May	926.0		
31-Aug	926.0		
1-Sep	925.0		
15-Sep	914.1		
22-Sep	908.4	Top of Dam Zone (c)	
30-Sep	901.6	All Year	941
7-Oct	895.4	Max Pool Zone (d)	
15-Oct	888.1	All Year	934
23-Oct	880.5	Primary Flood Control Zone (e)	
31-Oct	872.5	All Year	929
7-Nov	865.1	Secondary Flood Control Zone (f)	
15-Nov	856.1	All Year	856.0
22-Nov	842.7	Inactive Zone (g)	
30-Nov	825.1	All Year	825.0

3.5.6.3 Lookout Point Detailed Operational Descriptions

A description of each operation at Lookout Point is provided below followed by detailed screenshots of each operation in Figure B-3-39, Figure B-3-40, and Figure B-3-41.

- *No RO use above 900 ft* - RO cannot be used above 900 ft
- *Max Power Release* - Max flow through powerhouse
- *Min Power Release* - Min flow through powerhouse, but different than speed no load
- *Special Curves Normal* - induced surcharge function, a function of elevation and inflow. Designed for flood events that present risk of dam overtopping
- *Max Evacuation Release* - Max release as a function of pool elevation. Designed to mimic flood season maximum releases
- *Min for DEX* – Minimum daily average outflow from LOP to prevent cavitation at DEX power plant
- *BiOp MinTrib and Withdrawals by WY* - Includes minimum flows to satisfy the 2008 BiOp and 2050 projected consumptive withdrawals.
- *Harrisburg Flood Stage* - Harrisburg flood flow is 66,500 cfs
- *Jasper Bankfull Max* - Jasper bankfull flow is 20,000 cfs
- *Harrisburg Regulation Goal Max* - Harrisburg regulation goal is 52,000 cfs
- *Con Max* - Maximum outflow during the conservation season as a function of date. Rule limits drafting to meet minimum flows at Salem and Albany.
- *0.5ft Max Ramp Up at DEX* - Ramping rate restriction for Dexter
- *0.5ft Max Ramp Down at DEX* - Ramping rate restriction for Dexter, which is stricter than the 2008 BiOp requirement
- *Salem BiOp Min by WY* - 2008 BiOp min flow target at Salem
- *Albany BiOp Min by WY* - 2008 BiOp min flow target at Albany
- *BiOp Min* - 2008 BiOp minimum tributary flow



Operates Release From: Lookout Point
Induced Surcharge Rule: Special Curves Normal
Description:

● Use Induced Surcharge Function ○ Specify the ESRD Curves

Interpolation Type: Linear

Induced Surcharge Envelope Curve

Elevation (ft)	Release (cfs)
898.0	24000.0
899.0	27695.0
900.0	31605.0
901.0	35710.0
902.0	40015.0
903.0	44510.0
904.0	49185.0
905.0	54040.0
906.0	59070.0
907.0	64265.0
908.0	69630.0
909.0	75160.0
910.0	80850.0
911.0	86695.0
912.0	92700.0
913.0	98865.0
914.0	105185.0
915.0	111660.0
916.0	118300.0
917.0	125095.0
918.0	132055.0
919.0	139175.0
920.0	146470.0
921.0	153940.0
922.0	161585.0
923.0	169415.0
924.0	177430.0
925.0	185650.0
926.0	194070.0
927.0	202700.0
928.0	211555.0
929.0	220640.0
930.0	229965.0
931.0	239545.0
932.0	249385.0
933.0	259500.0
934.0	270000.0

Time of Recession (hrs): 28

Operates Release From: Lookout Point
Rule Name: Harrisburg Flood Stage
Description: SOP 2019
Function of: Date
Limit Type: Maximum
Interp.: Linear
Downstream Location: Willamette_at Harrisburg
Parameter: Flow

Date	Flow (cfs)
01Jan	66500.0

Operates Release From: Lookout Point-Regulated Outlet
Rule Name: No RO use above 900 ft
Description:
Function of: Lookout Point-Pool Elevation, Current Value
Limit Type: Maximum
Interp.: Step

Elev (ft)	Release (cfs)
694.0	24796.0
900.0	0.0
950.0	0.0

Operates Release From: Lookout Point-Power Plant
Rule Name: Max Power Release
Description:
Function of: Lookout Point-Pool Elevation, Current Value
Limit Type: Maximum
Interp.: Linear

Elev (ft)	Release (cfs)
817.0	6810.0
821.8	7180.0
849.0	8910.0
853.0	9075.0
860.0	9150.0
886.0	9300.0
893.0	8970.0
913.0	8295.0

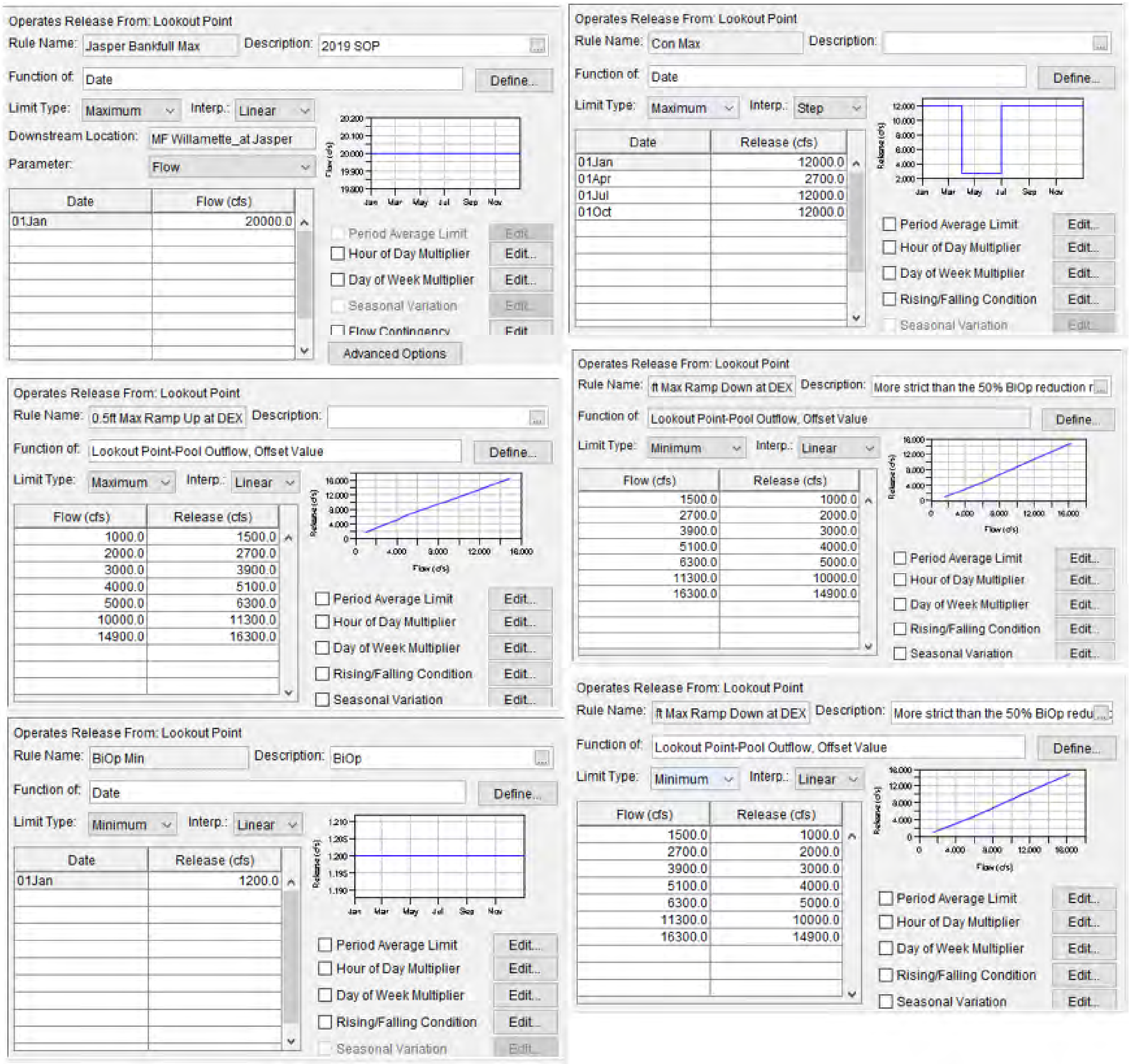
Operates Release From: Lookout Point
Rule Name: Min for DEX
Description:
Function of: Date
Limit Type: Minimum
Interp.: Linear

Date	Release (cfs)
01Jan	1350.0

Operates Release From: Lookout Point
Rule Name: .burg Regulation Goal Max
Description: 2019 SOP
Function of: Date
Limit Type: Maximum
Interp.: Linear
Downstream Location: Willamette_at Harrisburg
Parameter: Flow

Date	Flow (cfs)
01Jan	52000.0

Figure 3-39. Lookout Point NAA Operation Set Rules



Operates Release From: Lookout Point
Rule Name: Jasper Bankfull Max
Description: 2019 SOP
Function of: Date
Limit Type: Maximum
Interp.: Linear
Downstream Location: MF Willamette_at Jasper
Parameter: Flow

Date	Flow (cfs)
01Jan	20000.0

☐ Period Average Limit
☐ Hour of Day Multiplier
☐ Day of Week Multiplier
☐ Seasonal Variation
☐ Flow Contingency

Operates Release From: Lookout Point
Rule Name: 0.5ft Max Ramp Up at DEX
Description:
Function of: Lookout Point-Pool Outflow, Offset Value
Limit Type: Maximum
Interp.: Linear

Flow (cfs)	Release (cfs)
1000.0	1500.0
2000.0	2700.0
3000.0	3900.0
4000.0	5100.0
5000.0	6300.0
10000.0	11300.0
14900.0	16300.0

☐ Period Average Limit
☐ Hour of Day Multiplier
☐ Day of Week Multiplier
☐ Rising/Falling Condition
☐ Seasonal Variation

Operates Release From: Lookout Point
Rule Name: BiOp Min
Description: BiOp
Function of: Date
Limit Type: Minimum
Interp.: Linear

Date	Release (cfs)
01Jan	1200.0

☐ Period Average Limit
☐ Hour of Day Multiplier
☐ Day of Week Multiplier
☐ Rising/Falling Condition
☐ Seasonal Variation

Operates Release From: Lookout Point
Rule Name: Con Max
Description:
Function of: Date
Limit Type: Maximum
Interp.: Step

Date	Release (cfs)
01Jan	12000.0
01Apr	2700.0
01Jul	12000.0
01Oct	12000.0

☐ Period Average Limit
☐ Hour of Day Multiplier
☐ Day of Week Multiplier
☐ Rising/Falling Condition
☐ Seasonal Variation

Operates Release From: Lookout Point
Rule Name: ft Max Ramp Down at DEX
Description: More strict than the 50% BiOp reduction r
Function of: Lookout Point-Pool Outflow, Offset Value
Limit Type: Minimum
Interp.: Linear

Flow (cfs)	Release (cfs)
1500.0	1000.0
2700.0	2000.0
3900.0	3000.0
5100.0	4000.0
6300.0	5000.0
11300.0	10000.0
16300.0	14900.0

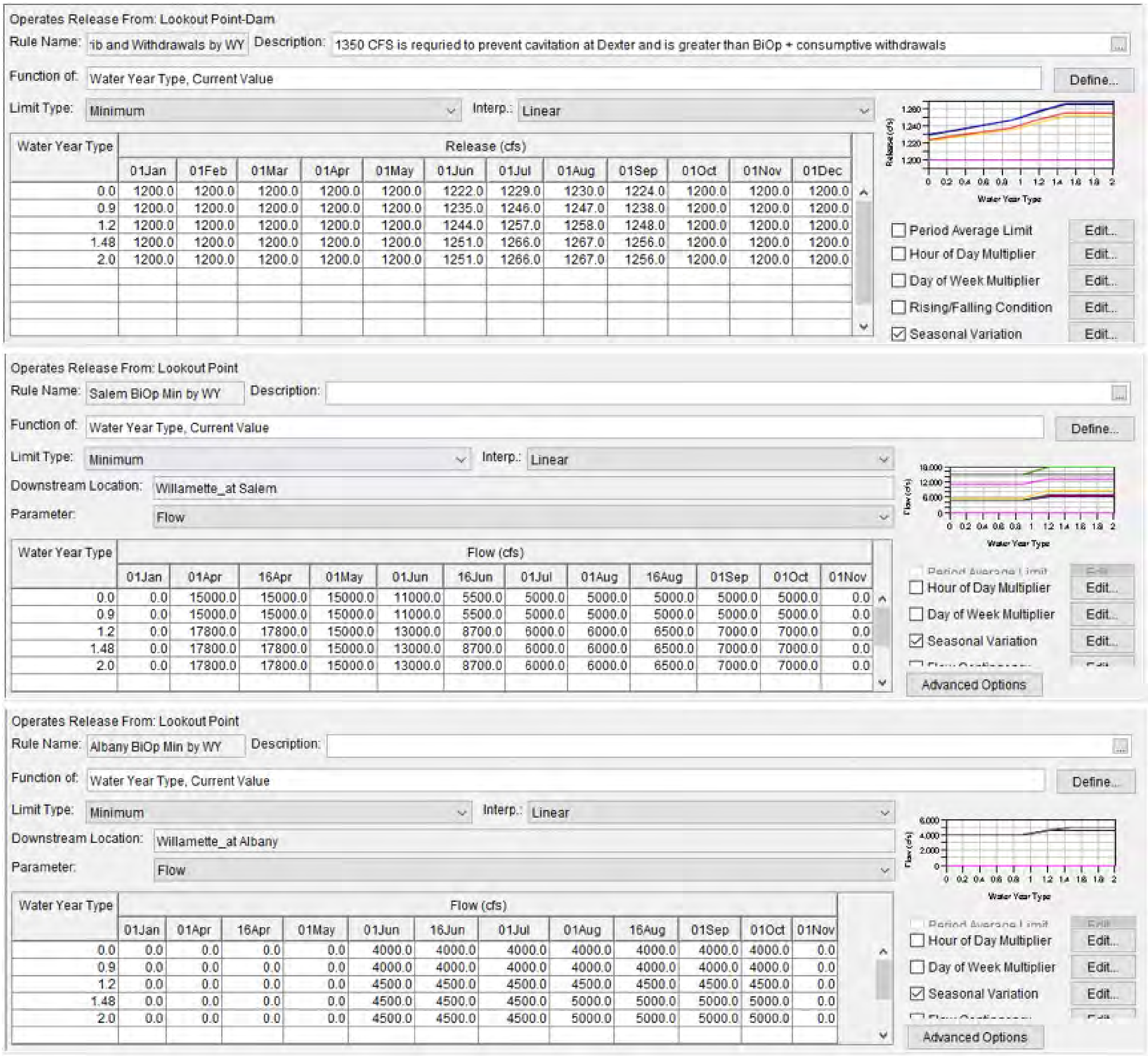
☐ Period Average Limit
☐ Hour of Day Multiplier
☐ Day of Week Multiplier
☐ Rising/Falling Condition
☐ Seasonal Variation

Operates Release From: Lookout Point
Rule Name: ft Max Ramp Down at DEX
Description: More strict than the 50% BiOp redu
Function of: Lookout Point-Pool Outflow, Offset Value
Limit Type: Minimum
Interp.: Linear

Flow (cfs)	Release (cfs)
1500.0	1000.0
2700.0	2000.0
3900.0	3000.0
5100.0	4000.0
6300.0	5000.0
11300.0	10000.0
16300.0	14900.0

☐ Period Average Limit
☐ Hour of Day Multiplier
☐ Day of Week Multiplier
☐ Rising/Falling Condition
☐ Seasonal Variation

Figure 3-40. Lookout Point NAA Operation Set Rules Continued



Operates Release From: Lookout Point-Dam
Rule Name: ib and Withdrawals by WY
Description: 1350 CFS is requried to prevent cavitation at Dexter and is greater than BiOp + consumptive withdrawals
Function of: Water Year Type, Current Value
Limit Type: Minimum
Interp.: Linear

Water Year Type	Release (cfs)											
	01Jan	01Feb	01Mar	01Apr	01May	01Jun	01Jul	01Aug	01Sep	01Oct	01Nov	01Dec
0.0	1200.0	1200.0	1200.0	1200.0	1200.0	1222.0	1229.0	1230.0	1224.0	1200.0	1200.0	1200.0
0.9	1200.0	1200.0	1200.0	1200.0	1200.0	1235.0	1246.0	1247.0	1238.0	1200.0	1200.0	1200.0
1.2	1200.0	1200.0	1200.0	1200.0	1200.0	1244.0	1257.0	1258.0	1248.0	1200.0	1200.0	1200.0
1.48	1200.0	1200.0	1200.0	1200.0	1200.0	1251.0	1266.0	1267.0	1256.0	1200.0	1200.0	1200.0
2.0	1200.0	1200.0	1200.0	1200.0	1200.0	1251.0	1266.0	1267.0	1256.0	1200.0	1200.0	1200.0

☐ Period Average Limit
☐ Hour of Day Multiplier
☐ Day of Week Multiplier
☐ Rising/Falling Condition
☑ Seasonal Variation

Operates Release From: Lookout Point
Rule Name: Salem BiOp Min by WY
Description:
Function of: Water Year Type, Current Value
Limit Type: Minimum
Interp.: Linear
Downstream Location: Willamette_at Salem
Parameter: Flow

Water Year Type	Flow (cfs)											
	01Jan	01Apr	16Apr	01May	01Jun	16Jun	01Jul	01Aug	16Aug	01Sep	01Oct	01Nov
0.0	0.0	15000.0	15000.0	15000.0	11000.0	5500.0	5000.0	5000.0	5000.0	5000.0	5000.0	0.0
0.9	0.0	15000.0	15000.0	15000.0	11000.0	5500.0	5000.0	5000.0	5000.0	5000.0	5000.0	0.0
1.2	0.0	17800.0	17800.0	15000.0	13000.0	8700.0	6000.0	6000.0	6500.0	7000.0	7000.0	0.0
1.48	0.0	17800.0	17800.0	15000.0	13000.0	8700.0	6000.0	6000.0	6500.0	7000.0	7000.0	0.0
2.0	0.0	17800.0	17800.0	15000.0	13000.0	8700.0	6000.0	6000.0	6500.0	7000.0	7000.0	0.0

☐ Hour of Day Multiplier
☐ Day of Week Multiplier
☑ Seasonal Variation

Operates Release From: Lookout Point
Rule Name: Albany BiOp Min by WY
Description:
Function of: Water Year Type, Current Value
Limit Type: Minimum
Interp.: Linear
Downstream Location: Willamette_at Albany
Parameter: Flow

Water Year Type	Flow (cfs)											
	01Jan	01Apr	16Apr	01May	01Jun	16Jun	01Jul	01Aug	16Aug	01Sep	01Oct	01Nov
0.0	0.0	0.0	0.0	0.0	4000.0	4000.0	4000.0	4000.0	4000.0	4000.0	4000.0	0.0
0.9	0.0	0.0	0.0	0.0	4000.0	4000.0	4000.0	4000.0	4000.0	4000.0	4000.0	0.0
1.2	0.0	0.0	0.0	0.0	4500.0	4500.0	4500.0	4500.0	4500.0	4500.0	4500.0	0.0
1.48	0.0	0.0	0.0	0.0	4500.0	4500.0	4500.0	5000.0	5000.0	5000.0	5000.0	0.0
2.0	0.0	0.0	0.0	0.0	4500.0	4500.0	4500.0	5000.0	5000.0	5000.0	5000.0	0.0

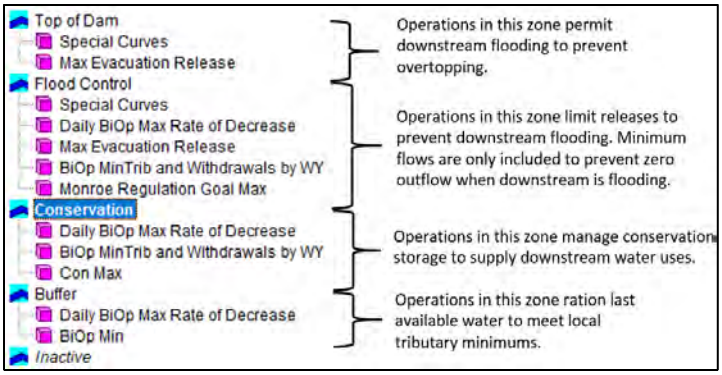
☐ Hour of Day Multiplier
☐ Day of Week Multiplier
☑ Seasonal Variation

Figure 3-41. Lookout Point NAA Operation Set Rules Continued

3.5.7 Fern Ridge Modeled Operations

3.5.7.1 Fern Ridge Operational Summary

A summary of reservoir zones, operations defined for each zone, and each zone's role in reservoir regulation is identified in Figure B-3-42. Operations only apply to the zone where they are located. The higher the location of an operation in a zone the higher the priority of that operation.



Top of Dam
  Special Curves
  Max Evacuation Release
Flood Control
  Special Curves
  Daily BiOp Max Rate of Decrease
  Max Evacuation Release
  BiOp MinTrib and Withdrawals by WY
  Monroe Regulation Goal Max
Conservation
  Daily BiOp Max Rate of Decrease
  BiOp MinTrib and Withdrawals by WY
  Con Max
Buffer
  Daily BiOp Max Rate of Decrease
  BiOp Min
Inactive

Operations in this zone permit downstream flooding to prevent overtopping.

Operations in this zone limit releases to prevent downstream flooding. Minimum flows are only included to prevent zero outflow when downstream is flooding.

Operations in this zone manage conservation storage to supply downstream water uses.

Operations in this zone ration last available water to meet local tributary minimums.

Figure 3-42. Fern Ridge Operational Summary

3.5.7.2 Fern Ridge ResSim Water Control Diagram

A water control diagram including all zones in ResSim for Fern Ridge is provided in Figure B-3-43. A table detailing seasonal zone elevations is provided in Table B-3-18. All zones are defined in the project's water control manual except for the buffer zone. The buffer zone is for modeling purposes intended to estimate likely conservation actions taken by regulators in extremely low storage situations when local tributary flows would be prioritized above withdrawals and mainstem flow targets.

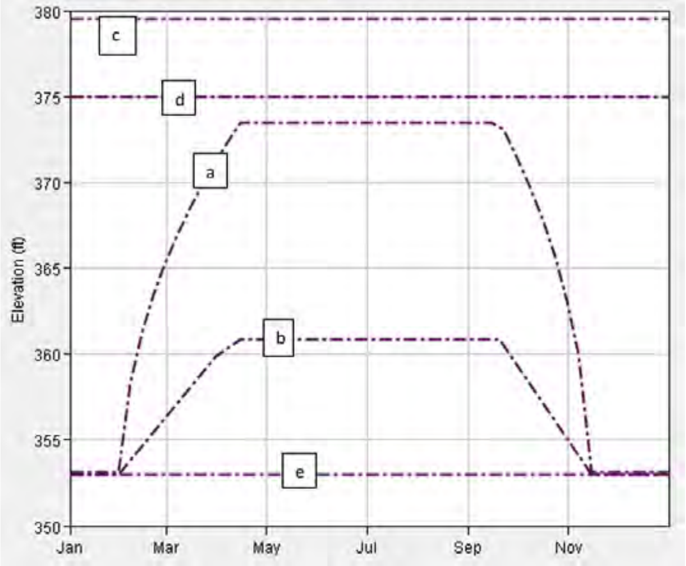


Figure 3-43. Fern Ridge ResSim Water Control Diagram

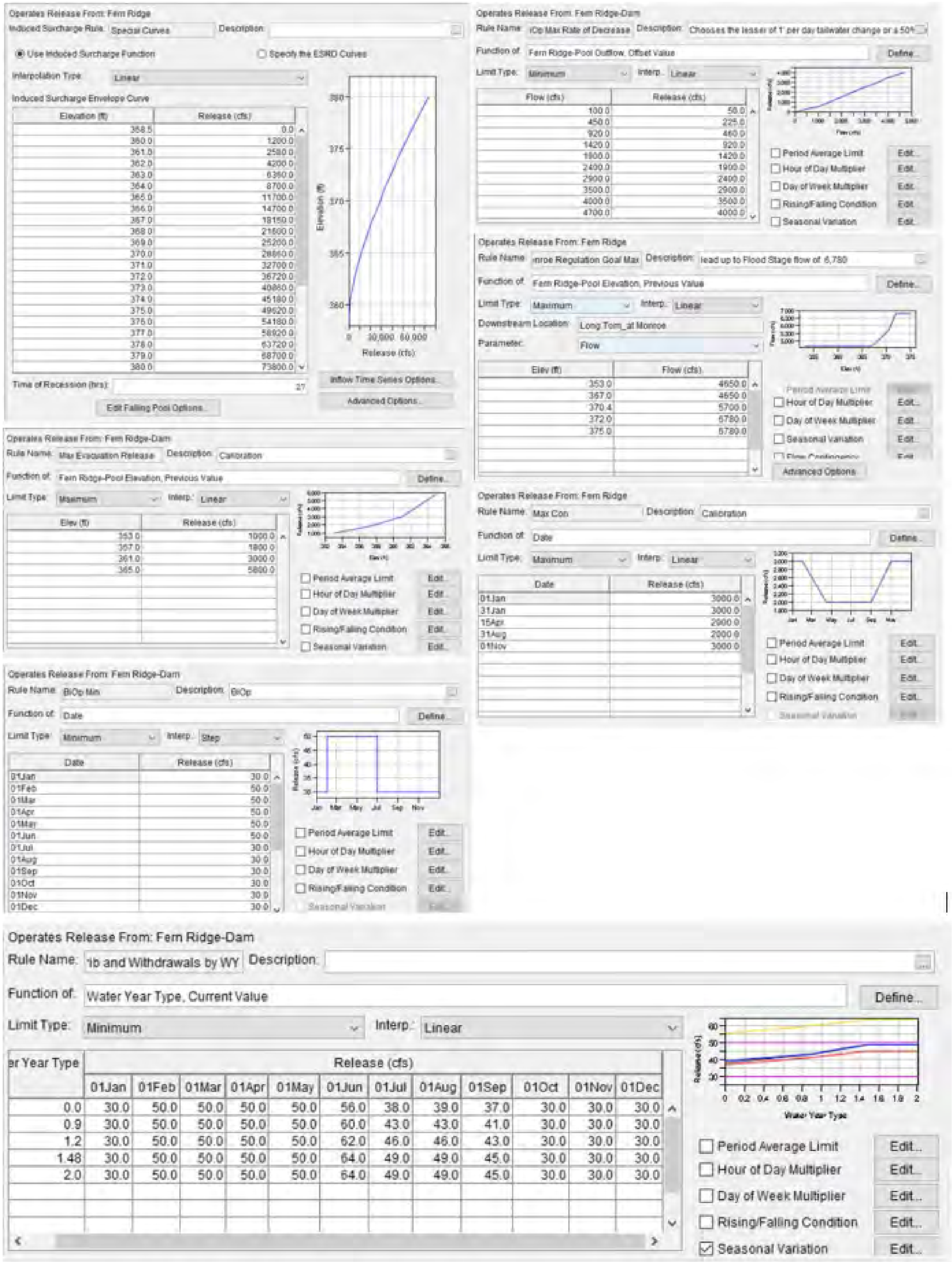
Table 3-18. Fern Ridge Reservoir Zone Elevations

Conservation Zone (a)		Buffer Zone (b)	
Date	Elevation, feet	Date	Elevation, feet
1-Jan	353.1	1-Jan	353.0
31-Jan	353.1	31-Jan	353.0
7-Feb	358.3	31-Mar	359.9
14-Feb	361.2	15-Apr	360.9
21-Feb	363.5	30-Jun	360.9
28-Feb	365.3	20-Sep	360.9
7-Mar	366.9	15-Nov	353.0
15-Mar	368.5	31-Dec	353.0
23-Mar	369.9		
31-Mar	371.2		
7-Apr	372.3		
15-Apr	373.5		
15-Sep	373.5		
22-Sep	373.1		
30-Sep	371.5		
7-Oct	370.0	Top of Dam Zone (c)	
15-Oct	368.1	All Year	379.5
23-Oct	365.9	Flood Control Zone (d)	
31-Oct	363.1	All Year	375
7-Nov	359.9	Inactive Zone (e)	
15-Nov	353.1	All Year	353

3.5.7.3 Fern Ridge Detailed Operational Descriptions

A description of each operation at Fern Ridge is provided below followed by detailed screenshots of each operation in Figure B-3-44.

- *Special Curves* - Induced surcharge function, a function of elevation and inflow. Designed for flood events that present risk of dam overtopping
- *Max Evacuation Release* - Max release as a function of pool elevation. Designed to mimic flood season maximum releases
- *Daily BiOp Max Rate of Decrease* - Defines the next day's minimum outflow as a function of current outflow. Designed to result in the lesser of 1' per day tailwater change or a 50% reduction in flow per the BiOp
- *BiOp MinTrib and Withdrawals by WY* - Includes minimum flows to satisfy the 2008 BiOp and 2050 projected consumptive withdrawals
- *Monroe Regulation Goal Max* - Function of Fern Ridge elevation. Target below bankfull when elevations are low, and flood stage when elevations are high
- *Con Max* - Normal maximum outflow during the conservation season as a function of date. Rule limits drafting to meet minimum flows at Salem and Albany
- *BiOp Min* - 2008 BiOp minimum tributary flows



Operates Release From: Fern Ridge
Induced Surcharge Rule: Special Curves
Description:

● Use Induced Surcharge Function ○ Specify the ESRD Curves

Interpolation Type: Linear

Induced Surcharge Envelope Curve

Elevation (ft)	Release (cfs)
358.5	0.0
360.0	1200.0
361.0	2580.0
362.0	4200.0
363.0	6360.0
364.0	8700.0
365.0	11700.0
366.0	14700.0
367.0	18150.0
368.0	21600.0
369.0	25200.0
370.0	28860.0
371.0	32700.0
372.0	36720.0
373.0	40860.0
374.0	45180.0
375.0	49620.0
376.0	54180.0
377.0	58920.0
378.0	63720.0
379.0	68700.0
380.0	73800.0

Time of Recession (hrs): 27

Operates Release From: Fern Ridge-Dam
Rule Name: iOp Max Rate of Decrease
Description: Chooses the lesser of 1' per day tailwater change or a 50%
Function of: Fern Ridge-Pool Outflow, Offset Value
Limit Type: Minimum
Interp.: Linear

Flow (cfs)	Release (cfs)
100.0	50.0
450.0	225.0
920.0	460.0
1420.0	920.0
1900.0	1420.0
2400.0	1900.0
2900.0	2400.0
3500.0	2900.0
4000.0	3500.0
4700.0	4000.0

☐ Period Average Limit
☐ Hour of Day Multiplier
☐ Day of Week Multiplier
☐ Rising/Falling Condition
☐ Seasonal Variation

Operates Release From: Fern Ridge
Rule Name: nroe Regulation Goal Max
Description: lead up to Flood Stage flow of 6,780
Function of: Fern Ridge-Pool Elevation, Previous Value
Limit Type: Maximum
Interp.: Linear
Downstream Location: Long Tom_at Monroe
Parameter: Flow

Elev (ft)	Flow (cfs)
353.0	4650.0
367.0	4650.0
370.4	5700.0
372.0	6780.0
375.0	6780.0

Period Average Limit
☐ Hour of Day Multiplier
☐ Day of Week Multiplier
☐ Seasonal Variation
☐ Flow Contingency

Operates Release From: Fern Ridge-Dam
Rule Name: Max Evacuation Release
Description: Calibration
Function of: Fern Ridge-Pool Elevation, Previous Value
Limit Type: Maximum
Interp.: Linear

Elev (ft)	Release (cfs)
353.0	1000.0
357.0	1800.0
361.0	3000.0
365.0	5800.0

☐ Period Average Limit
☐ Hour of Day Multiplier
☐ Day of Week Multiplier
☐ Rising/Falling Condition
☐ Seasonal Variation

Operates Release From: Fern Ridge
Rule Name: Max Con
Description: Calibration
Function of: Date
Limit Type: Maximum
Interp.: Linear

Date	Release (cfs)
01Jan	3000.0
31Jan	3000.0
15Apr	2000.0
31Aug	2000.0
01Nov	3000.0

☐ Period Average Limit
☐ Hour of Day Multiplier
☐ Day of Week Multiplier
☐ Rising/Falling Condition
Seasonal Variation

Operates Release From: Fern Ridge-Dam
Rule Name: BiOp Min
Description: BiOp
Function of: Date
Limit Type: Minimum
Interp.: Step

Date	Release (cfs)
01Jan	30.0
01Feb	50.0
01Mar	50.0
01Apr	50.0
01May	50.0
01Jun	50.0
01Jul	30.0
01Aug	30.0
01Sep	30.0
01Oct	30.0
01Nov	30.0
01Dec	30.0

☐ Period Average Limit
☐ Hour of Day Multiplier
☐ Day of Week Multiplier
☐ Rising/Falling Condition
Seasonal Variation

Operates Release From: Fern Ridge-Dam
Rule Name: ib and Withdrawals by WY
Description:
Function of: Water Year Type, Current Value
Limit Type: Minimum
Interp.: Linear

er Year Type	Release (cfs)											
	01Jan	01Feb	01Mar	01Apr	01May	01Jun	01Jul	01Aug	01Sep	01Oct	01Nov	01Dec
0.0	30.0	50.0	50.0	50.0	50.0	56.0	38.0	39.0	37.0	30.0	30.0	30.0
0.9	30.0	50.0	50.0	50.0	50.0	60.0	43.0	43.0	41.0	30.0	30.0	30.0
1.2	30.0	50.0	50.0	50.0	50.0	62.0	46.0	46.0	43.0	30.0	30.0	30.0
1.48	30.0	50.0	50.0	50.0	50.0	64.0	49.0	49.0	45.0	30.0	30.0	30.0
2.0	30.0	50.0	50.0	50.0	50.0	64.0	49.0	49.0	45.0	30.0	30.0	30.0

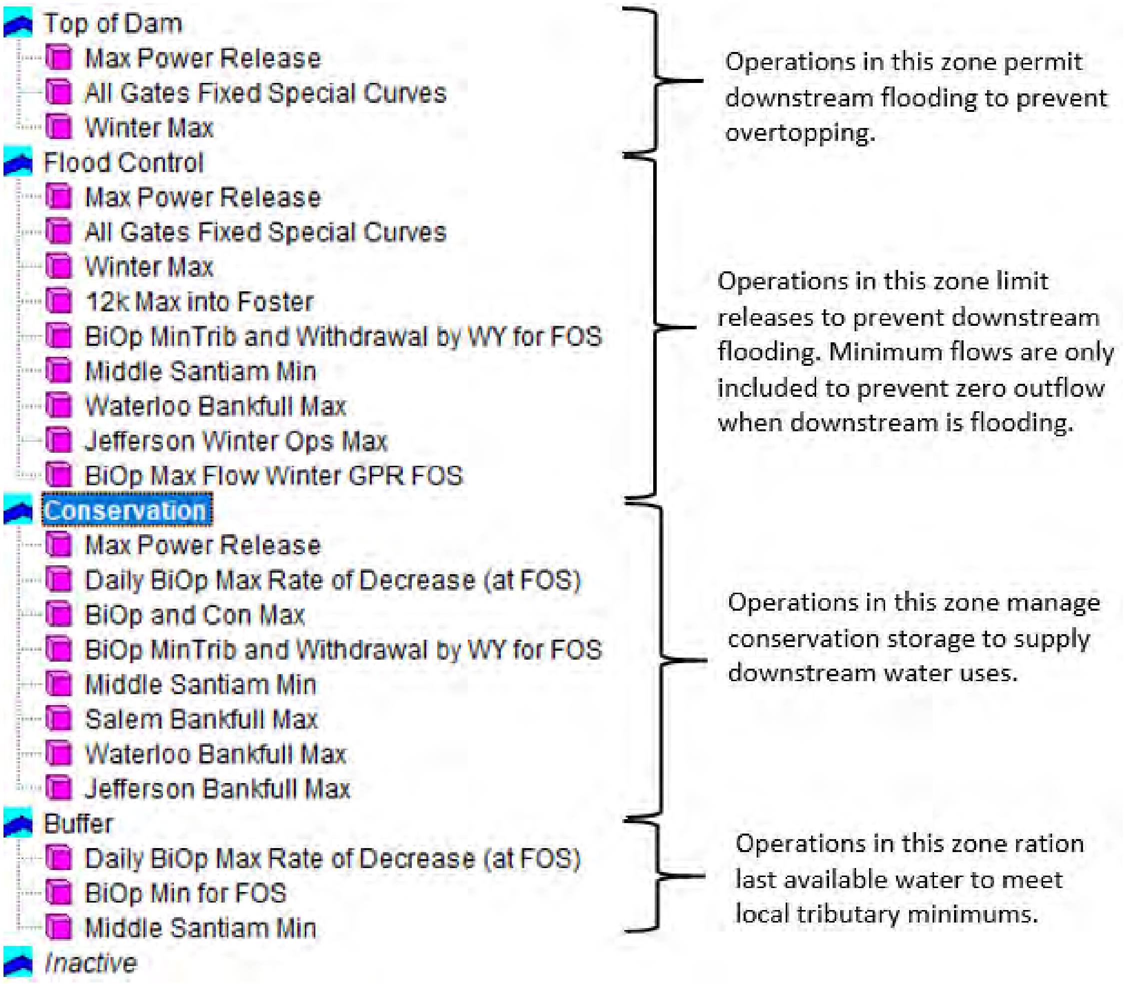
☐ Period Average Limit
☐ Hour of Day Multiplier
☐ Day of Week Multiplier
☐ Rising/Falling Condition
☑ Seasonal Variation

Figure 3-44. Fern Ridge NAA Operation Set Rules

3.5.8 Green Peter Modeled Operations

3.5.8.1 Green Peter Operational Summary

A summary of reservoir zones, operations defined for each zone, and each zone's role in reservoir regulation is identified in Figure B-3-45. Operations only apply to the zone where they are located. The higher the location of an operation in a zone the higher the priority of that operation. Foster reservoir elevations are generally prioritized above Green Peter elevations. Many operations at Green Peter are designed to meet targets downstream of Foster without drafting Foster below the rule curve.



- Top of Dam
  - Max Power Release
  - All Gates Fixed Special Curves
  - Winter Max
- Flood Control
  - Max Power Release
  - All Gates Fixed Special Curves
  - Winter Max
  - 12k Max into Foster
  - BiOp MinTrib and Withdrawal by WY for FOS
  - Middle Santiam Min
  - Waterloo Bankfull Max
  - Jefferson Winter Ops Max
  - BiOp Max Flow Winter GPR FOS
- Conservation
  - Max Power Release
  - Daily BiOp Max Rate of Decrease (at FOS)
  - BiOp and Con Max
  - BiOp MinTrib and Withdrawal by WY for FOS
  - Middle Santiam Min
  - Salem Bankfull Max
  - Waterloo Bankfull Max
  - Jefferson Bankfull Max
- Buffer
  - Daily BiOp Max Rate of Decrease (at FOS)
  - BiOp Min for FOS
  - Middle Santiam Min
- *Inactive*

Operations in this zone permit downstream flooding to prevent overtopping.

Operations in this zone limit releases to prevent downstream flooding. Minimum flows are only included to prevent zero outflow when downstream is flooding.

Operations in this zone manage conservation storage to supply downstream water uses.

Operations in this zone ration last available water to meet local tributary minimums.

Figure 3-45. Green Peter Operational Summary

3.5.8.2 Green Peter ResSim Water Control Diagram

A water control diagram including all zones in ResSim for Green Peter is provided in Figure B-3-46. A table detailing seasonal zone elevations is provided in Table B-3-19. All zones are defined in the project's water control manual except for the buffer zone. The buffer zone is for modeling purposes intended to estimate likely conservation actions taken by regulators in extremely low storage situations when local tributary flows would be prioritized above withdrawals and mainstem flow targets.

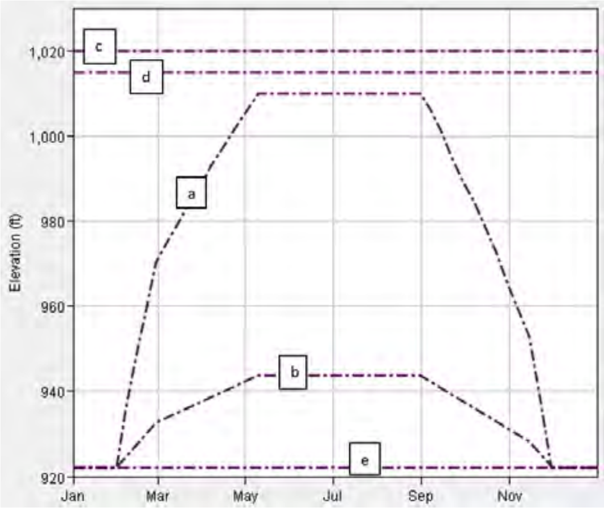
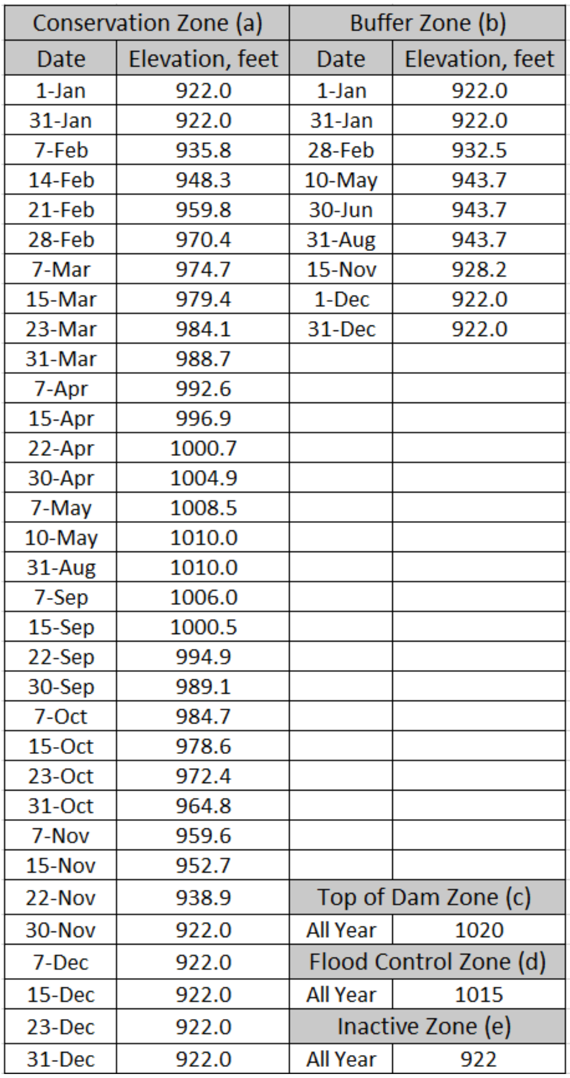


Figure 3-46. Green Peter ResSim Water Control Diagram

Table 3-19. Green Peter Reservoir Zone Elevations



Conservation Zone (a)		Buffer Zone (b)	
Date	Elevation, feet	Date	Elevation, feet
1-Jan	922.0	1-Jan	922.0
31-Jan	922.0	31-Jan	922.0
7-Feb	935.8	28-Feb	932.5
14-Feb	948.3	10-May	943.7
21-Feb	959.8	30-Jun	943.7
28-Feb	970.4	31-Aug	943.7
7-Mar	974.7	15-Nov	928.2
15-Mar	979.4	1-Dec	922.0
23-Mar	984.1	31-Dec	922.0
31-Mar	988.7		
7-Apr	992.6		
15-Apr	996.9		
22-Apr	1000.7		
30-Apr	1004.9		
7-May	1008.5		
10-May	1010.0		
31-Aug	1010.0		
7-Sep	1006.0		
15-Sep	1000.5		
22-Sep	994.9		
30-Sep	989.1		
7-Oct	984.7		
15-Oct	978.6		
23-Oct	972.4		
31-Oct	964.8		
7-Nov	959.6		
15-Nov	952.7		
22-Nov	938.9	Top of Dam Zone (c)	
30-Nov	922.0	All Year	1020
7-Dec	922.0	Flood Control Zone (d)	
15-Dec	922.0	All Year	1015
23-Dec	922.0	Inactive Zone (e)	
31-Dec	922.0	All Year	922

3.5.8.3 Green Peter Detailed Operational Descriptions

A description of each operation at Green Peter is provided below followed by detailed screenshots of each operation in Figure B-3-47 and Figure B-3-48.

- *Max Power Release* - Max flow through powerhouse
- *All Gates Fixed Special Curves* - induced surcharge function, a function of elevation and inflow. Designed for flood events that present risk of dam overtopping
- *Winter Max* - Max release as a function of pool elevation. Designed to mimic flood season maximum releases
- *12k Max into Foster* - Don't release more than 12,000 cfs into Foster
- *BiOp Min Trib and Withdrawal by WY for FOS* - Target minimum downstream of Foster to satisfy BiOp and withdrawals.

- *Middle Santiam Min* – Minimum tributary flow of 50 cfs between Green Peter and Foster
- *Waterloo Bankfull Max* - Waterloo bankfull flow is 19,000 cfs
- *Jefferson Winter Ops Max* - allows bankfull or flood stage at Jefferson depending on elevation
- *BiOp Max Spawning Flow GPR FOS* - Max flow in September of 3,000 cfs for spawning
- *Daily BiOp Max Rate of Decrease (at FOS)* - Defines the next day's minimum outflow as a function of current outflow. Designed to result in the lesser of 1' per day tailwater change or a 50% reduction in flow per the BiOp
- *BiOp and Con Max* - Max BiOp outflow in Sept used all conservation season as normal max outflow
- *Salem Bankfulll Max* - Salem Bankfull is 94,000 cfs
- *Jefferson Bankfull Max* - Jefferson bankfull is 43,000 cfs

Operates Release From: Green Peter-Power Plant
Rule Name: Max Power Release
Description:
Function of: Green Peter-Pool Elevation, Current Value
Limit Type: Maximum
Interp.: Linear

Elev (ft)	Release (cfs)
881.5	4200.0
901.0	4480.0
937.1	4760.0
962.2	4860.0
967.0	4740.0
981.9	4480.0
992.7	4340.0
1021.2	4040.0

Operates Release From: Green Peter
Induced Surcharge Rule: ates Fixed Special Curves
Description:
● Use Induced Surcharge Function ○ Specify the ESRD Curves
Interpolation Type: Linear
Induced Surcharge Envelope Curve

Elevation (ft)	Release (cfs)
978.0	8500.0
979.0	10000.0
980.0	11800.0
981.0	13680.0
982.0	15560.0
983.0	17440.0
984.0	19320.0
985.0	21200.0
986.0	23400.0
987.0	25600.0
988.0	27800.0
989.0	30000.0
990.0	32200.0
991.0	34760.0
992.0	37320.0
993.0	39880.0
994.0	42440.0
995.0	45000.0
996.0	47960.0
997.0	50920.0
998.0	53880.0
999.0	56840.0
1000.0	59800.0
1001.0	63040.0
1002.0	66280.0
1003.0	69520.0
1004.0	72760.0
1005.0	76000.0
1006.0	79360.0
1007.0	82720.0
1008.0	86080.0
1009.0	89440.0
1010.0	92800.0
1011.0	96240.0
1012.0	99680.0
1013.0	103120.0
1014.0	106560.0
1015.0	110000.0

Time of Recession (hrs): 17.1

Operates Release From: Green Peter
Rule Name: Middle Santiam Min
Description:
Function of: Date
Limit Type: Minimum
Interp.: Linear

Date	Release (cfs)
01Jan	50.0

Operates Release From: Green Peter
Rule Name: Winter Max
Description: Calibration at lowest elevations - RO capacity at upper elevati
Function of: Green Peter-Pool Elevation, Previous Value
Limit Type: Maximum
Interp.: Linear

Elev (ft)	Release (cfs)
922.0	4650.0
950.0	10000.0
953.0	10720.0
965.1	10840.0
987.0	12080.0
988.7	12150.0
1004.0	13000.0
1008.0	13000.0
1010.0	13000.0
1011.0	13000.0

Operates Release From: Green Peter-Dam
Rule Name: 12k Max into Foster
Description:
Function of: Foster - Flow-Loc Inc (Cascadia) Known Flow, Period Average, -0.0 hr offset, 4.0 hr period
Limit Type: Maximum
Interp.: Linear

Flow (cfs)	Release (cfs)
0.0	11500.0
5800.0	5700.0
11450.0	50.0
99999.0	50.0

Operates Release From: Green Peter
Rule Name: Waterloo Bankfull Max
Description: 2019 SOP
Function of: Date
Limit Type: Maximum
Interp.: Linear
Downstream Location: So Santiam_at Waterloo
Parameter: Flow

Date	Flow (cfs)
01Jan	19000.0

Operates Release From: Green Peter
Rule Name: Jefferson Winter Ops Max
Description: 2019 SOP Bankful 43,000 flood 55,900
Function of: Detroit-Pool Elevation, Current Value
Limit Type: Maximum
Interp.: Linear
Downstream Location: Santiam_at Jefferson
Parameter: Flow

Elev (ft)	Flow (cfs)
1424.0	43000.0
1536.0	43000.0
1546.0	55900.0
1574.0	55900.0

Figure 3-47. Green Peter NAA Operation Set Rules

Operates Release From: Green Peter
Rule Name: Withdrawal by WY for FOS
Description:
Function of: Water Year Type, Previous Value
Limit Type: Minimum
Interp.: Linear
Downstream Location: Foster_OUT
Parameter: Flow

Water Year Type	Flow (cfs)														
	01Jan	01Feb	01Mar	16Mar	01Apr	01May	16May	01Jun	01Jul	01Aug	01Sep	01Oct	16Oct	01Nov	01Dec
0.0	1100.0	800.0	800.0	1500.0	1500.0	1500.0	1100.0	1126.0	833.0	834.0	1528.0	1500.0	1100.0	1100.0	1100.0
0.9	1100.0	800.0	800.0	1500.0	1500.0	1500.0	1100.0	1129.0	838.0	838.0	1532.0	1500.0	1100.0	1100.0	1100.0
1.2	1100.0	800.0	800.0	1500.0	1500.0	1500.0	1100.0	1136.0	847.0	848.0	1540.0	1500.0	1100.0	1100.0	1100.0
1.48	1100.0	800.0	800.0	1500.0	1500.0	1500.0	1100.0	1142.0	855.0	856.0	1546.0	1500.0	1100.0	1100.0	1100.0
2.0	1100.0	800.0	800.0	1500.0	1500.0	1500.0	1100.0	1142.0	855.0	856.0	1546.0	1500.0	1100.0	1100.0	1100.0

Period Average Limit
☐ Hour of Day Multiplier
☐ Day of Week Multiplier
☑ Seasonal Variation
☐ Flow Contingency

Operates Release From: Green Peter
Rule Name: Max Flow Winter GPR FOS
Description:
Function of: Date
Limit Type: Maximum
Interp.: Step

Date	Release (cfs)
01Jan	999999.0
01Sep	3000.0
16Oct	999999.0

☐ Period Average Limit
☐ Hour of Day Multiplier
☐ Day of Week Multiplier
☐ Rising/Falling Condition
Seasonal Variation

Operates Release From: Green Peter
Rule Name: Rate of Decrease (at FOS)
Description: Choose the lesser of 1' per day tailwater change or a 50%
Function of: Foster-Pool Outflow, Offset Value
Limit Type: Minimum
Interp.: Linear
Downstream Location: Foster_IN
Parameter: Flow

Flow (cfs)	Flow (cfs)
1200.0	600.0
1650.0	825.0
3300.0	1650.0
5500.0	3300.0
8200.0	5500.0
11300.0	8200.0
15100.0	11300.0
19400.0	15100.0

Period Average Limit
☐ Hour of Day Multiplier
☐ Day of Week Multiplier
☐ Seasonal Variation
☐ Flow Contingency

Operates Release From: Green Peter
Rule Name: BiOp and Con Max
Description: For Calibration - Also covers max BiOp flows
Function of: Date
Limit Type: Maximum
Interp.: Linear

Date	Release (cfs)
01Jan	3000.0

☐ Period Average Limit
☐ Hour of Day Multiplier
☐ Day of Week Multiplier
☐ Rising/Falling Condition
Seasonal Variation

Operates Release From: Green Peter
Rule Name: Salem Bankfull Max
Description: 2019 SOP
Function of: Date
Limit Type: Maximum
Interp.: Linear
Downstream Location: Willamette_at Salem
Parameter: Flow

Date	Flow (cfs)
01Jan	94000.0

Period Average Limit
☐ Hour of Day Multiplier
☐ Day of Week Multiplier
Seasonal Variation
☐ Flow Contingency

Operates Release From: Green Peter
Rule Name: BiOp Min for FOS
Description:
Function of: Date
Limit Type: Minimum
Interp.: Step
Downstream Location: Foster_OUT
Parameter: Flow

Date	Flow (cfs)
01Jan	1100.0
01Feb	800.0
01Mar	800.0
16Mar	1500.0
01Apr	1500.0
01May	1500.0
16May	1100.0
01Jun	1100.0
01Jul	800.0
01Aug	800.0
01Sep	1500.0
01Oct	1500.0
16Oct	1100.0
01Nov	1100.0
01Dec	1100.0

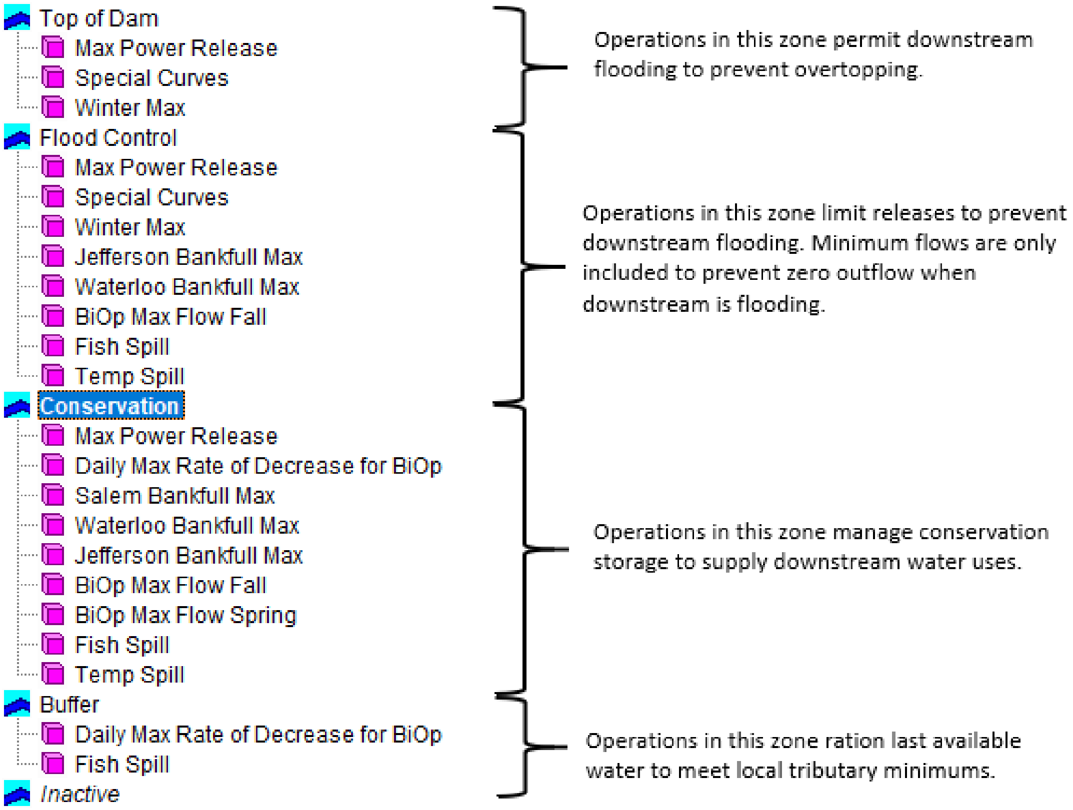
Period Average Limit
☐ Hour of Day Multiplier
☐ Day of Week Multiplier
Seasonal Variation
☐ Flow Contingency

Figure 3-48. Green Peter NAA Operation Set Rules Continued

3.5.9 Foster Modeled Operations

3.5.9.1 Foster Operational Summary

A summary of reservoir zones, operations defined for each zone, and each zone's role in reservoir regulation is identified in Figure B-3-49. Operations only apply to the zone where they are located. The higher the location of an operation in a zone the higher the priority of that operation. Foster reservoir elevations are generally prioritized above Green Peter elevations, and so many operations at Foster are coordinated with operations at Green Peter. In the NAA, minimum tributary flows are defined at Green Peter targeting the desired flow below Foster. Foster passes inflow from Green Peter and the South Santiam to meet its minimum outflow requirements.



- Top of Dam
  - Max Power Release
  - Special Curves
  - Winter Max
- Flood Control
  - Max Power Release
  - Special Curves
  - Winter Max
  - Jefferson Bankfull Max
  - Waterloo Bankfull Max
  - BiOp Max Flow Fall
  - Fish Spill
  - Temp Spill
- Conservation
  - Max Power Release
  - Daily Max Rate of Decrease for BiOp
  - Salem Bankfull Max
  - Waterloo Bankfull Max
  - Jefferson Bankfull Max
  - BiOp Max Flow Fall
  - BiOp Max Flow Spring
  - Fish Spill
  - Temp Spill
- Buffer
  - Daily Max Rate of Decrease for BiOp
  - Fish Spill
- *Inactive*

Operations in this zone permit downstream flooding to prevent overtopping.

Operations in this zone limit releases to prevent downstream flooding. Minimum flows are only included to prevent zero outflow when downstream is flooding.

Operations in this zone manage conservation storage to supply downstream water uses.

Operations in this zone ration last available water to meet local tributary minimums.

Figure 3-49. Foster Operational Summary

3.5.9.2 Foster ResSim Water Control Diagram

A water control diagram including all zones in ResSim for Foster is provided in Figure B-3-50A table detailing seasonal zone elevations is provided in Table B-3-20. All zones are defined in the project's water control manual except for the buffer zone. The buffer zone is for modeling purposes intended to estimate likely conservation actions taken by regulators in extremely low storage situations when local tributary flows would be prioritized above withdrawals and mainstem flow targets.

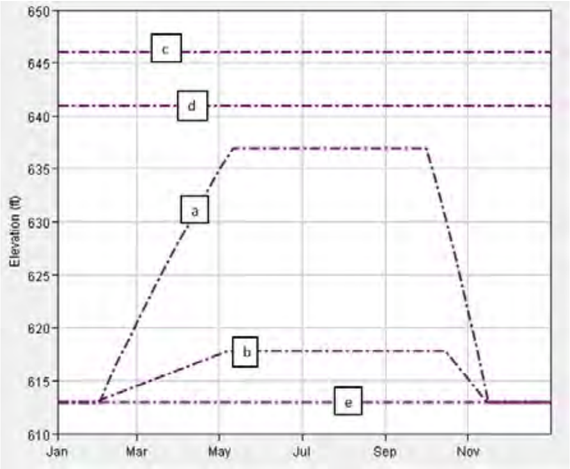


Figure 3-50. Foster ResSim Water Control Diagram

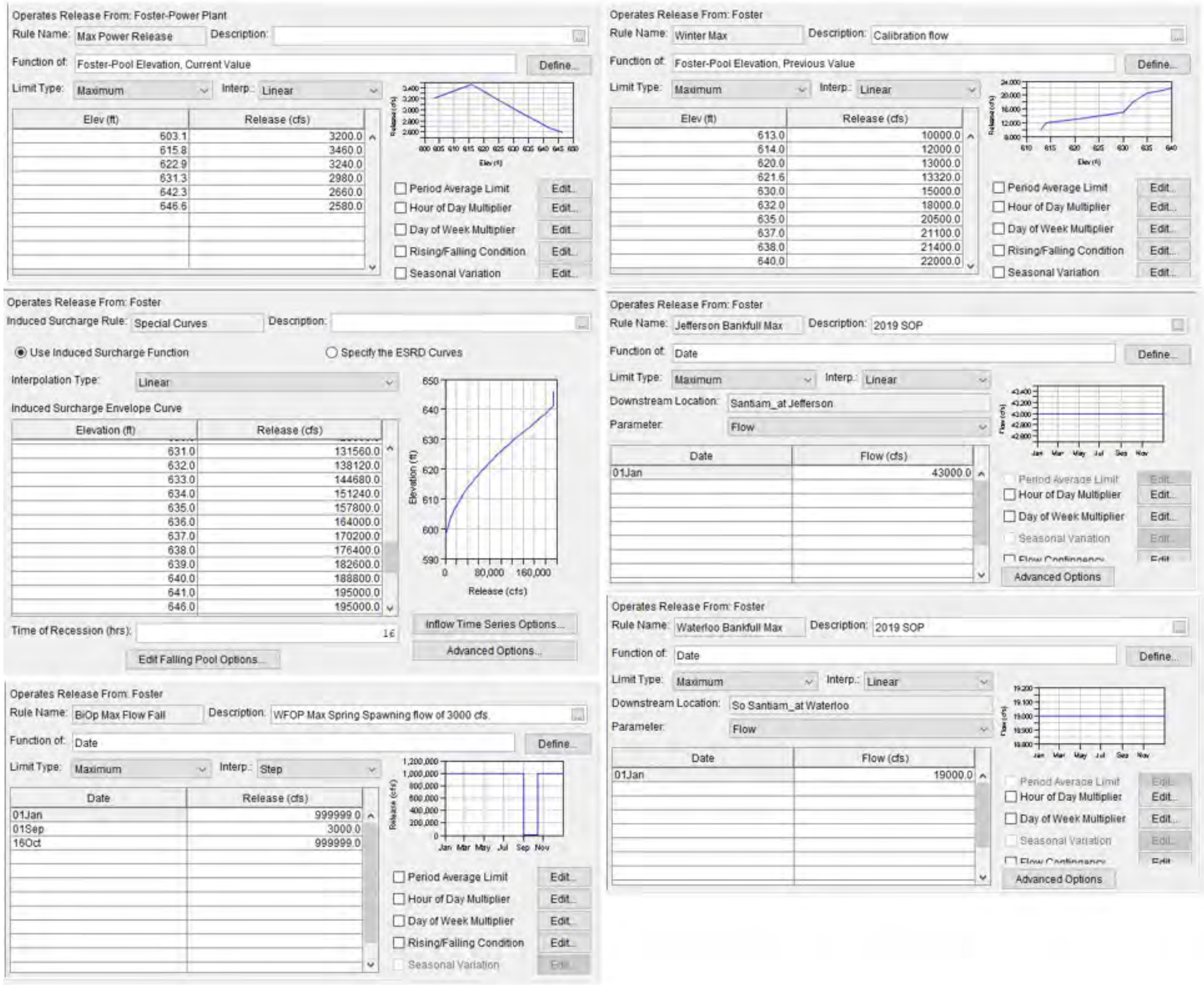
Table 3-20. Foster Reservoir Zone Elevations

Conservation Zone (a)		Buffer Zone (b)	
Date	Elevation, feet	Date	Elevation, feet
1-Jan	613.0	1-Jan	613.0
7-Jan	613.0	31-Jan	613.0
15-Jan	613.0	1-Feb	613.2
23-Jan	613.0	7-May	617.8
1-Feb	613.0	20-May	617.8
7-Feb	614.7	15-Oct	617.8
15-Feb	616.9	15-Nov	613.0
23-Feb	619.0	31-Dec	613.0
1-Mar	620.6		
7-Mar	622.1		
15-Mar	624.1		
23-Mar	626.0		
1-Apr	628.2		
7-Apr	629.5		
15-Apr	631.4		
23-Apr	633.2		
1-May	634.9		
7-May	636.2		
11-May	637.0		
1-Oct	637.0		
7-Oct	634.2		
15-Oct	630.4		
23-Oct	626.4	Top of Dam Zone (c)	
1-Nov	621.7	All Year	646
7-Nov	618.3	Flood Control Zone (d)	
15-Nov	613.6	All Year	641
16-Nov	613.0	Inactive Zone (e)	
1-Dec	613.0	All Year	613

3.5.9.3 Foster Detailed Operational Descriptions

A description of each operation at Foster is provided below followed by detailed screenshots of each operation in Figure B-3-51 and Figure B-3-52.

- *Max Power Release* - Max flow through powerhouse.
- *Special Curves* - induced surcharge function, a function of elevation and inflow. Designed for flood events that present risk of dam overtopping.
- *Winter Max* - Max release as a function of pool elevation. Designed to mimic flood season maximum releases
- ***** minimum outflow downstream of FOS defined at Green Peter *****
- *Fish Spill* – Releases half of flow (all flow for half of day) over spillway for downstream fish passage except when outflow is less than station service (150 cfs)
- *Temp Spill* – Flow released through new outlet (modeled over spillway) to manage temperature
- *Jefferson Bankfull Max* - Bankfull at Jefferson is 43,000 cfs.
- *Waterloo Bankfull Max* - Bankfull at Waterloo is 19,000 cfs.
- BiOp Max Flow Fall - Max fall spawning flow is 3,000 cfs.
- *Daily Max Rate of Decrease for BiOp* - Defines the next day’s minimum outflow as a function of current outflow. Designed to result in the lesser of 1' per day tailwater change or a 50% reduction in flow per the BiOp.
- *Salem Bankfull Max* - Salem Bankfull is 94,000 cfs.
- *BiOp Max Flow Spring* - Max flow in spring is 3,000 cfs.
- *BiOp Min Fos* - 2008 BiOp minimum release.



Operates Release From: Foster-Power Plant
Rule Name: Max Power Release
Description:
Function of: Foster-Pool Elevation, Current Value
Limit Type: Maximum
Interp.: Linear

Elev (ft)	Release (cfs)
603.1	3200.0
615.8	3460.0
622.9	3240.0
631.3	2980.0
642.3	2660.0
646.6	2580.0

☐ Period Average Limit
☐ Hour of Day Multiplier
☐ Day of Week Multiplier
☐ Rising/Falling Condition
☐ Seasonal Variation

Operates Release From: Foster
Induced Surcharge Rule: Special Curves
Description:
● Use Induced Surcharge Function
○ Specify the ESRD Curves
Interpolation Type: Linear
Induced Surcharge Envelope Curve

Elevation (ft)	Release (cfs)
631.0	131560.0
632.0	138120.0
633.0	144680.0
634.0	151240.0
635.0	157800.0
636.0	164000.0
637.0	170200.0
638.0	176400.0
639.0	182600.0
640.0	188800.0
641.0	195000.0
646.0	195000.0

Time of Recession (hrs): 16

Operates Release From: Foster
Rule Name: BiOp Max Flow Fall
Description: WFOP Max Spring Spawning flow of 3000 cfs.
Function of: Date
Limit Type: Maximum
Interp.: Step

Date	Release (cfs)
01Jan	999999.0
01Sep	3000.0
16Oct	999999.0

☐ Period Average Limit
☐ Hour of Day Multiplier
☐ Day of Week Multiplier
☐ Rising/Falling Condition
☐ Seasonal Variation

Operates Release From: Foster
Rule Name: Winter Max
Description: Calibration flow
Function of: Foster-Pool Elevation, Previous Value
Limit Type: Maximum
Interp.: Linear

Elev (ft)	Release (cfs)
613.0	10000.0
614.0	12000.0
620.0	13000.0
621.6	13320.0
630.0	15000.0
632.0	18000.0
635.0	20500.0
637.0	21100.0
638.0	21400.0
640.0	22000.0

☐ Period Average Limit
☐ Hour of Day Multiplier
☐ Day of Week Multiplier
☐ Rising/Falling Condition
☐ Seasonal Variation

Operates Release From: Foster
Rule Name: Jefferson Bankfull Max
Description: 2019 SOP
Function of: Date
Limit Type: Maximum
Interp.: Linear
Downstream Location: Santiam_at Jefferson
Parameter: Flow

Date	Flow (cfs)
01Jan	43000.0

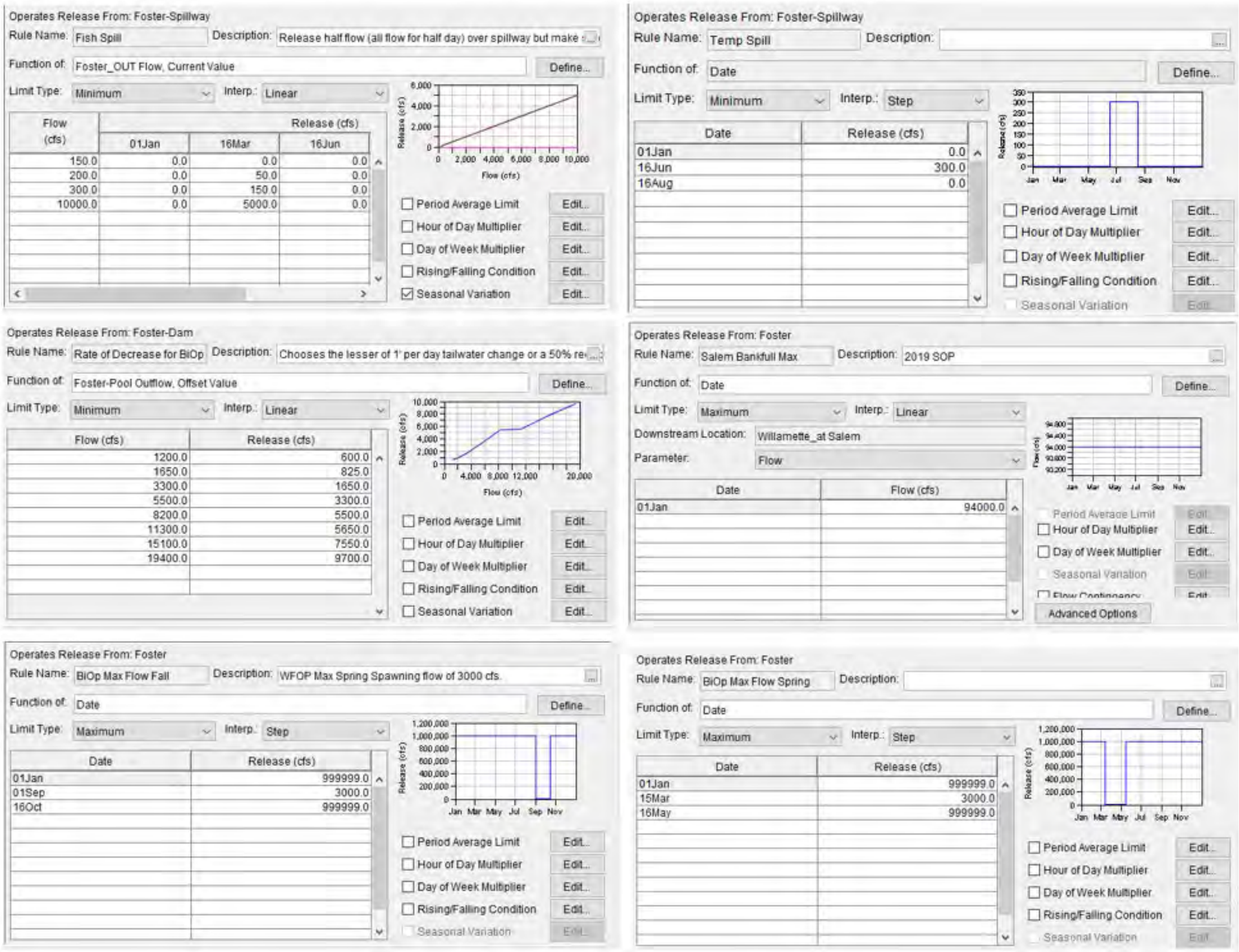
☐ Period Average Limit
☐ Hour of Day Multiplier
☐ Day of Week Multiplier
☐ Seasonal Variation
☐ Flow Contingency

Operates Release From: Foster
Rule Name: Waterloo Bankfull Max
Description: 2019 SOP
Function of: Date
Limit Type: Maximum
Interp.: Linear
Downstream Location: So Santiam_at Waterloo
Parameter: Flow

Date	Flow (cfs)
01Jan	19000.0

☐ Period Average Limit
☐ Hour of Day Multiplier
☐ Day of Week Multiplier
☐ Seasonal Variation
☐ Flow Contingency

Figure 3-51. Foster NAA Operation Set Rules



Operates Release From: Foster-Spillway
Rule Name: Fish Spill
Description: Release half flow (all flow for half day) over spillway but make
Function of: Foster_OUT Flow, Current Value
Limit Type: Minimum
Interp.: Linear

Flow (cfs)	Release (cfs)		
	01Jan	16Mar	16Jun
150.0	0.0	0.0	0.0
200.0	0.0	50.0	0.0
300.0	0.0	150.0	0.0
10000.0	0.0	5000.0	0.0

☐ Period Average Limit
☐ Hour of Day Multiplier
☐ Day of Week Multiplier
☐ Rising/Falling Condition
☑ Seasonal Variation

Operates Release From: Foster-Spillway
Rule Name: Temp Spill
Description:
Function of: Date
Limit Type: Minimum
Interp.: Step

Date	Release (cfs)
01Jan	0.0
16Jun	300.0
16Aug	0.0

☐ Period Average Limit
☐ Hour of Day Multiplier
☐ Day of Week Multiplier
☐ Rising/Falling Condition
Seasonal Variation

Operates Release From: Foster-Dam
Rule Name: Rate of Decrease for BiOp
Description: Chooses the lesser of 1' per day tailwater change or a 50% re
Function of: Foster-Pool Outflow, Offset Value
Limit Type: Minimum
Interp.: Linear

Flow (cfs)	Release (cfs)
1200.0	600.0
1650.0	825.0
3300.0	1650.0
5500.0	3300.0
8200.0	5500.0
11300.0	5650.0
15100.0	7550.0
19400.0	9700.0

☐ Period Average Limit
☐ Hour of Day Multiplier
☐ Day of Week Multiplier
☐ Rising/Falling Condition
☐ Seasonal Variation

Operates Release From: Foster
Rule Name: Salem Bankfull Max
Description: 2019 SOP
Function of: Date
Limit Type: Maximum
Interp.: Linear
Downstream Location: Willamette_at Salem
Parameter: Flow

Date	Flow (cfs)
01Jan	94000.0

Period Average Limit
☐ Hour of Day Multiplier
☐ Day of Week Multiplier
Seasonal Variation
☐ Flow Contingency

Operates Release From: Foster
Rule Name: BiOp Max Flow Fall
Description: WFOP Max Spring Spawning flow of 3000 cfs.
Function of: Date
Limit Type: Maximum
Interp.: Step

Date	Release (cfs)
01Jan	999999.0
01Sep	3000.0
16Oct	999999.0

☐ Period Average Limit
☐ Hour of Day Multiplier
☐ Day of Week Multiplier
☐ Rising/Falling Condition
Seasonal Variation

Operates Release From: Foster
Rule Name: BiOp Max Flow Spring
Description:
Function of: Date
Limit Type: Maximum
Interp.: Step

Date	Release (cfs)
01Jan	999999.0
15Mar	3000.0
16May	999999.0

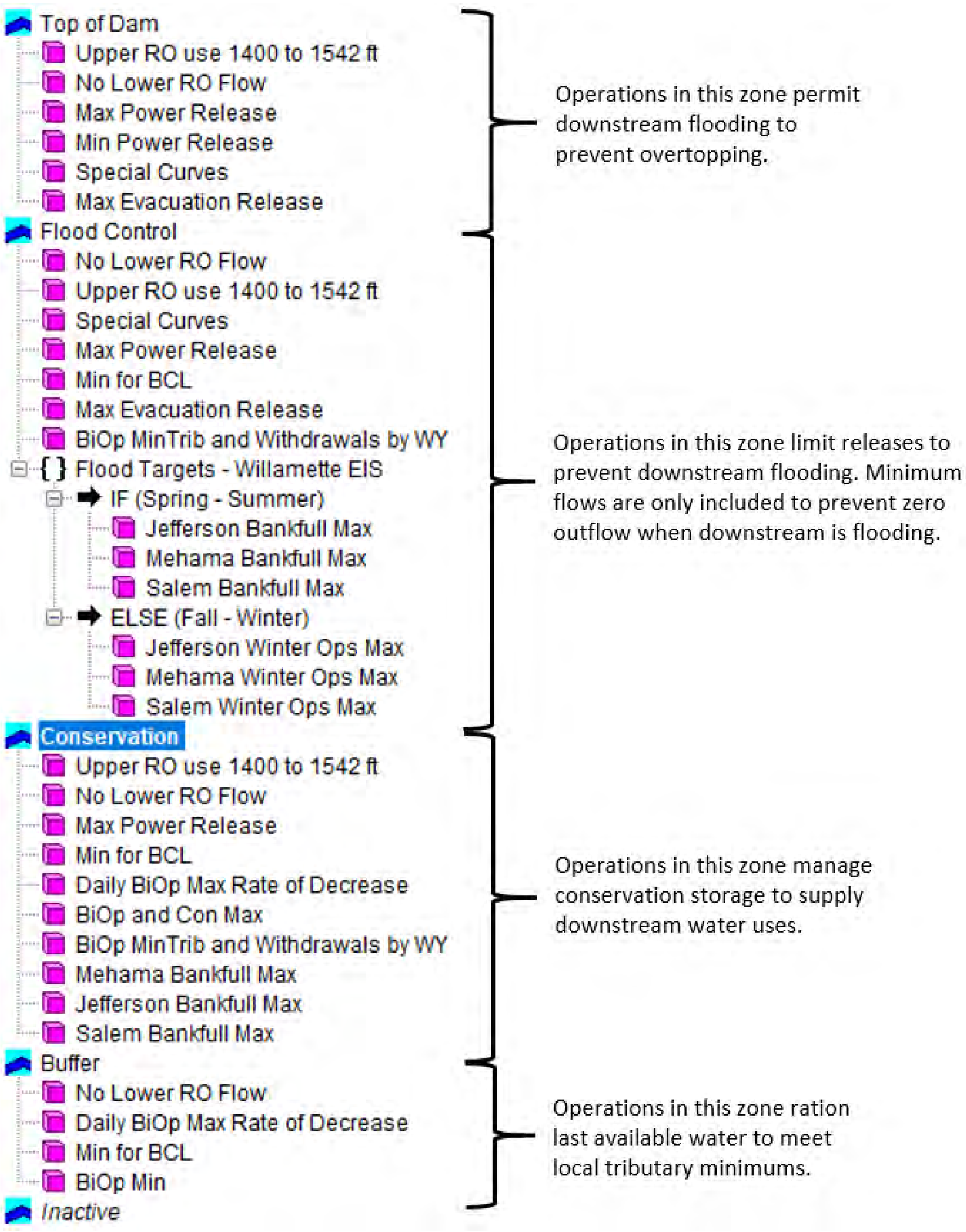
☐ Period Average Limit
☐ Hour of Day Multiplier
☐ Day of Week Multiplier
☐ Rising/Falling Condition
Seasonal Variation

Figure 3-52. Foster NAA Operation Set Rules Continued

3.5.10 Detroit Modeled Operations

3.5.10.1 Detroit Operational Summary

A summary of reservoir zones, operations defined for each zone, and each zone's role in reservoir regulation is identified in Figure B-3-53. Operations only apply to the zone where they are located. The higher the location of an operation in a zone the higher the priority of that operation.



Operations in this zone permit downstream flooding to prevent overtopping.

Operations in this zone limit releases to prevent downstream flooding. Minimum flows are only included to prevent zero outflow when downstream is flooding.

Operations in this zone manage conservation storage to supply downstream water uses.

Operations in this zone ration last available water to meet local tributary minimums.

Figure 3-53. Detroit Operational Summary

3.5.10.2 Detroit ResSim Water Control Diagram

A water control diagram including all zones in ResSim for Detroit is provided in Figure B-3-54. A table detailing seasonal zone elevations is provided in Table B-3-21. Detroit currently (August 2020) has an Interim Risk Reduction Measure (IRRM) pool restriction, but this pool restriction is not in the NAA because it is interim. All zones are defined in the project's water control manual except for the buffer zone. The buffer zone is for modeling purposes intended to estimate likely conservation actions taken by regulators in extremely low storage situations when local tributary flows would be prioritized above withdrawals and mainstem flow targets.

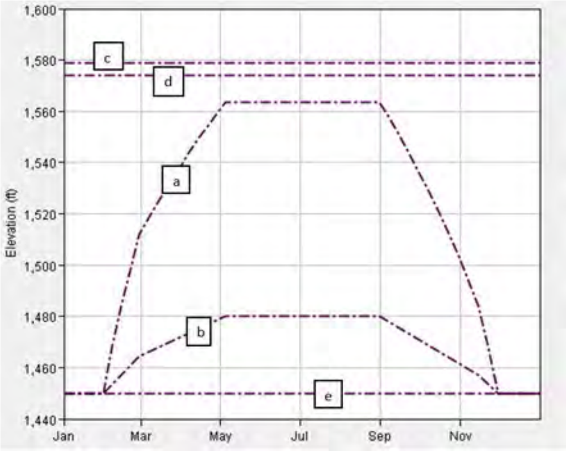
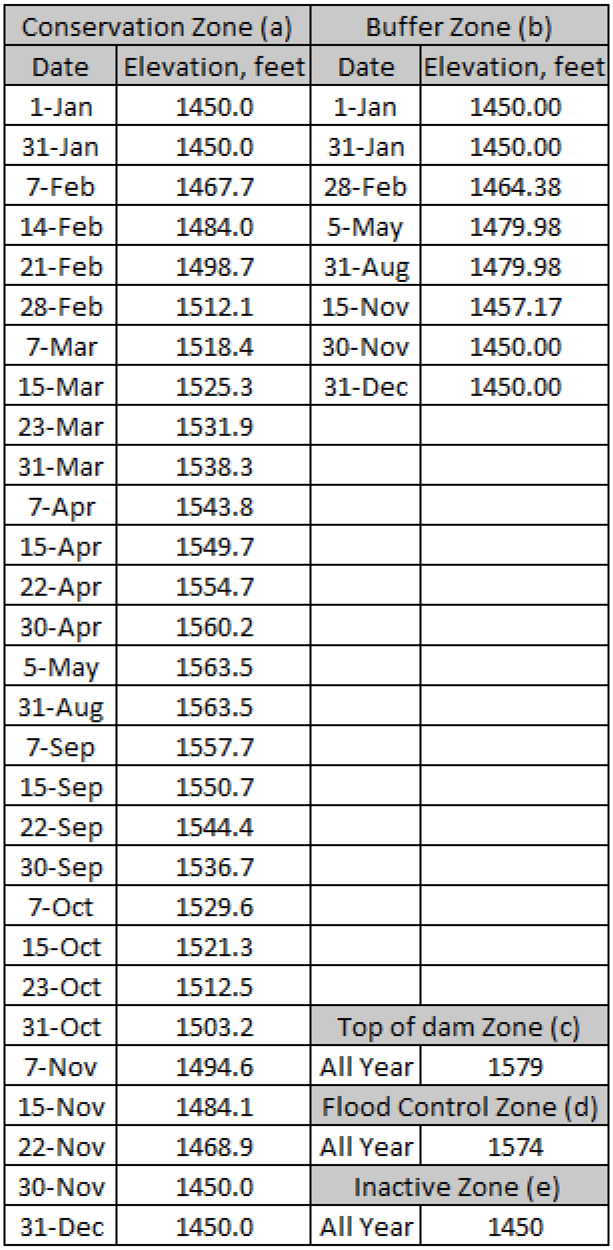


Figure 3-54. Detroit ResSim Water Control Diagram

Table 3-21. Detroit Reservoir Zone Elevations



Conservation Zone (a)		Buffer Zone (b)	
Date	Elevation, feet	Date	Elevation, feet
1-Jan	1450.0	1-Jan	1450.00
31-Jan	1450.0	31-Jan	1450.00
7-Feb	1467.7	28-Feb	1464.38
14-Feb	1484.0	5-May	1479.98
21-Feb	1498.7	31-Aug	1479.98
28-Feb	1512.1	15-Nov	1457.17
7-Mar	1518.4	30-Nov	1450.00
15-Mar	1525.3	31-Dec	1450.00
23-Mar	1531.9		
31-Mar	1538.3		
7-Apr	1543.8		
15-Apr	1549.7		
22-Apr	1554.7		
30-Apr	1560.2		
5-May	1563.5		
31-Aug	1563.5		
7-Sep	1557.7		
15-Sep	1550.7		
22-Sep	1544.4		
30-Sep	1536.7		
7-Oct	1529.6		
15-Oct	1521.3		
23-Oct	1512.5		
31-Oct	1503.2	Top of dam Zone (c)	
7-Nov	1494.6	All Year	1579
15-Nov	1484.1	Flood Control Zone (d)	
22-Nov	1468.9	All Year	1574
30-Nov	1450.0	Inactive Zone (e)	
31-Dec	1450.0	All Year	1450

3.5.10.3 Detroit Detailed Operational Descriptions

A description of each operation at Detroit is provided below followed by detailed screenshots of each operation in Figure B-3-55, Figure B-3-56, and Figure B-3-57.

- Upper RO use 1400 to 1542 ft - Only use upper RO when above 1400' and below 1542'
- No Lower RO Flow - Do not use lower RO.
- Max Power Release - Max flow through powerhouse.

- Min Power Release - Min flow through powerhouse to prevent cavitation at Big Cliff (different than speed no load).
- Special Curves - induced surcharge function, a function of elevation and inflow. Designed for flood events that present risk of dam overtopping.
- Max Evacuation Release - Max release as a function of pool elevation. Designed to mimic flood season maximum releases
- BiOp MinTrib and Withdrawals by WY – Includes minimum flows to satisfy the 2008 BiOp and 2050 projected consumptive withdrawals
- Flood Targets IF Block - Divides flood reduction operations into spring and winter.
- Jefferson Bankfull Max - Jefferson Bankfull is 43,000 cfs.
- Mehama Bankfull Max - Mehama Bankfull is 17,000 cfs.
- Salem Bankfull Max - Salem Bankfull is 94,000 fcs.
- Jefferson Winter Ops Max - Downstream flood reduction depending on reservoir elevation
- Mehama Winter Ops Max - Downstream flood reduction depending on reservoir elevation
- Salem Winter Ops Max - Downstream flood reduction depending on reservoir elevation
- Daily BiOp Max Rate of Decrease - Defines the next day's minimum outflow as a function of current outflow. Designed to result in the lesser of 1' per day tailwater change or a 50% reduction in flow per the BiOp.
- BiOp and Con Max - BiOp Max applied all conservation season to match typically max summer flows
- BiOp Min - 2008 BiOp minimum release.
- *A temperature spill operation is post processed outside of ResSim into the Detroit results. The temperature spill operation releases 60% of the total outflow over the spillway 15Jun-15Nov when reservoir elevations are above the spillway, and 60% of the total outflow through the RO 01Oct-15Nov when elevations are below the spillway.

Operates Release From: Detroit-Upper Controlled Outlet

Rule Name:)er RO use 1400 to 1542 ft

Description:

Function of: Detroit-Pool Elevation, Current Value

Limit Type: Maximum

Interp.: Step

Elev (ft)	Release (cfs)
1399.9	0.0
1400.0	12140.0
1420.0	12140.0
1542.0	12140.0
1542.1	0.0

☐ Period Average Limit
☐ Hour of Day Multiplier
☐ Day of Week Multiplier
☐ Rising/Falling Condition
☐ Seasonal Variation

Operates Release From: Detroit-Lower Controlled Outlet

Rule Name: No Lower RO Flow

Description: The lower RO has physical properties listed, but there should be n

Function of: Date

Limit Type: Maximum

Interp.: Step

Date	Release (cfs)
01Jan	0.0

☐ Period Average Limit
☐ Hour of Day Multiplier
☐ Day of Week Multiplier
☐ Rising/Falling Condition
Seasonal Variation

Operates Release From: Detroit-Power Plant

Rule Name: Max Power Release

Description:

Function of: Detroit-Pool Elevation, Current Value

Limit Type: Maximum

Interp.: Linear

Elev (ft)	Release (cfs)
1427.0	4050.0
1452.0	4900.0
1485.0	5850.0
1492.0	5550.0
1512.0	5050.0
1542.0	4550.0
1582.0	4200.0

☐ Period Average Limit
☐ Hour of Day Multiplier
☐ Day of Week Multiplier
☐ Rising/Falling Condition
☐ Seasonal Variation

Operates Release From: Detroit-Power Plant

Rule Name: Min Power Release

Description: To prevent cavitation (rule added August 2020)

Function of: Date

Limit Type: Minimum

Interp.: Linear

Date	Release (cfs)
01Jan	1050.0

☐ Period Average Limit
☐ Hour of Day Multiplier
☐ Day of Week Multiplier
☐ Rising/Falling Condition
Seasonal Variation

Operates Release From: Detroit

Induced Surcharge Rule: Special Curves

Description:

● Use Induced Surcharge Function ○ Specify the ESRD Curves

Interpolation Type: Linear

Induced Surcharge Envelope Curve

Elevation (ft)	Release (cfs)
1541.0	0.0
1543.0	2520.0
1544.0	4320.0
1545.0	6480.0
1546.0	9000.0
1547.0	11880.0
1548.0	15120.0
1549.0	18720.0
1550.0	22680.0
1551.0	27120.0
1552.0	31920.0
1553.0	37020.0
1554.0	42420.0
1555.0	48060.0
1556.0	53880.0
1557.0	59820.0
1558.0	65820.0
1559.0	71940.0
1560.0	78240.0
1561.0	84780.0
1562.0	91560.0
1563.0	98580.0
1564.0	105840.0
1565.0	113340.0
1566.0	121080.0
1567.0	129060.0
1568.0	137280.0
1569.0	145740.0
1570.0	154440.0
1571.0	163380.0
1572.0	172560.0
1573.0	181980.0
1574.0	191640.0

Time of Recession (hrs): 23.3

Operates Release From: Detroit-Dam

Rule Name: Max Evacuation Release

Description: Calibration

Function of: Detroit-Pool Elevation, Previous Value

Limit Type: Maximum

Interp.: Linear

Elev (ft)	Release (cfs)
1450.0	5000.0
1465.0	5000.0
1500.0	10000.0
1545.0	15000.0
1563.0	17000.0

☐ Period Average Limit
☐ Hour of Day Multiplier
☐ Day of Week Multiplier
☐ Rising/Falling Condition
☐ Seasonal Variation

Operates Release From: Detroit

Rule Name: Min for BCL

Description:

Function of: Date

Limit Type: Minimum

Interp.: Linear

Date	Release (cfs)
01Jan	1050.0

☐ Period Average Limit
☐ Hour of Day Multiplier
☐ Day of Week Multiplier
☐ Rising/Falling Condition
Seasonal Variation

Figure 3-55. Detroit NAA Operation Set Rules

Operates Release From: Detroit-Dam
Rule Name: 1b and Withdrawals by WY
Description:
Function of: Water Year Type, Current Value
Limit Type: Minimum
Interp.: Linear

Water Year Type	Release (cfs)														
	01Jan	01Feb	01Mar	16Mar	01Apr	01May	01Jun	01Jul	15Jul	01Aug	01Sep	01Oct	16Oct	01Nov	01Dec
0.0	1200.0	1000.0	1000.0	1500.0	1500.0	1500.0	1226.0	1234.0	1034.0	1035.0	1529.0	1500.0	1200.0	1200.0	1200.0
0.9	1200.0	1000.0	1000.0	1500.0	1500.0	1500.0	1232.0	1242.0	1042.0	1043.0	1535.0	1500.0	1200.0	1200.0	1200.0
1.2	1200.0	1000.0	1000.0	1500.0	1500.0	1500.0	1240.0	1252.0	1052.0	1053.0	1543.0	1500.0	1200.0	1200.0	1200.0
1.48	1200.0	1000.0	1000.0	1500.0	1500.0	1500.0	1246.0	1260.0	1060.0	1062.0	1550.0	1500.0	1200.0	1200.0	1200.0
2.0	1200.0	1000.0	1000.0	1500.0	1500.0	1500.0	1246.0	1260.0	1060.0	1062.0	1550.0	1500.0	1200.0	1200.0	1200.0

☐ Period Average Limit
☐ Hour of Day Multiplier
☐ Day of Week Multiplier
☐ Rising/Falling Condition
☑ Seasonal Variation

Operates Release From: Detroit
Rule Name: Jefferson Bankfull Max
Description: 2019 SOP
Function of: Date
Limit Type: Maximum
Interp.: Linear
Downstream Location: Santiam_at Jefferson
Parameter: Flow

Date	Flow (cfs)
01Jan	43000.0

Period Average Limit
☐ Hour of Day Multiplier
☐ Day of Week Multiplier
Seasonal Variation
☐ Flow Contingency

Operates Release From: Detroit
Rule Name: Jefferson Winter Ops Max
Description: 2019 SOP Bankful 43,000 flood 55,900
Function of: Detroit-Pool Elevation, Current Value
Limit Type: Maximum
Interp.: Linear
Downstream Location: Santiam_at Jefferson
Parameter: Flow

Elev (ft)	Flow (cfs)
1424.0	43000.0
1536.0	43000.0
1546.0	55900.0
1574.0	55900.0

Period Average Limit
☐ Hour of Day Multiplier
☐ Day of Week Multiplier
☐ Seasonal Variation
☐ Flow Contingency

Operates Release From: Detroit
Rule Name: Mehama Bankfull Max
Description: 2019 SOP
Function of: Date
Limit Type: Maximum
Interp.: Linear
Downstream Location: No Santiam_at Mehama
Parameter: Flow

Date	Flow (cfs)
01Jan	17000.0

Period Average Limit
☐ Hour of Day Multiplier
☐ Day of Week Multiplier
Seasonal Variation
☐ Flow Contingency

Operates Release From: Detroit
Rule Name: Mehama Winter Ops Max
Description:
Function of: Detroit-Pool Elevation, Current Value
Limit Type: Maximum
Interp.: Linear
Downstream Location: No Santiam_at Mehama
Parameter: Flow

Elev (ft)	Flow (cfs)
1424.0	17000.0
1536.0	17000.0
1546.0	30500.0
1574.0	30500.0

Period Average Limit
☐ Hour of Day Multiplier
☐ Day of Week Multiplier
☐ Seasonal Variation
☐ Flow Contingency

Operates Release From: Detroit
Rule Name: Salem Bankfull Max
Description: 2019 SOP
Function of: Date
Limit Type: Maximum
Interp.: Linear
Downstream Location: Willamette_at Salem
Parameter: Flow

Date	Flow (cfs)
01Jan	94000.0

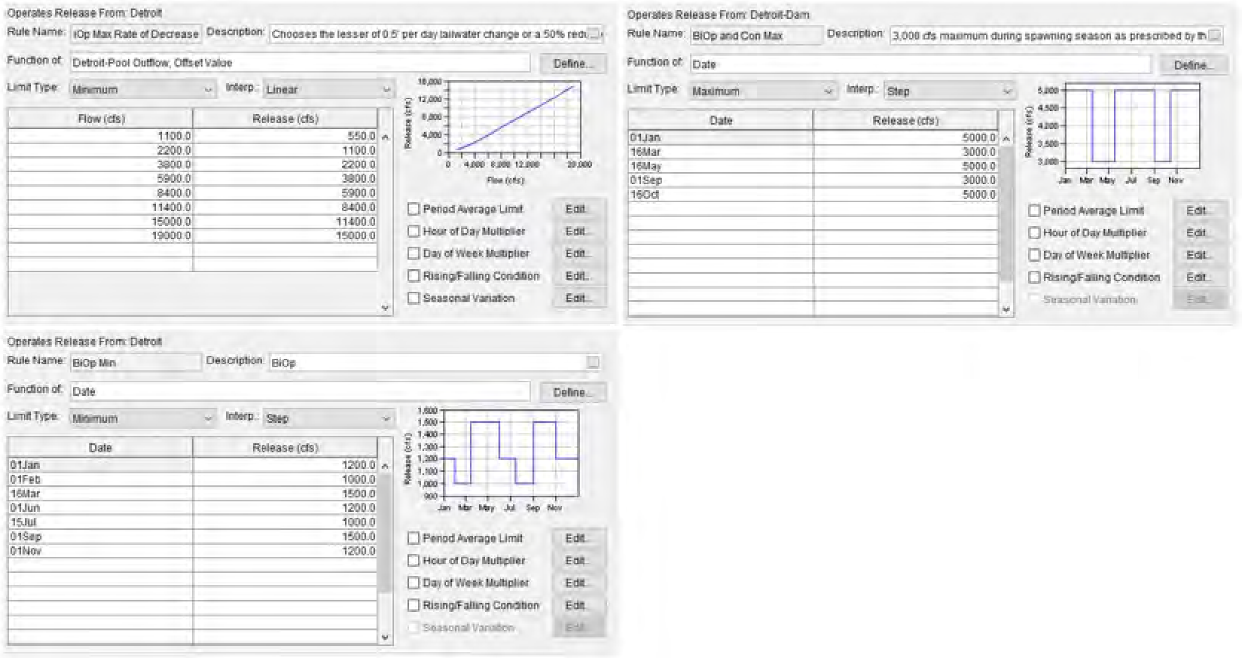
Period Average Limit
☐ Hour of Day Multiplier
☐ Day of Week Multiplier
Seasonal Variation
☐ Flow Contingency

Operates Release From: Detroit
Rule Name: Salem Winter Ops Max
Description:
Function of: Detroit-Pool Elevation, Current Value
Limit Type: Maximum
Interp.: Linear
Downstream Location: Willamette_at Salem
Parameter: Flow

Elev (ft)	Flow (cfs)
1424.0	94000.0
1536.0	94000.0
1546.0	154300.0
1574.0	154300.0

Period Average Limit
☐ Hour of Day Multiplier
☐ Day of Week Multiplier
☐ Seasonal Variation
☐ Flow Contingency

Figure 3-56. Detroit NAA Operation Set Rules Continued



Operates Release From: Detroit

Rule Name: iOp Max Rate of Decrease

Description: Chooses the lesser of 0.5' per day tailwater change or a 50% redu

Function of: Detroit-Pool Outflow, Offset Value

Limit Type: Minimum

Interp.: Linear

Flow (cfs)	Release (cfs)
1100.0	550.0
2200.0	1100.0
3800.0	2200.0
5900.0	3800.0
8400.0	5900.0
11400.0	8400.0
15000.0	11400.0
19000.0	15000.0

☐ Period Average Limit
☐ Hour of Day Multiplier
☐ Day of Week Multiplier
☐ Rising/Falling Condition
☐ Seasonal Variation

Operates Release From: Detroit-Dam

Rule Name: BiOp and Con Max

Description: 3,000 cfs maximum during spawning season as prescribed by th

Function of: Date

Limit Type: Maximum

Interp.: Step

Date	Release (cfs)
01Jan	5000.0
16Mar	3000.0
16May	5000.0
01Sep	3000.0
16Oct	5000.0

☐ Period Average Limit
☐ Hour of Day Multiplier
☐ Day of Week Multiplier
☐ Rising/Falling Condition
Seasonal Variation

Operates Release From: Detroit

Rule Name: BiOp Min

Description: BiOp

Function of: Date

Limit Type: Minimum

Interp.: Step

Date	Release (cfs)
01Jan	1200.0
01Feb	1000.0
16Mar	1500.0
01Jun	1200.0
15Jul	1000.0
01Sep	1500.0
01Nov	1200.0

☐ Period Average Limit
☐ Hour of Day Multiplier
☐ Day of Week Multiplier
☐ Rising/Falling Condition
Seasonal Variation

Figure 3-57. Detroit NAA Operation Set Rules Continued

3.6 HEC-RESSIM NAA SIMULATION RESULTS

The ResSim results for the NAA Simulation are in a HEC-DSS file from the program that is labeled by default *"simulation.dss"*. Each time series record contains daily data for the duration of the simulation, which was 01 October 1935 through 30 September 2019. The program evaluates every computation point, river reach, and every dam outlet and parameter for each of the daily time steps in the simulation.

The NAA simulation was verified to be a realistic representation of current conservation season operations based a visual comparison of modeled and observed reservoir elevations and control point flows between 2008 and 2019 which represents the period of record for post 2008 BiOp implementation operations. Adaptive management and maintenance operations are not modeled. The model used is not intended to model winter operations with high precision. Figure B-3-58 through Figure B-3-68 show the comparison plots of reservoir elevations used to validate the model.

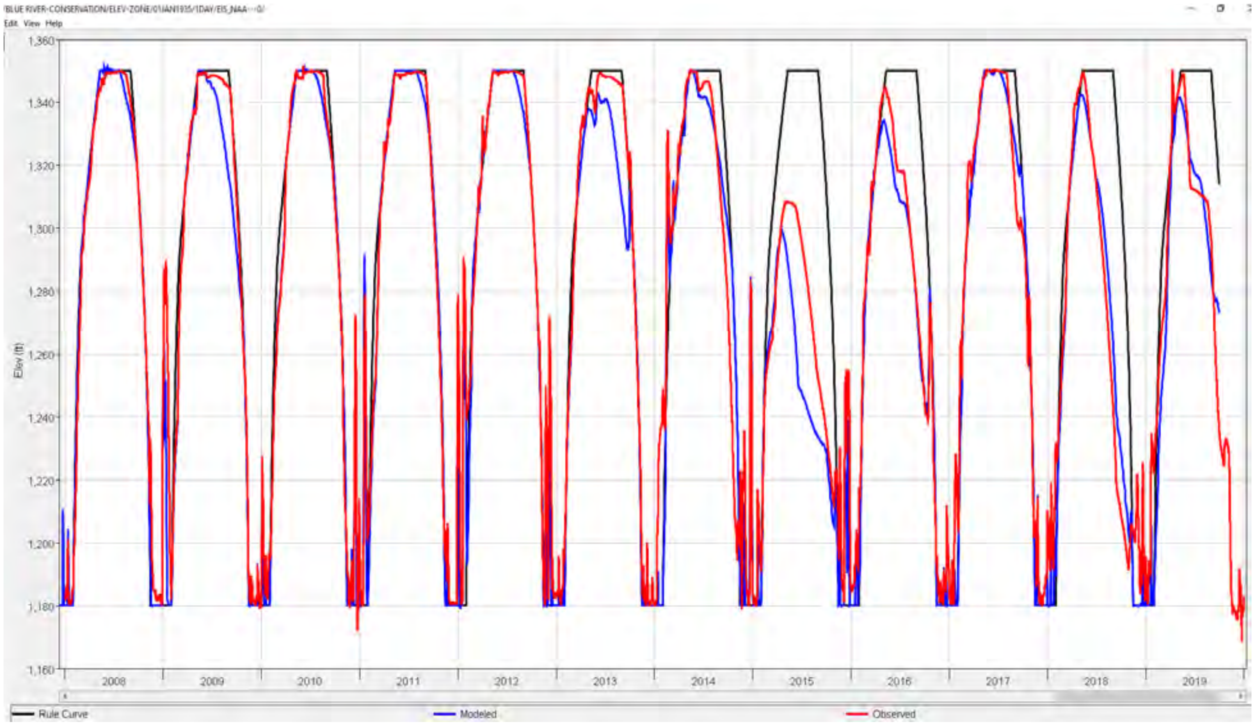


Figure 3-58. Blue River Validation

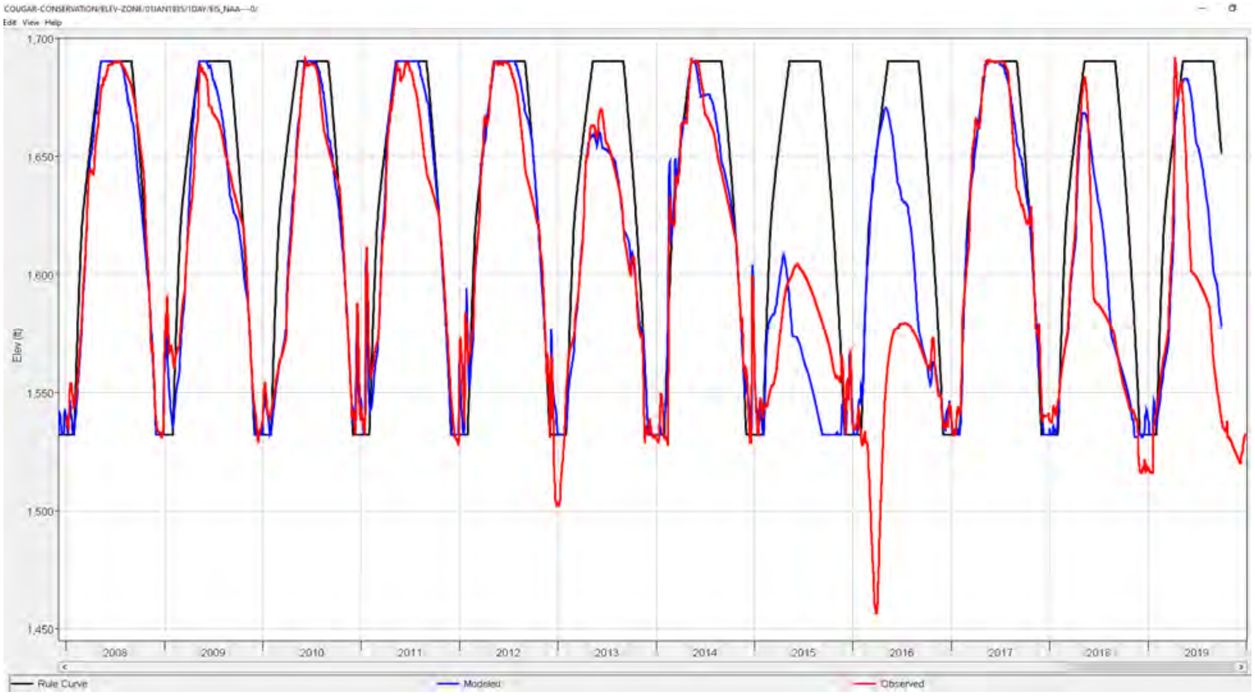


Figure 3-59. Cougar Model Validation

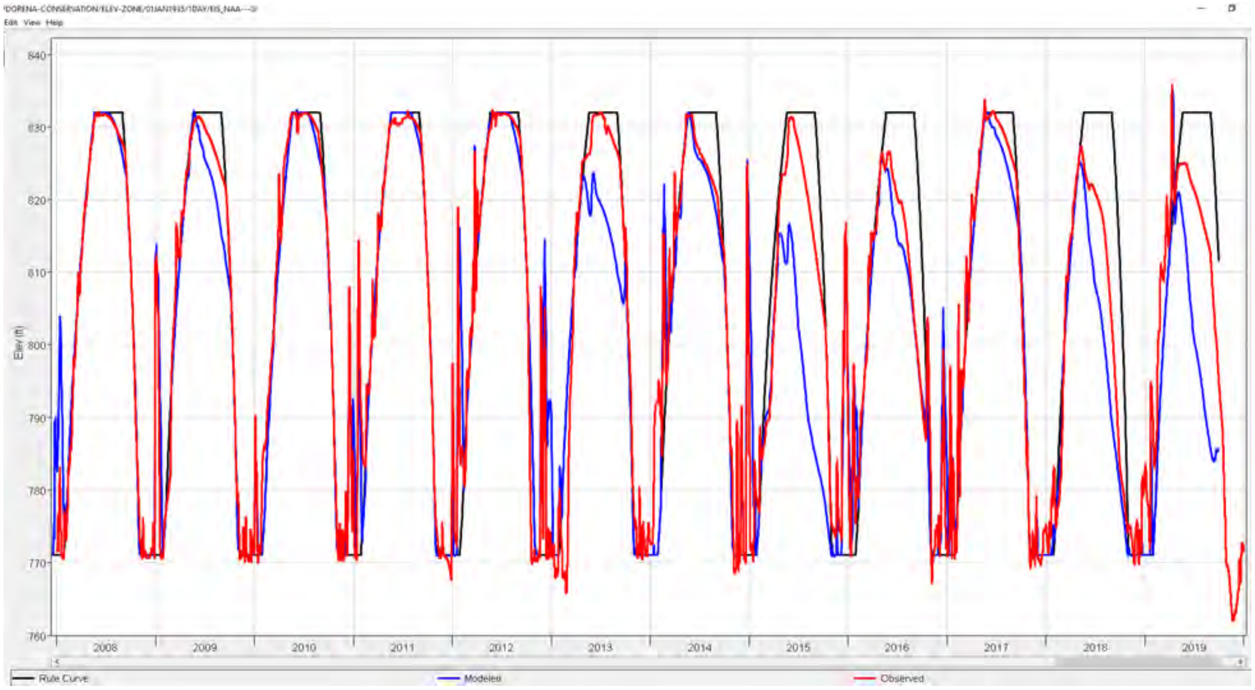


Figure 3-60. Dorena Model Validation

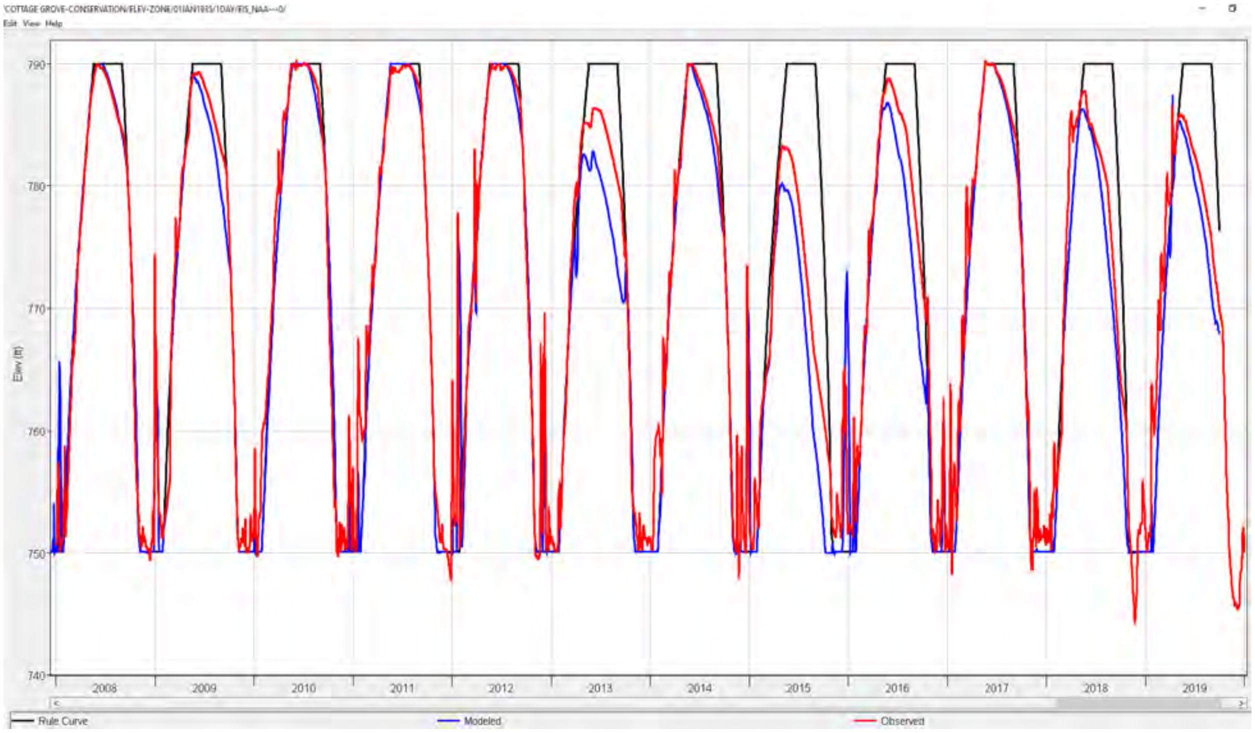


Figure 3-61. Cottage Grove Model Validation

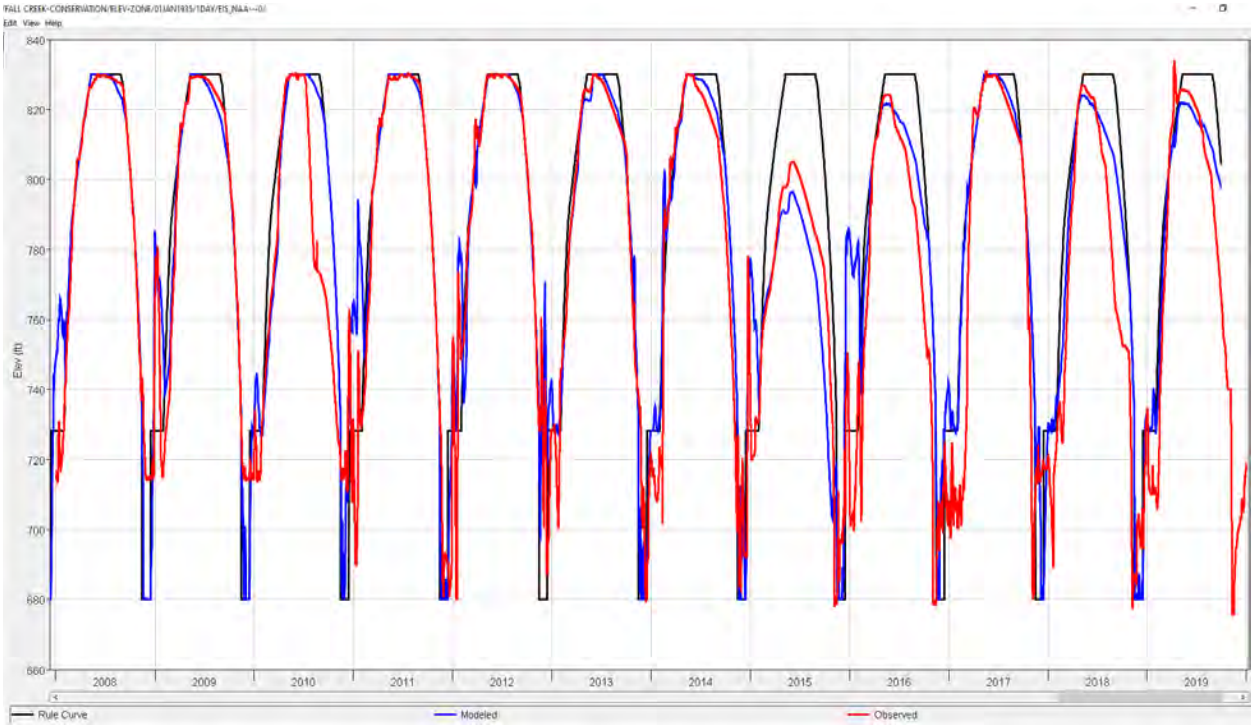


Figure 3-62. Fall Creek Model Validation

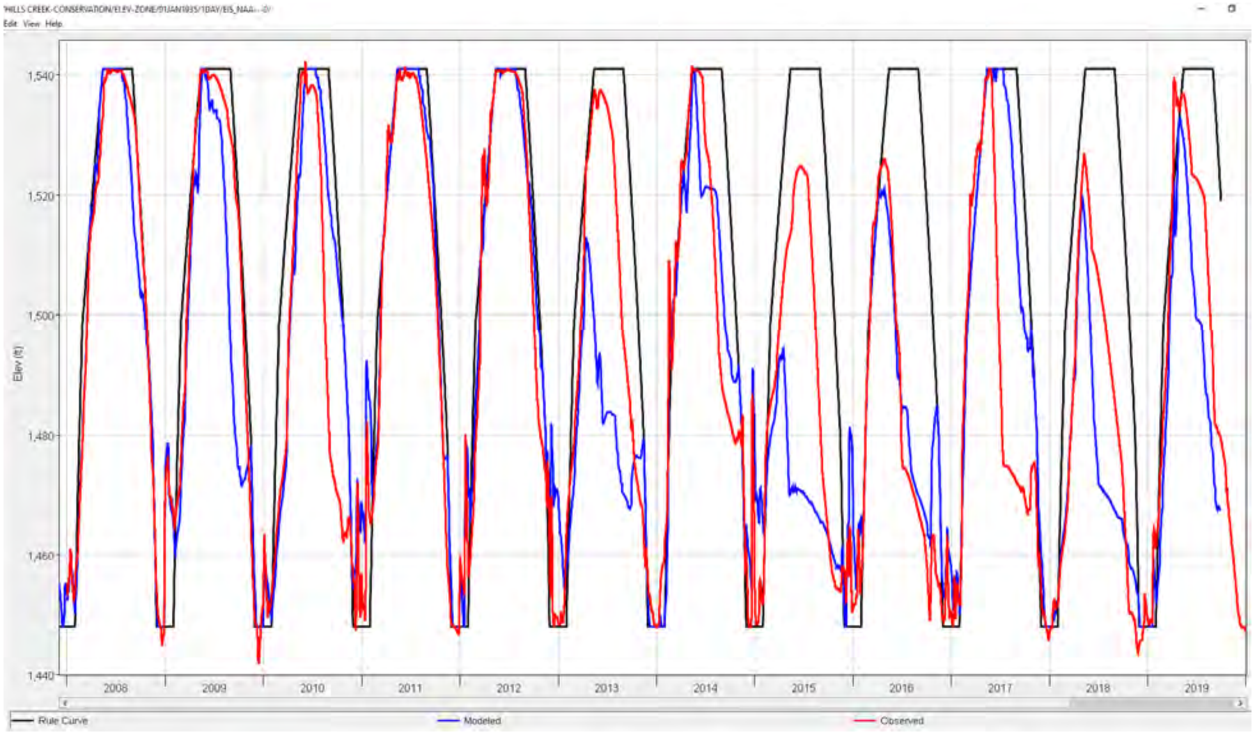


Figure 3-63. Hills Creek Model Validation

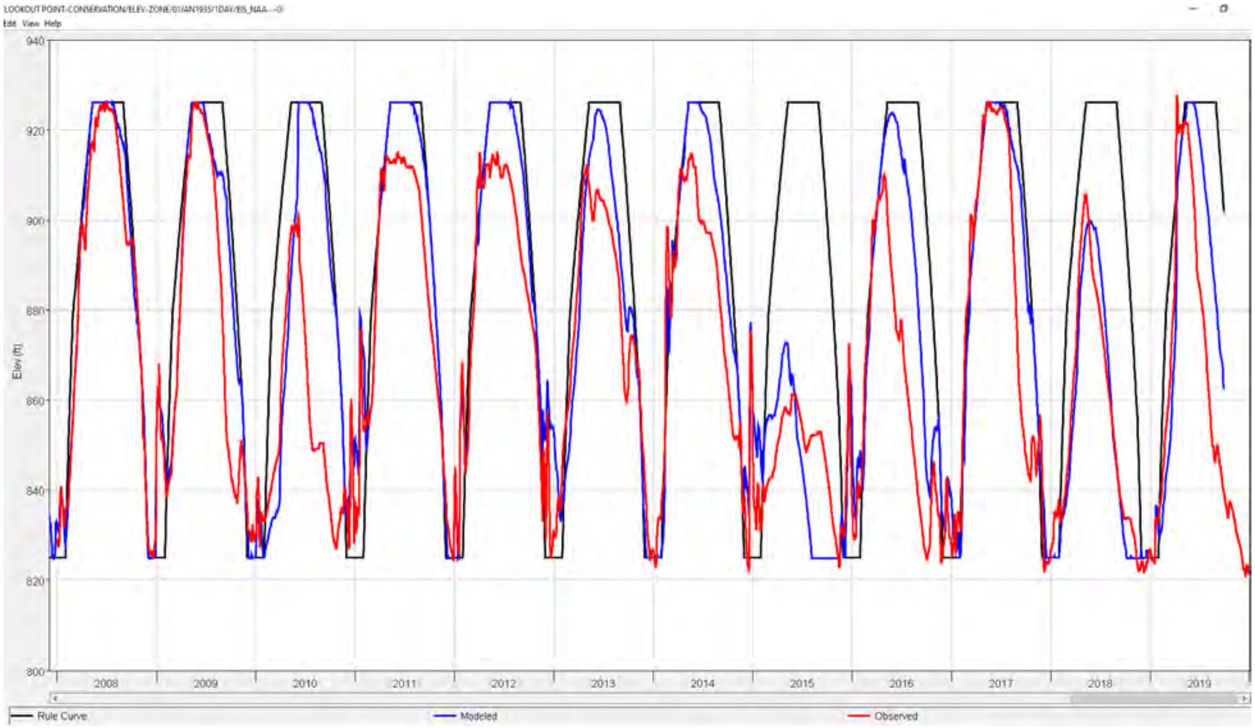


Figure 3-64. Lookout Point Model Validation

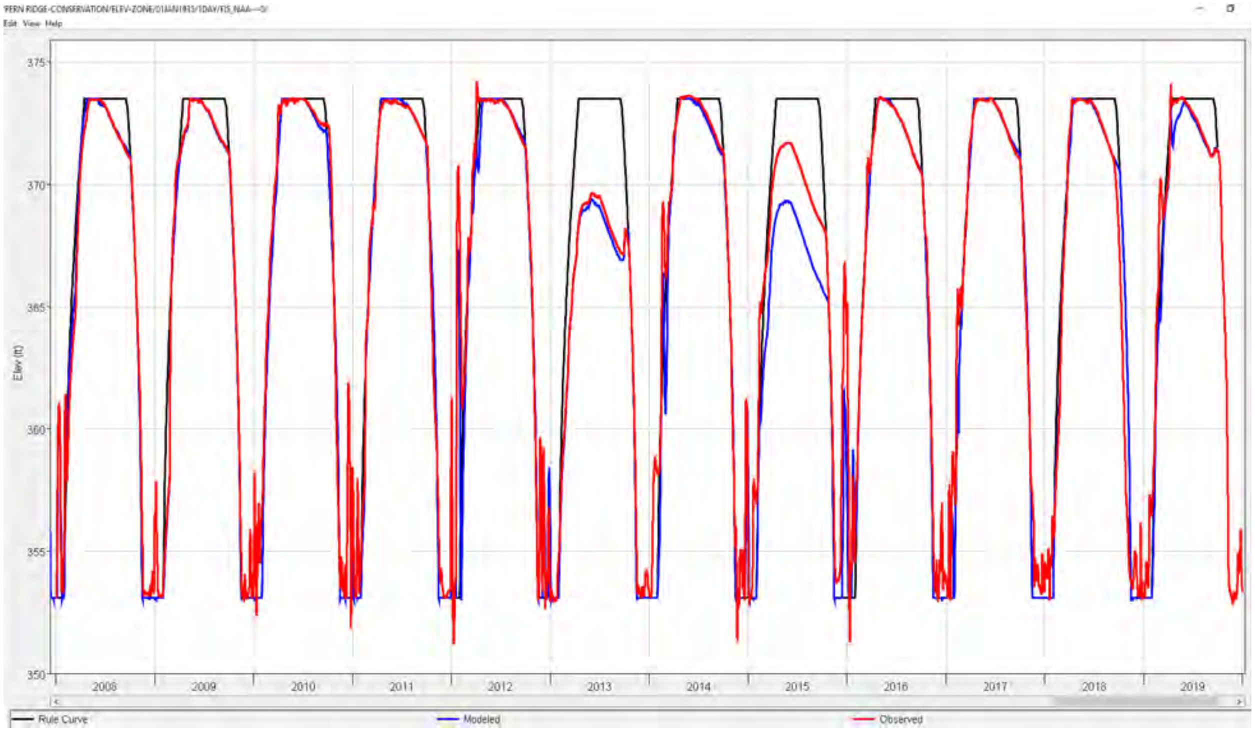


Figure 3-65. Fern Ridge Model Validation

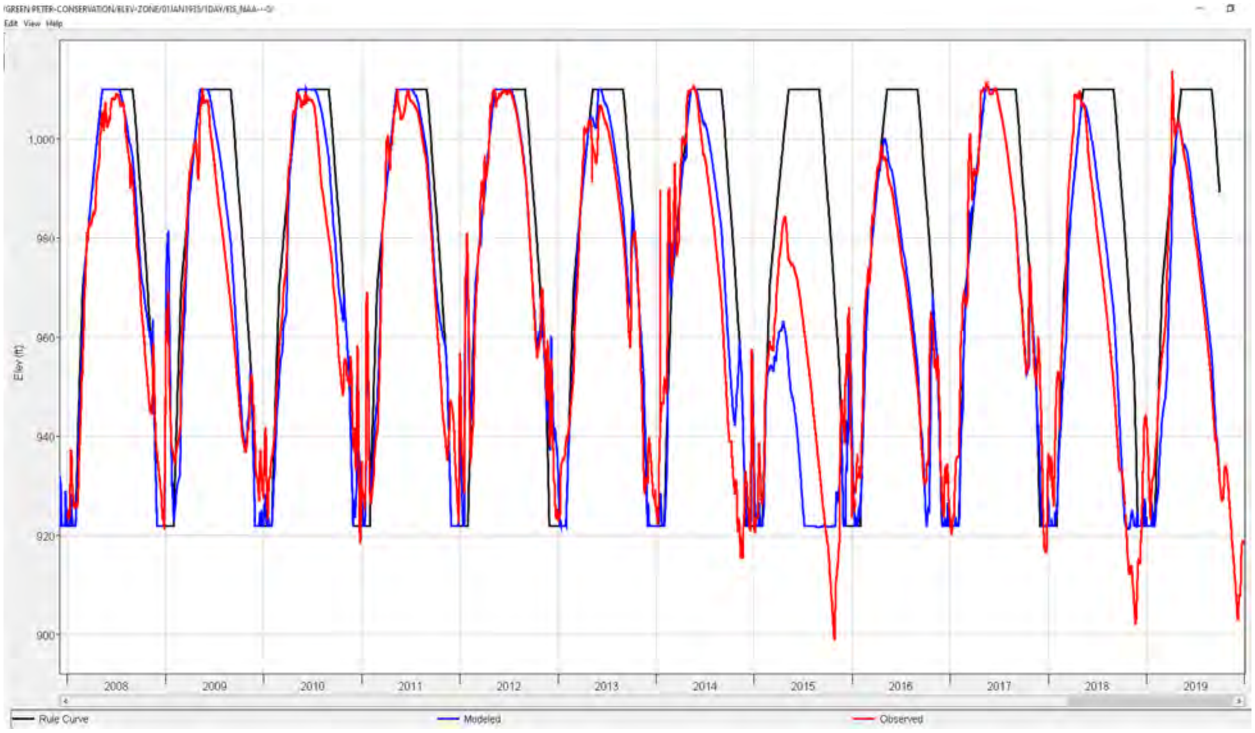


Figure 3-66. Green Peter Model Validation

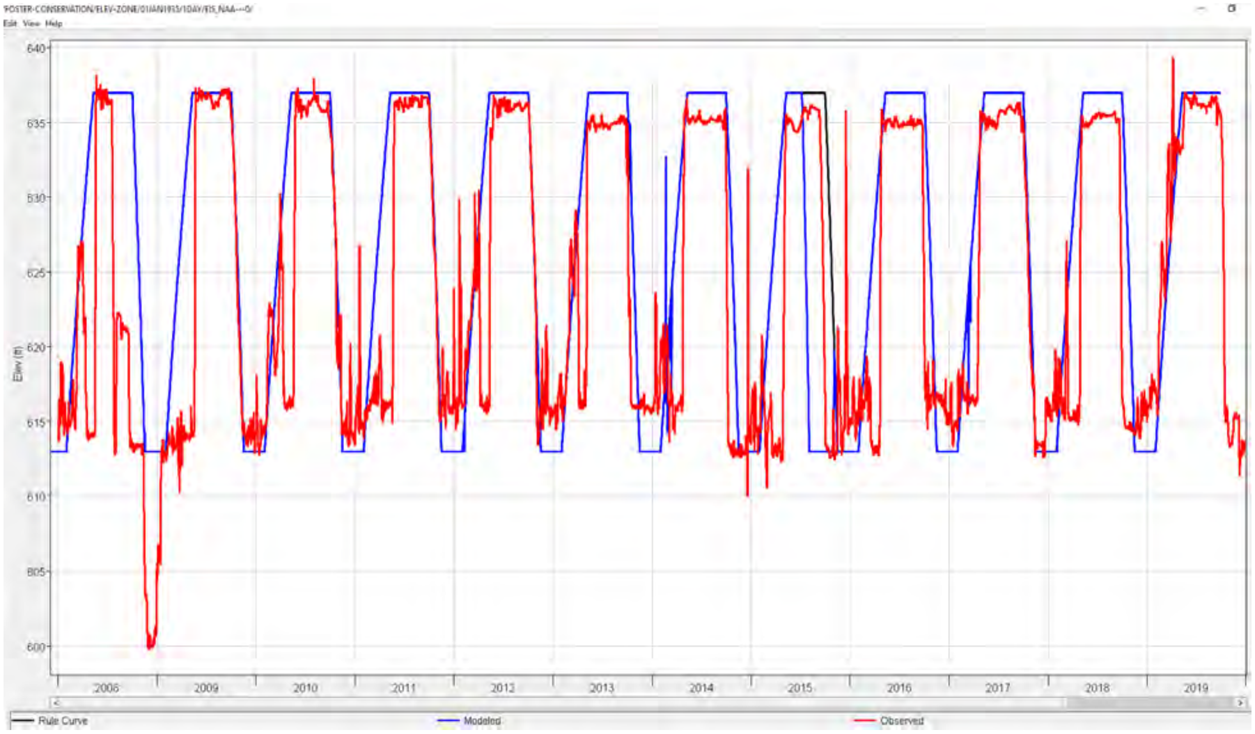


Figure 3-67. Foster Model Validation

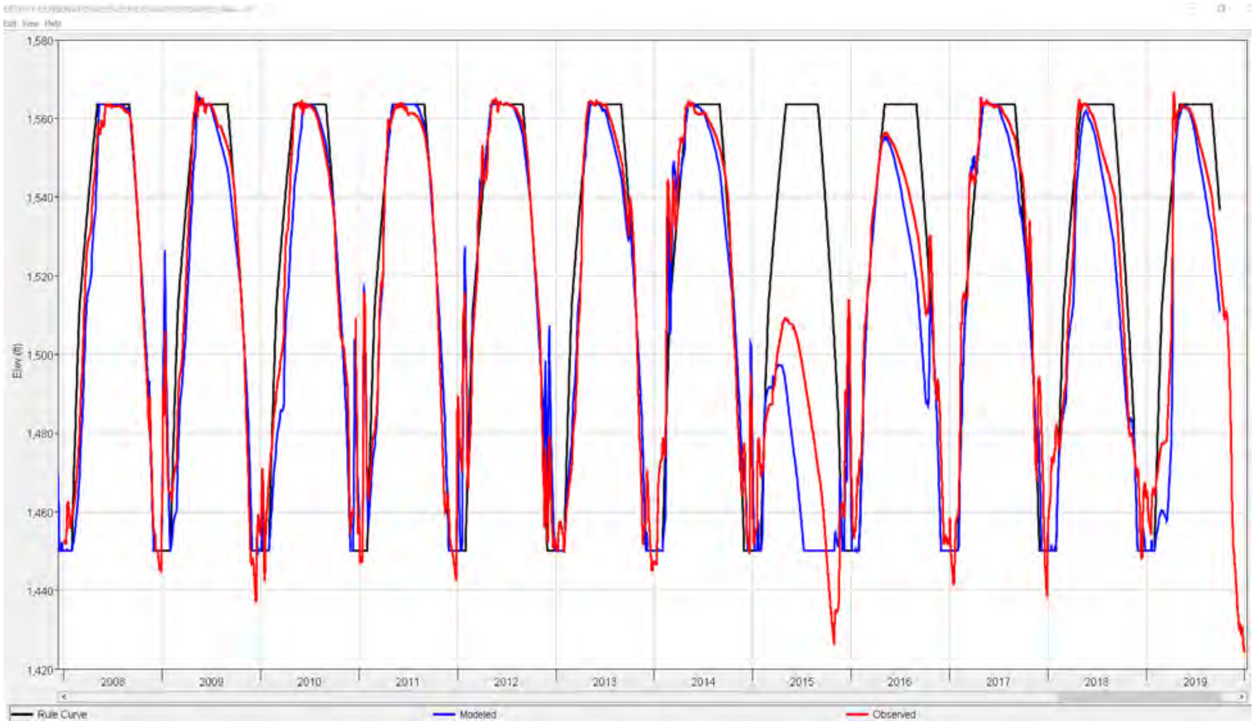


Figure 3-68. Detroit Model Validation

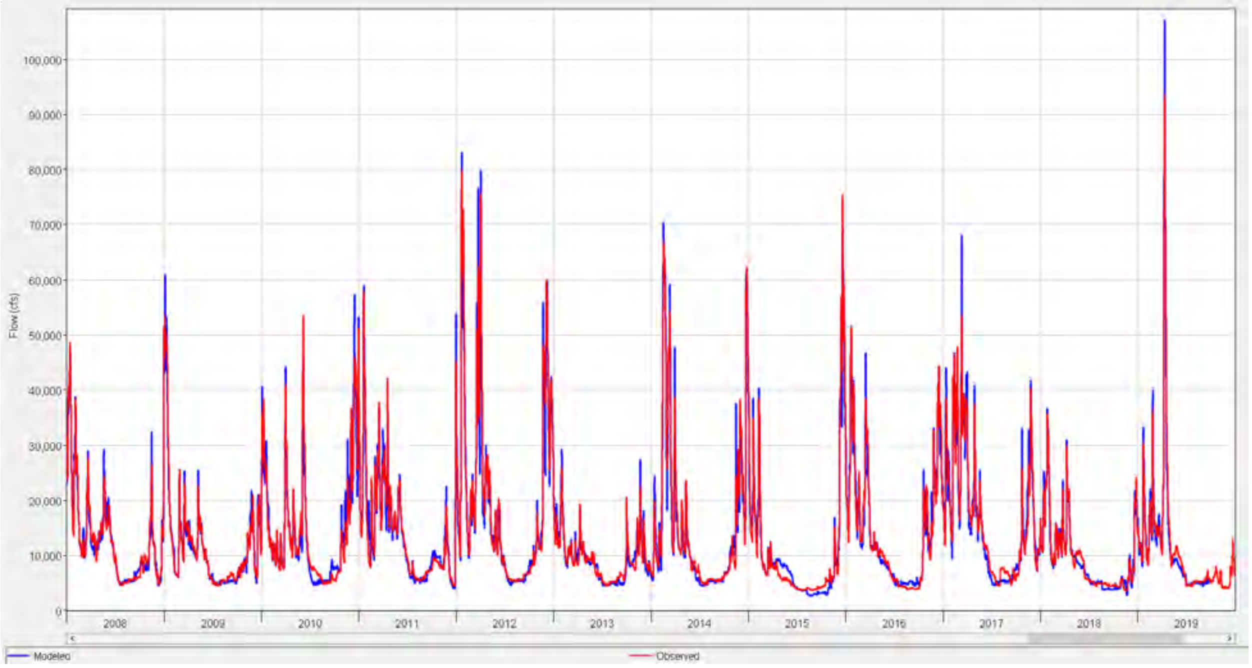


Figure 3-69. Willamette at Albany Model Validation

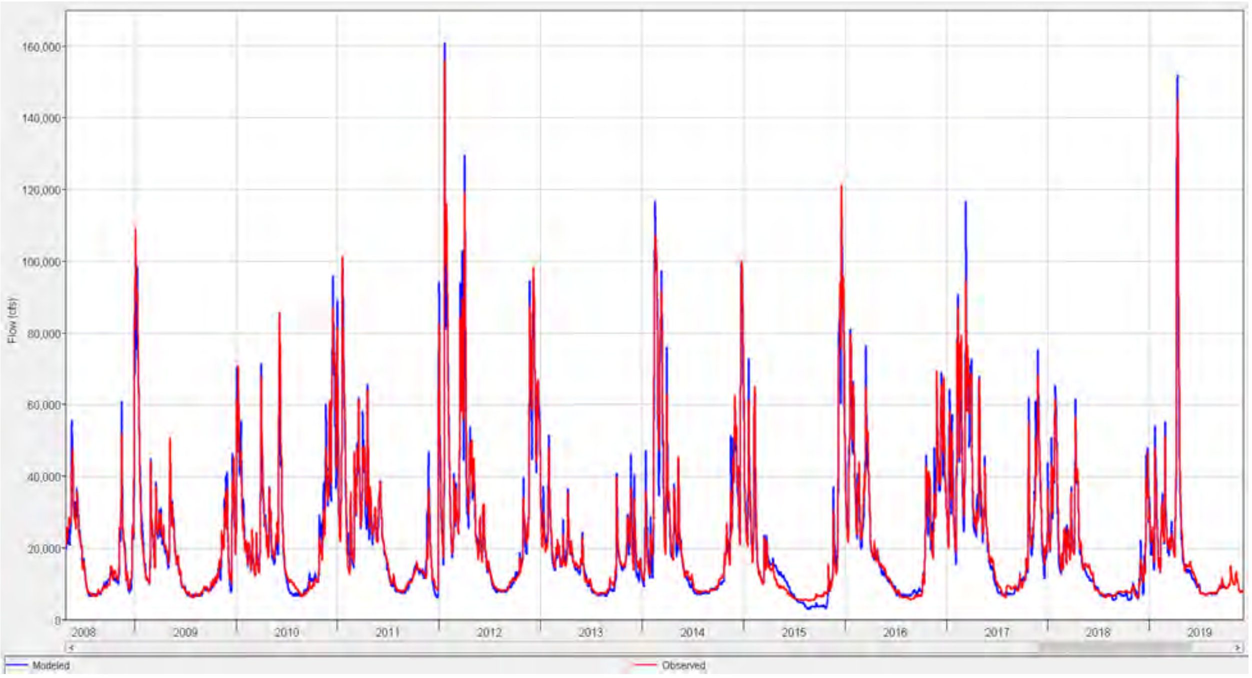


Figure 3-70. Willamette at Salem Model Validation

4 ALTERNATIVE MODELING ASSUMPTIONS

Each alternative is modeled in HEC-ResSim by modifying the No Action Alternative HEC-ResSim Model described in section 3. This section describes changes to the NAA modeled for each alternative. The following section (section 5) provides figures showing the results for each alternative compared to NAA. Not all measures included in each alternative are modeled in HEC-ResSim. Only measures that result in changes to reservoir elevations, total outflows, and outlet specific outflows are modeled.

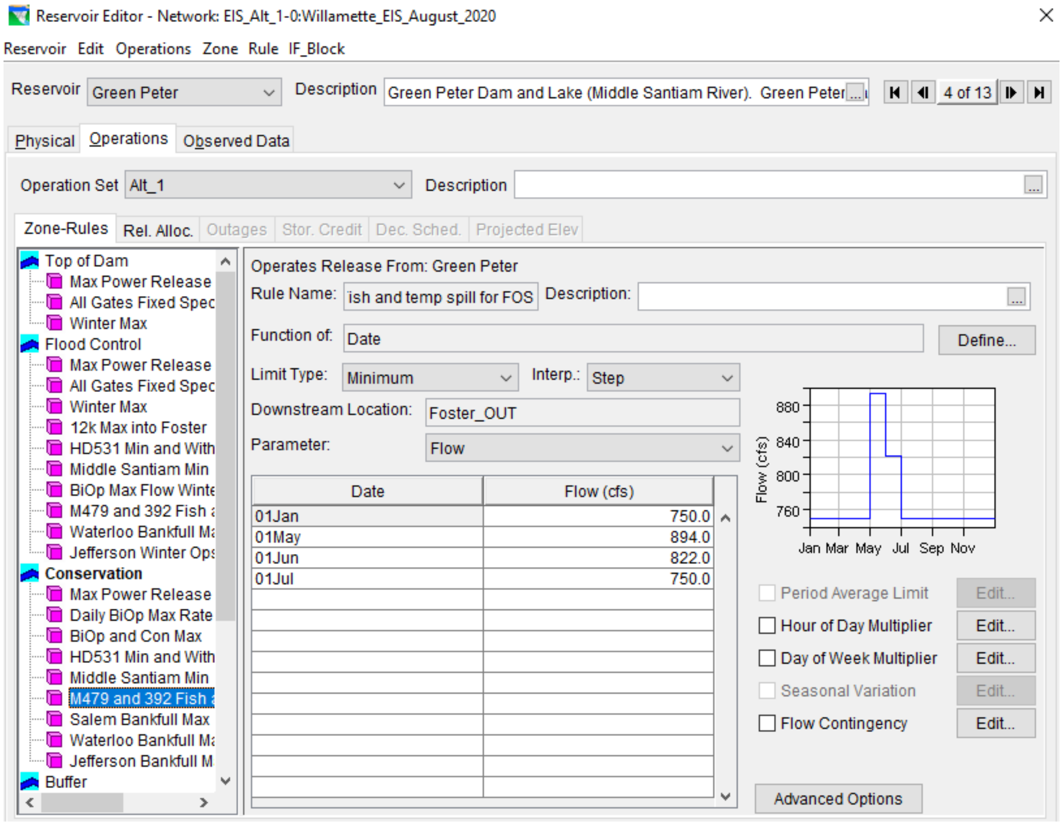
Some measures allocate reservoir releases to multiple outlets in ways that are not effectively modeled in HEC-ResSim. Those flow allocations are calculated in excel spreadsheets outside of the HEC-ResSim model. The logic for the reallocation of flow in excel is also provided in this section.

4.1 ALTERNATIVE 1 MODELING ASSUMPTIONS

4.1.1 Measure 392

Measure 392 has a min flow of 600 cfs over the spillway year-round at FOS. M479 (described in section 4.1.2) requires an additional release of 144 cfs in May and 72cfs in June. Station service requires 150 cfs through the penstock. M497 and M392 minimums are combined with the station service flow into a single minimum flow rule at GPR targeting the flow out of Foster (Figure B-4-1).

Measure 392 minimum flow requirements at other projects were not modeled because other minimum flows in Alternative 1 are higher.



Reservoir Editor - Network: EIS_Alt_1-0:Willamette_EIS_August_2020

Reservoir: Green Peter

Description: Green Peter Dam and Lake (Middle Santiam River). Green Peter

4 of 13

Operation Set: Alt_1

Operates Release From: Green Peter

Rule Name: ish and temp spill for FOS

Function of: Date

Limit Type: Minimum

Interp.: Step

Downstream Location: Foster_OUT

Parameter: Flow

Date	Flow (cfs)
01Jan	750.0
01May	894.0
01Jun	822.0
01Jul	750.0

☐ Period Average Limit

☐ Hour of Day Multiplier

☐ Day of Week Multiplier

☐ Seasonal Variation

☐ Flow Contingency

Figure 4-1. M479, M392, and station service target below FOS from GPR

4.1.2 Measure 479

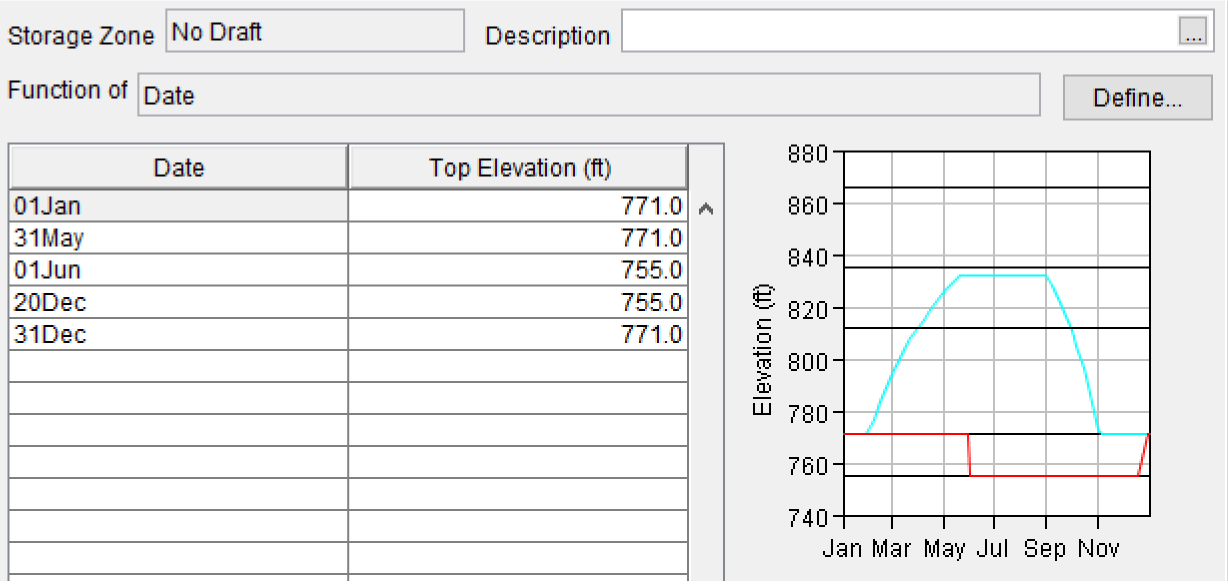
Measure 479 calls for a temperature control pipe at Foster requiring a minimum flow of 144 in May and 72 in June through a new outlet. This release was defined as going over the spillway instead of making a new outlet. This was noted when passing results to other models. This operation can only occur when FOS is above 630'. Foster follows the Rule Curve unless Green Peter completely empties in this model so that restriction is adhered to. Outflow for this measure is added to minimum spill required for measure 392 as shown in Figure B-4-1. Flow is allocated to the correct outlet at Foster in MS Excel with logic that adheres to outlet minimum and maximum releases without changing total project outflow.

4.1.3 Measure 105

Measure 105 calls for a temperature control tower at Detroit that will replace the temperature spill operation in the NAA that allocates flow over the spillway and through the regulating outlet. The re-allocation of flow at Detroit in the NAA was post processed in MS Excel but for Alt 1, the flow re-allocation was used directly from ResSim Temperature control towers at other projects do not change total flow or outlet specific flow from the NAA and are not modeled.

4.1.4 Measure 718

The inactive zone at Cottage Grove, Dorena, Fall Creek, and Blue River is lowered to an elevation 10ft above the RO to permit drafting into the inactive pool to meet minimum tributary and mainstem targets. An additional zone labeled the “no draft” zone delineates the minimum desired drafting elevation. Below this elevation there is a rule that prevents a reduction in pool elevation, and the minimum tributary rule. Drafting below the minimum conservation elevation is permitted from 01Jun until 20Dec. If elevations are below minimum conservation elevation on 20Dec, ResSim will release inflow until inflow is greater than the minimum flow, at which time the reservoir elevation will rise. An example water control diagram showing the bottom of the newly available storage is shown in Figure B-4-2.



Storage Zone: No Draft

Description:

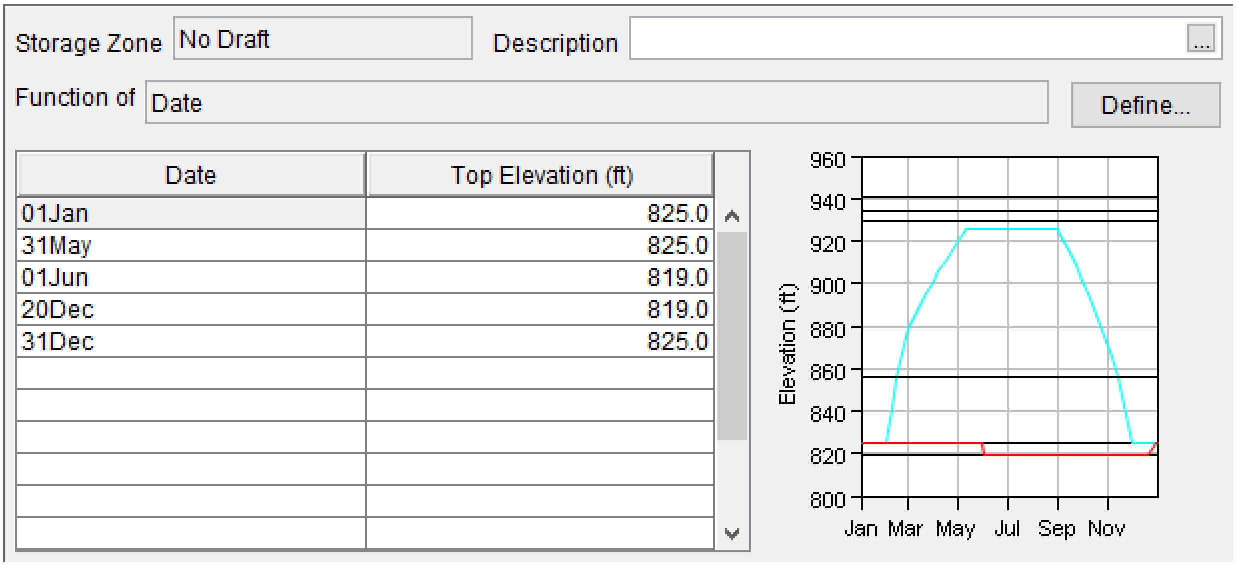
Function of: Date

Date	Top Elevation (ft)
01Jan	771.0
31May	771.0
01Jun	755.0
20Dec	755.0
31Dec	771.0

Figure 4-2. M718 draft limit at Dorena

4.1.5 Measure 304

Measure 304 lowers the inactive zone at Lookout Point, Hills Creek, Cougar, and Green Peter to permit drafting to the bottom of the power pool to meet minimum tributary and mainstem targets. An additional zone labeled the “no draft” zone delineates the minimum permissible drafting elevation. Below this elevation there is a rule that prevents a reduction in pool elevation, and the minimum tributary rule. Drafting below the minimum conservation elevation is permitted from 01Jun until 20Dec. If elevations are below minimum conservation elevation on 20Dec, ResSim will release inflow until inflow is greater than the minimum flow, at which time the reservoir elevation will rise. An example water control diagram showing the bottom of the newly available storage is shown in Figure B-4-3.



Storage Zone: No Draft

Description:

Function of: Date

Date	Top Elevation (ft)
01Jan	825.0
31May	825.0
01Jun	819.0
20Dec	819.0
31Dec	825.0

Figure 4-3. M304 draft limit at Lookout Point

4.1.6 Measure 723

This measure replaces the NAA minimum BiOp flows with HD531 minimum tributary flows at all projects (Figure B-4-4) and on the mainstem (Table B-4-1). HD531 tributary flows are only defined 01Feb-30Nov, but the lowest HD531 min is applied for the remainder of the year so that there is always a minimum flow rule to prevent zero outflows when the downstream control point is above bank full. Contributions to withdrawals are added to these minimum flows when above the minimum conservation elevation but are not added when below the minimum conservation elevation. Withdrawals are the same in the watershed in every year because there is no option in ResSim to adjust a withdrawal downsteam when a given reservoir drafts below a certain limit. Physical minimums defined at some reservoirs may be larger than the HD531 + contribution to withdrawals and will be the controlling minimum flow.

HD 531 flows predate Foster reservoir and anticipated Cascadia reservoir would be built on the South Santiam. To account for this, the minimum flows below Foster are the sum of the Green Peter and Cascadia minimum flows. The minimum flow in the middle Santiam directly below Green Peter is defined as 50 cfs.

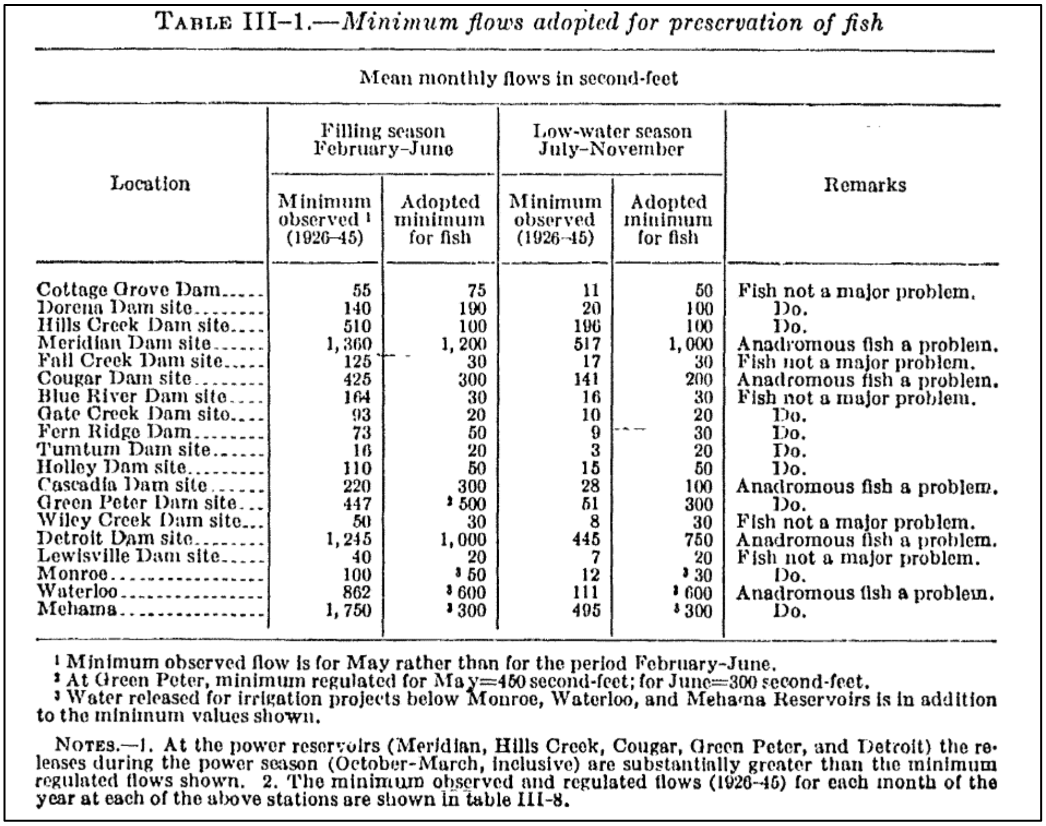


TABLE III–1.—*Minimum flows adopted for preservation of fish*

Mean monthly flows in second-feet

Location	Filling season February–June		Low-water season July–November		Remarks
	Minimum observed [1] (1926–45)	Adopted minimum for fish	Minimum observed (1926–45)	Adopted minimum for fish	
Cottage Grove Dam	55	75	11	50	Fish not a major problem.
Dorena Dam site	140	190	20	100	Do.
Hills Creek Dam site	510	100	196	100	Do.
Meridian Dam site	1,360	1,200	517	1,000	Anadromous fish a problem.
Fall Creek Dam site	125	30	17	30	Fish not a major problem.
Cougar Dam site	425	300	141	200	Anadromous fish a problem.
Blue River Dam site	164	30	16	30	Fish not a major problem.
Gate Creek Dam site	93	20	10	20	Do.
Fern Ridge Dam	73	50	9	30	Do.
Tumtum Dam site	16	20	3	20	Do.
Holley Dam site	110	50	15	50	Do.
Cascadia Dam site	220	300	28	100	Anadromous fish a problem.
Green Peter Dam site	447	[2] 500	51	300	Do.
Wiley Creek Dam site	50	30	8	30	Fish not a major problem.
Detroit Dam site	1,245	1,000	445	750	Anadromous fish a problem.
Lewisville Dam site	40	20	7	20	Fish not a major problem.
Monroe	100	[3] 50	12	[3] 30	Do.
Waterloo	862	[3] 600	111	[3] 600	Anadromous fish a problem.
Mehama	1,750	[3] 300	495	[3] 300	Do.

[1] Minimum observed flow is for May rather than for the period February–June.

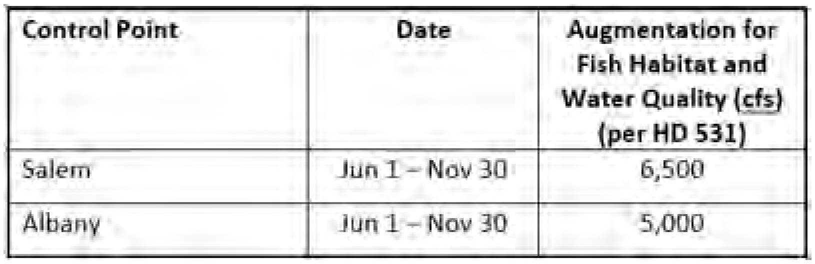
[2] At Green Peter, minimum regulated for May=450 second-feet; for June=300 second-feet.

[3] Water released for irrigation projects below Monroe, Waterloo, and Mehama Reservoirs is in addition to the minimum values shown.

NOTES.—1. At the power reservoirs (Meridian, Hills Creek, Cougar, Green Peter, and Detroit) the releases during the power season (October–March, inclusive) are substantially greater than the minimum regulated flows shown. 2. The minimum observed and regulated flows (1926–45) for each month of the year at each of the above stations are shown in table III–8.

Figure 4-4. M723 HD531 minimum tributary flows

Table 4-1. HD531 Mainstem Targets



Control Point	Date	Augmentation for Fish Habitat and Water Quality (cfs) (per HD 531)
Salem	Jun 1 – Nov 30	6,500
Albany	Jun 1 – Nov 30	5,000

4.1.7 Measure 174

Measure 174 calls for structural modifications to manage total dissolved gasses below reservoirs. These modifications will not change total outflow or outlet specific flow and are not modeled.

4.1.8 Measure 722

Measure 722 addresses fish facilities. This does not change total outflow or outlet specific outflow and is not modeled.

4.1.9 Measure 52

Measure 52 addresses lamprey passage. This does not change total outflow or outlet specific outflow and is not modeled.

4.1.10 Basin Wide Measures 9, 384, 719, 726

These basin wide measures do not change total outflow or outlet specific outflow and are not modeled.

4.2 ALTERNATIVE 2A AND 2B MODELING ASSUMPTIONS

Modeling assumptions for 2A and 2B are detailed below. The modeled differences between Alternative 2A and 2B are limited to Cougar reservoir. Alternative 2A has no fall or spring drawdown at Cougar whereas alternative 2B has a deep spring and fall drawdown to 1330’. Cougar targets a minimum tributary flow of 300 cfs and will not contribute explicitly to mainstem targets in Alt 2B.

Table 4-2. Alt2A and 2B Drawdowns

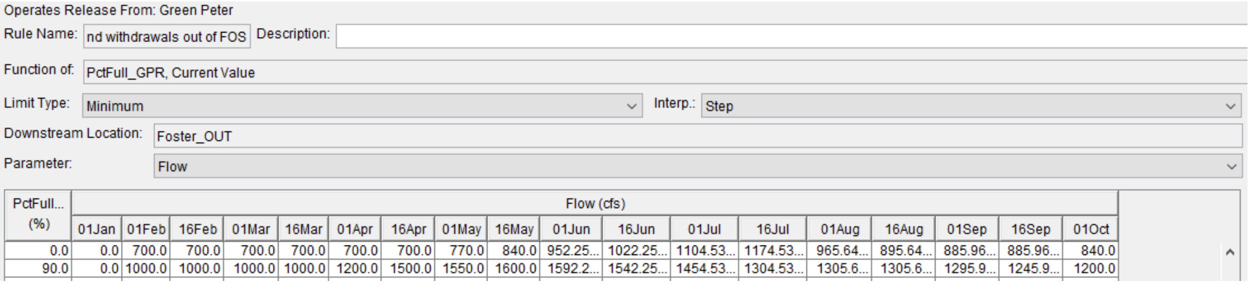
Alternative	Drawdown	Project	
		GPR	CGR
2A	Spring	***No***	***No***
	Fall	780'	***No***
2B	Spring	***No***	1330'
	Fall	780'	1330'

4.2.1 Measure 30

Measure 30 defines minimum tributary flows out of Lookout Point, Cougar, Green Peter, and Detroit based on % reservoir storage being either greater than or less than 90%, relative to the rule curve, evaluated every 2 weeks between 01Feb and 01Jun. The 01Jun % full determination sets the flow regime for the remainder of the year. An example is shown in Figure B-4-5. The remaining reservoirs maintain the 2008 BiOp minimum flow schedule with additions for the NAA abundant water year contributions to withdrawals.

Mainstem flow targets at Salem are determined by an external daily timeseries of the future average 7-day max air temp. The rule in ResSim is shown in Figure B-4-6. There are also base minimum mainstem flow targets of 4500 cfs at Albany and 5000 cfs at Salem. Hills Creek, Lookout Point, Fall Creek, Cottage Grove, Dorena, Cougar, and Blue River contribute to mainstem targets.

Cougar has a deep spring drawdown in Alt 2B. In Alt 2B, Cougar will have a tributary minimum of 300 cfs, and will not explicitly contribute additional flow to supplement mainstem targets.



Operates Release From: Green Peter

Rule Name: nd withdrawals out of FOS

Description:

Function of: PctFull_GPR, Current Value

Limit Type: Minimum

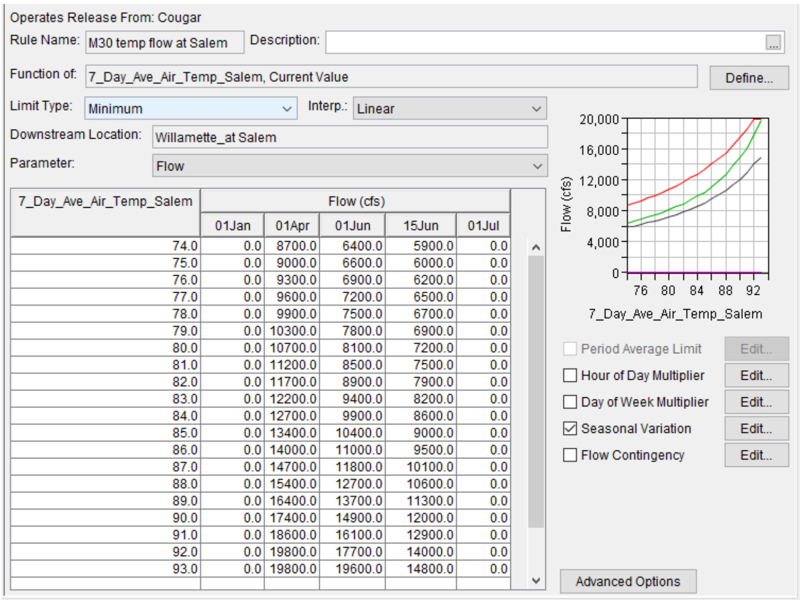
Interp.: Step

Downstream Location: Foster_OUT

Parameter: Flow

PctFull... (%)	Flow (cfs)																	
	01Jan	01Feb	16Feb	01Mar	16Mar	01Apr	16Apr	01May	16May	01Jun	16Jun	01Jul	16Jul	01Aug	16Aug	01Sep	16Sep	01Oct
0.0	0.0	700.0	700.0	700.0	700.0	700.0	700.0	770.0	840.0	952.25...	1022.25...	1104.53...	1174.53...	965.64...	895.64...	885.96...	885.96...	840.0
90.0	0.0	1000.0	1000.0	1000.0	1000.0	1200.0	1500.0	1550.0	1600.0	1592.2...	1542.25...	1454.53...	1304.53...	1305.6...	1305.6...	1295.9...	1245.9...	1200.0

Figure 4-5. M30 minimum tributary flow at Green Peter



Operates Release From: Cougar

Rule Name: M30 temp flow at Salem

Description:

Function of: 7_Day_Ave_Air_Temp_Salem, Current Value

Limit Type: Minimum

Interp.: Linear

Downstream Location: Willamette_at Salem

Parameter: Flow

7_Day_Ave_Air_Temp_Salem	Flow (cfs)				
	01Jan	01Apr	01Jun	15Jun	01Jul
74.0	0.0	8700.0	6400.0	5900.0	0.0
75.0	0.0	9000.0	6600.0	6000.0	0.0
76.0	0.0	9300.0	6900.0	6200.0	0.0
77.0	0.0	9600.0	7200.0	6500.0	0.0
78.0	0.0	9900.0	7500.0	6700.0	0.0
79.0	0.0	10300.0	7800.0	6900.0	0.0
80.0	0.0	10700.0	8100.0	7200.0	0.0
81.0	0.0	11200.0	8500.0	7500.0	0.0
82.0	0.0	11700.0	8900.0	7900.0	0.0
83.0	0.0	12200.0	9400.0	8200.0	0.0
84.0	0.0	12700.0	9900.0	8600.0	0.0
85.0	0.0	13400.0	10400.0	9000.0	0.0
86.0	0.0	14000.0	11000.0	9500.0	0.0
87.0	0.0	14700.0	11800.0	10100.0	0.0
88.0	0.0	15400.0	12700.0	10600.0	0.0
89.0	0.0	16400.0	13700.0	11300.0	0.0
90.0	0.0	17400.0	14900.0	12000.0	0.0
91.0	0.0	18600.0	16100.0	12900.0	0.0
92.0	0.0	19800.0	17700.0	14000.0	0.0
93.0	0.0	19800.0	19600.0	14800.0	0.0

☐ Period Average Limit
☐ Hour of Day Multiplier
☐ Day of Week Multiplier
☑ Seasonal Variation
☐ Flow Contingency

Figure 4-6. M30 Temperature minimum flow at Salem

4.2.2 Measure 721

Measure 721 calls for spill over the spillway at Green Peter in the spring. If above spillway in the spring after 15April, 60% of the flow is released over the spillway until 15Nov, or until the reservoir drafts below the spillway. This re-allocation of flow is post processed in MS Excel outside of HEC-ResSim. Total outflow is not changed.

4.2.3 Measure 166

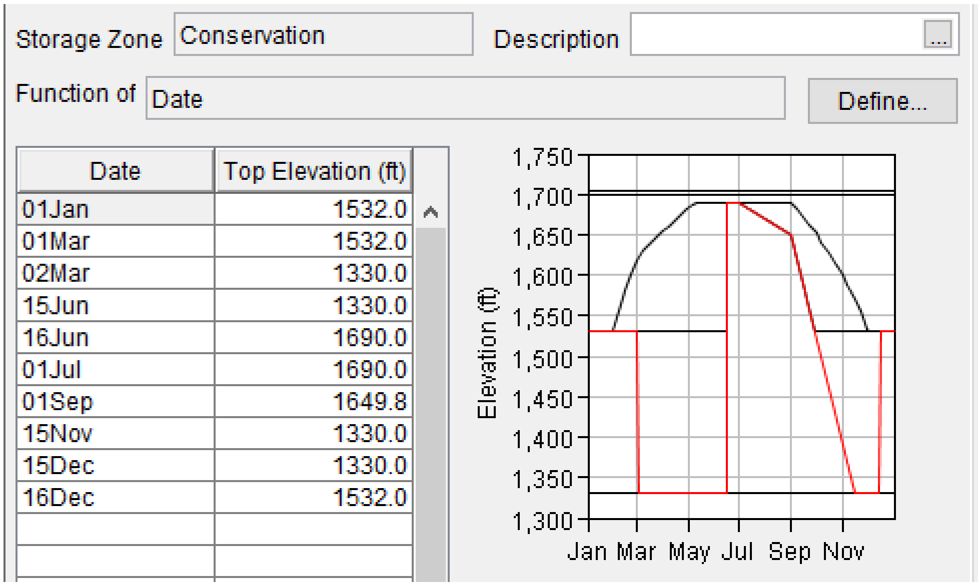
Measure 166 calls for spill through the regulating outlet in the fall at Green Peter. After 01Oct, if below the spillway, release 60% of flow through the RO until 15Nov. The fall drawdown targets an elevation below the minimum power pool on or about 01Oct which results in all flow going through the RO. This re-allocation of flow is post processed in MS Excel outside of HEC-ResSim. Total outflow is not changed.

4.2.4 Measure 714

Measure 714 calls for all flow at Green Peter to go over the spillway when greater than 25’ over the spillway May-Jul. The spring temperature spill operation (M721) takes precedence over this spill operation, so this operation is not modeled.

4.2.5 Measure 720

Measure 720 calls for a drawdown to 1330’ at Cougar in Alternative 2B. When below the minimum conservation elevation of 1532’ Cougar will draft at a rate no greater than 3ft/day. The drawdown will begin on 01 March and refill will begin on 15 June. The penstock will not be used for 1/3 of the day when within 50’ of the saddle leading to the penstock and regulating outlet inlet works. The conservation season target elevation at Cougar, including the spring drawdown, is identified in Figure B-4-7.



Storage Zone: Conservation

Description:

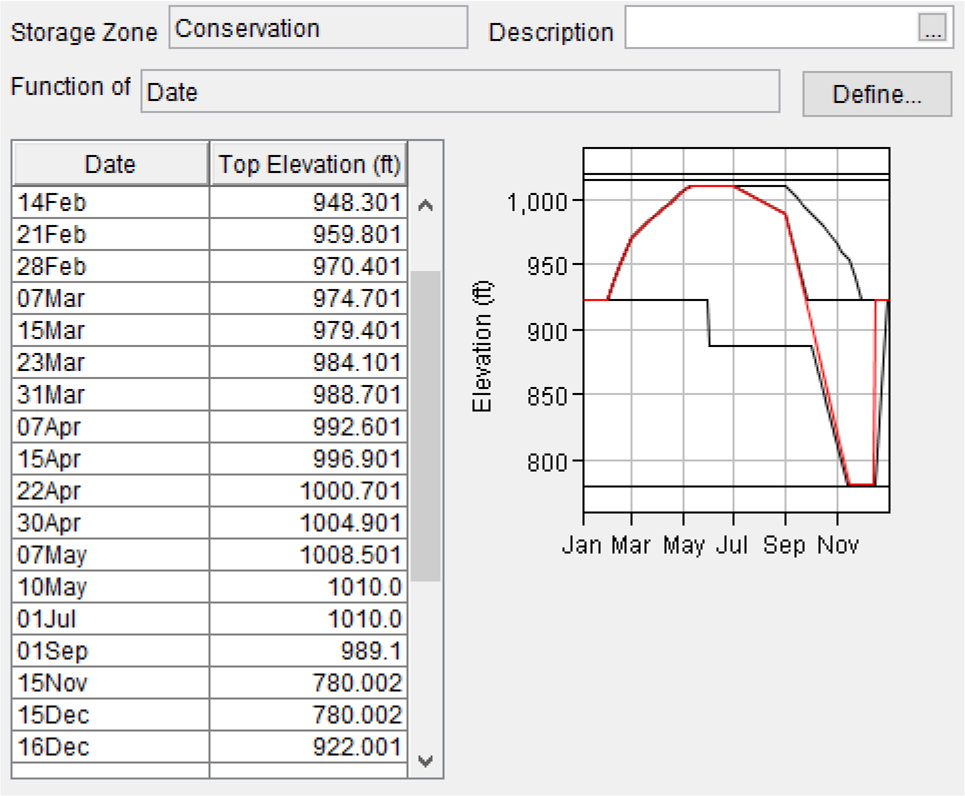
Function of: Date

Date	Top Elevation (ft)
01Jan	1532.0
01Mar	1532.0
02Mar	1330.0
15Jun	1330.0
16Jun	1690.0
01Jul	1690.0
01Sep	1649.8
15Nov	1330.0
15Dec	1330.0
16Dec	1532.0

Figure 4-7. Cougar spring and fall drawdown target elevations

4.2.6 Measure 40

Measure 40 calls for a fall drawdown at Green Peter to 780’ and at Cougar to 1330’ in Alt 2B. Alt2A does not have a fall drawdown at Cougar. Drafting at Cougar is limited to a maximum release of 5,000 cfs when below 1532’. The Green Peter fall drawdown target elevation is shown in Figure B-4-8. The Cougar fall drawdown elevation is shown in Figure B-4-7.



Storage Zone: Conservation

Description:

Function of: Date

Date	Top Elevation (ft)
14Feb	948.301
21Feb	959.801
28Feb	970.401
07Mar	974.701
15Mar	979.401
23Mar	984.101
31Mar	988.701
07Apr	992.601
15Apr	996.901
22Apr	1000.701
30Apr	1004.901
07May	1008.501
10May	1010.0
01Jul	1010.0
01Sep	989.1
15Nov	780.002
15Dec	780.002
16Dec	922.001

Figure 4-8. Green Peter fall drawdown target elevation

4.2.7 Measure 718

The inactive zone at, Fall Creek, and Blue River is lowered to an elevation 10ft above the RO to permit drafting into the inactive pool to meet minimum tributary and mainstem targets. This operation is not applied at Fern Ridge because of the shallow storage/elevation profile. This operation is not applied at Cottage Grove or Dorena in Alt5 because model results showed unrealistic drafting during the fall conservation season drawdown in previous alternatives. An additional zone labeled the “no draft” zone delineates the minimum desired drafting elevation. Below this elevation there is a rule that prevents a reduction in pool elevation, and the minimum tributary rule. Drafting below the minimum conservation elevation is permitted from 01Jun until 20Dec. If elevations are below minimum conservation elevation on 20Dec, ResSim will release inflow until inflow is greater than the minimum flow, at which time the reservoir elevation will rise. An example water control diagram showing the bottom of the newly available storage is shown in Figure B-4-2.

4.2.8 Measure 304

Measure 304 lowers the inactive zone at Lookout Point, Hills Creek, Cougar, Detroit, and Green Peter to permit drafting to the bottom of the power pool to meet minimum tributary and mainstem targets. An additional zone labeled the “no draft” zone delineates the minimum permissible drafting elevation. Below this elevation there is a rule that prevents a reduction in pool elevation, and the minimum tributary rule. Drafting below the minimum conservation elevation is permitted from 01Jun until 20Dec. If elevations are below minimum conservation elevation on 20Dec, ResSim will release inflow until inflow is greater than the minimum flow, at which time the reservoir elevation will rise. An example water control diagram showing the bottom of the newly available storage is shown in Figure B-4-3.

4.2.9 Measure 105

Measure 105 calls for a temperature control tower at Detroit that will replace the temperature spill operation in the NAA that allocates flow over the spillway and through the regulating outlet. The re-allocation of flow at Detroit in the NAA was post processed in MS Excel, but for Alt 2A and 2B, the flow re-allocation was used directly from ResSim.. Temperature control towers at other projects do not change total flow or outlet specific flow from the NAA and are not modeled.

4.2.10 Measure 392

Measure 392 has a min flow of 600 cfs over the spillway year-round at FOS. M479 (described in section 4.1.2) requires an additional release of 144 cfs in May and 72cfs in June. Station service requires 150 cfs through the penstock. M479 and M392 minimums are combined with the station service flow into a single minimum flow rule at GPR targeting the flow out of Foster (Figure B-4-1).

Measure 392 minimum flow requirements at other projects were not modeled because other minimum flows in Alternative 2A and 2B are higher.

4.2.11 Measure 479

Measure 479 calls for a temperature control pipe at Foster requiring a minimum flow of 144 in May and 72 in June through a new outlet. This release will be defined as going over the spillway instead of making a new outlet. Outflow for this measure is added to minimum spill required for measure 392 as shown in Figure B-4-1. Flow is allocated to the correct outlet at Foster in MS Excel with logic that adheres to outlet minimum and maximum releases without changing total project outflow.

4.2.12 Measure 722

Measure 722 addresses fish facilities. This does not change total outflow or outlet specific outflow and is not modeled.

4.2.13 Measure 52

Measure 52 addresses lamprey passage. This does not change total outflow or outlet specific outflow and is not modeled.

4.2.14 Basin Wide Measures 9, 384, 719, 726

These basin wide measures do not change total outflow or outlet specific outflow and are not modeled.

4.3 ALTERNATIVE 3A AND 3B MODELING ASSUMPTIONS

Modeling assumptions for 3A and 3B are detailed below. The modeled differences between Alternative 3A and 3B are limited to changes in the locations of fall and spring drawdowns as identified in Table B-4-3. Locations with spring drawdowns will not explicitly supplement mainstem flows and will release for dry year tributary targets.

Table 4-3. Alt3A and 3B Drawdowns

Alternative	Drawdown	Project					
		BLU	HCR	GPR	DET	LOP	CGR
3A	Spring	***No***	***No***	***No***	1375'	761'	1517'
	Fall	1165'	1446'	780'	1375'	761'	1517'
3B	Spring	***No***	1446'	780'	***No***	***No***	1330'
	Fall	1165'	1446'	780'	1375'	761'	1330'

4.3.1 Measure 30

Measure 30 defines minimum tributary flows out of Lookout Point, Cougar, Green Peter, and Detroit based on % reservoir storage being either greater than or less than 90%, relative to the rule curve, evaluated every 2 weeks between 01Feb and 01Jun. The 01Jun % full determination sets the flow regime for the remainder of the year. An example is shown in Figure B-4-5. The remaining reservoirs maintain the 2008 BiOp minimum flow schedule with additions for the NAA abundant water year contributions to withdrawals.

Mainstem flow targets at Salem are determined by an external daily timeseries of the future average 7-day max air temp. The rule in ResSim is shown in Figure B-4-6. There are also base minimum mainstem flow targets of 4500 cfs at Albany and 5000 cfs at Salem. Hills Creek, Lookout Point, Fall Creek, Cottage Grove, Dorena, Cougar and Blue River contribute to mainstem targets.

Reservoirs with spring drawdowns will not contribute explicitly to mainstem targets. Reservoirs with spring drawdowns will release the minimum flow designated when less than 90% of the rule curve. Table B-4-3 indicates locations of fall and spring drawdowns.

Cougar has a deep spring drawdown in Alt 3B. In Alt 3B, Cougar will have a tributary minimum of 300 cfs, and will not explicitly contribute additional flow to supplement mainstem targets.

4.3.2 Measure 721

Measure 721 calls for spill over the spillway in spring at Lookout Point, Hills Creek, Blue River, and Green Peter. If above spillway in the spring after 15April, 60% of the flow is released over the spillway until 15Nov, or until the reservoir drafts below the spillway. This is identical to the NAA spring spill operation at Detroit, which is also included in Alt 3A and 3B. This re-allocation of flow is post processed in MS Excel outside of HEC-ResSim. Total outflow is not changed.

Reservoirs with spring drawdowns will not have spring spill operations. Refer to Table B-4-3 to identify reservoirs with spring drawdowns in Alt3A and 3B.

4.3.3 Measure 166

Measure 166 calls for spill through the regulating outlet in the fall at Green Peter and Lookout Point. After 01Oct, release 60% of flow through the RO until 15Nov. This is identical to the NAA fall spill operation at Detroit, which is also included in Alt 3A and 3B. Penstock flow is to be further reduced to 1/3 of the day when within 25' of the penstock and eliminated when below the minimum power pool. This re-allocation of flow is post processed in MS Excel outside of HEC-ResSim. Total outflow is not changed.

4.3.4 Measure 714

Measure 714 calls for all flow to go over the spillway when greater than 25' over the spillway, May-Jul. The spring temperature spill operation (M721) takes precedence over this spill operation, so this operation is only modeled at Dexter, Big Cliff, and Fall Creek. Flow is allocated to the correct outlet in MS Excel with logic that adheres to outlet minimum and maximum releases without changing total project outflow.

4.3.5 Measure 720

Measure 720 defines spring drawdowns as indicated Table B-4-3. Projects will draft no more than 3ft/day When below the minimum conservation elevation. The drawdown will begin on 01 March at each project, refill will begin on 21 May at Green Peter, and refill on 15 June at the other projects. The penstock will not be used for 1/3 of the day when within 50' of regulating outlet at Cougar and Hills Creek or within 25' of the penstock at other projects. An example of a spring and fall drawdown target elevation curve is shown in Figure B-4-7.

4.3.6 Measure 40

Measure 40 defines fall drawdowns as indicated Table B-4-3. Projects will draft no more than 3ft/day when below the minimum conservation elevation. The penstock will not be used for 1/3 of the day when within 50' of regulating outlet at Cougar and Hills Creek or within 25' of the penstock at other projects. A spring and fall drawdown target elevation curve is shown in Figure B-4-7. An example of a fall drawdown only is shown in Figure B-4-8.

4.3.7 Measure 718

The inactive zone at Cottage Grove, Dorena, Fall Creek, and Blue River is lowered to an elevation 10ft above the RO to permit drafting into the inactive pool to meet minimum tributary and mainstem targets. An additional zone labeled the “no draft” zone delineates the minimum desired drafting elevation. Below this elevation there is a rule that prevents a reduction in pool elevation, and the minimum tributary rule. Drafting below the minimum conservation elevation is permitted from 01Jun until 20Dec. If elevations are below minimum conservation elevation on 20Dec, ResSim will release inflow until inflow is greater than the minimum flow, at which time the reservoir elevation will rise. An example water control diagram showing the bottom of the newly available storage is shown in Figure B-4-2.

4.3.8 Measure 304

Measure 304 lowers the inactive zone at Lookout Point, Hills Creek, Cougar, Detroit, and Green Peter to permit drafting to the bottom of the power pool to meet minimum tributary and mainstem targets. An additional zone labeled the "no draft" zone delineates the minimum permissible drafting elevation. Below this elevation there is a rule that prevents a reduction in pool elevation, and the minimum tributary rule. Drafting below the minimum conservation elevation is permitted from 01Jun until 20Dec. If elevations are below minimum conservation elevation on 20Dec, ResSim will release inflow until inflow is greater than the minimum flow, at which time the reservoir elevation will rise. Hills Creek will not draft below 1446' to facilitate the volitional fish passage operation. An example water control diagram showing the bottom of the newly available storage is shown in Figure B-4-3.

4.3.9 Measure 722

Measure 722 addresses fish facilities. This does not change total outflow or outlet specific outflow and is not modeled.

4.3.10 Measure 52

Measure 52 addresses lamprey passage. This does not change total outflow or outlet specific outflow and is not modeled.

4.3.11 Basin Wide Measures 9, 384, 719, 726

These basin wide measures do not change total outflow or outlet specific outflow and are not modeled.

4.4 ALTERNATIVE 4 MODELING ASSUMPTIONS

4.4.1 Measure 30

Measure 30 defines minimum tributary flows out of Lookout Point, Cougar, Green Peter, and Detroit based on % reservoir storage being either greater than or less than 90%, relative to the rule curve, evaluated every 2 weeks between 01Feb and 01Jun. The 01Jun % full determination sets the flow regime for the remainder of the year. An example is shown in Figure B-4-5. The remaining reservoirs maintain the 2008 BiOp minimum flow schedule with additions for the NAA abundant water year contributions to withdrawals.

Mainstem flow targets at Salem are determined by an external daily timeseries of the future average 7-day max air temp. The rule in ResSim is shown in Figure B-4-6. There are also base minimum mainstem flow targets of 4500 cfs at Albany and 5000 cfs at Salem. Hills Creek, Lookout Point, Fall Creek, Cottage Grove, Dorena, Cougar and Blue River contribute to mainstem targets.

4.4.2 Measure 721

Measure 721 calls for spill over the spillway at Green Peter in the spring. If above spillway in the spring after 15April, 60% of the flow is released over the spillway until 15Nov, or until the reservoir drafts below the spillway. This re-allocation of flow is post processed in MS Excel outside of HEC-ResSim. Total outflow is not changed.

4.4.3 Measure 166

Measure 166 calls for spill through the regulating outlet in the fall at Green Peter. After 01Oct, if below the spillway, release 60% of flow through the RO until 15Nov. The fall drawdown targets an elevation below the minimum power pool on or about 01Oct which results in all flow going through the RO. This re-allocation of flow is post processed in MS Excel outside of HEC-ResSim. Total outflow is not changed.

4.4.4 Measure 392

Measure 392 has a min flow of 600 cfs over the spillway year-round at FOS. M479 (described in section 4.1.2) requires an additional release of 144 cfs in May and 72cfs in June. Station service requires 150 cfs through the penstock. M497 and M392 minimums are combined with the station service flow into a single minimum flow rule at GPR targeting the flow out of Foster (Figure B-4-1).

Measure 392 minimum flow requirements at other projects were not modeled because other minimum flows in Alternative 4 are higher.

4.4.5 Measure 479

Measure 479 calls for a temperature control pipe at Foster requiring a minimum flow of 144 in May and 72 in June through a new outlet. This release will be defined as going over the spillway instead of making a new outlet. This will be noted when passing results to other models. This operation can only occur when FOS is above 630’. Foster follows the Rule Curve unless Green Peter completely empties in this model so that restriction is adhered to. Outflow for this measure is added to minimum spill required for measure 392 as shown in Figure B-4-1. Flow is allocated to the correct outlet at Foster in MS Excel with logic that adheres to outlet minimum and maximum releases without changing total project outflow.

4.4.6 Measure 105

Measure 105 calls for a temperature control tower at Detroit that will replace the temperature spill operation in the NAA that allocates flow over the spillway and through the regulating outlet. The re-allocation of flow at Detroit in the NAA was post processed in MS Excel, but for Alt 4, the flow re-allocation was used directly from ResSim. Temperature control towers at other projects do not change total flow or outlet specific flow from the NAA and are not modeled.

4.4.7 Measure 718

The inactive zone at Cottage Grove, Dorena, Fall Creek, and Blue River is lowered to an elevation 10ft above the RO to permit drafting into the inactive pool to meet minimum tributary and mainstem targets. An additional zone labeled the “no draft” zone delineates the minimum desired drafting elevation. Below this elevation there is a rule that prevents a reduction in pool elevation, and the minimum tributary rule. Drafting below the minimum conservation elevation is permitted from 01Jun until 20Dec. If elevations are below minimum conservation elevation on 20Dec, ResSim will release inflow until inflow is greater than the minimum flow, at which time the reservoir elevation will rise. An example water control diagram showing the bottom of the newly available storage is shown in Figure B-4-2.

4.4.8 Measure 304

Measure 304 lowers the inactive zone at Lookout Point, Hills Creek, Cougar, Detroit, and Green Peter to permit drafting to the bottom of the power pool to meet minimum tributary and mainstem targets. An additional zone labeled the “no draft” zone delineates the minimum permissible drafting elevation. Below this elevation there is a rule that prevents a reduction in pool elevation, and the minimum tributary rule. Drafting below the minimum conservation elevation is permitted from 01Jun until 20Dec. If elevations are below minimum conservation elevation on 20Dec, ResSim will release inflow until inflow is greater than the minimum flow, at which time the reservoir elevation will rise. An example water control diagram showing the bottom of the newly available storage is shown in Figure B-4-3.

4.4.9 Measure 174

Measure 174 calls for structural modifications to manage total dissolved gasses below reservoirs. These modifications will not change total outflow or outlet specific flow and are not modeled.

4.4.10 Measure 711

Measure 711 calls for mechanical de-gassing at reservoir outlets that will not change total flow or outlet specific outflow and is not modeled.

4.4.11 Measure 722

Measure 722 addresses fish facilities. This does not change total outflow or outlet specific outflow and is not modeled.

4.4.12 Measure 52

Measure 52 addresses lamprey passage. This does not change total outflow or outlet specific outflow and is not modeled.

4.4.13 Basin Wide Measures 9, 384, 719, 726

These basin wide measures do not change total outflow or outlet specific outflow and are not modeled.

4.5 ALTERNATIVE 5 MODELING ASSUMPTIONS

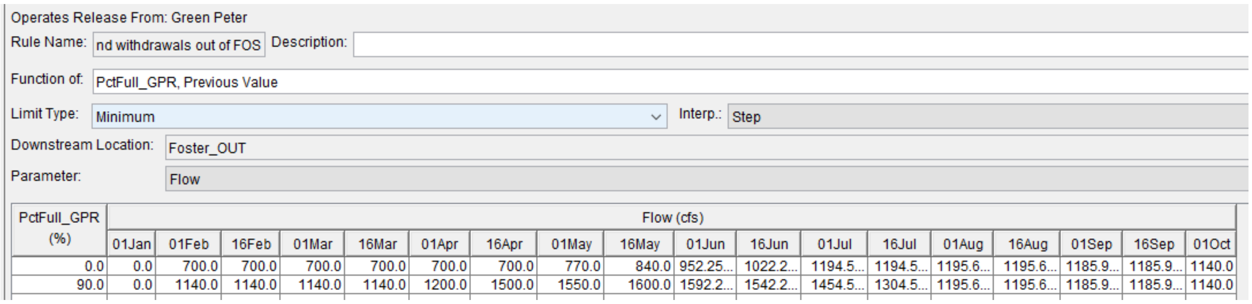
4.5.1 Measure 30B

Measure 30B defines minimum tributary flows out of Lookout Point, Cougar, Green Peter, and Detroit based on % reservoir storage being either greater than or less than 90%, relative to the rule curve, evaluated every 2 weeks between 01Feb and 01Jun. The 01Jun % full determination sets the flow regime for the remainder of the year. These tributary targets are identical to M30 except at Green Peter (Figure B-4-9).

The mainstem flow targets at Salem are a function of an external annual timeseries which designates a year based on the percentile of normal unregulated flow at Salem achieved in a year (Figure B-4-10), and an external daily timeseries of the future average 7-day max air temp shown in Figure B-4-6. The Albany target is 4,500 cfs.

The remaining reservoirs maintain the 2008 BiOp minimum flow schedule with additions for the NAA abundant water year contributions to withdrawals.

Cougar has a deep spring drawdown in Alt 5. In Alt 5, Cougar will have a tributary minimum of 300 cfs, and will not explicitly contribute additional flow to supplement mainstem targets.



Operates Release From: Green Peter

Rule Name: nd withdrawals out of FOS

Description:

Function of: PctFull_GPR, Previous Value

Limit Type: Minimum

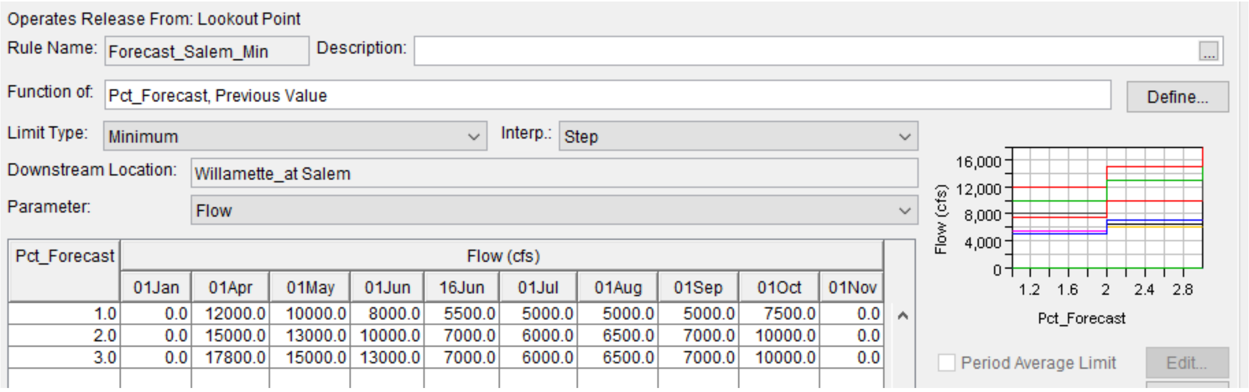
Interp.: Step

Downstream Location: Foster_OUT

Parameter: Flow

PctFull_GPR (%)	Flow (cfs)																
	01Jan	01Feb	16Feb	01Mar	16Mar	01Apr	16Apr	01May	16May	01Jun	16Jun	01Jul	16Jul	01Aug	16Aug	01Sep	16Sep	01Oct
0.0	0.0	700.0	700.0	700.0	700.0	700.0	700.0	770.0	840.0	952.25...	1022.2...	1194.5...	1194.5...	1195.6...	1195.6...	1185.9...	1185.9...	1140.0
90.0	0.0	1140.0	1140.0	1140.0	1140.0	1200.0	1500.0	1550.0	1600.0	1592.2...	1542.2...	1454.5...	1304.5...	1195.6...	1195.6...	1185.9...	1185.9...	1140.0

Figure 4-9. M30B minimum tributary flow at Green Peter



Operates Release From: Lookout Point

Rule Name: Forecast_Salem_Min

Description:

Function of: Pct_Forecast, Previous Value

Limit Type: Minimum

Interp.: Step

Downstream Location: Willamette_at Salem

Parameter: Flow

Pct_Forecast	Flow (cfs)									
	01Jan	01Apr	01May	01Jun	16Jun	01Jul	01Aug	01Sep	01Oct	01Nov
1.0	0.0	12000.0	10000.0	8000.0	5500.0	5000.0	5000.0	5000.0	7500.0	0.0
2.0	0.0	15000.0	13000.0	10000.0	7000.0	6000.0	6500.0	7000.0	10000.0	0.0
3.0	0.0	17800.0	15000.0	13000.0	7000.0	6000.0	6500.0	7000.0	10000.0	0.0

Figure 4-10. M30B Forecast minimum flow at Salem

4.5.2 Measure 721

Measure 721 calls for spill over the spillway at Green Peter in the spring. If above spillway in the spring after 15April, 60% of the flow is released over the spillway until 15Nov, or until the reservoir drafts below the spillway. This re-allocation of flow is post processed in MS Excel outside of HEC-ResSim. Total outflow is not changed.

4.5.3 Measure 166

Measure 166 calls for spill through the regulating outlet in the fall at Green Peter. After 01Oct, if below the spillway, release 60% of flow through the RO until 15Nov. The fall drawdown targets an elevation below the minimum power pool on or about 01Oct which results in all flow going through the RO. This re-allocation of flow is post processed in MS Excel outside of HEC-ResSim. Total outflow is not changed.

4.5.4 Measure 714

Measure 714 calls for all flow at Green Peter to go over the spillway when greater than 25’ over the spillway May-Jul. The spring temperature spill operation (M721) takes precedent over this spill operation, so this operation is not modeled.

4.5.5 Measure 720

Measure 720 calls for a drawdown to 1330’ at Cougar. When below the minimum conservation elevation of 1532’ Cougar will draft at a rate no greater than 5000 cfs. The drawdown will begin on 01 March and refill will begin on 15 June. The penstock will not be used for 1/3 of the day when within 50’ of the saddle leading to the penstock and regulating outlet inlet works. The conservation season target elevation at Cougar, including the spring drawdown, is identified in Figure B-4-7.

4.5.6 Measure 40

Measure 40 calls for a fall drawdown at Green Peter to 780’ and at Cougar to 1330’. Drafting at Cougar is limited to a maximum release of 5,000 cfs when below 1532’. The Green Peter fall drawdown target elevation is shown in Figure B-4-8. The Cougar fall drawdown elevation is shown in Figure B-4-7.

4.5.7 Measure 718

The inactive zone at Fall Creek, and Blue River is lowered to an elevation 10ft above the RO to permit drafting into the inactive pool to meet minimum tributary and mainstem targets. This operation is not applied at Fern Ridge because of the shallow storage/elevation profile. This operation is not applied at Cottage Grove or Dorena in Alt5 because model results showed unrealistic drafting during the fall conservation season drawdown in previous alternatives. An additional zone labeled the “no draft” zone delineates the minimum desired drafting elevation. Below this elevation there is a rule that prevents a reduction in pool elevation, and the minimum tributary rule. Drafting below the minimum conservation elevation is permitted from 01Jun until 20Dec. If elevations are below minimum conservation elevation on 20Dec, ResSim will release inflow until inflow is greater than the minimum flow, at which time the reservoir elevation will rise. An example water control diagram showing the bottom of the newly available storage is shown in Figure B-4-2.

4.5.8 Measure 304

Measure 304 lowers the inactive zone at Lookout Point, Hills Creek, Cougar, Detroit and Green Peter to permit drafting to the bottom of the power pool to meet minimum tributary and mainstem targets. An additional zone labeled the “no draft” zone delineates the minimum permissible drafting elevation. Below this elevation there is a rule that prevents a reduction in pool elevation, and the minimum tributary rule. Drafting below the minimum conservation elevation is permitted from 01Jun until 20Dec. If elevations are below minimum conservation elevation on 20Dec, ResSim will release inflow until inflow is greater than the minimum flow, at which time the reservoir elevation will rise. An example water control diagram showing the bottom of the newly available storage is shown in Figure B-4-3.

4.5.9 Measure 105

Measure 105 calls for a temperature control tower at Detroit that will replace the temperature spill operation in the NAA that allocates flow over the spillway and through the regulating outlet. The re-allocation of flow at Detroit in the NAA was post processed in MS Excel, but for Alt 5, the flow re-allocation was used directly from ResSim. Temperature control towers at other projects do not change total flow or outlet specific flow from the NAA and are not modeled.

4.5.10 Measure 392

Measure 392 has a min flow of 600 cfs over the spillway year-round at Foster . M479 (described in section 4.1.2) requires an additional release of 144 cfs in May and 72cfs in June. Station service requires 150 cfs through the penstock. M479 and M392 minimums are combined with the station service flow into a single minimum flow rule at GPR targeting the flow out of Foster (Figure B-4-1).

Measure 392 minimum flow requirements at other projects were not modeled because other minimum flows in Alternative 5 are higher.

4.5.11 Measure 479

Measure 479 calls for a temperature control pipe at Foster requiring a minimum flow of 144 in May and 72 in June through a new outlet. This release will be defined as going over the spillway instead of making a new outlet. Outflow for this measure is added to minimum spill required for measure 392 as shown in Figure B-4-1. Flow is allocated to the correct outlet at Foster in MS Excel with logic that adheres to outlet minimum and maximum releases without changing total project outflow.

4.5.12 Measure 722

Measure 722 addresses fish facilities. This does not change total outflow or outlet specific outflow and is not modeled.

4.5.13 Measure 52

Measure 52 addresses lamprey passage. This does not change total outflow or outlet specific outflow and is not modeled.

4.5.14 Basin Wide Measures 9, 384, 719, 726

These basin wide measures do not change total outflow or outlet specific outflow and are not modeled.

4.6 MODELING DISCREPANCIES

4.6.1 Measure 30 Temperature Flows at Salem

Measure 30 temp flow at Salem is formulated to be a function of 7-day average daily high temperature at Salem. The ResSim model is formulated to accept this input and produce the minimum flow requirements based on temperature. However, the input supplied to the ResSim model (in the Temp_Min_Flows.dss file) does not appear to be temperature. It appears to be pre-calculated flow targets that vary abruptly from 0 cfs to many thousands of cfs. ResSim interprets this as "temperature", which makes it think that either the temperature is very cold or very hot, using the very lowest target or the very highest target in the table, with nothing in between.

Alternative 5 was re-run with the M30 temperature rule corrected. Results show that the original rule calls on ResSim to release slightly more water than the corrected rule in time frames when the rule controls for minimum flow. However, the system as modeled has limited capacity to spike flows at Salem in response to the M30 temperature rule in both instances and the difference in realized flows is very small (Figure B-4-11).Correcting the rule would not increase or diminish the original valuation of individual alternatives or the ranking of alternatives.

Figure 4-11. M30 temp flow adherence at Salem – Red = fixed temp minimum target and flow, Green = Original temp minimum target and flow

4.6.2 Measure 718

Dorena and Cottage Grove were permitted to draw down into the inactive pool in Alternatives 1, 3a, and 3b. Results in these alternatives showed that the reservoirs never significantly drafted into the inactive zone to meet minimum flow requirements but would draft into the inactive pool after normal conservation season drawdown which is not the intent of the measure. This operation was removed from Alternatives 2 and 5.

4.6.3 Measure 304

For all alternatives that implement measure 304 at Hills Creek (use the Power Pool to augment flows), the ResSim project releases increase when the pool elevation drops below min conservation (1448') in the summer in some years (like June 1992). This causes Hills Creek to draft more quickly and reach the bottom of the power pool relatively rapidly. This behavior is because the "Max Con" rule is present only in the Conservation zone, and not in the Buffer zone in ResSim. In reality, releases from Hills Creek would likely taper off as the pool dropped, not increase. As a result, Hills Creek is unable to maintain a minimum release of 400 cfs later in the summer.

4.6.4 Measure 40

The max spawning flow of 3000 cfs from 01Sep-15Oct downstream of Foster is applied in the NAA in ResSim as a rule at Foster. It works well for the NAA, but in alternatives where there is a deep fall drawdown at Green Peter (Alts 2a, 2b, 3a, 3b, 5) it produces unexpected results. Often, the increased releases from Green Peter make it difficult for Foster to maintain 3000 cfs. A maximum release of 2825 cfs is applied at Green Peter in the model, assuming that flows from the South Santiam above Foster would contribute 175 cfs to generate 3000 cfs total. When flows are higher than this, the releases from Green Peter would need to be cut back. This would likely be implemented in real-time operations, but this logic is not incorporated into the ResSim model, leading to the results at Foster. As a result, it attempts to maintain 3000 cfs, which causes the pool to rise into the flood control zone, which then results in some oscillating releases.

4.6.5 Measure 392 and 479

Alternatives 2a, 2b, and 5 do not add the measure 479 warm water conduit diversion of 144cfs in May and 72 cfs in June to the measure 392 spillway flow requirement of 600 cfs, which is inconsistent with how the measures were modeled together in alternatives 1 and 4.

The measure description for measure 392 states that “The design would utilize a flow rate of 500-800 cfs (over the spillway). For modeling, a 600 cfs flow will be assumed.” The minimum tributary flow below Foster in alternatives 2a, 2b, and 5 requires a minimum of 770 - 1550 cfs in May and 910 - 1550 cfs in June, depending on whether Green Peter is greater than or less than 90% full. Therefore, the total flow out of Foster is adequate for the operation and only a small discrepancy in the allocation of flow between the spillway and power plant results from the omission.

4.6.6 3ft/day draft limit below minimum conservation elevation

A rule limiting the draft rate to 3ft/day or less when below the normal minimum conservation elevation was not applied at Cougar in Alternative 3a permitting the reservoir to draft faster than desired between 1532’ and 1517’ during the fall and spring drawdowns.

5 ALTERNATIVE NON-EXCEEDANCE PLOTS

Non exceedance plots comparing modeled alternatives to the NAA are provided below. Non exceedance plots show the probability that an elevation or flow does not exceed a given value on a given day. The colored lines indicate non-exceedance percentiles for the modeled alternative and the shaded regions indicate percentiles for the NAA. In example Figure B-5-1, in 5% of years on May 1st, alternative elevations do not exceed 1511’ and NAA elevations do not exceed 1494’. It is important to note that a line or shaded region on a plot does not represent a continuous year. The reservoir may have a relatively high elevation in the spring in the same year it has a relatively low elevation in the fall.

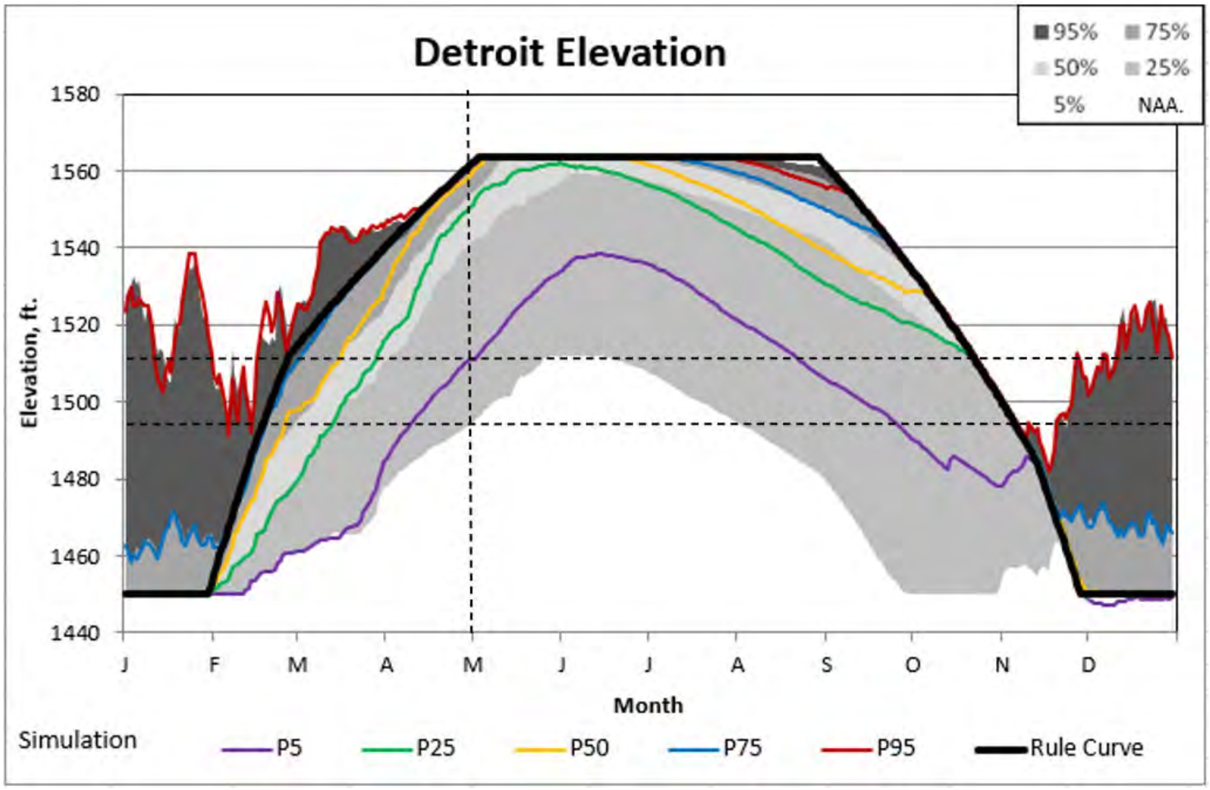


Figure 5-1. Example Non-Exceedance Plot

5.1 ALTERNATIVE 1

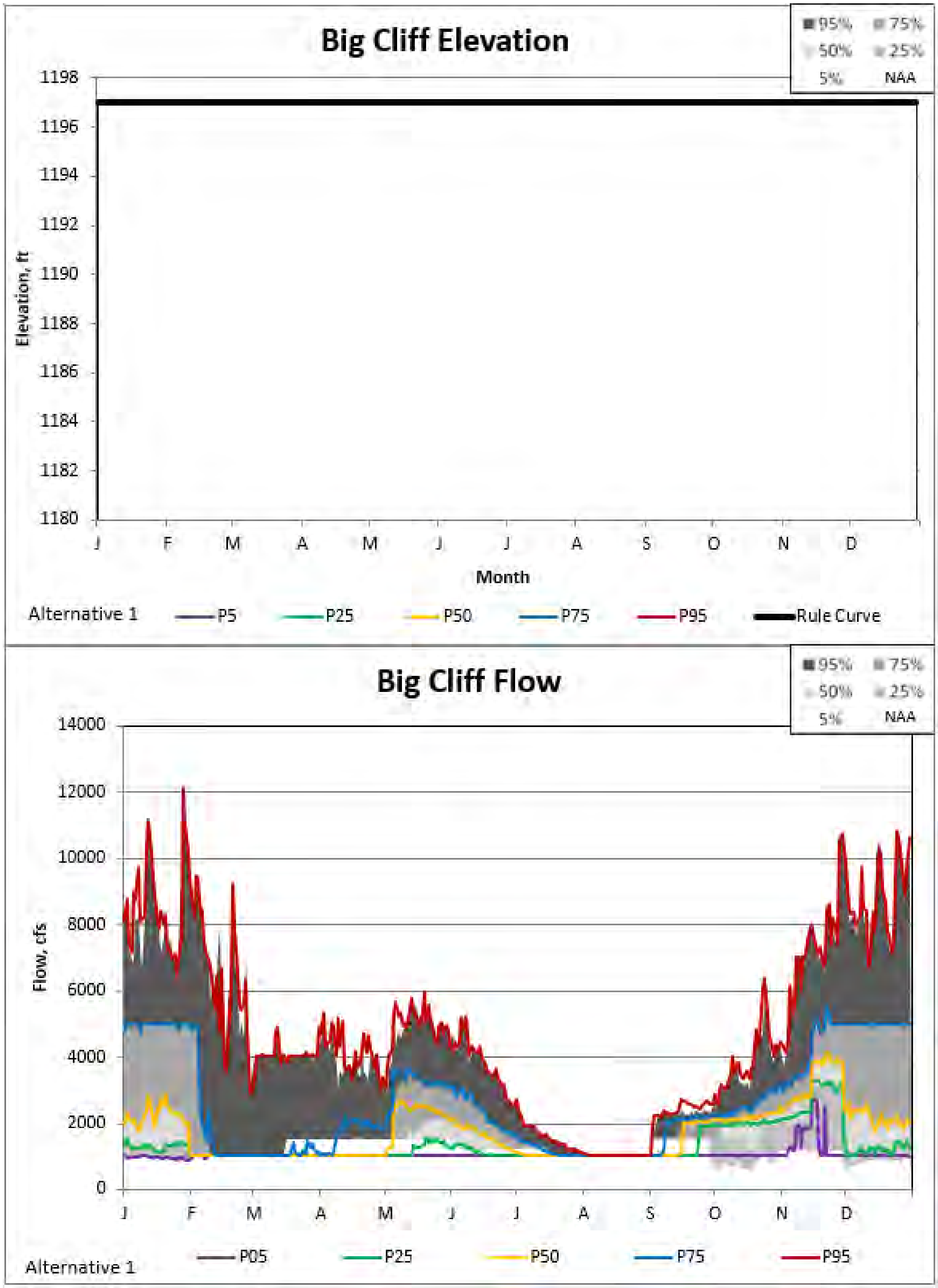


Figure 5-2. Big Cliff Alternative 1 Non-Exceedance Plot

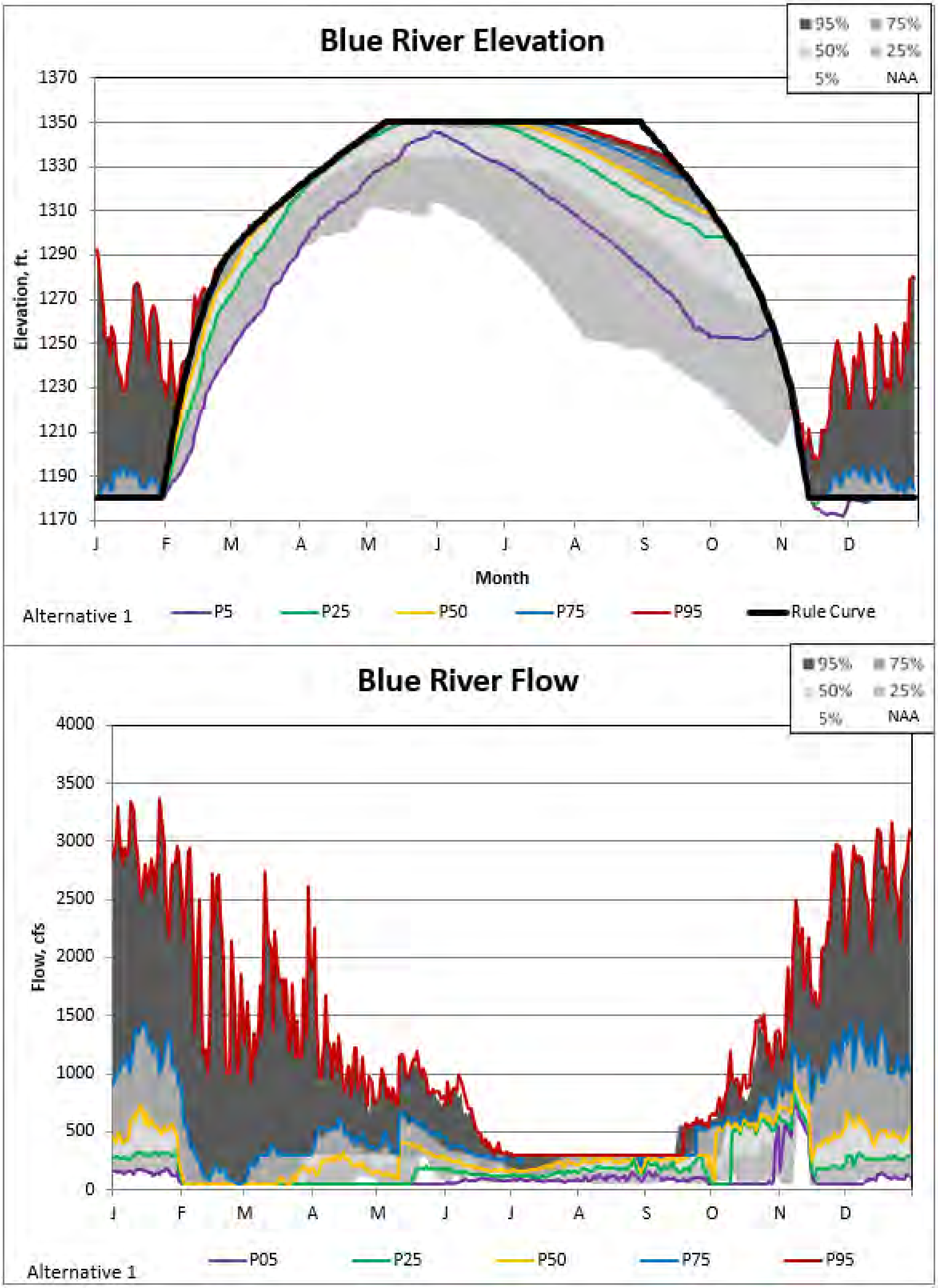


Figure 5-3. Blue River Alternative 1 Non-Exceedance Plot

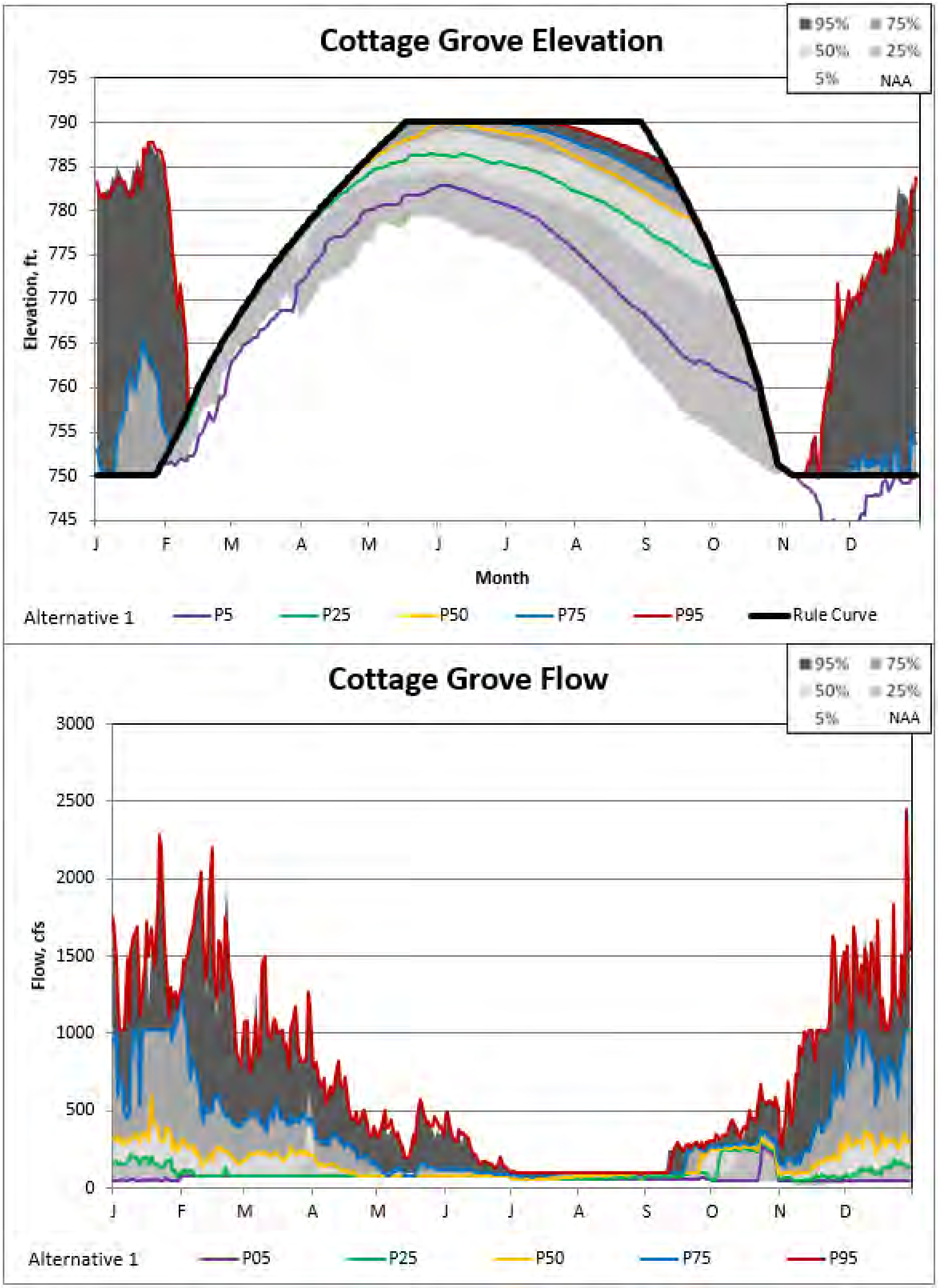


Figure 5-4. Cottage Grove Alternative 1 Non-Exceedance Plot

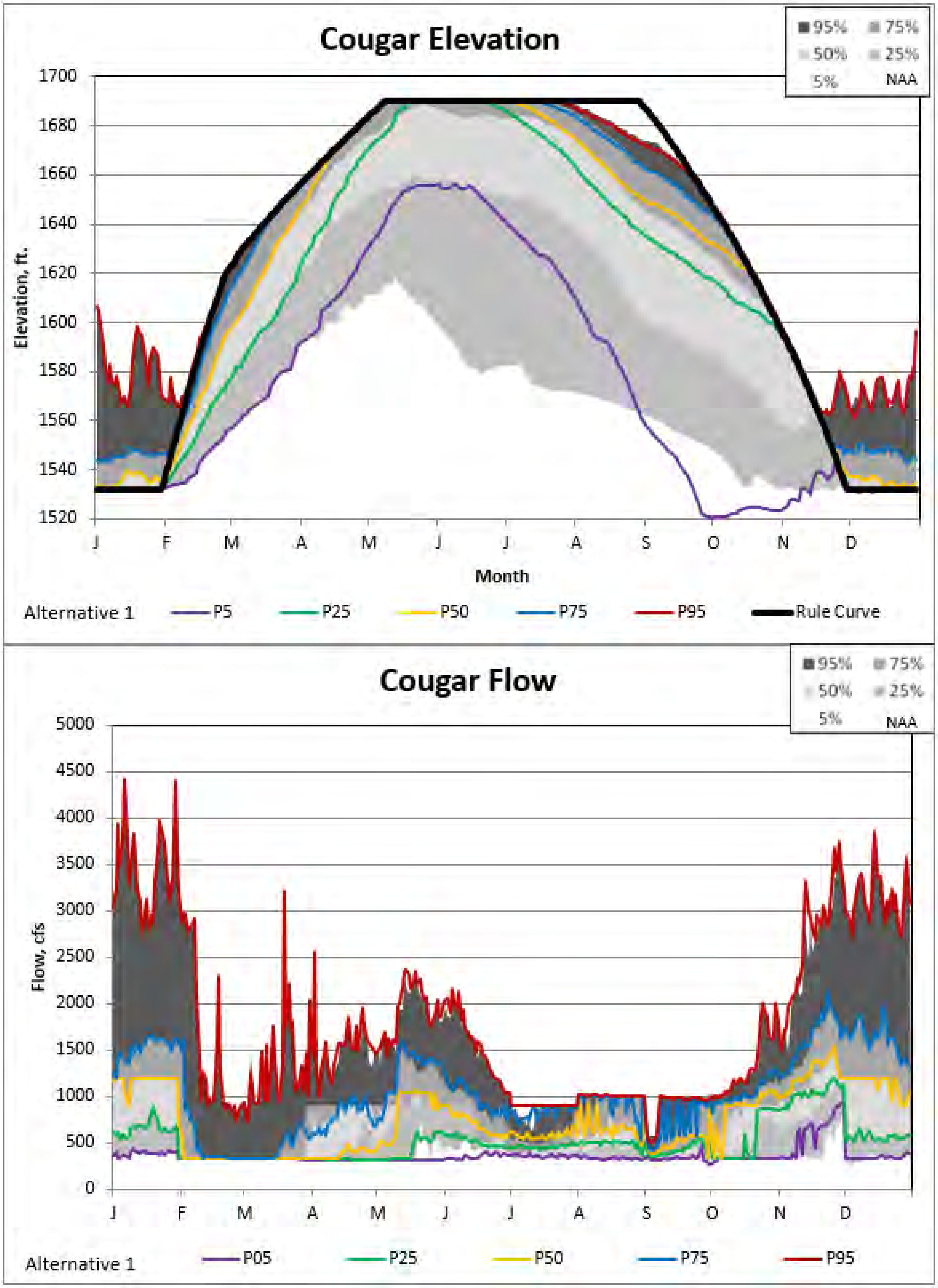


Figure 5-5. Cougar Alternative 1 Non-Exceedance Plot

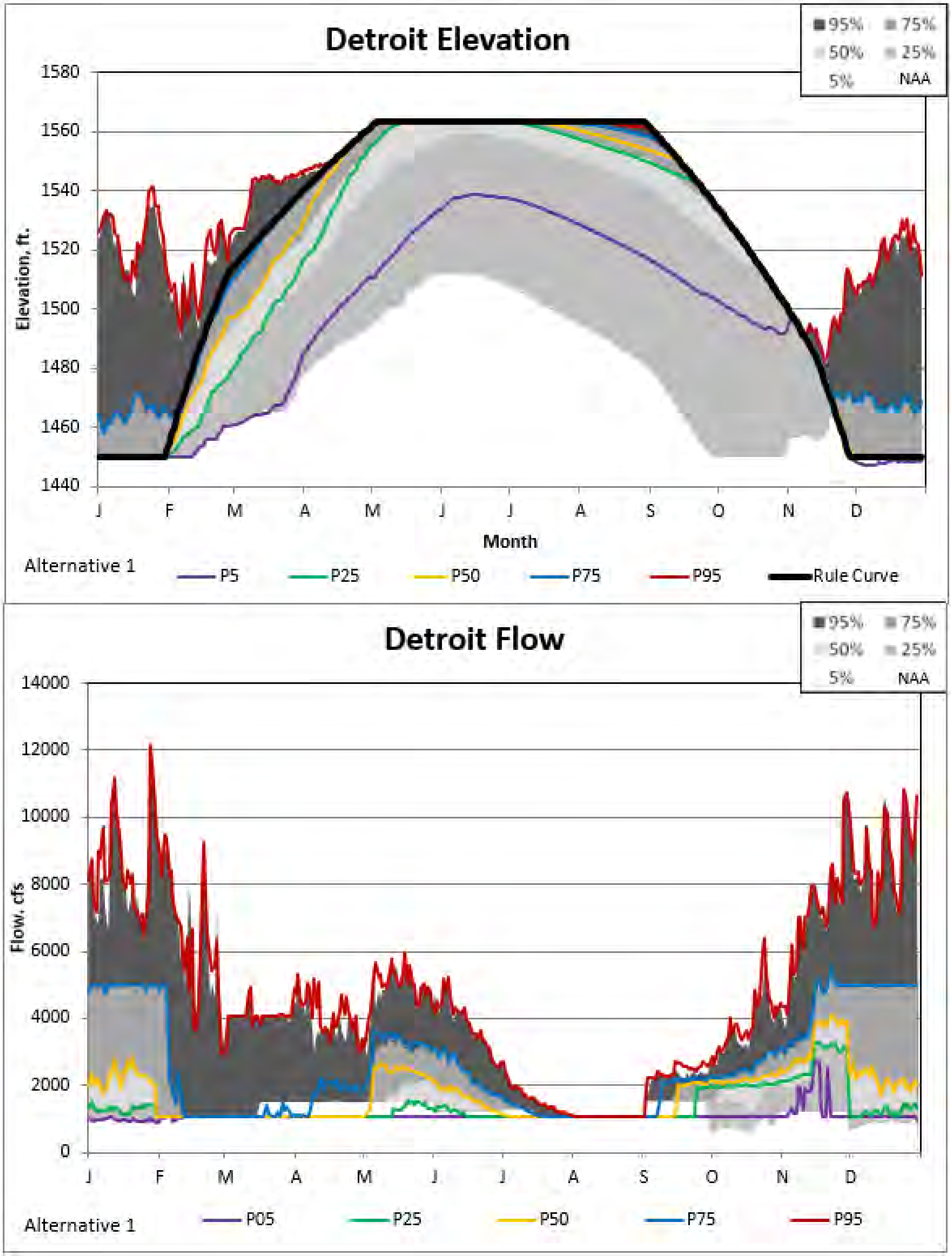


Figure 5-6. Detroit Alternative 1 Non-Exceedance Plot

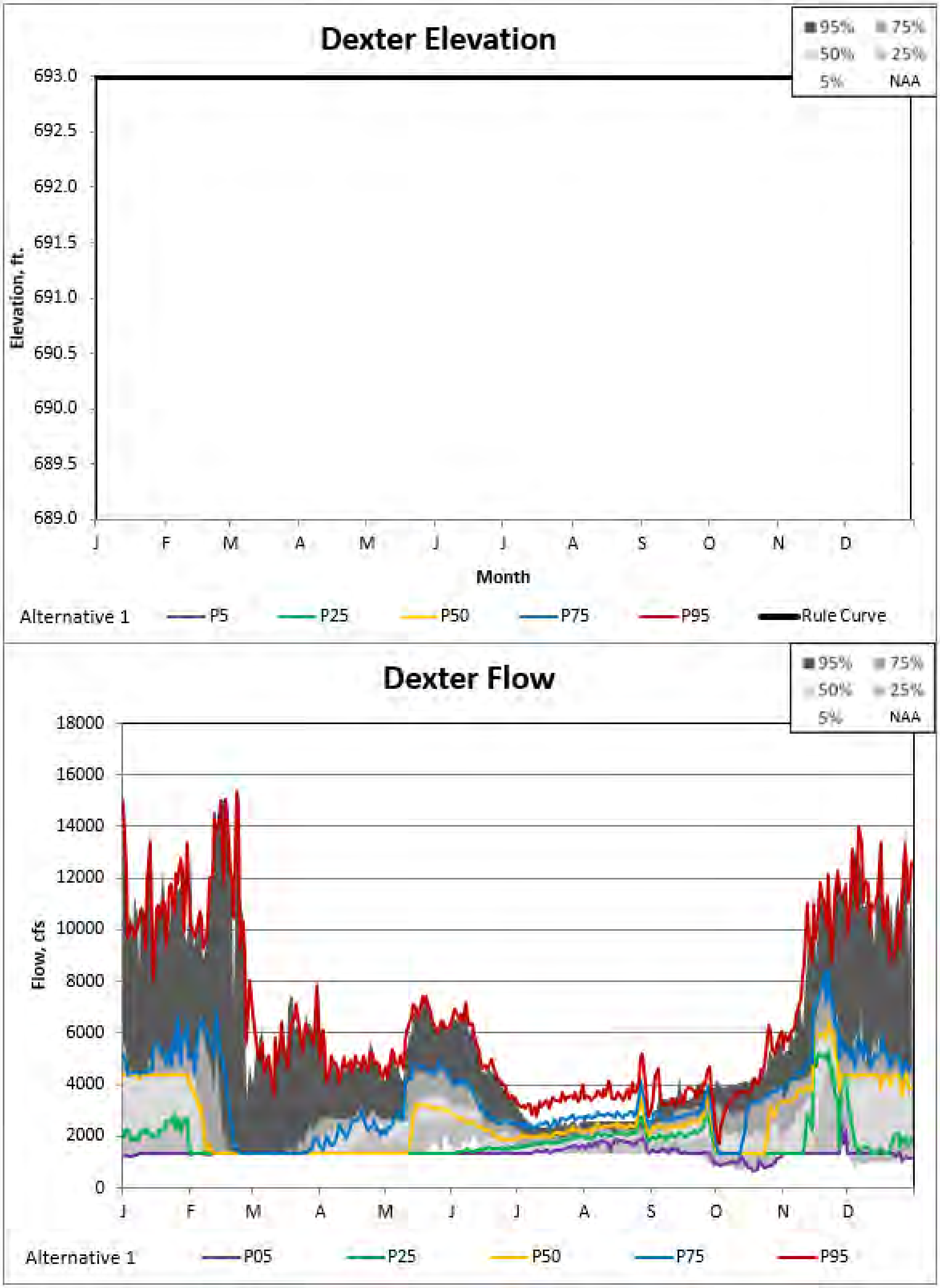


Figure 5-7. Dexter Alternative 1 Non-Exceedance Plot

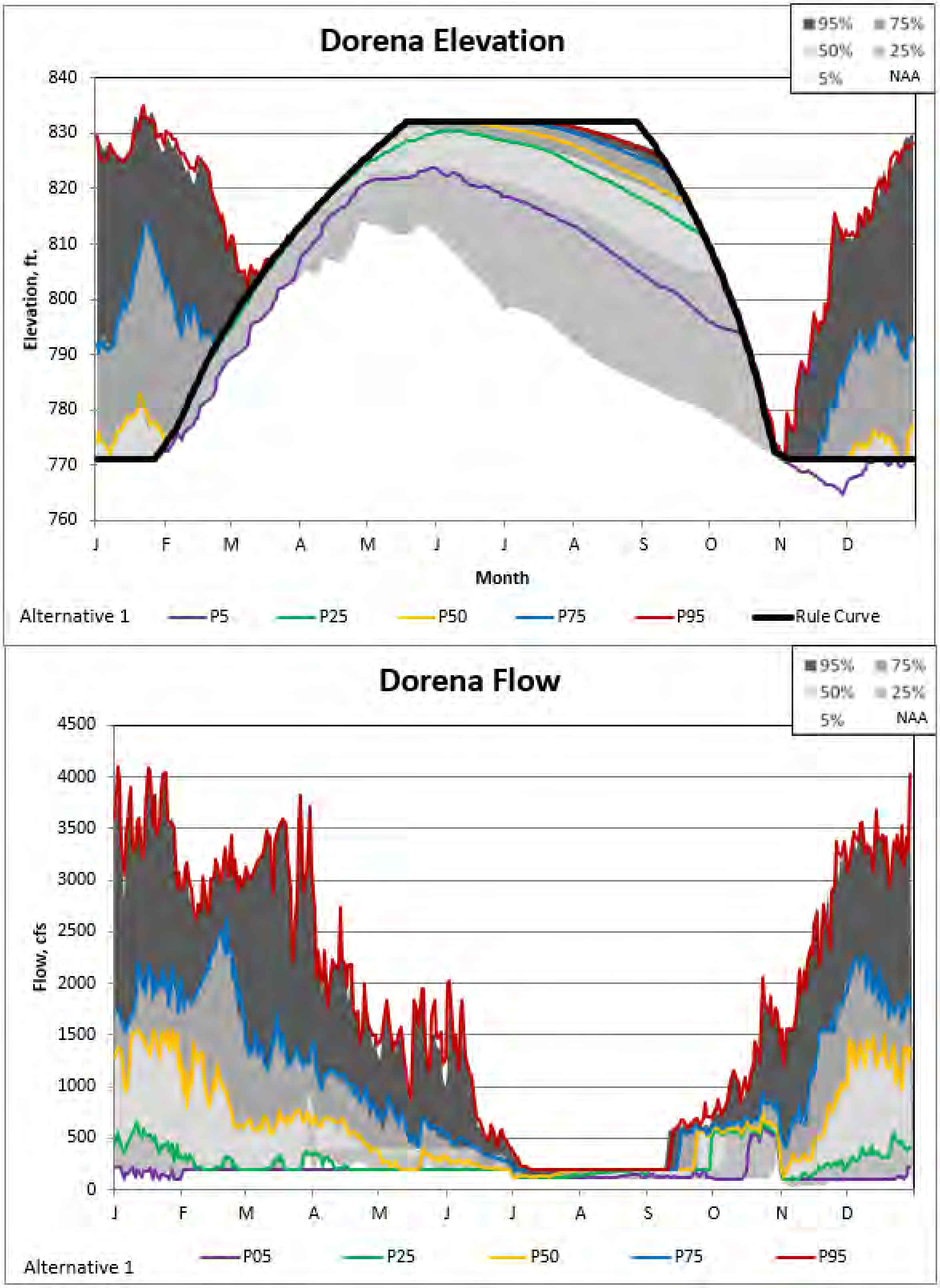


Figure 5-8. Dorena Alternative 1 Non-Exceedance Plot

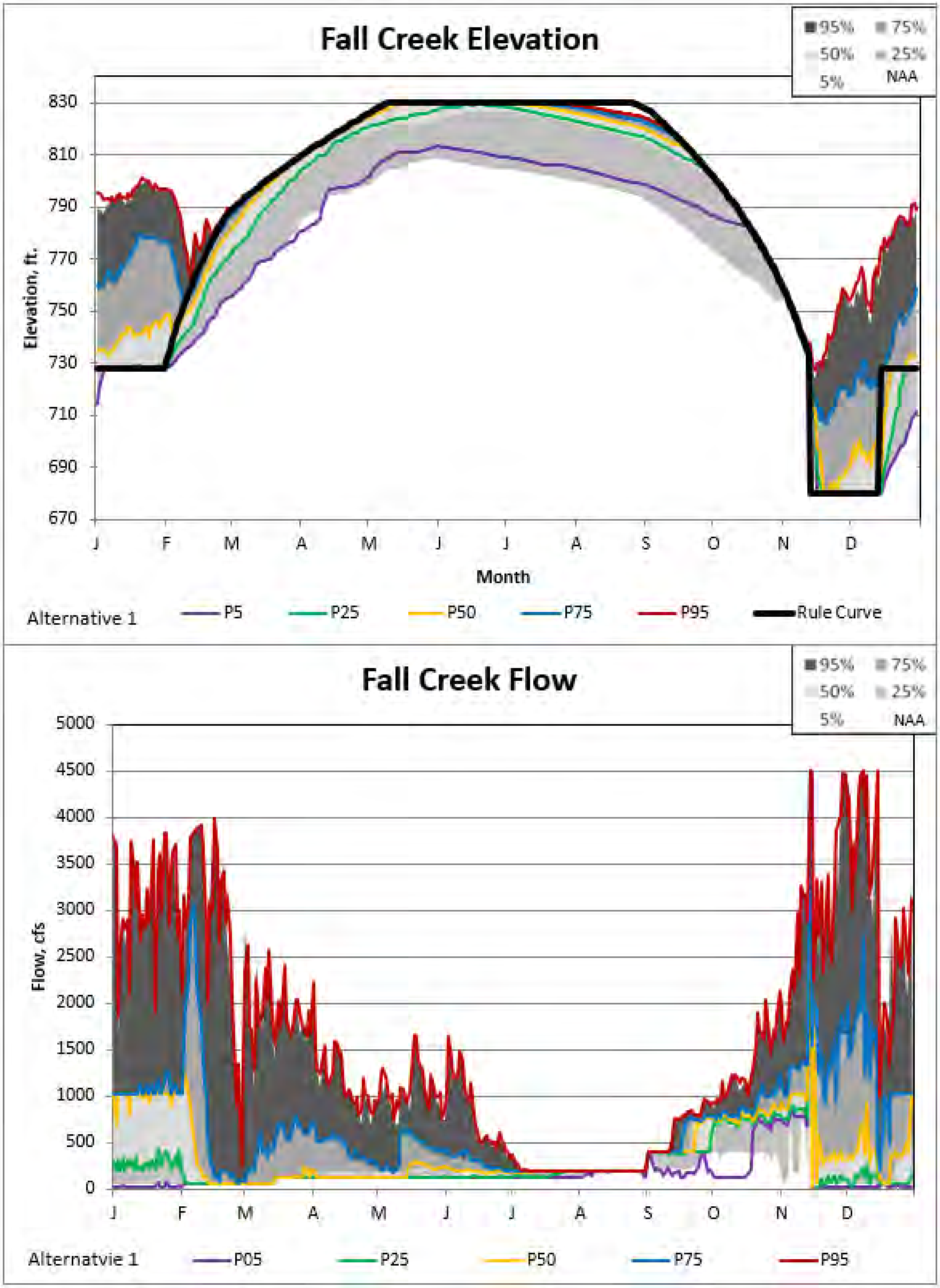


Figure 5-9. Fall Creek Alternative 1 Non-Exceedance Plot

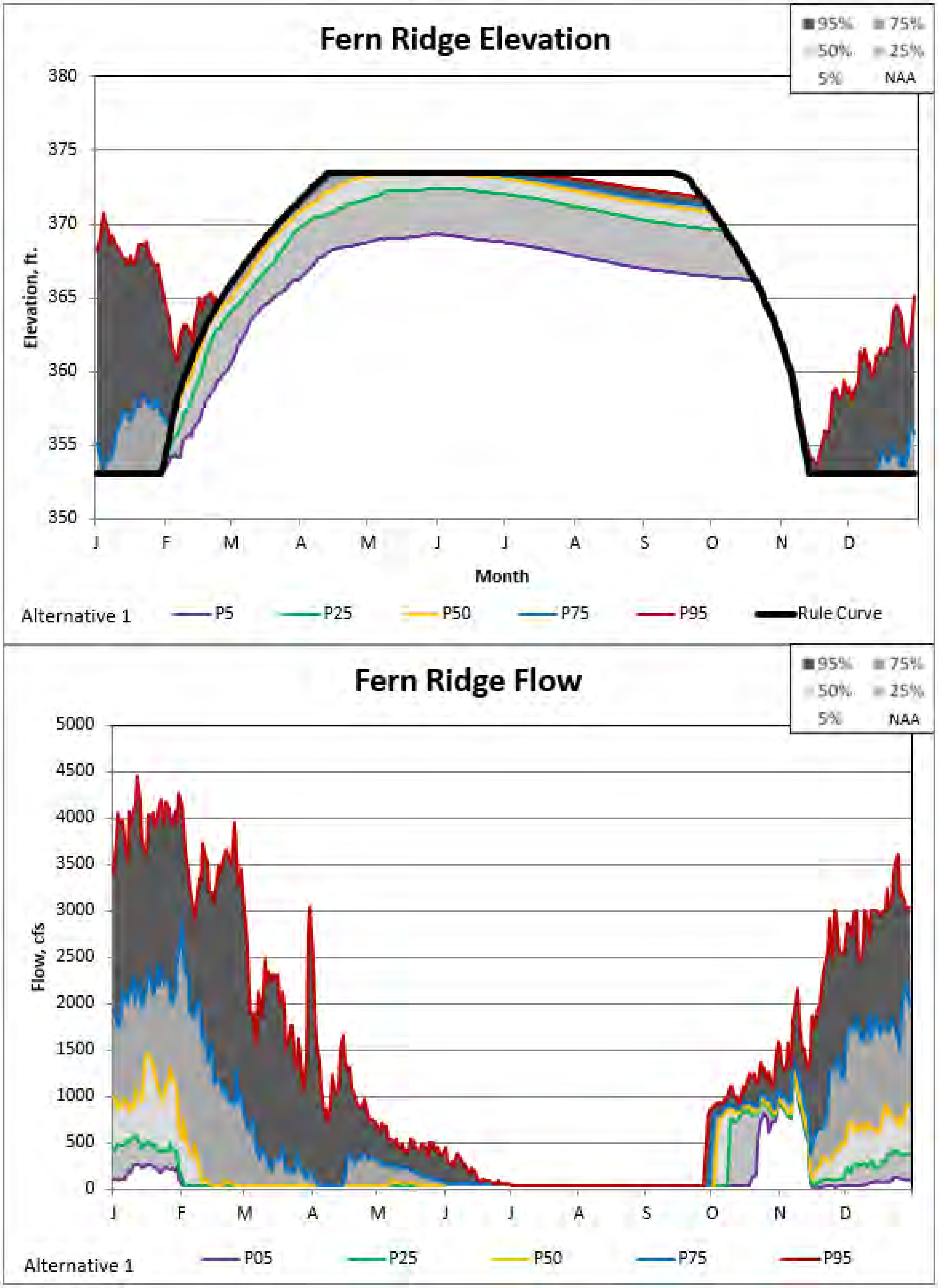


Figure 5-10. Fern Ridge Alternative 1 Non-Exceedance Plot

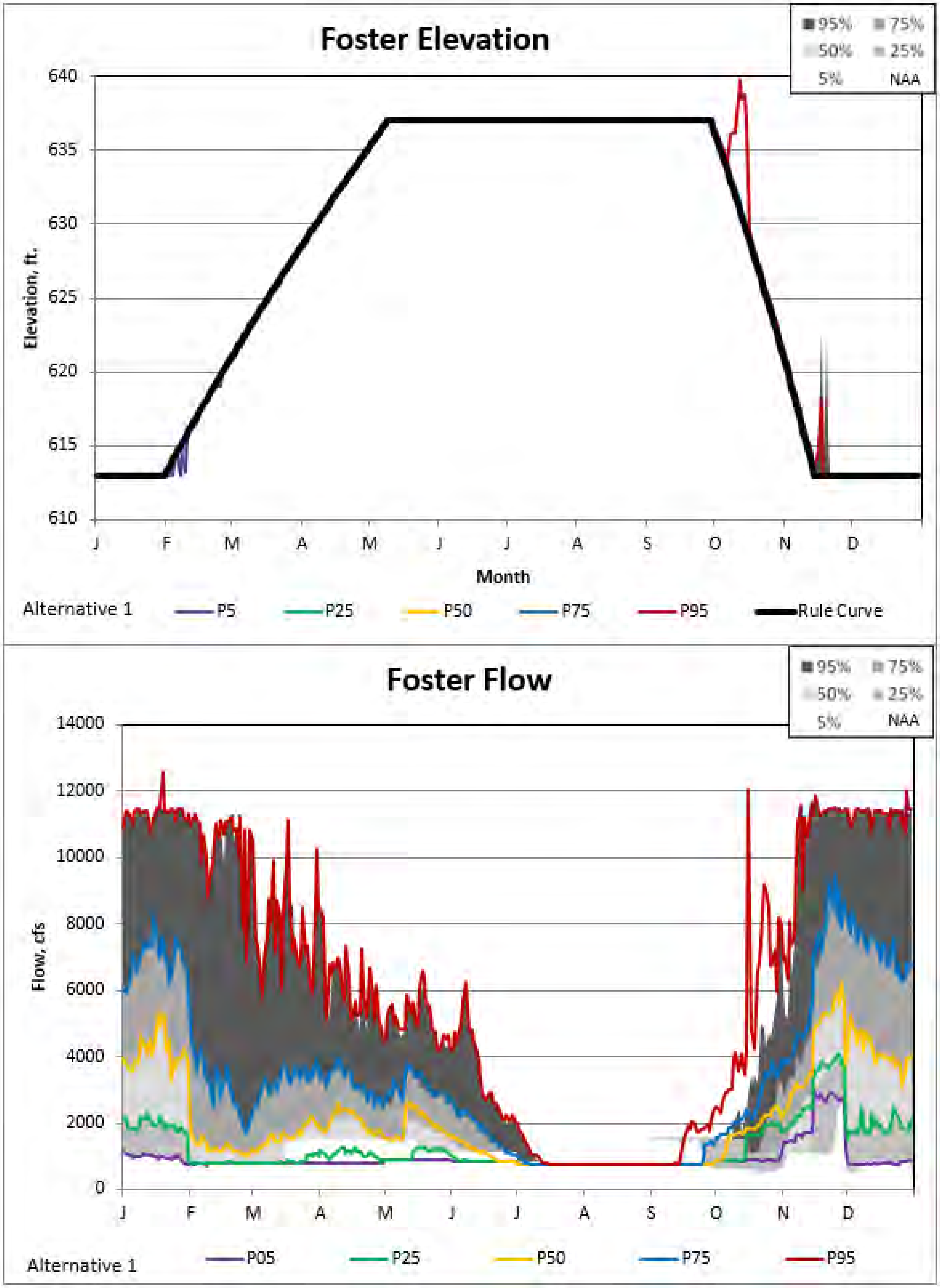


Figure 5-11. Foster Alternative 1 Non-Exceedance Plot

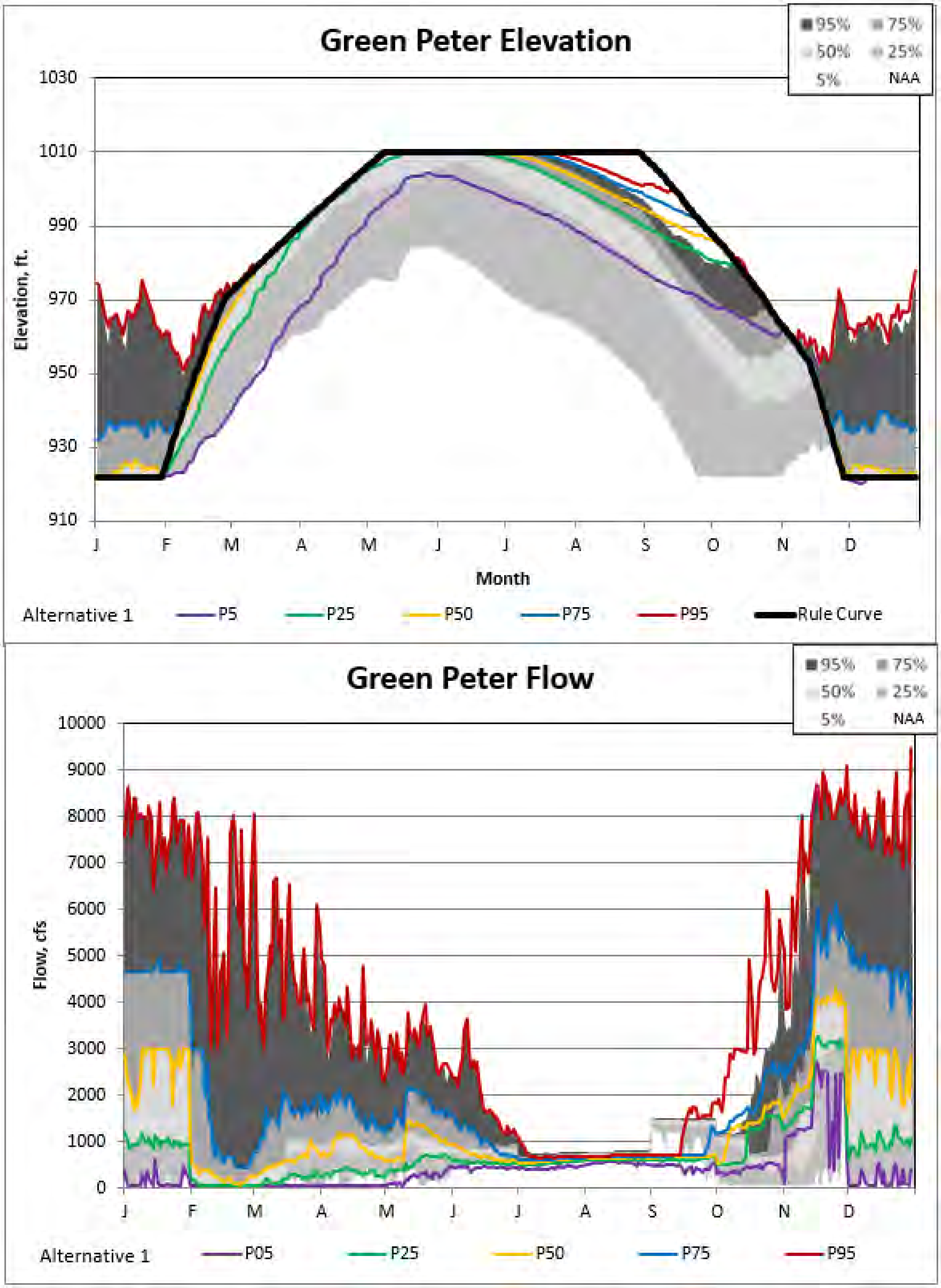


Figure 5-12. Green Peter Alternative 1 Non-Exceedance Plot

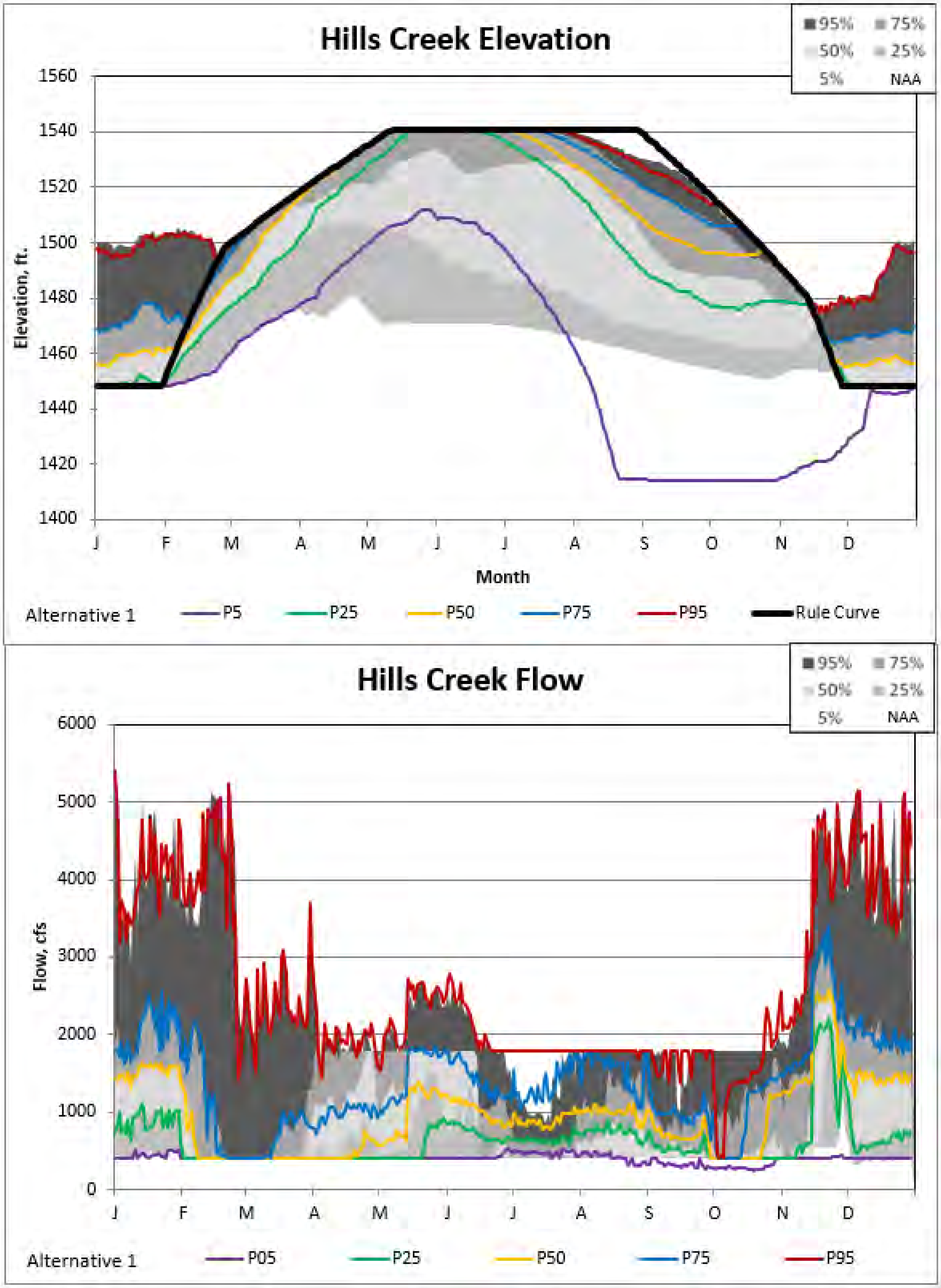


Figure 5-13. Hills Creek Alternative 1 Non-Exceedance Plot

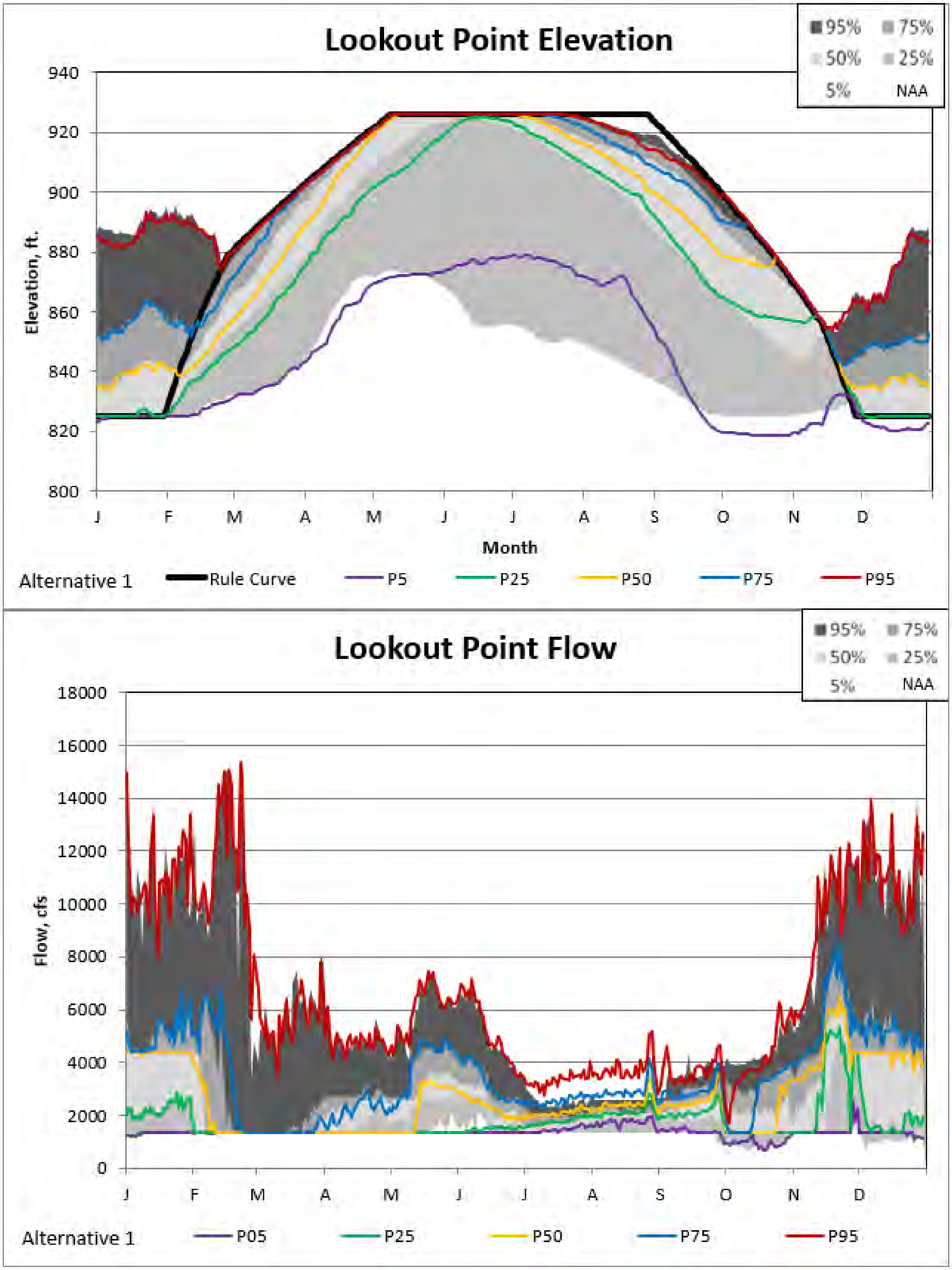


Figure 5-14. Lookout Point Alternative 1 Non-Exceedance Plot

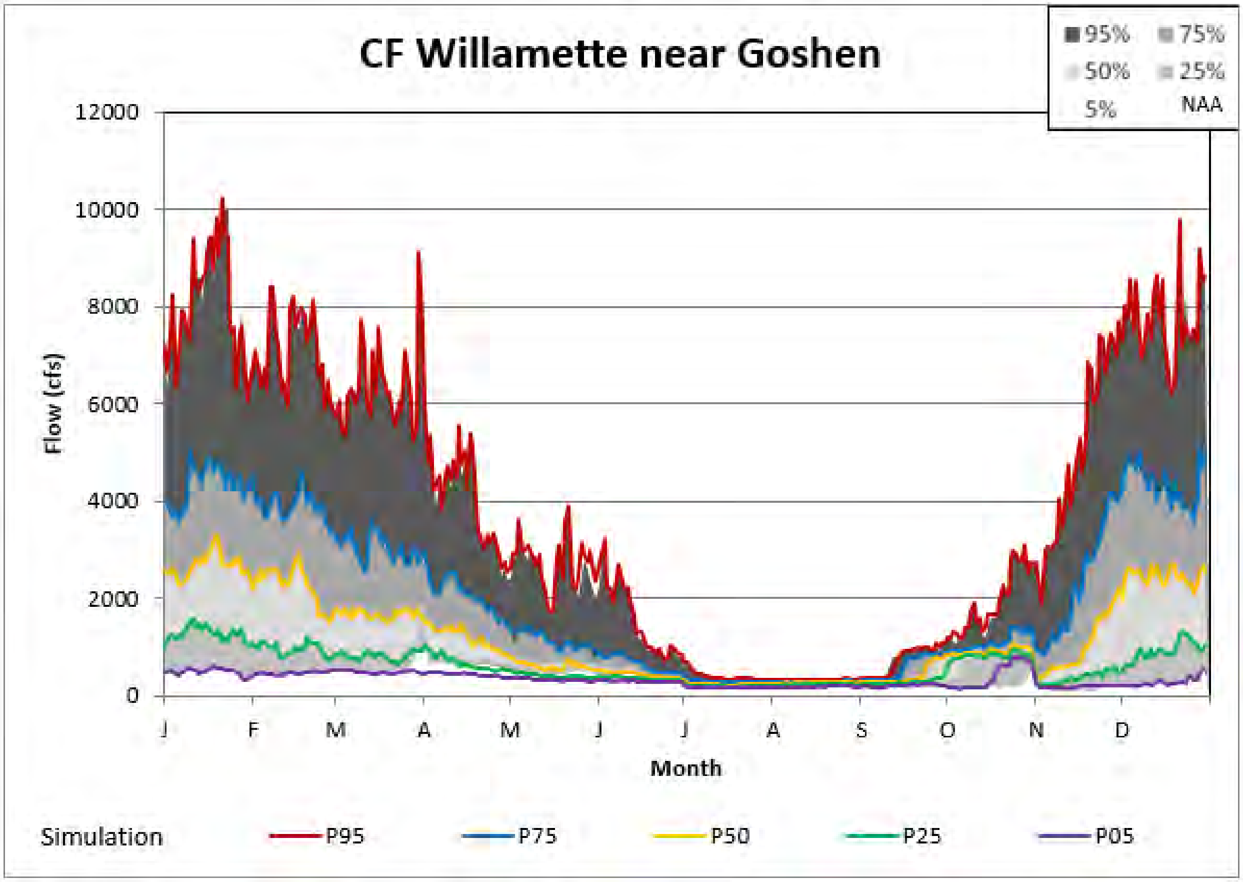


Figure-5-15. Goshen Alternative 1 Non-Exceedance Plot

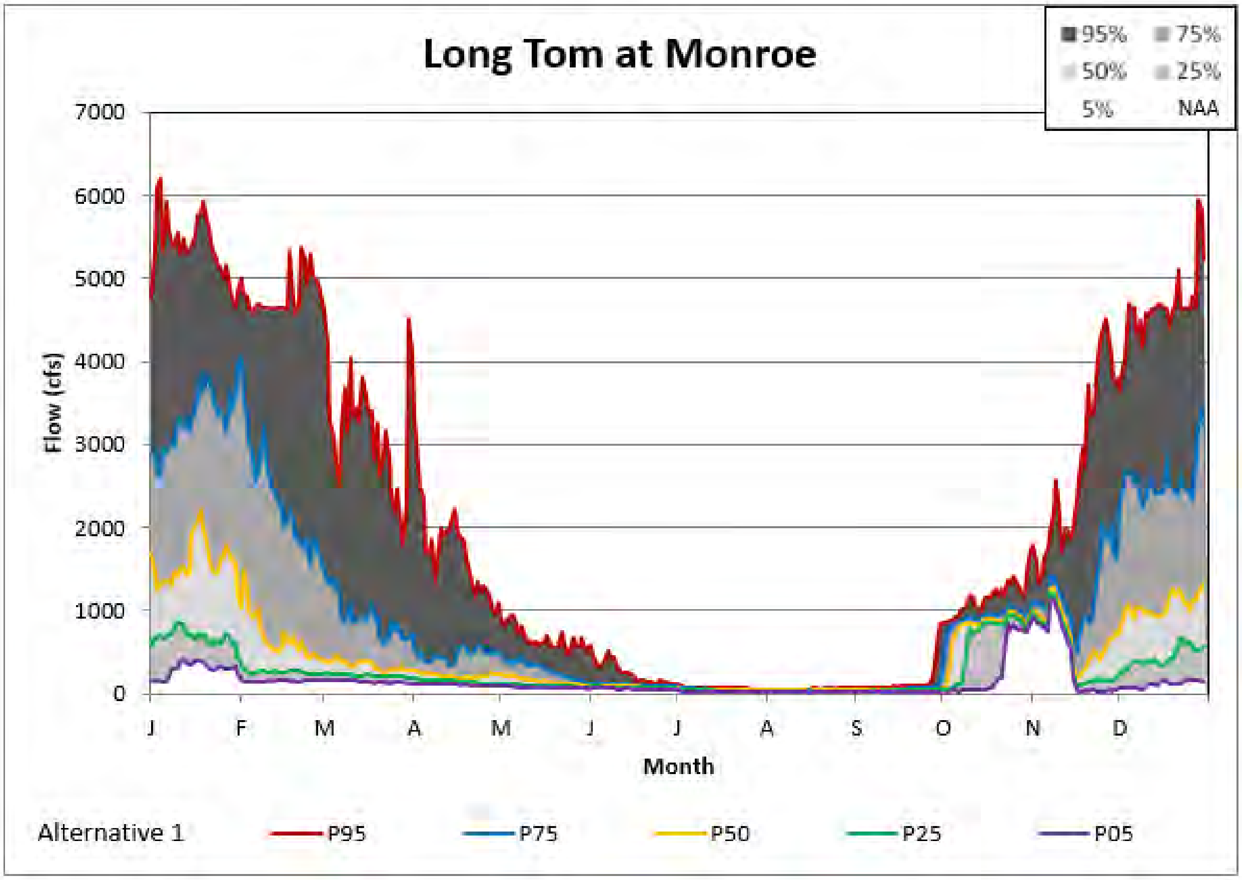


Figure 5-16. Monroe Alternative 1 Non-Exceedance Plot

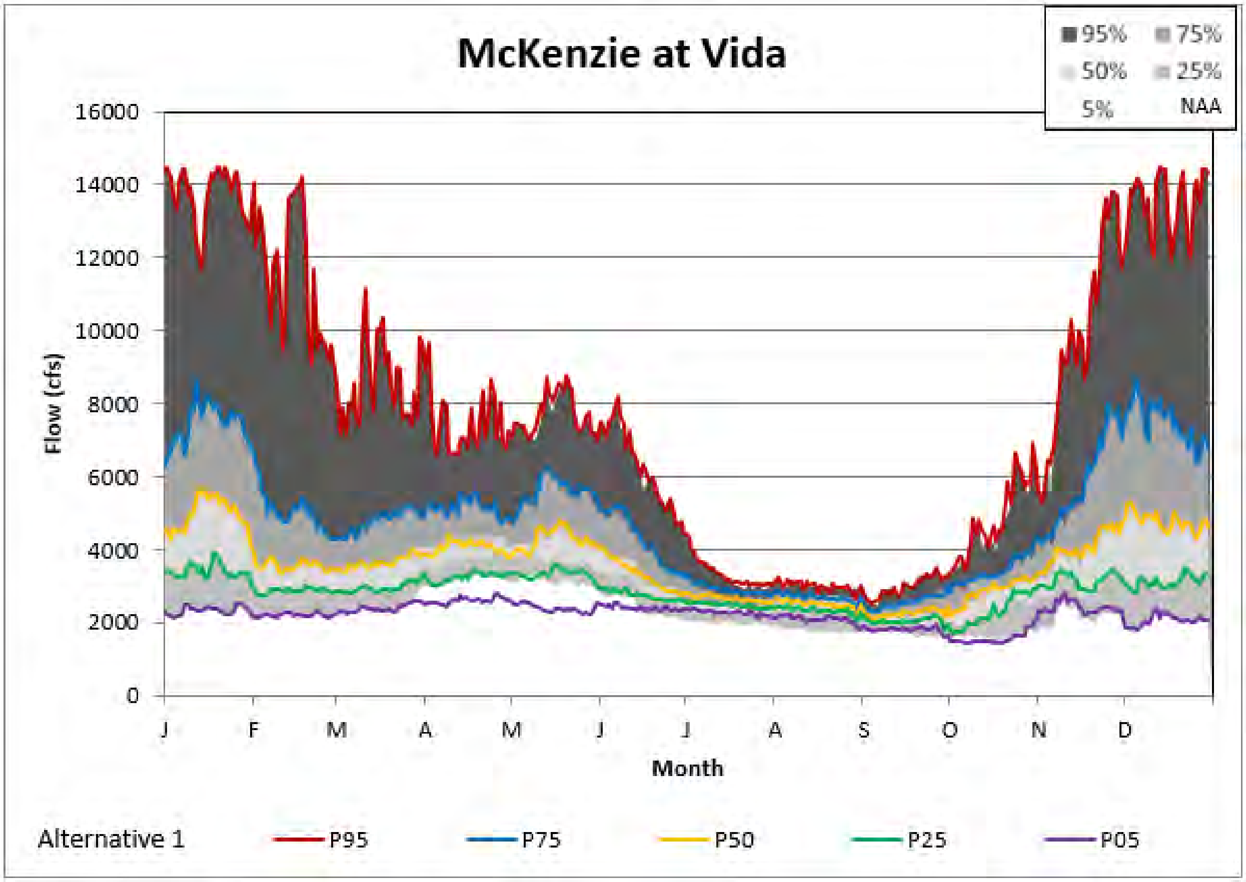


Figure 5-17. Vida Alternative 1 Non-Exceedance Plot

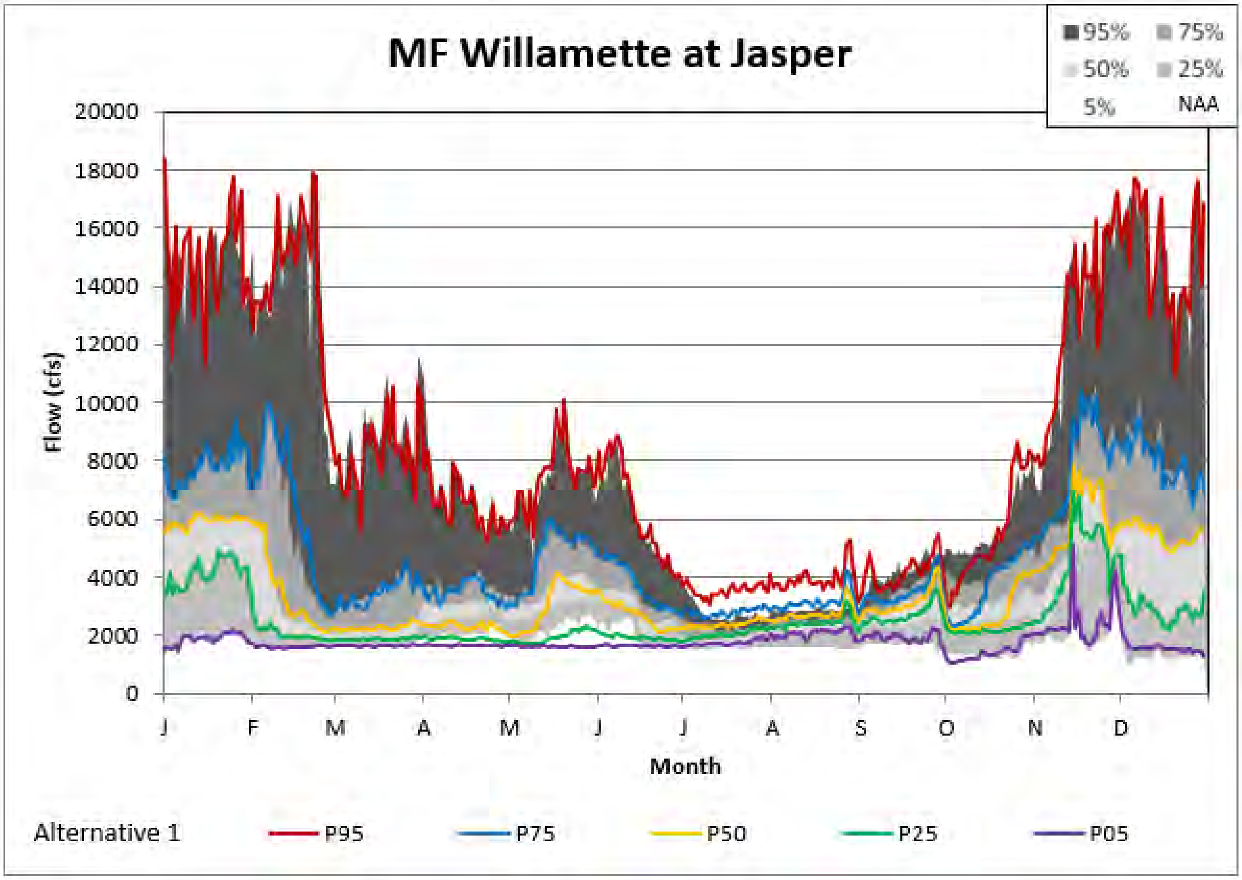


Figure 5-18. Jasper Alternative 1 Non-Exceedance Plot

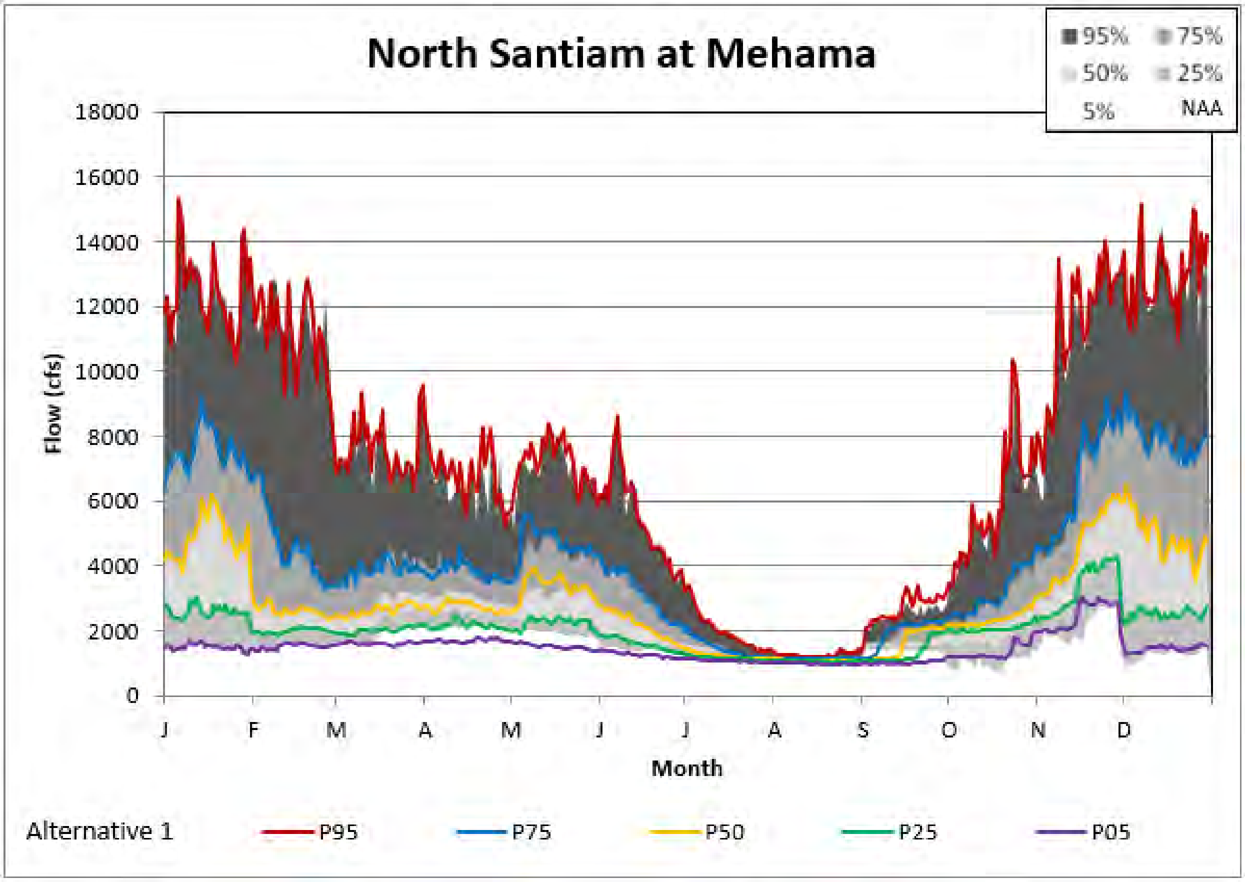


Figure 5-19. Mehama Alternative 1 Non-Exceedance Plot

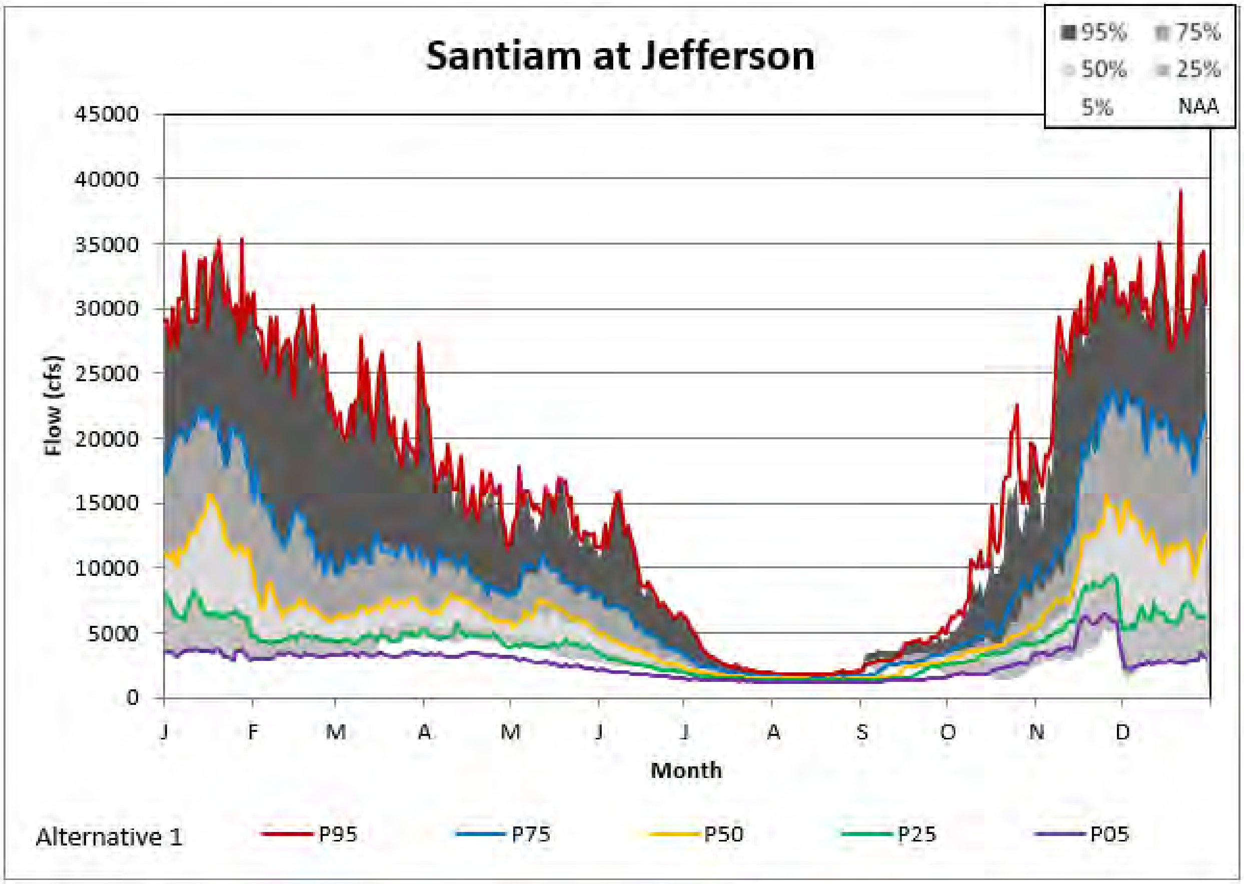


Figure 5-20. Jefferson Alternative 1 Non-Exceedance Plot

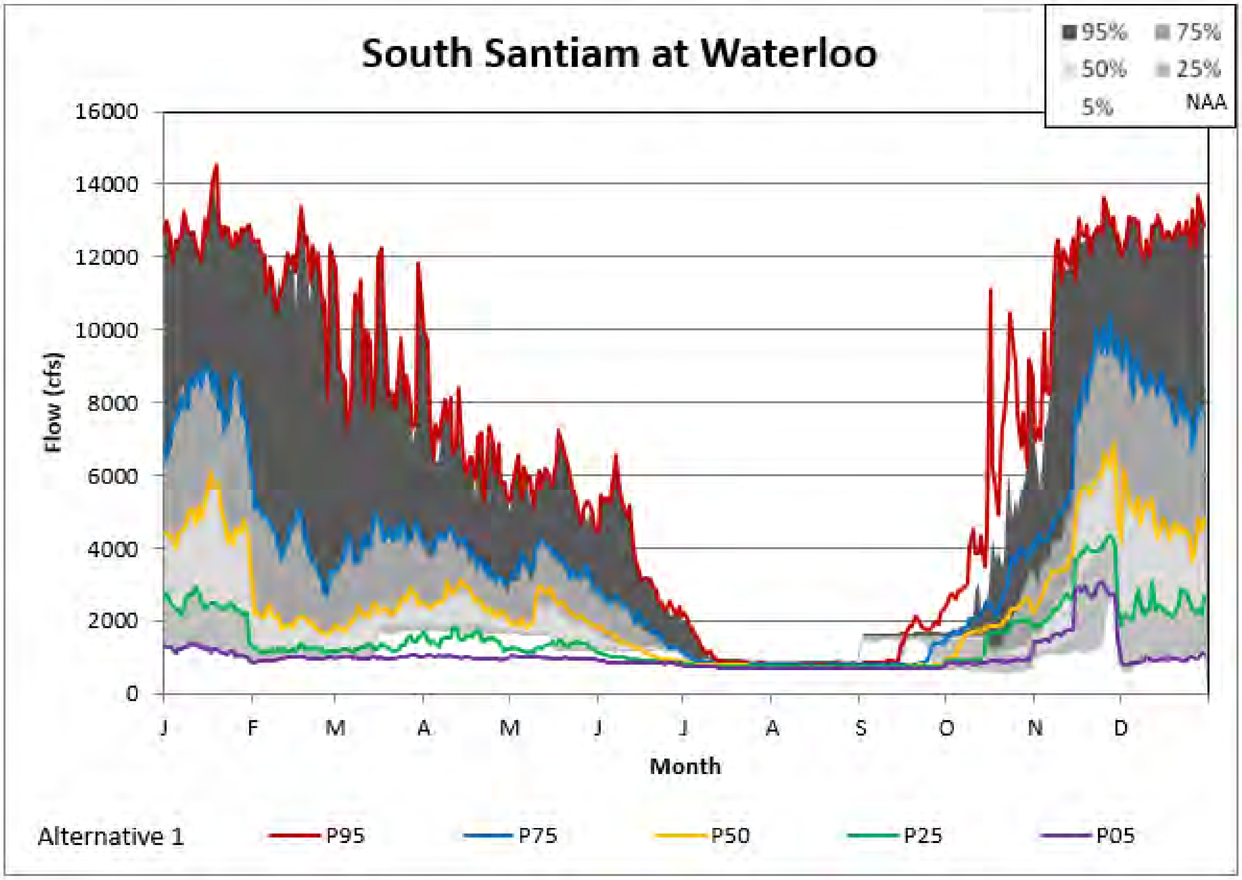


Figure 5-21. Waterloo Alternative 1 Non-Exceedance Plot

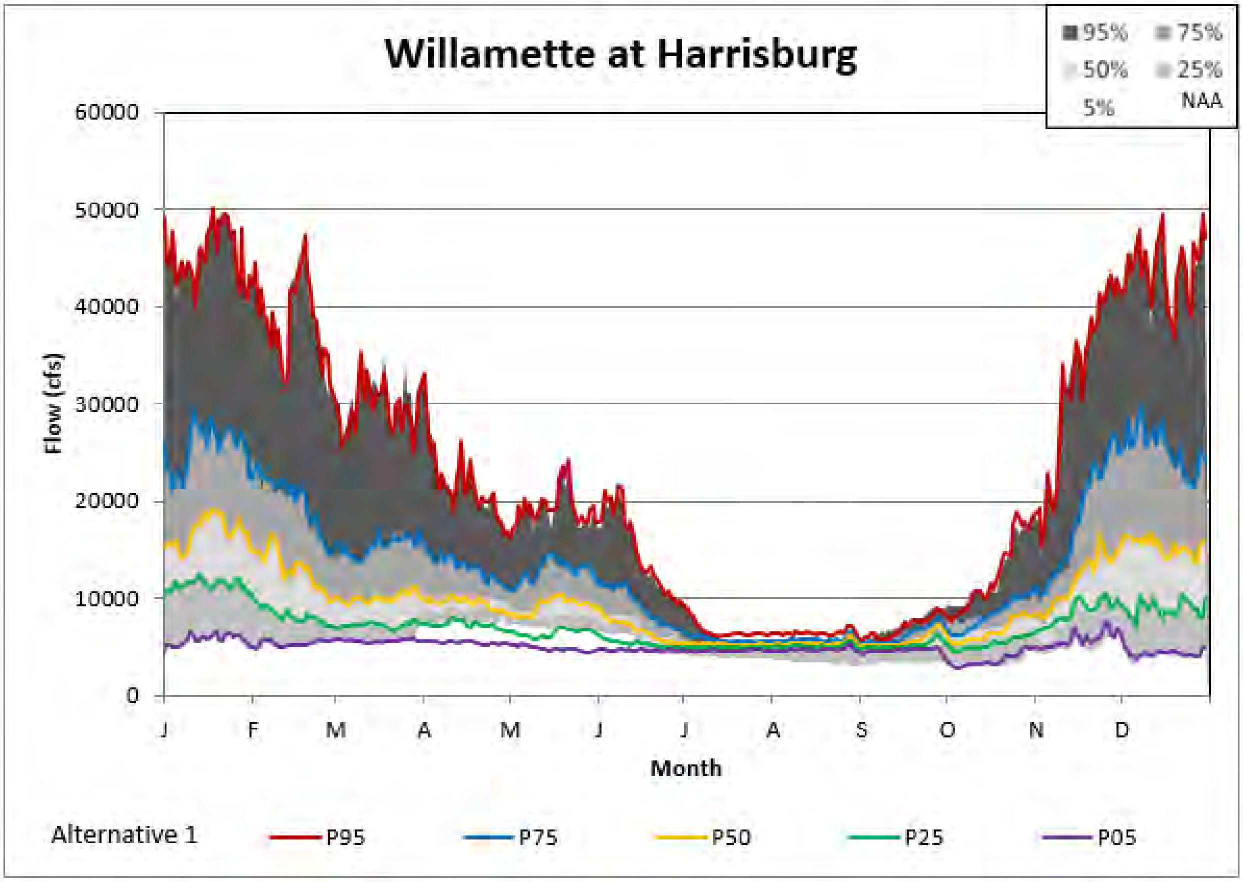


Figure 5-22. Harrisburg Alternative 1 Non-Exceedance Plot

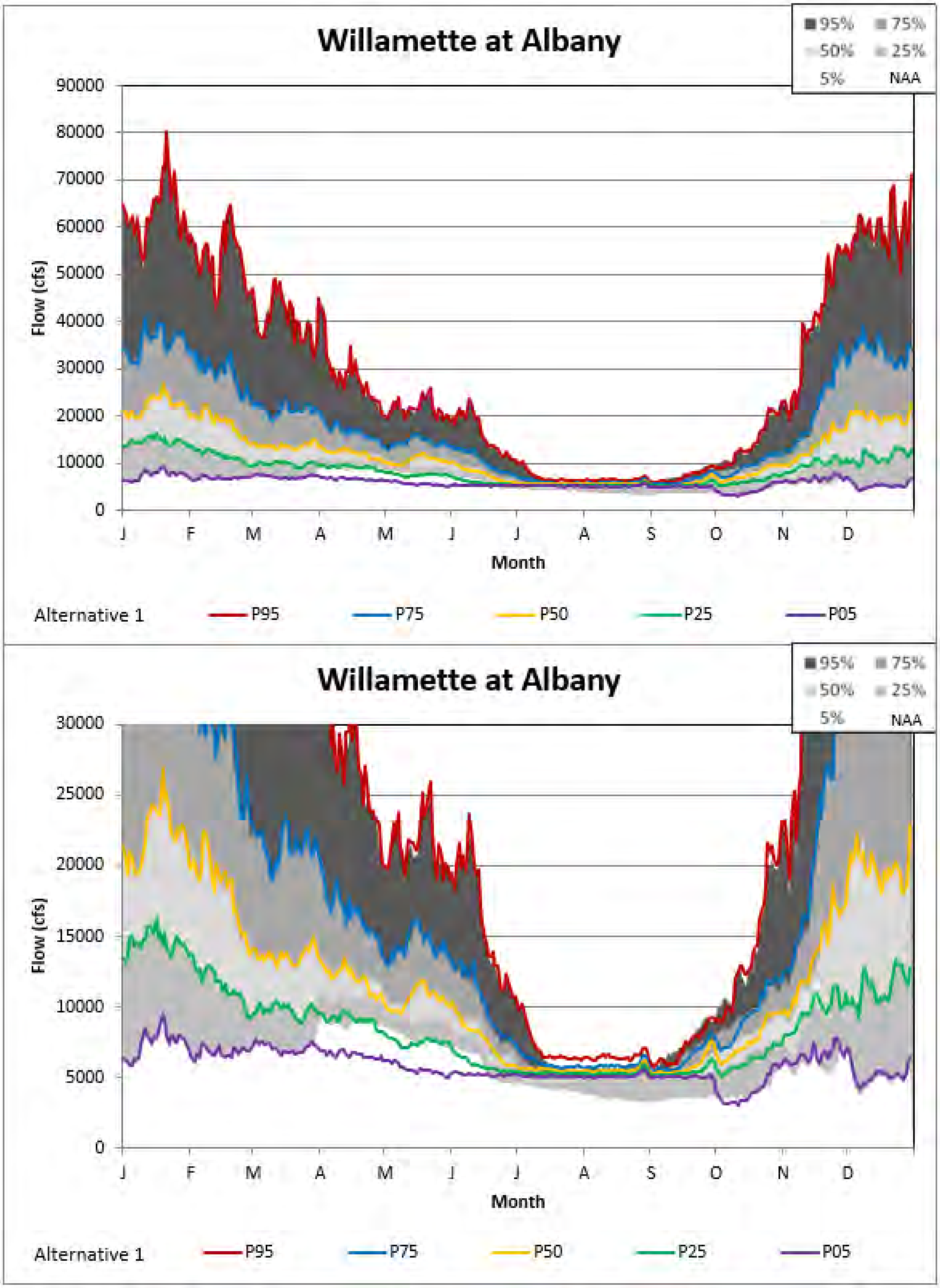


Figure 5-23. Albany Alternative 1 Non-Exceedance Plot

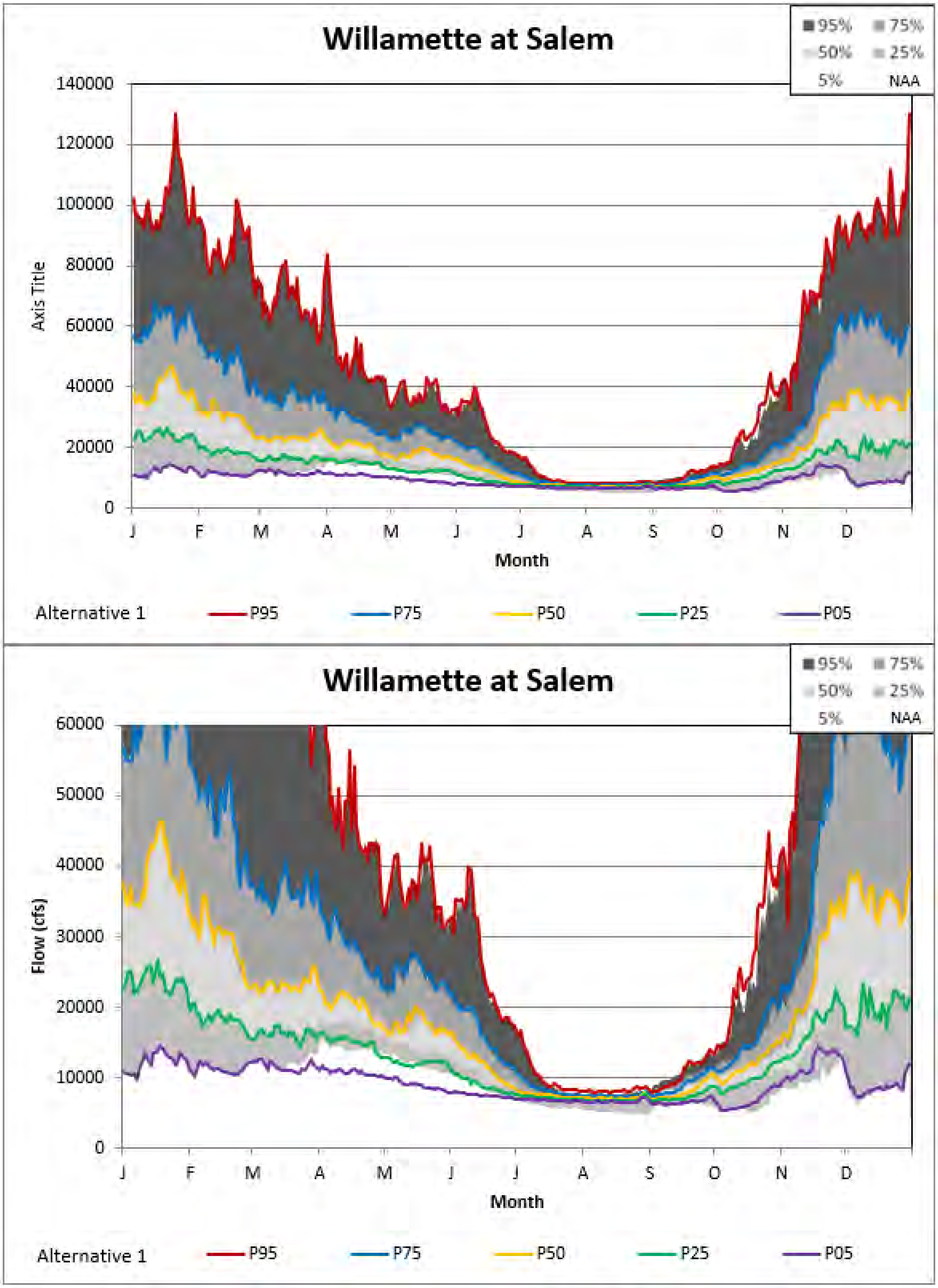


Figure 5-24. Salem Alternative 1 Non-Exceedance Plot

5.2 ALTERNATIVE 2A

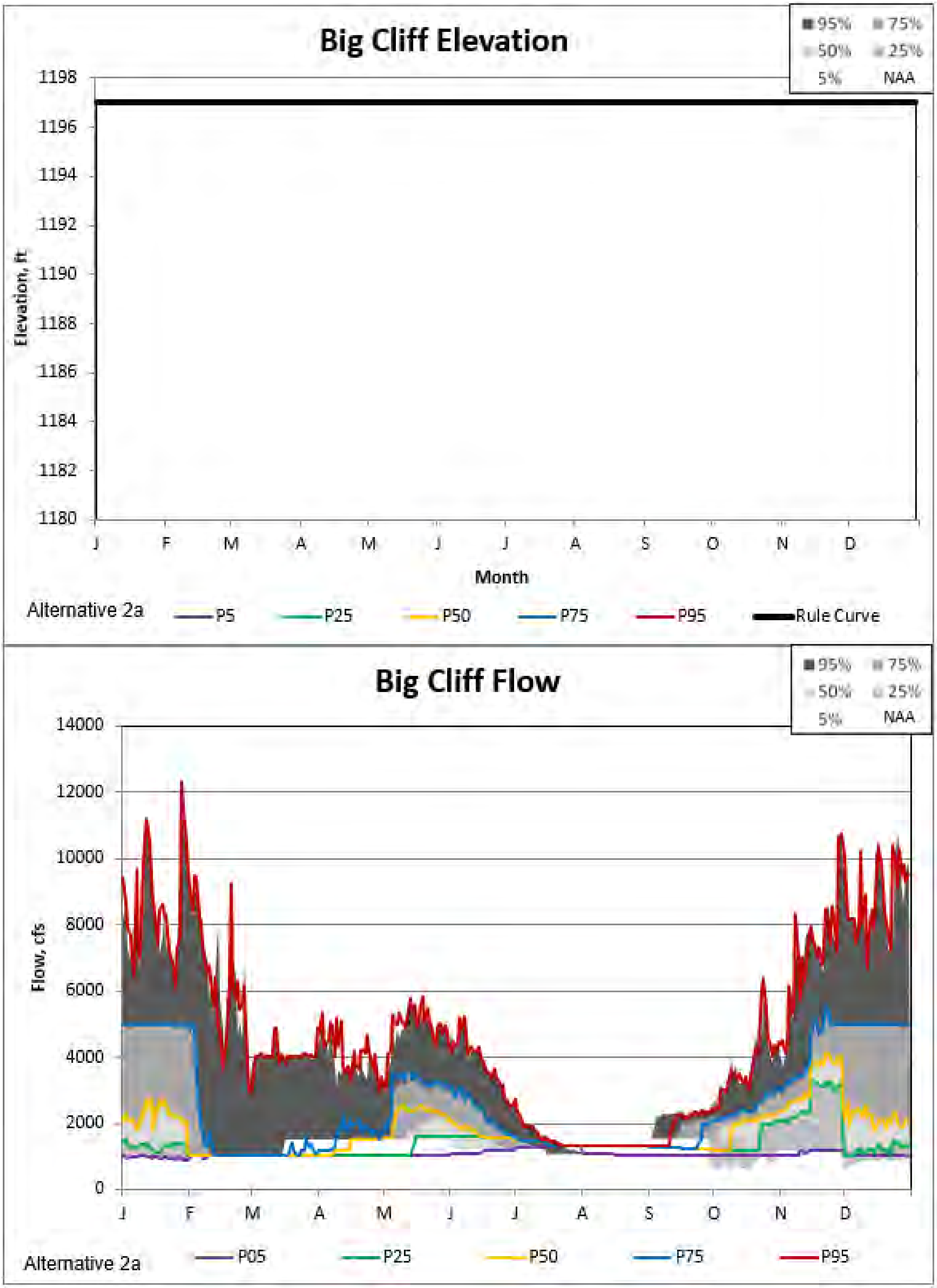


Figure 5-25. Big Cliff Alternative 2a Non-Exceedance Plot

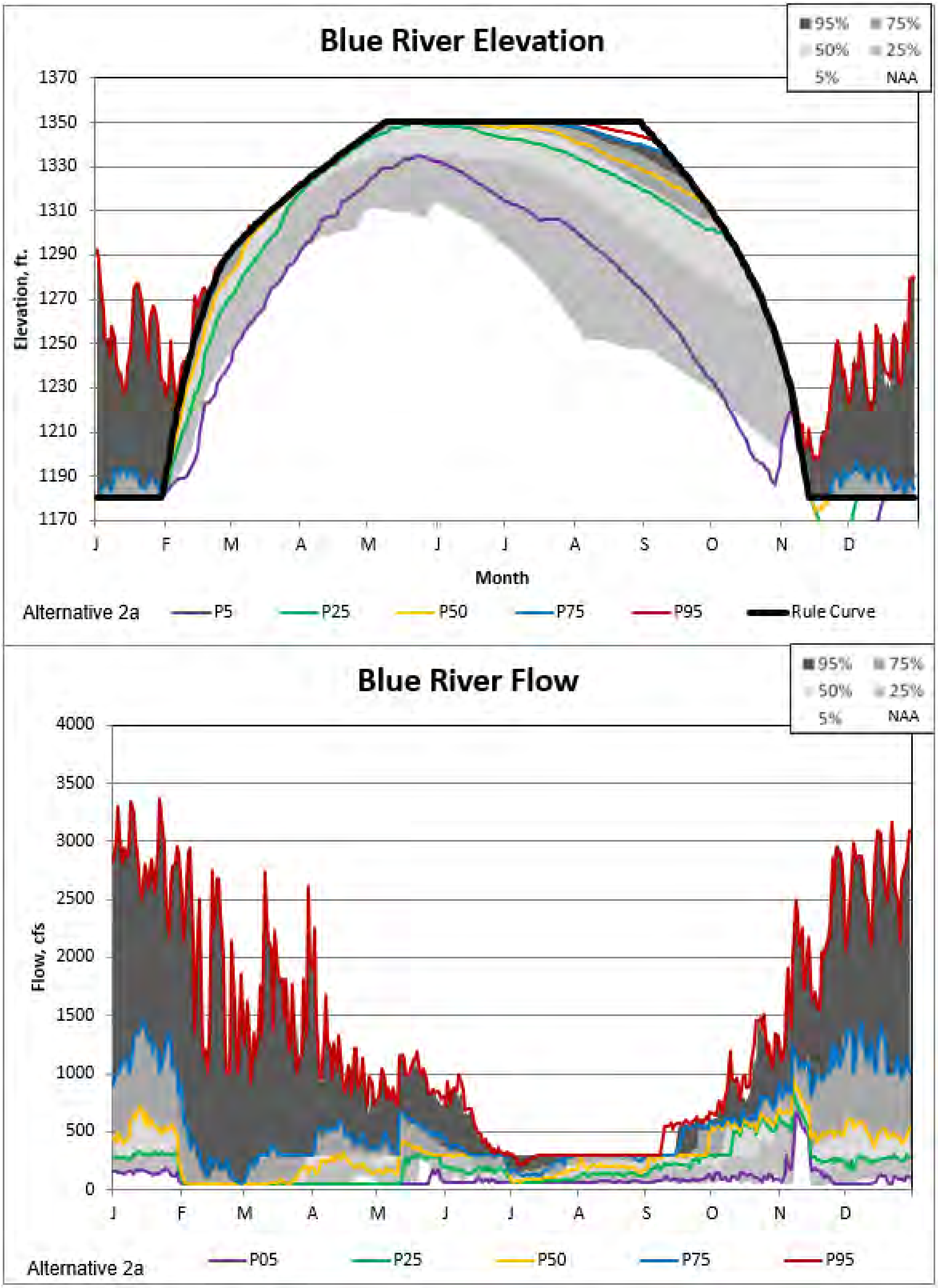


Figure 5-26. Blue River Alternative 2a Non-Exceedance Plot

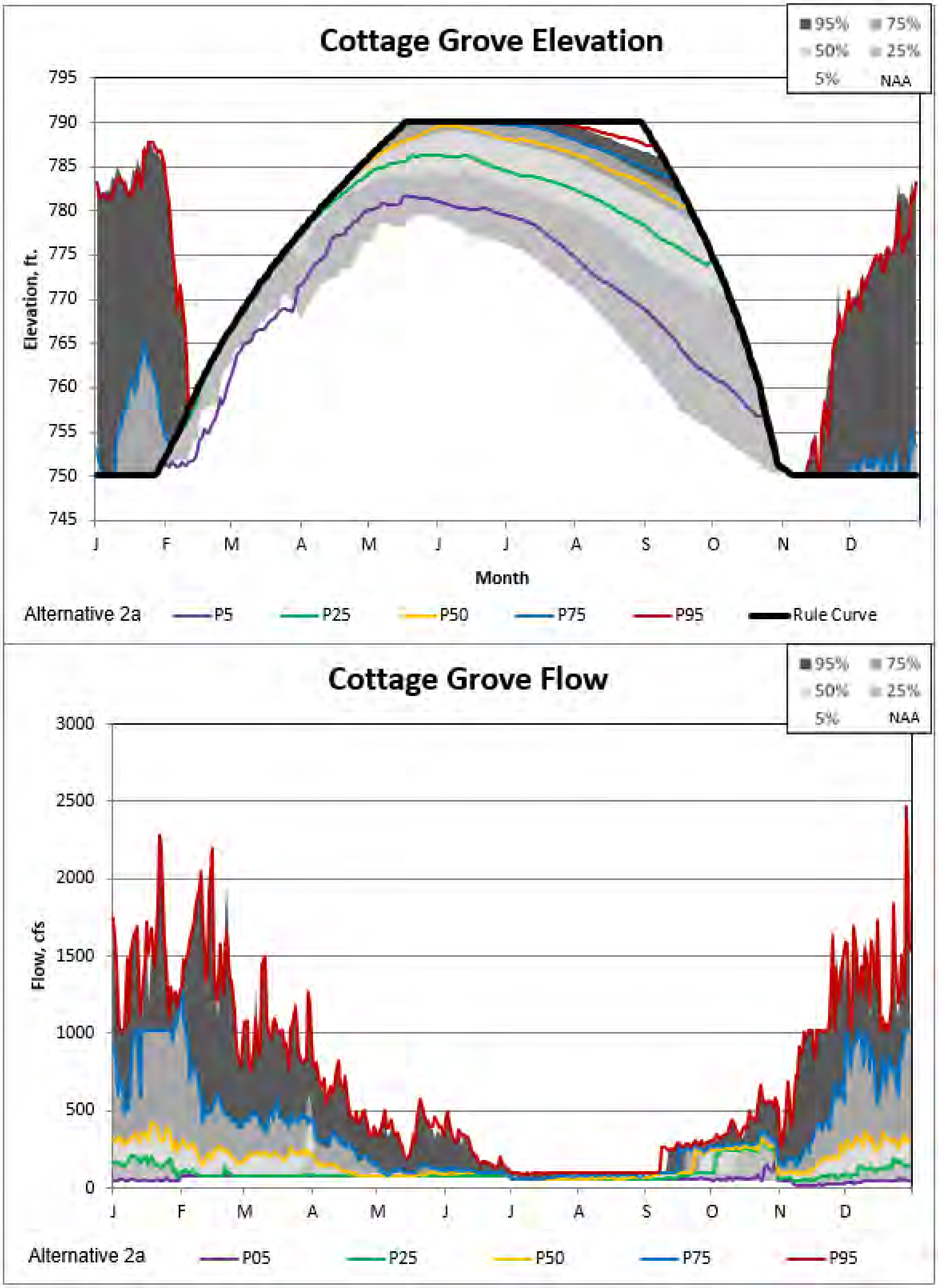


Figure 5-27. Cottage Grove Alternative 2a Non-Exceedance Plot

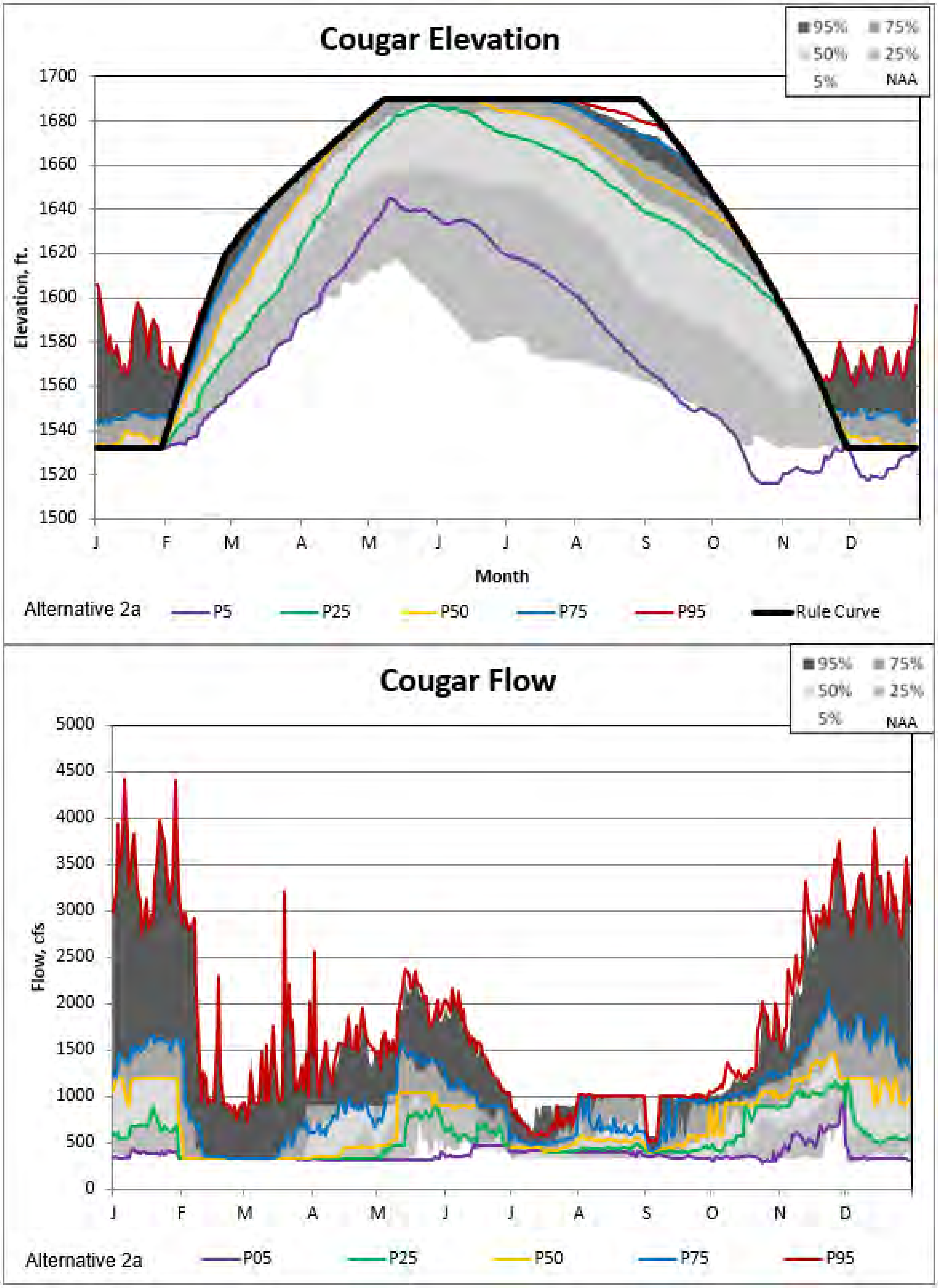


Figure 5-28. Cougar Alternative 2a Non-Exceedance Plot

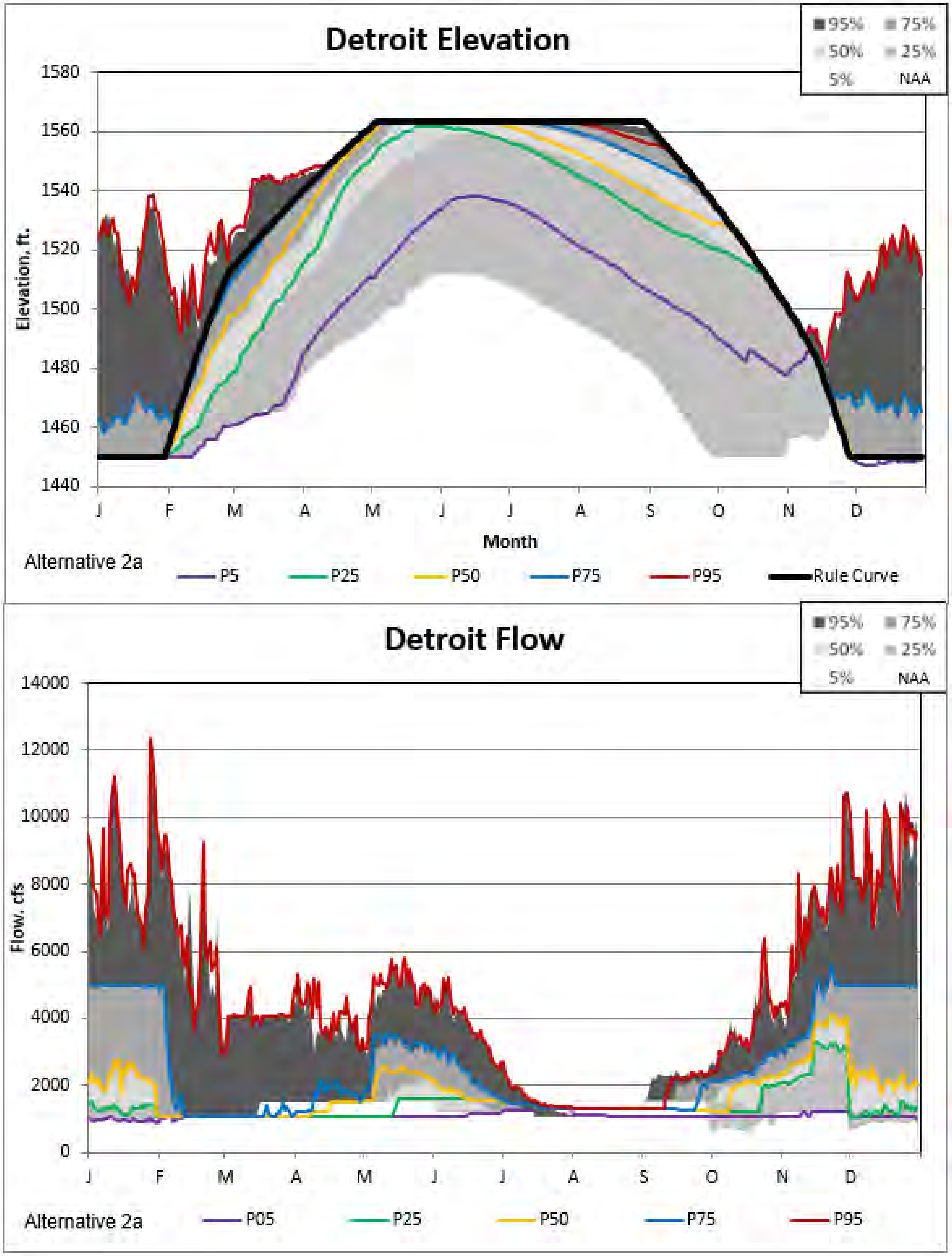


Figure 5-29. Detroit Alternative 2a Non-Exceedance Plot

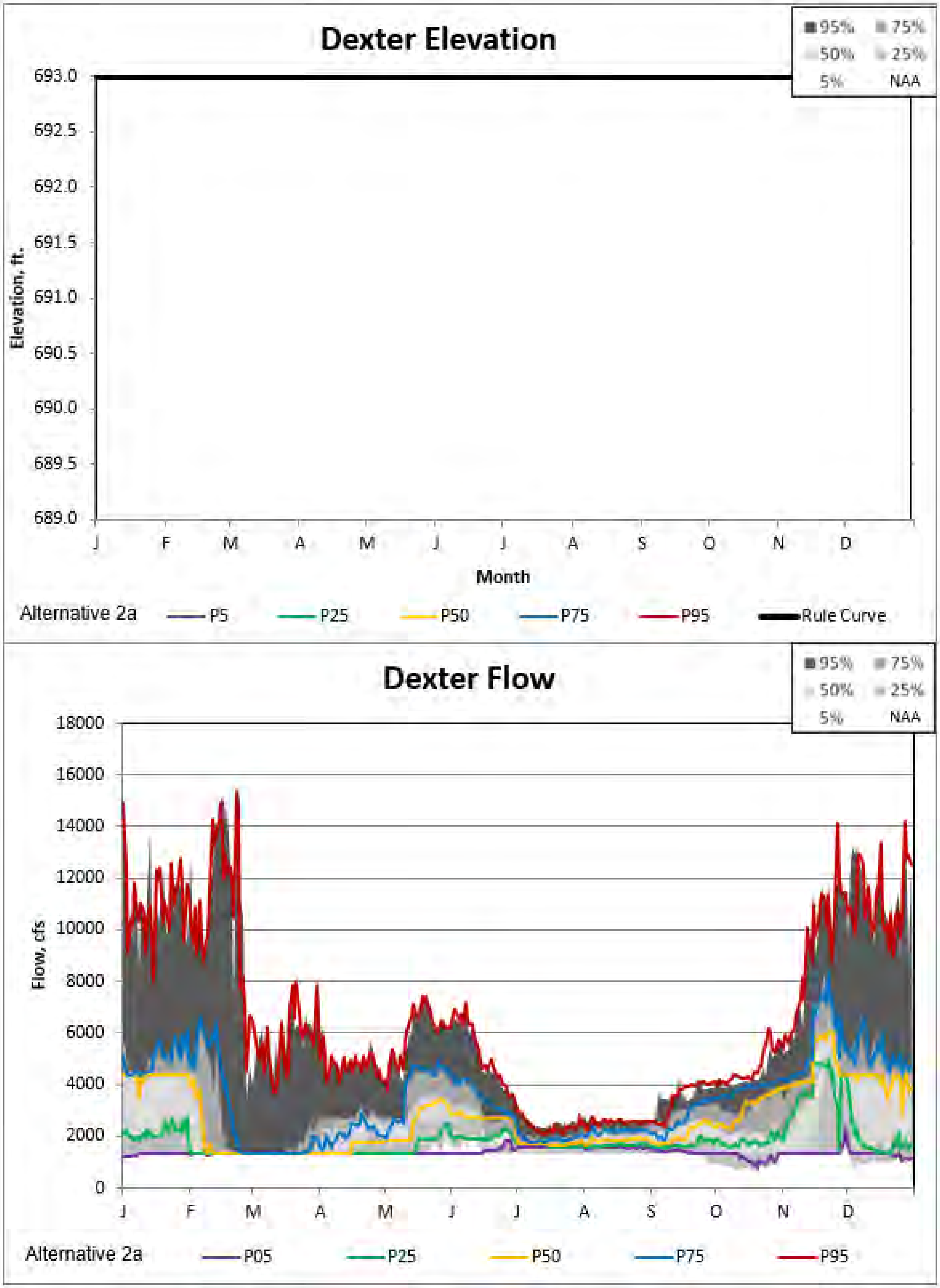


Figure 5-30. Dexter Alternative 2a Non-Exceedance Plot

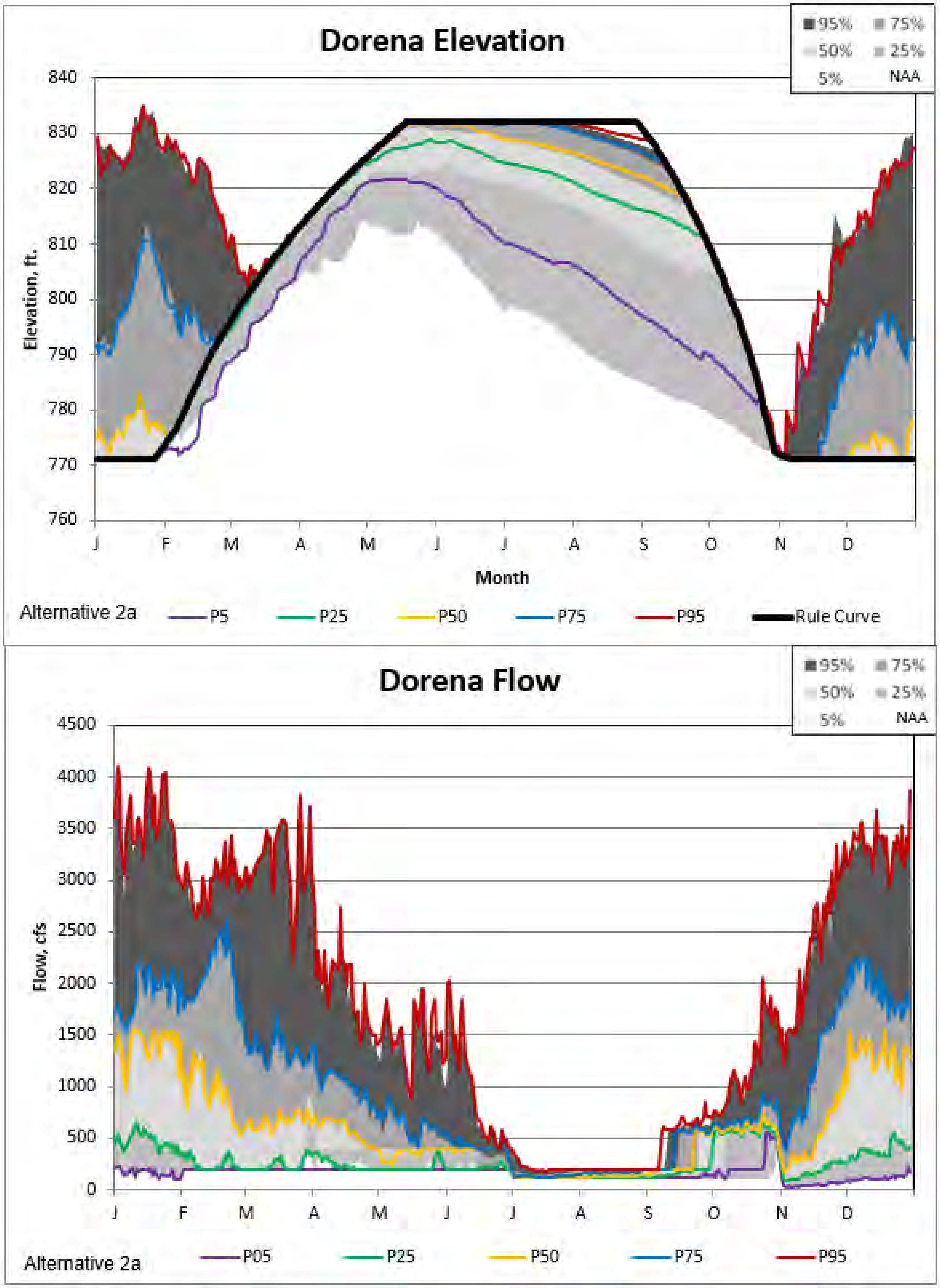


Figure 5-31. Dorena Alternative 2a Non-Exceedance Plot

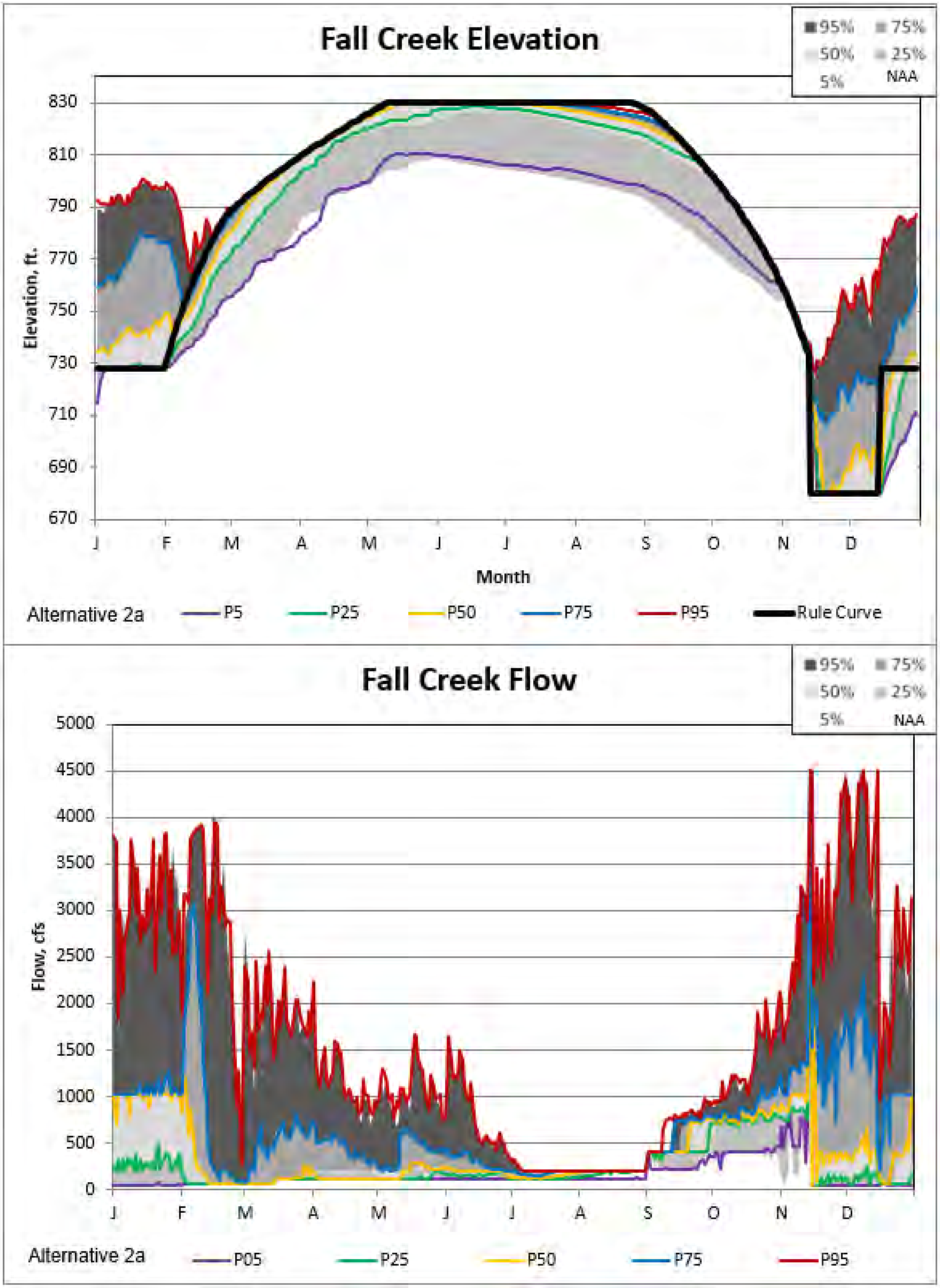


Figure 5-32. Fall Creek Alternative 2a Non-Exceedance Plot

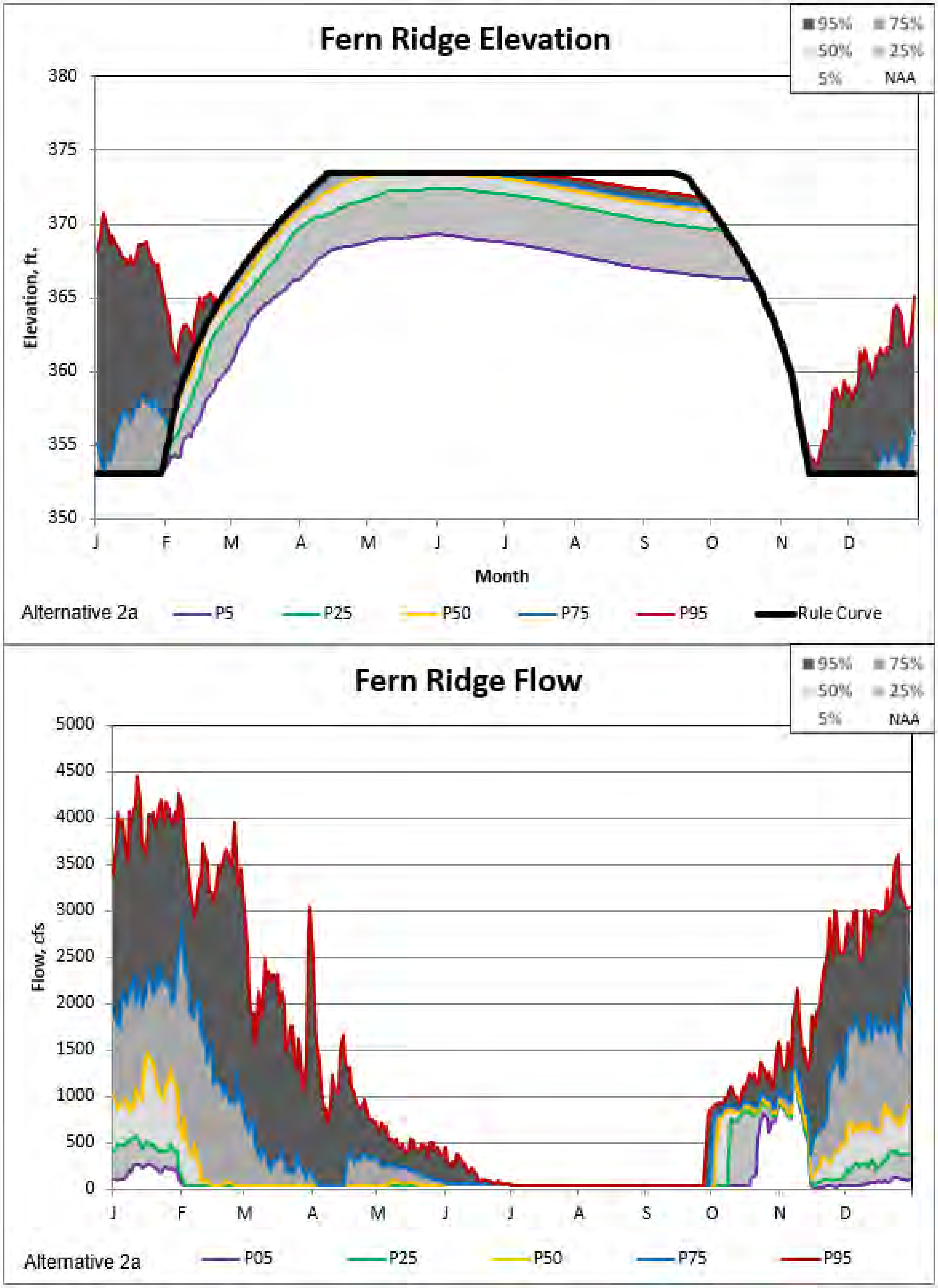


Figure 5-33. Fern Ridge Alternative 2a Non-Exceedance Plot

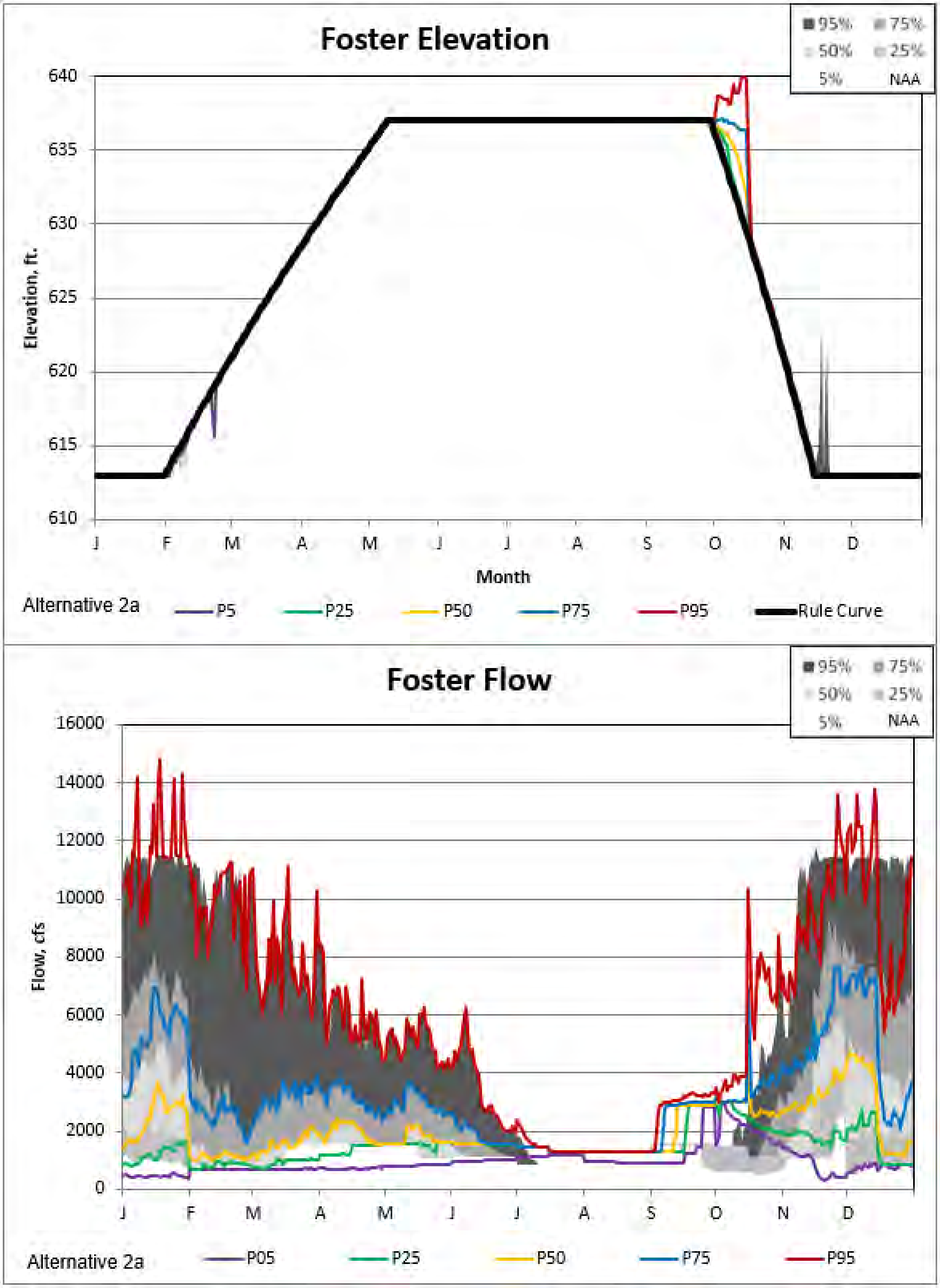


Figure 5-34. Foster Alternative 2a Non-Exceedance Plot

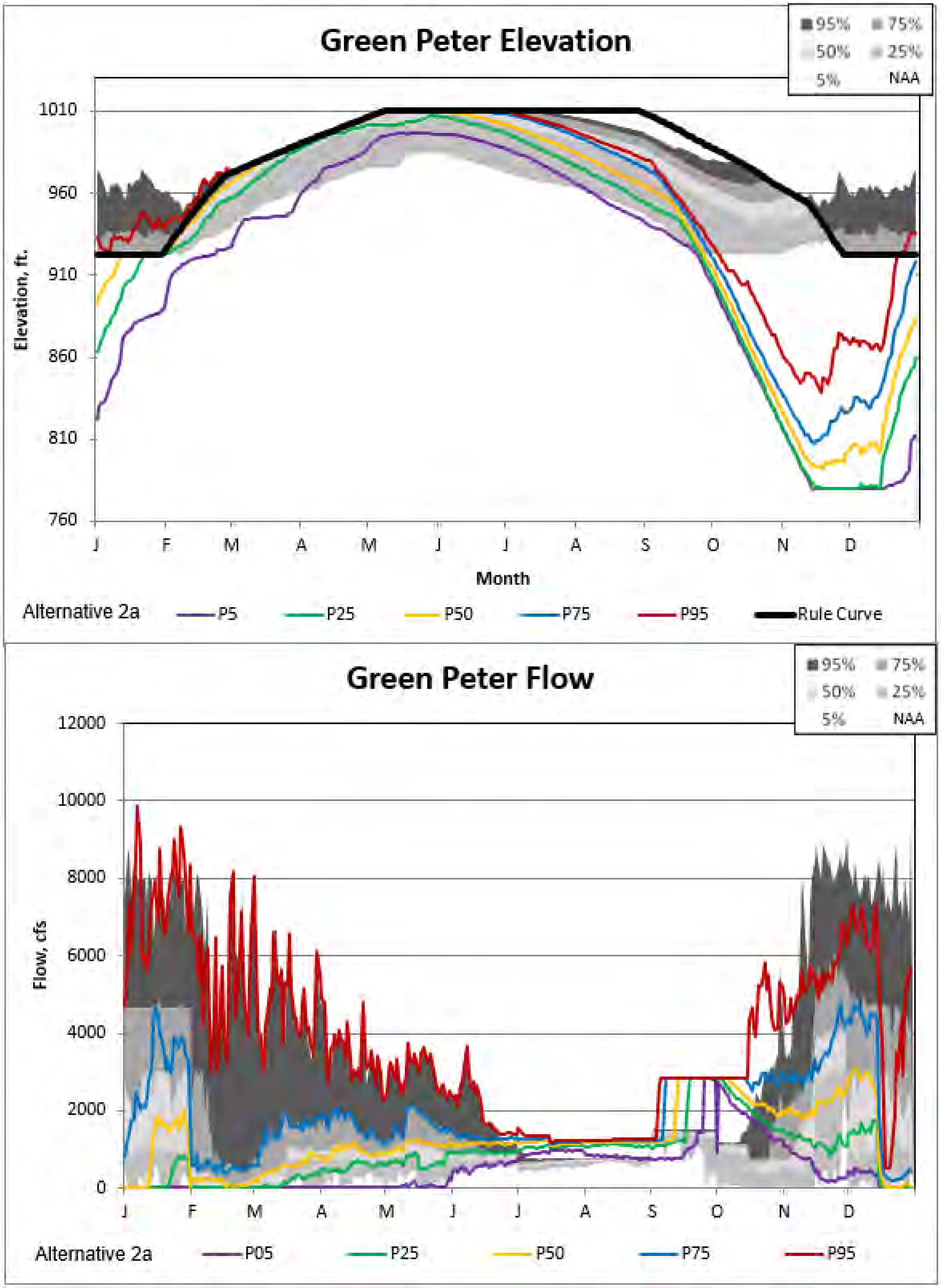


Figure 5-35. Green Peter Alternative 2a Non-Exceedance Plot

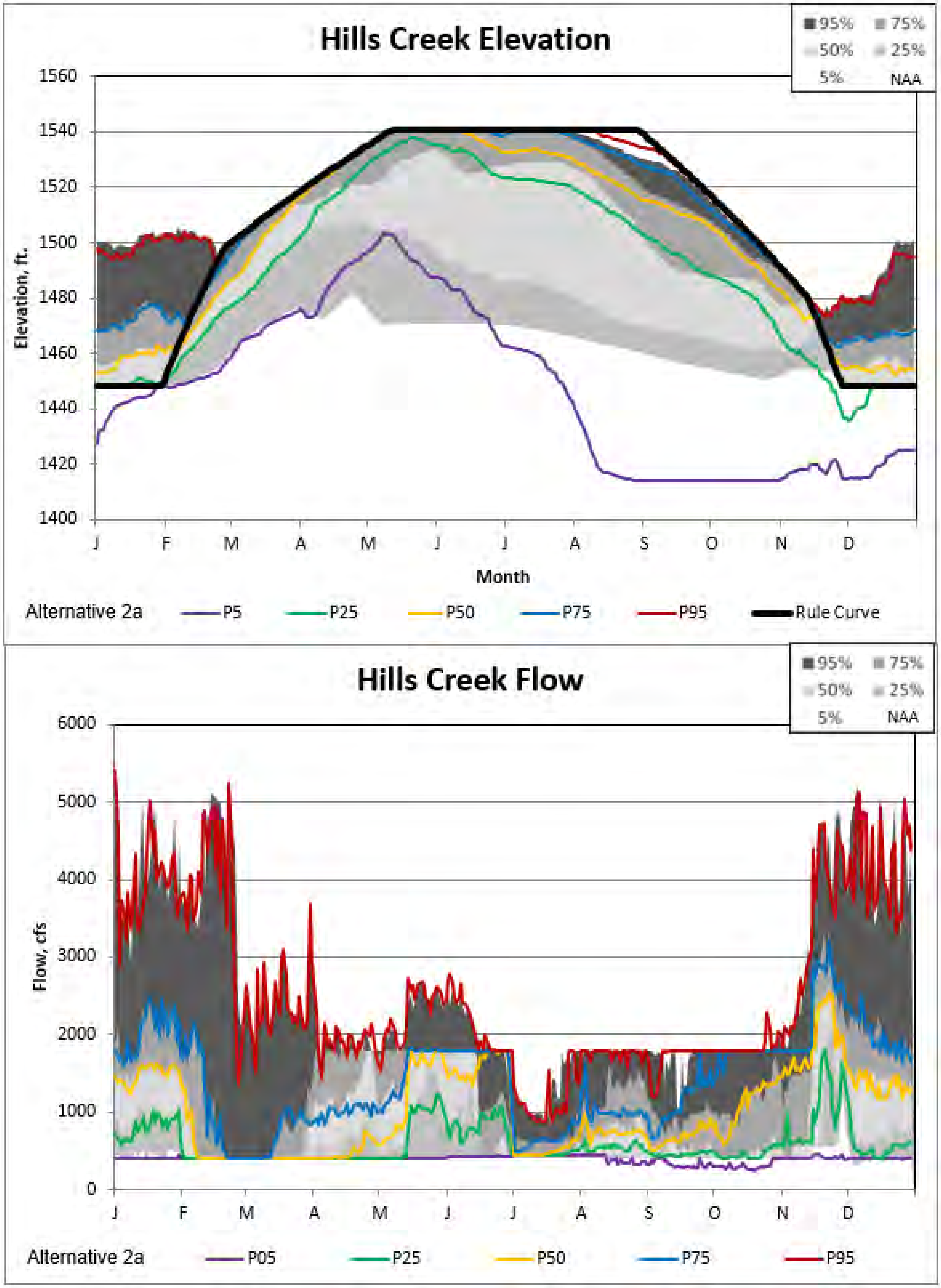


Figure 5-36. Hills Creek Alternative 2a Non-Exceedance Plot

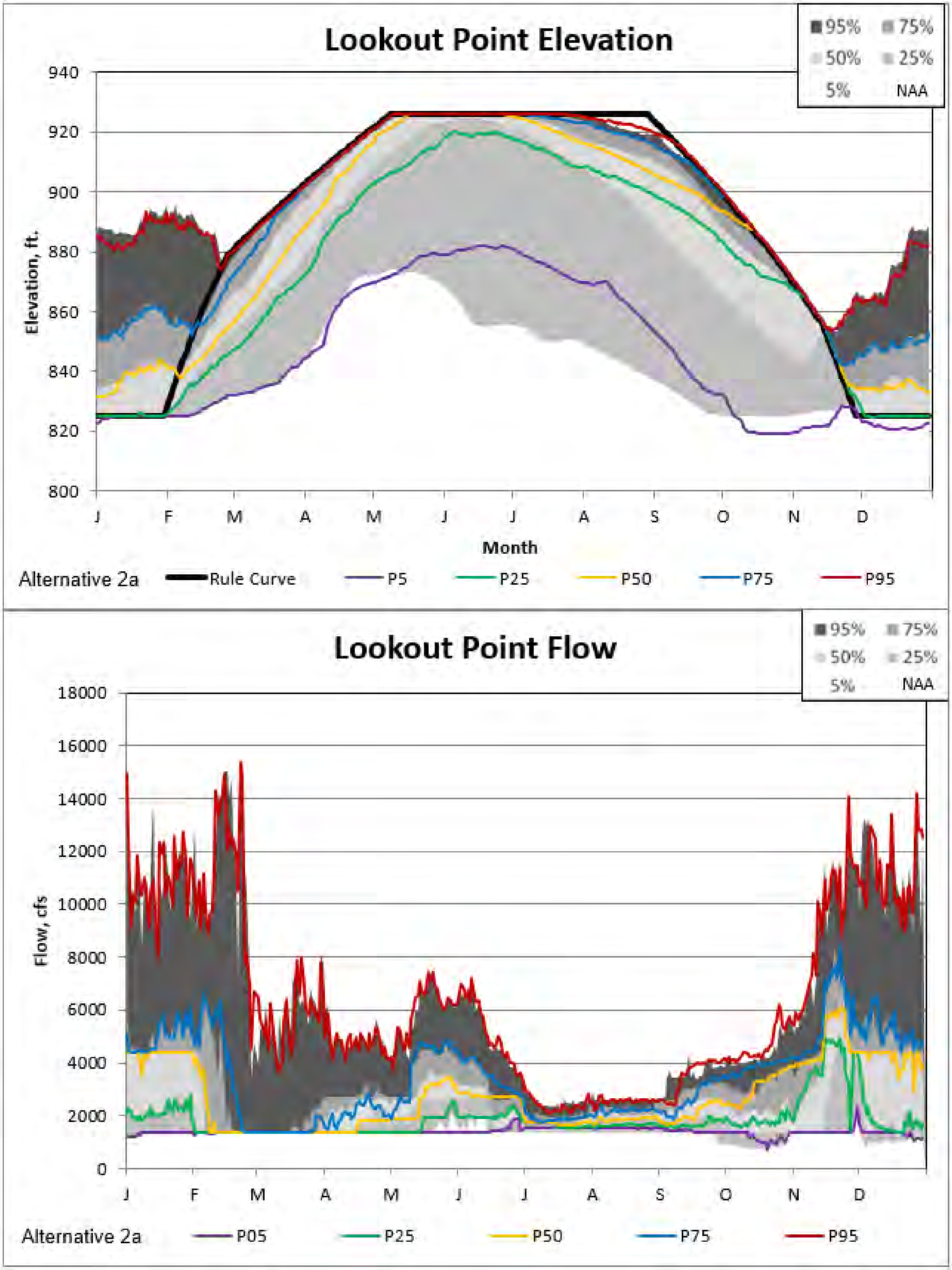


Figure 5-37. Lookout Point Alternative 2a Non-Exceedance Plot

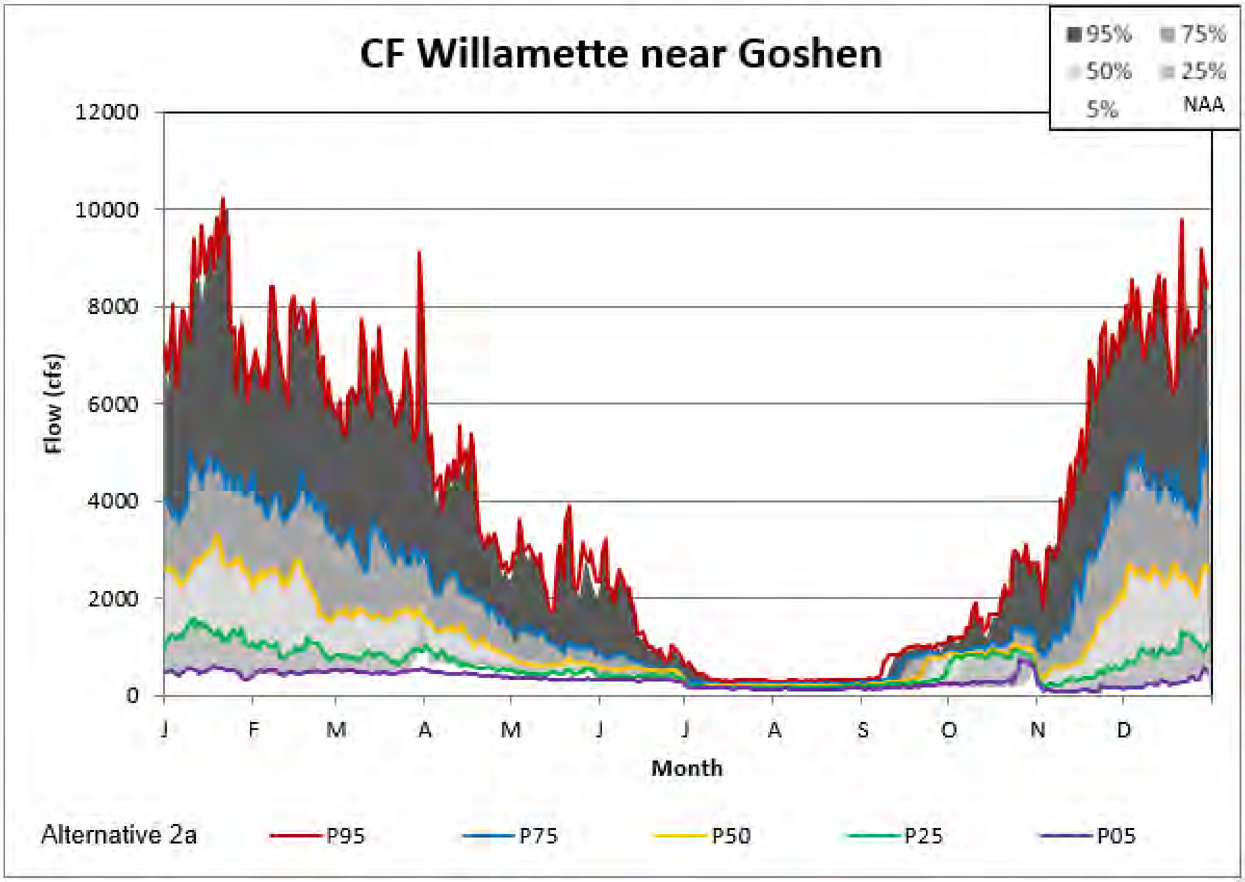


Figure 5-38. Goshen Alternative 2a Non-Exceedance Plot

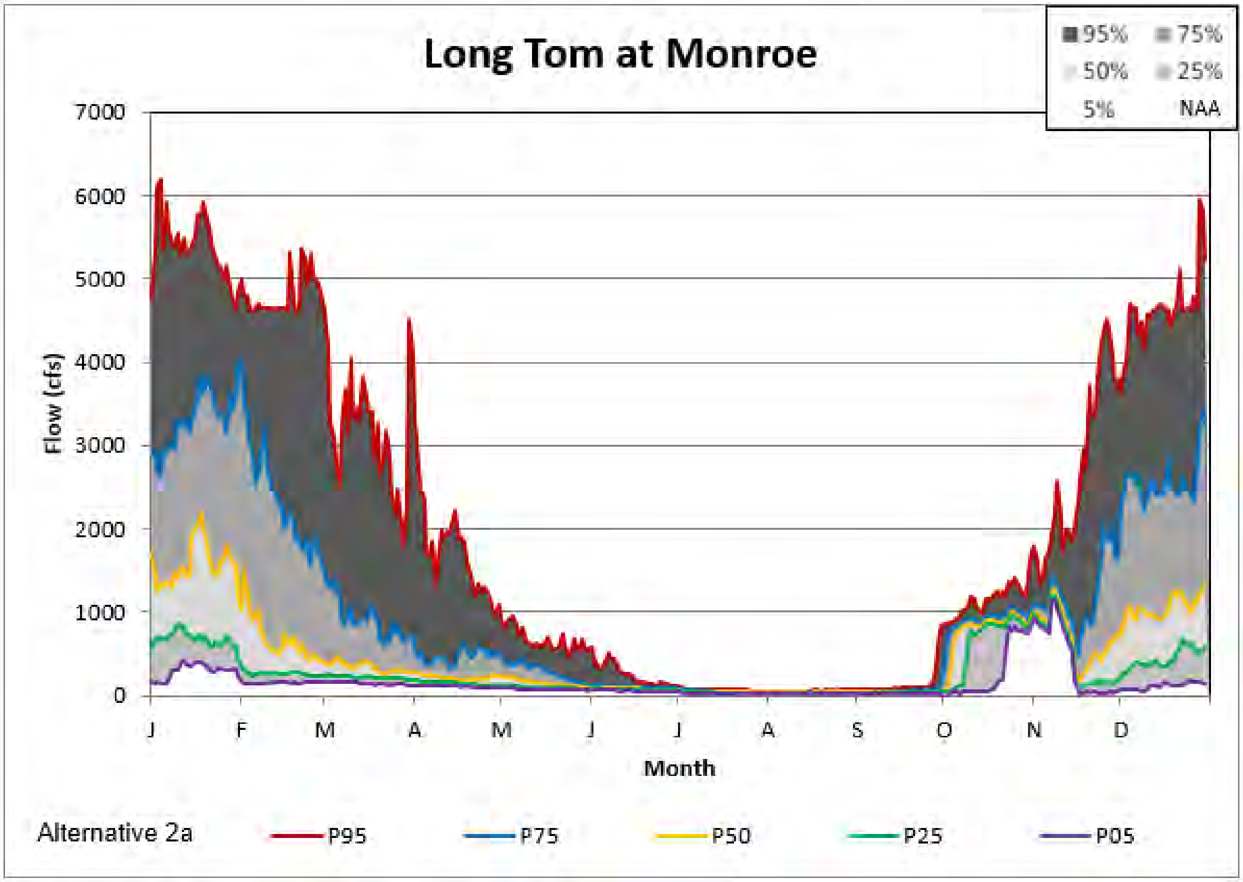


Figure 5-39. Monroe Alternative 2a Non-Exceedance Plot

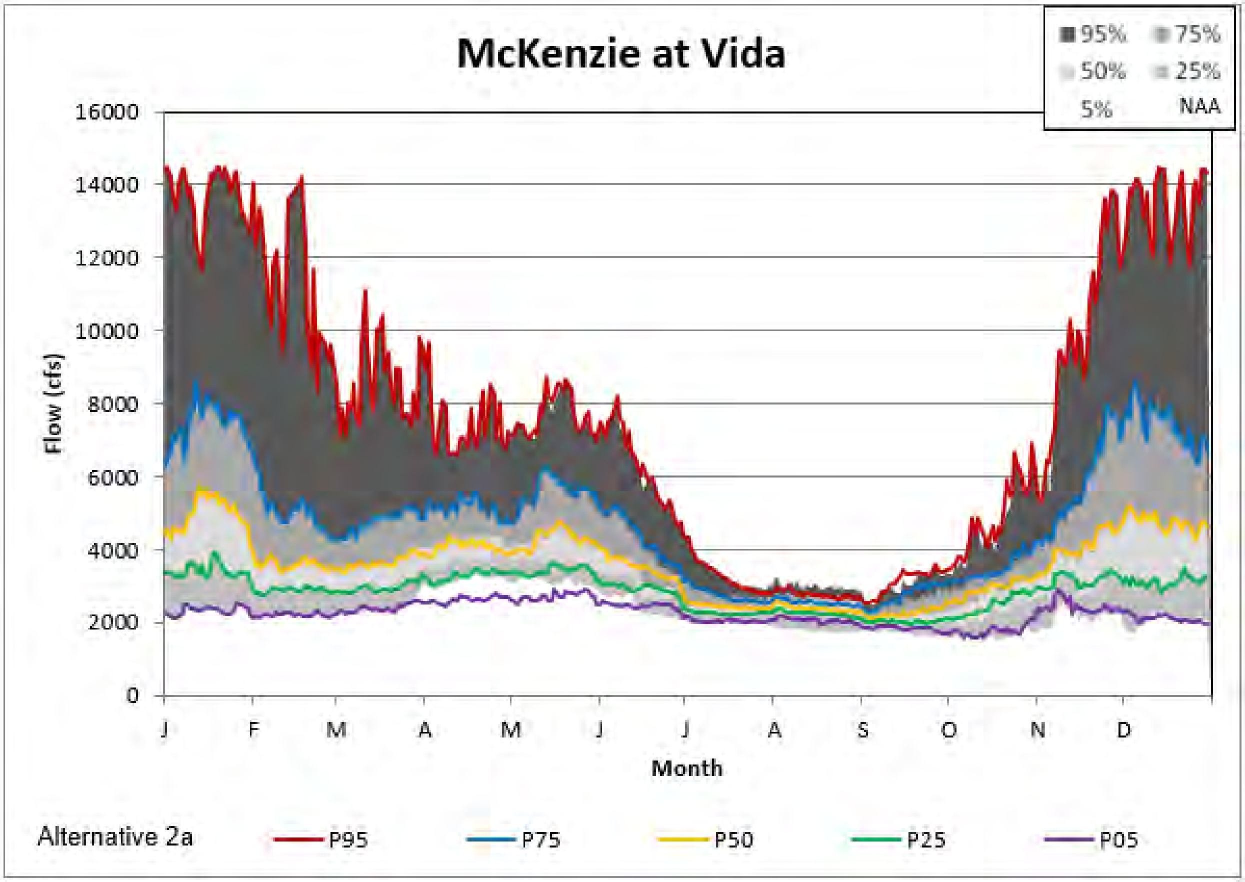


Figure 5-40. Vida Alternative 2a Non-Exceedance Plot

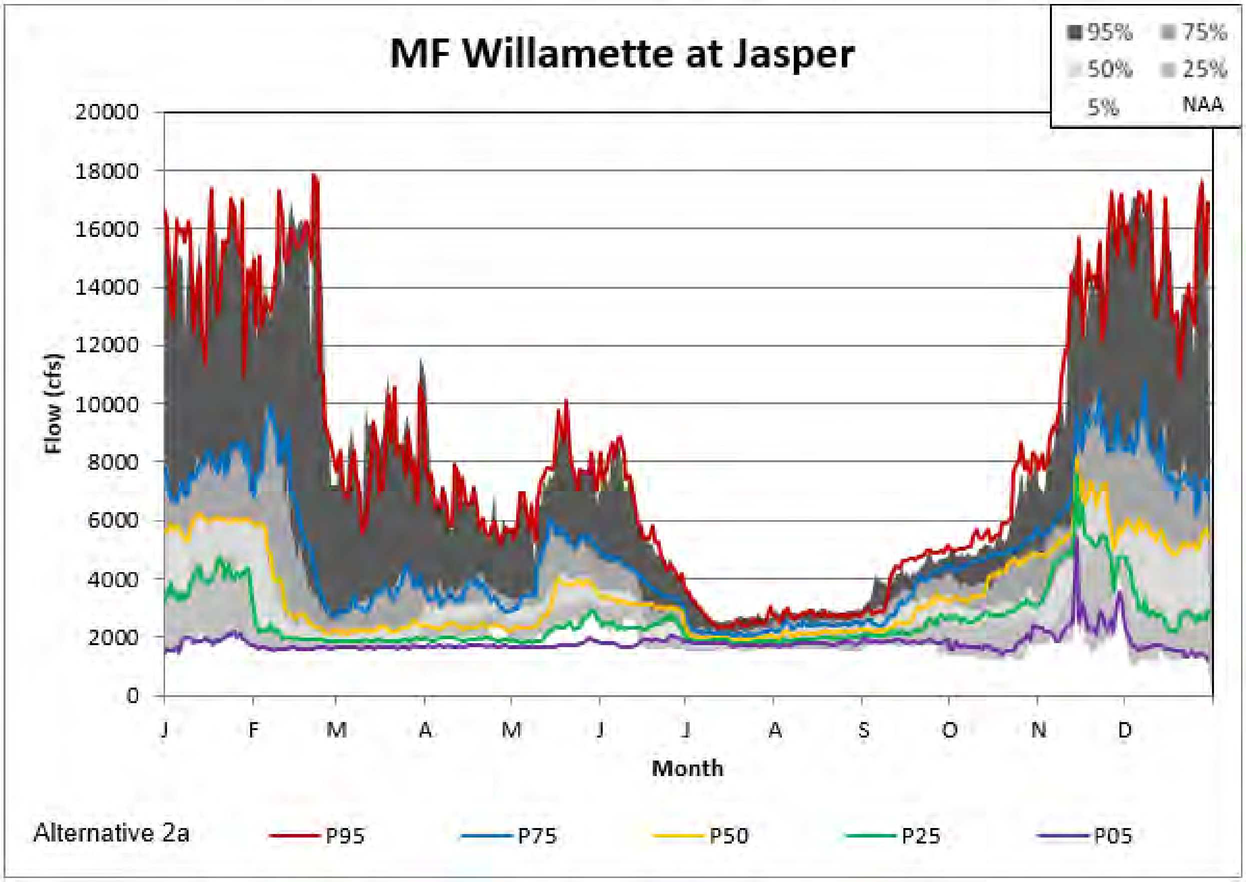


Figure 5-41. Jasper Alternative 2a Non-Exceedance Plot

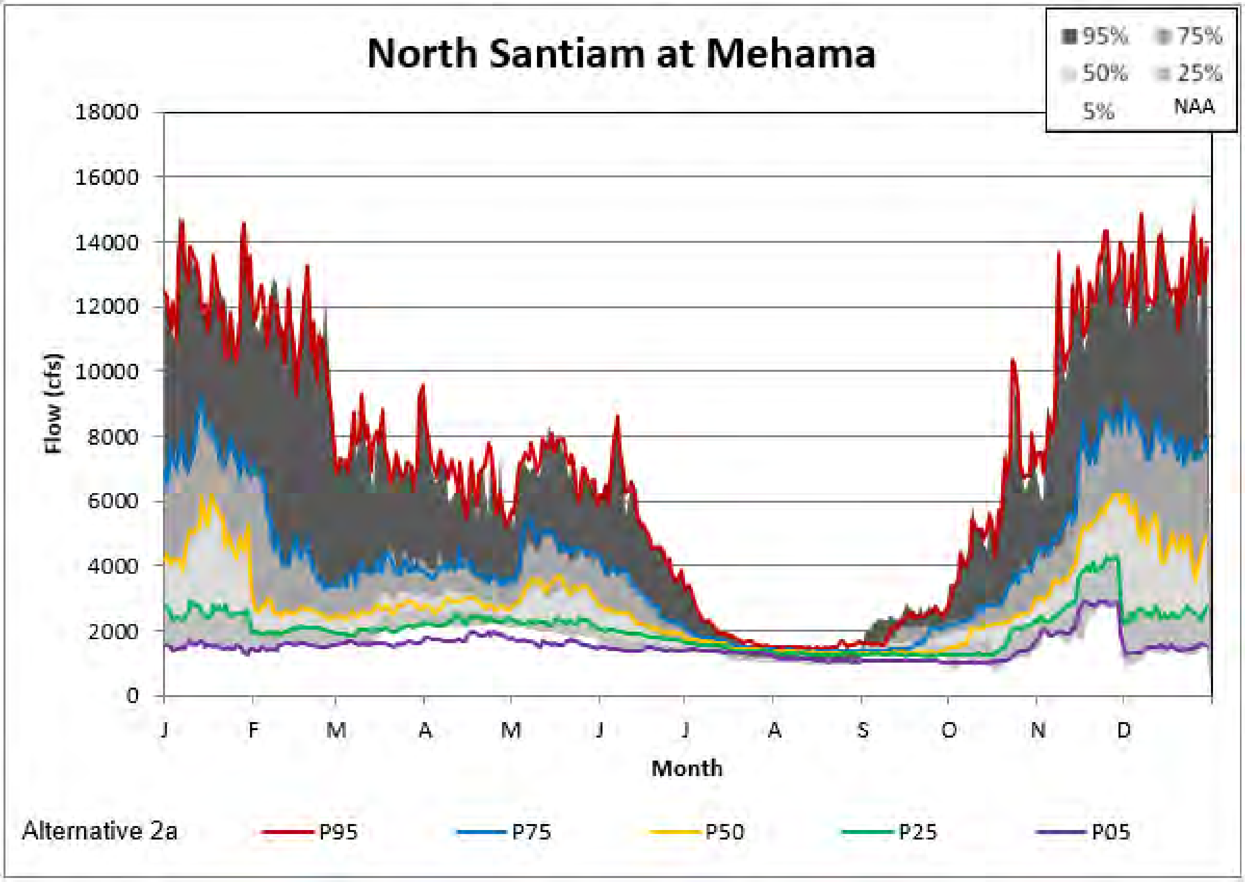


Figure 5-42. Mehama Alternative 2a Non-Exceedance Plot

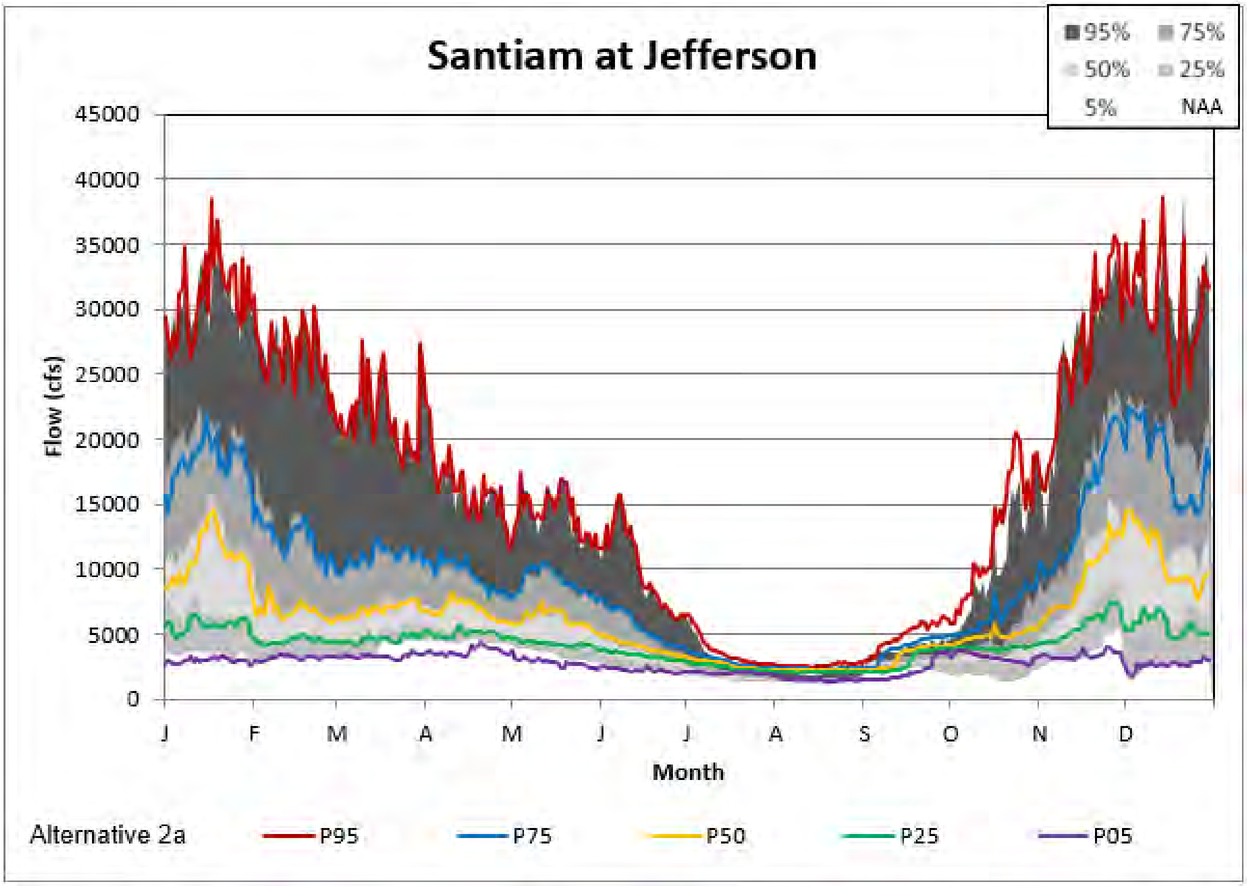


Figure 5-43. Jefferson Alternative 2a Non-Exceedance Plot

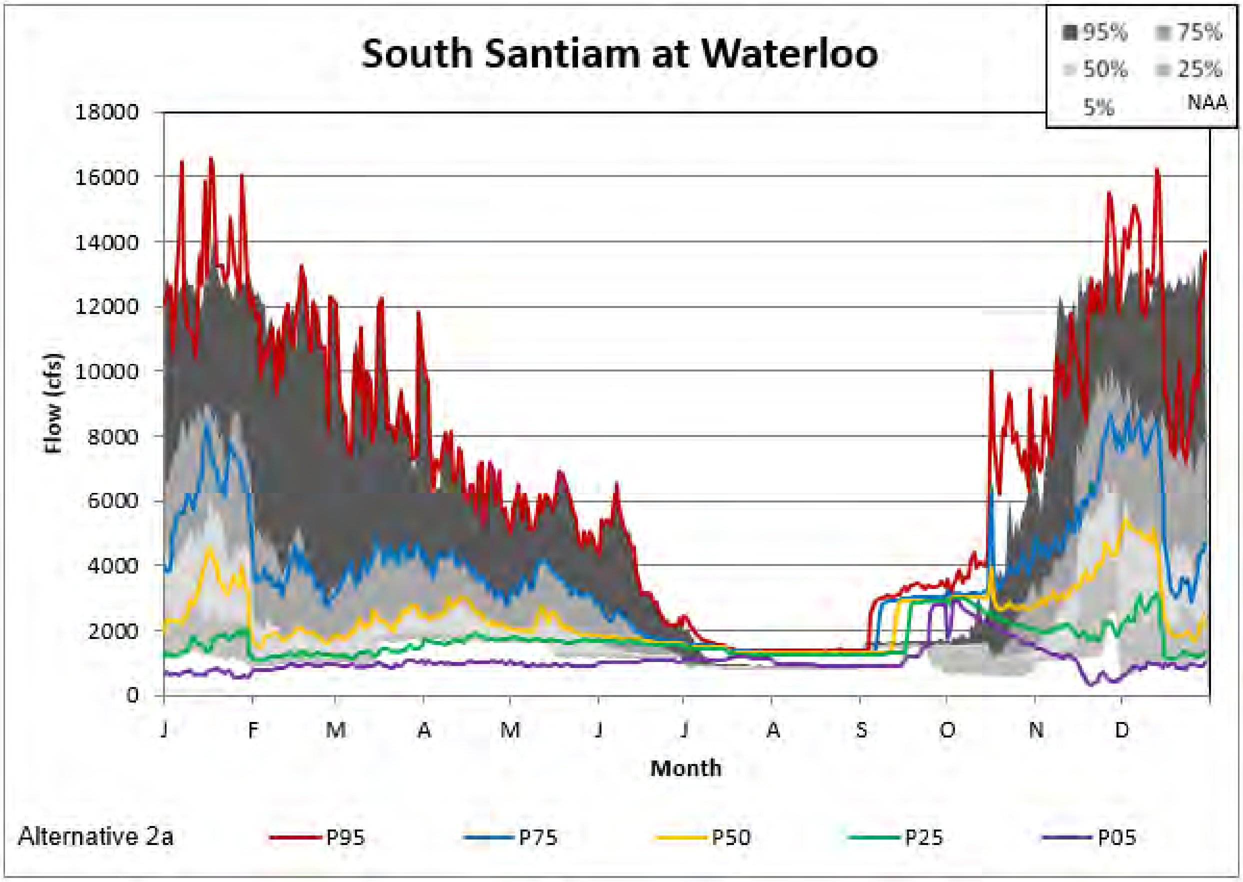


Figure 5-44. Waterloo Alternative 2a Non-Exceedance Plot

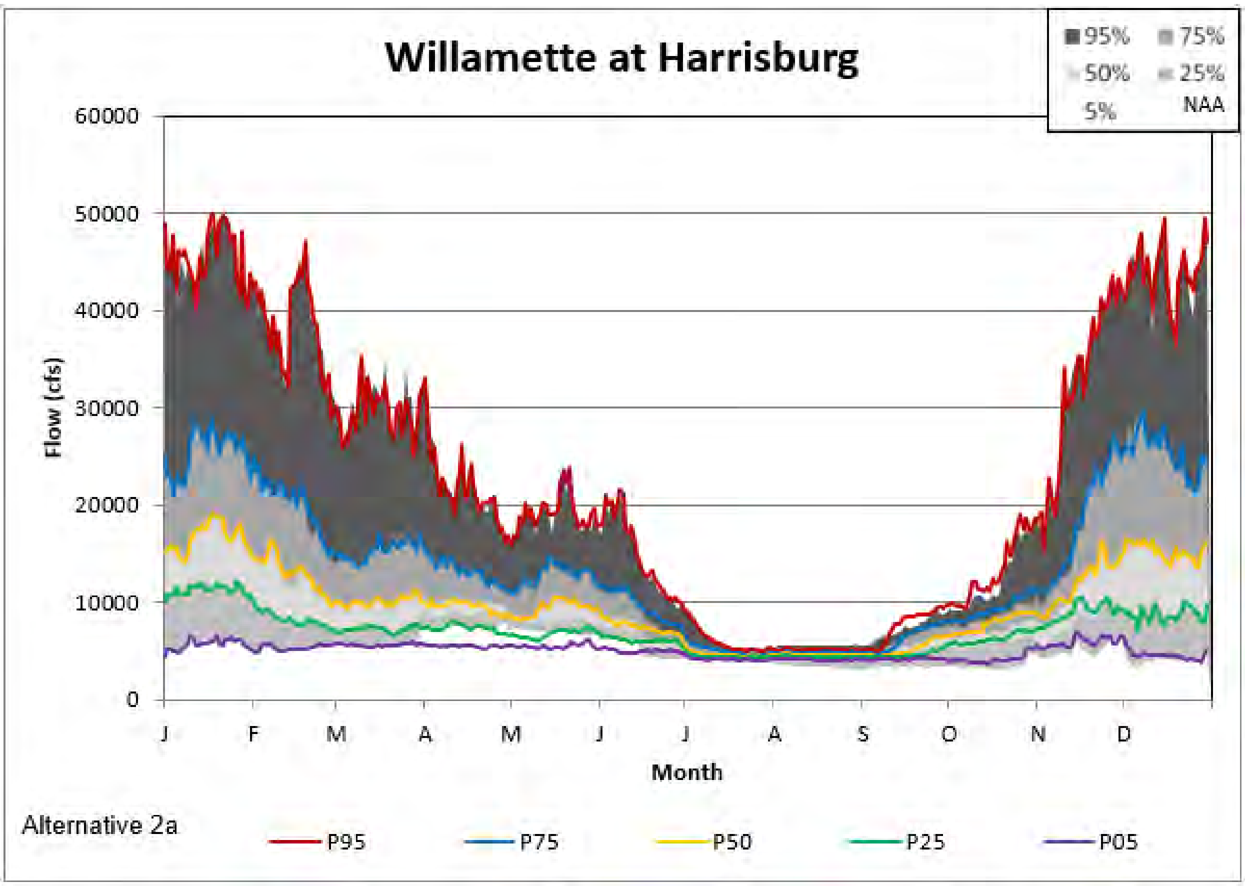


Figure 5-45. Harrisburg Alternative 2a Non-Exceedance Plot

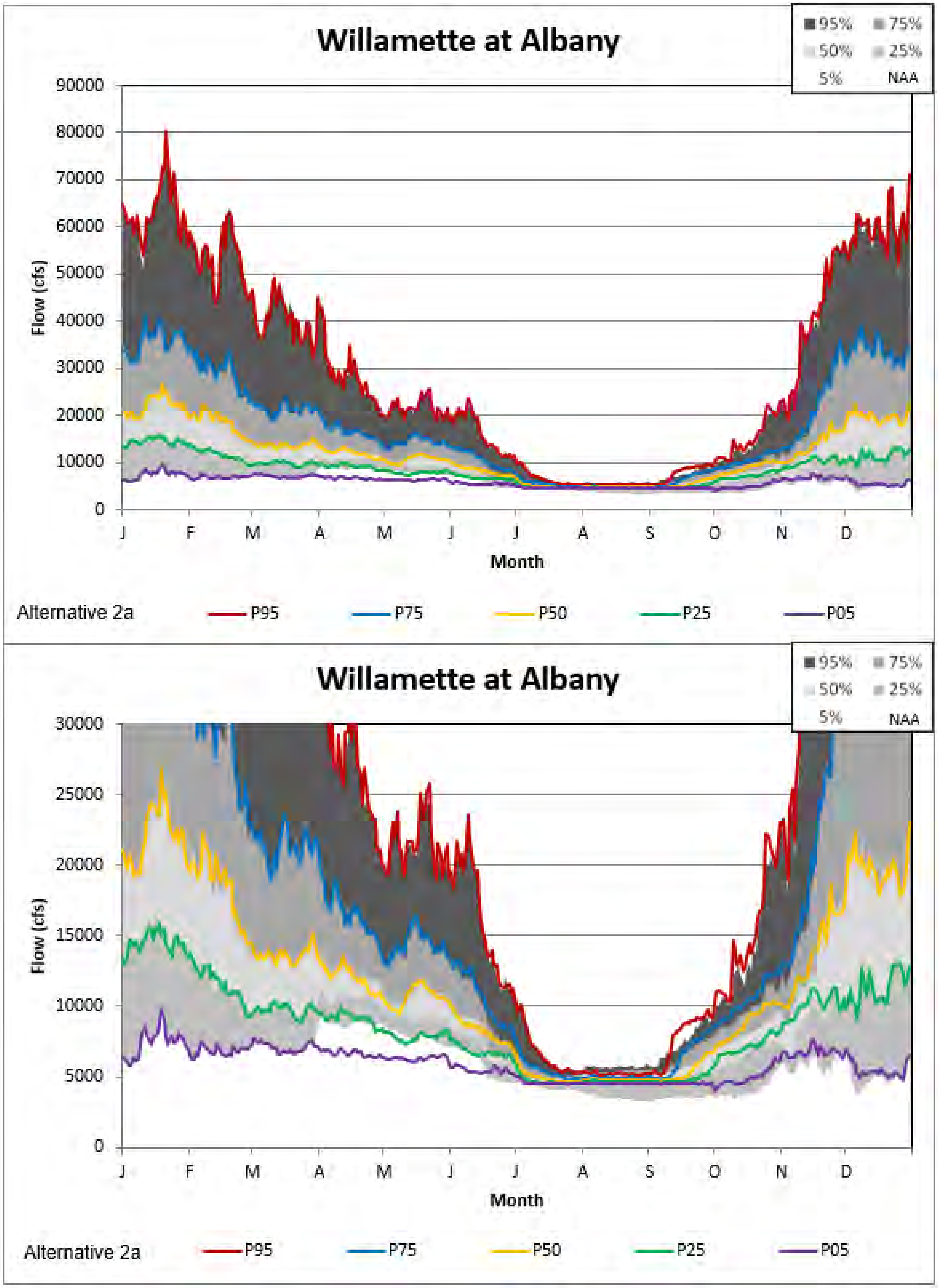


Figure 5-46. Albany Alternative 2a Non-Exceedance Plot

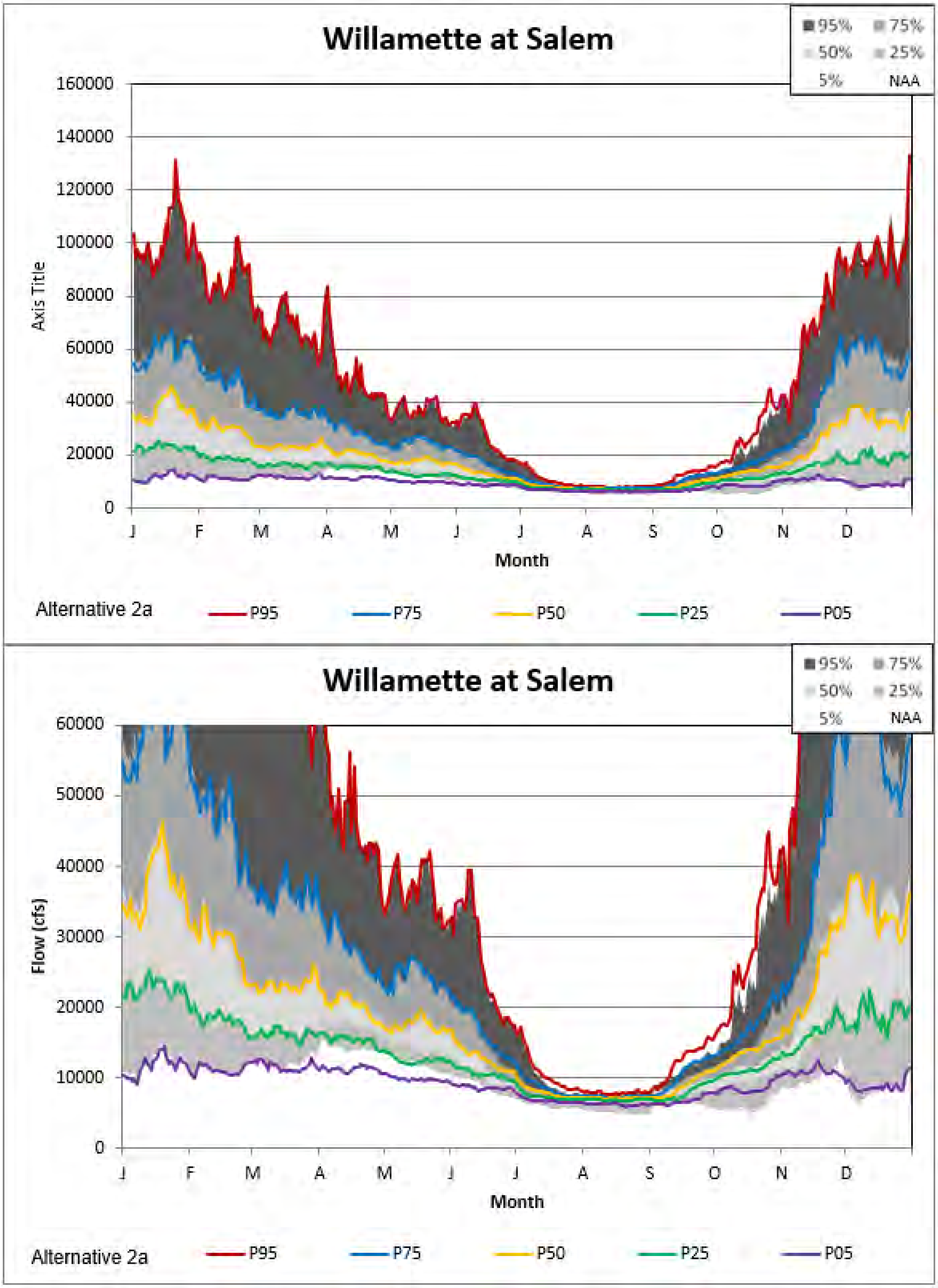


Figure 5-47. Salem Alternative 2a Non-Exceedance Plot

5.3 ALTERNATIVE 2B

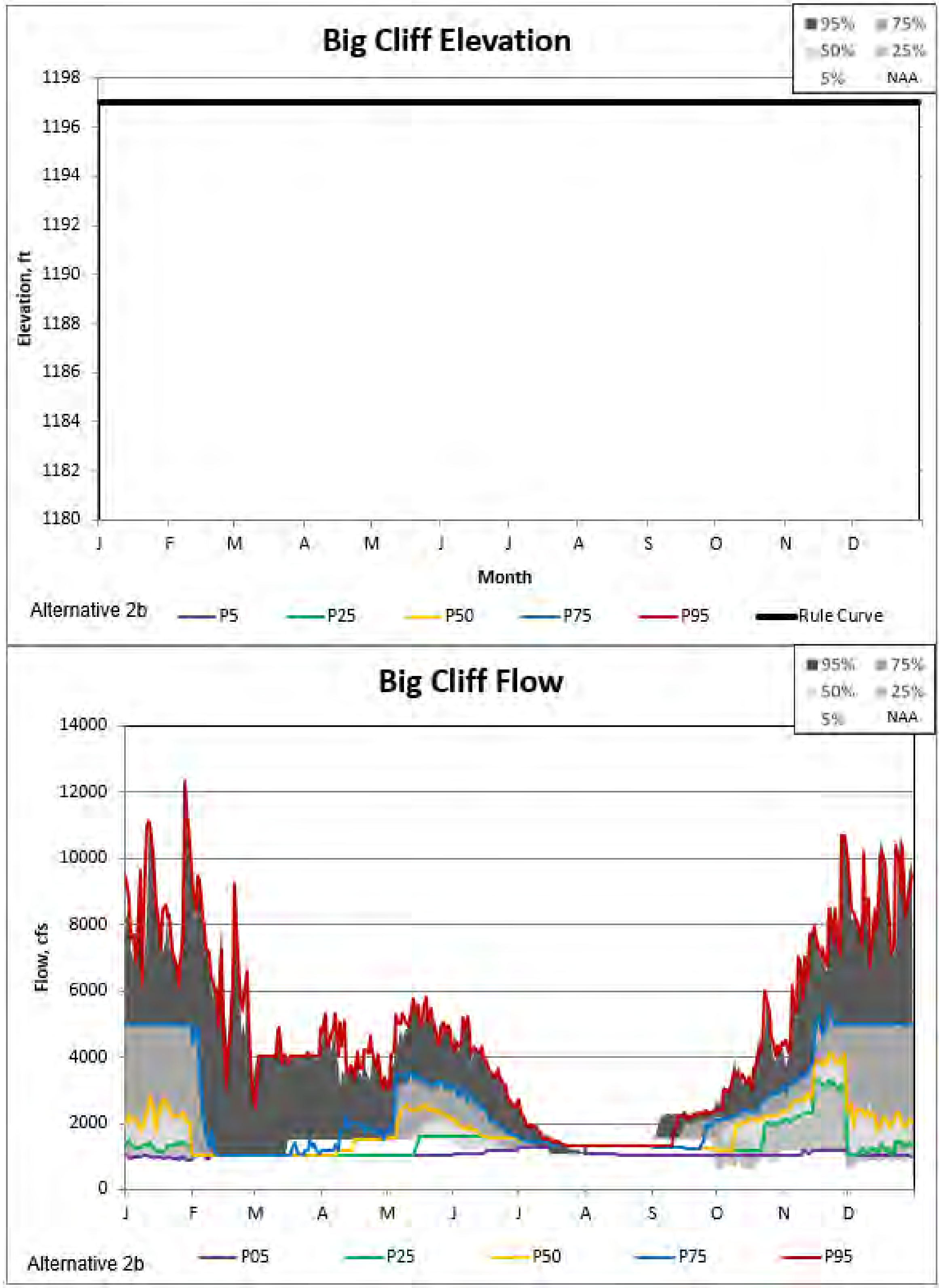


Figure 5-48. Big Cliff Alternative 2b Non-Exceedance Plot

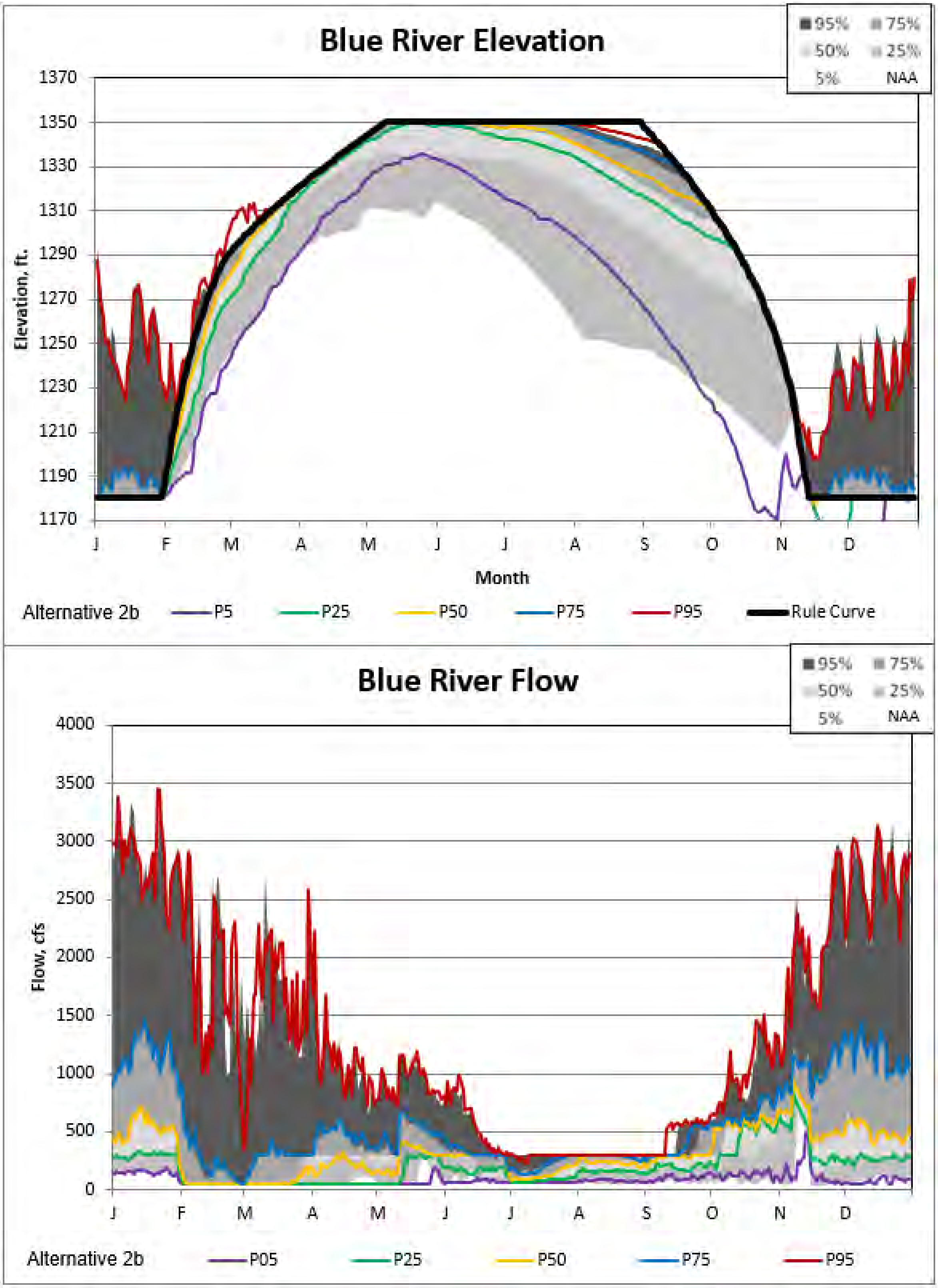


Figure 5-49. Blue River Alternative 2b Non-Exceedance Plot

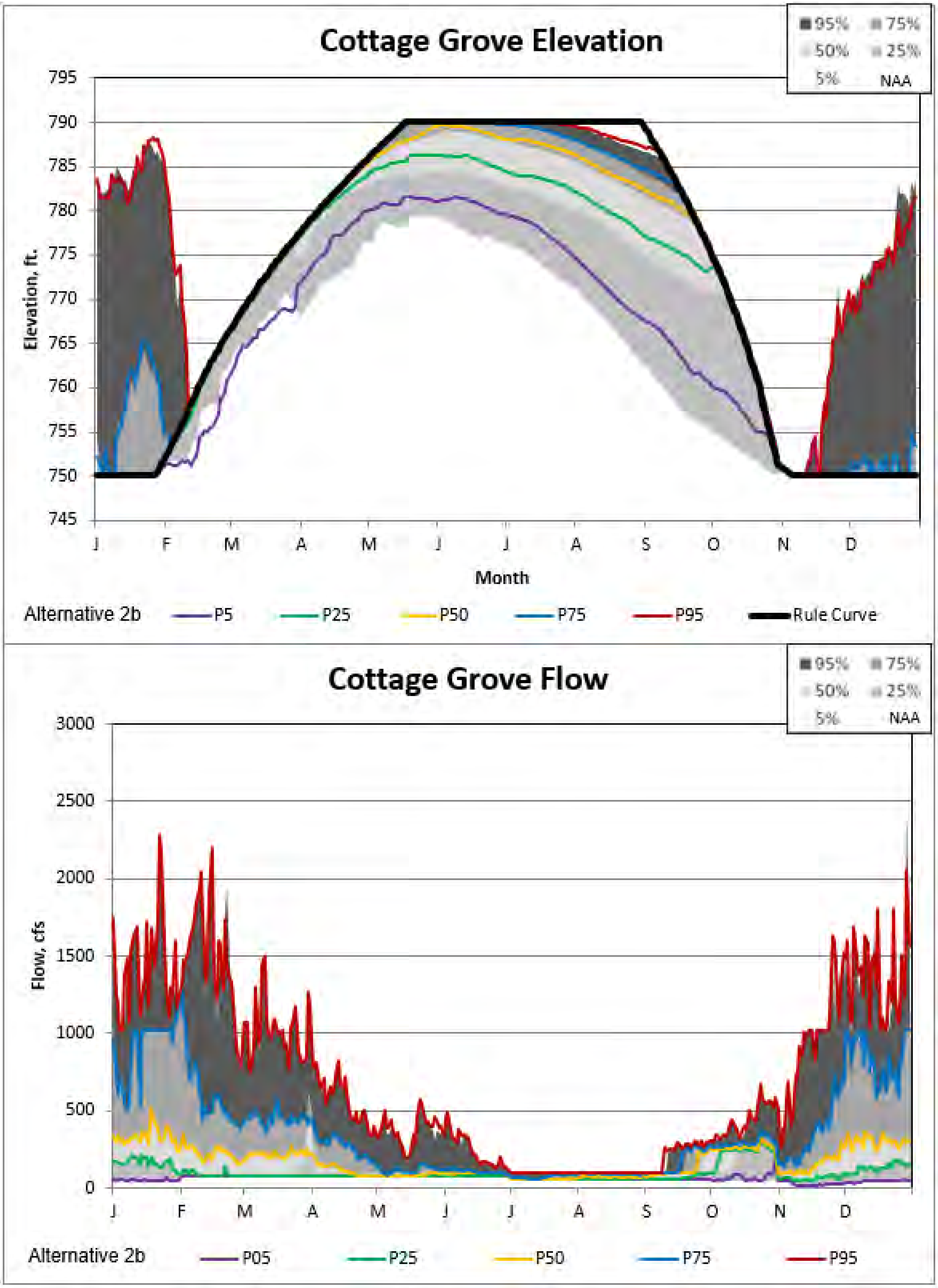


Figure 5-50. Cottage Grove Alternative 2b Non-Exceedance Plot

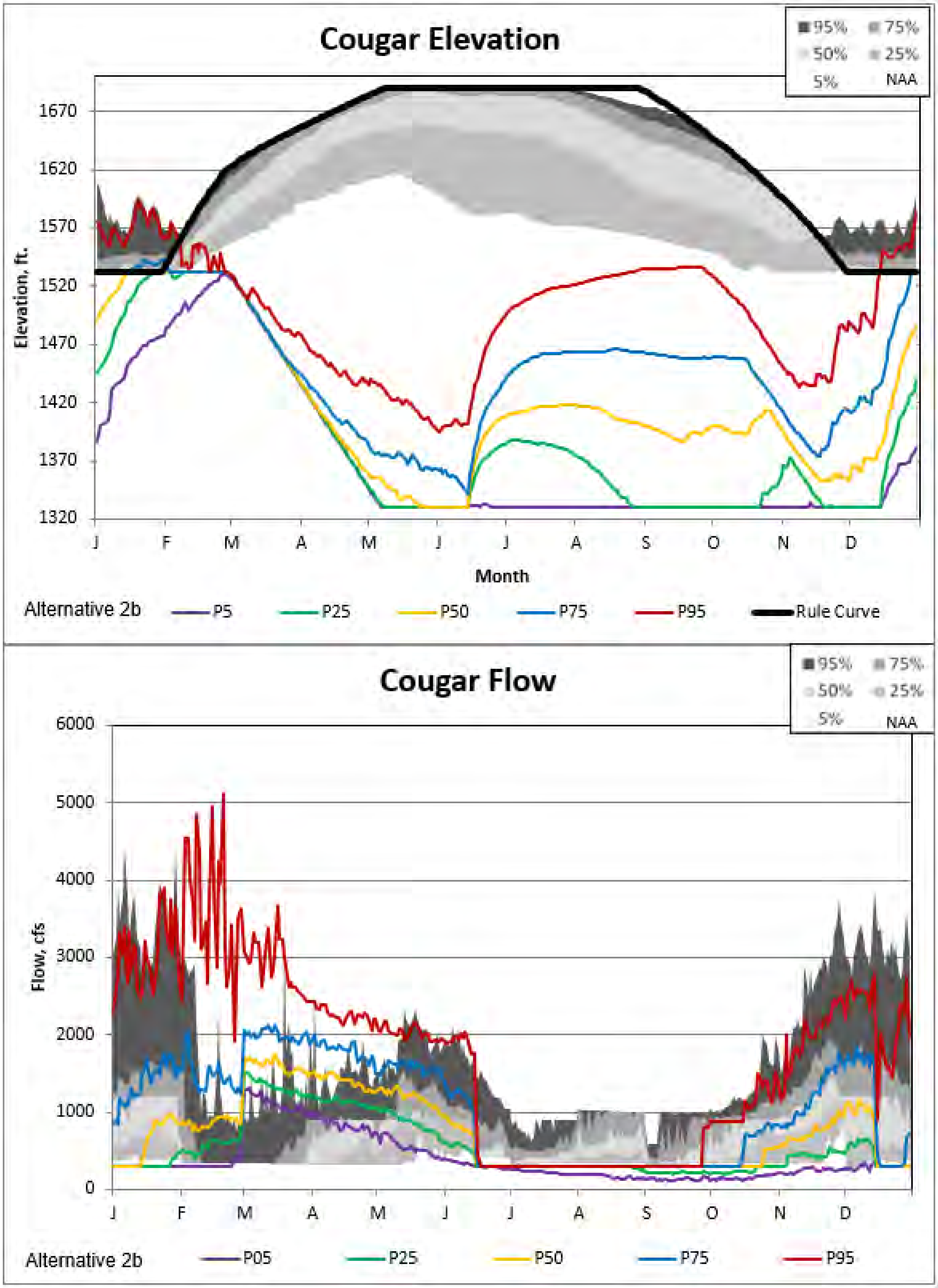


Figure 5-51. Cougar Alternative 2b Non-Exceedance Plot

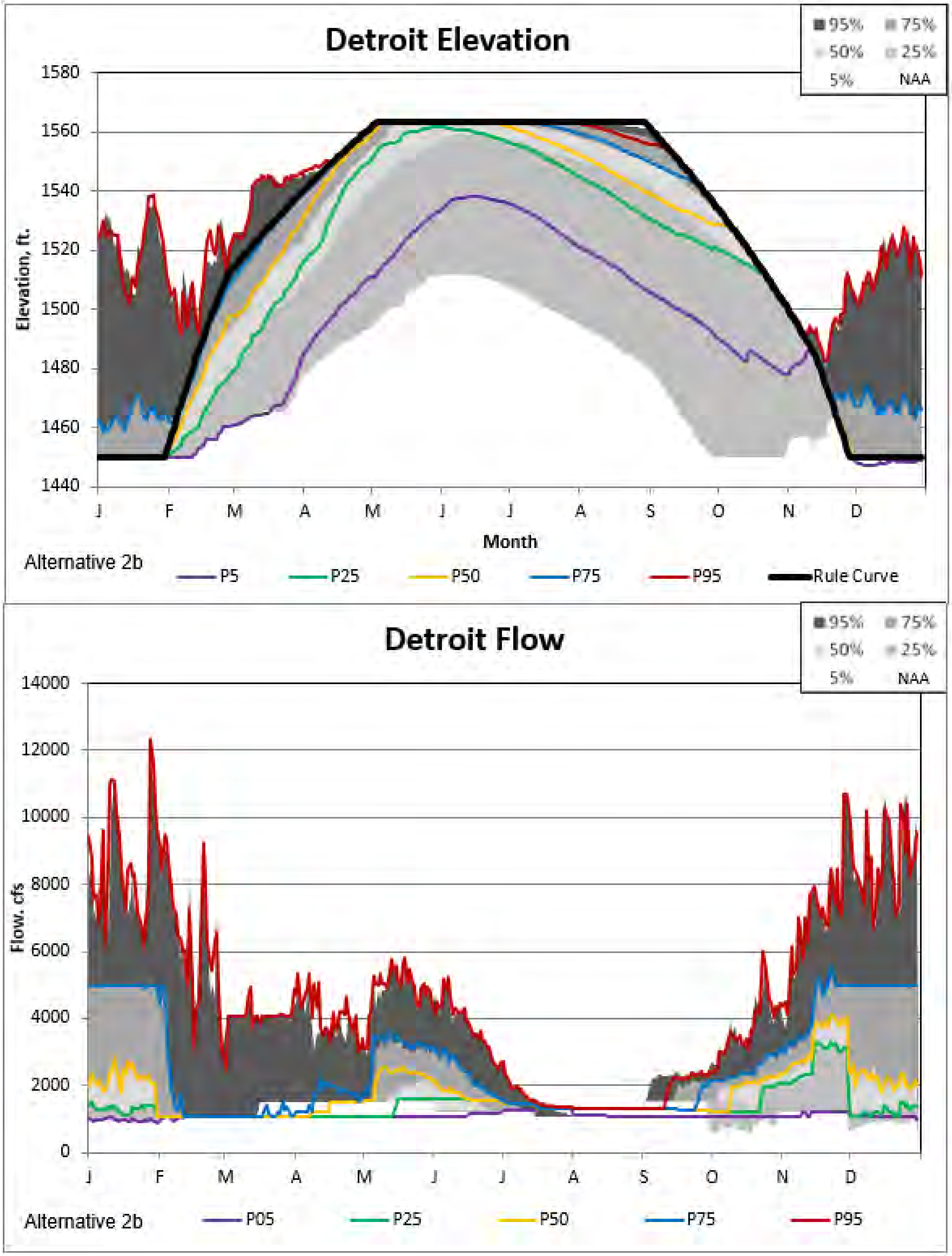


Figure 5-52. Detroit Alternative 2b Non-Exceedance Plot

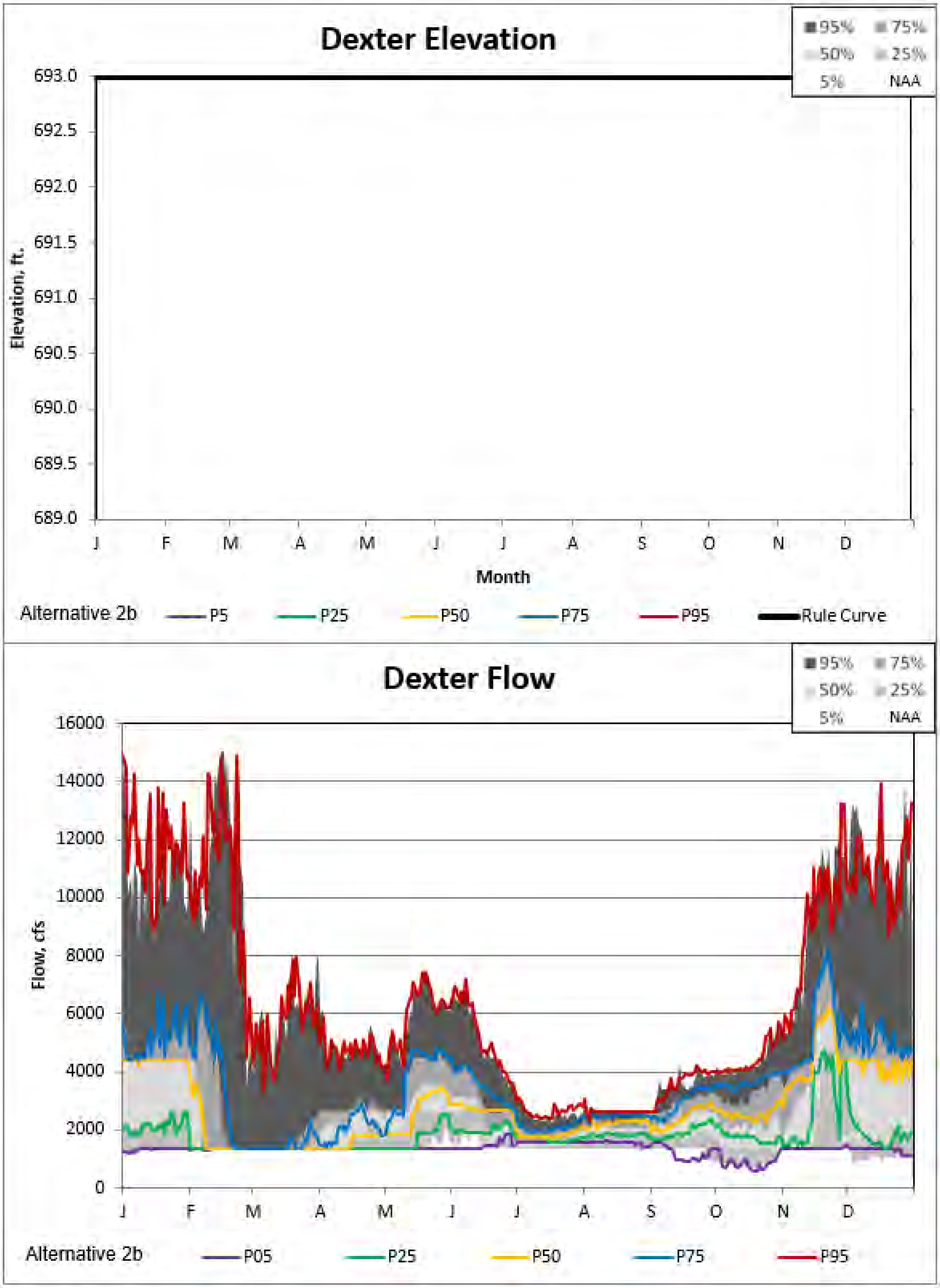


Figure 5-53. Dexter Alternative 2b Non-Exceedance Plot

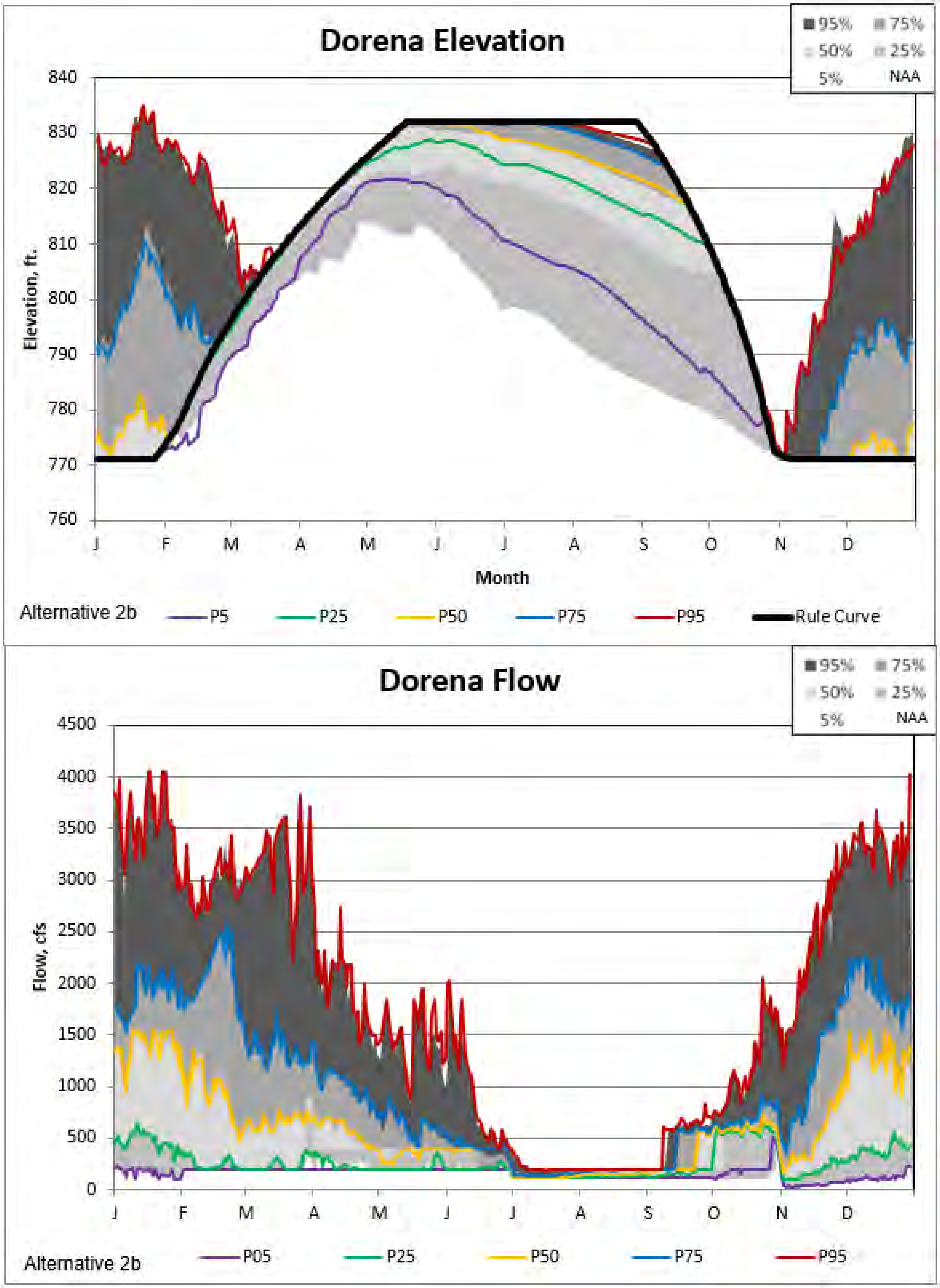


Figure 5-54. Dorena Alternative 2b Non-Exceedance Plot

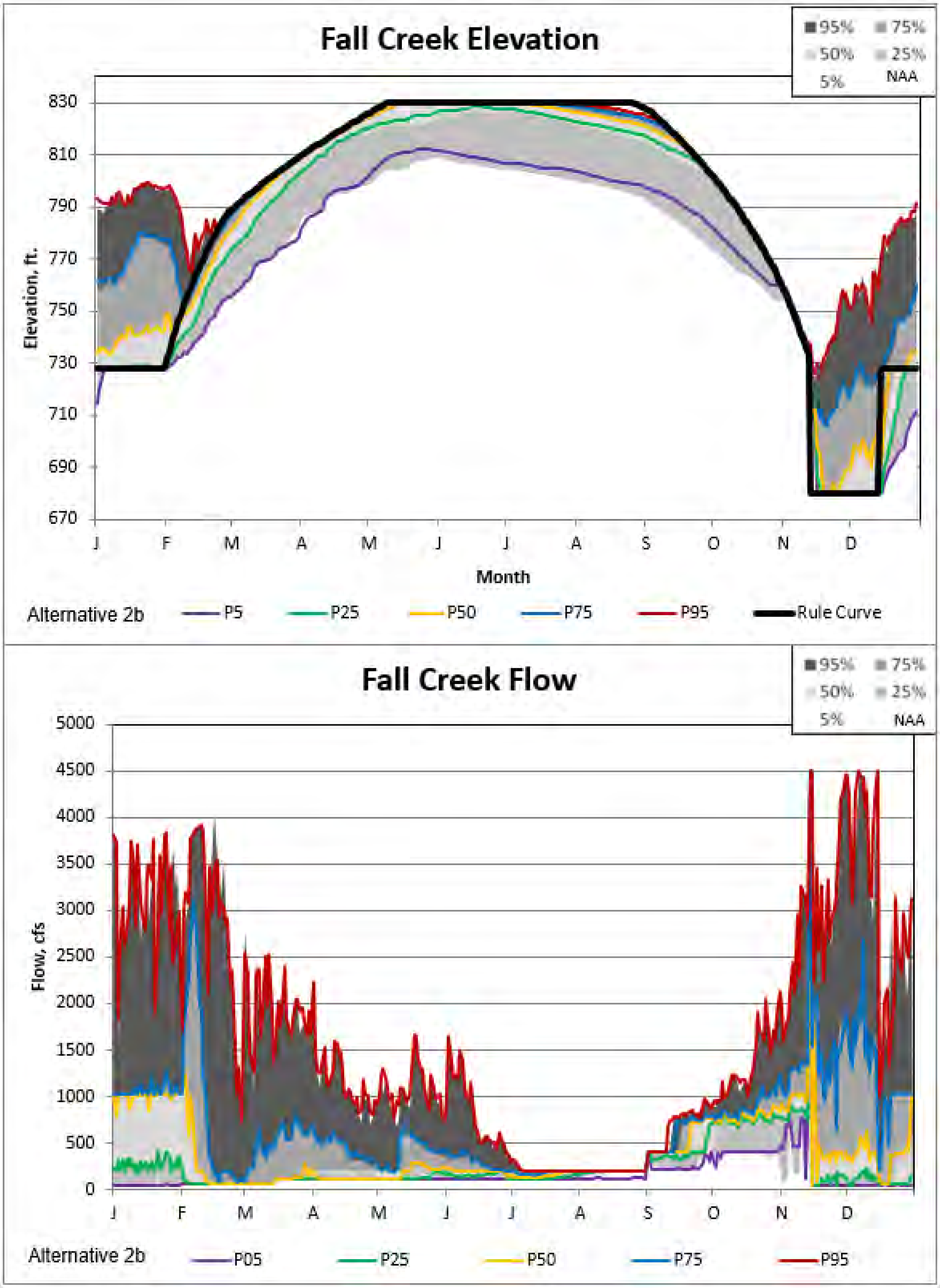


Figure 5-55. Fall Creek Alternative 2b Non-Exceedance Plot

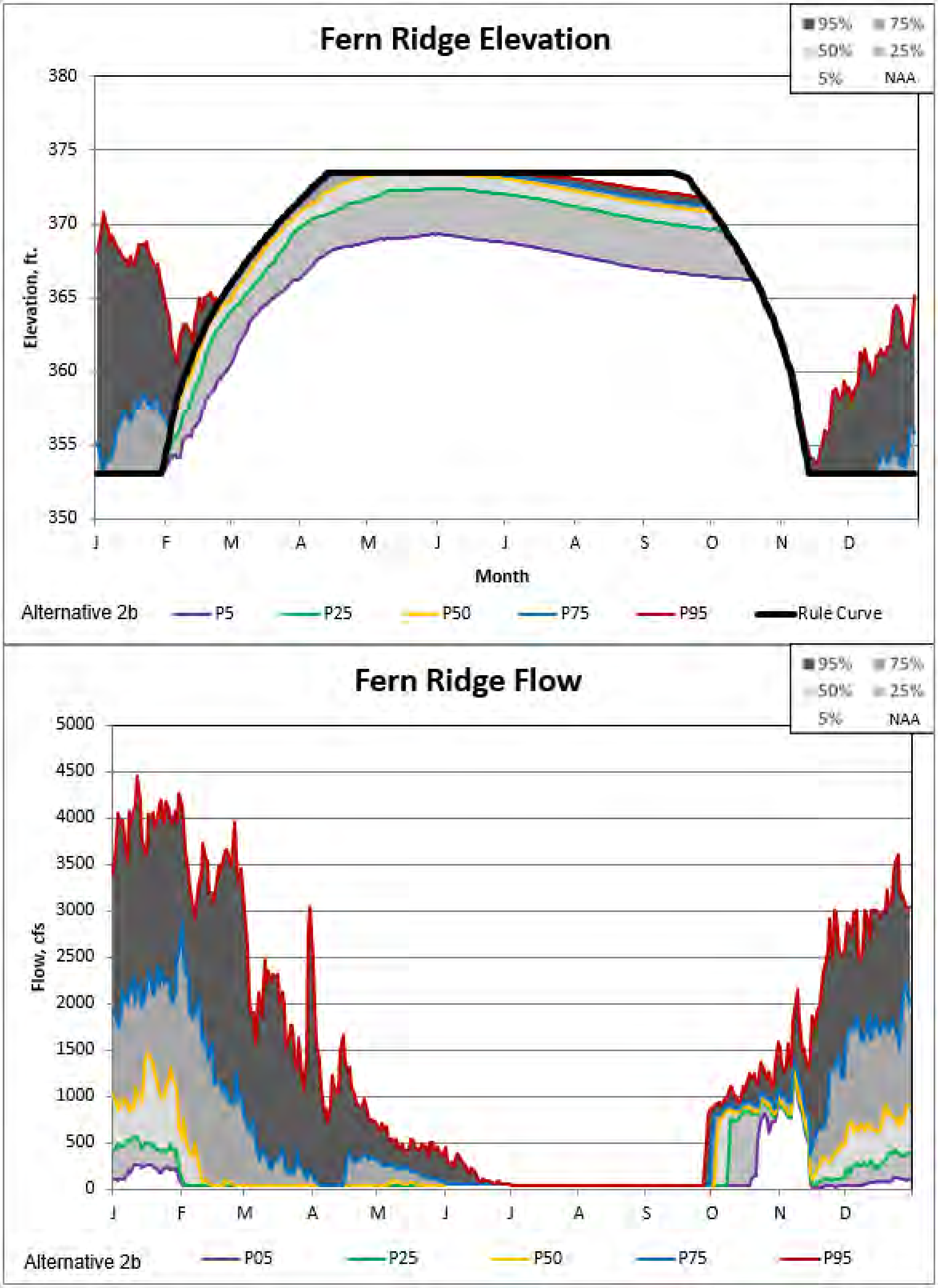


Figure 5-56. Fern Ridge Alternative 2b Non-Exceedance Plot

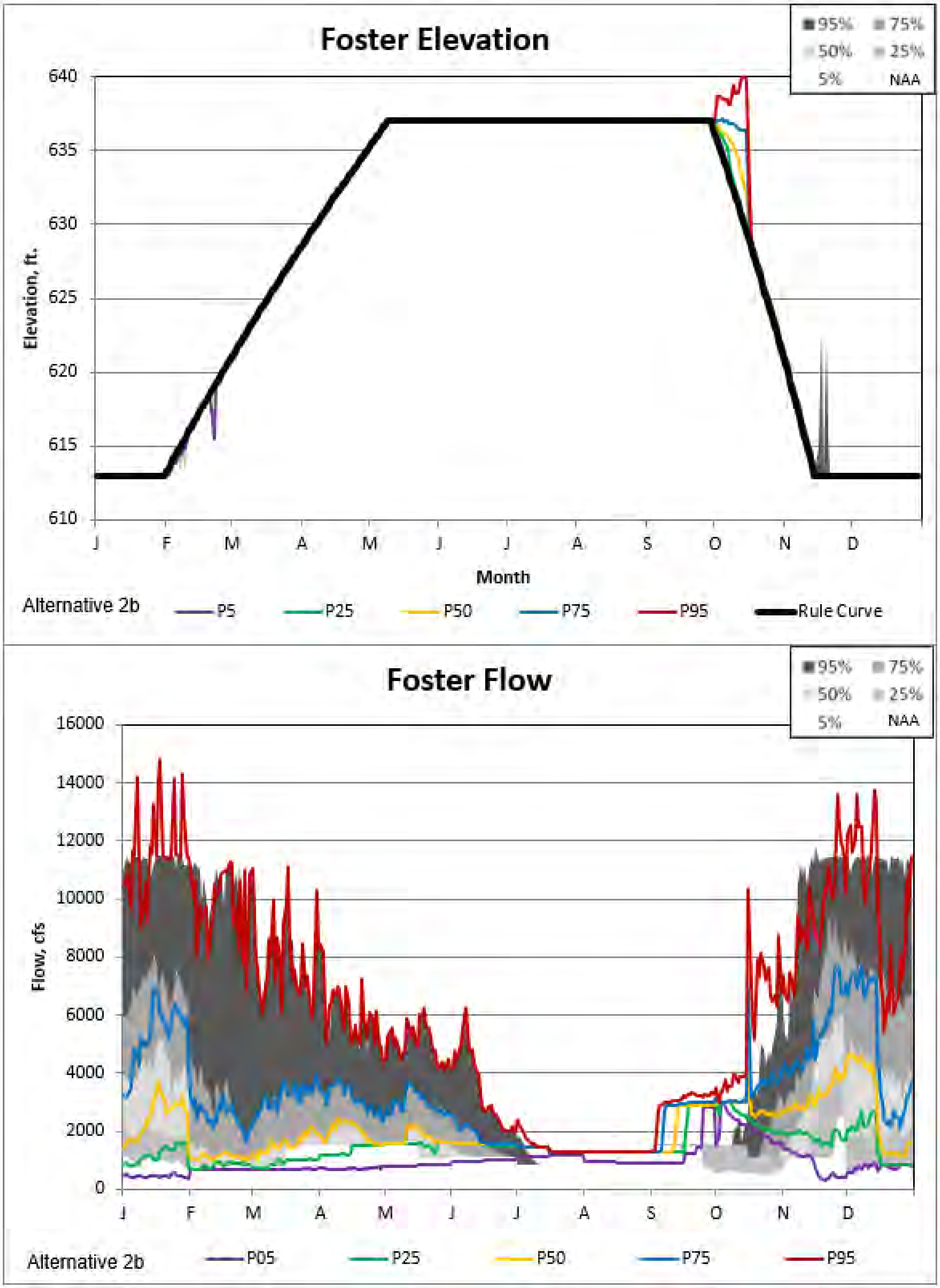


Figure 5-57. Foster Alternative 2b Non-Exceedance Plot

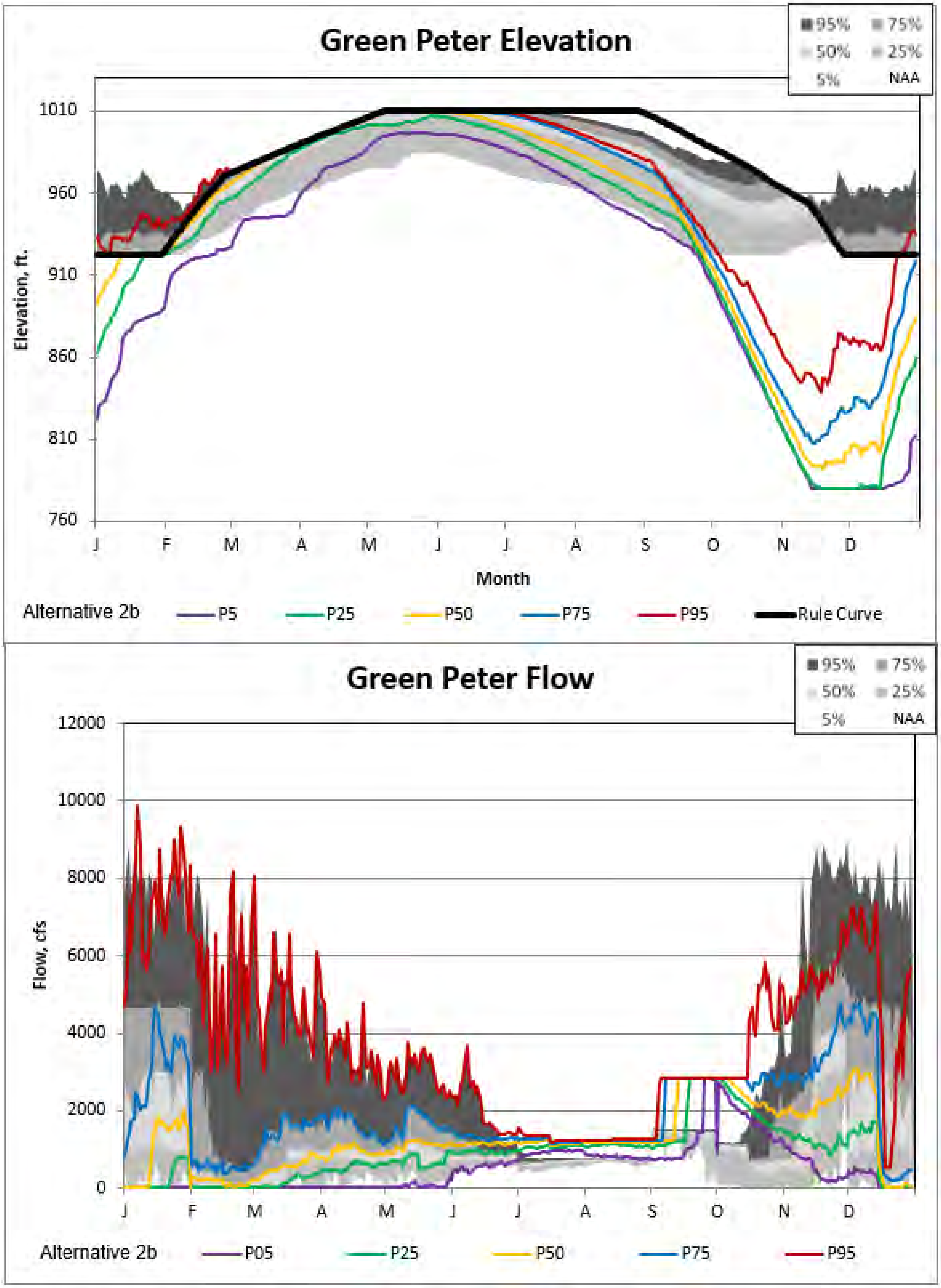


Figure 5-58. Green Peter Alternative 2b Non-Exceedance Plot

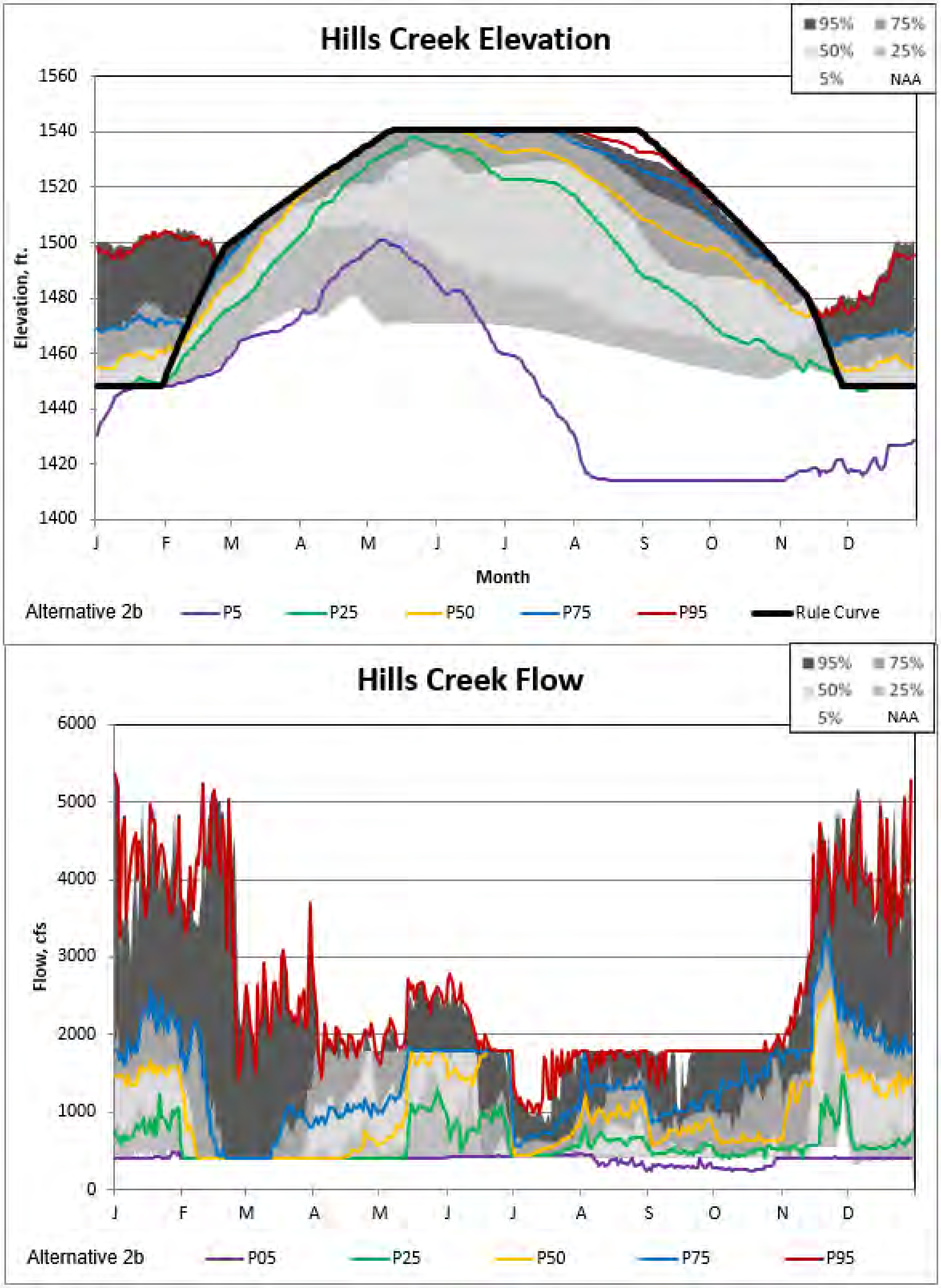
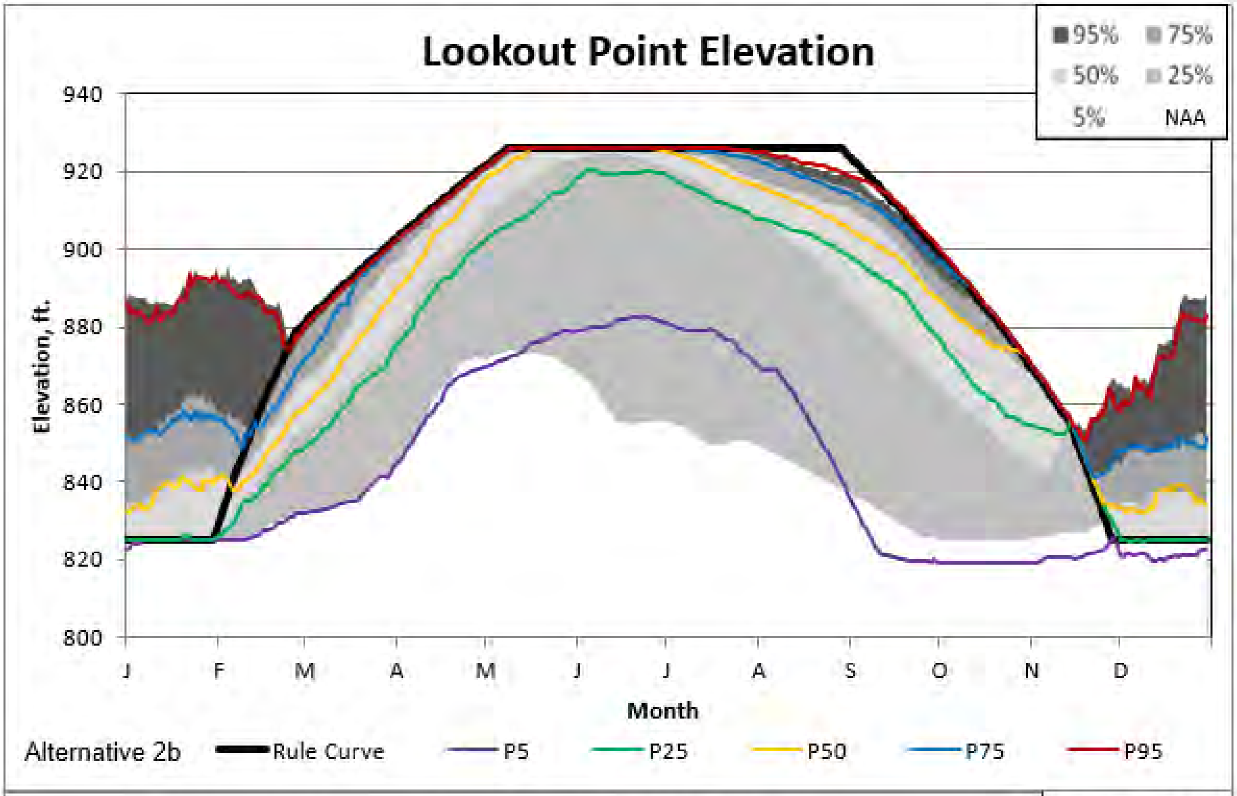


Figure 5-59. Hills Creek Alternative 2b Non-Exceedance Plot



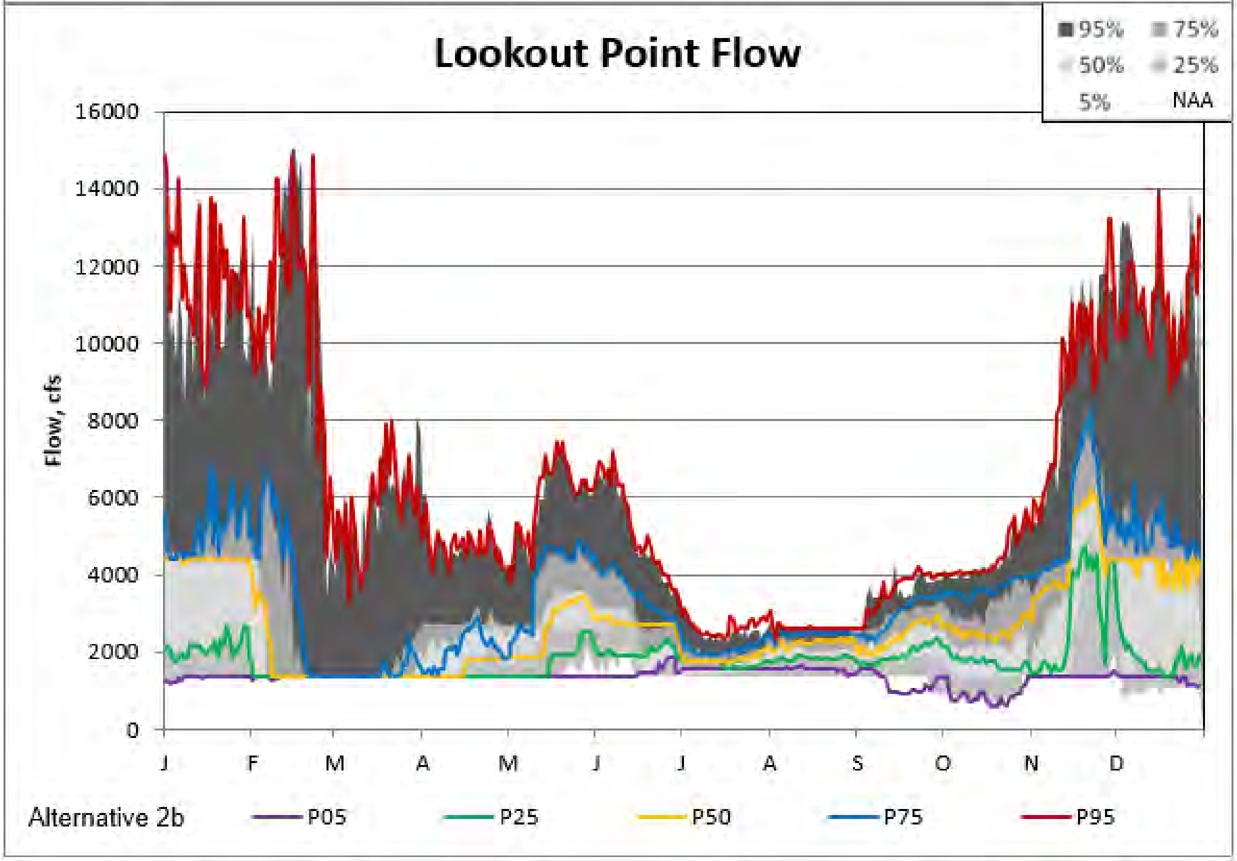


Figure 5-60. Lookout Point Alternative 2b Non-Exceedance Plot

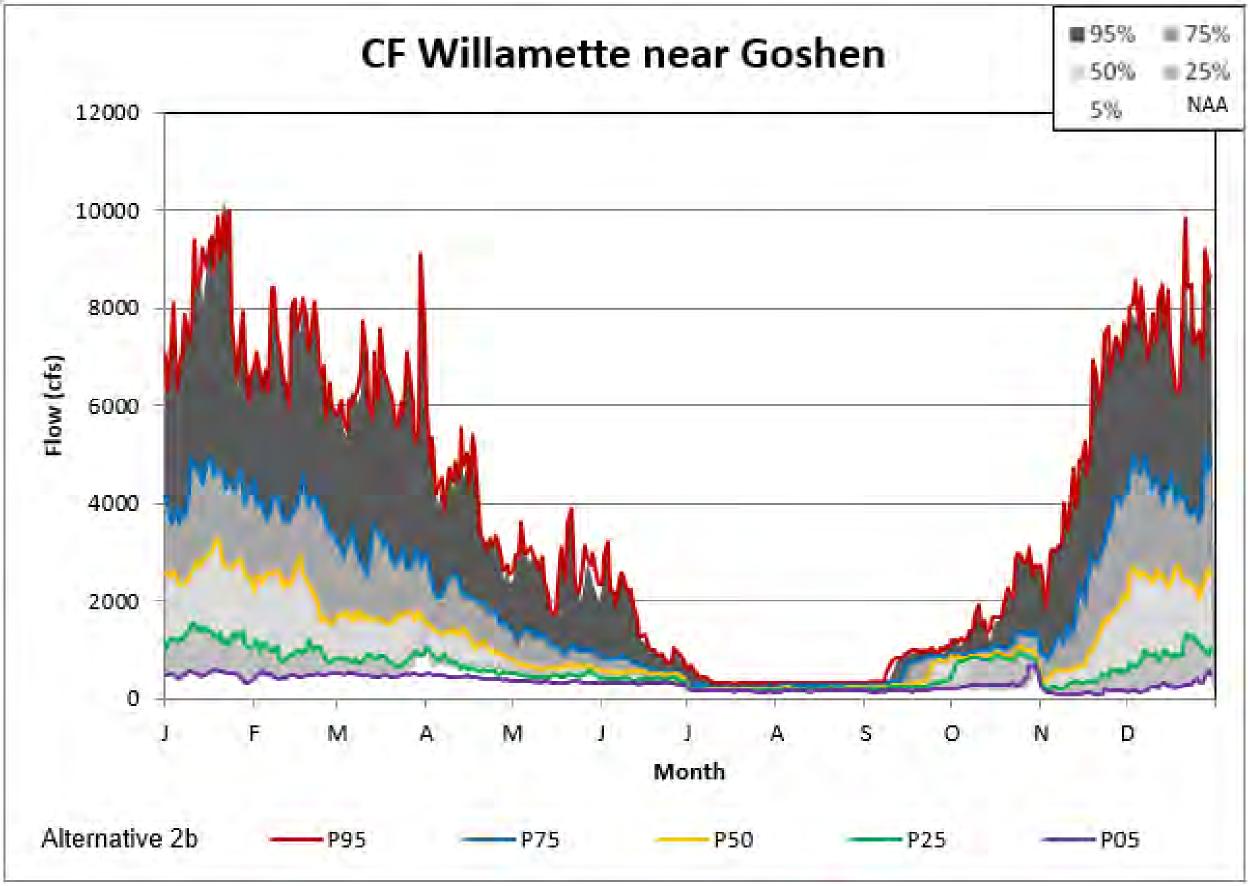


Figure 5-61. Goshen Alternative 2b Non-Exceedance Plot

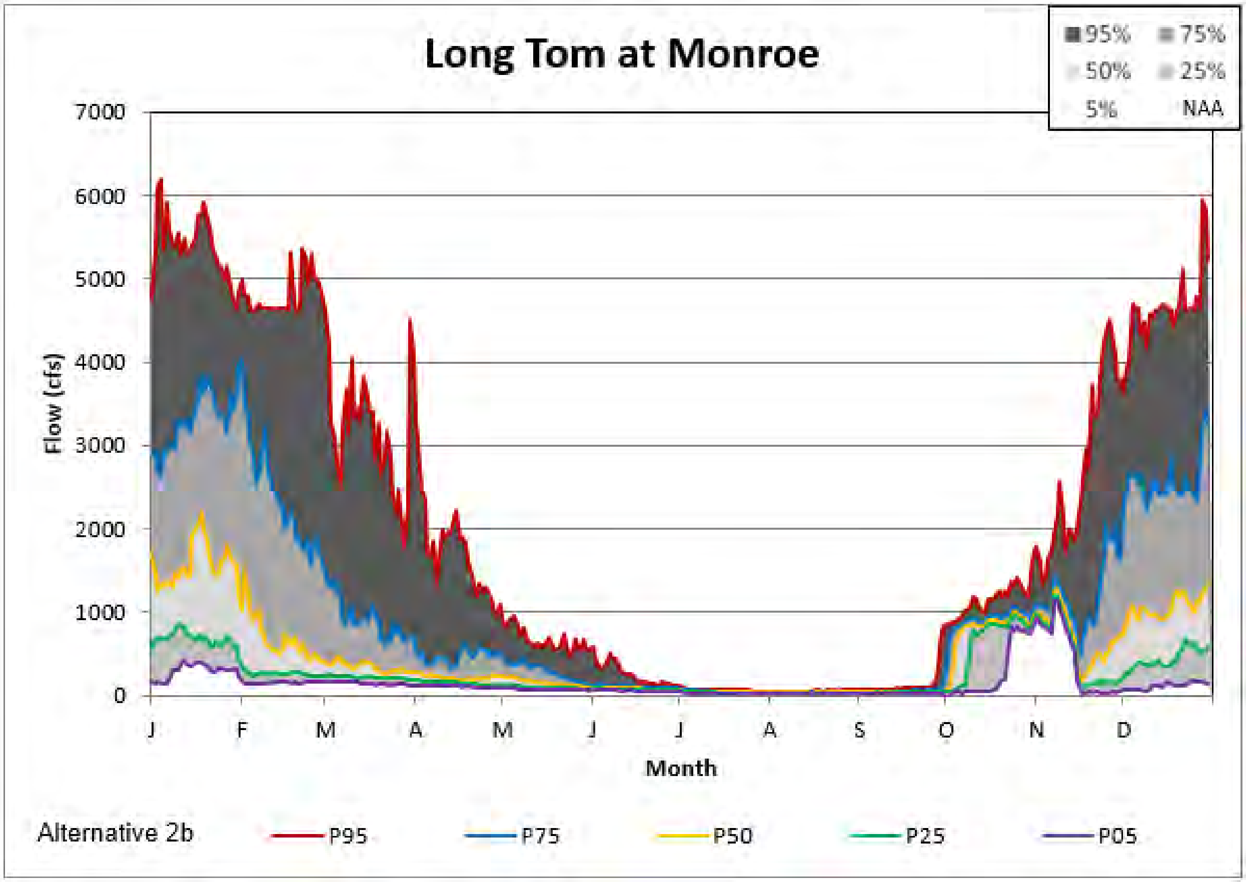


Figure 5-62. Monroe Alternative 2b Non-Exceedance Plot

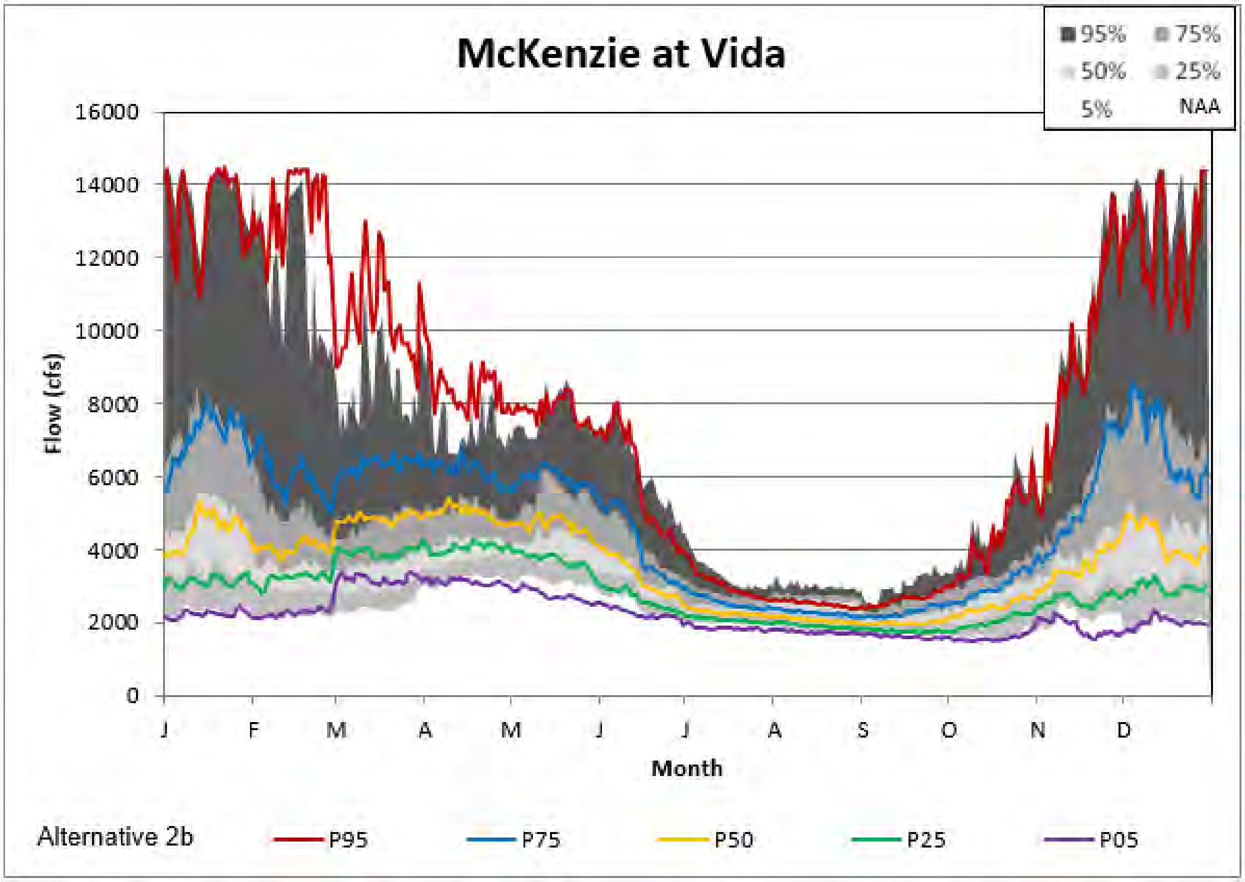


Figure 5-63. Vida Alternative 2b Non-Exceedance Plot

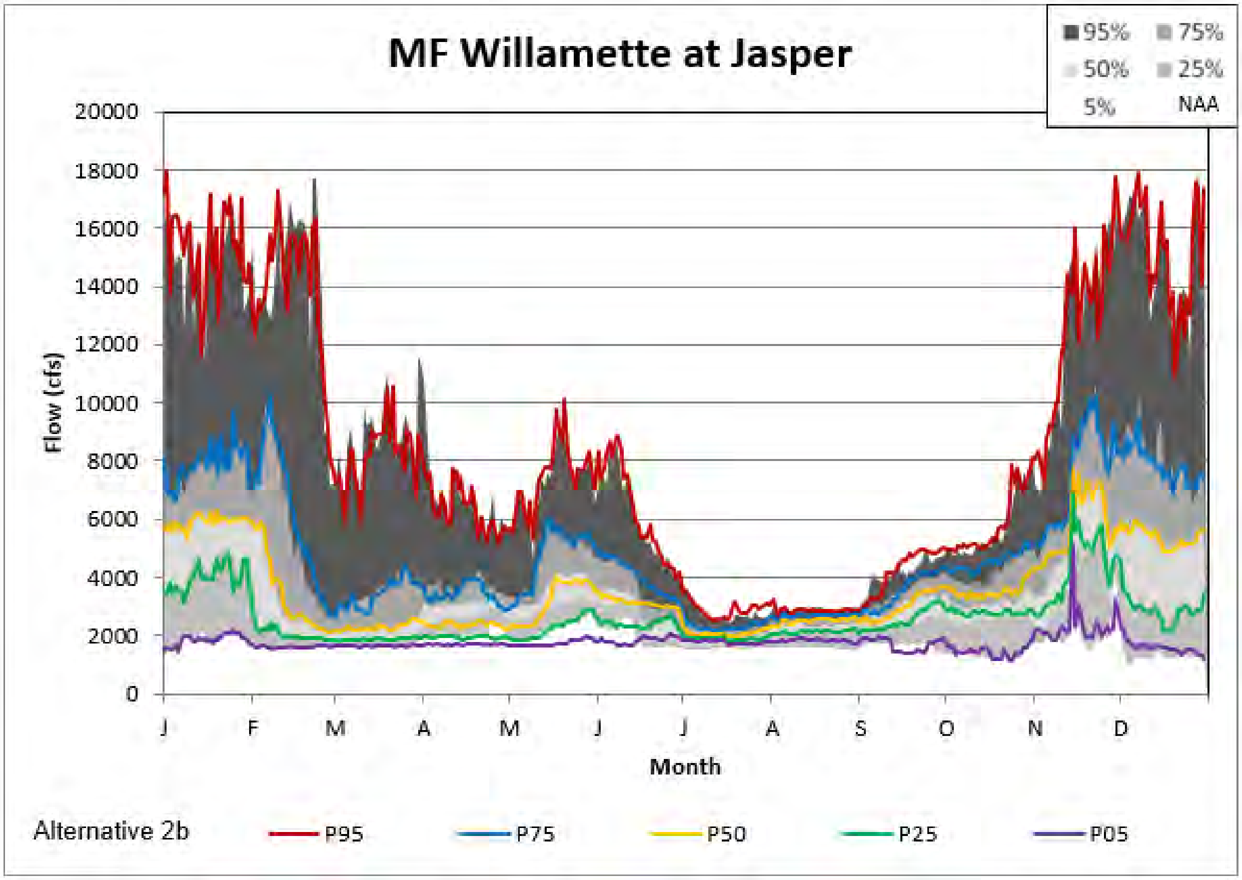


Figure 5-64. Jasper Alternative 2b Non-Exceedance Plot

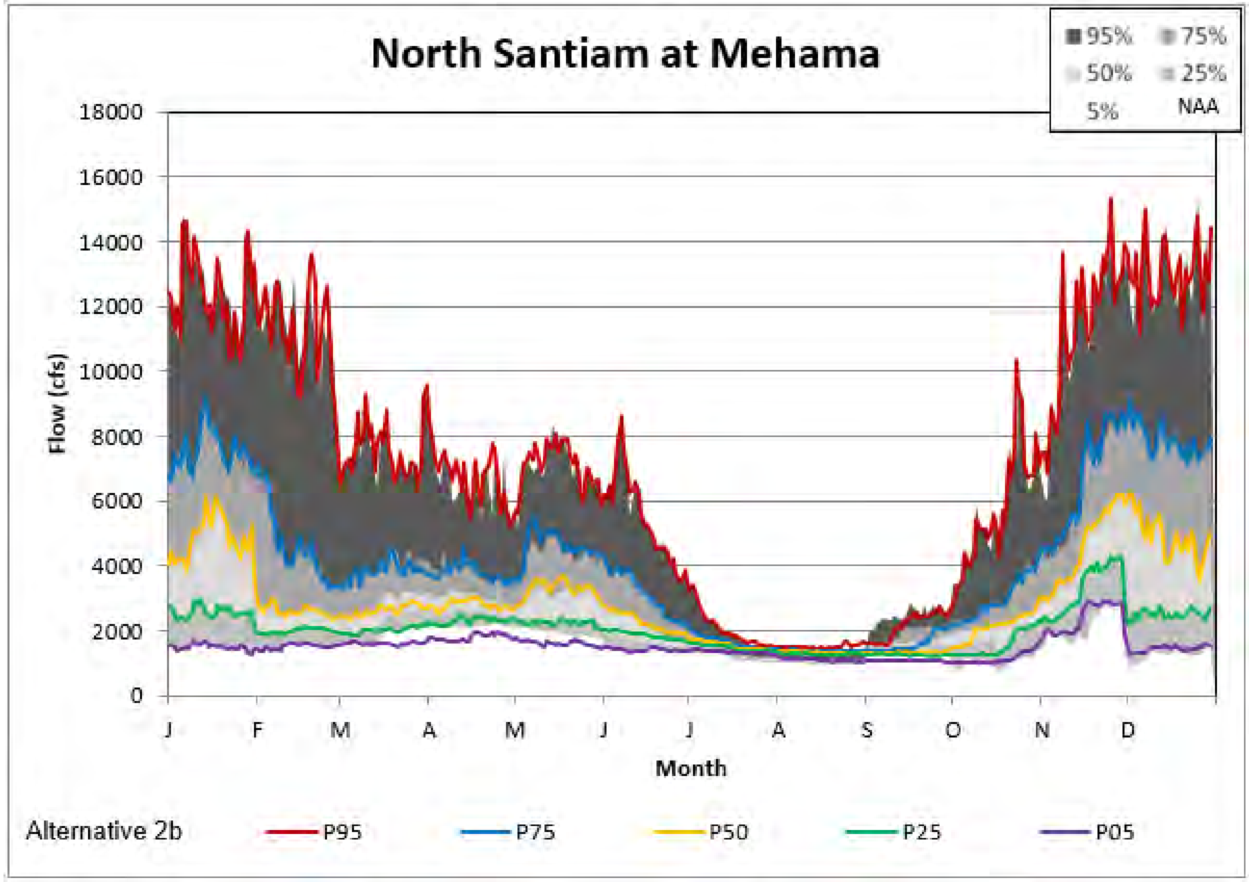


Figure 5-65. Mehama Alternative 2b Non-Exceedance Plot

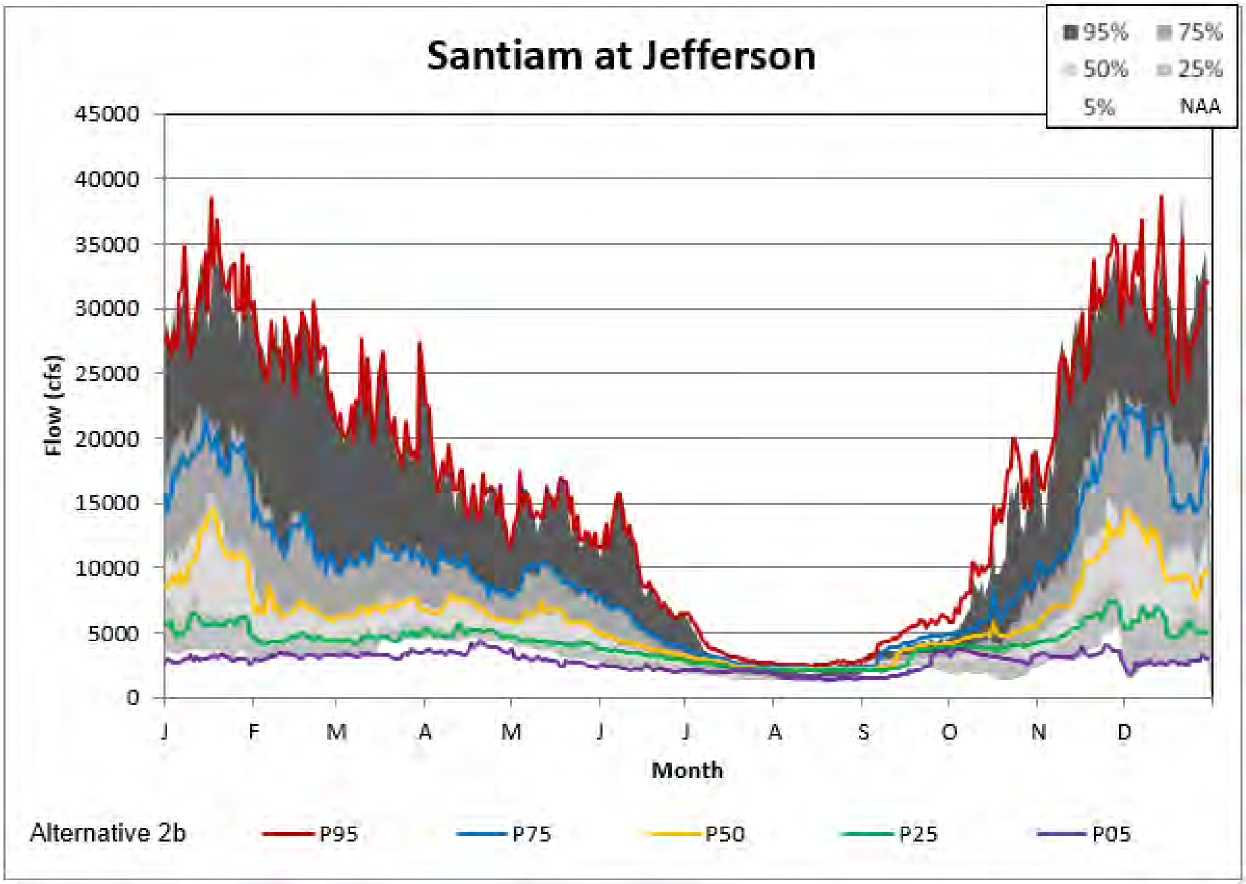


Figure 5-66. Jefferson Alternative 2b Non-Exceedance Plot

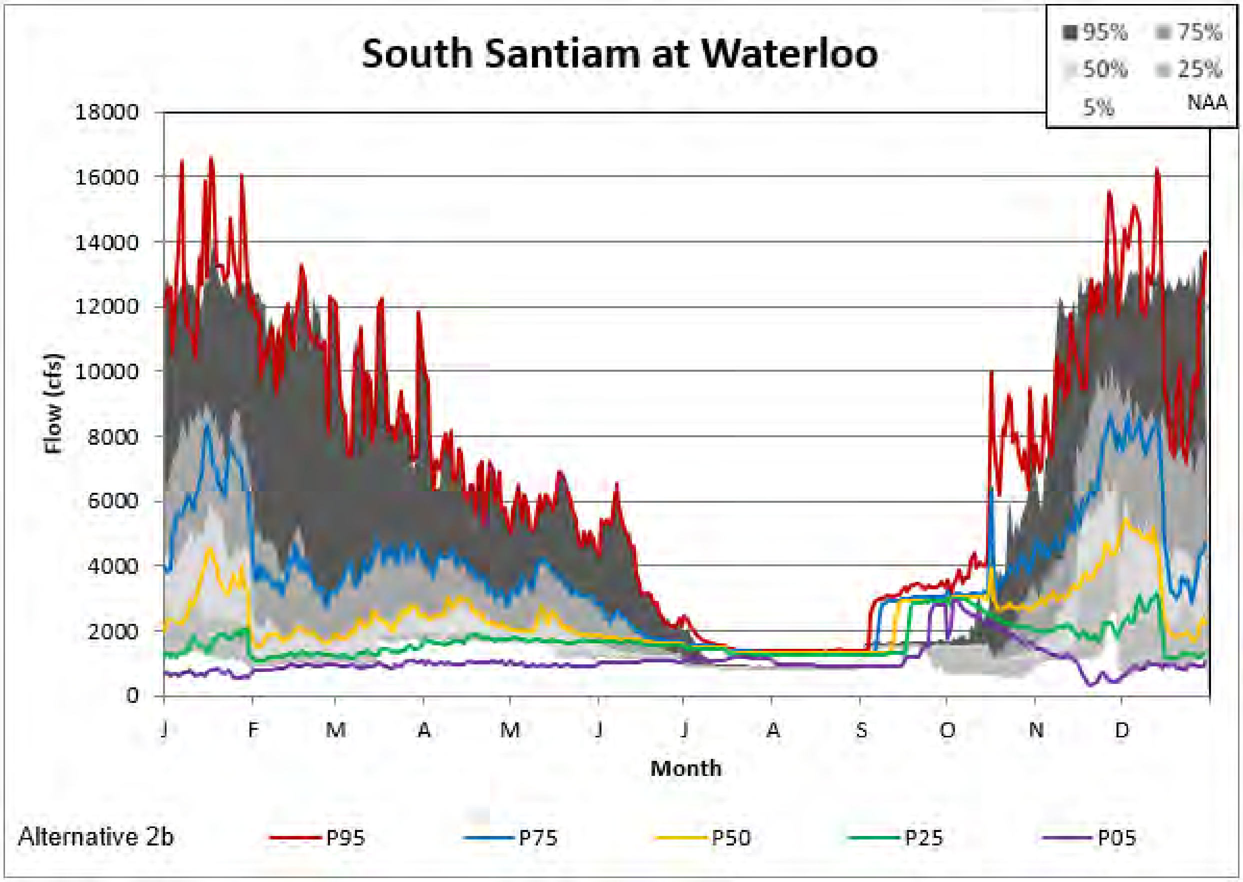


Figure 5-67. Waterloo Alternative 2b Non-Exceedance Plot

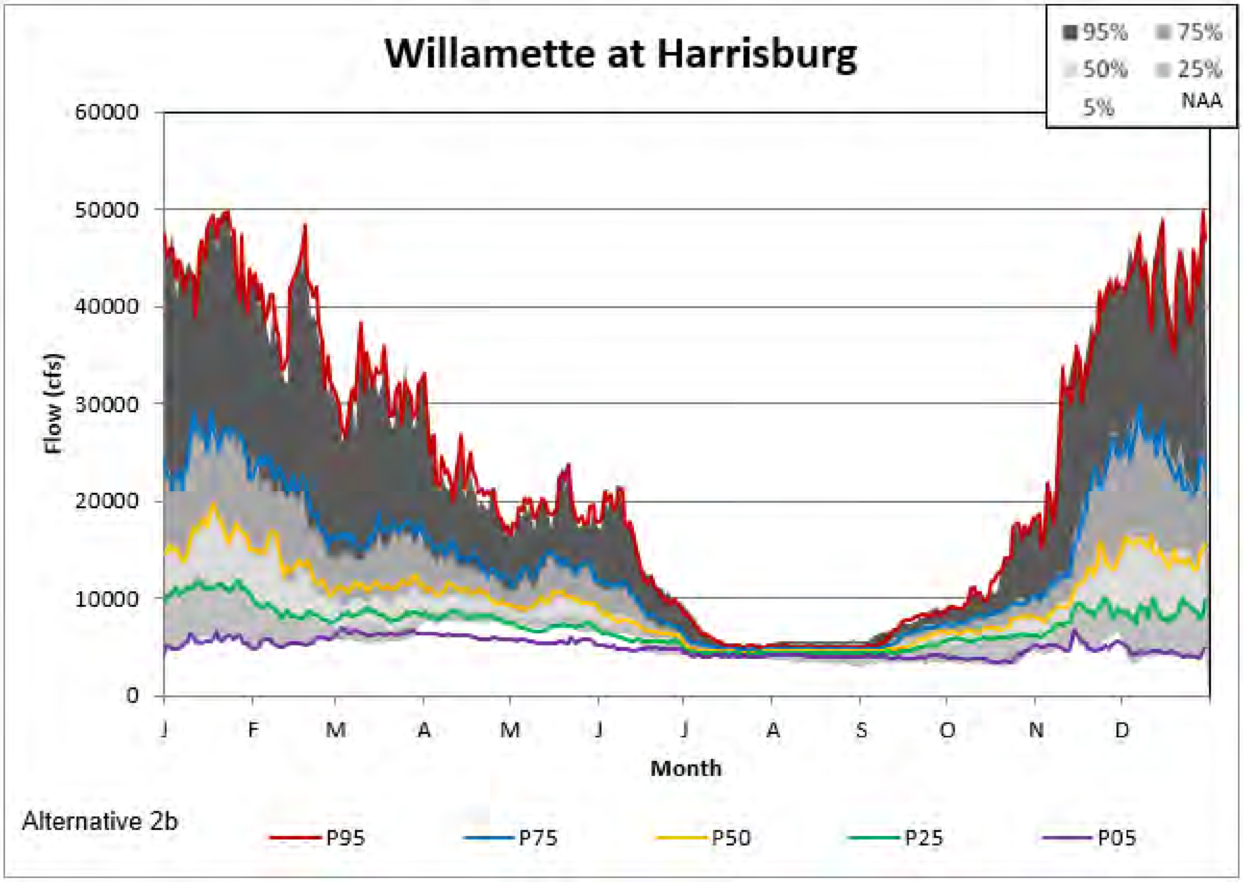


Figure 5-68. Harrisburg Alternative 2b Non-Exceedance Plot

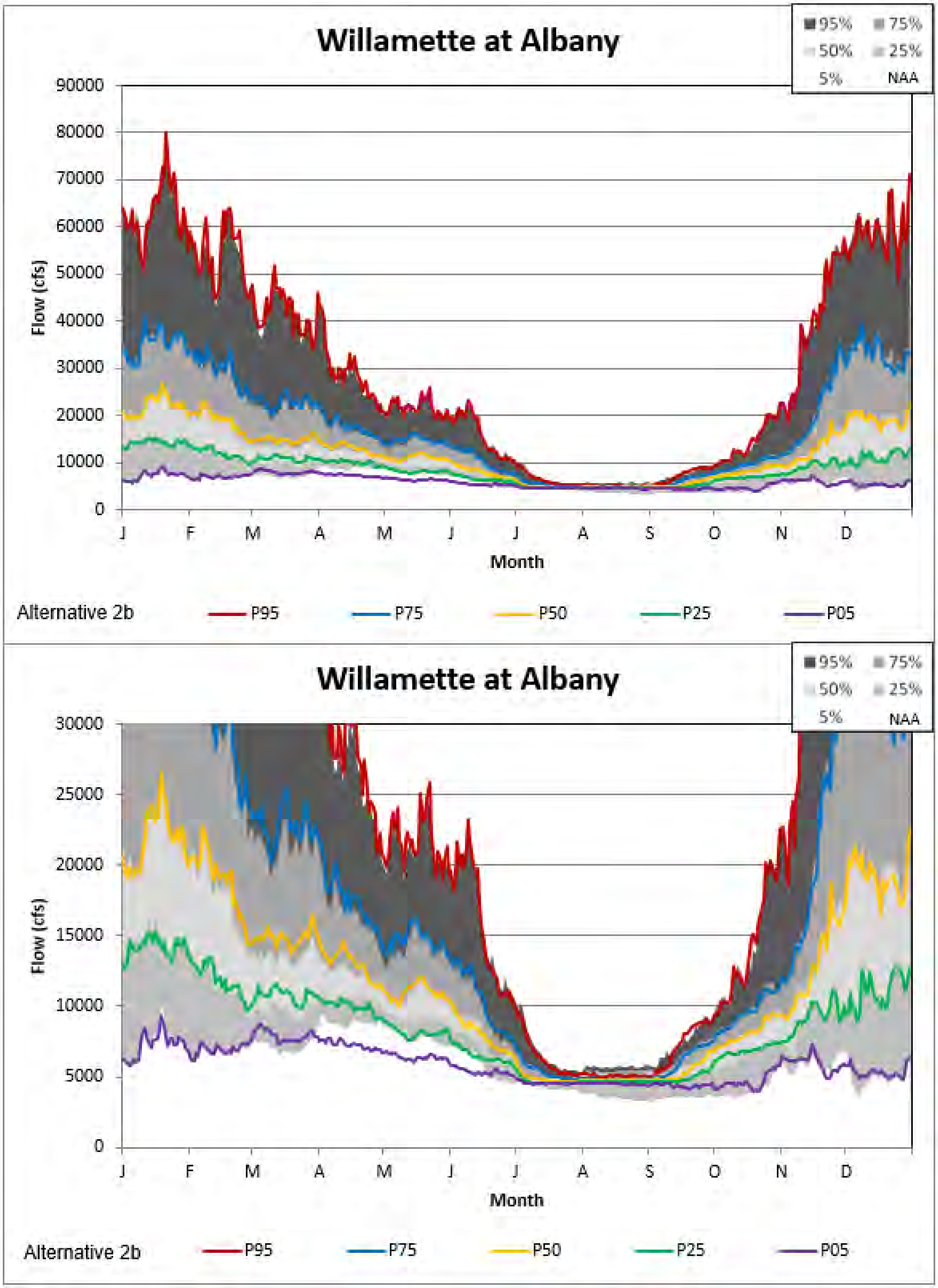


Figure 5-69. Albany Alternative 2b Non-Exceedance Plot

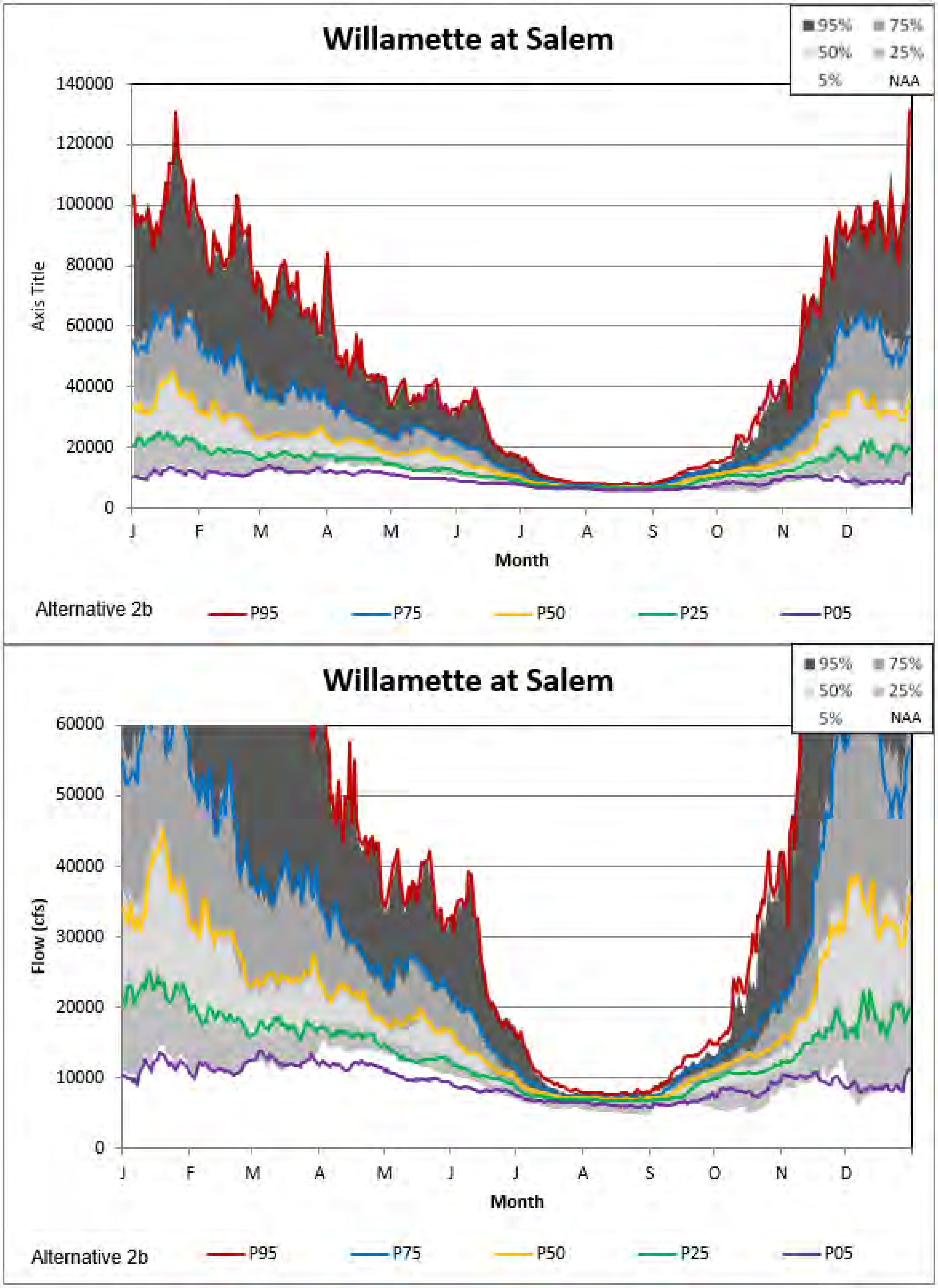


Figure 5-70. Salem Alternative 2b Non-Exceedance Plot

5.4 ALTERNATIVE 3A

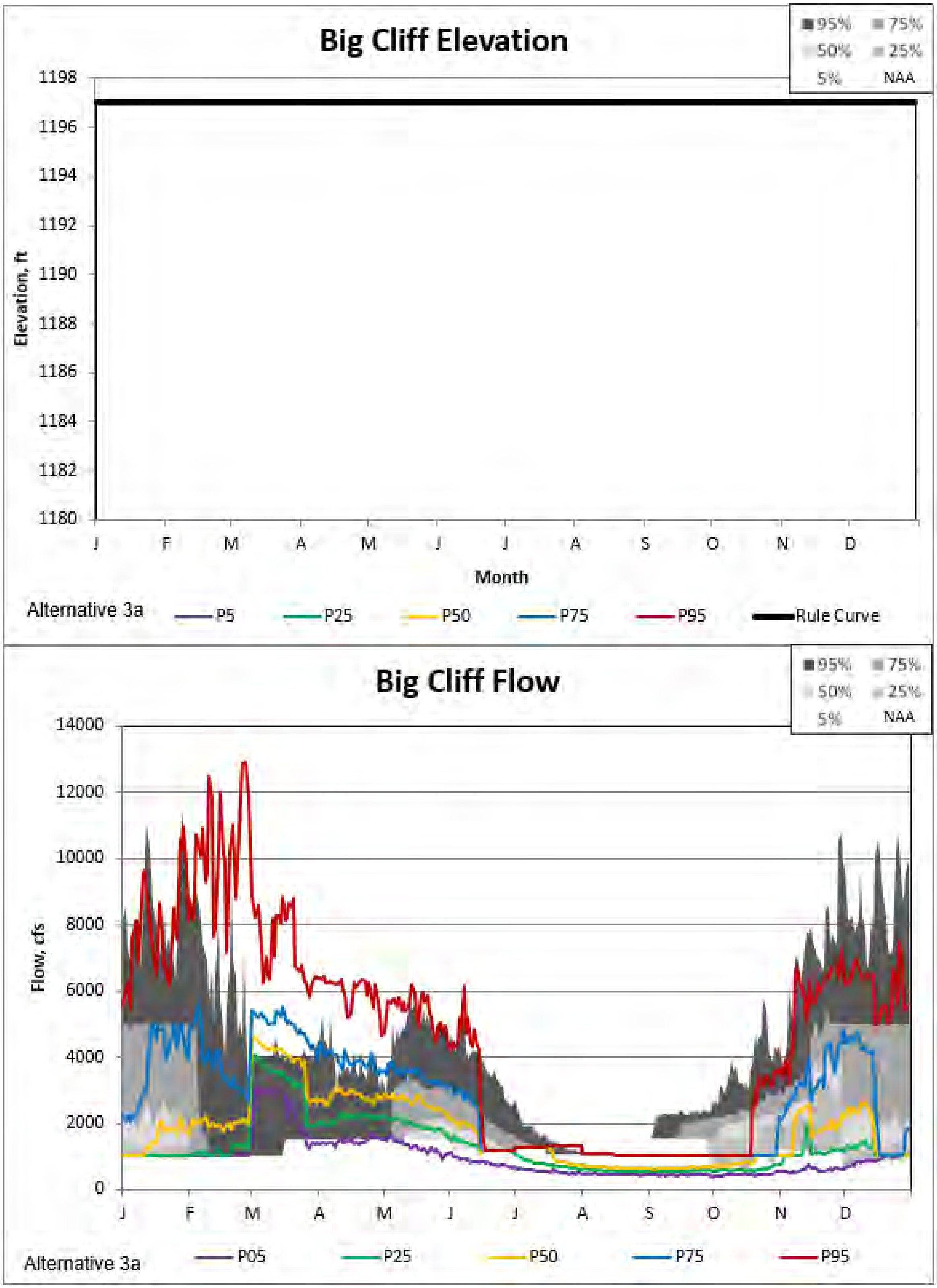


Figure 5-71. Big Cliff Alternative 3a Non-Exceedance Plot

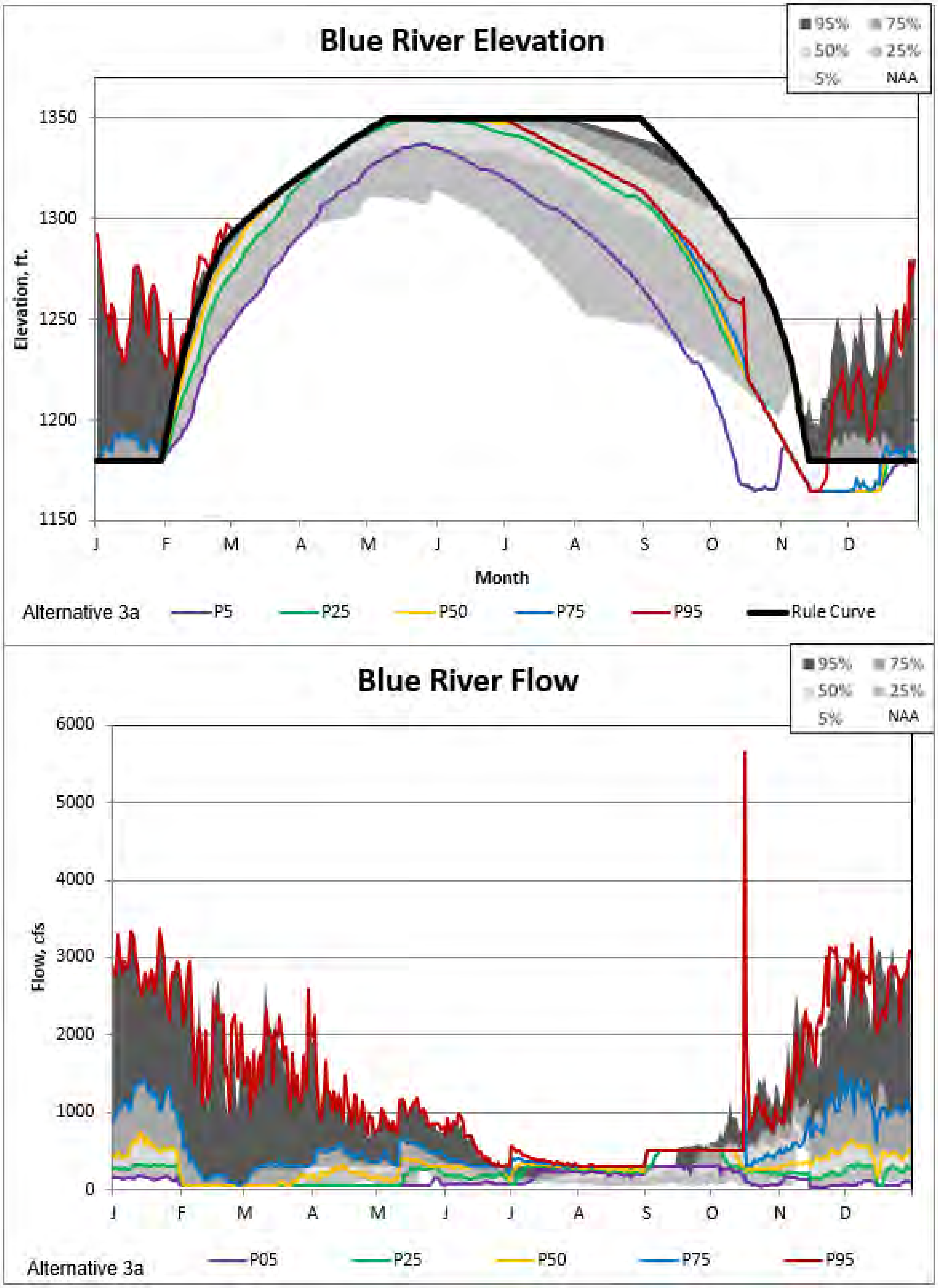


Figure 5-72. Blue River Alternative 3a Non-Exceedance Plot

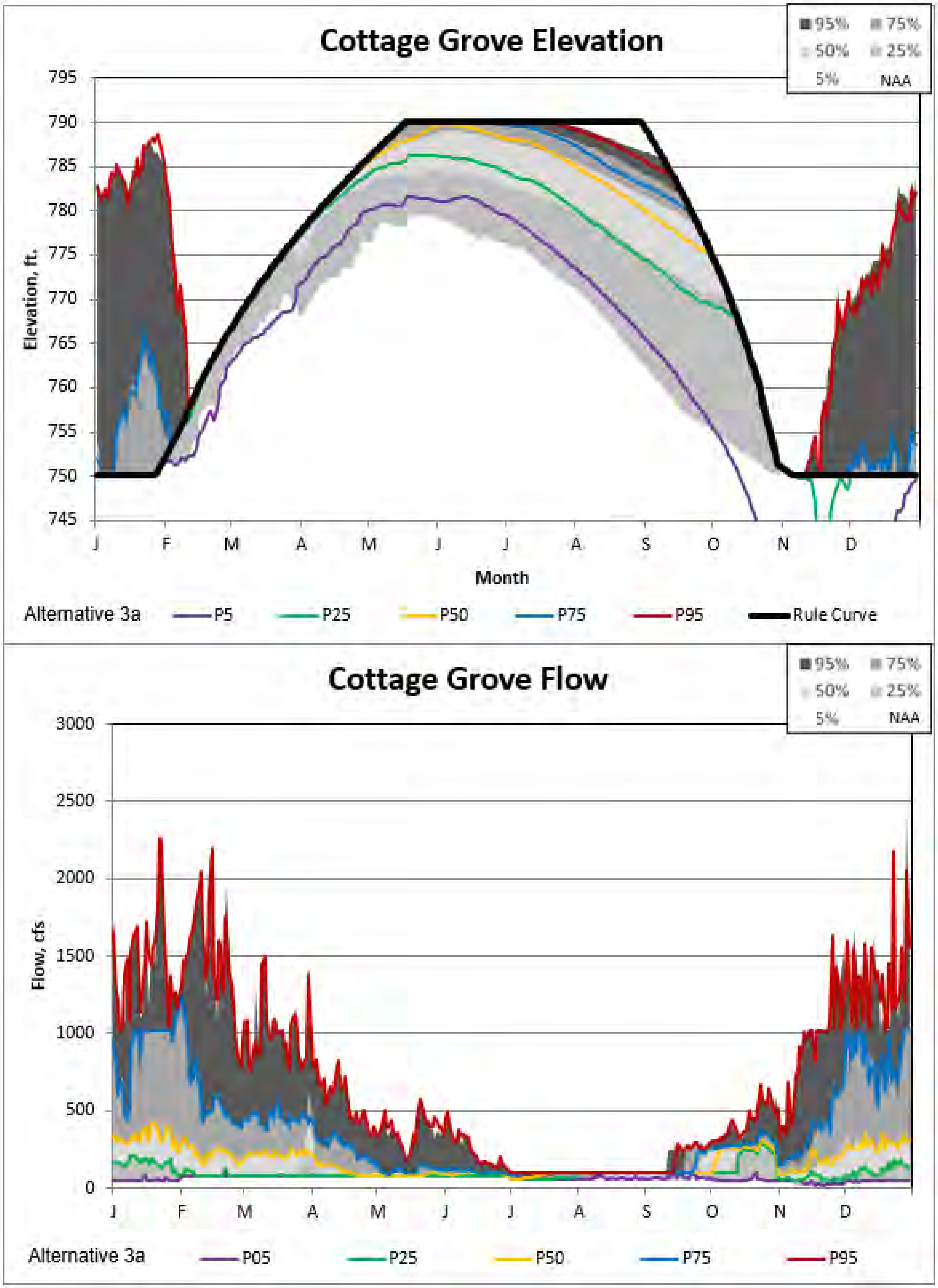


Figure 5-73. Cottage Grove Alternative 3a Non-Exceedance Plot

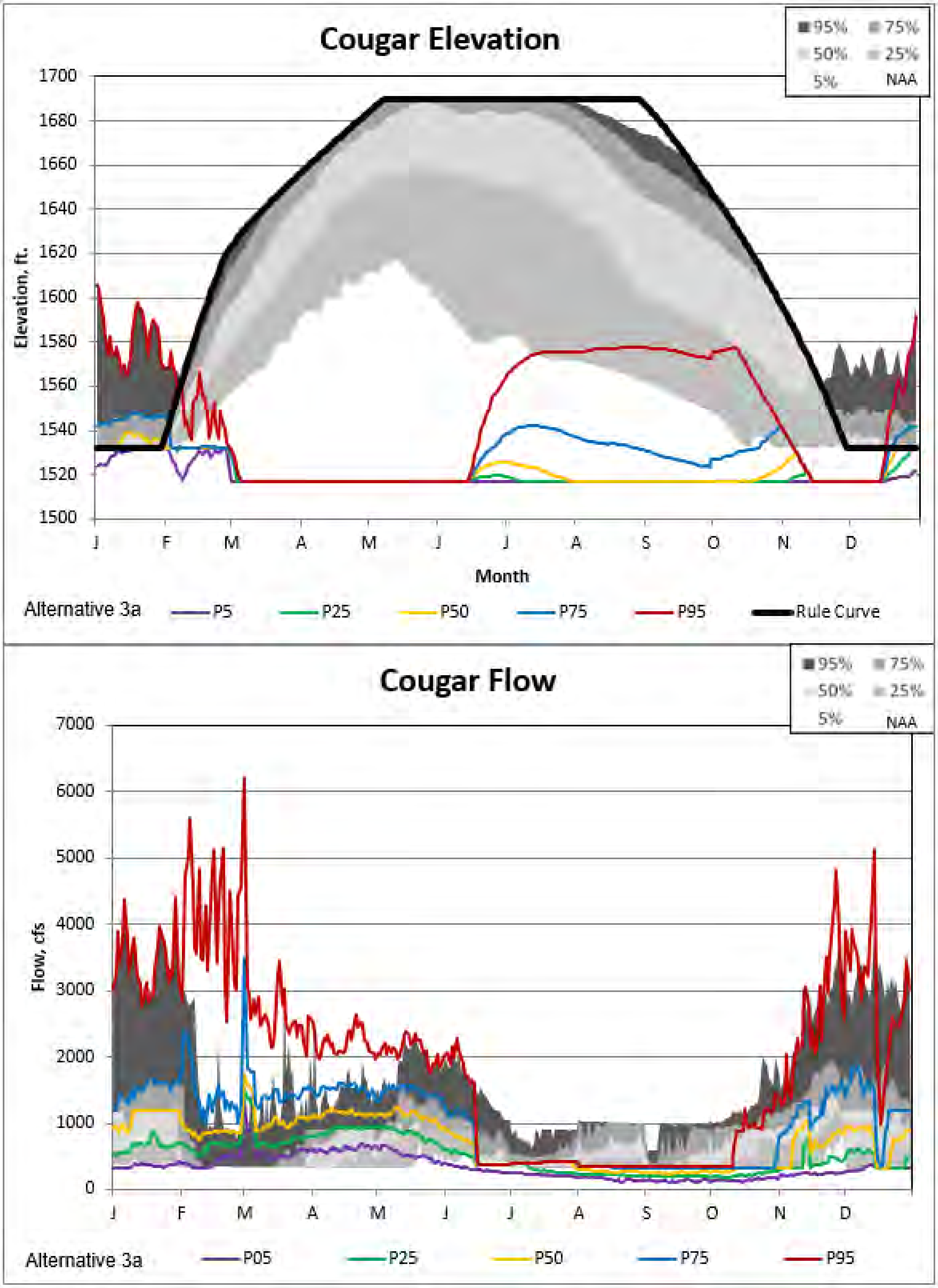


Figure 5-74. Cougar Alternative 3a Non-Exceedance Plot

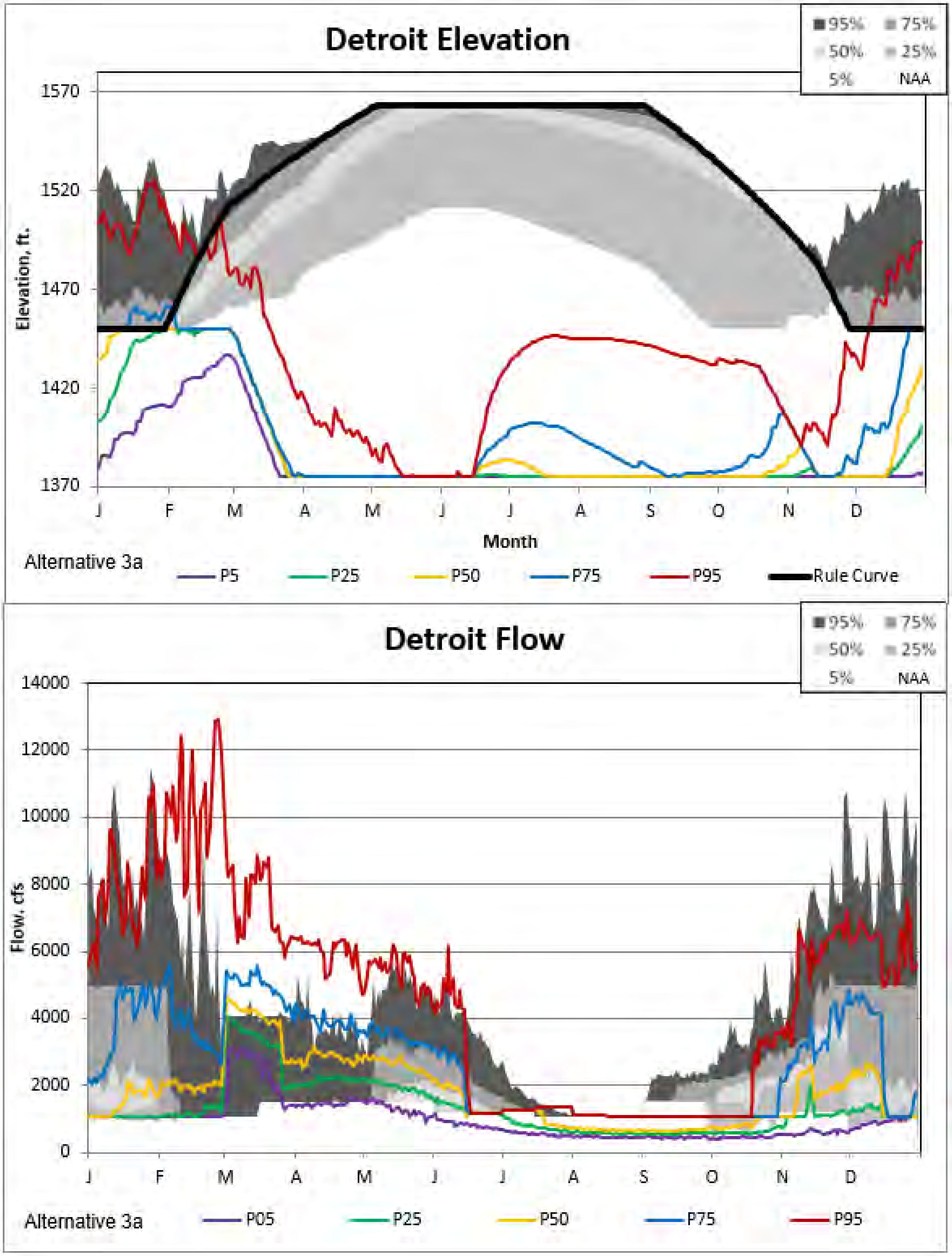


Figure 5-75. Detroit Alternative 3a Non-Exceedance Plot

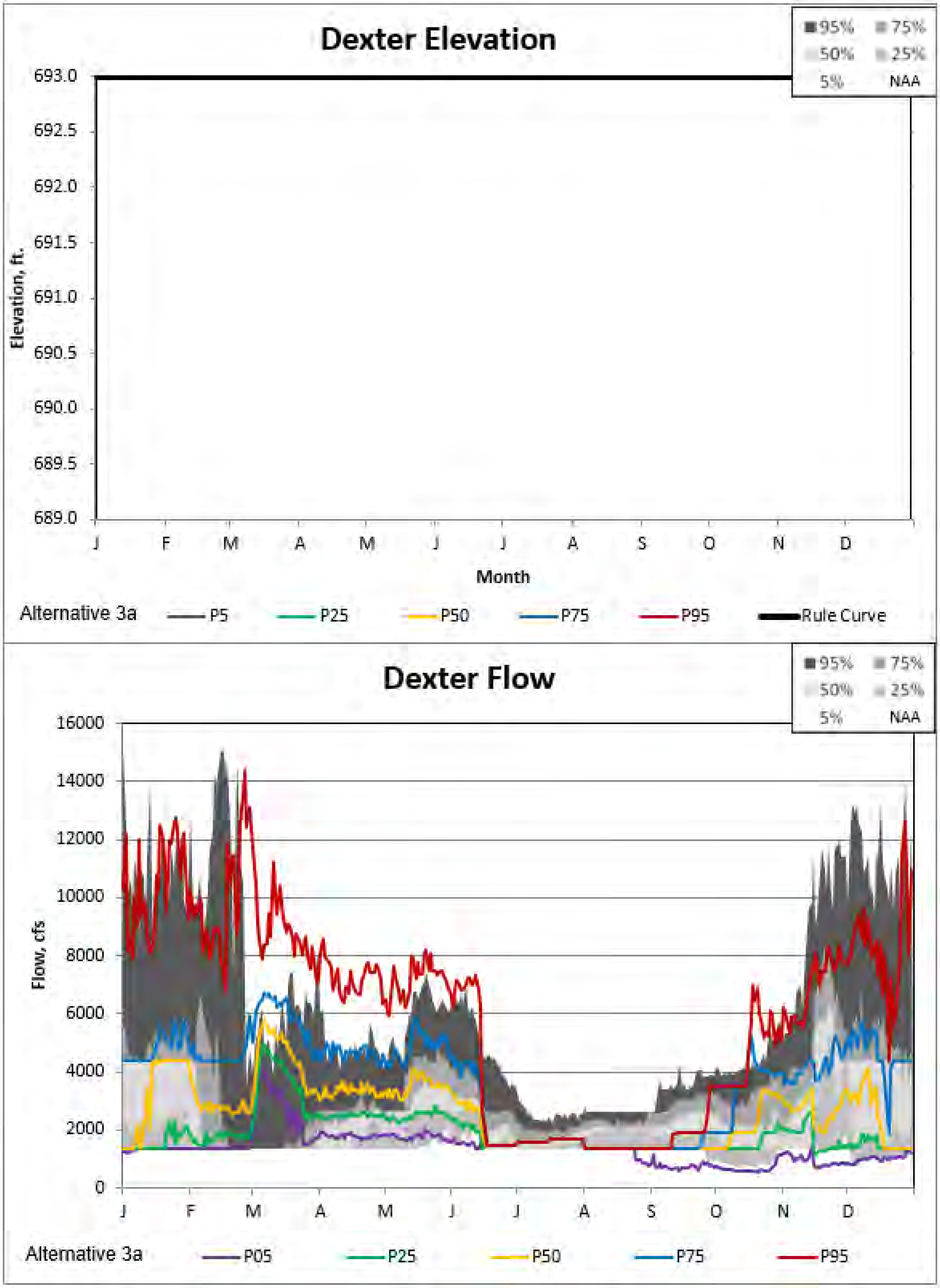


Figure 5-76. Dexter Alternative 3a Non-Exceedance Plot

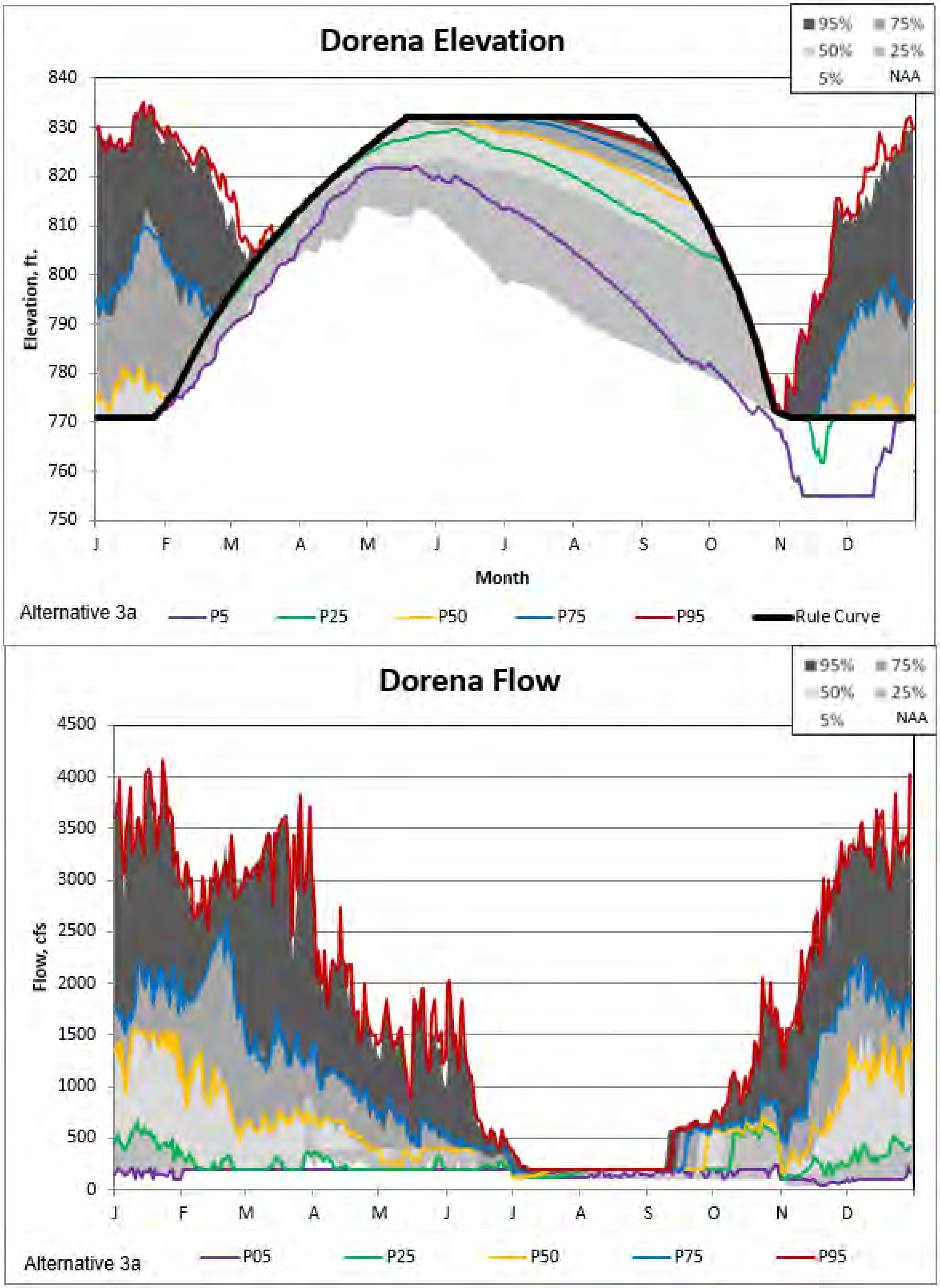


Figure 5-77. Dorena Alternative 3a Non-Exceedance Plot

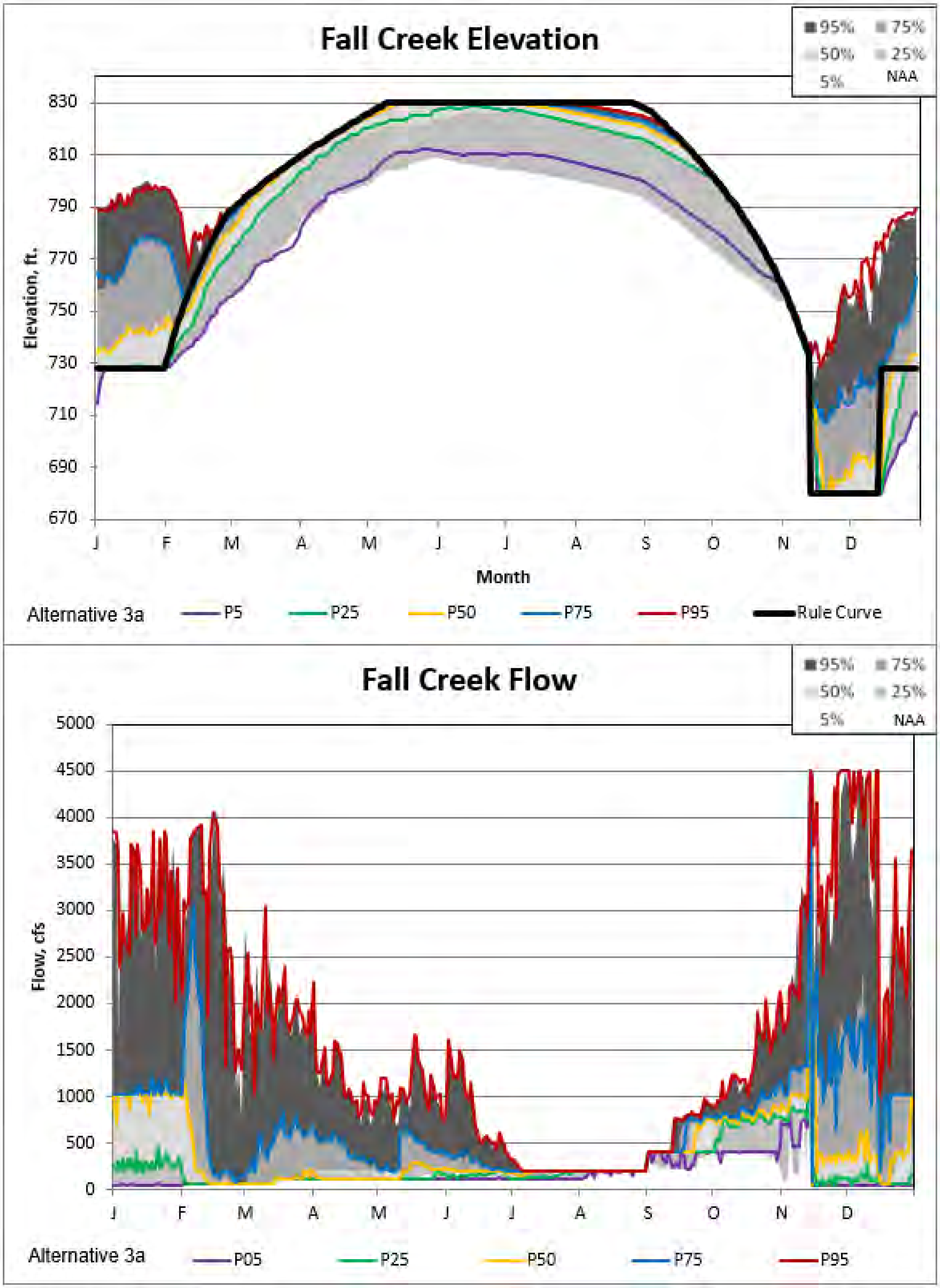


Figure 5-78. Fall Creek Alternative 3a Non-Exceedance Plot

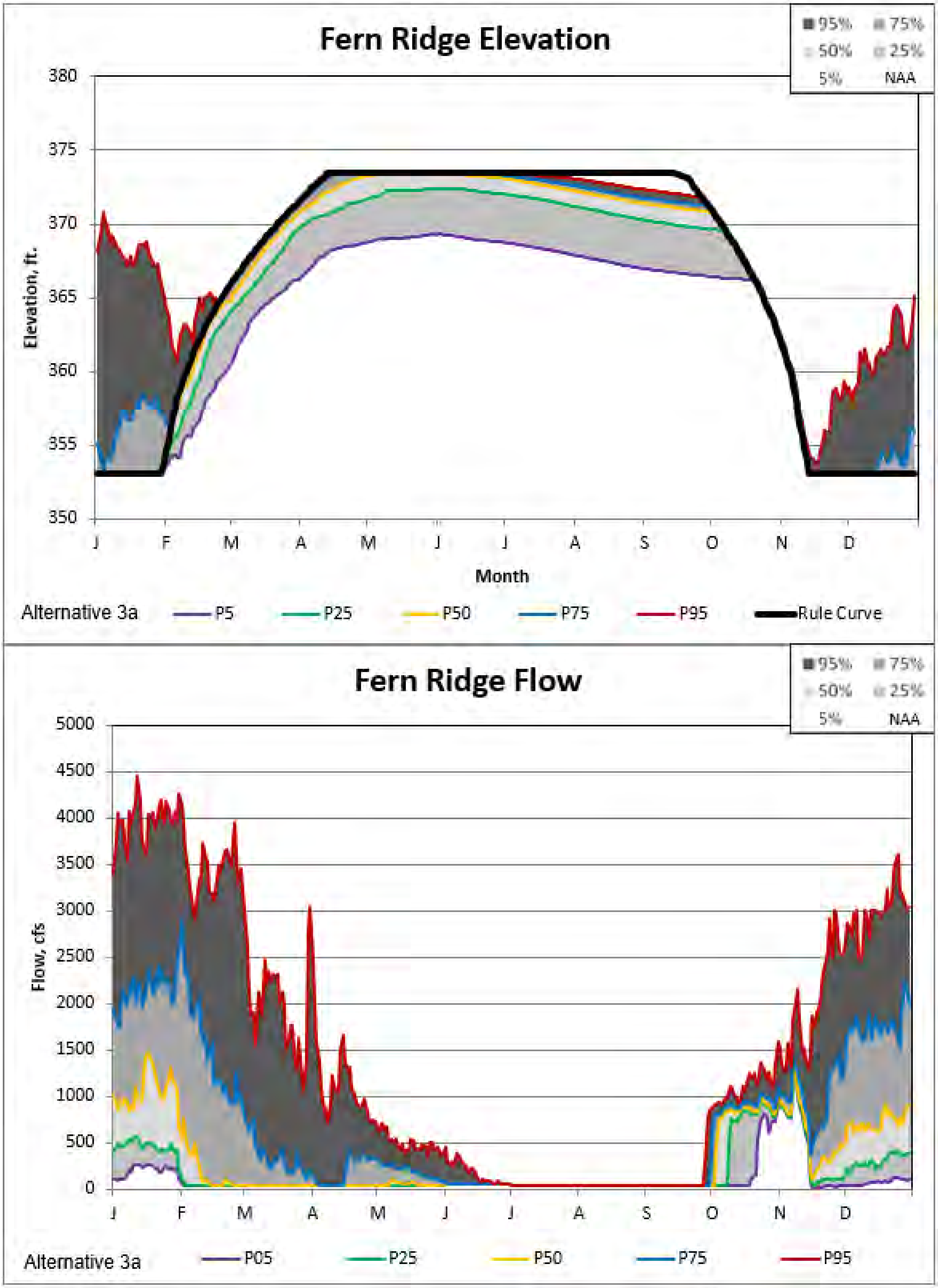


Figure 5-79. Fern Ridge Alternative 3a Non-Exceedance Plot

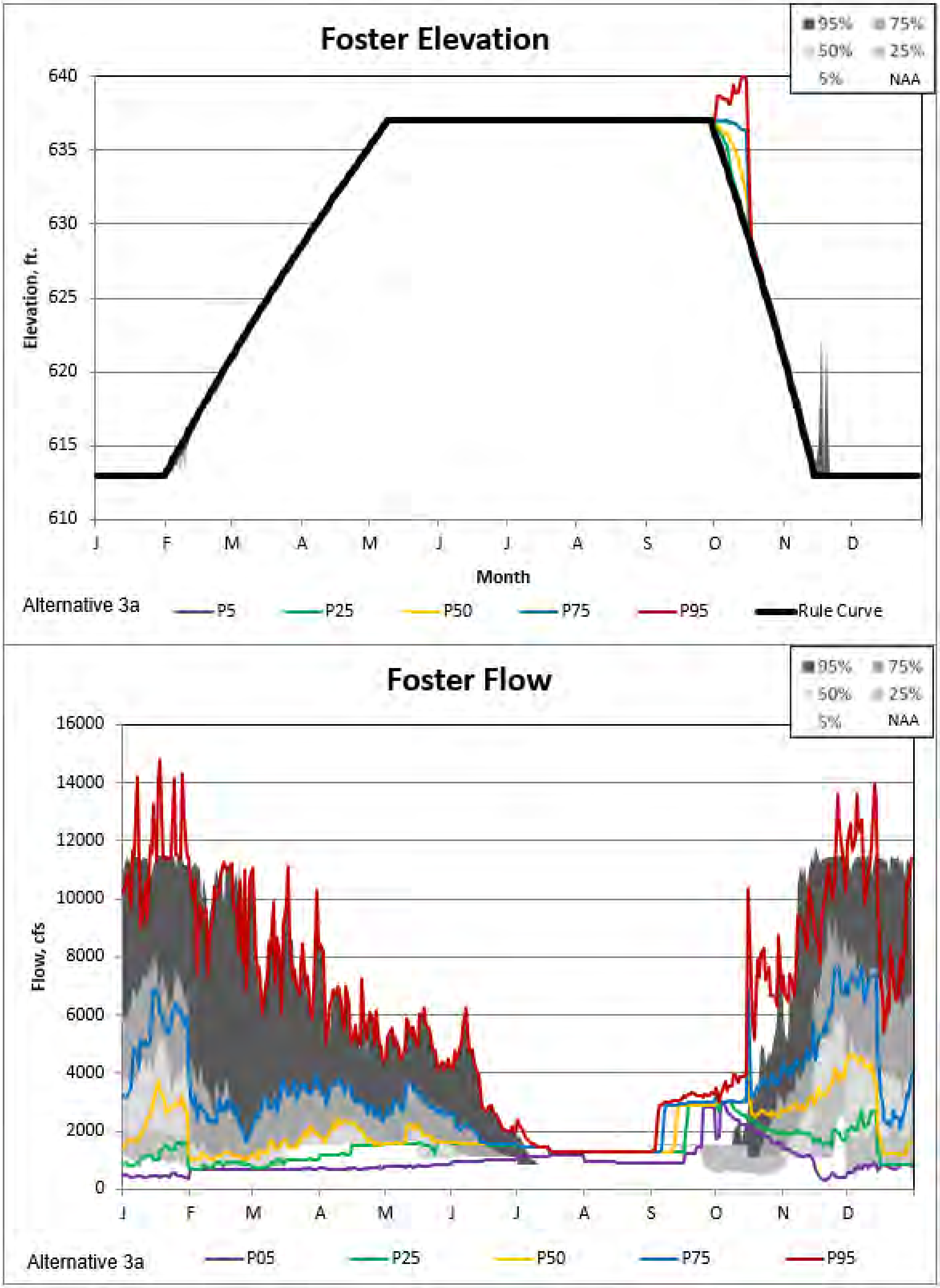


Figure 5-80. Foster Alternative 3a Non-Exceedance Plot

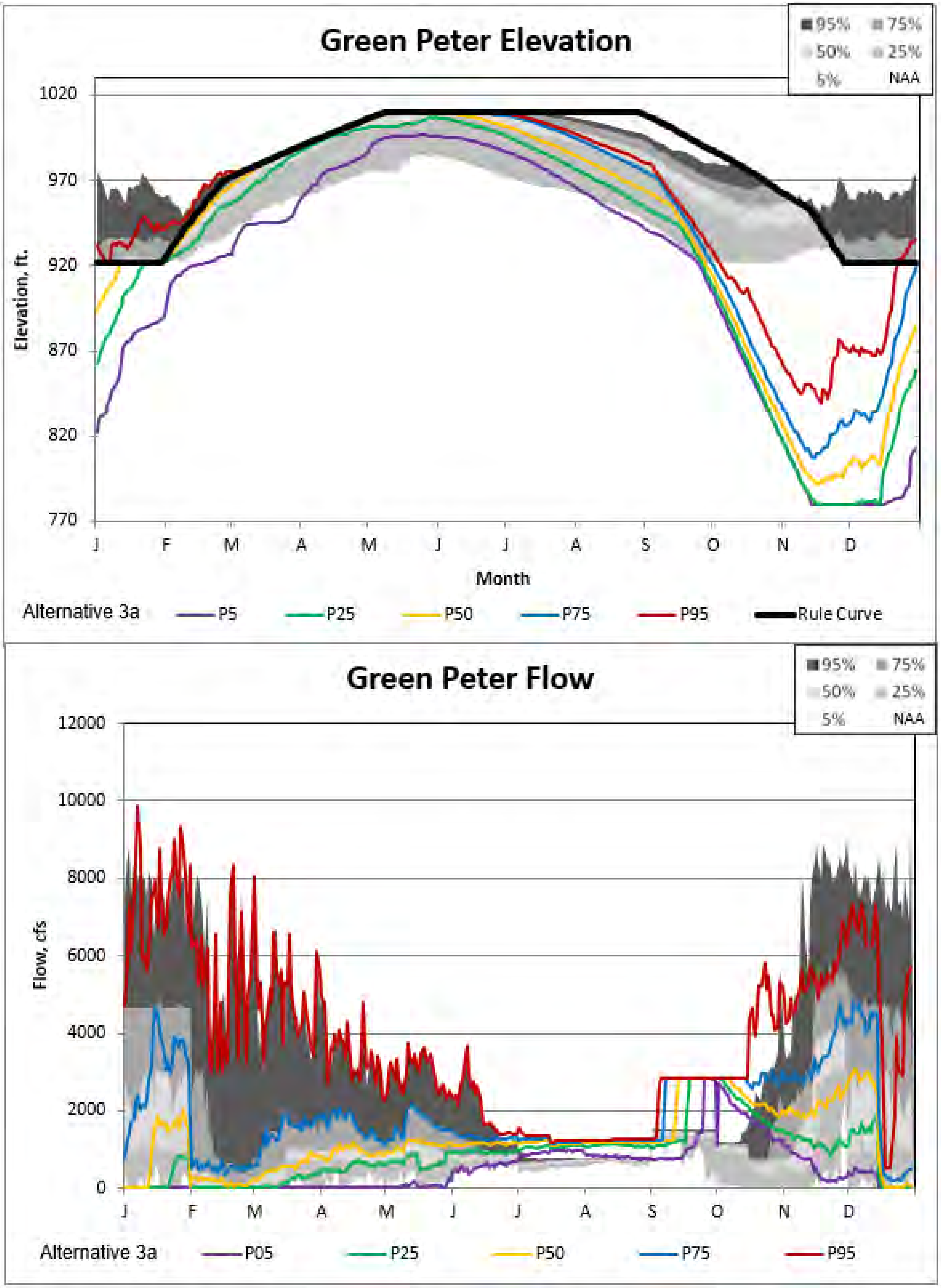


Figure 5-81. Green Peter Alternative 3a Non-Exceedance Plot

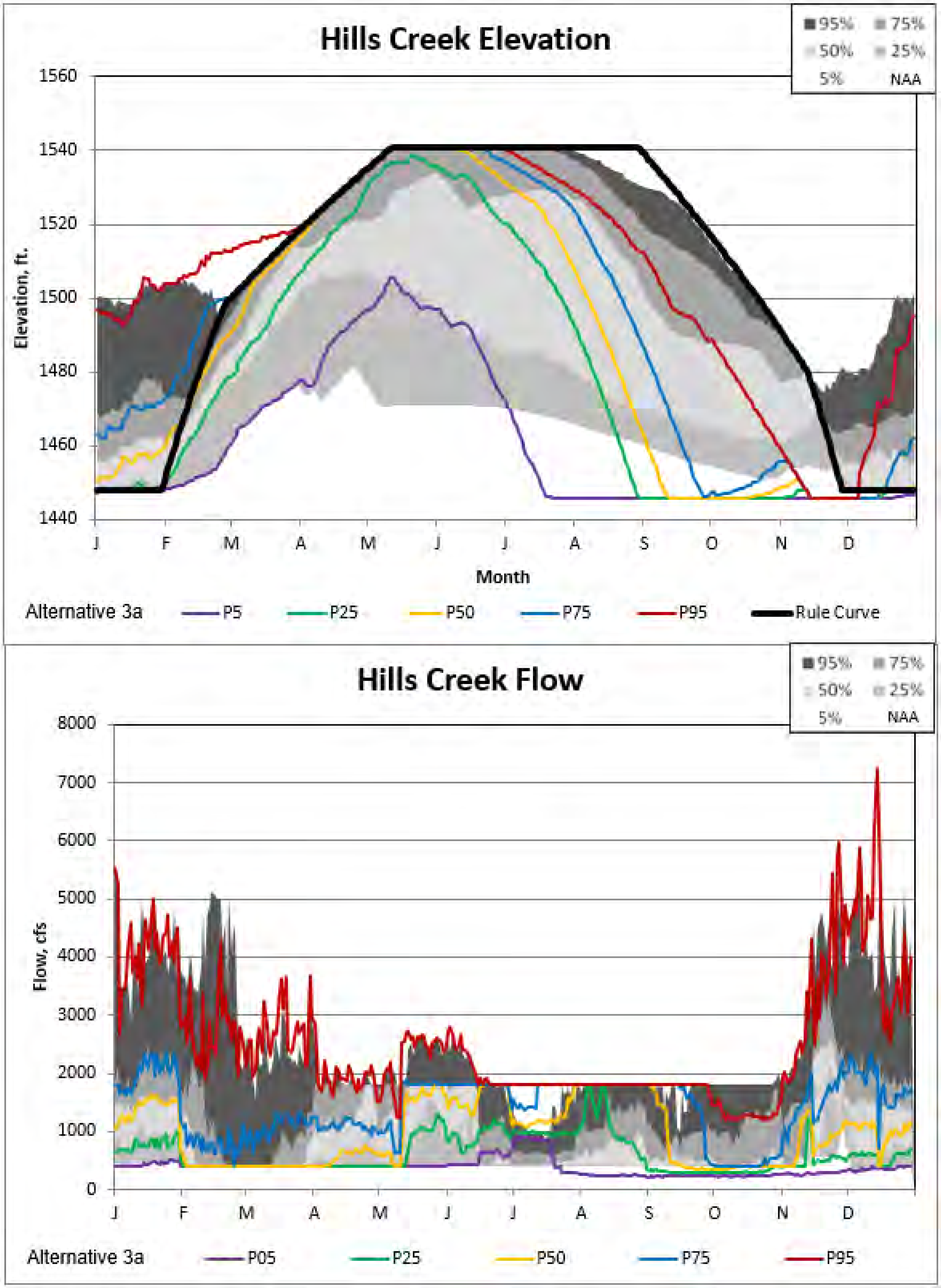


Figure 5-82. Hills Creek Alternative 3a Non-Exceedance Plot

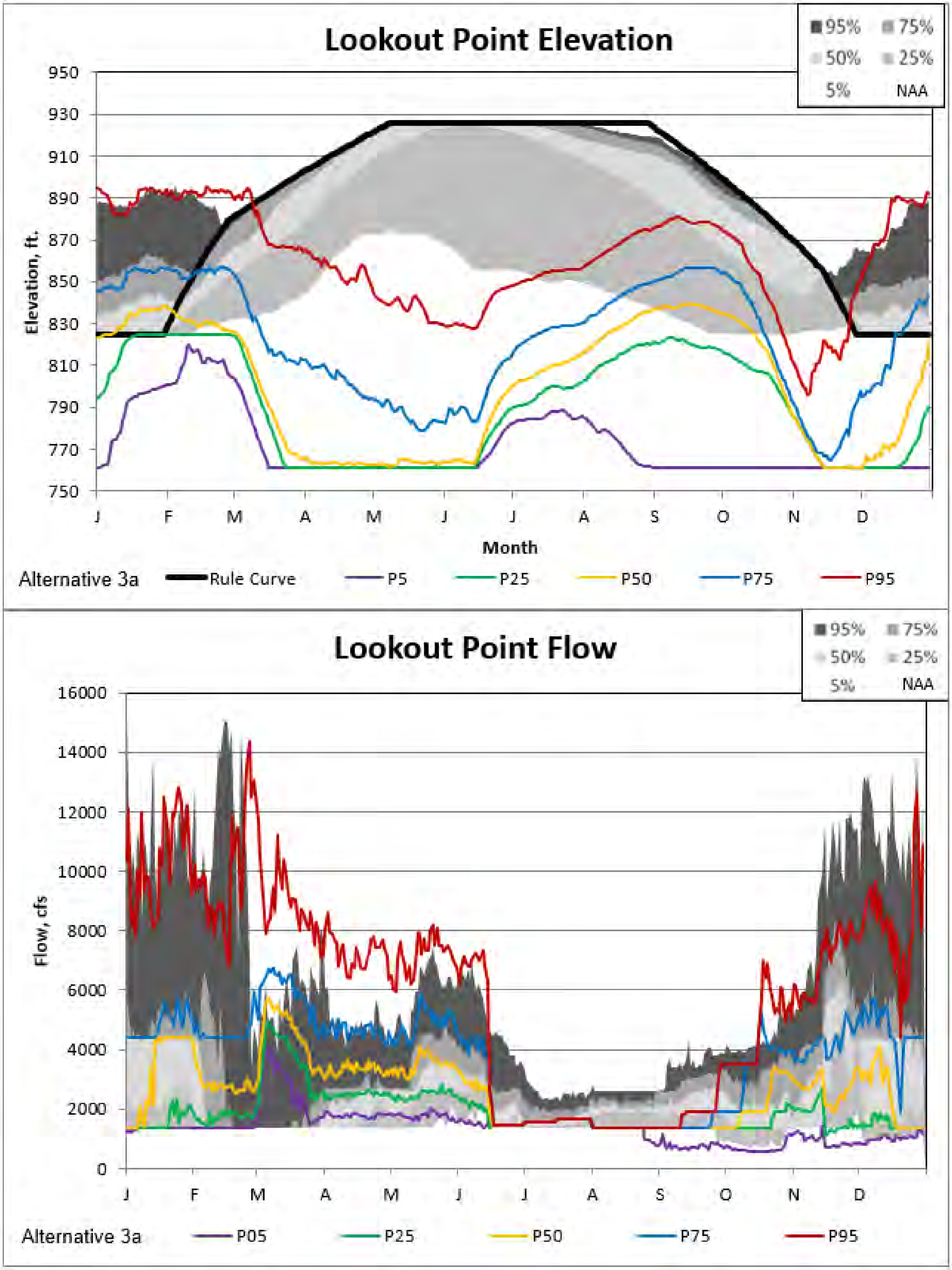


Figure 5-83. Lookout Point Alternative 3a Non-Exceedance Plot

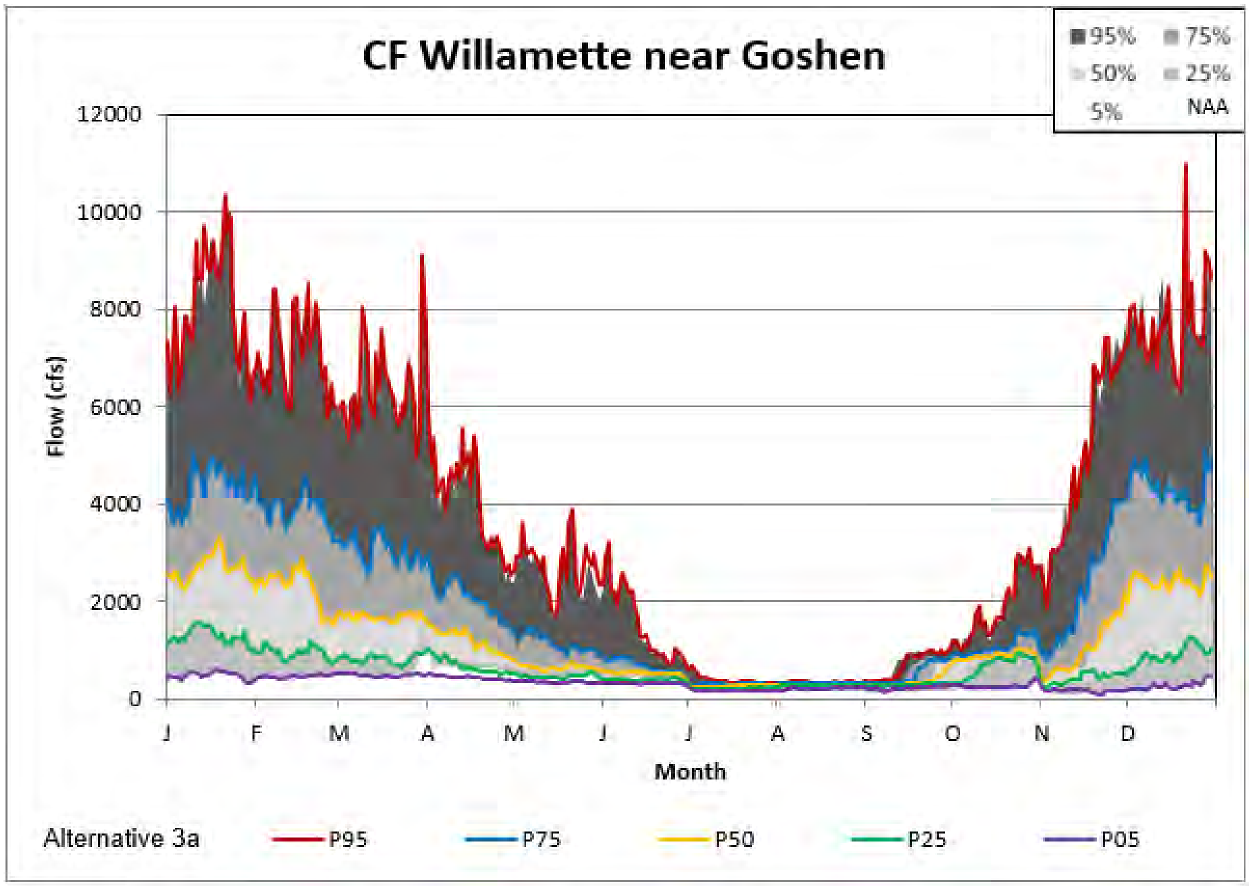


Figure 5-84. Goshen Alternative 3a Non-Exceedance Plot

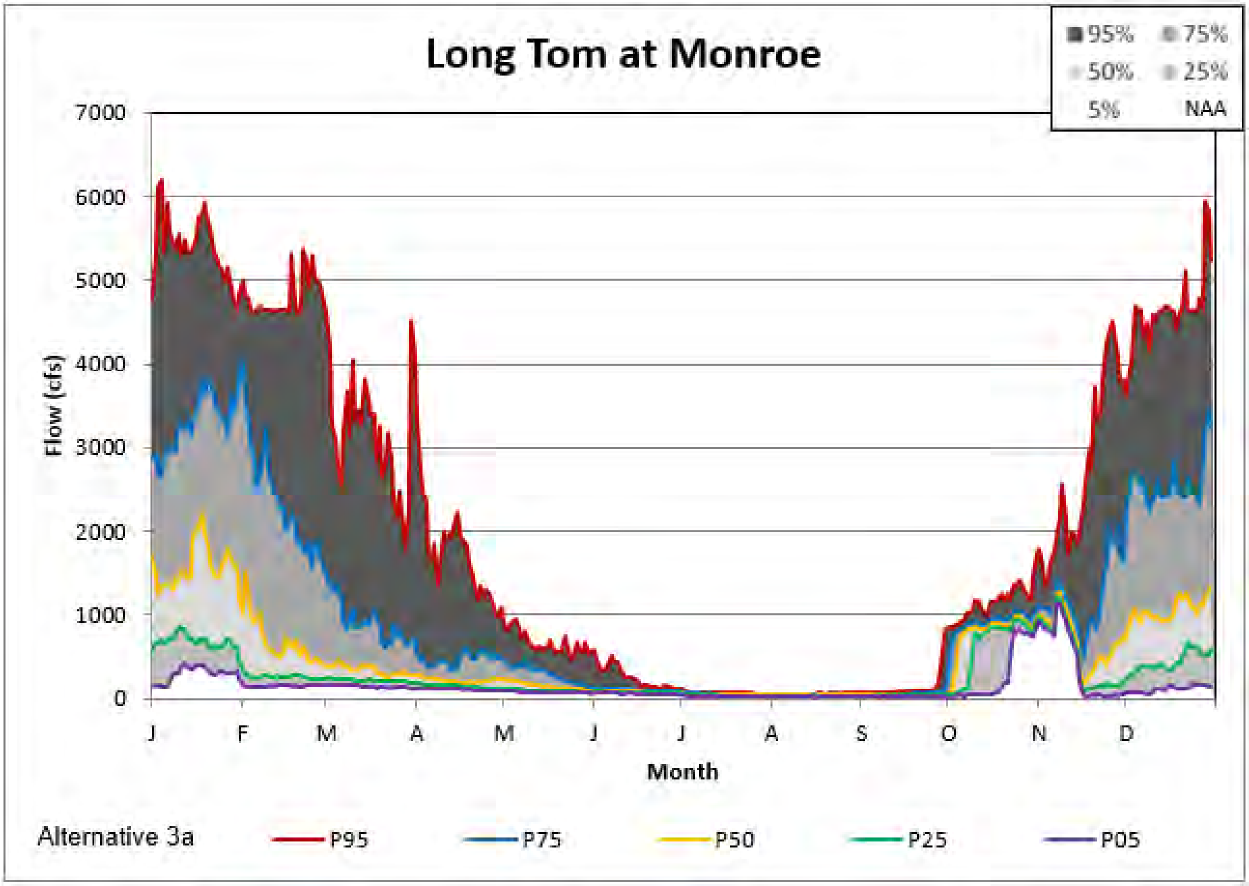


Figure 5-85. Monroe Alternative 3a Non-Exceedance Plot

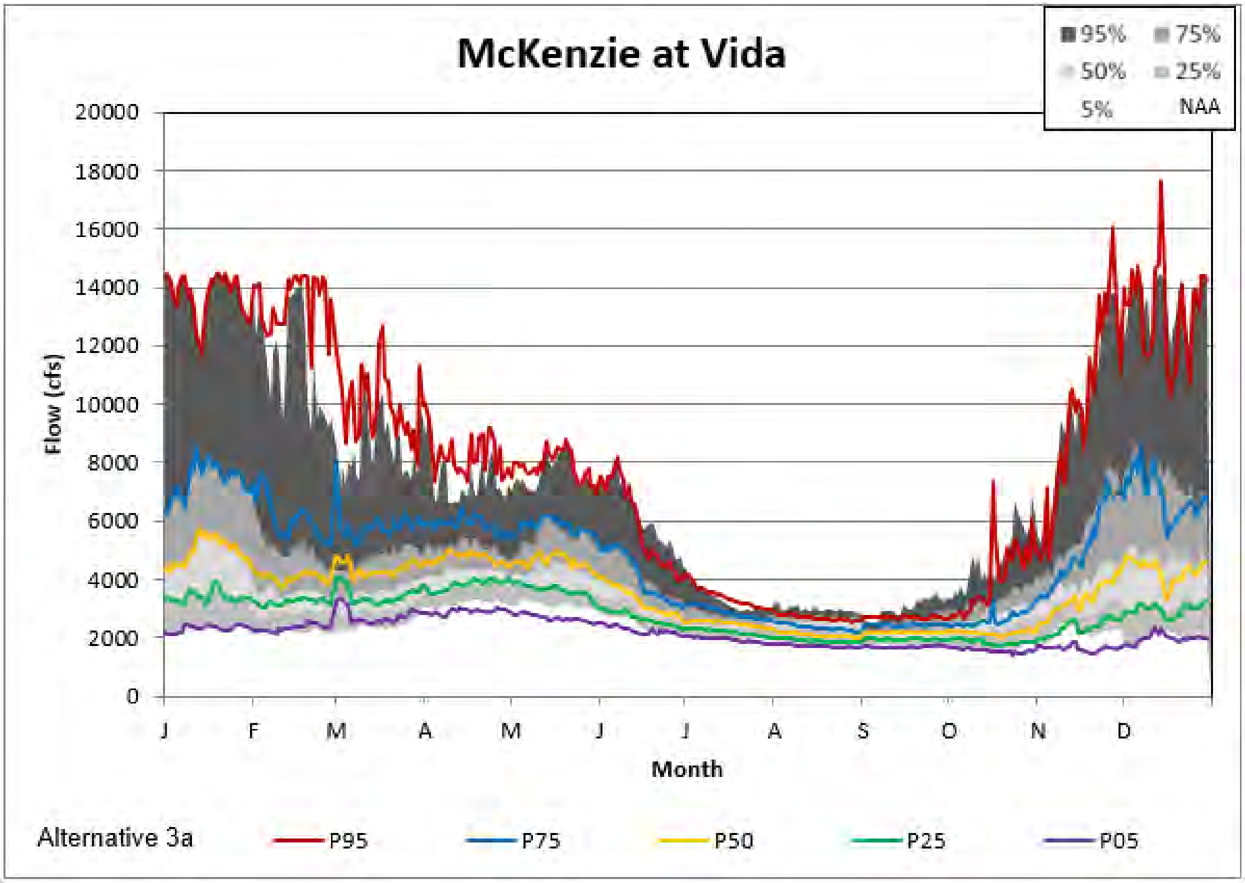


Figure 5-86. Vida Alternative 3a Non-Exceedance Plot

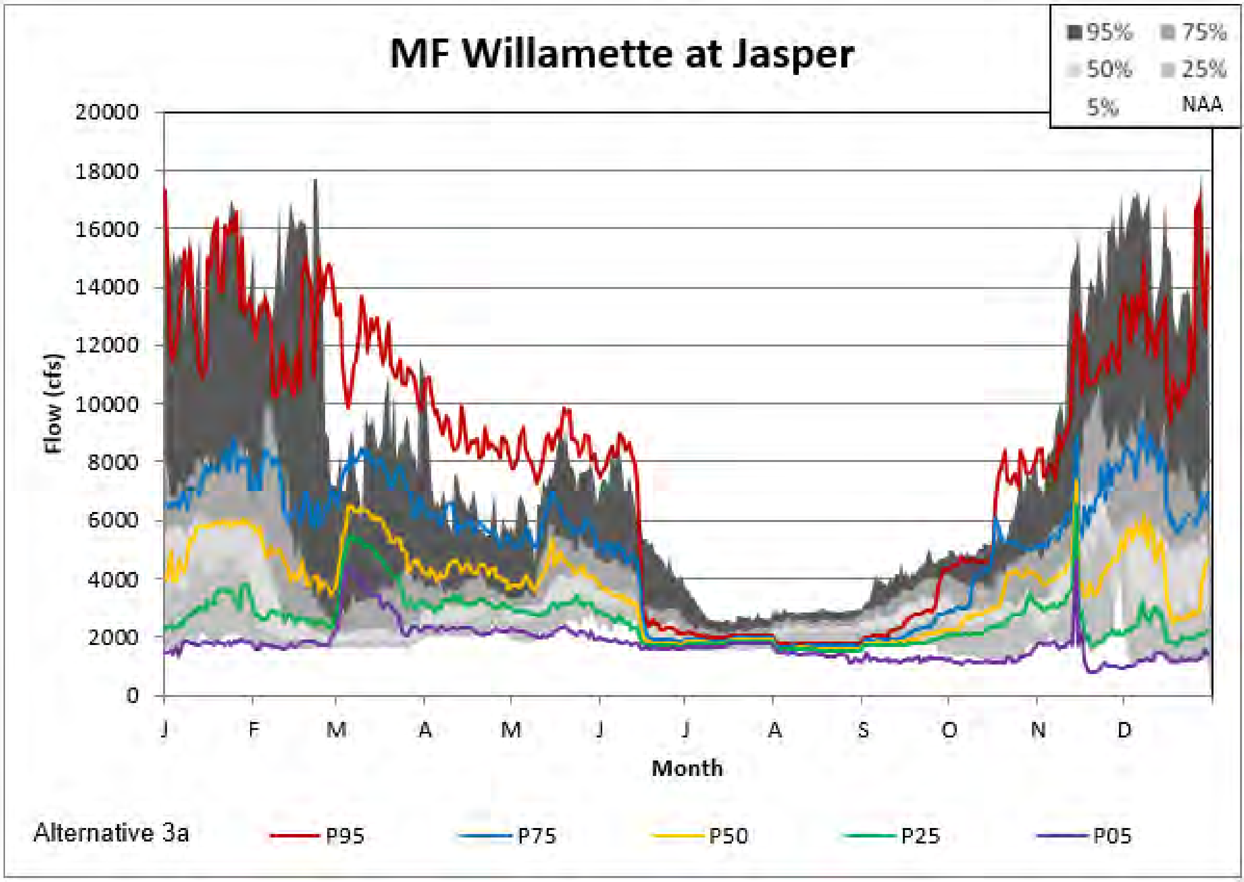


Figure 5-87. Jasper Alternative 3a Non-Exceedance Plot

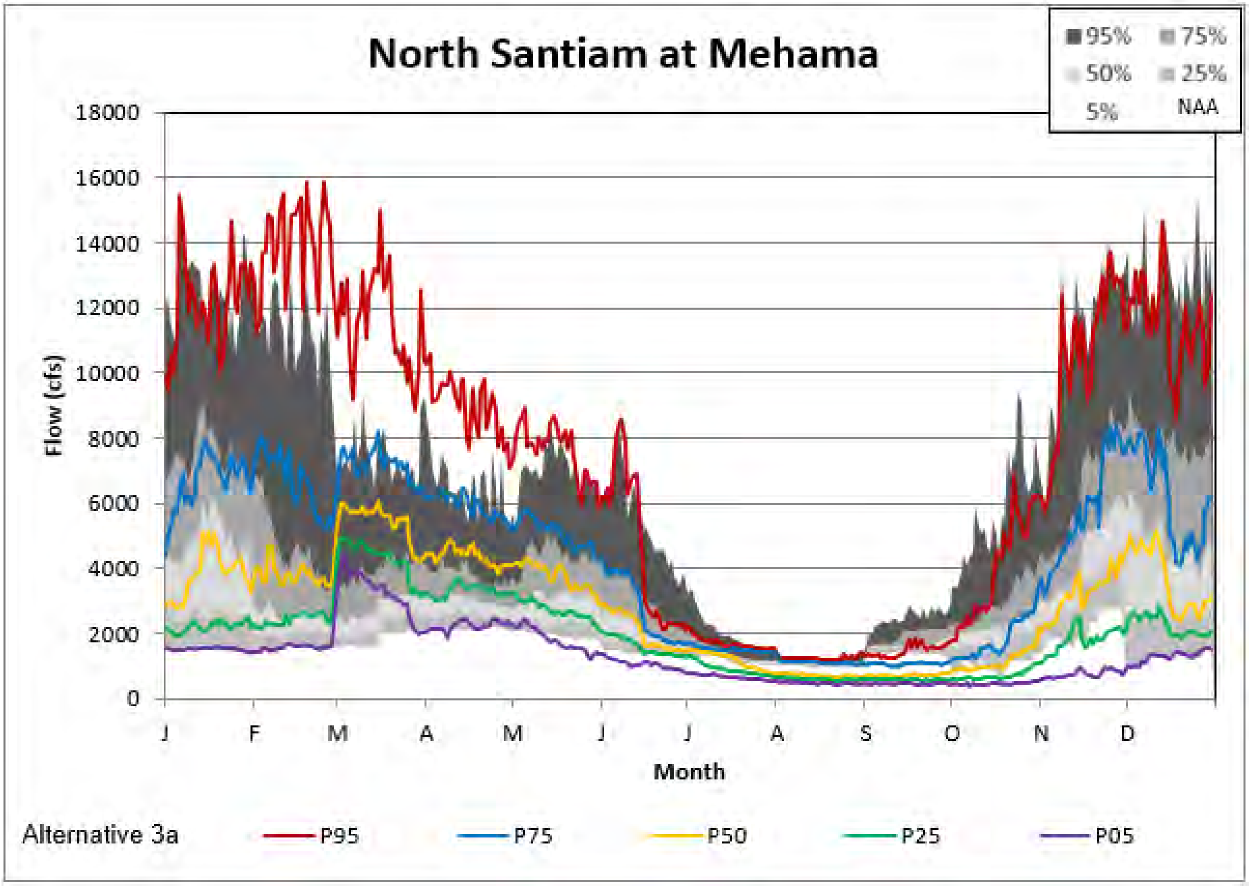


Figure 5-88. Mehama Alternative 3a Non-Exceedance Plot

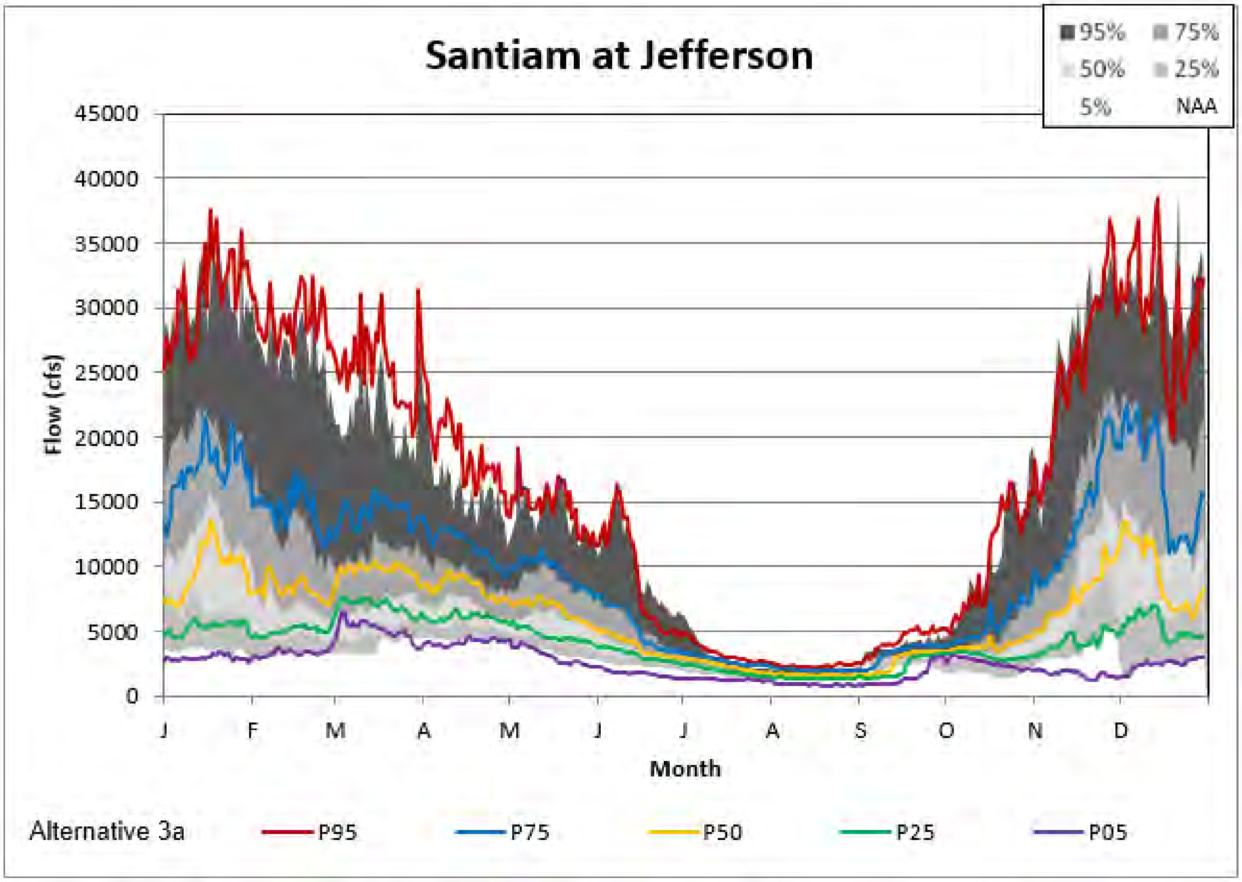


Figure 5-89. Jefferson Alternative 3a Non-Exceedance Plot

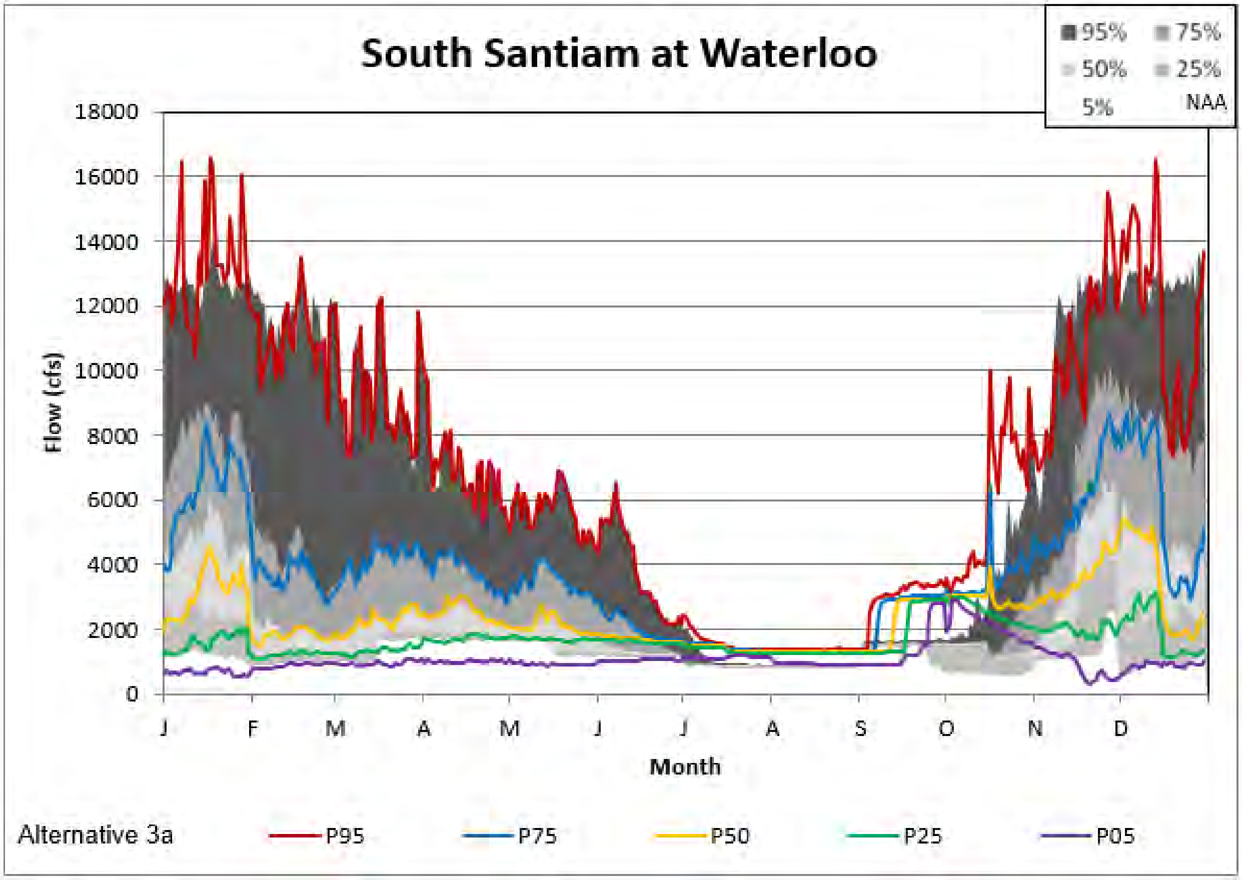


Figure 5-90. Waterloo Alternative 3a Non-Exceedance Plot

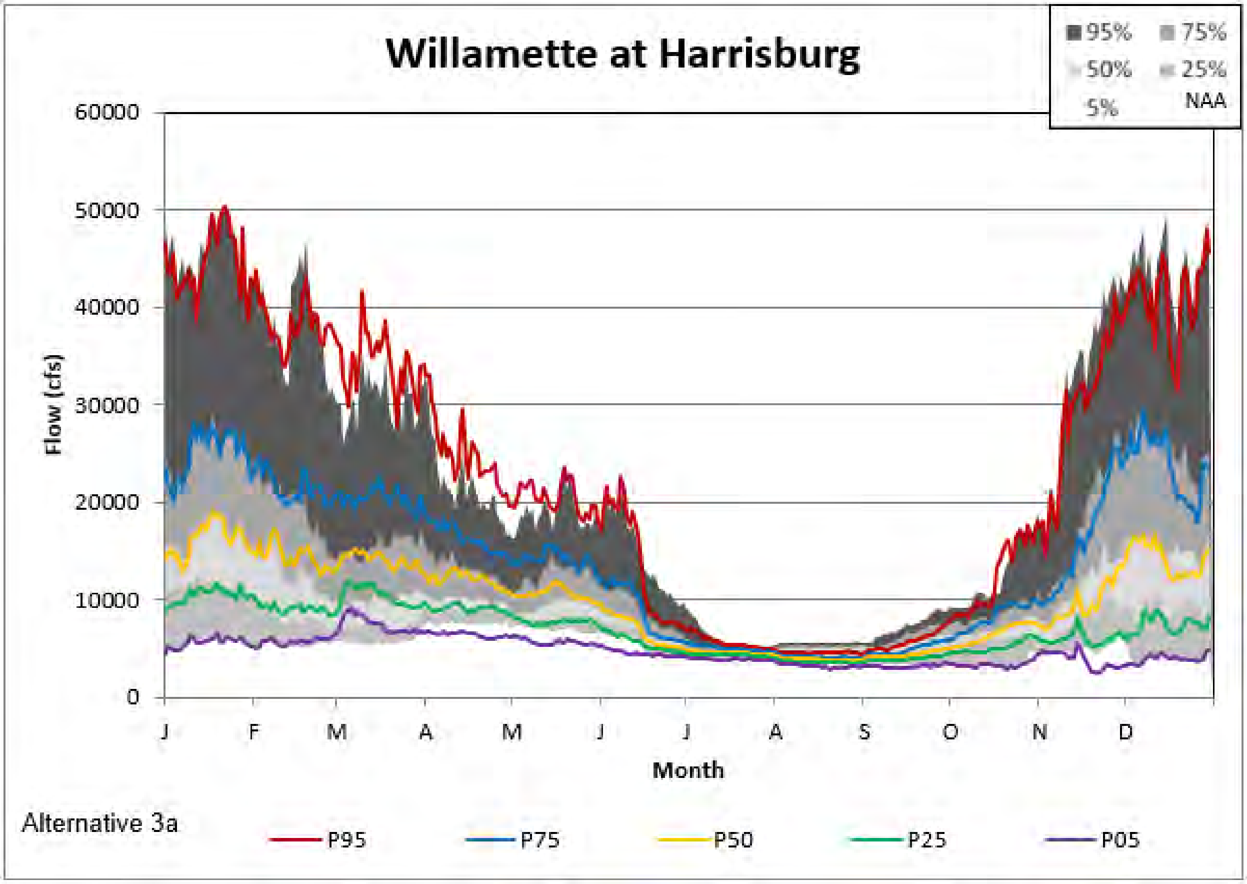


Figure 5-91. Harrisburg Alternative 3a Non-Exceedance Plot

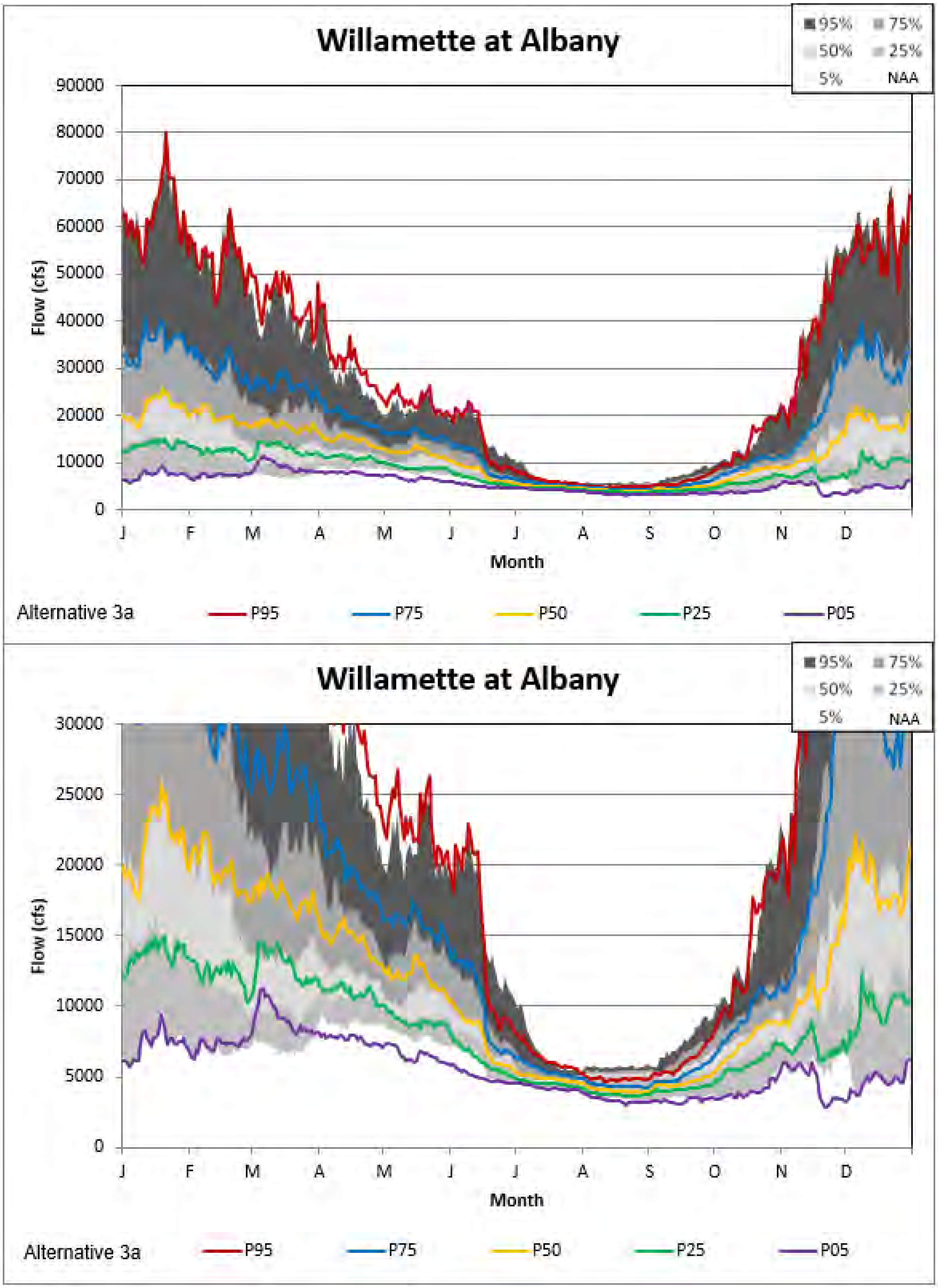


Figure 5-92. Albany Alternative 3a Non-Exceedance Plot

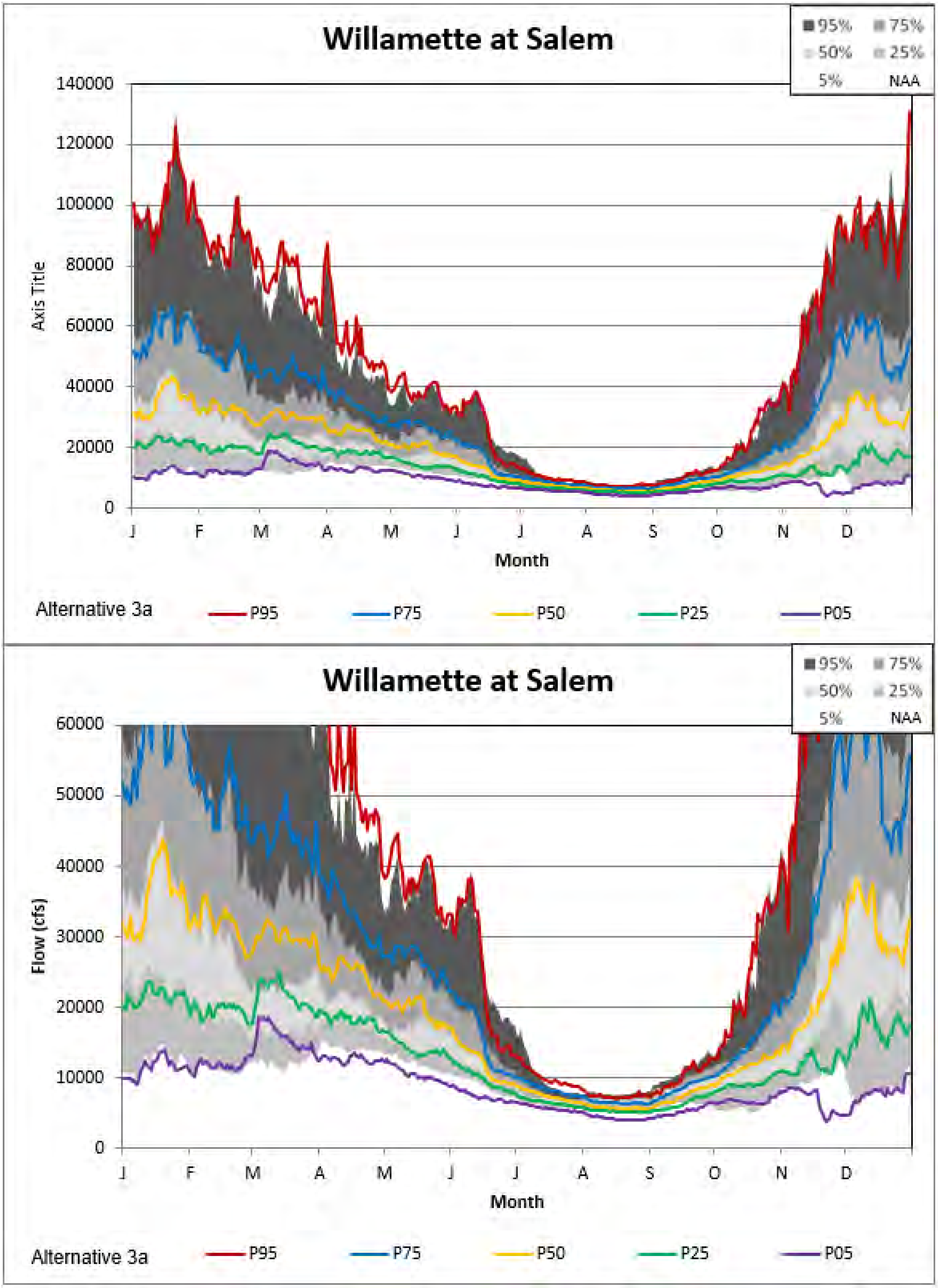


Figure 5-93. Salem Alternative 3a Non-Exceedance Plot

5.5 ALTERNATIVE 3B

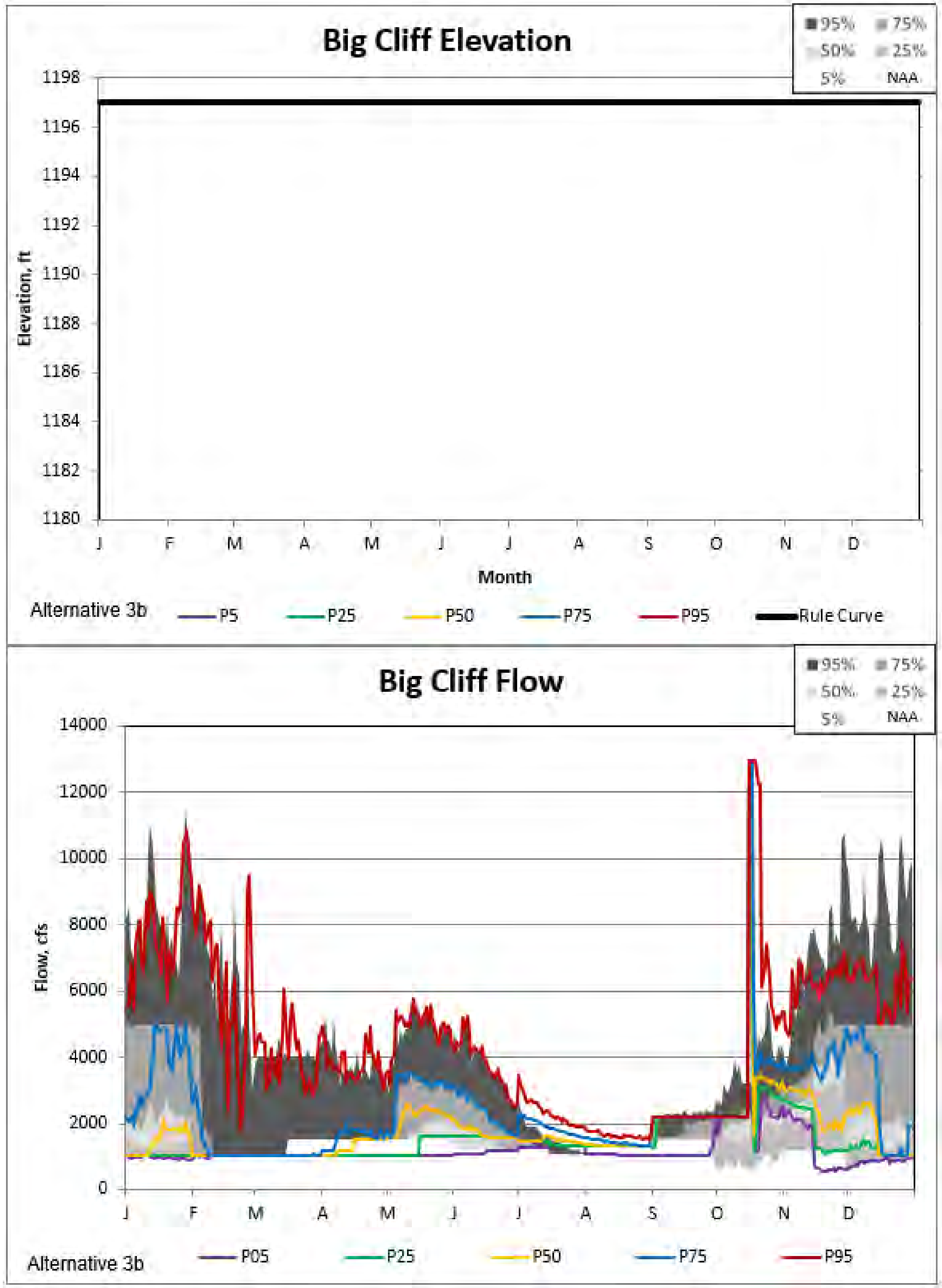


Figure 5-94. Big Cliff Alternative 3b Non-Exceedance Plot

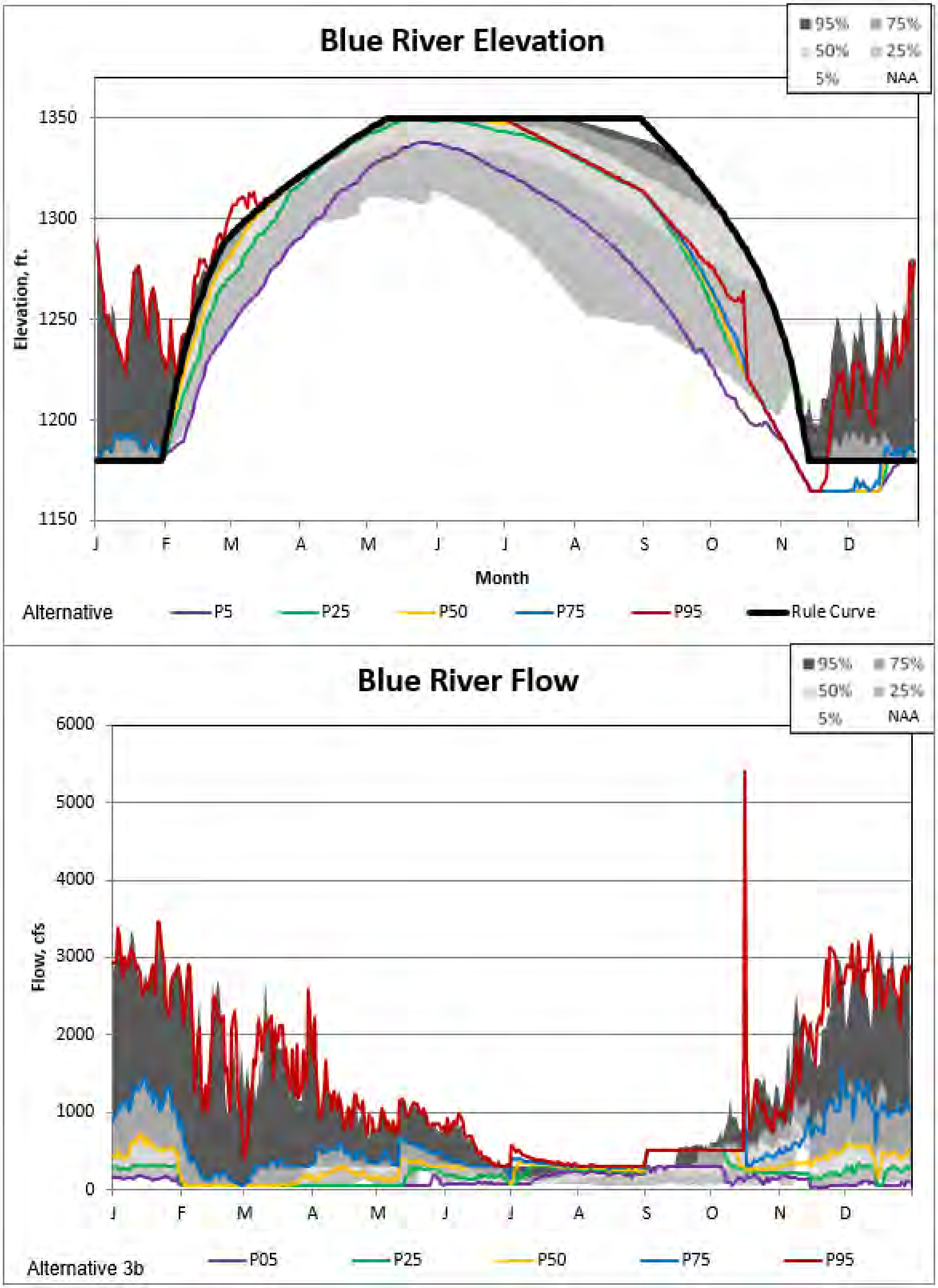


Figure 5-95. Blue River Alternative 3b Non-Exceedance Plot

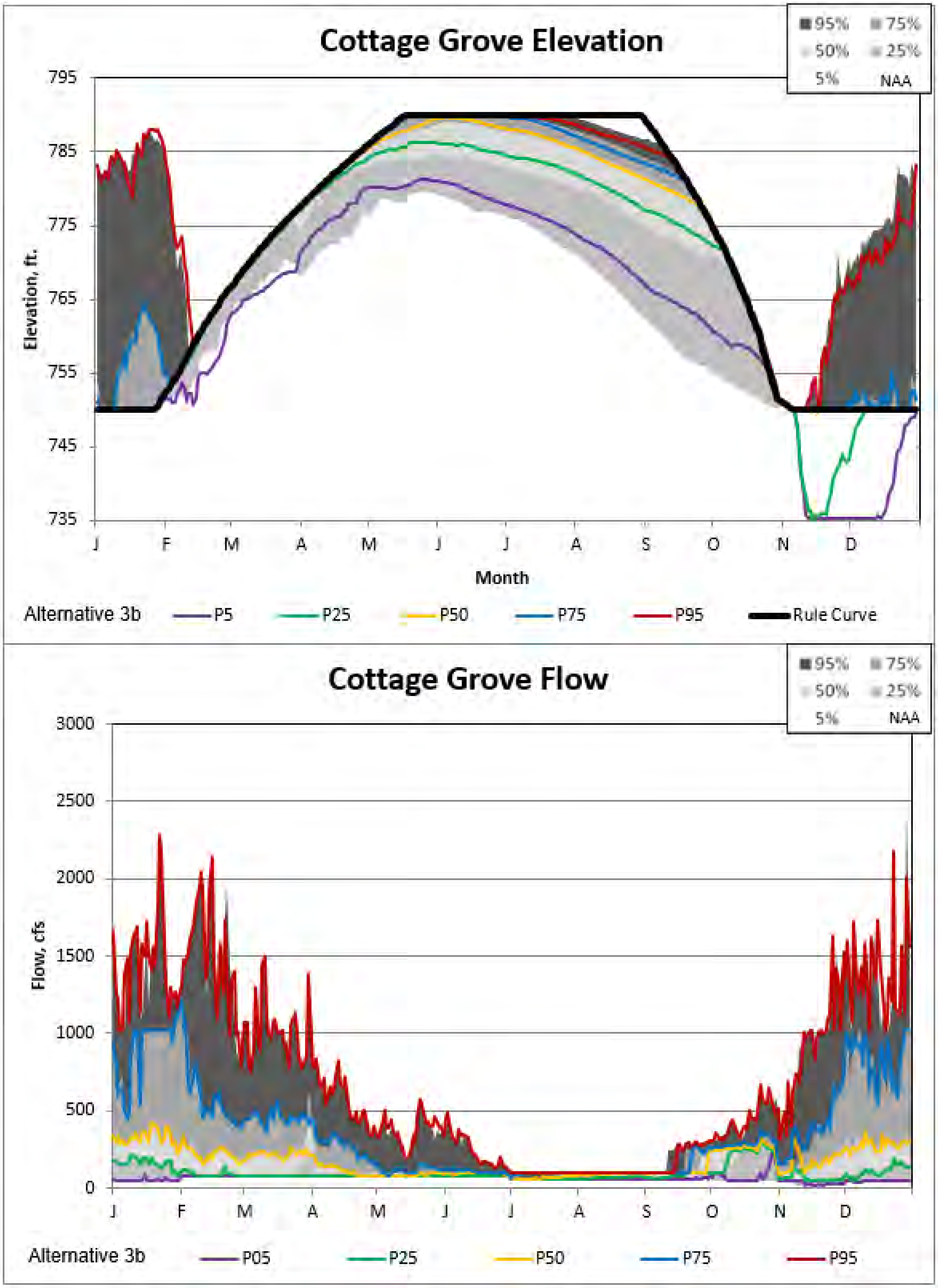


Figure 5-96. Cottage Grove Alternative 3b Non-Exceedance Plot

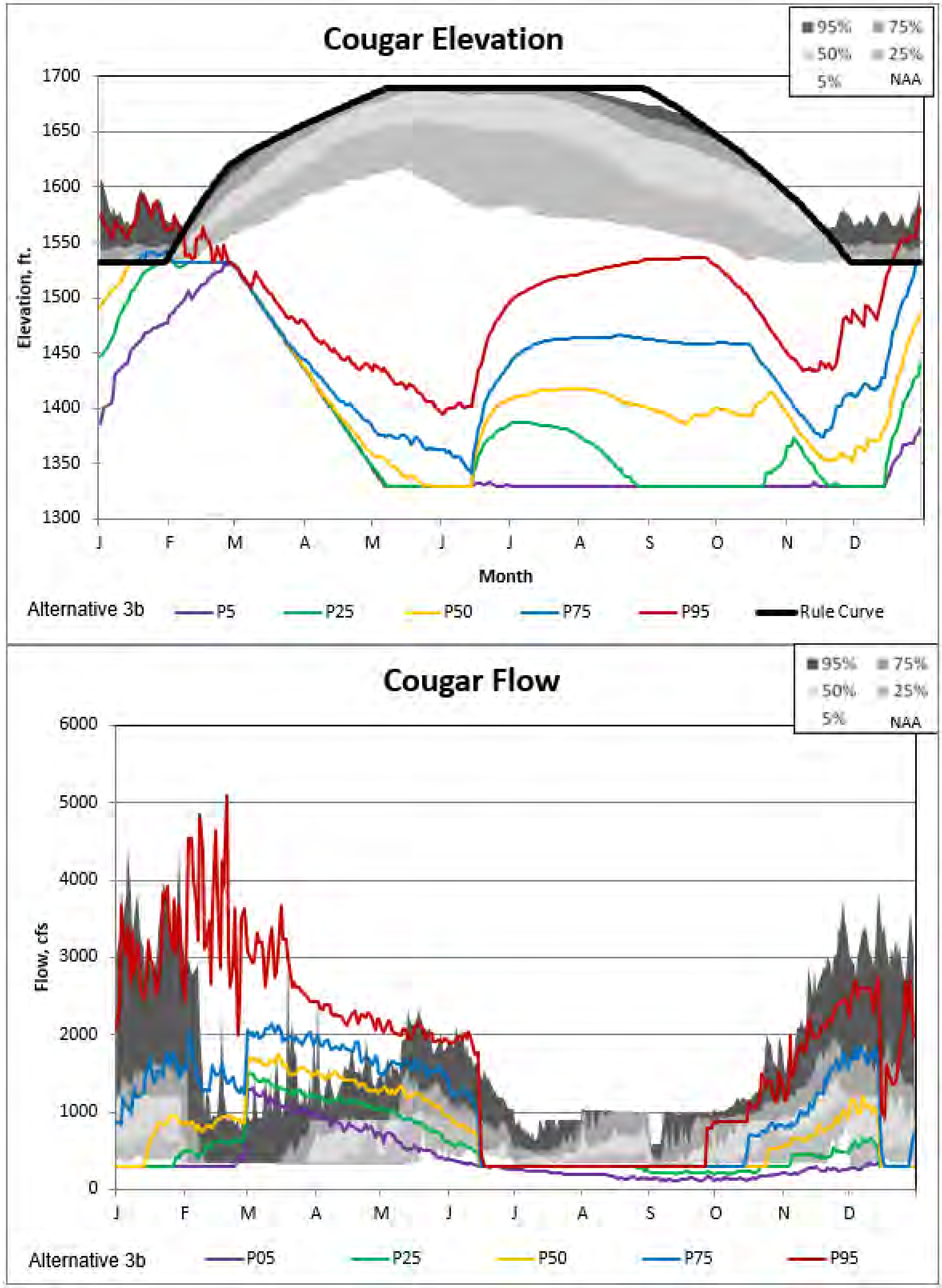


Figure 5-97. Cougar Alternative 3b Non-Exceedance Plot

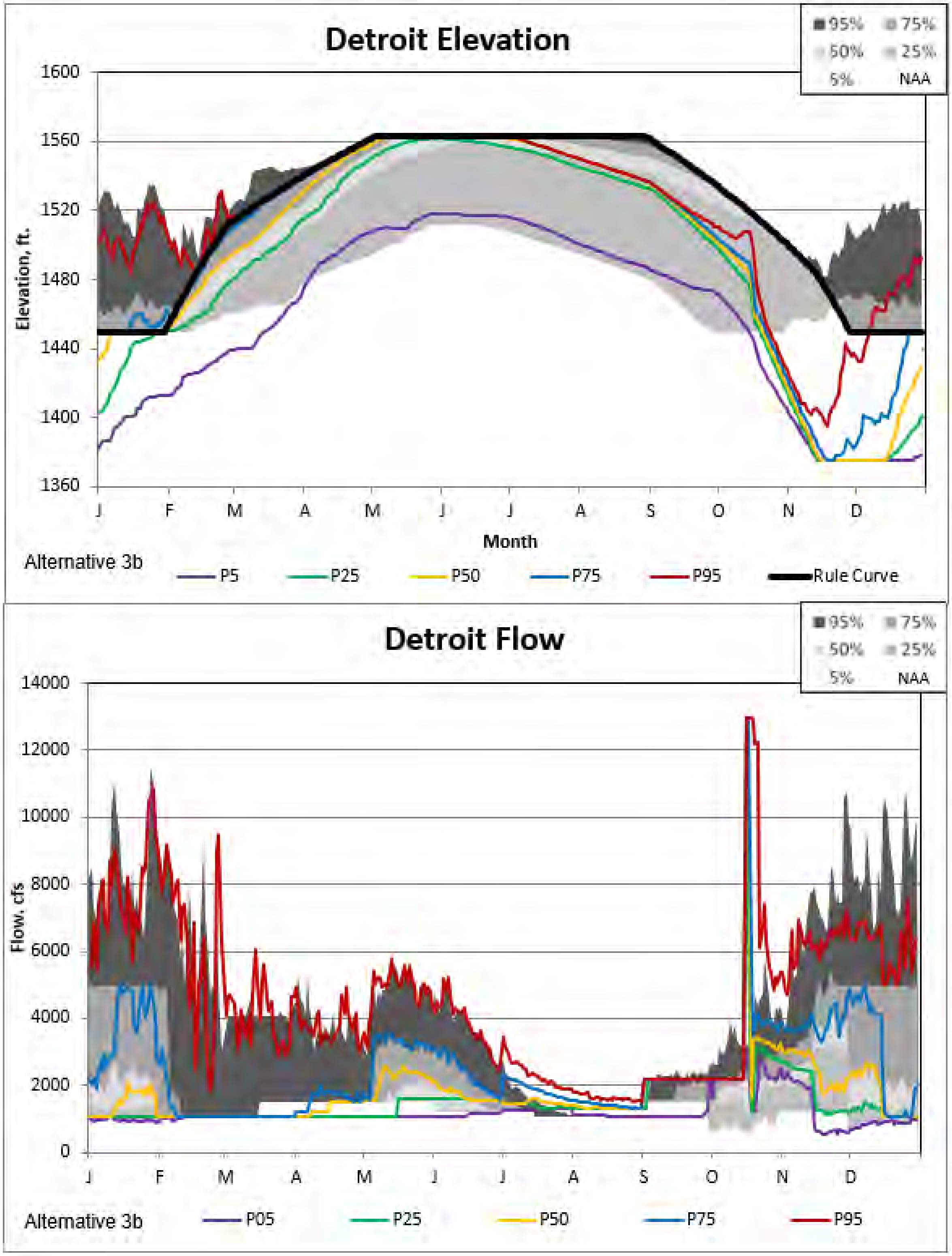


Figure 5-98. Detroit Alternative 3b Non-Exceedance Plot

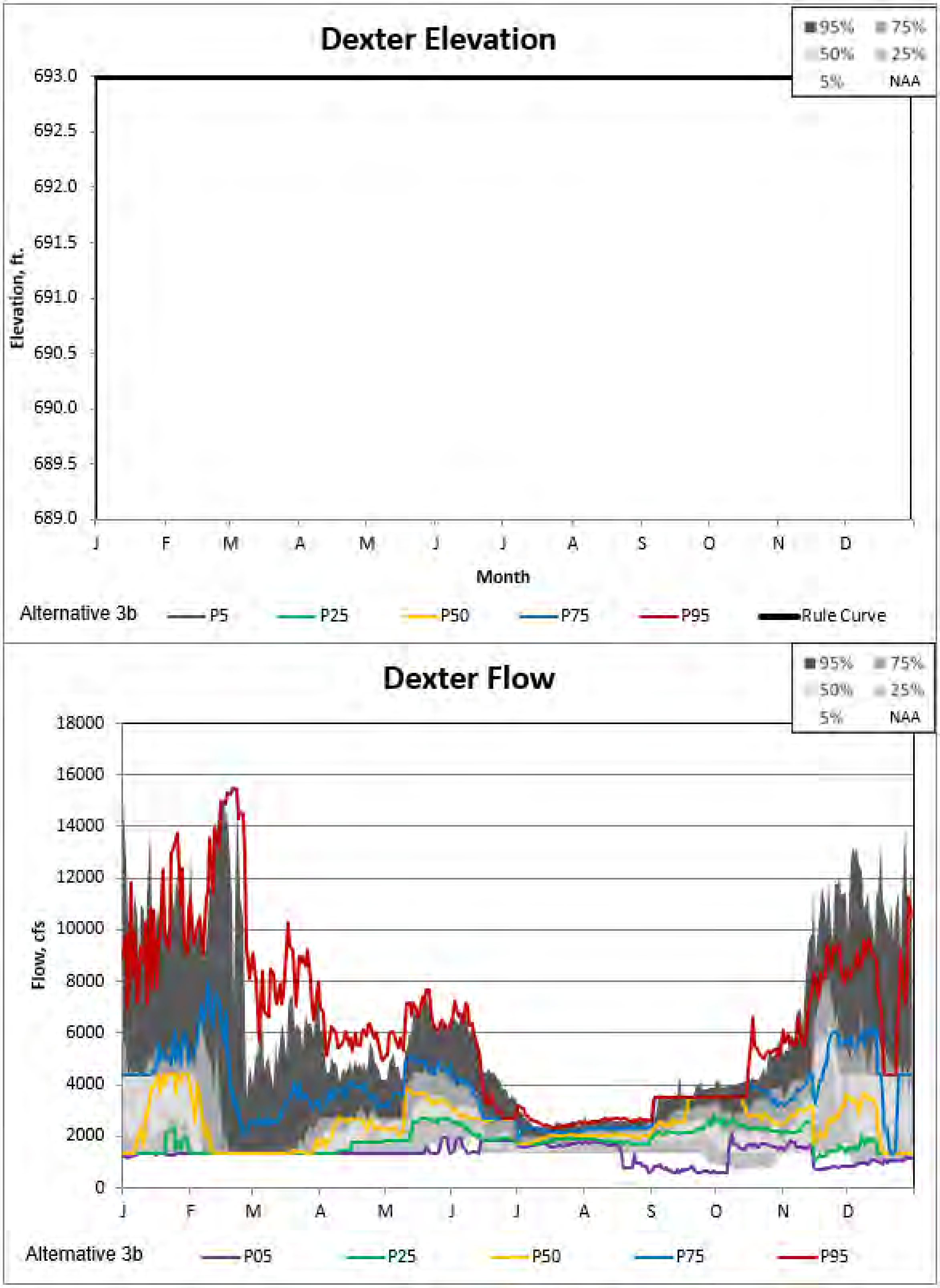


Figure 5-99. Dexter Alternative 3b Non-Exceedance Plot

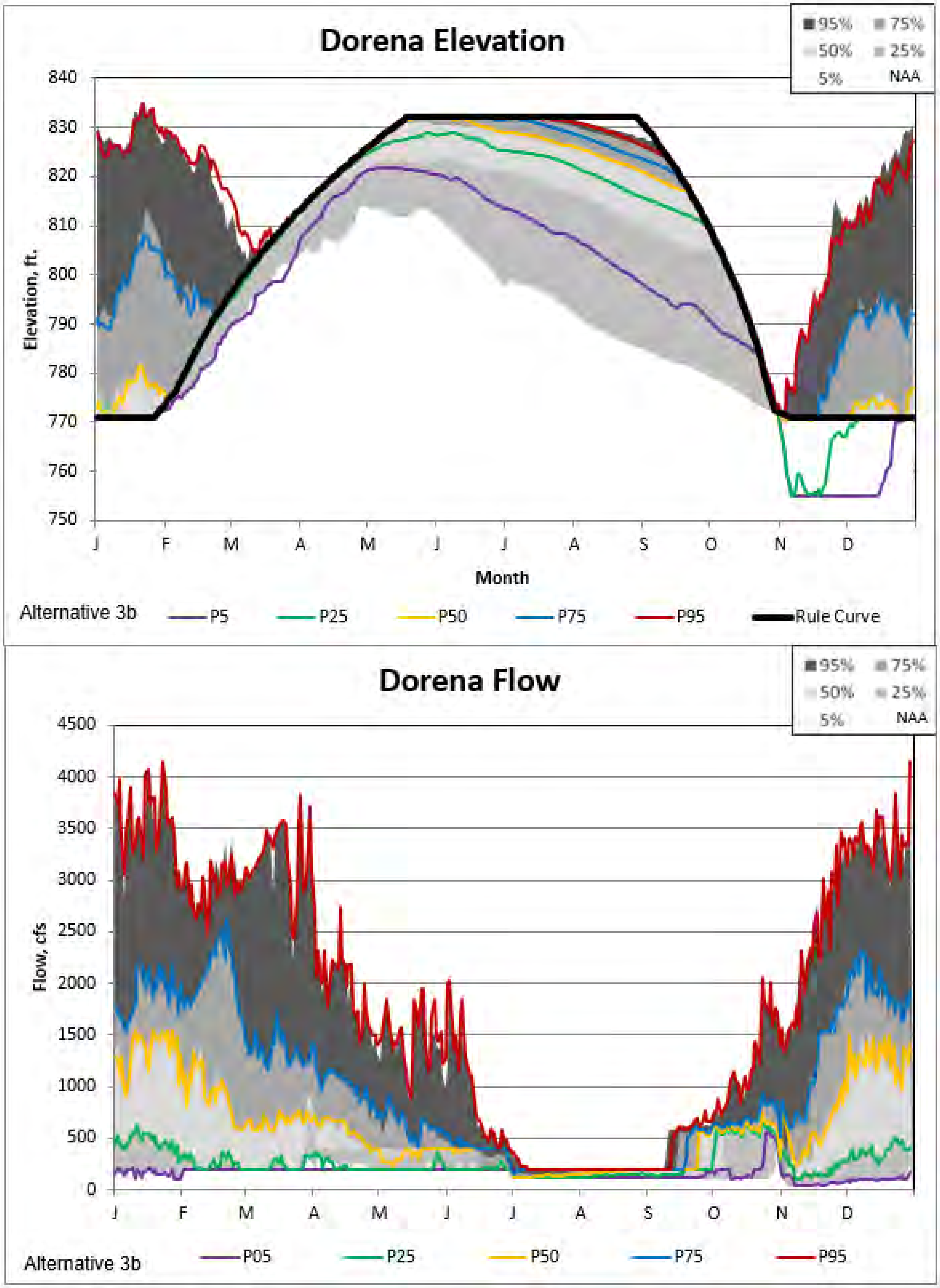


Figure 5-100. Dorena Alternative 3b Non-Exceedance Plot

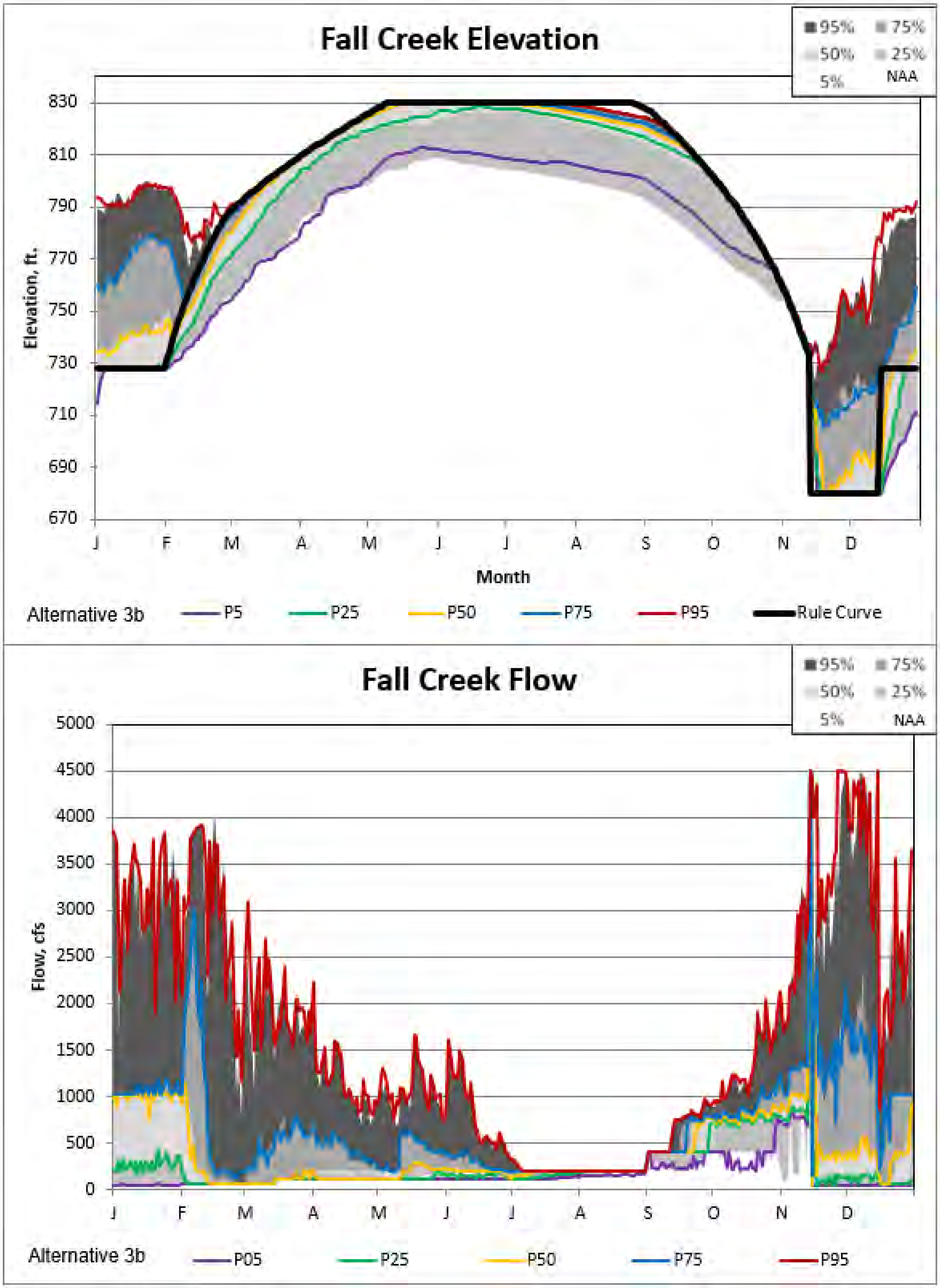


Figure 5-101. Fall Creek Alternative 3b Non-Exceedance Plot

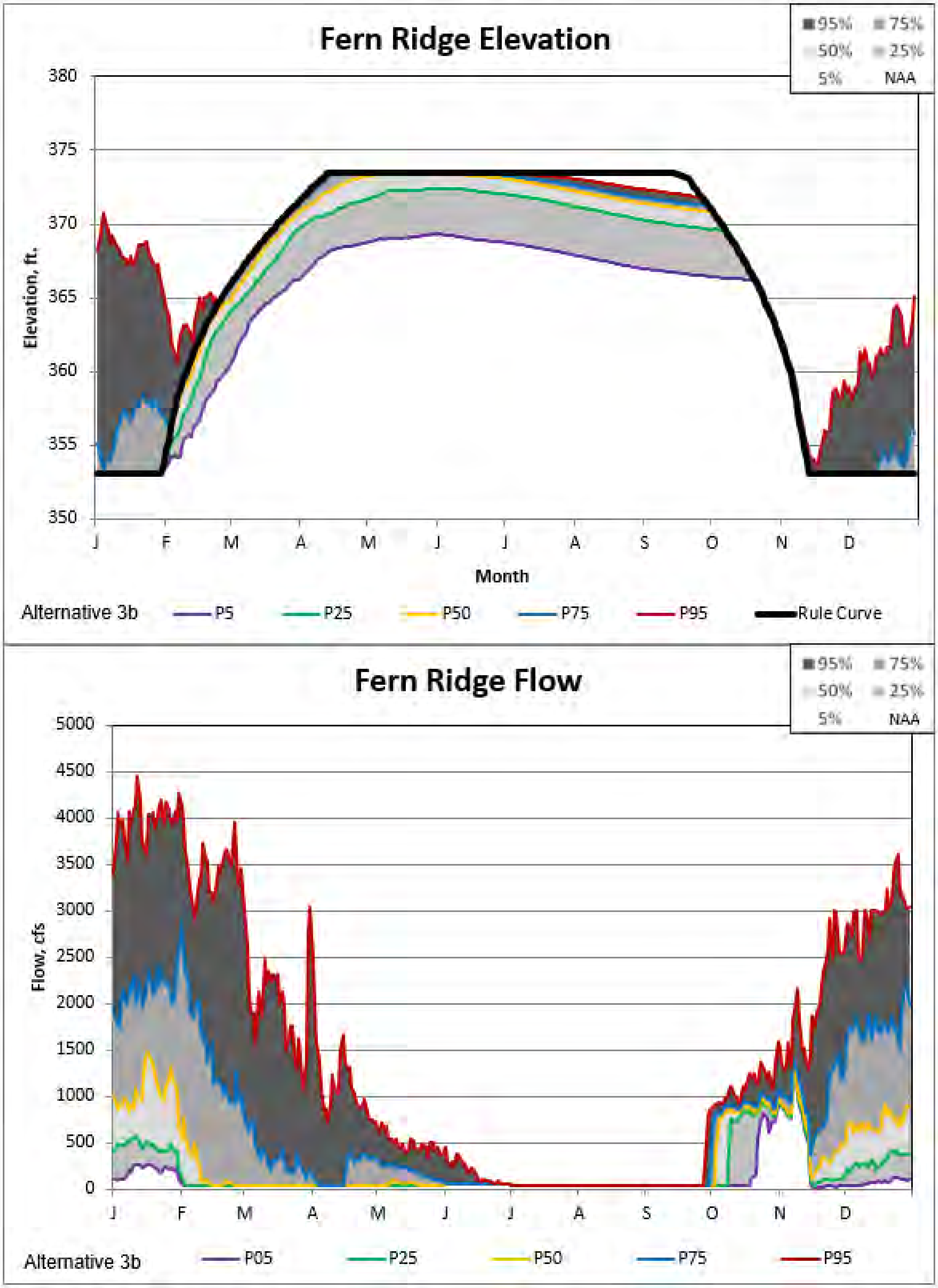


Figure 5-102. Fern Ridge Alternative 3b Non-Exceedance Plot

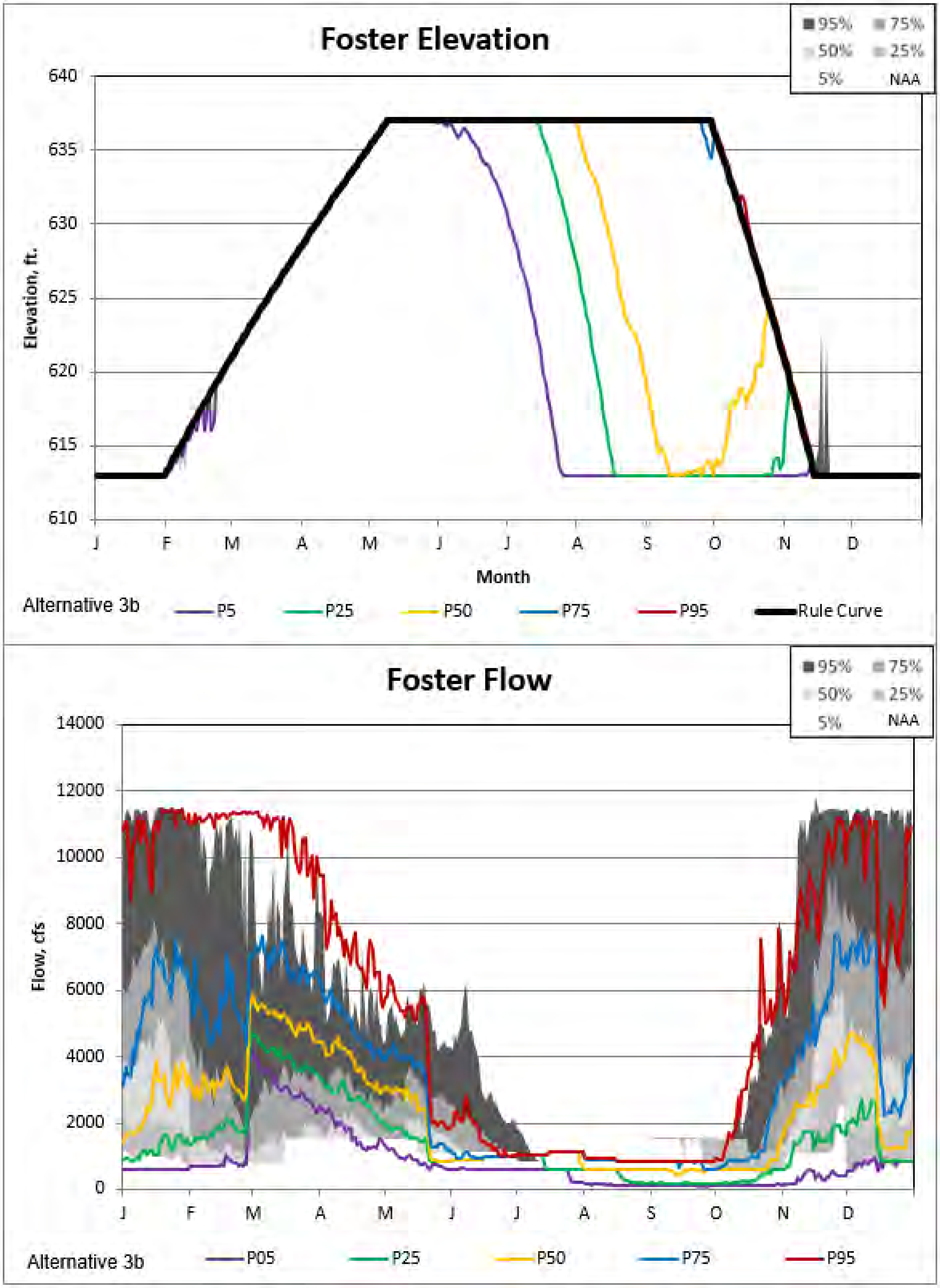


Figure 5-103. Foster Alternative 3b Non-Exceedance Plot

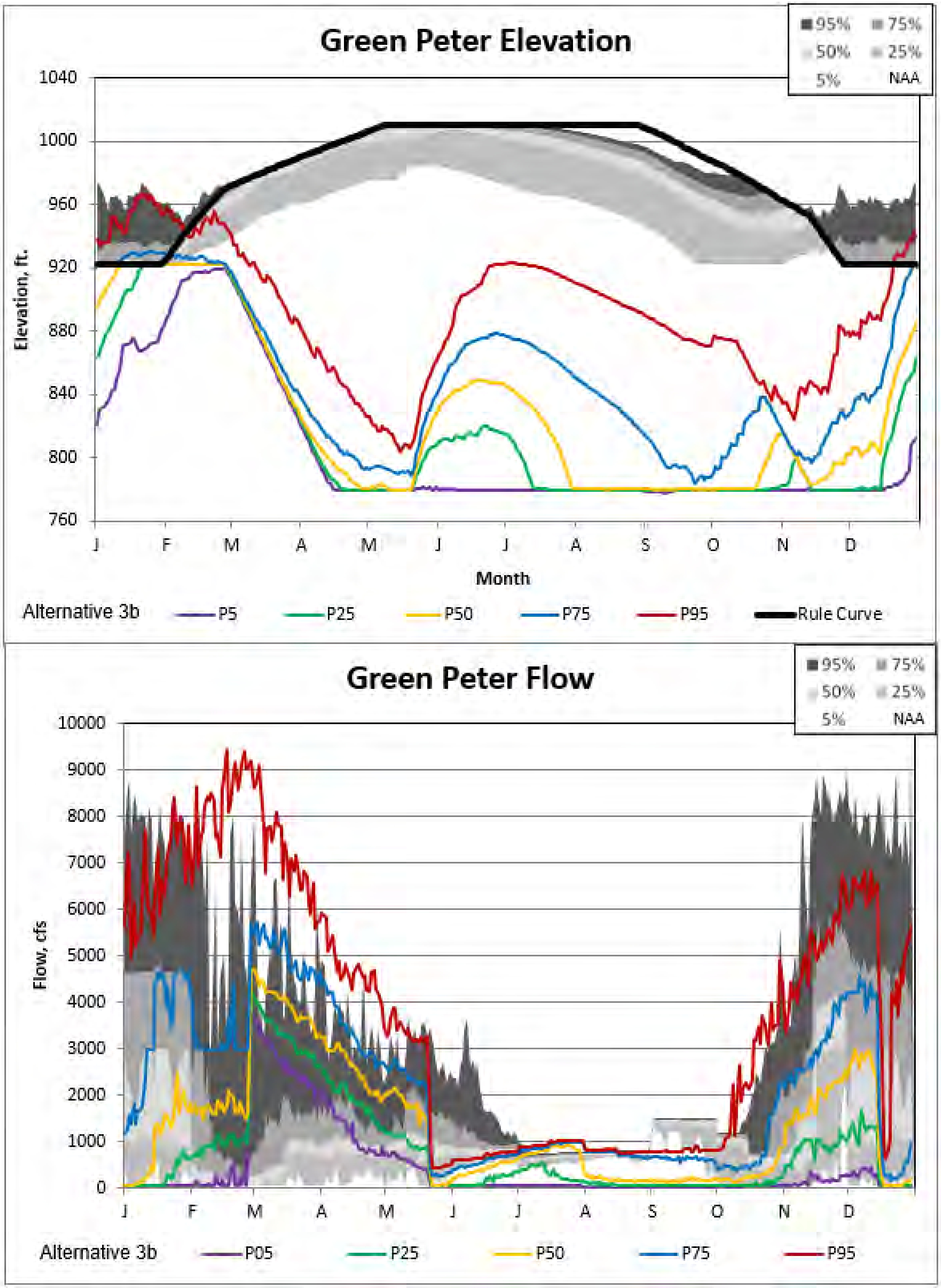


Figure 5-104. Green Peter Alternative 3b Non-Exceedance Plot

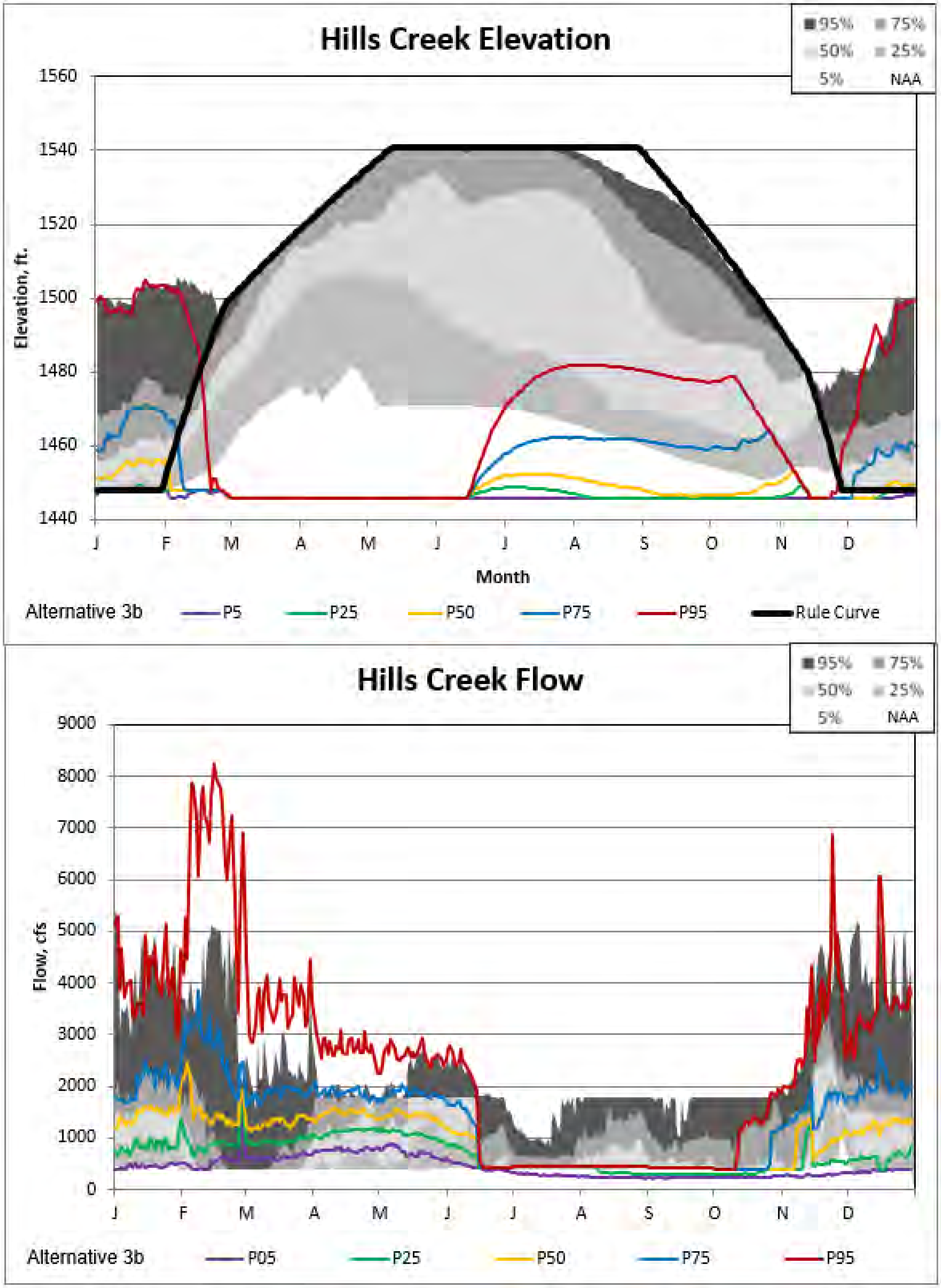


Figure 5-105. Hills Creek Alternative 3b Non-Exceedance Plot

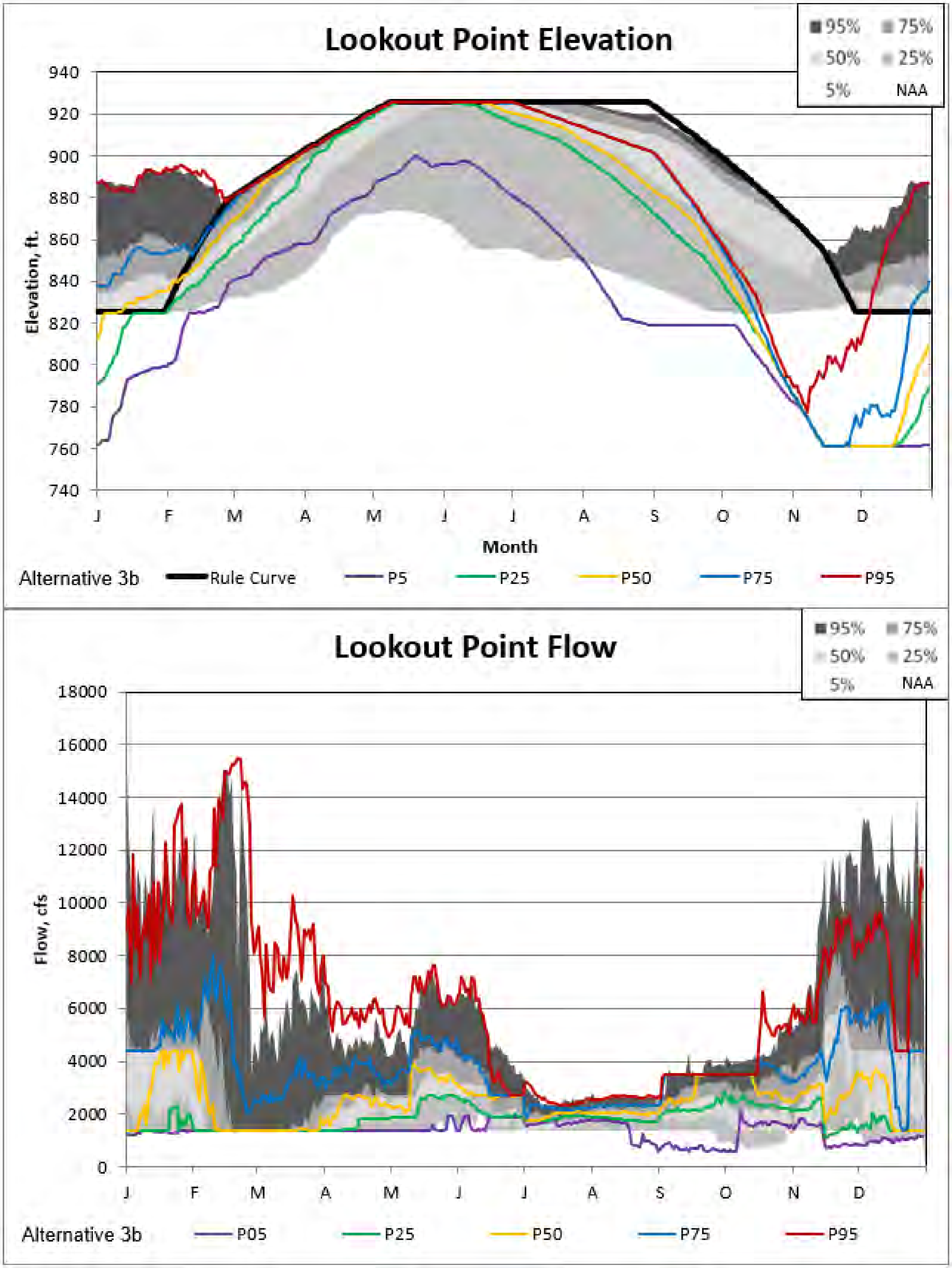


Figure 5-106. Lookout Point Alternative 3b Non-Exceedance Plot

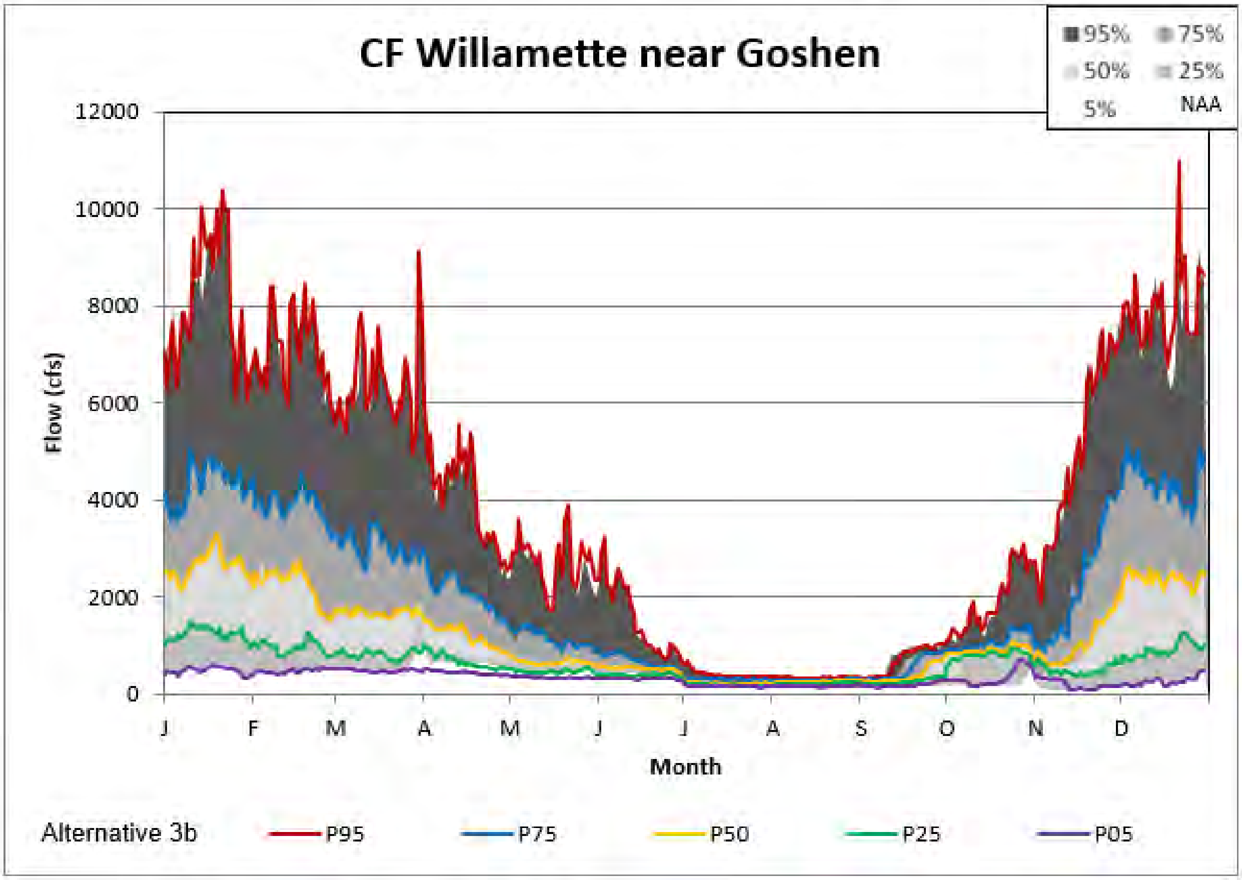


Figure 5-107. Goshen Alternative 3b Non-Exceedance Plot

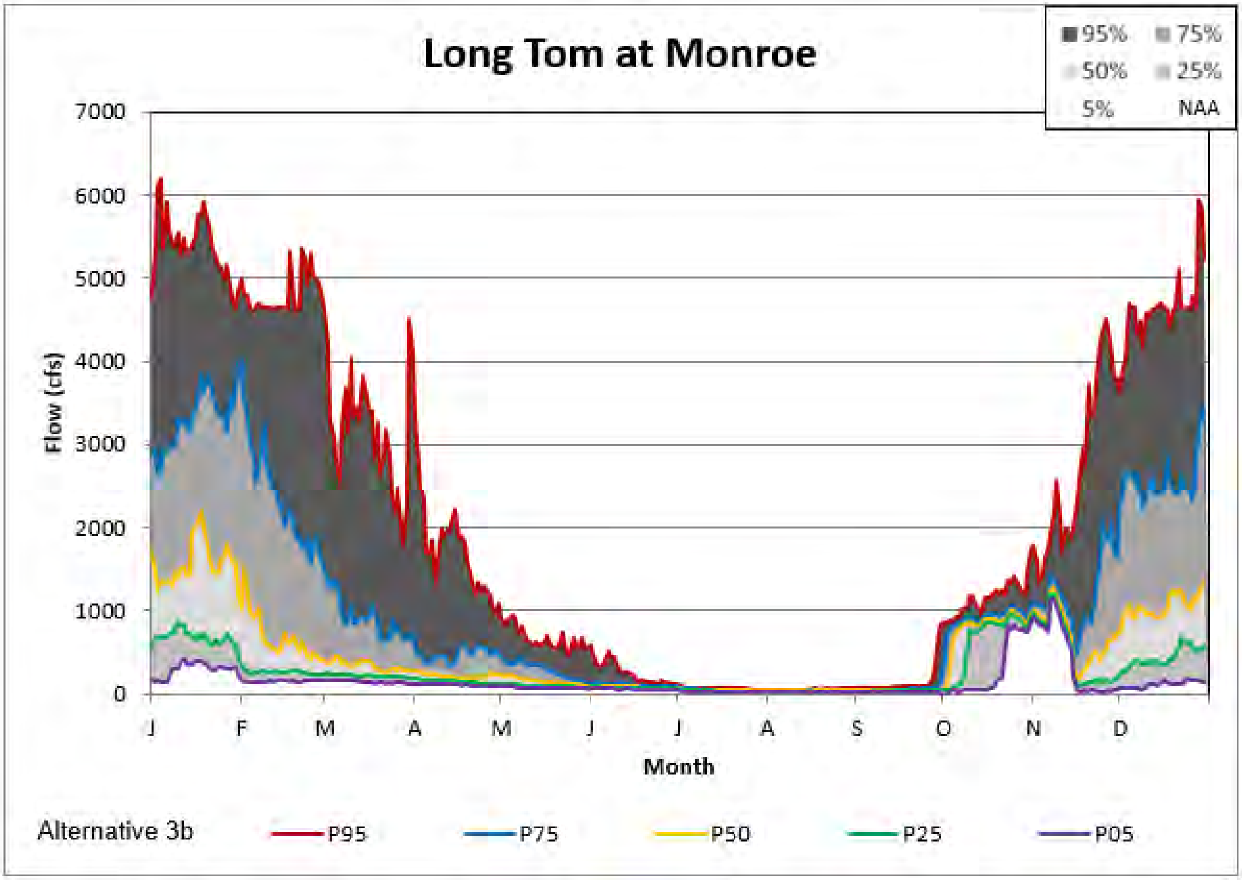


Figure 5-108. Monroe Alternative 3b Non-Exceedance Plot

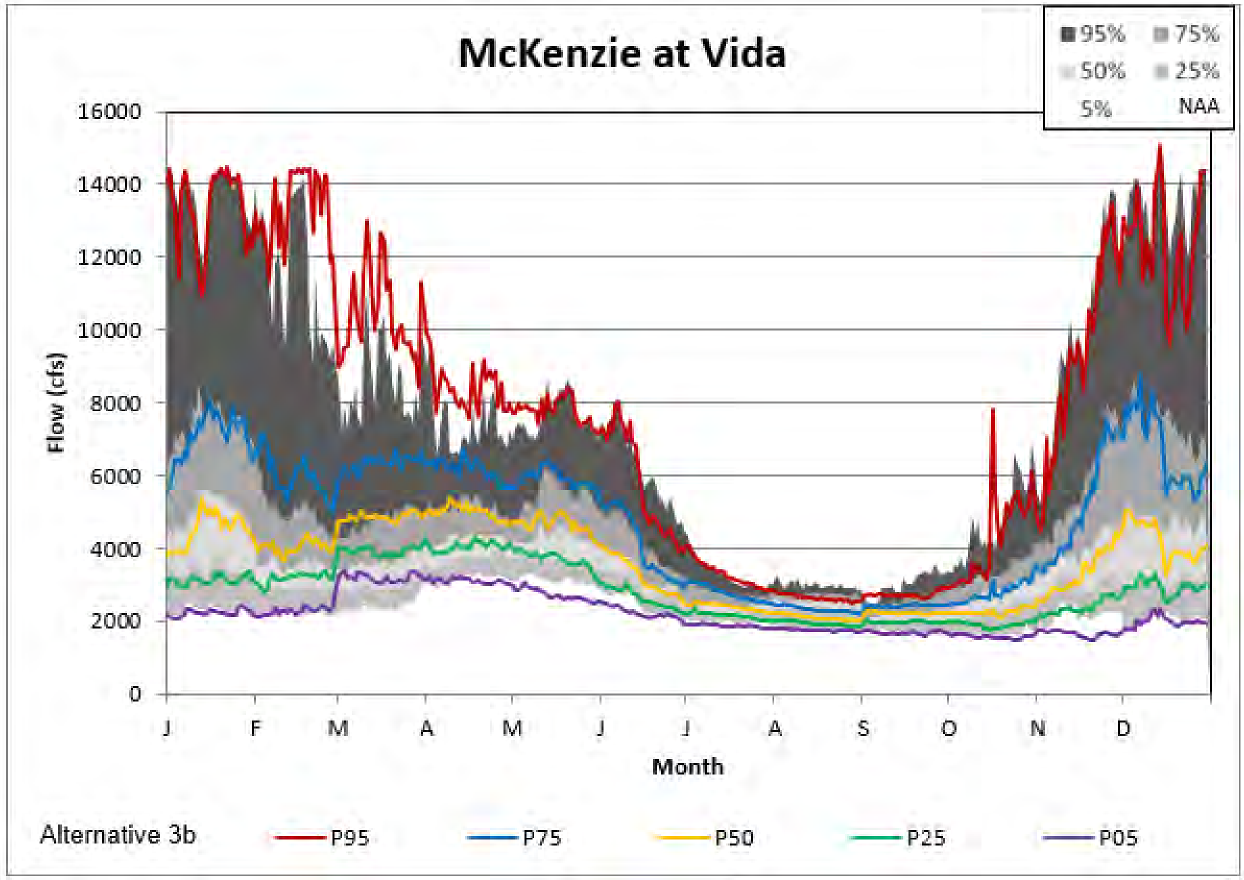


Figure 5-109. Vida Alternative 3b Non-Exceedance Plot

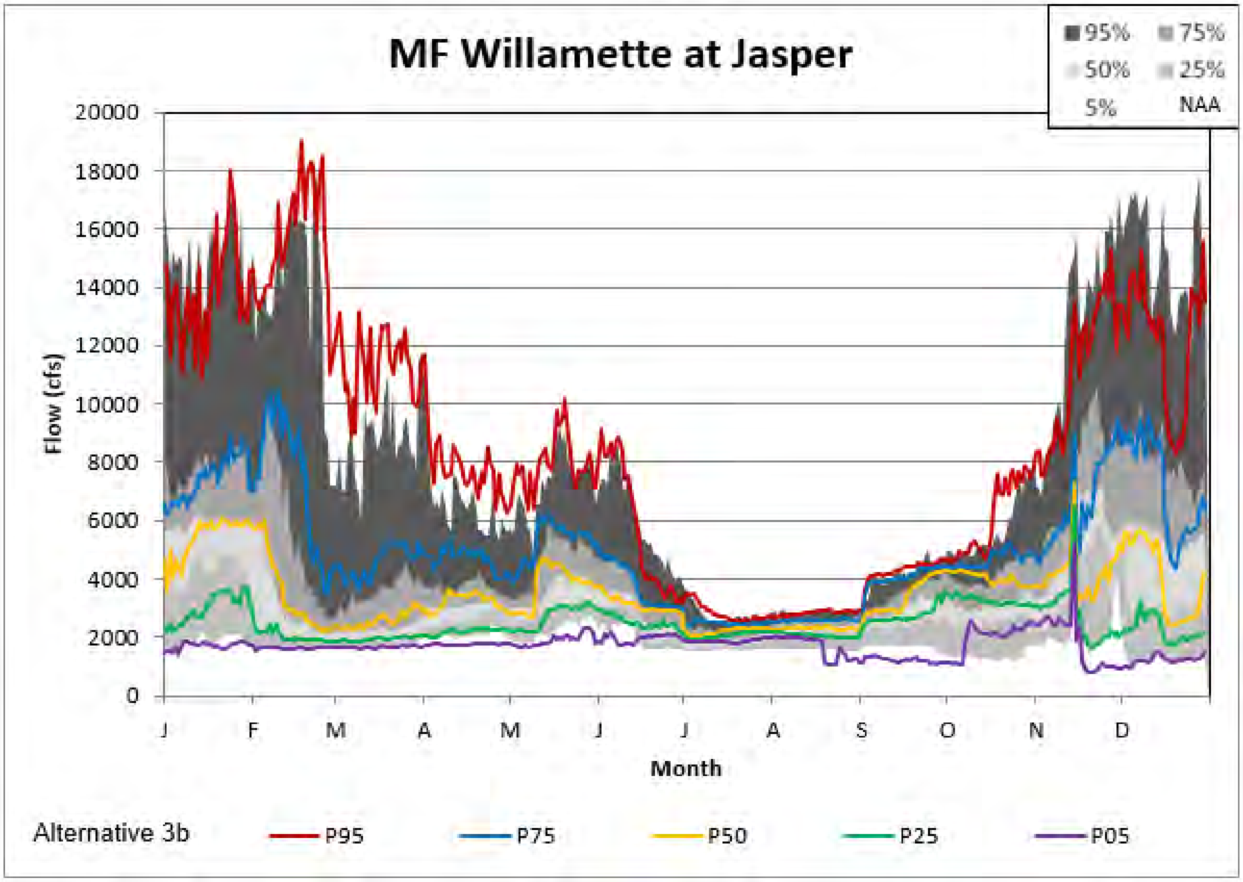


Figure 5-110. Jasper Alternative 3b Non-Exceedance Plot

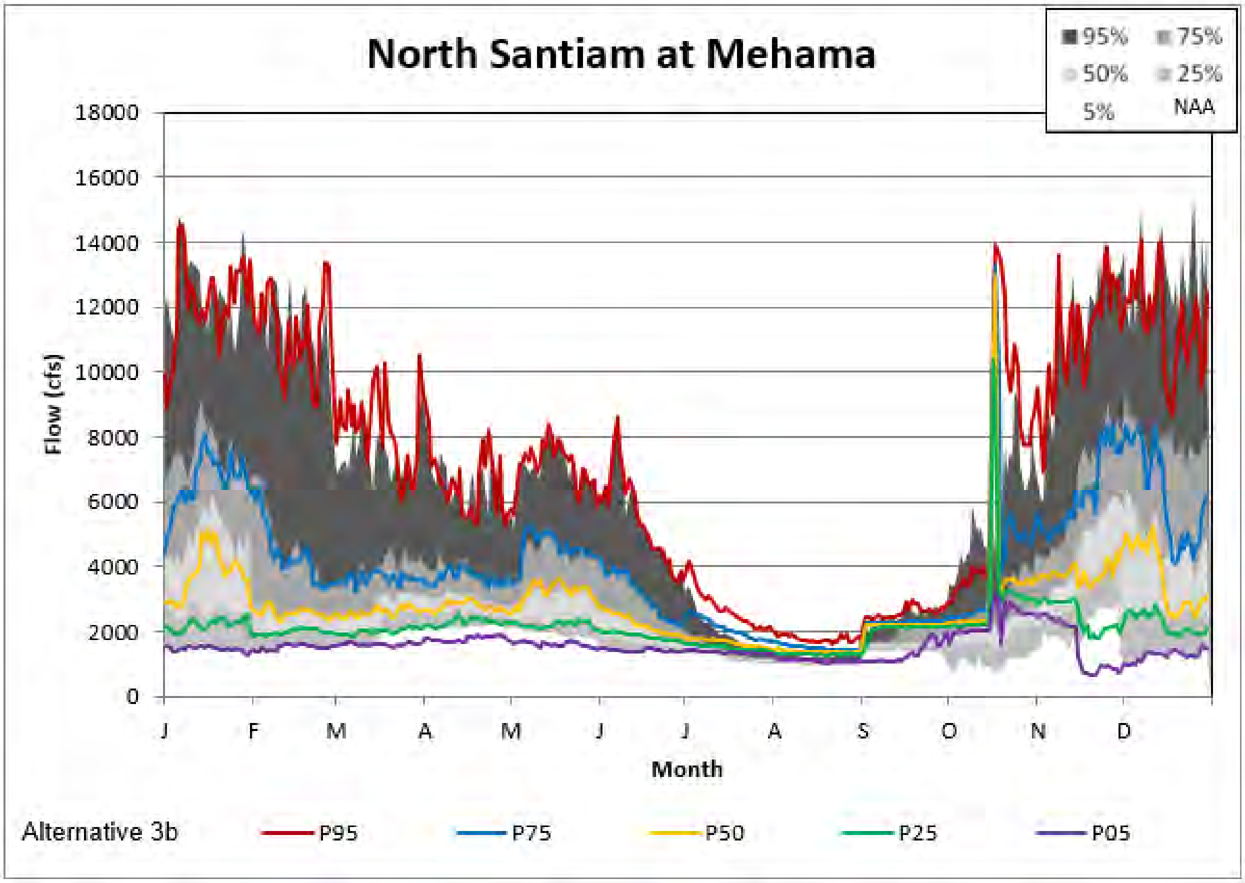


Figure 5-111. Mehama Alternative 3b Non-Exceedance Plot

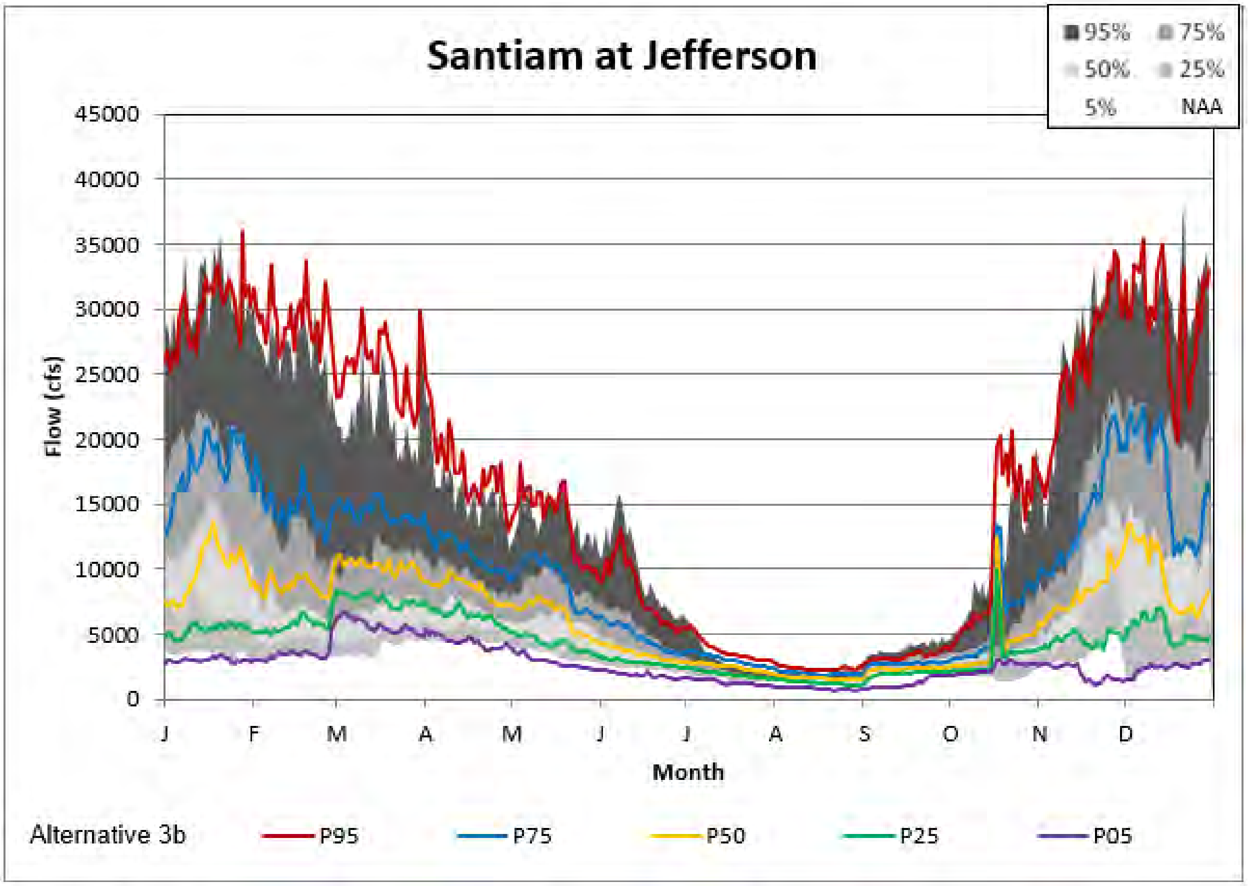


Figure 5-112. Jefferson Alternative 3b Non-Exceedance Plot

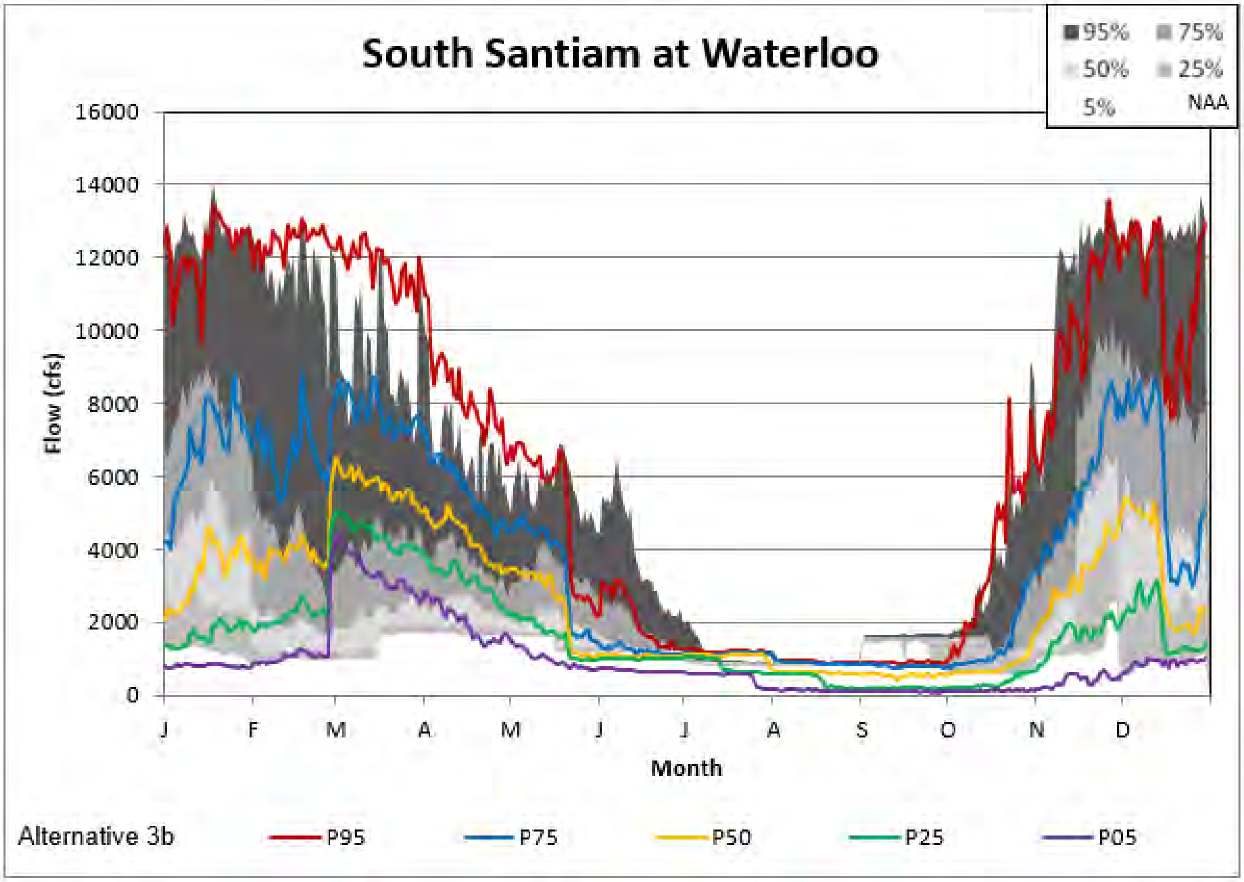


Figure 5-113. Waterloo Alternative 3b Non-Exceedance Plot

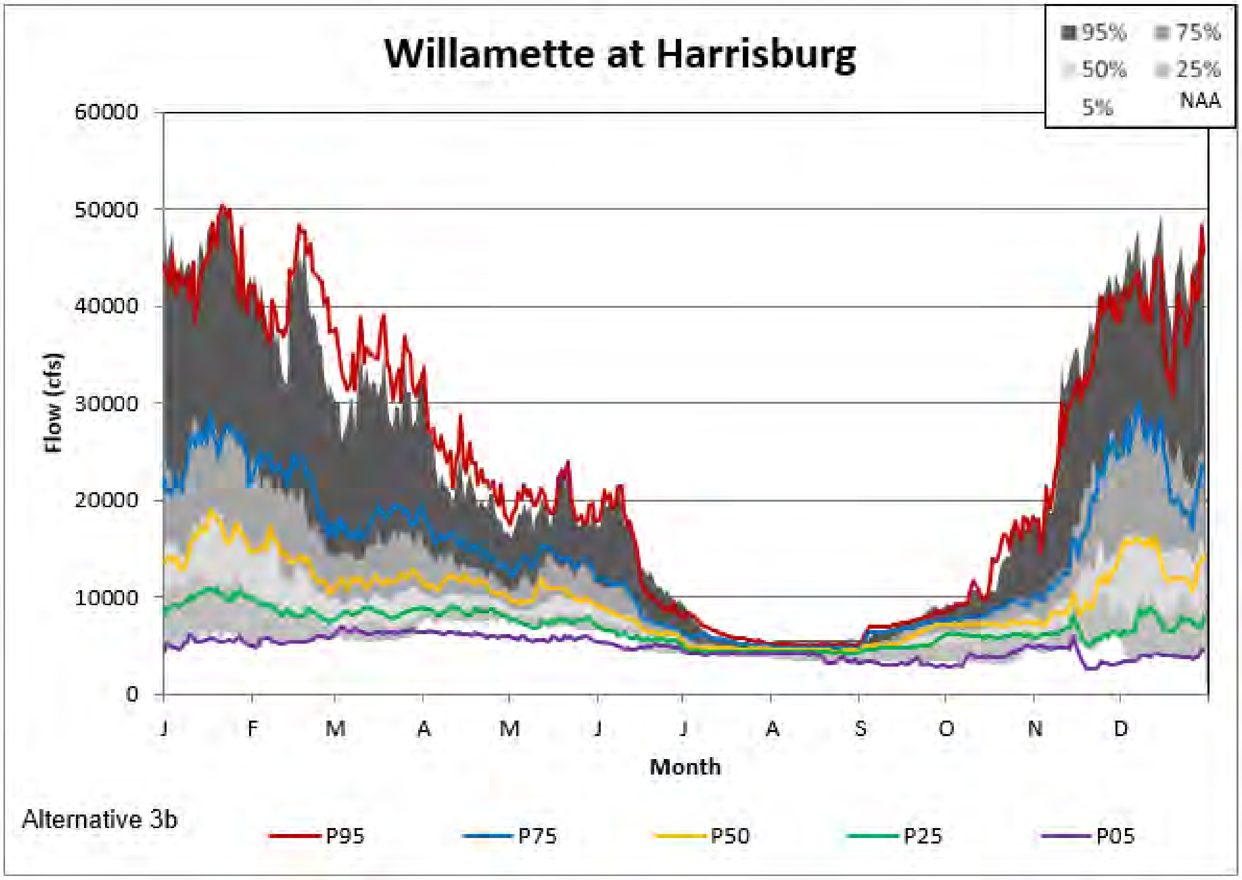


Figure 5-114. Harrisburg Alternative 3b Non-Exceedance Plot

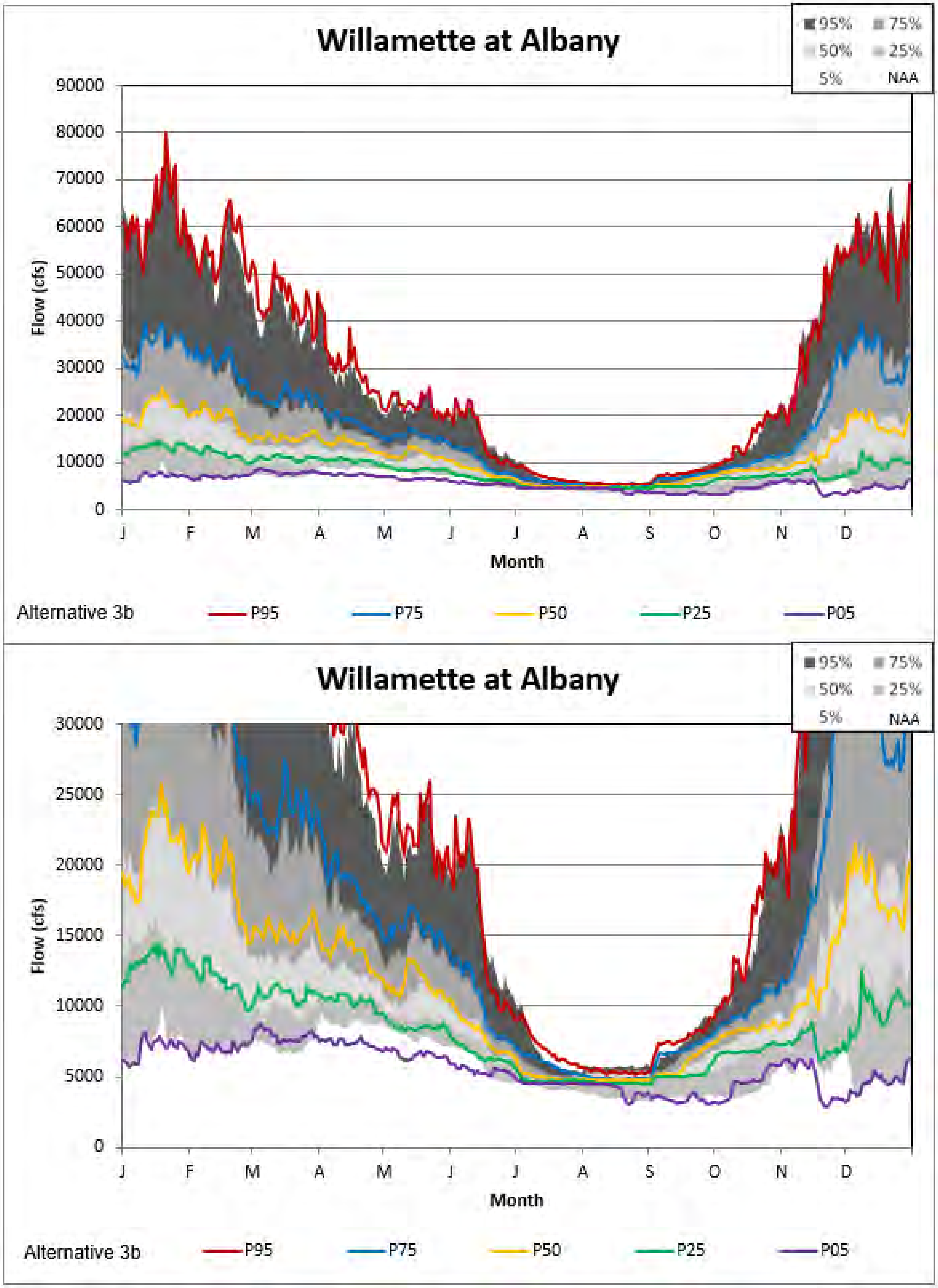


Figure 5-115. Albany Alternative 3b Non-Exceedance Plot

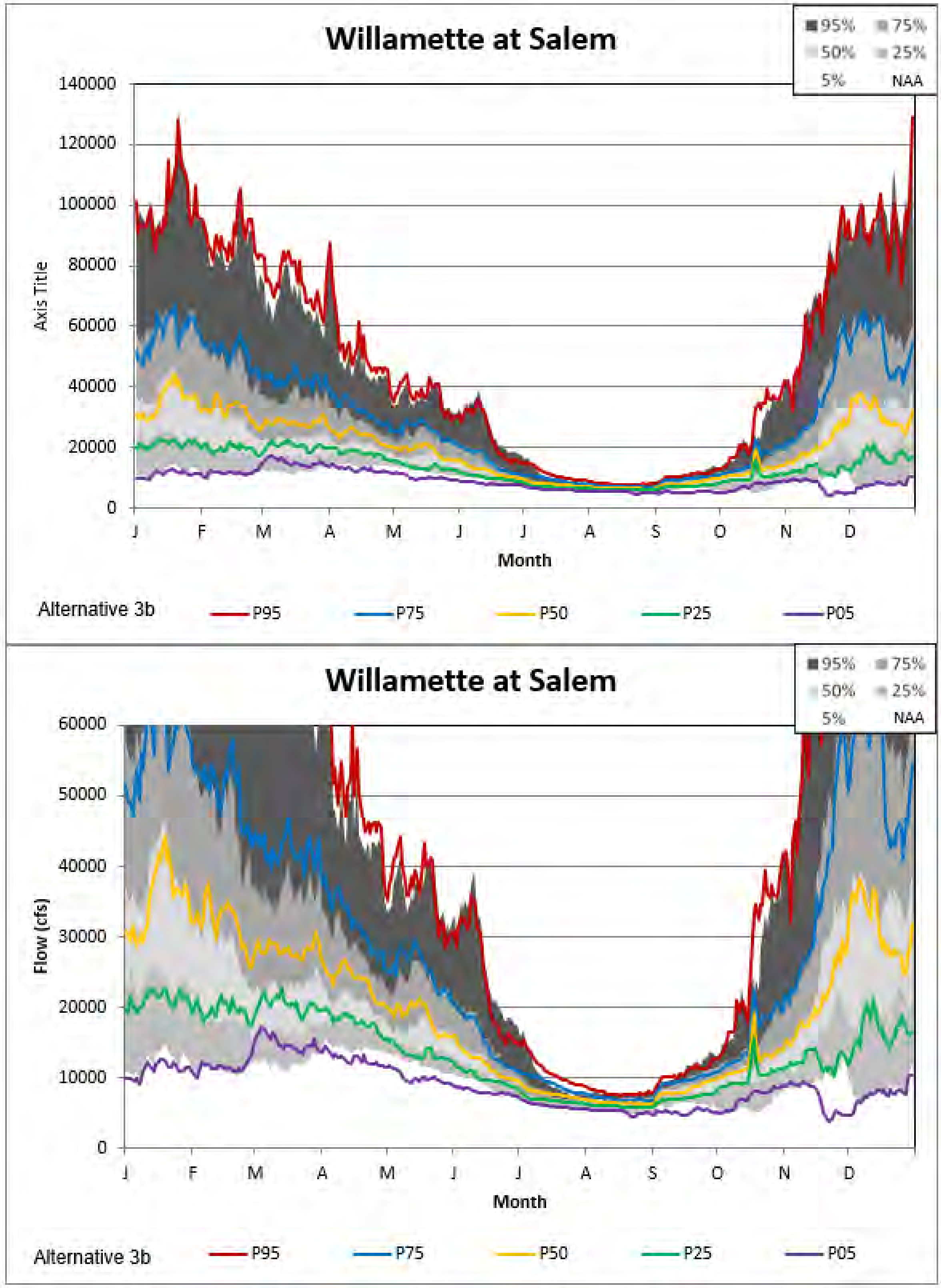


Figure 5-116. Salem Alternative 3b Non-Exceedance Plot

5.6 ALTERNATIVE 4

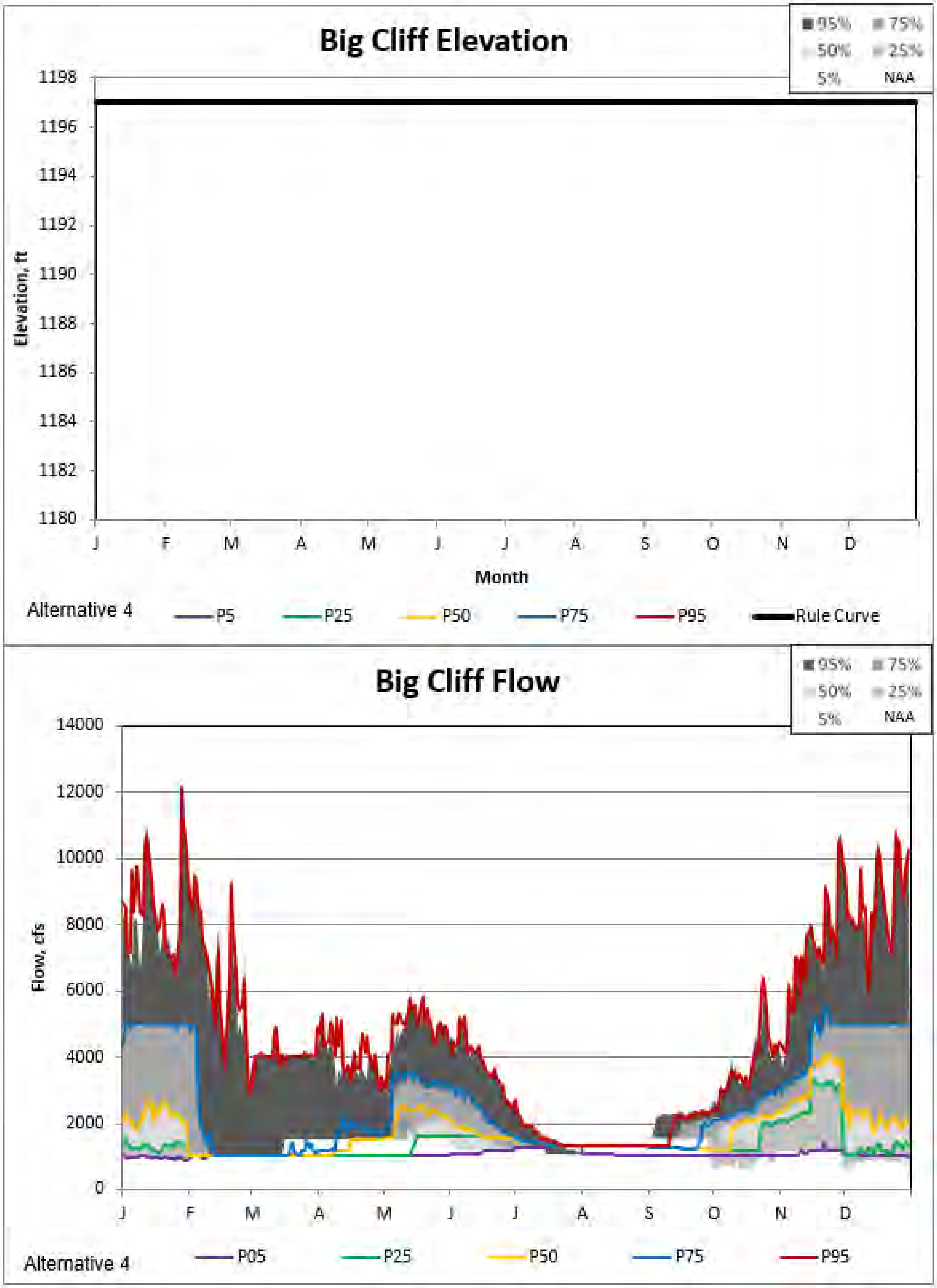


Figure 5-117. Big Cliff Alternative 4 Non-Exceedance Plot

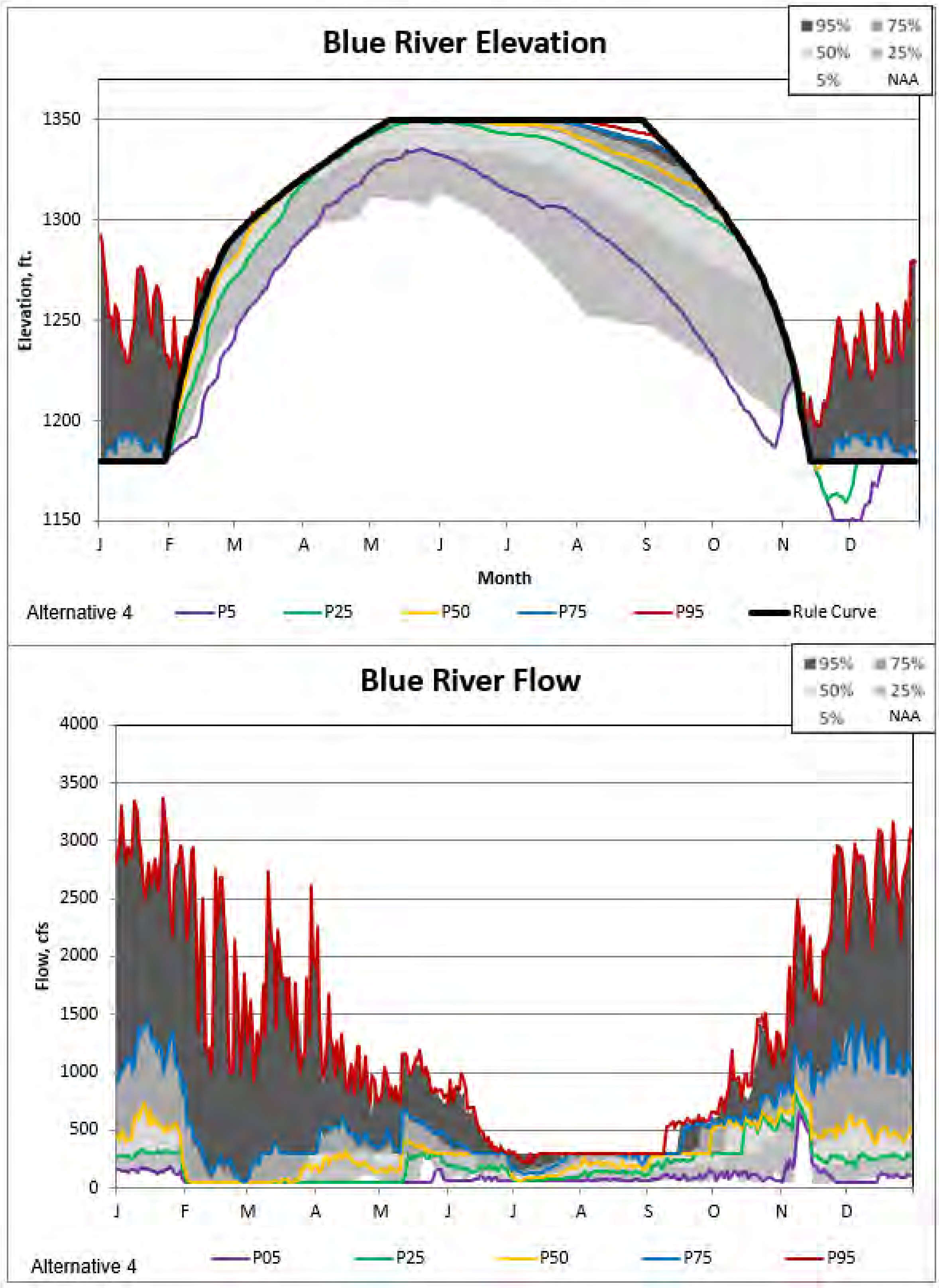


Figure 5-118. Blue River Alternative 4 Non-Exceedance Plot

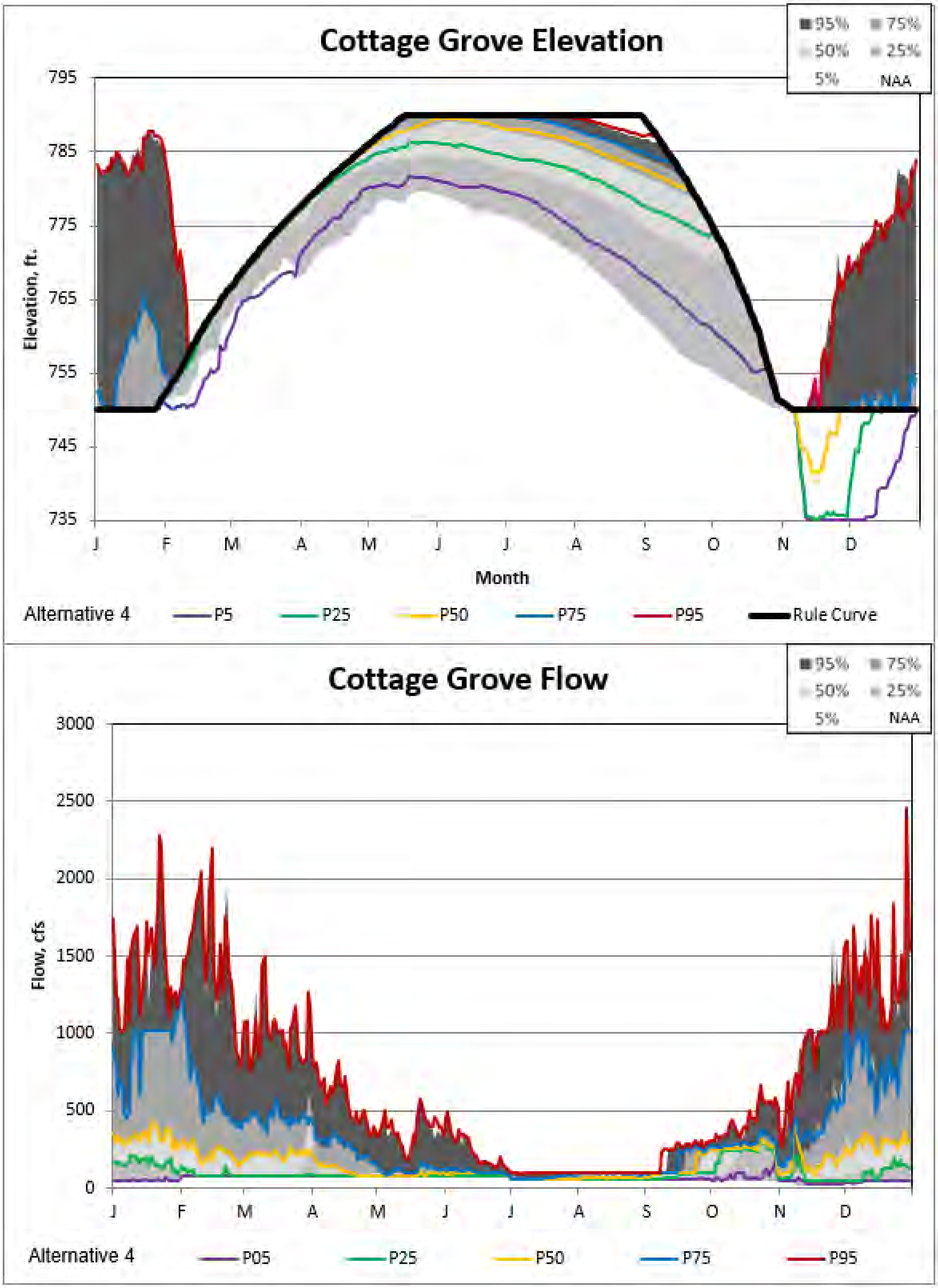


Figure 5-119. Cottage Grove Alternative 4 Non-Exceedance Plot

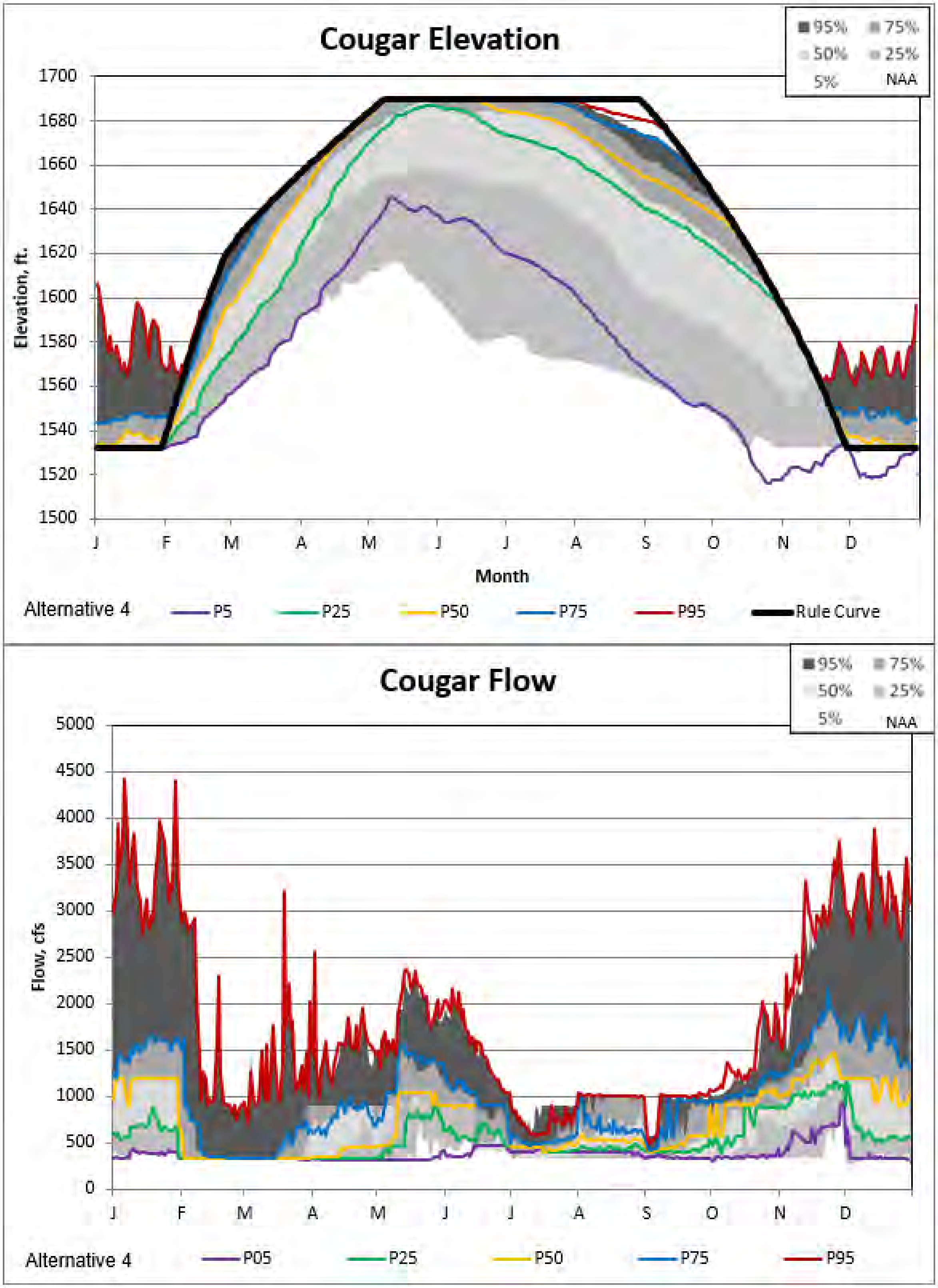


Figure 5-120. Cougar Alternative 4 Non-Exceedance Plot

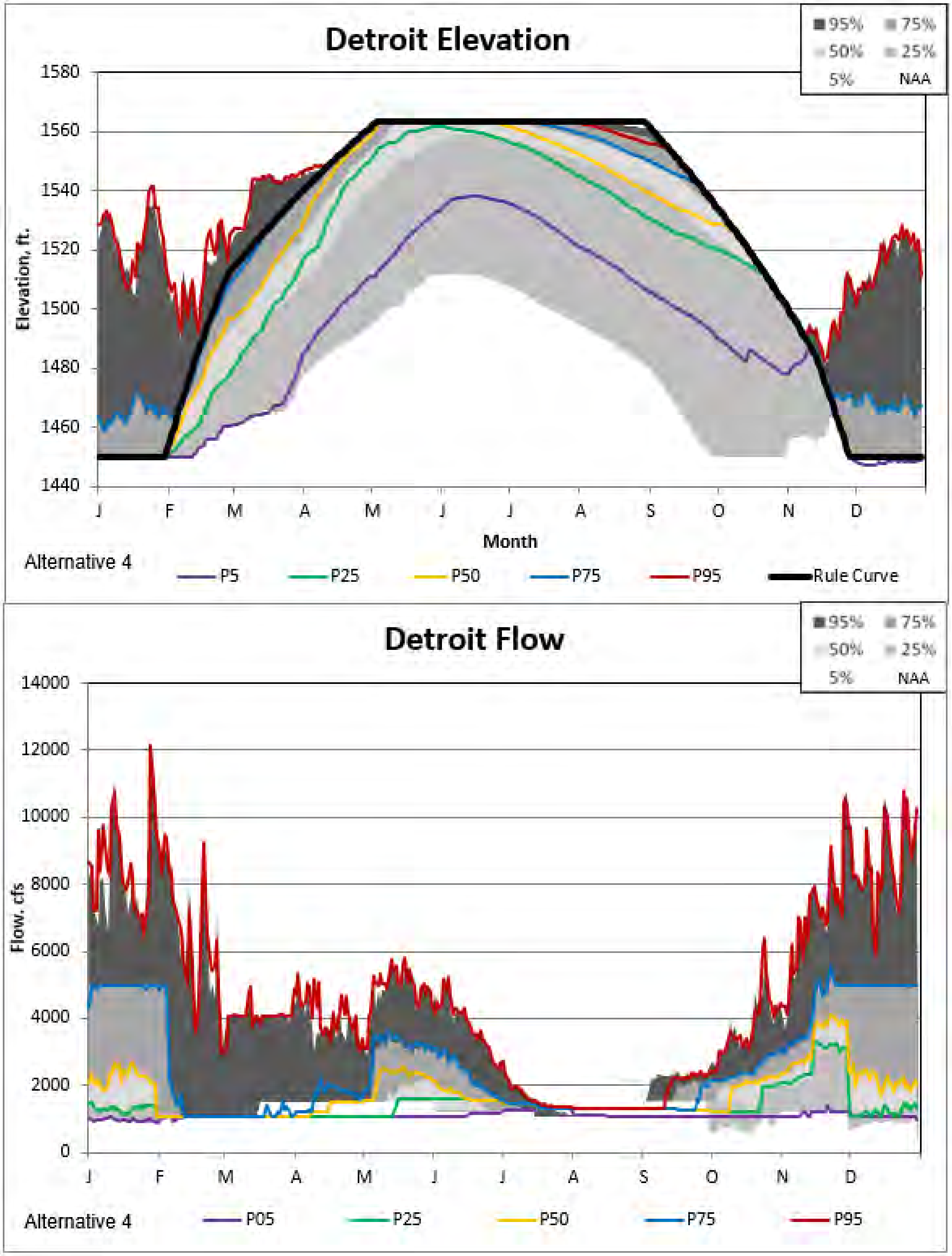


Figure 5-121. Detroit Alternative 4 Non-Exceedance Plot

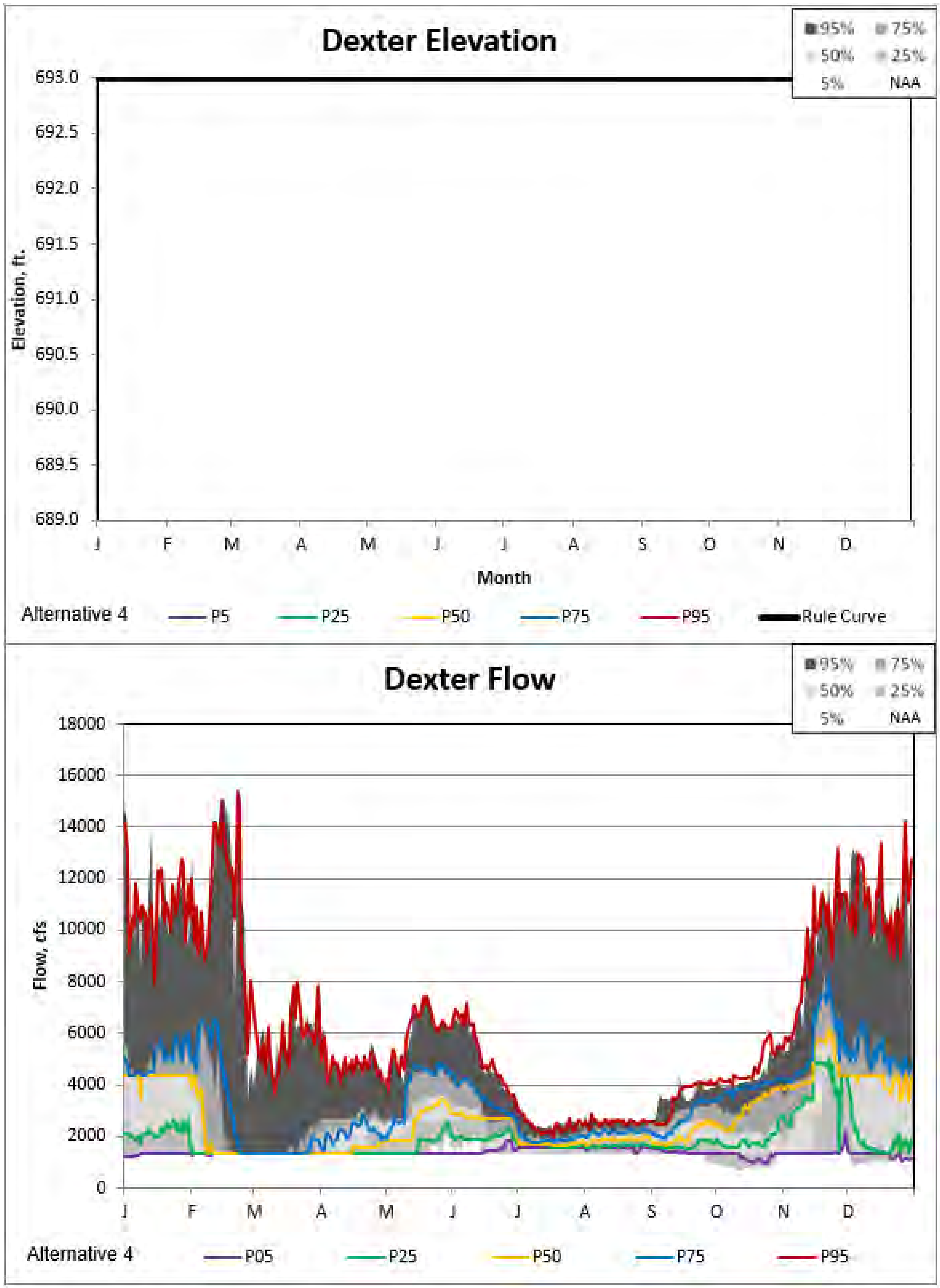


Figure 5-122. Dexter Alternative 4 Non-Exceedance Plot

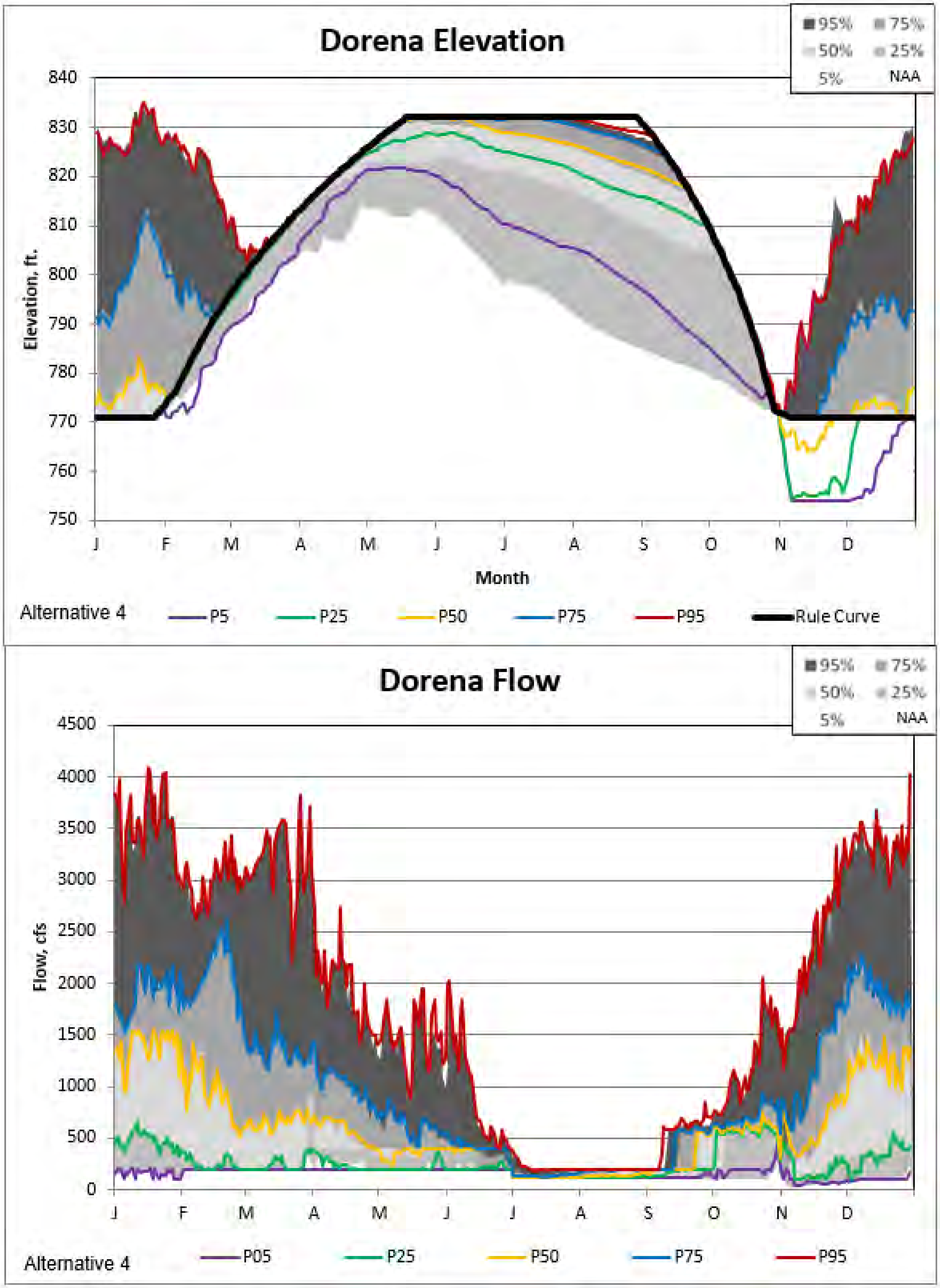


Figure 5-123. Dorena Alternative 4 Non-Exceedance Plot

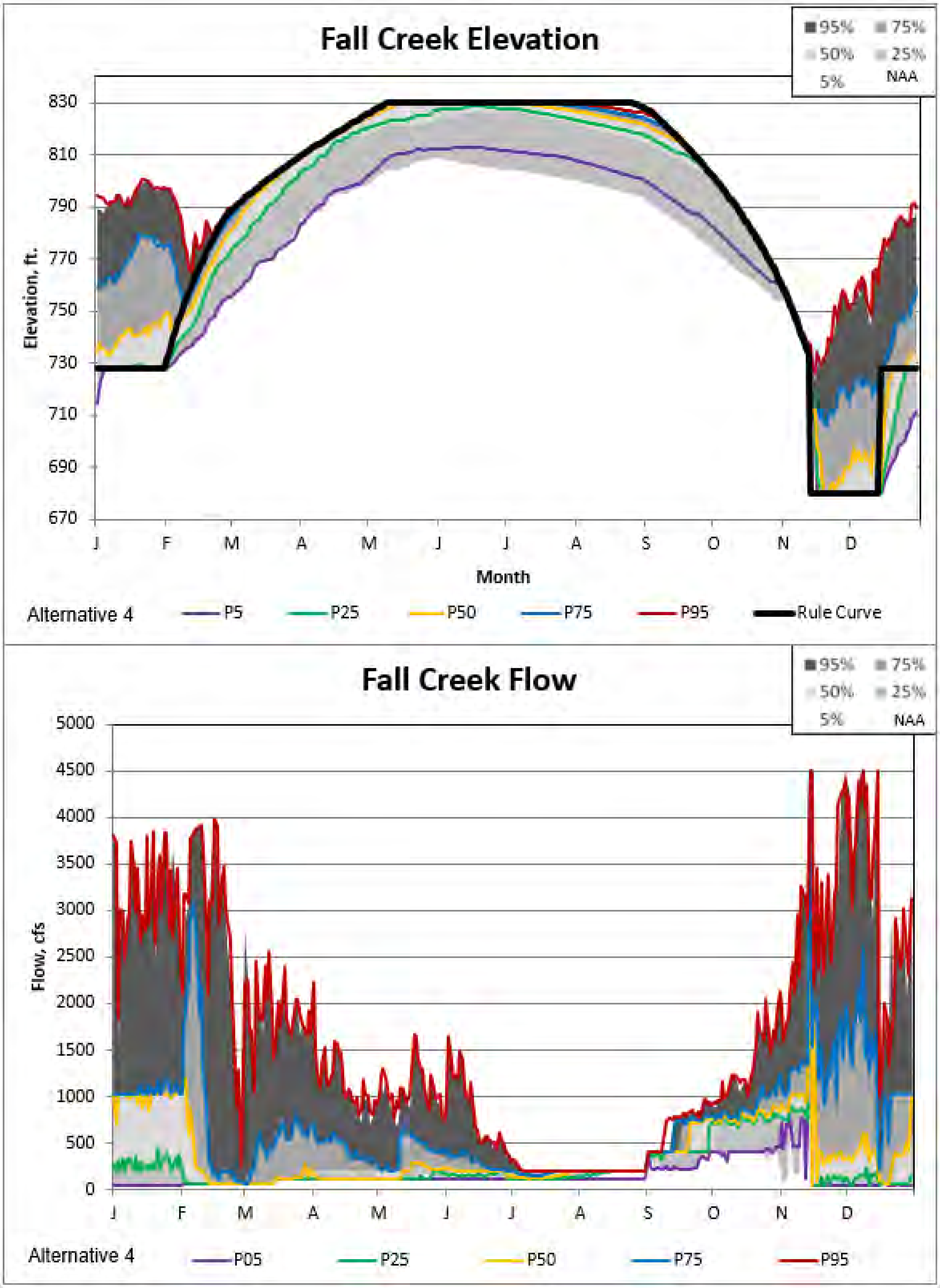


Figure 5-124. Fall Creek Alternative 4 Non-Exceedance Plot

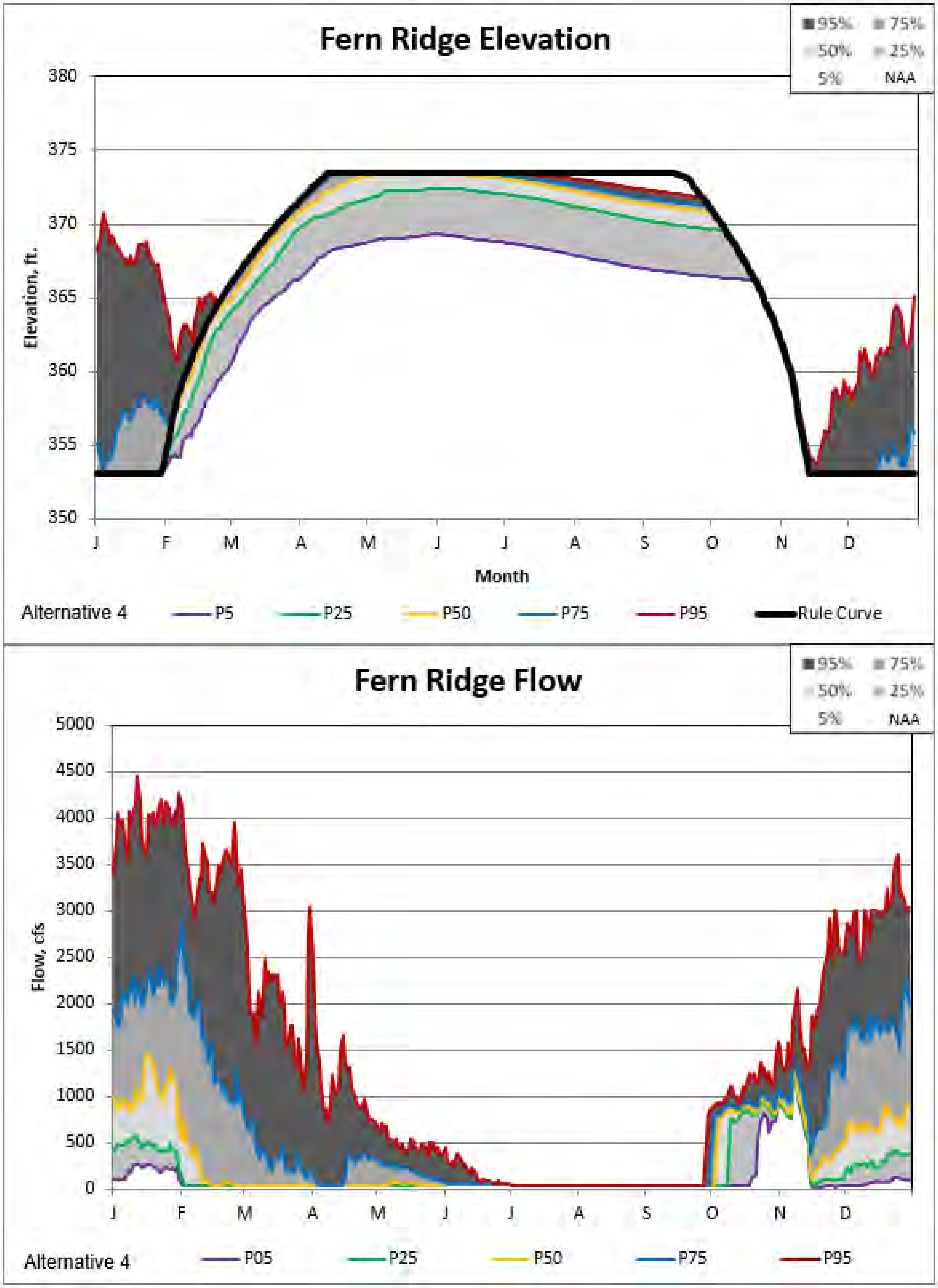


Figure 5-125. Fern Ridge Alternative 4 Non-Exceedance Plot

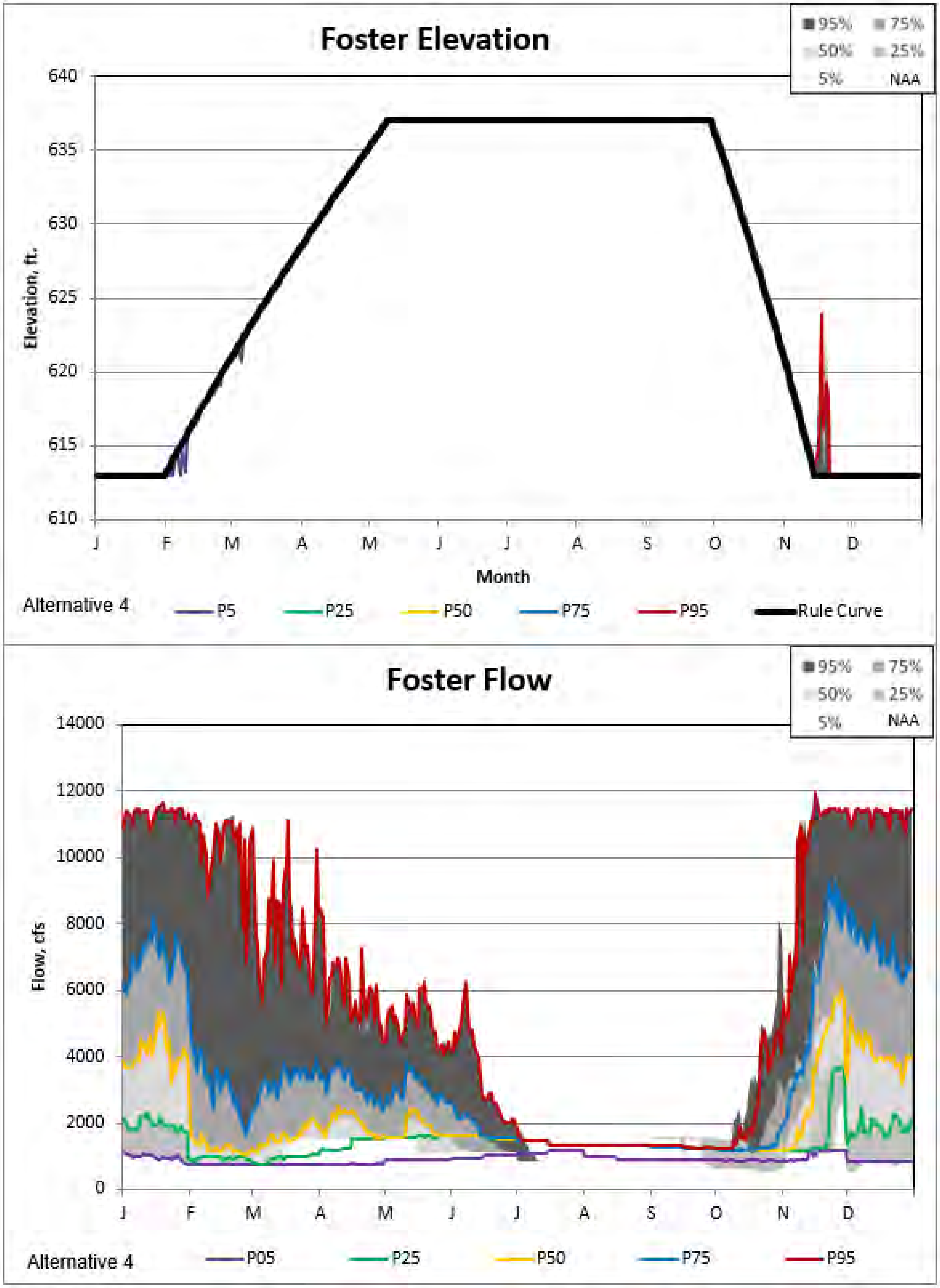


Figure 5-126. Foster Alternative 4 Non-Exceedance Plot

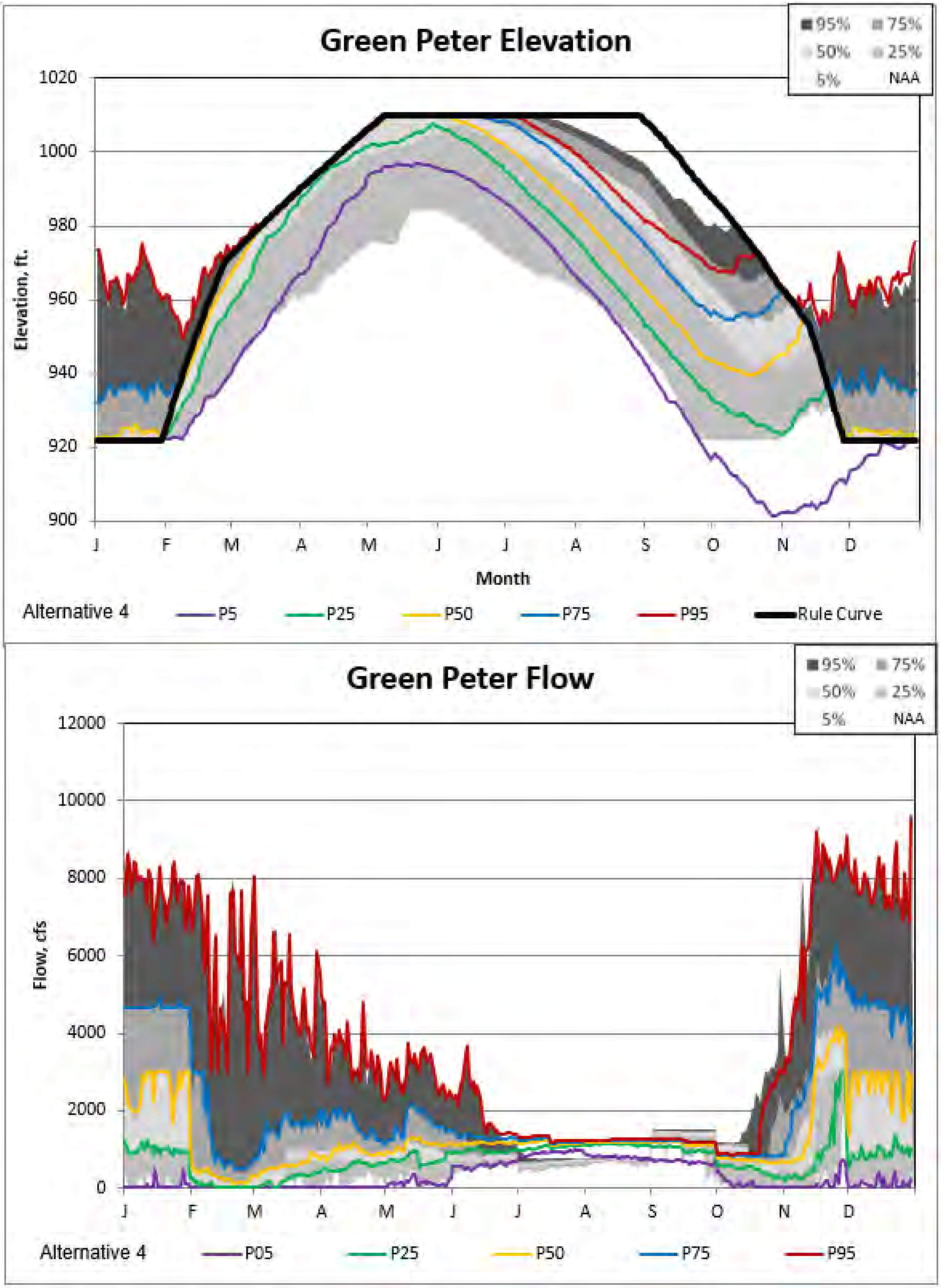


Figure 5-127. Green Peter Alternative 4 Non-Exceedance Plot

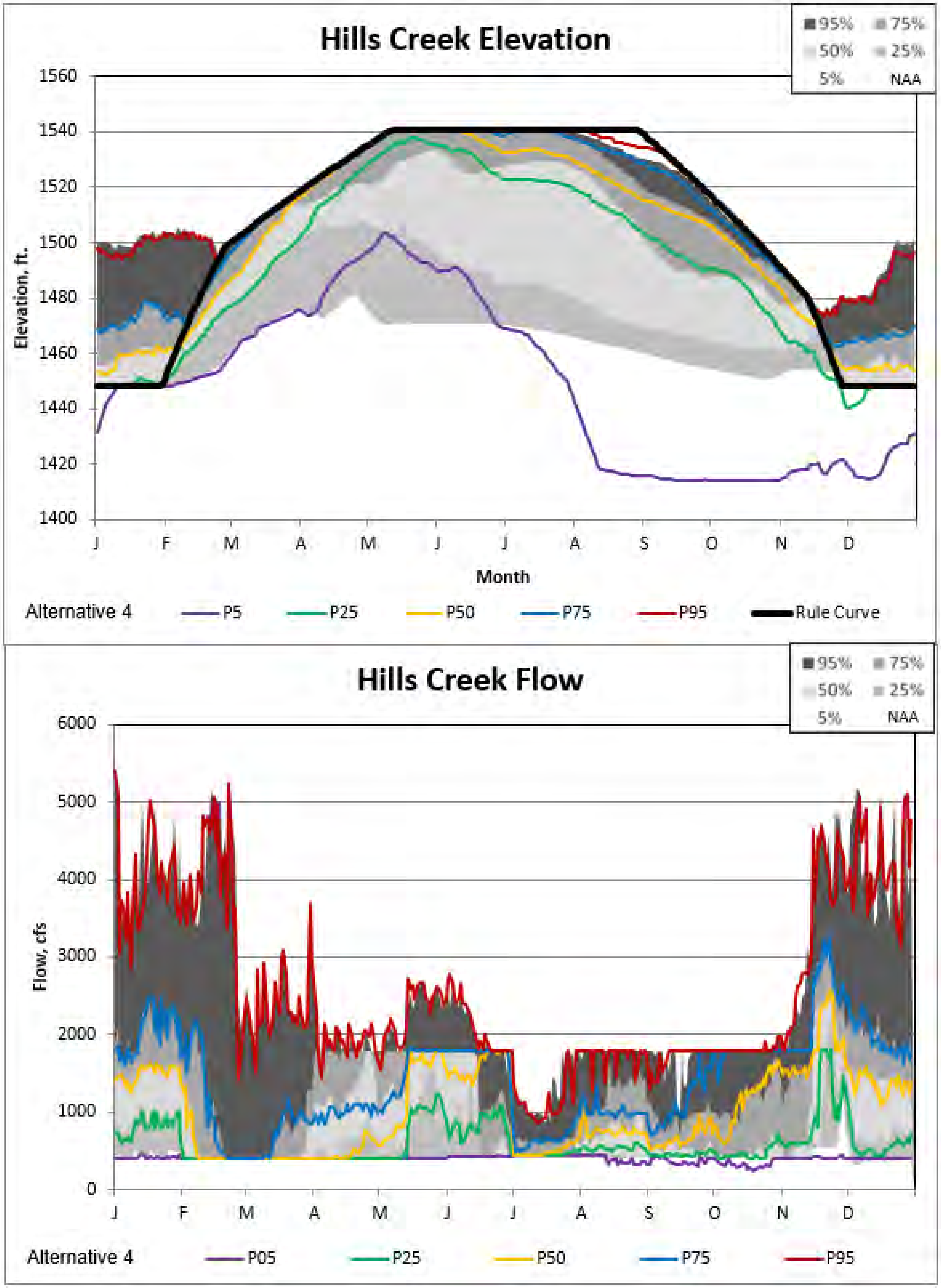


Figure 5-128. Hills Creek Alternative 4 Non-Exceedance Plot

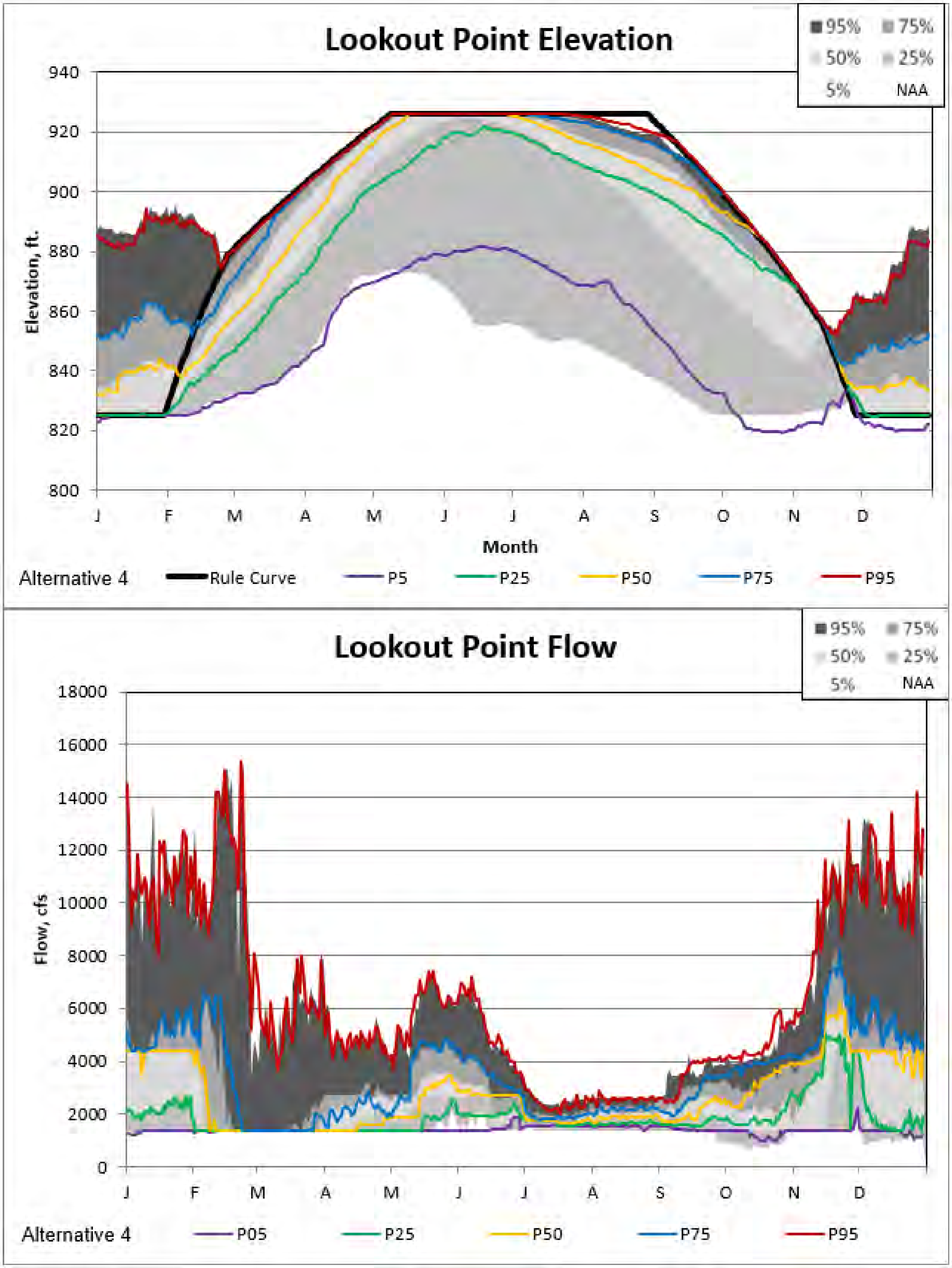


Figure 5-129. Lookout Point Alternative 4 Non-Exceedance Plot

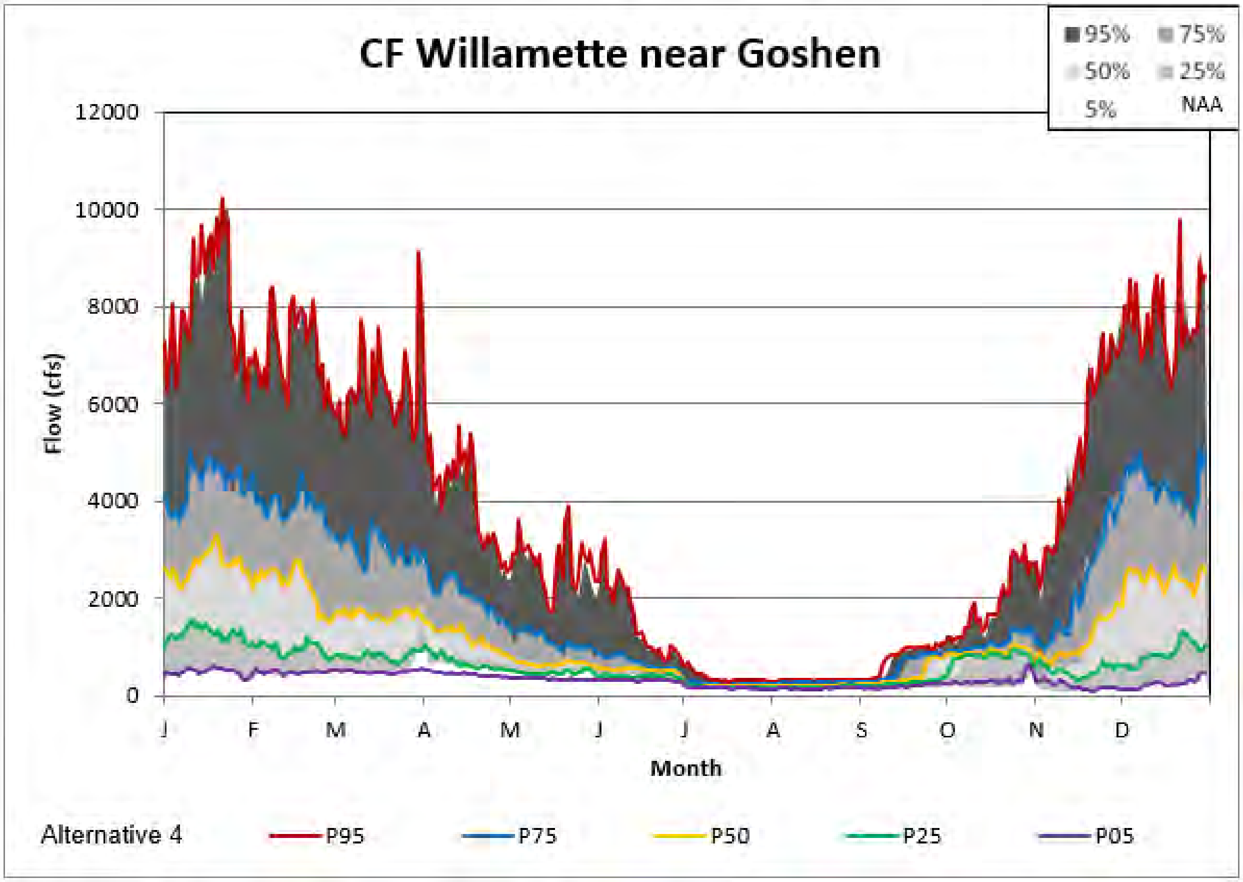


Figure 5-130. Goshen Alternative 4 Non-Exceedance Plot

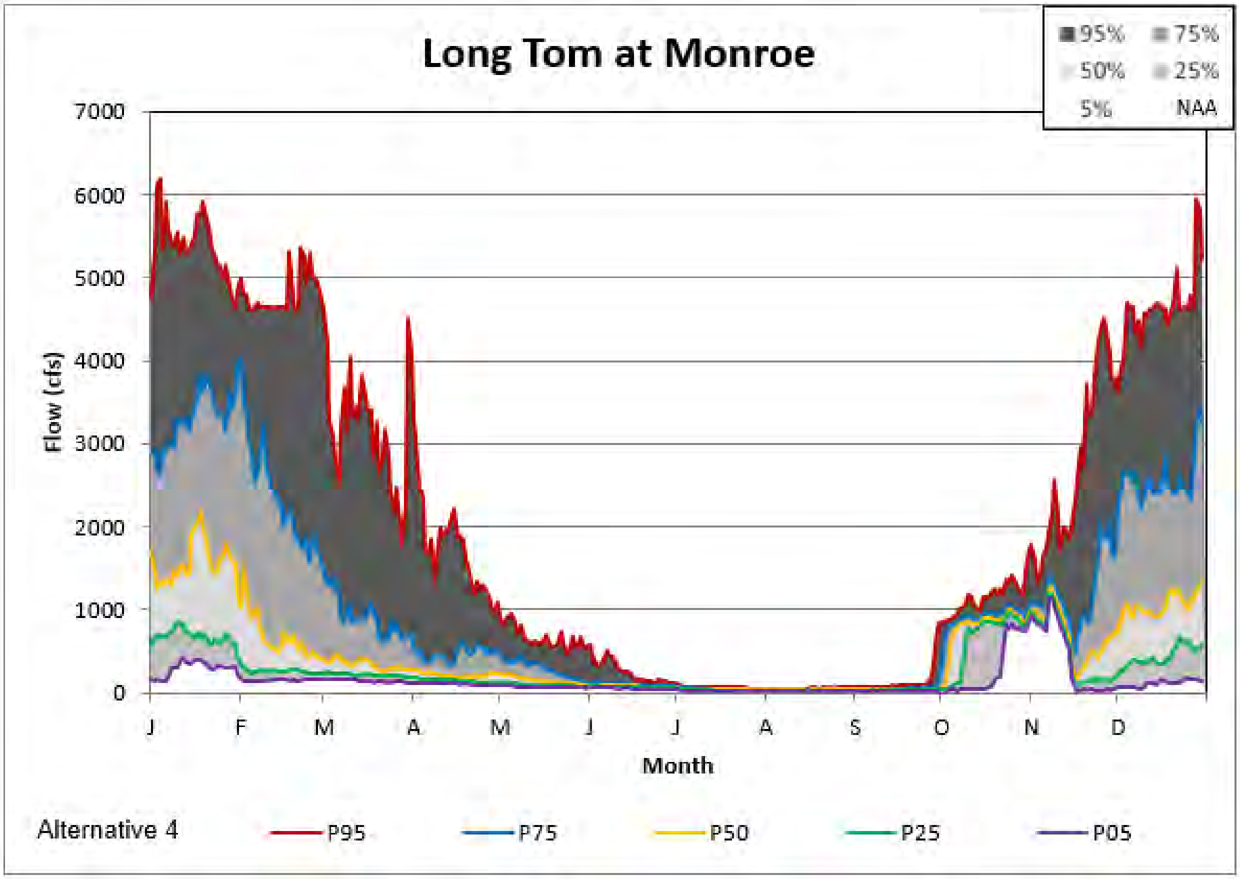


Figure 5-131. Monroe Alternative 4 Non-Exceedance Plot

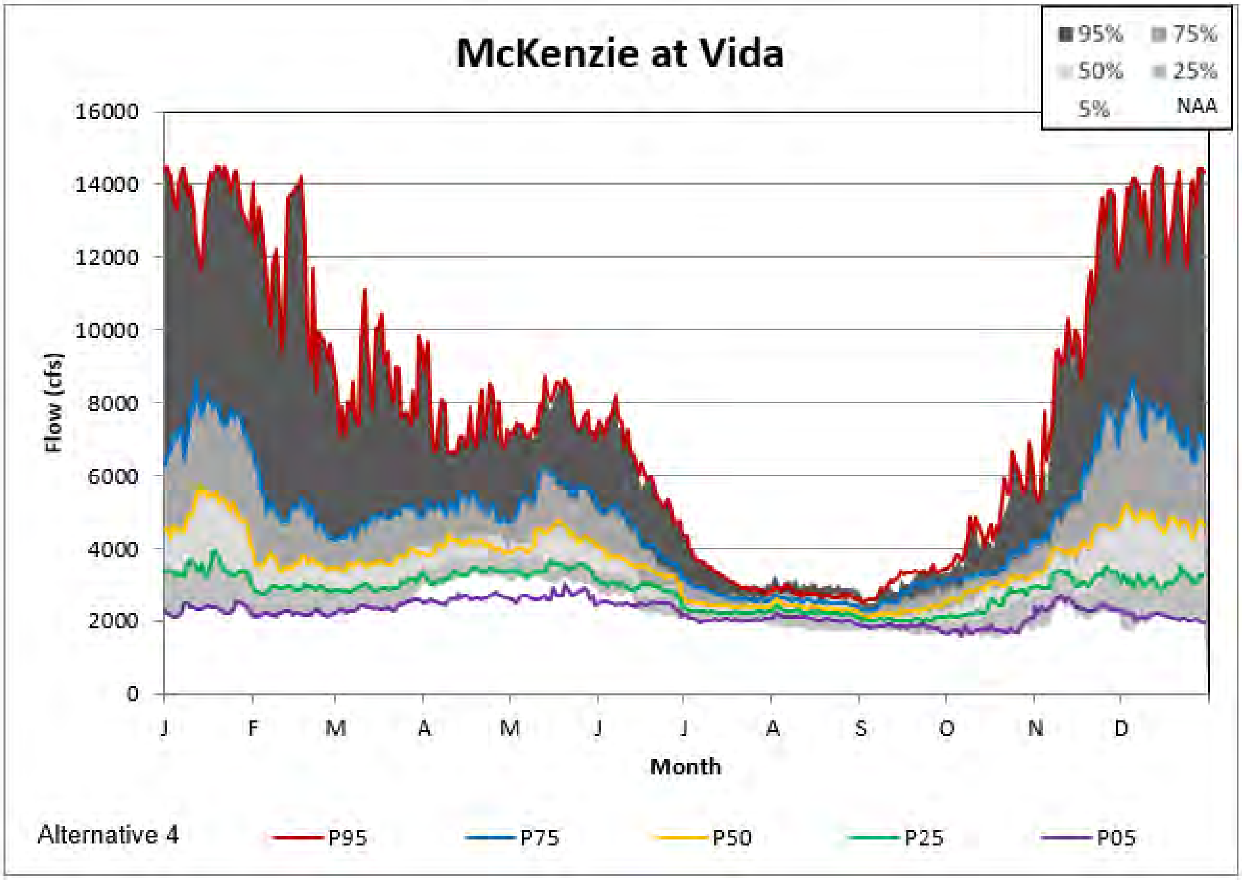


Figure 5-132. Vida Alternative 4 Non-Exceedance Plot

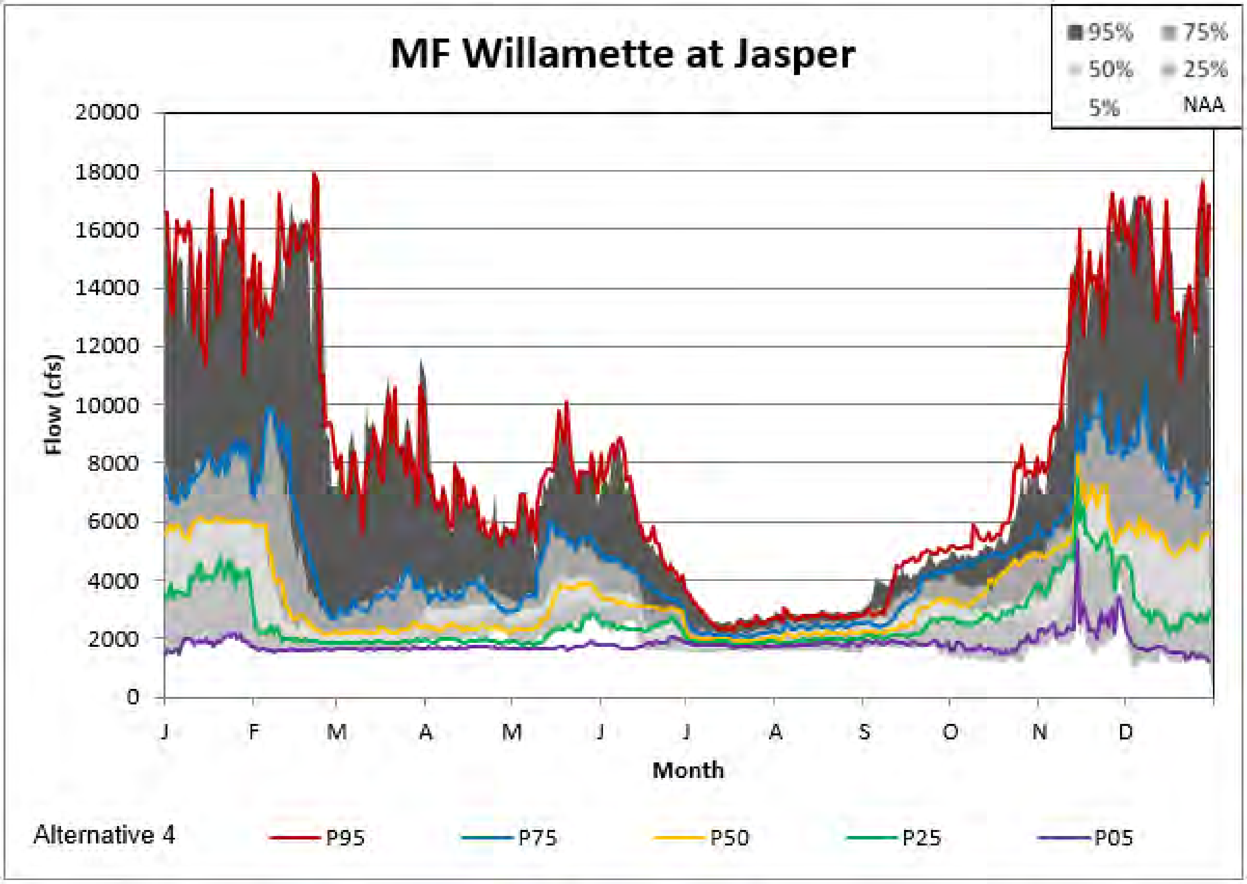


Figure 5-133. Jasper Alternative 4 Non-Exceedance Plot

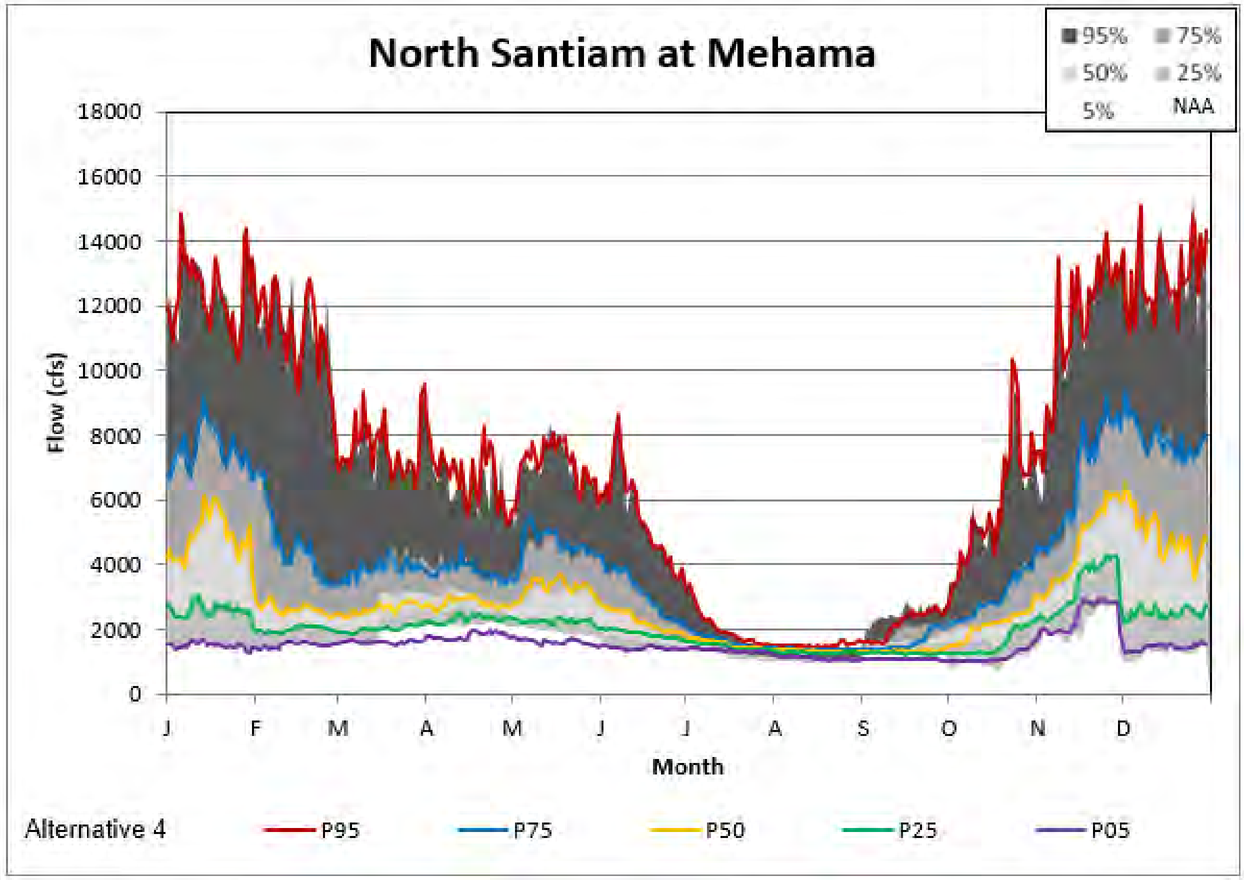


Figure 5-134. Mehama Alternative 4 Non-Exceedance Plot

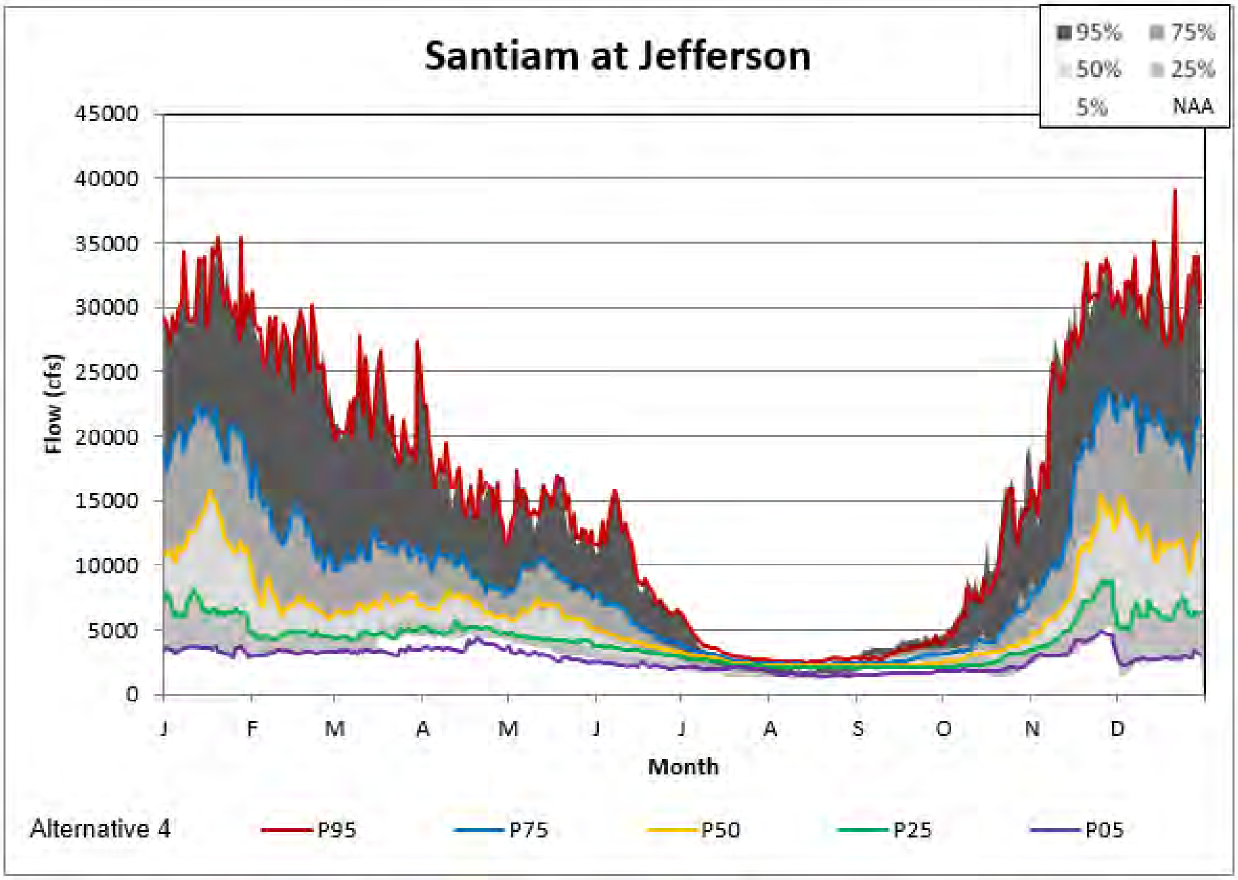


Figure 5-135. Jefferson Alternative 4 Non-Exceedance Plot

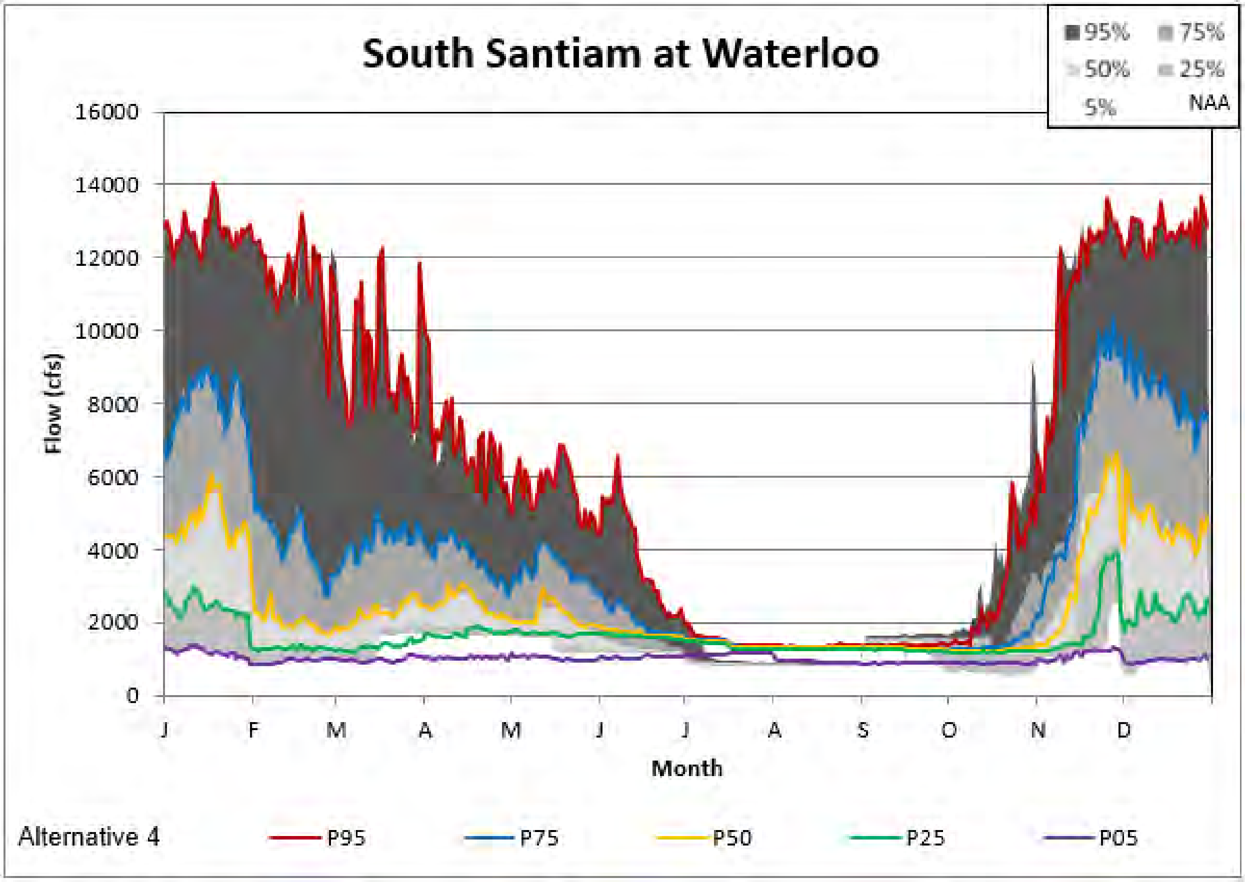


Figure 5-136. Waterloo Alternative 4 Non-Exceedance Plot

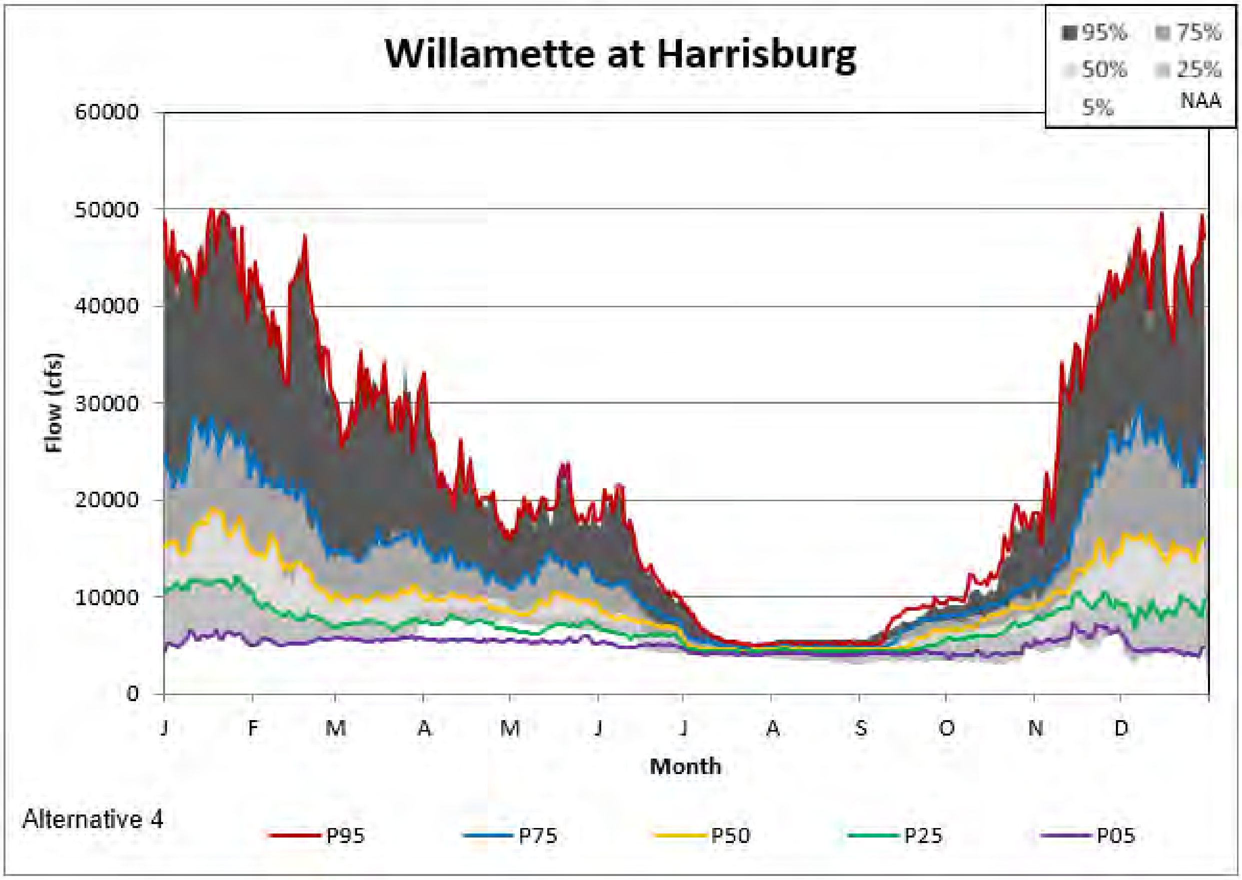


Figure 5-137. Harrisburg Alternative 4 Non-Exceedance Plot

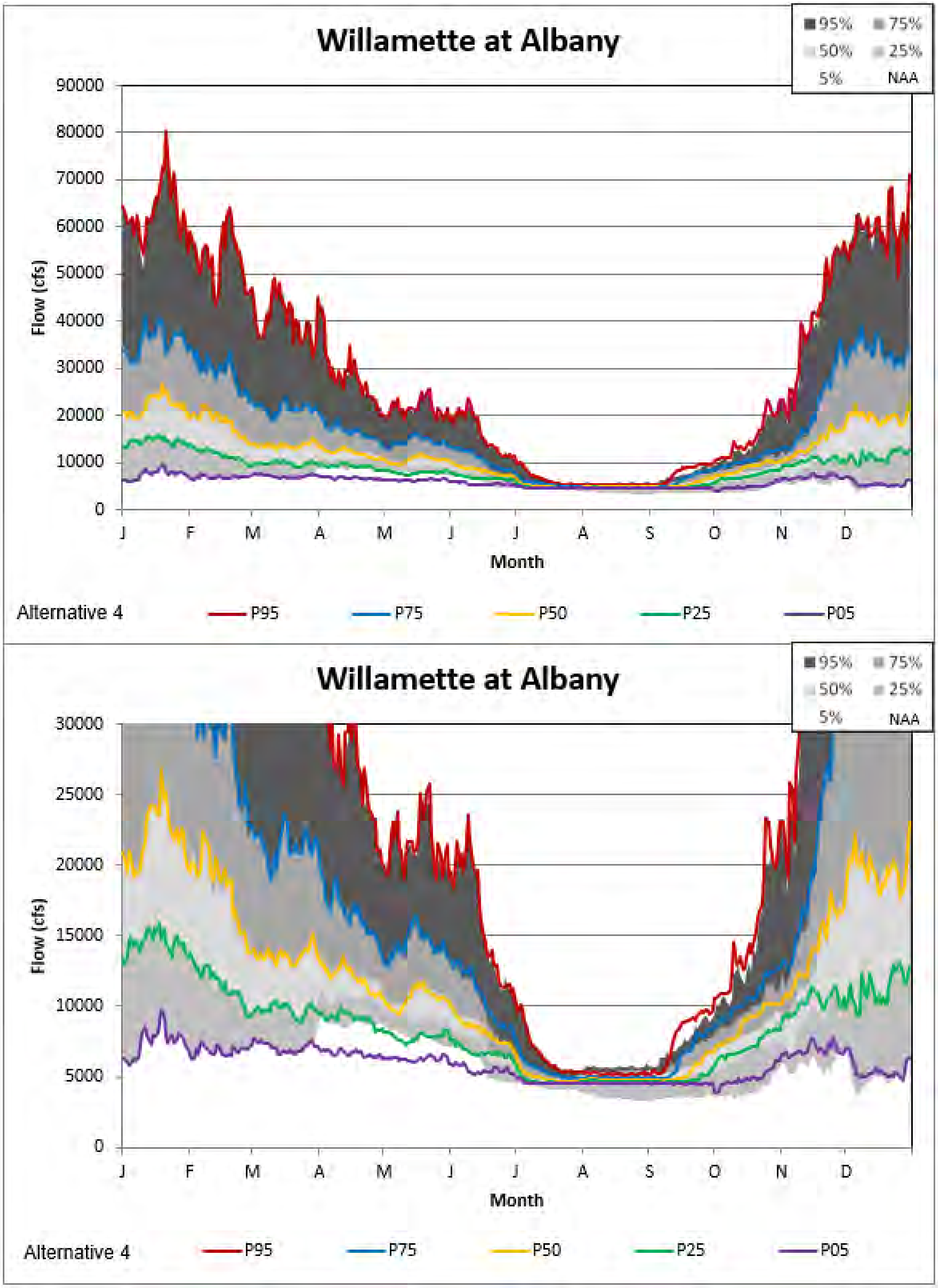


Figure 5-138. Albany Alternative 4 Non-Exceedance Plot

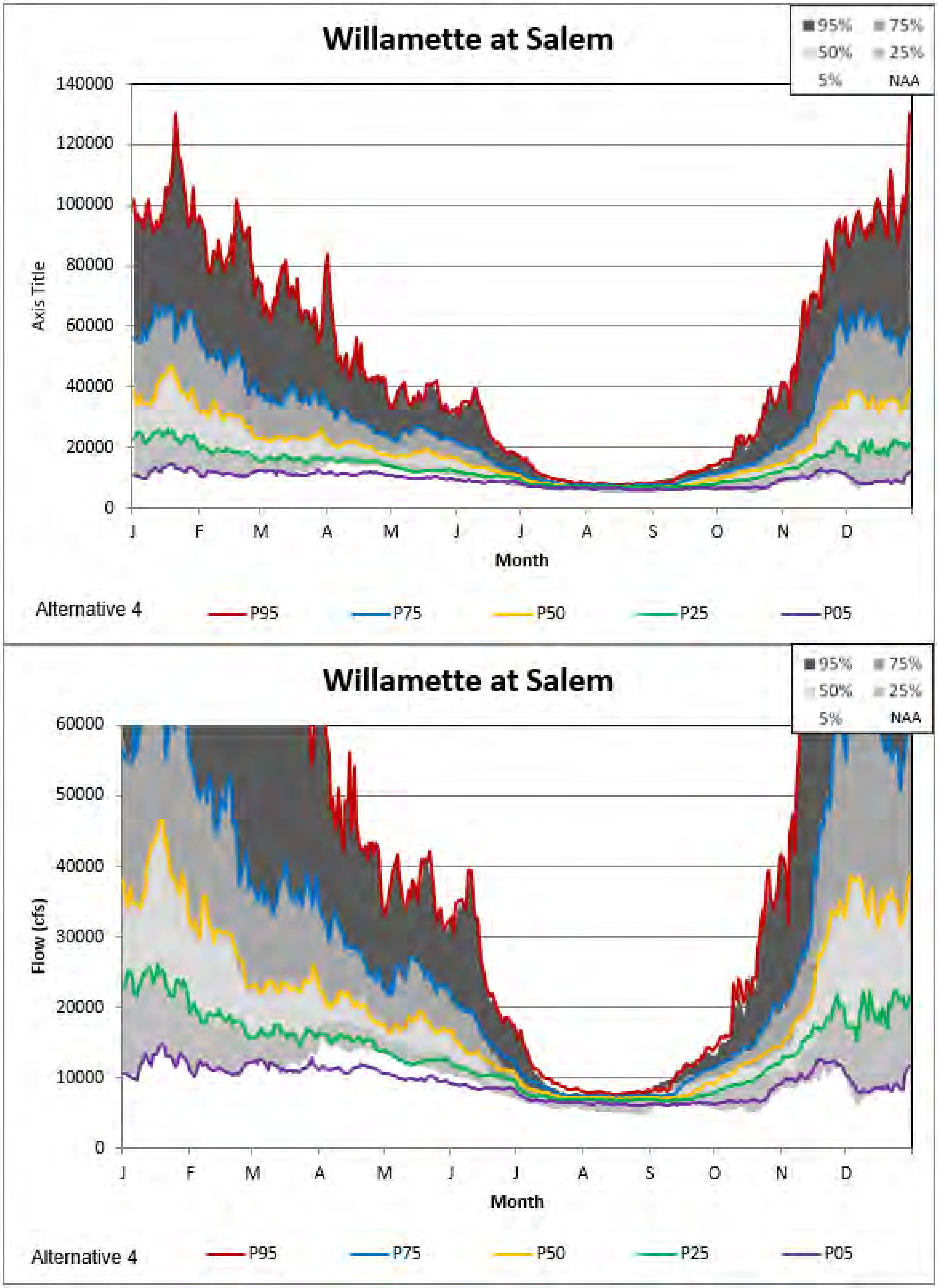


Figure 5-139. Salem Alternative 4 Non-Exceedance Plot

5.7 ALTERNATIVE 5

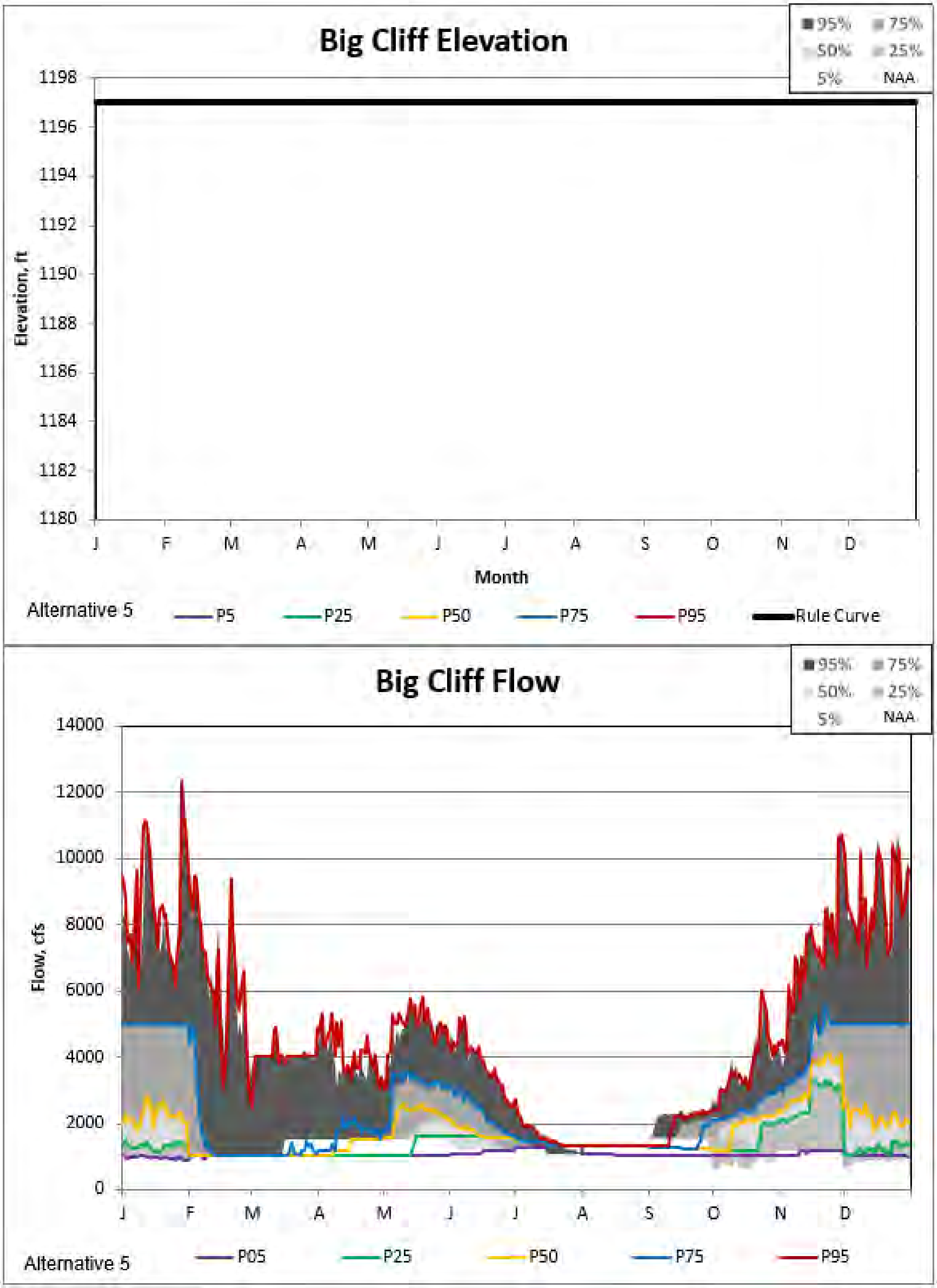


Figure 5-140. Big Cliff Alternative 5 Non-Exceedance Plot

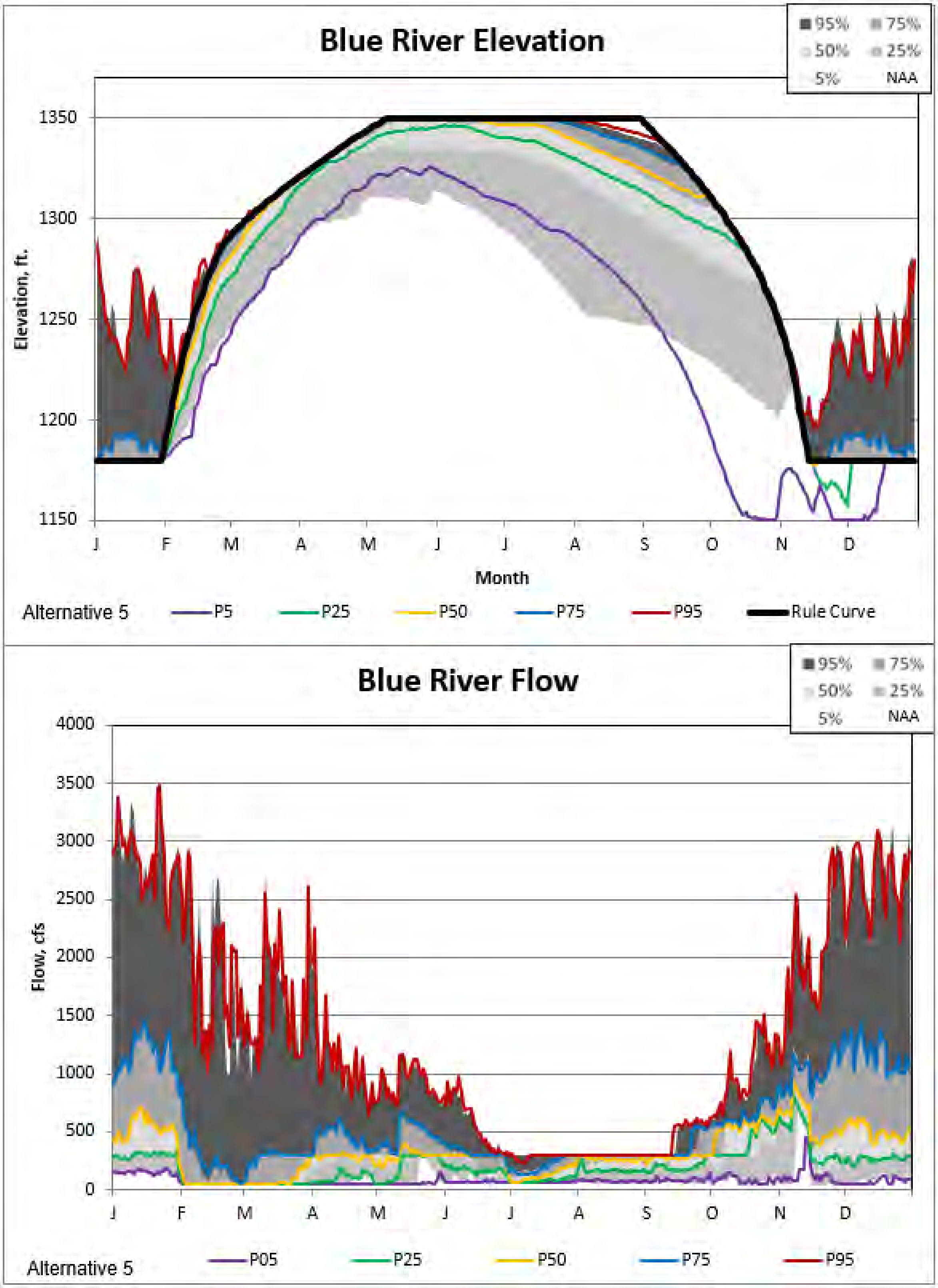


Figure 5-141. Blue River Alternative 5 Non-Exceedance Plot

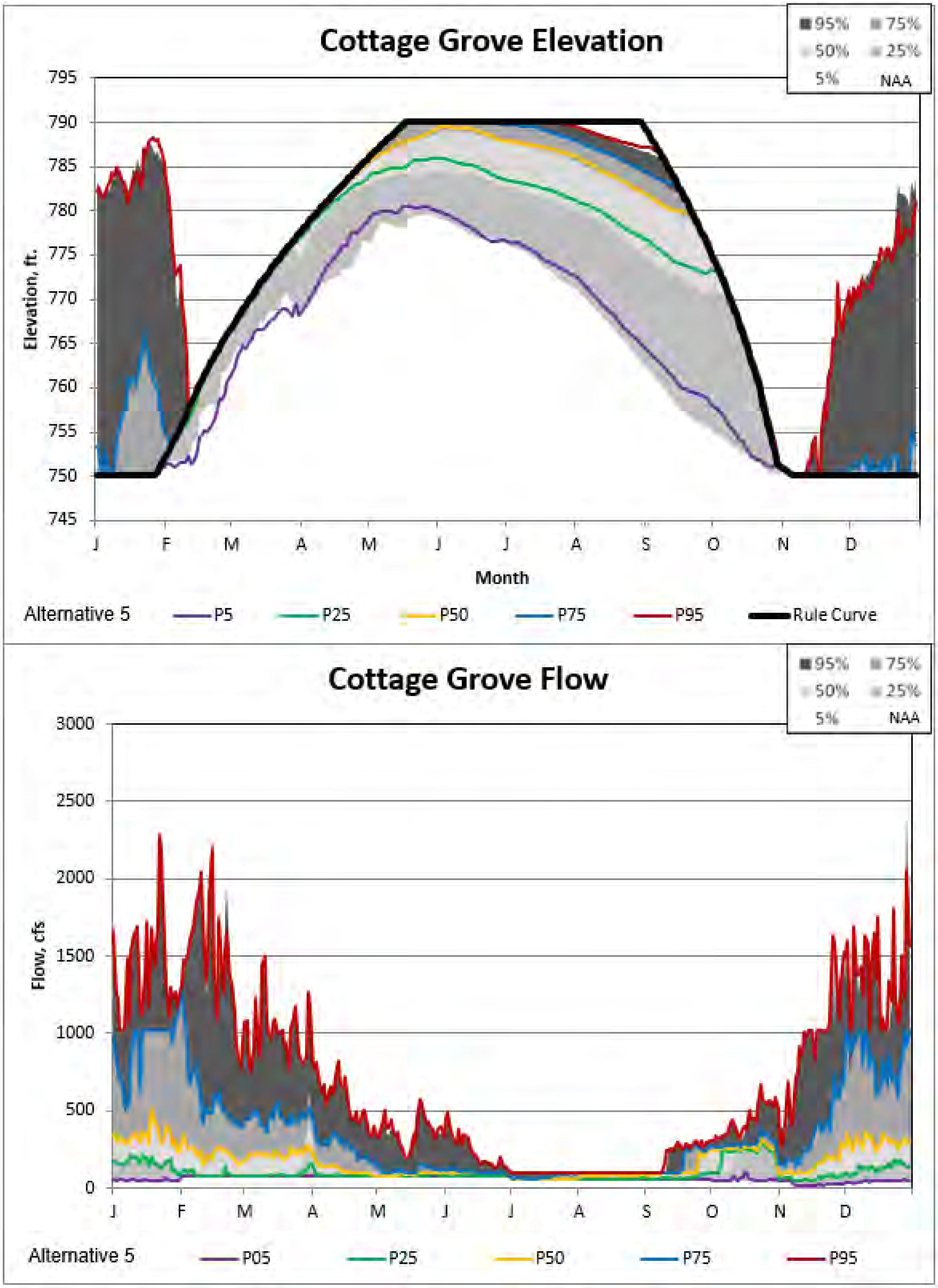


Figure 5-142. Cottage Grove Alternative 5 Non-Exceedance Plot

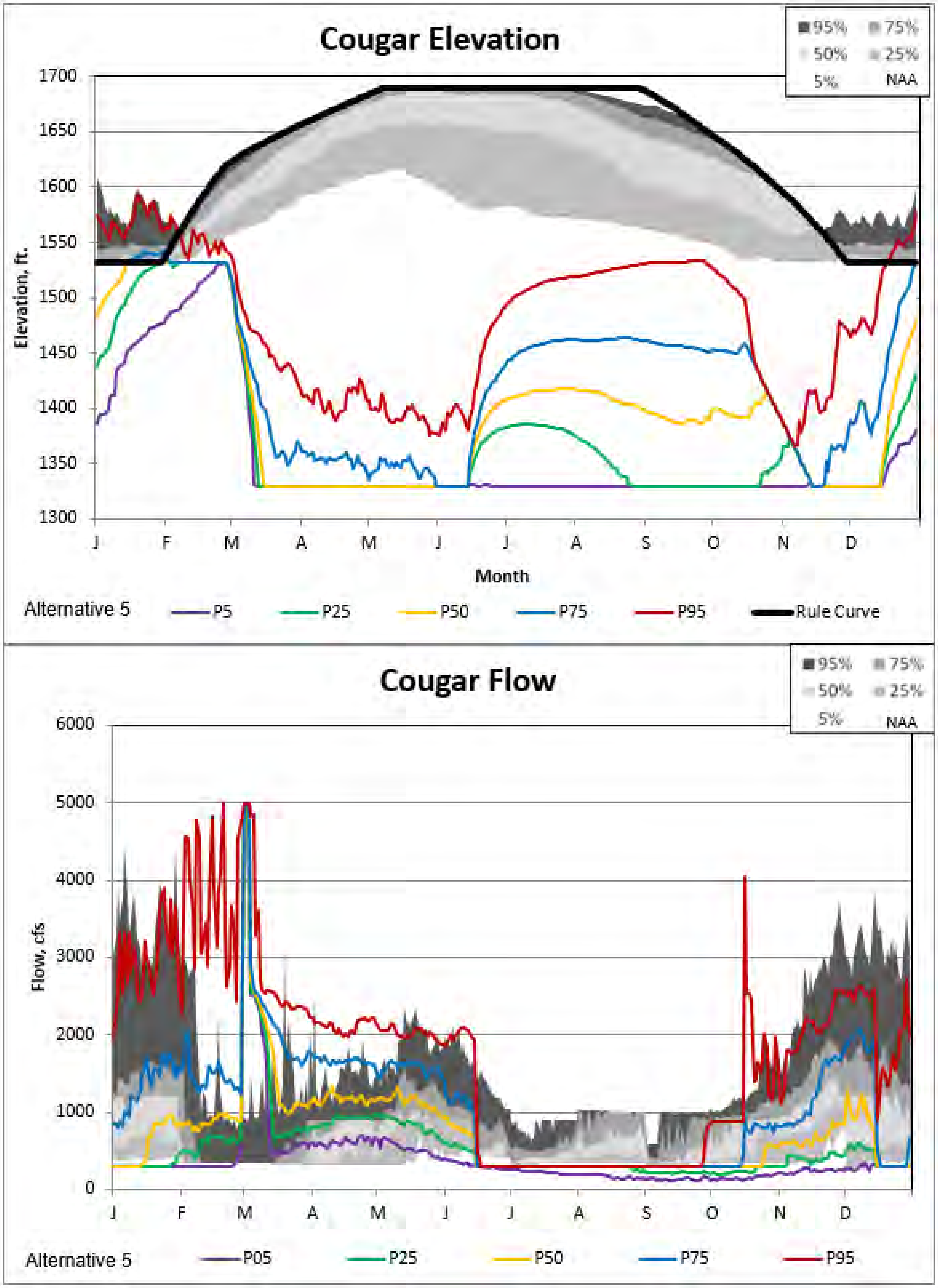


Figure 5-143. Cougar Alternative 5 Non-Exceedance Plot

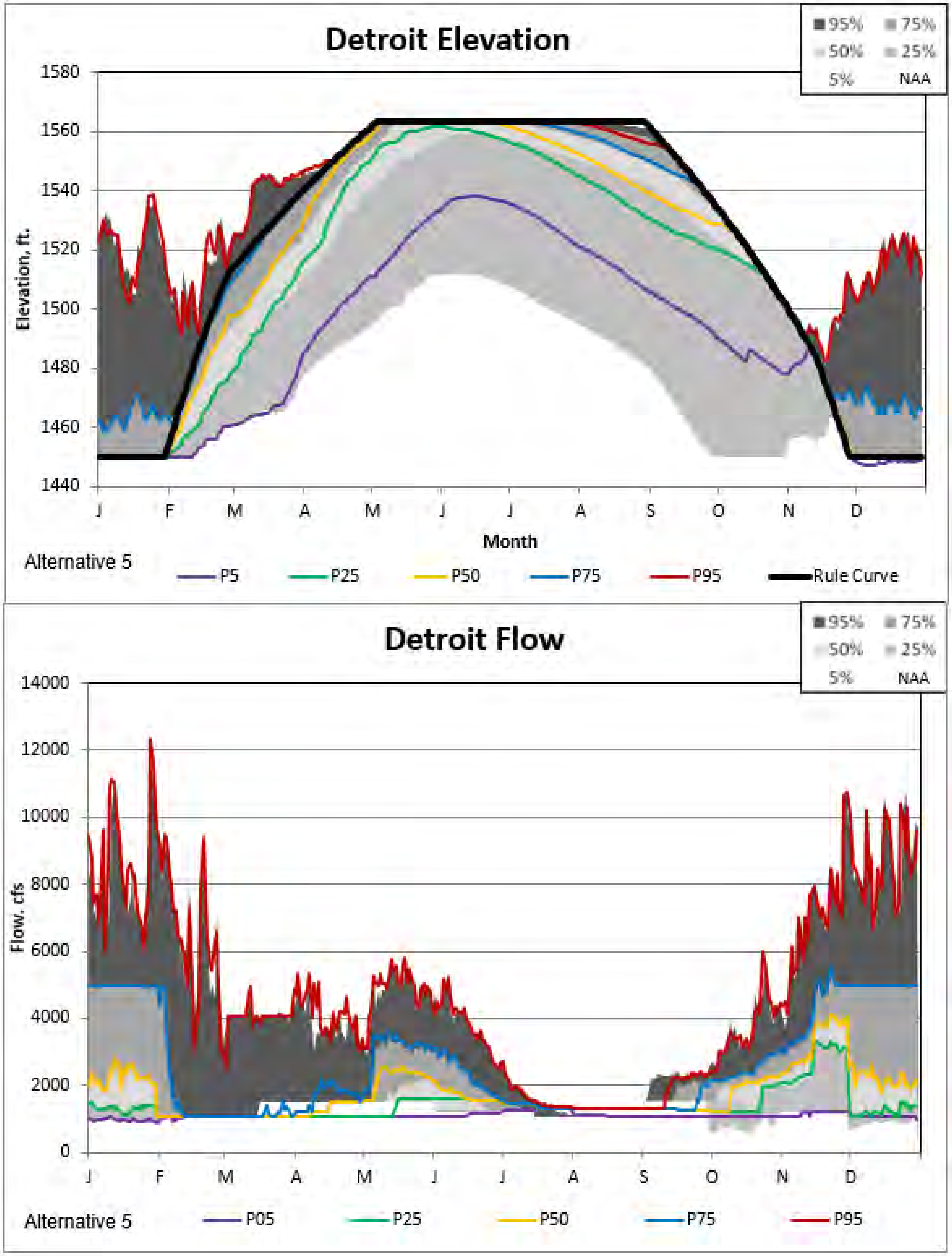


Figure 5-144. Detroit Alternative 5 Non-Exceedance Plot

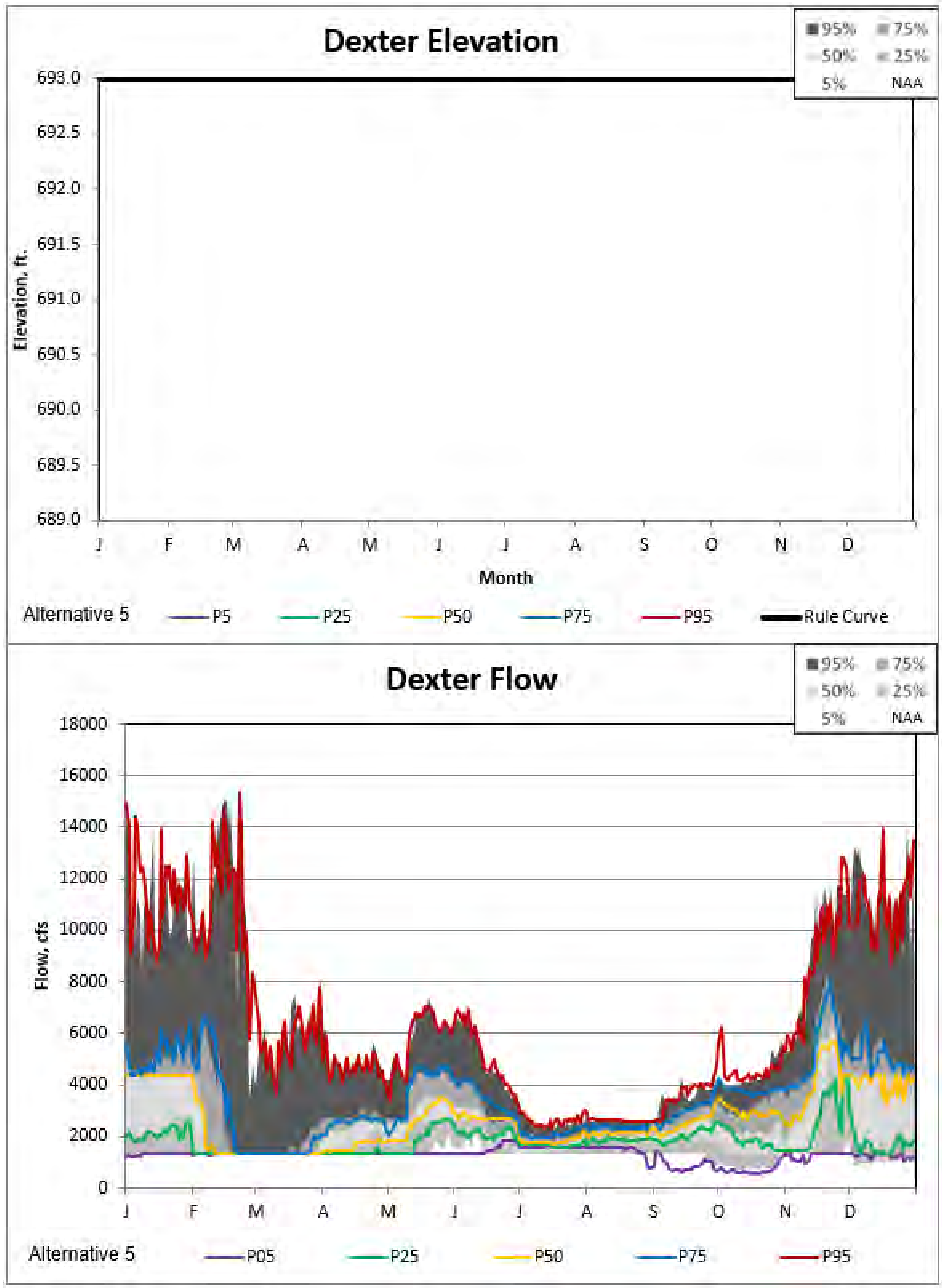


Figure 5-145. Dexter Alternative 5 Non-Exceedance Plot

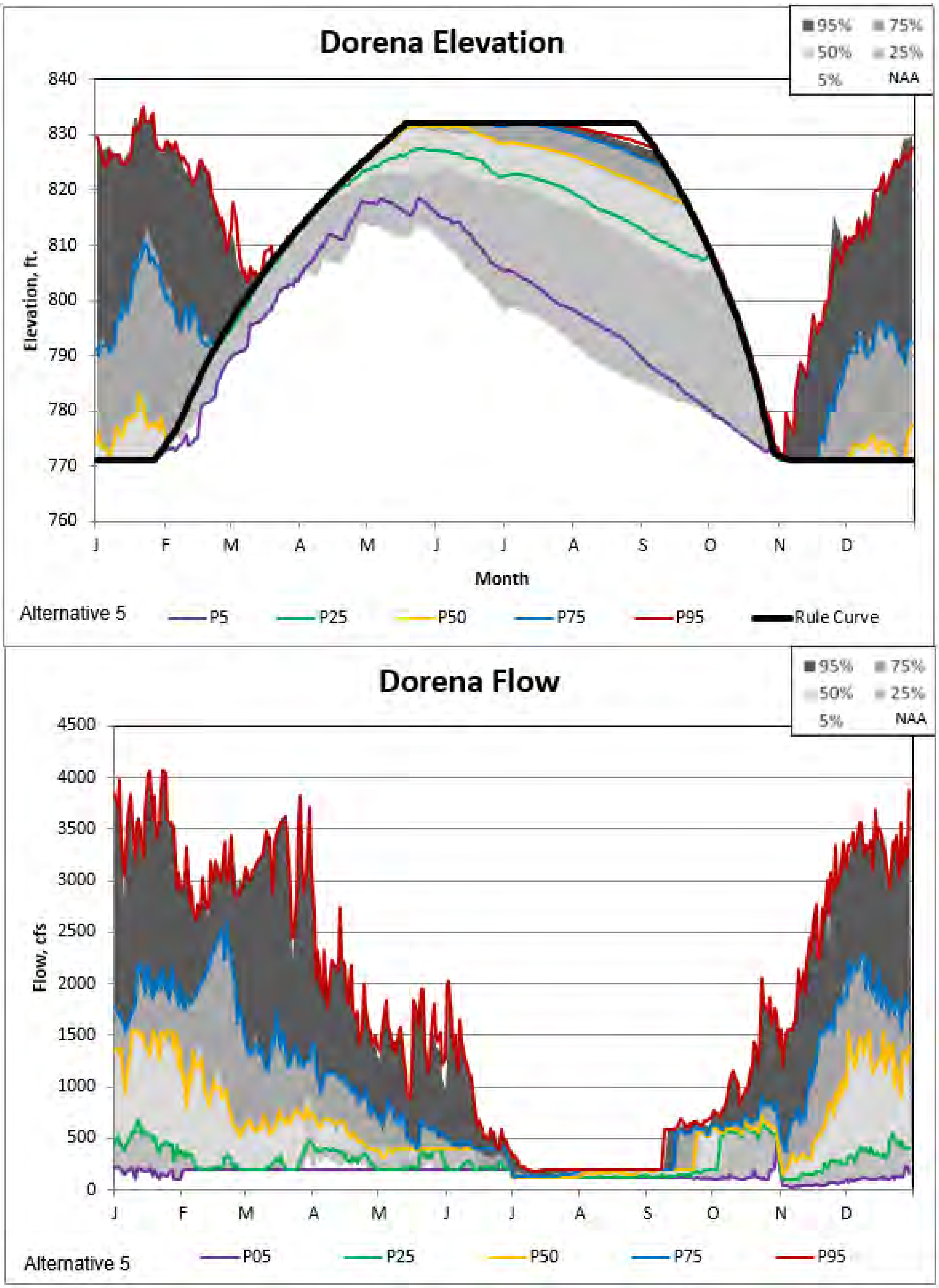


Figure 5-146. Dorena Alternative 5 Non-Exceedance Plot

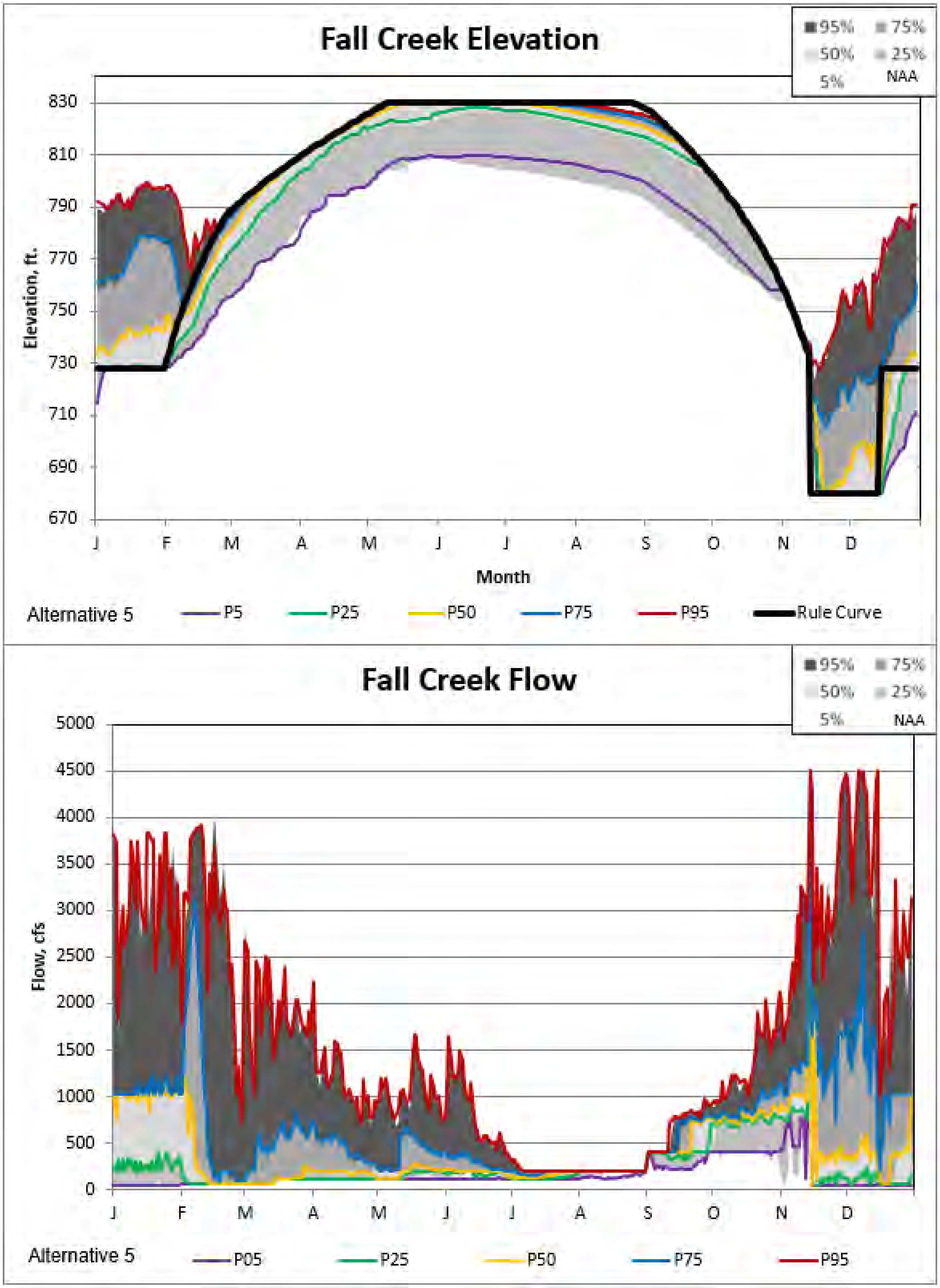


Figure 5-147. Fall Creek Alternative 5 Non-Exceedance Plot

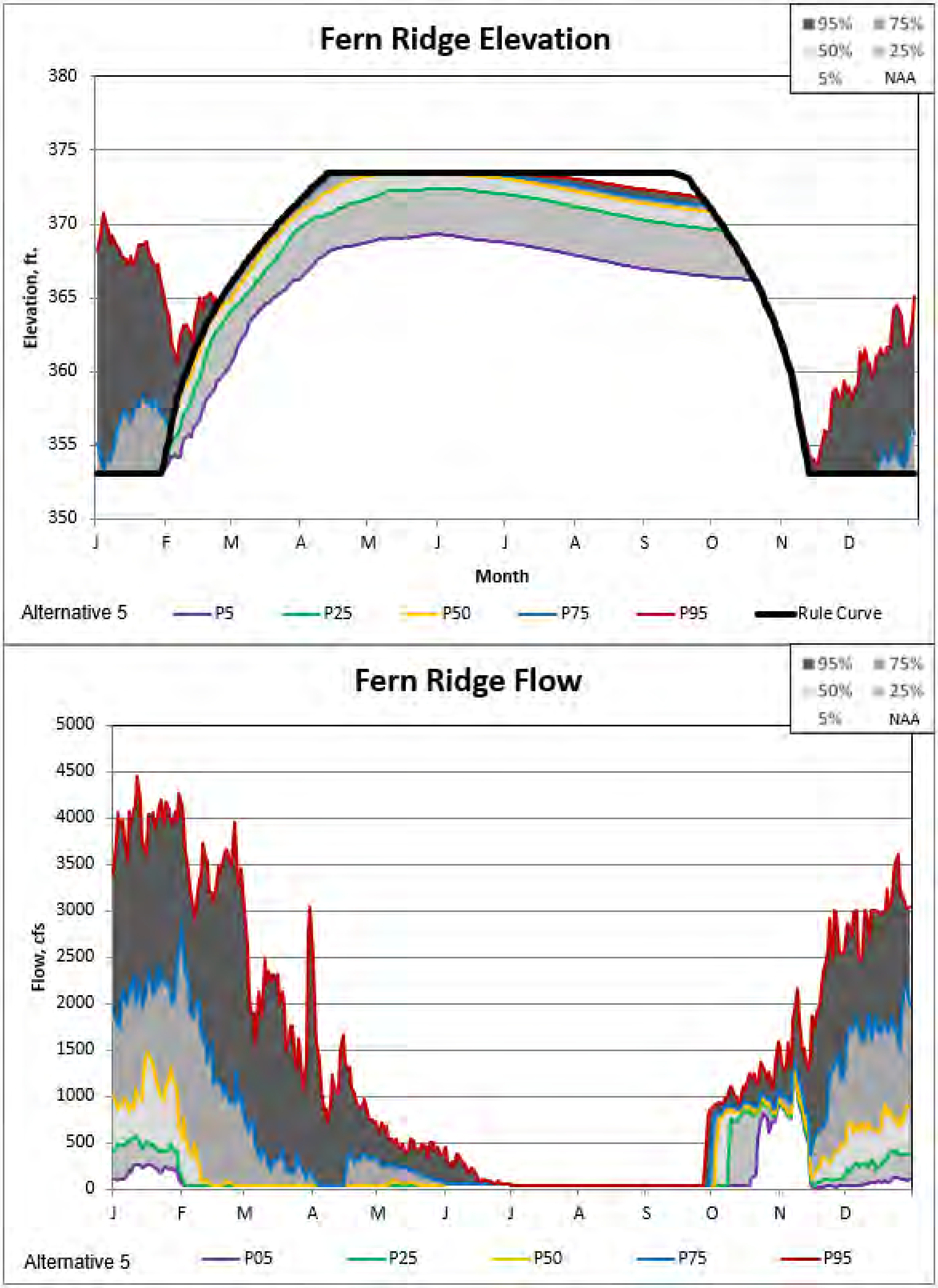


Figure 5-148. Fern Ridge Alternative 5 Non-Exceedance Plot

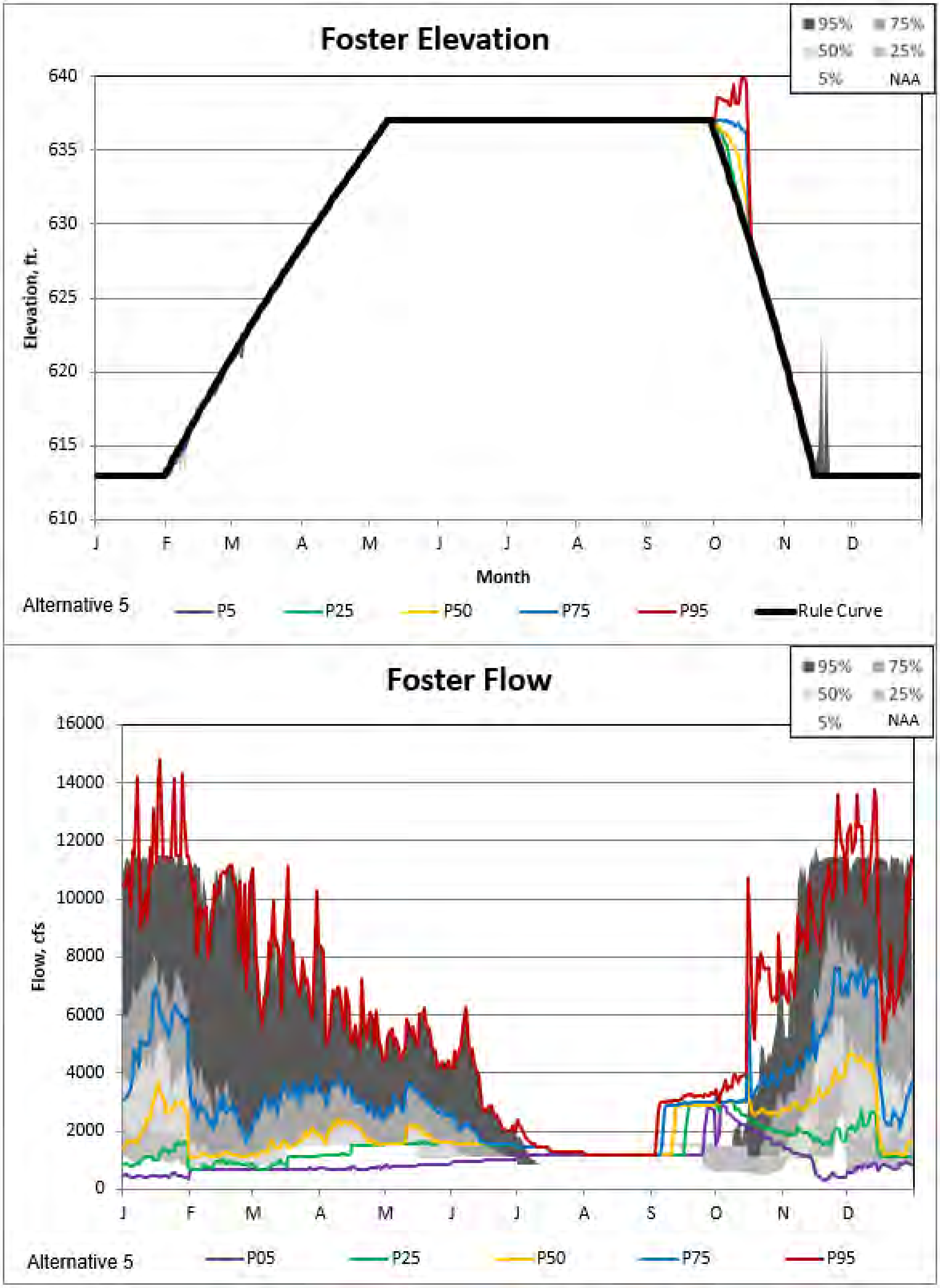


Figure 5-149. Foster Alternative 5 Non-Exceedance Plot

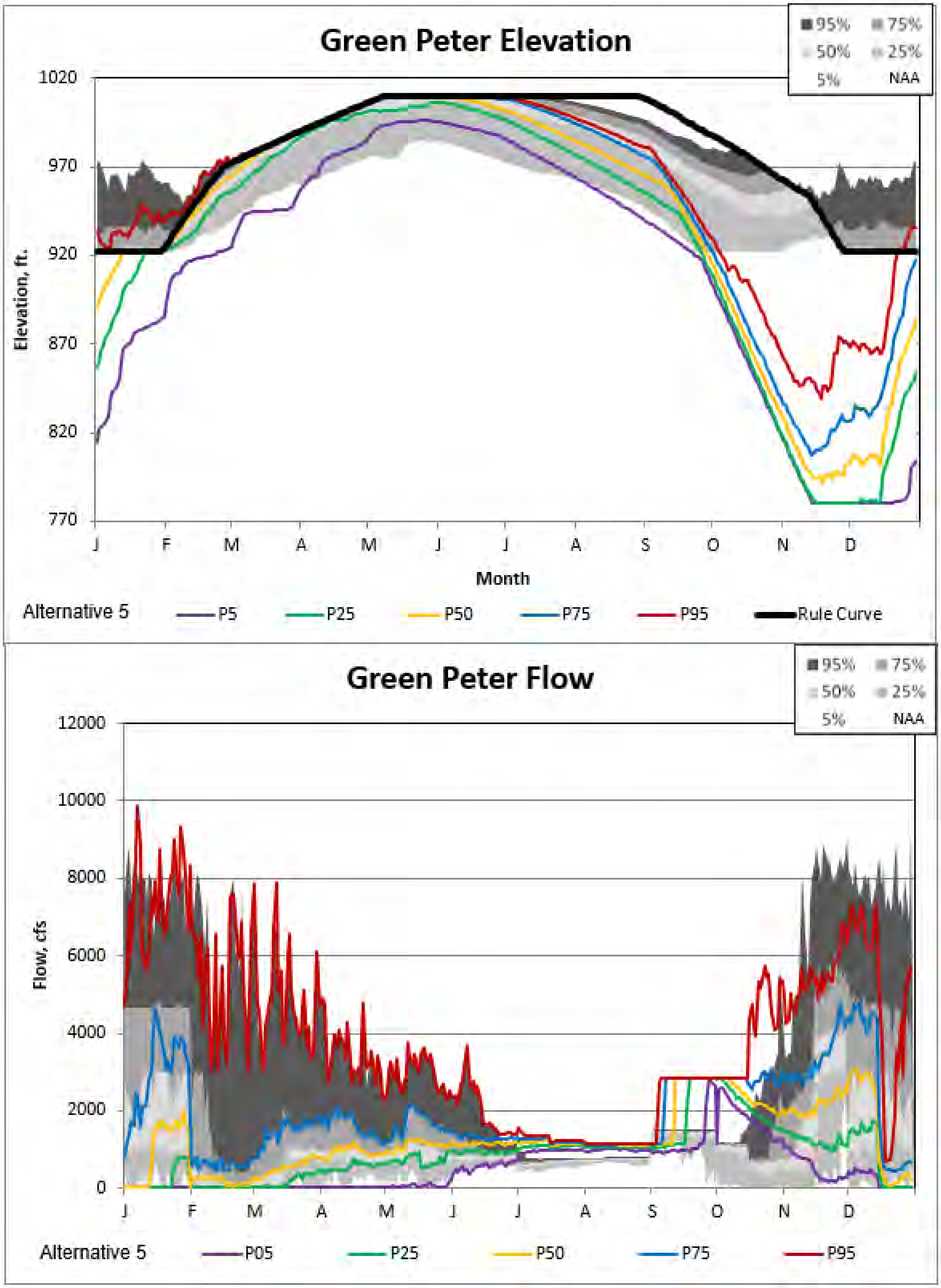


Figure 5-150. Green Peter Alternative 5 Non-Exceedance Plot

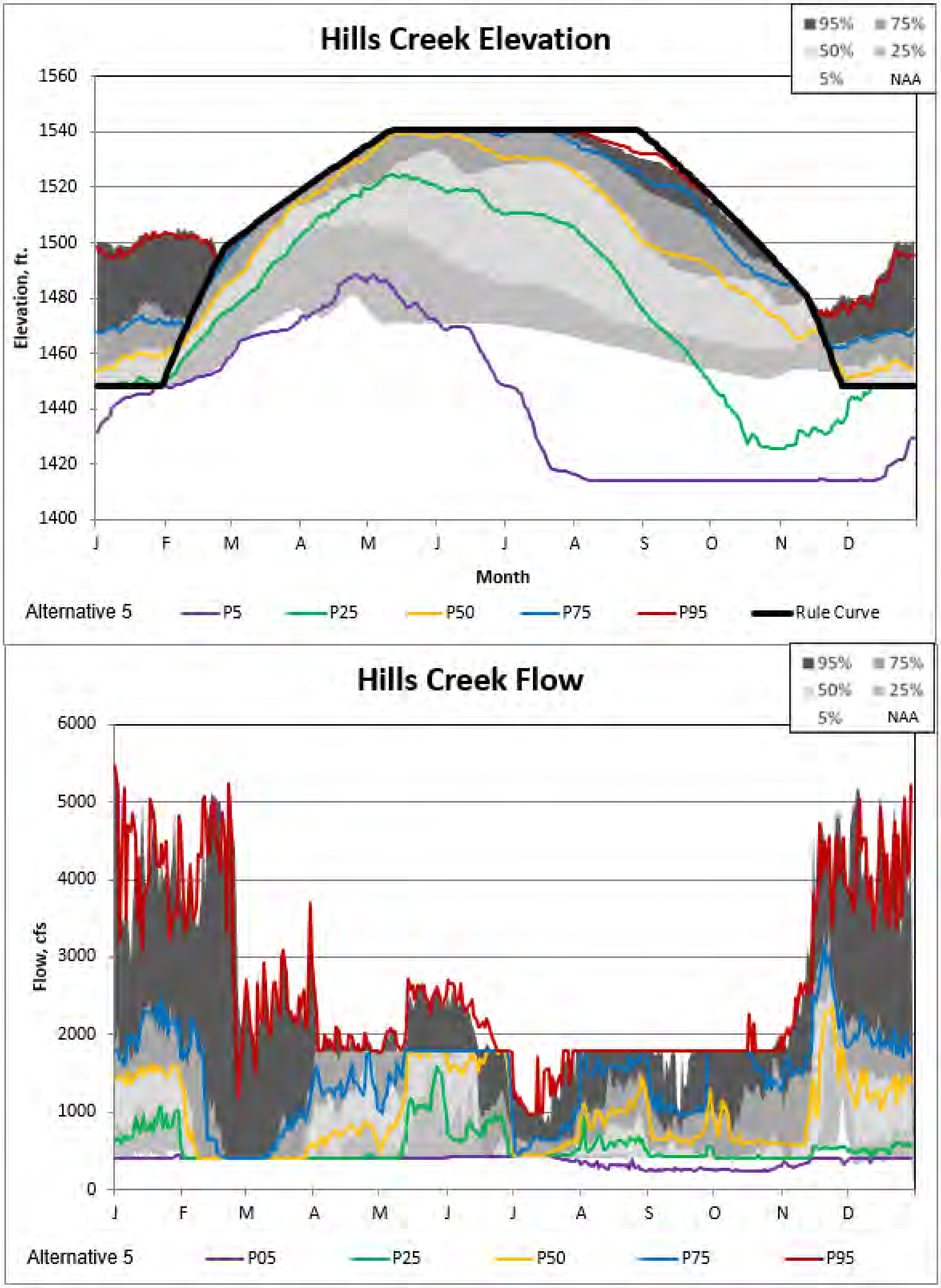


Figure 5-151. Hills Creek Alternative 5 Non-Exceedance Plot

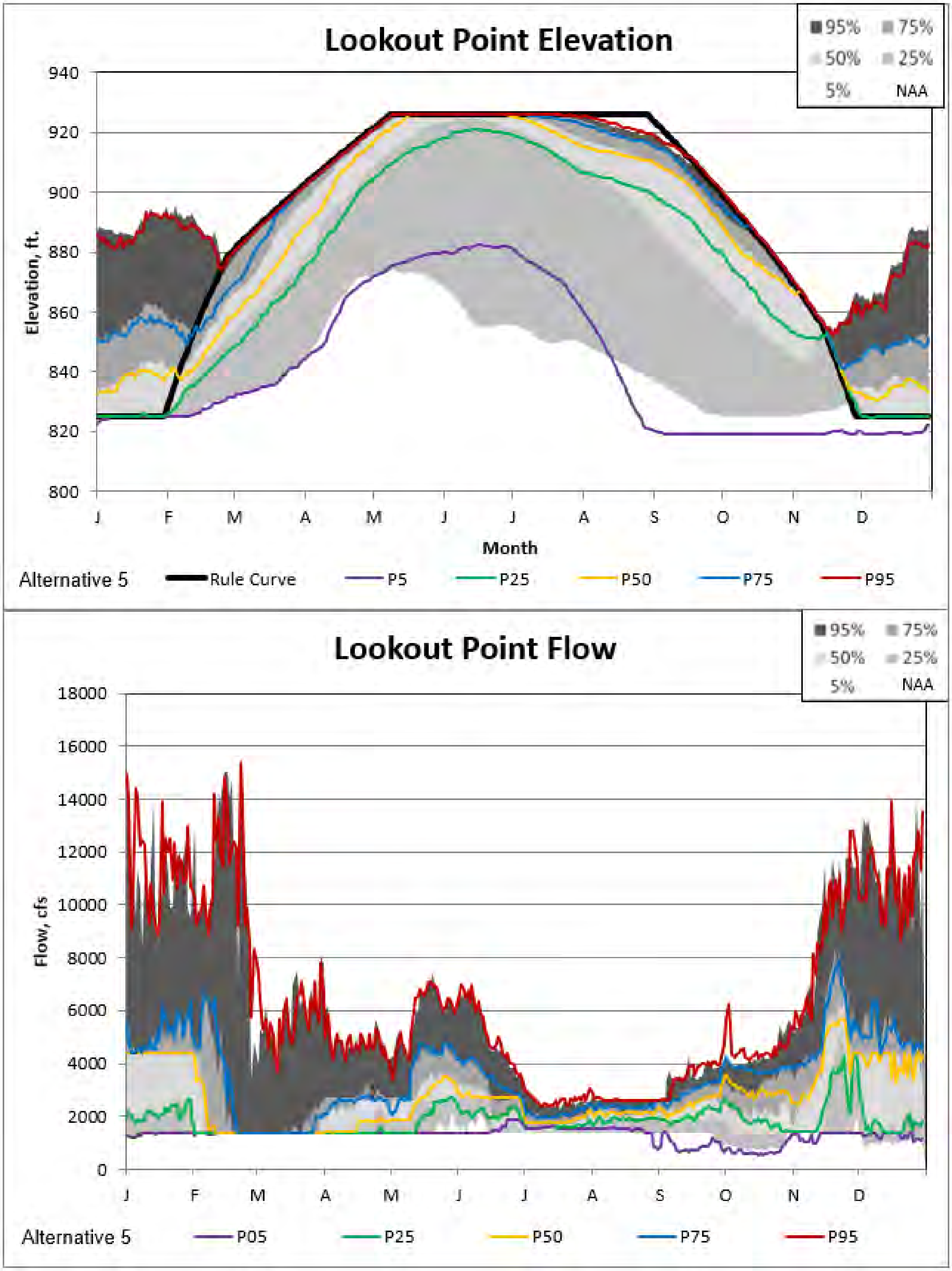


Figure 5-152. Lookout Point Alternative 5 Non-Exceedance Plot

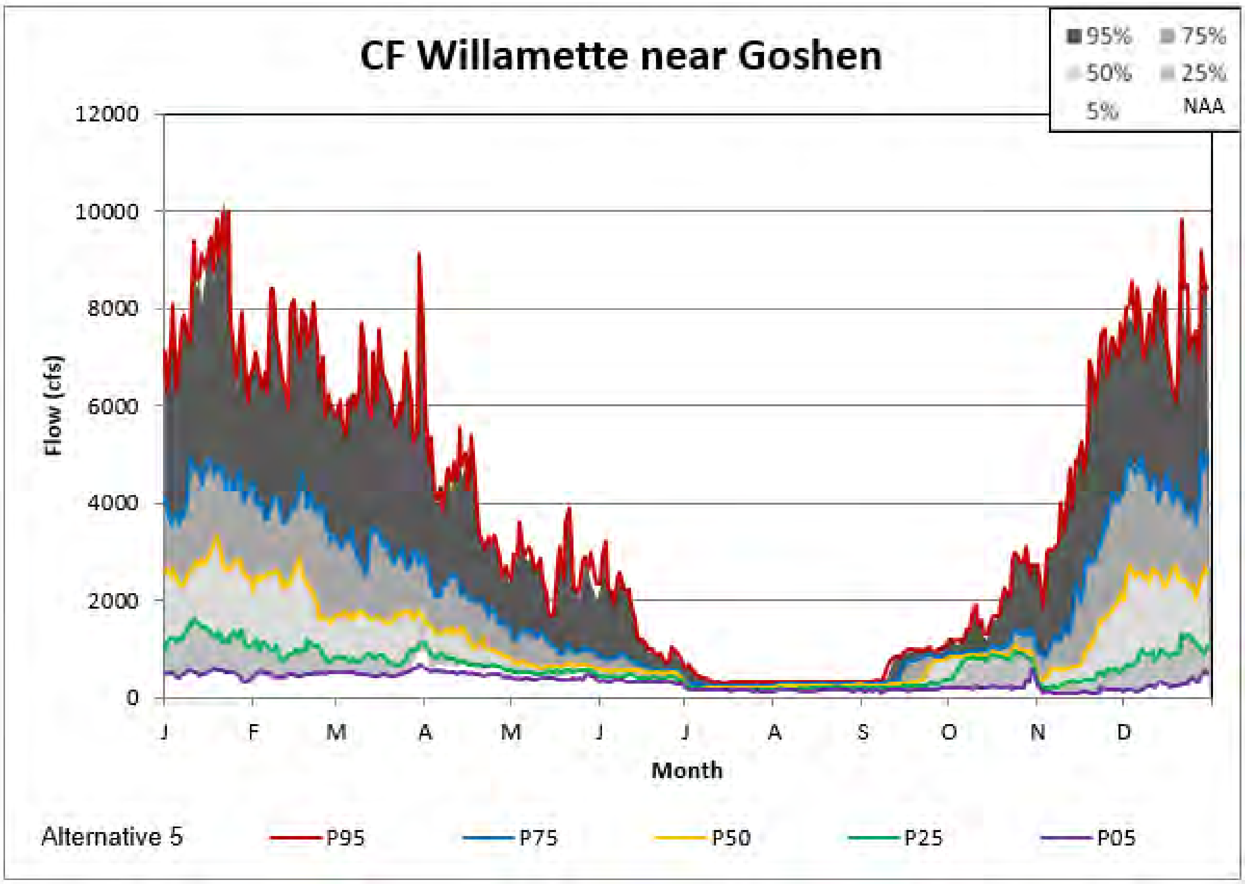


Figure 5-153. Goshen Alternative 5 Non-Exceedance Plot

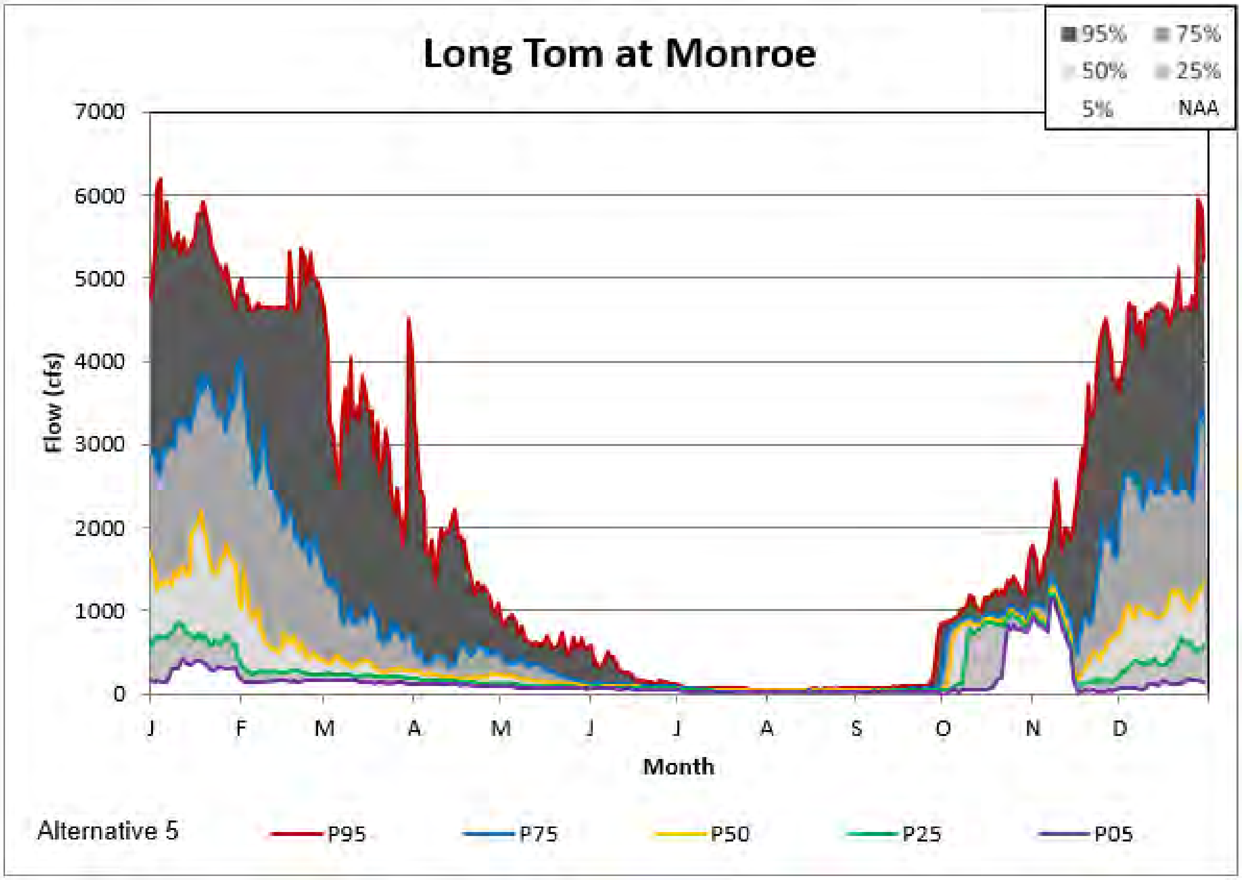


Figure 5-154. Monroe Alternative 5 Non-Exceedance Plot

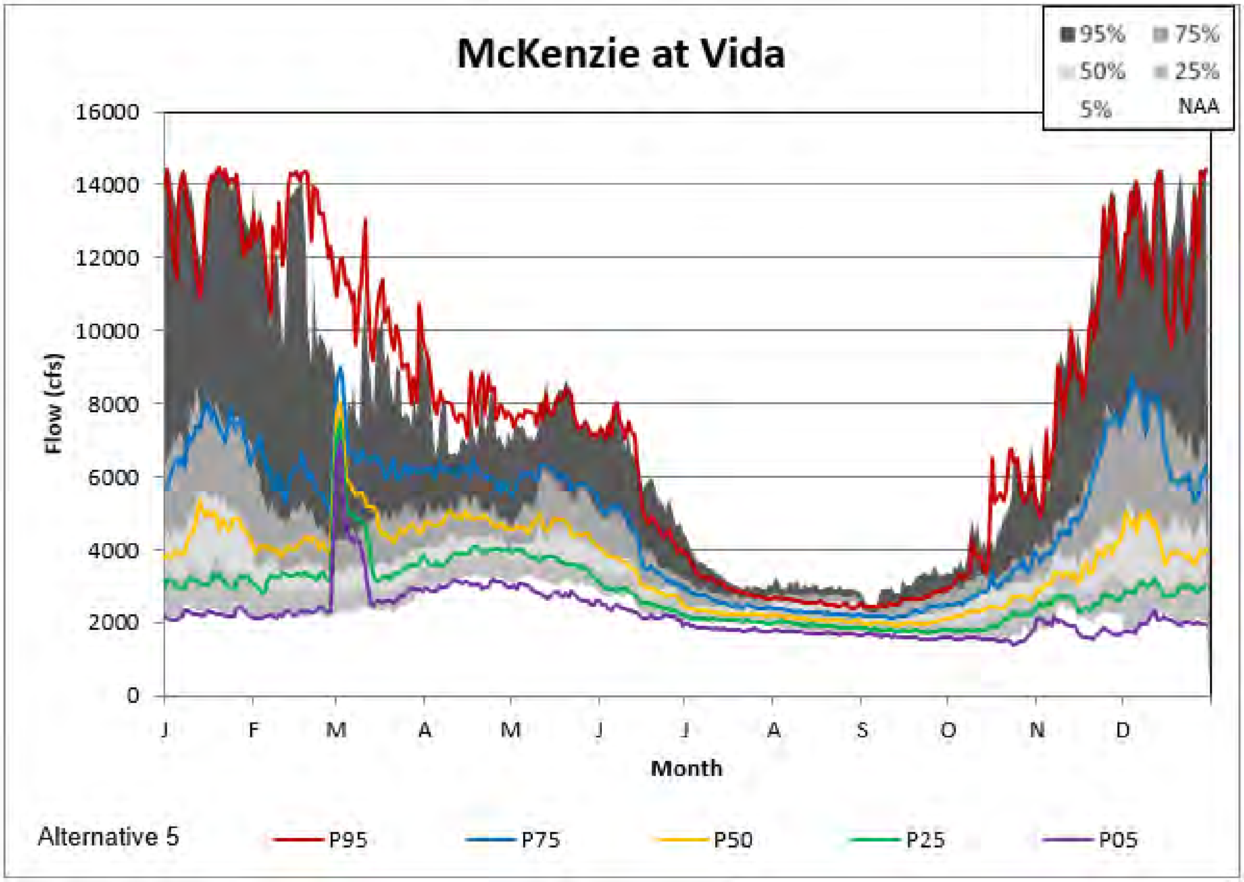


Figure 5-155. Vida Alternative 5 Non-Exceedance Plot

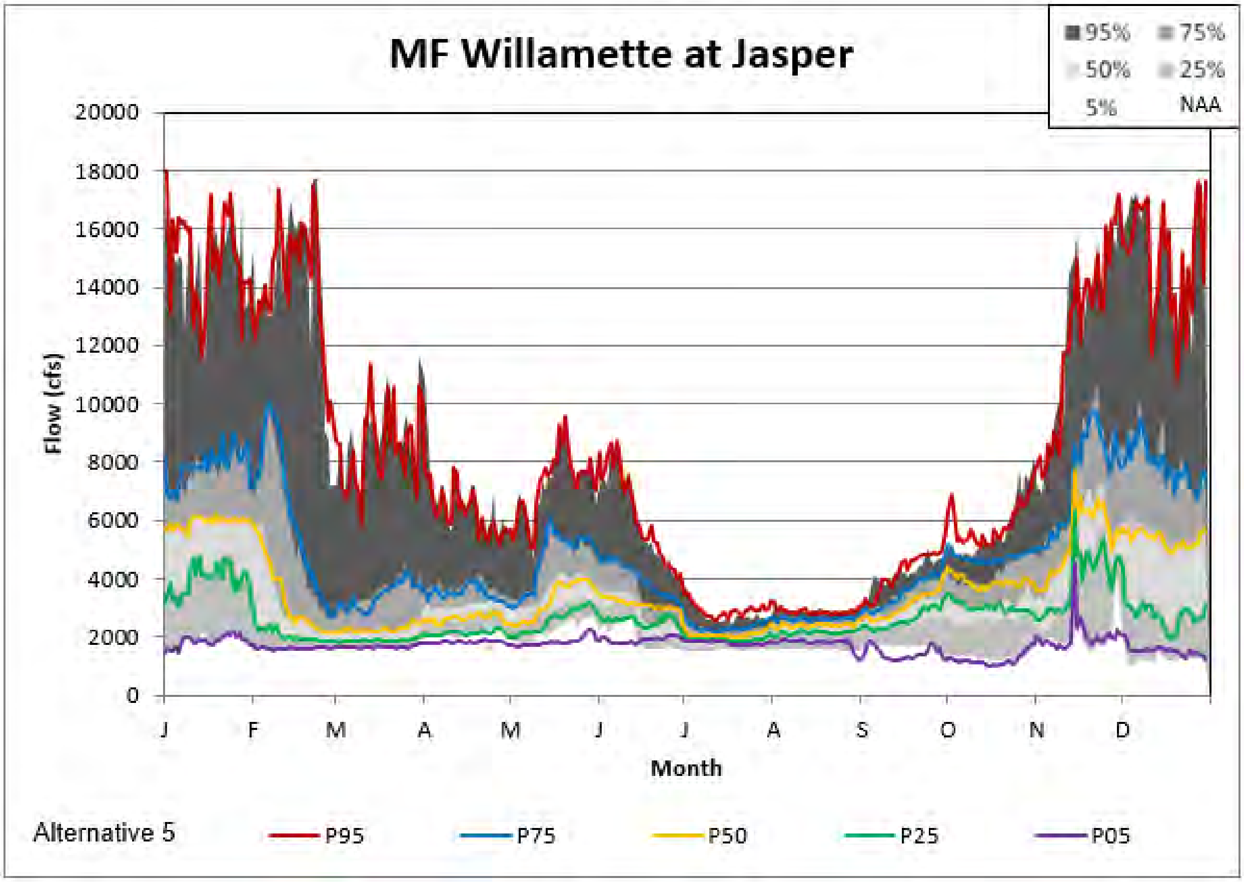


Figure 5-156. Jasper Alternative 5 Non-Exceedance Plot

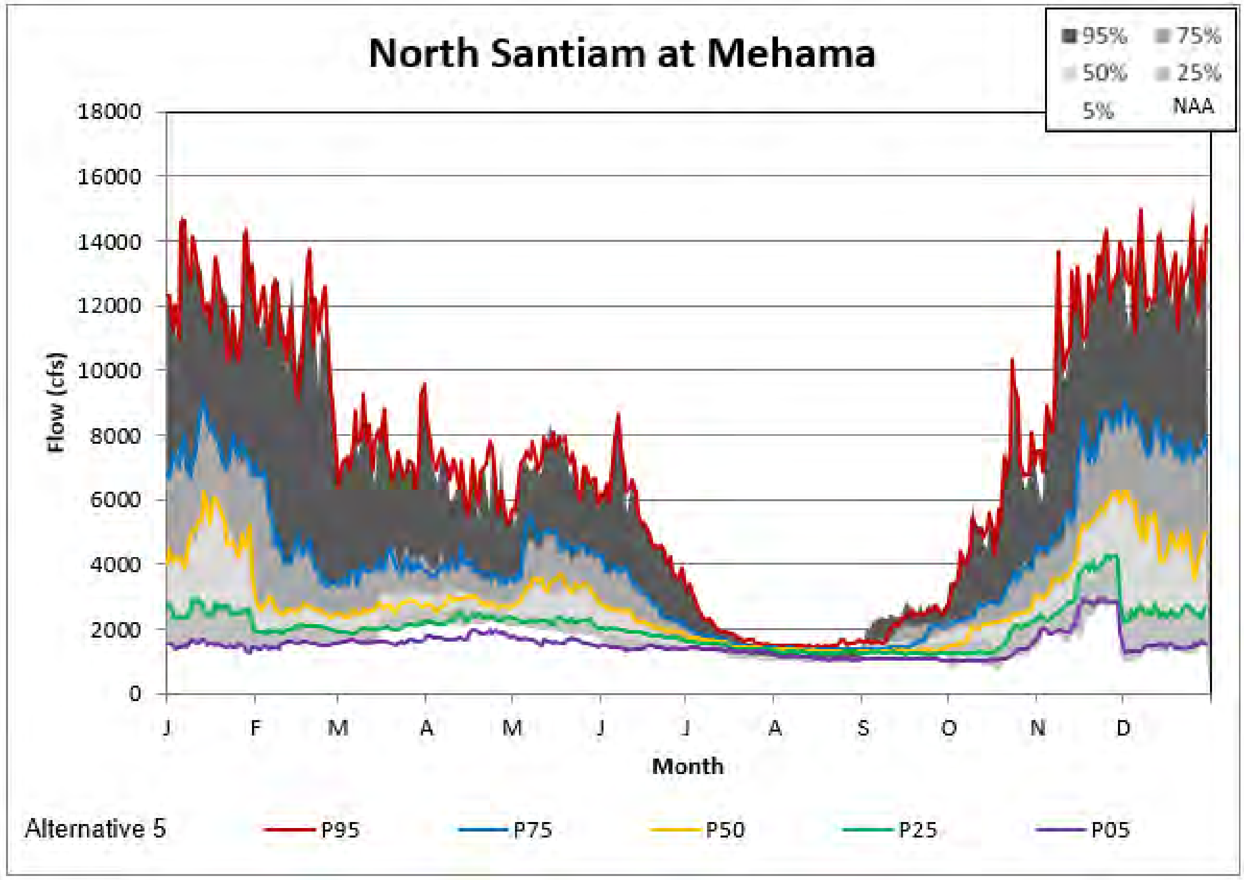


Figure 5-157. Mehama Alternative 5 Non-Exceedance Plot

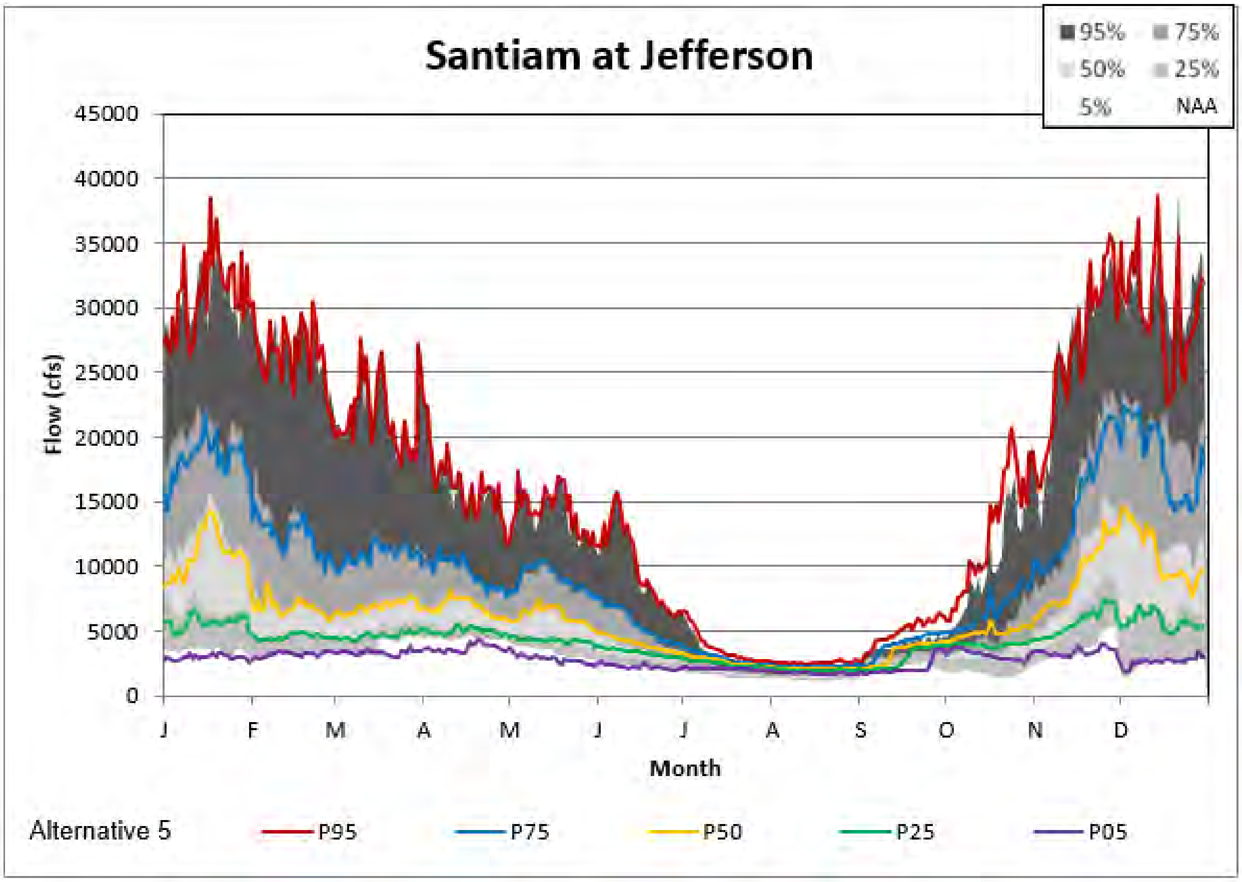


Figure 5-158. Jefferson Alternative 5 Non-Exceedance Plot

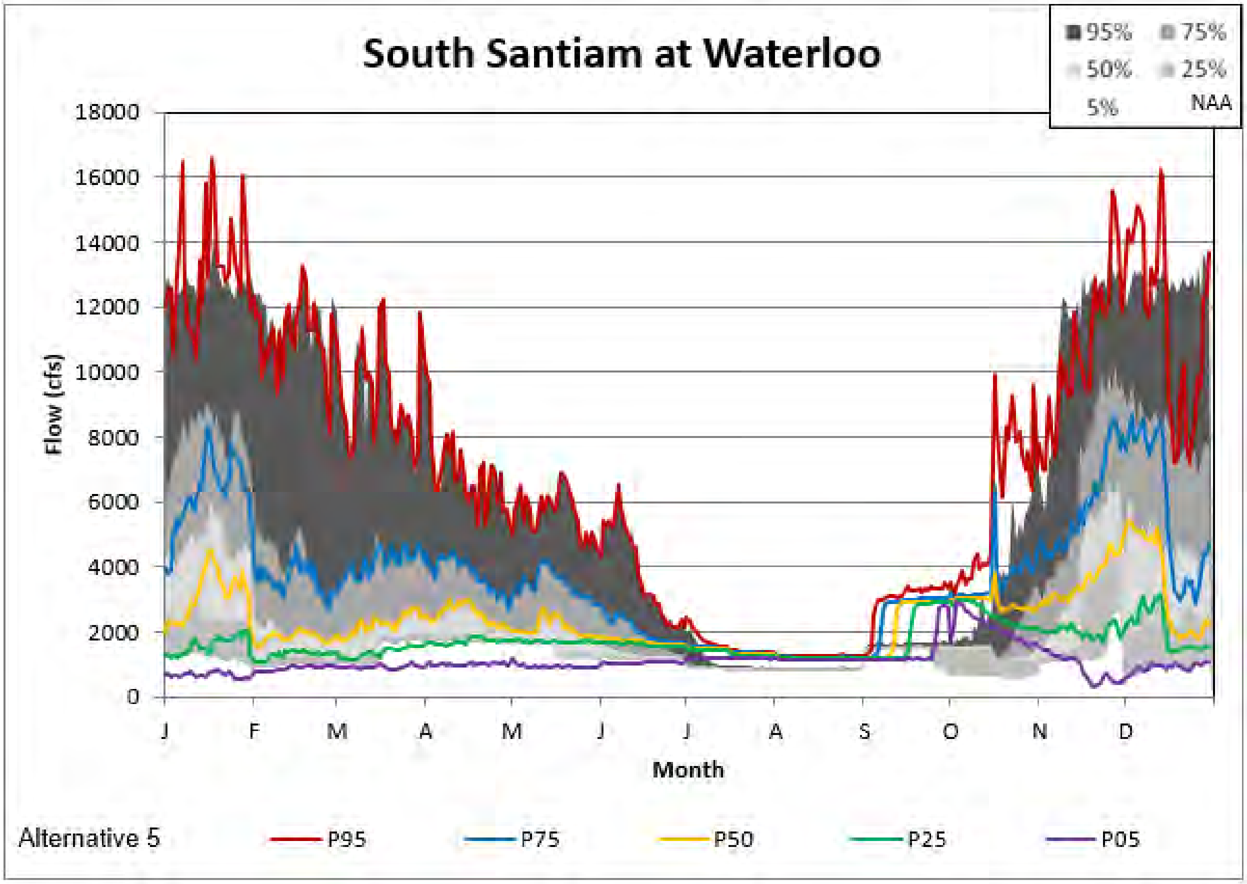


Figure 5-159. Waterloo Alternative 5 Non-Exceedance Plot

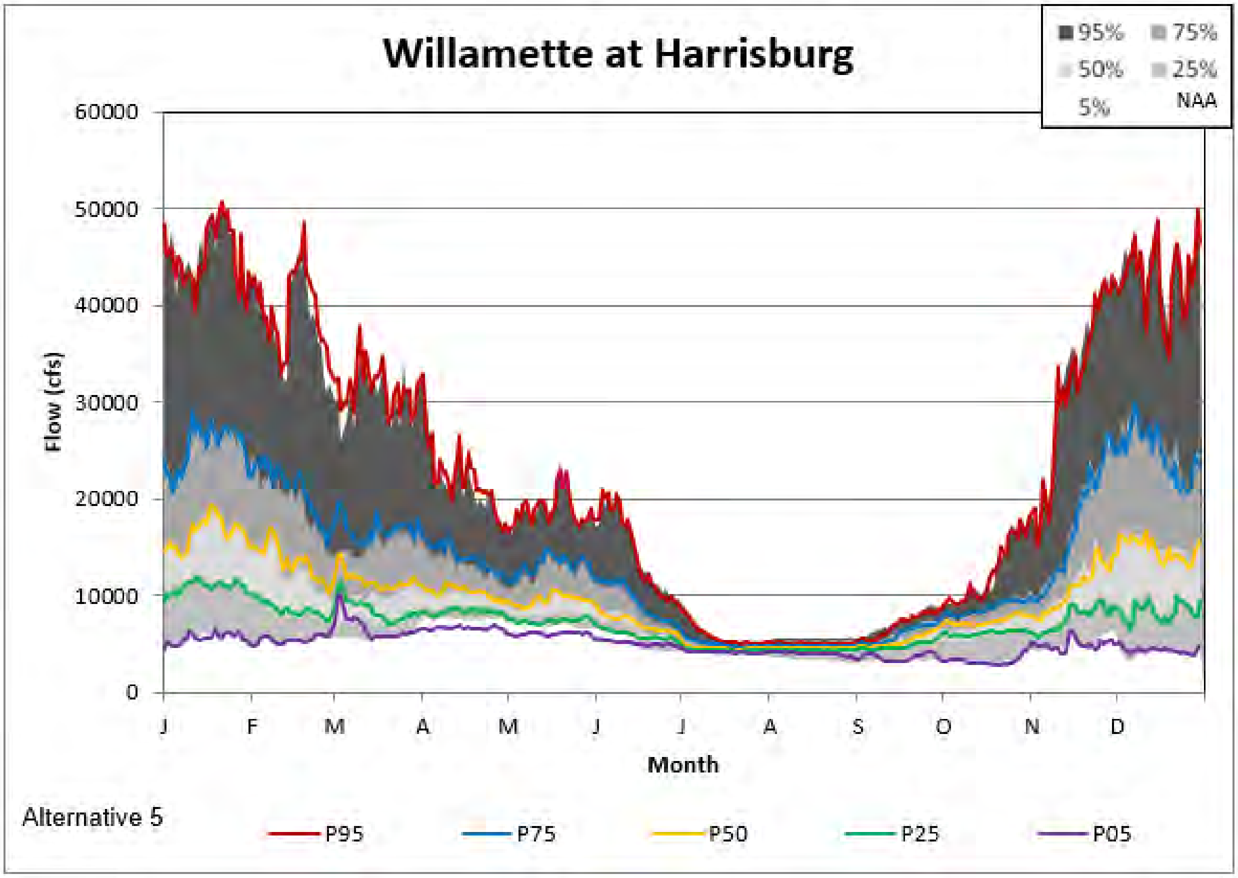


Figure 5-160. Harrisburg Alternative 5 Non-Exceedance Plot

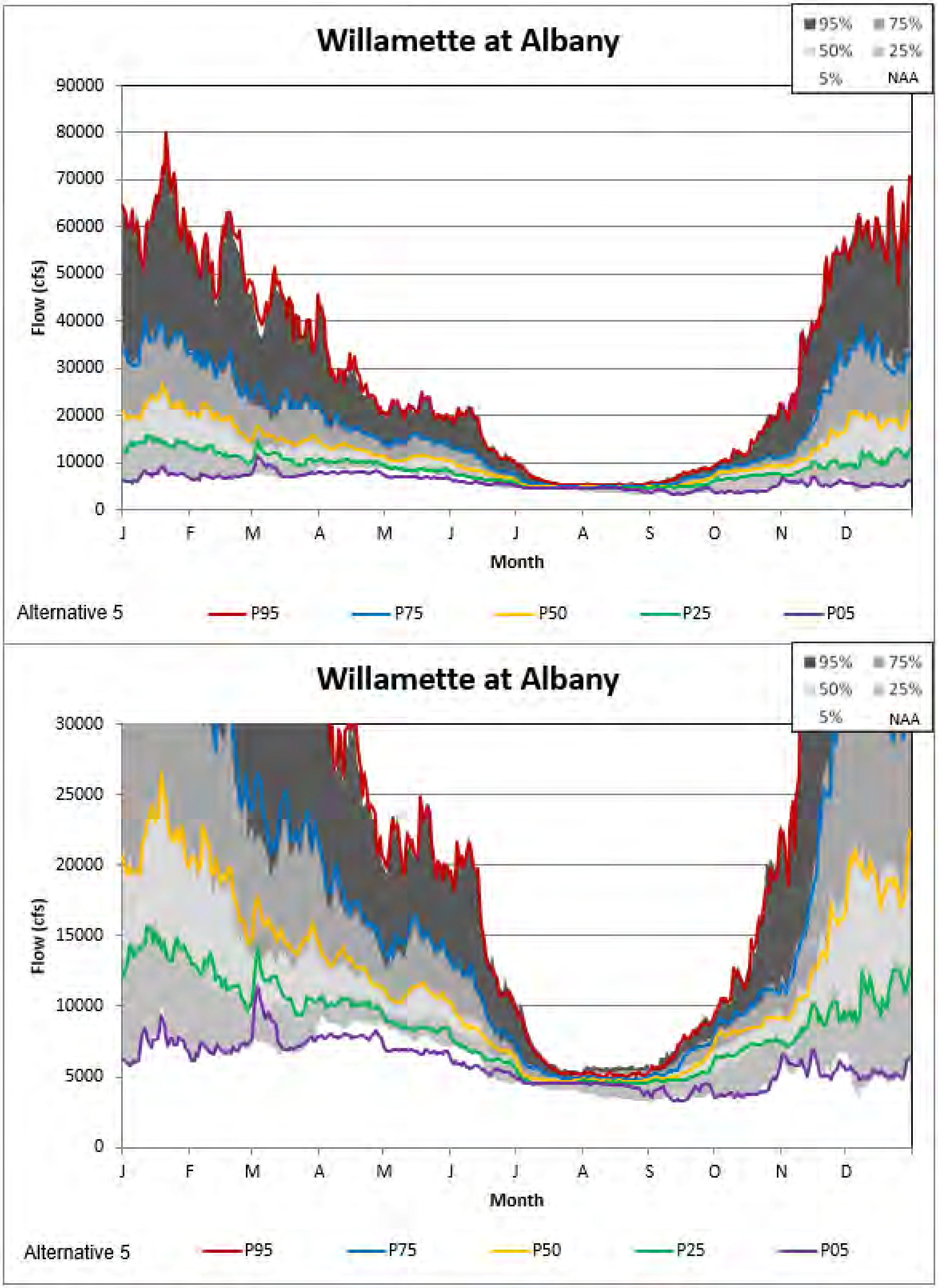


Figure 5-161. Albany Alternative 5 Non-Exceedance Plot

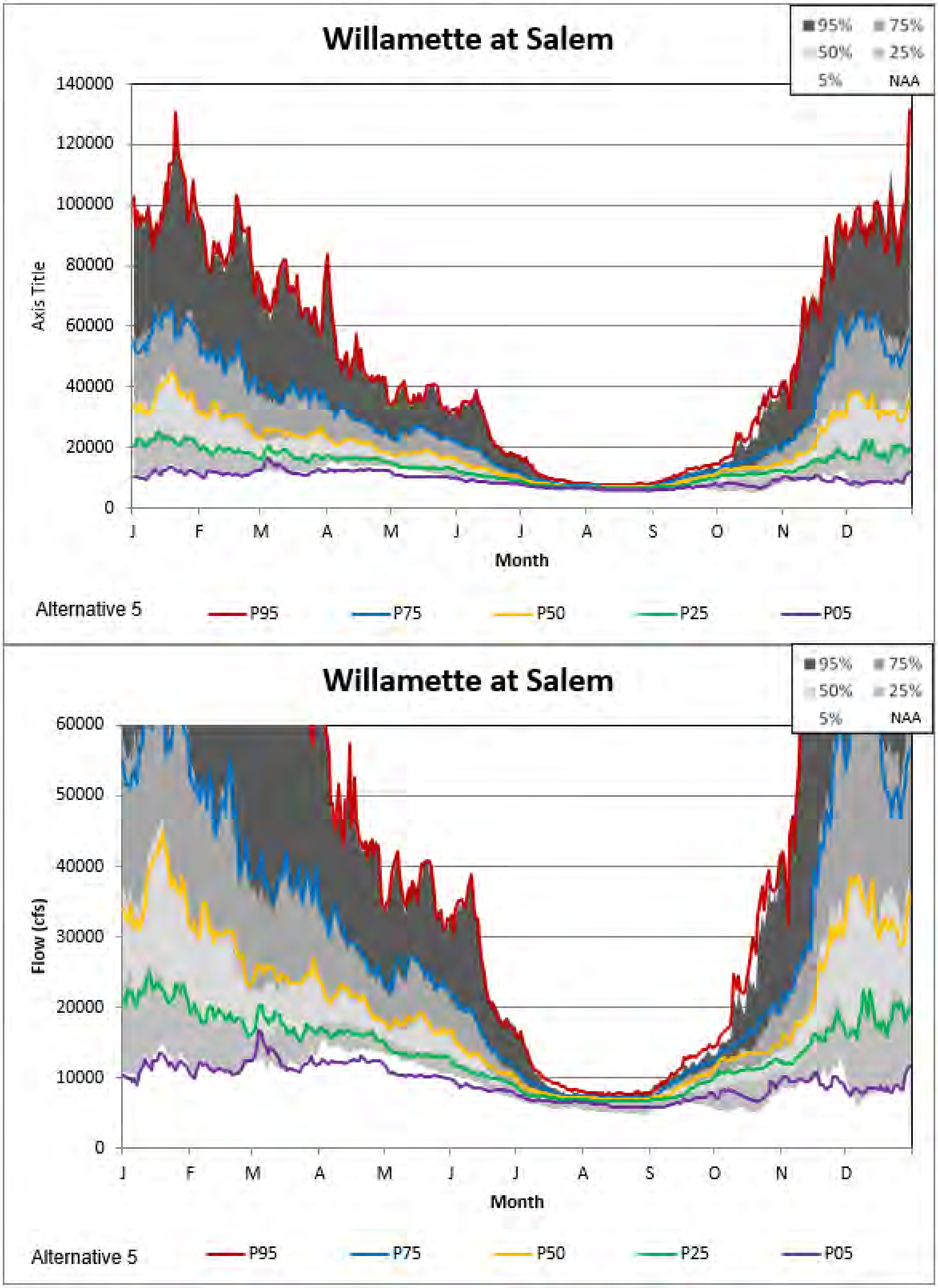


Figure 5-162. Salem Alternative 5 Non-Exceedance Plot

5.8 ALTERNATIVE 5 / ALTERNATIVE 2B COMPARISON PLOTS

Modeled measures in Alternative 5 are identical to Alternative 2B except for the minimum mainstem flows at Salem, minimum tributary flows below Foster, and the allowable drawdown rate at Cougar. This section shows non-exceedance plots where the shaded non-exceedance percentiles are results from Alternative 2B and the colored lines show results from Alternative 5, and annual results comparing Alternative 5 and 2B for the years 2011, 2015, and 2016.

5.9 ALTERNATIVE 5/ALTERNATIVE 2B NON-EXCEEDANCE PLOTS

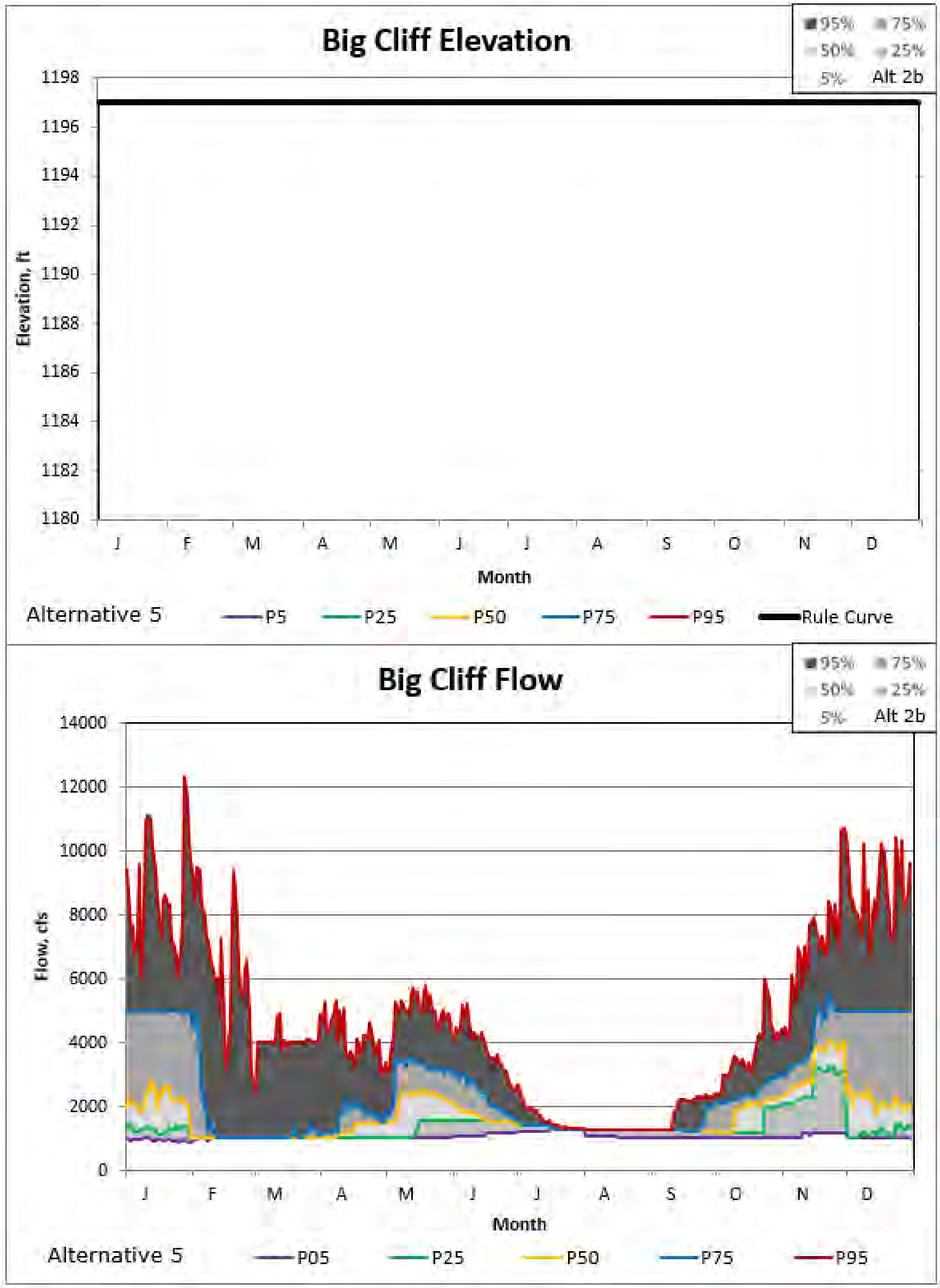


Figure 5-163. Big Cliff Alternative 5 / 2b Non-Exceedance Plot

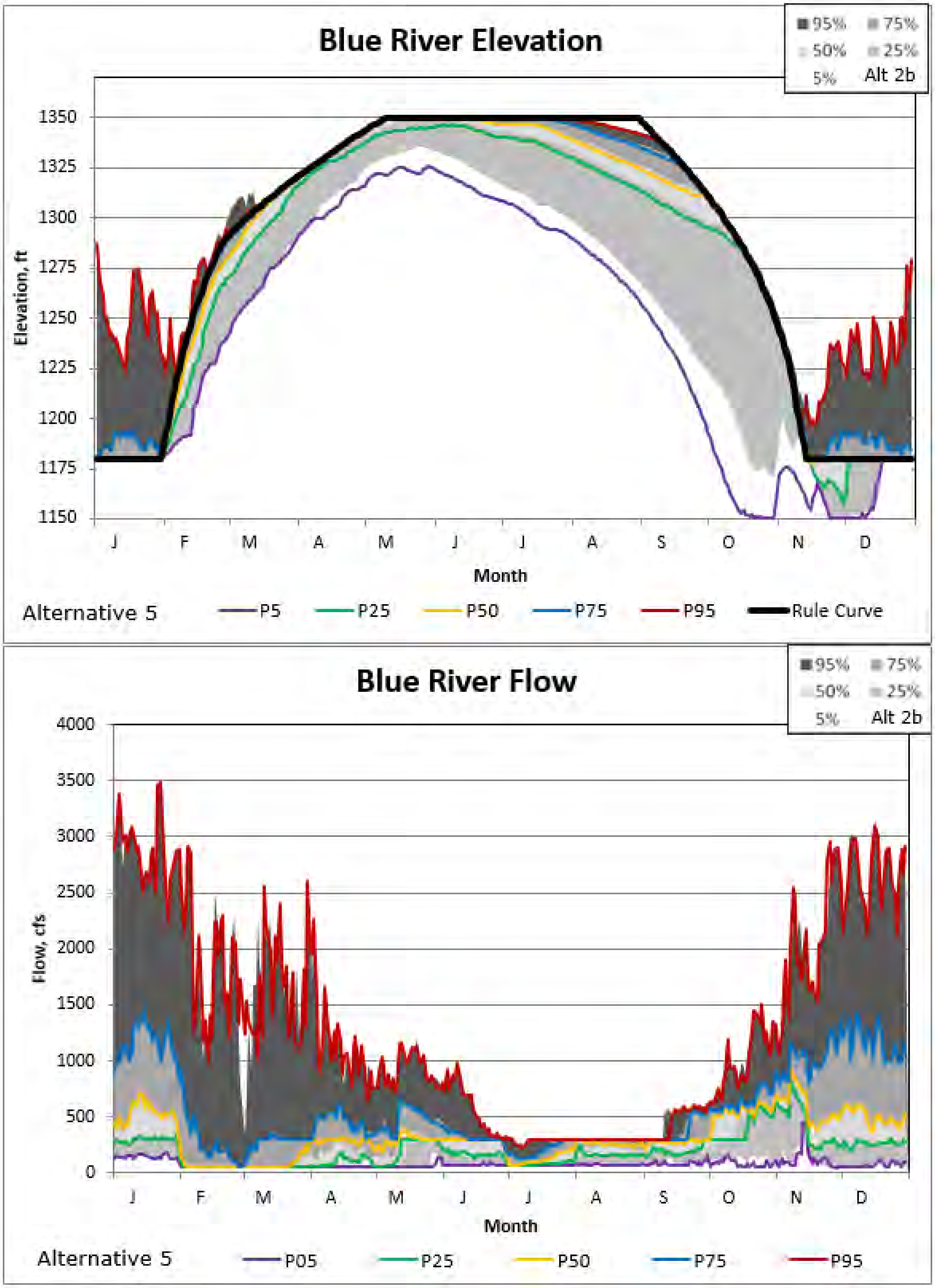


Figure 5-164. Blue River Alternative 5 / 2b Non-Exceedance Plot

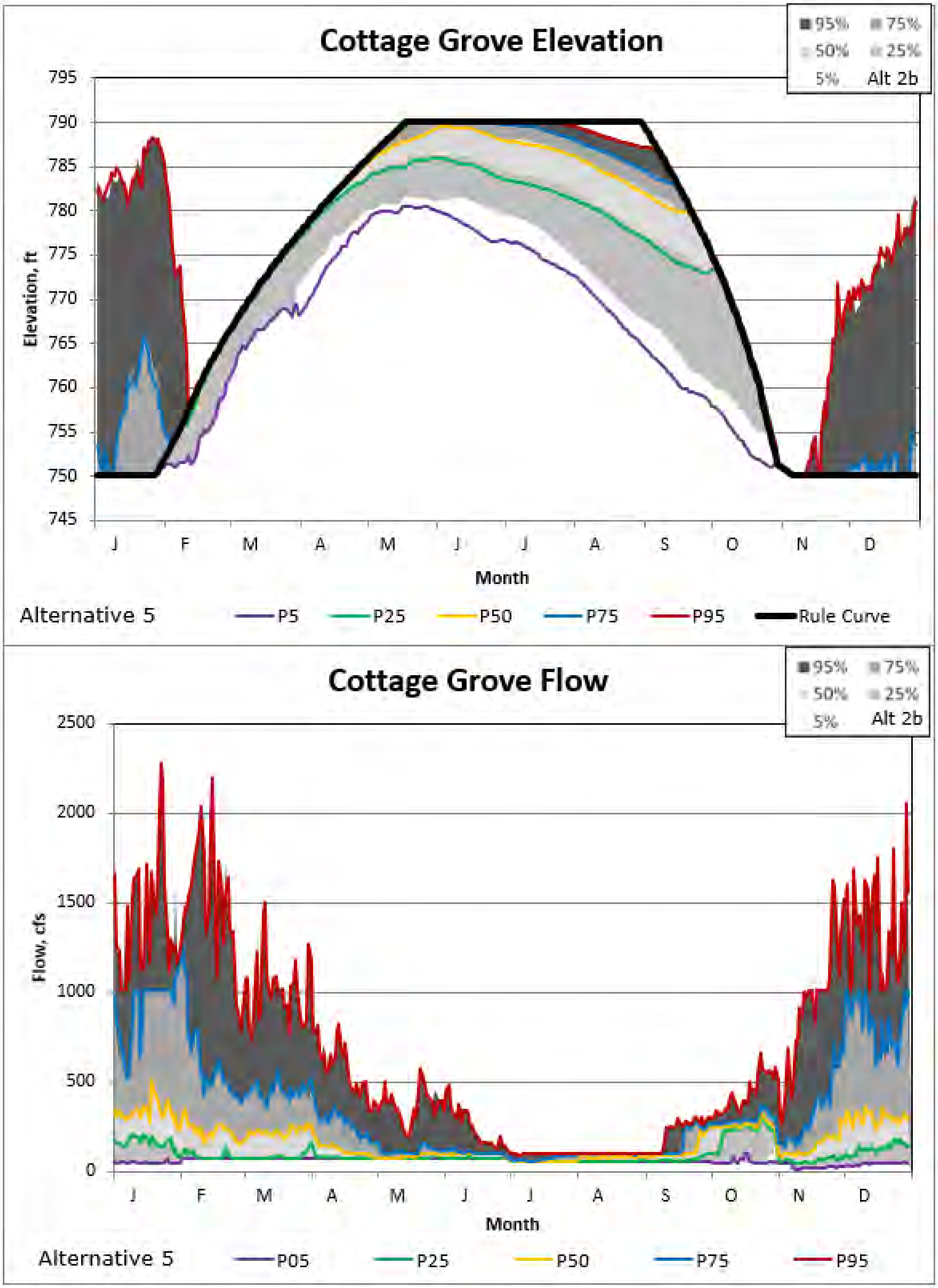


Figure 5-165. Cottage Grove Alternative 5 / 2b Non-Exceedance Plot

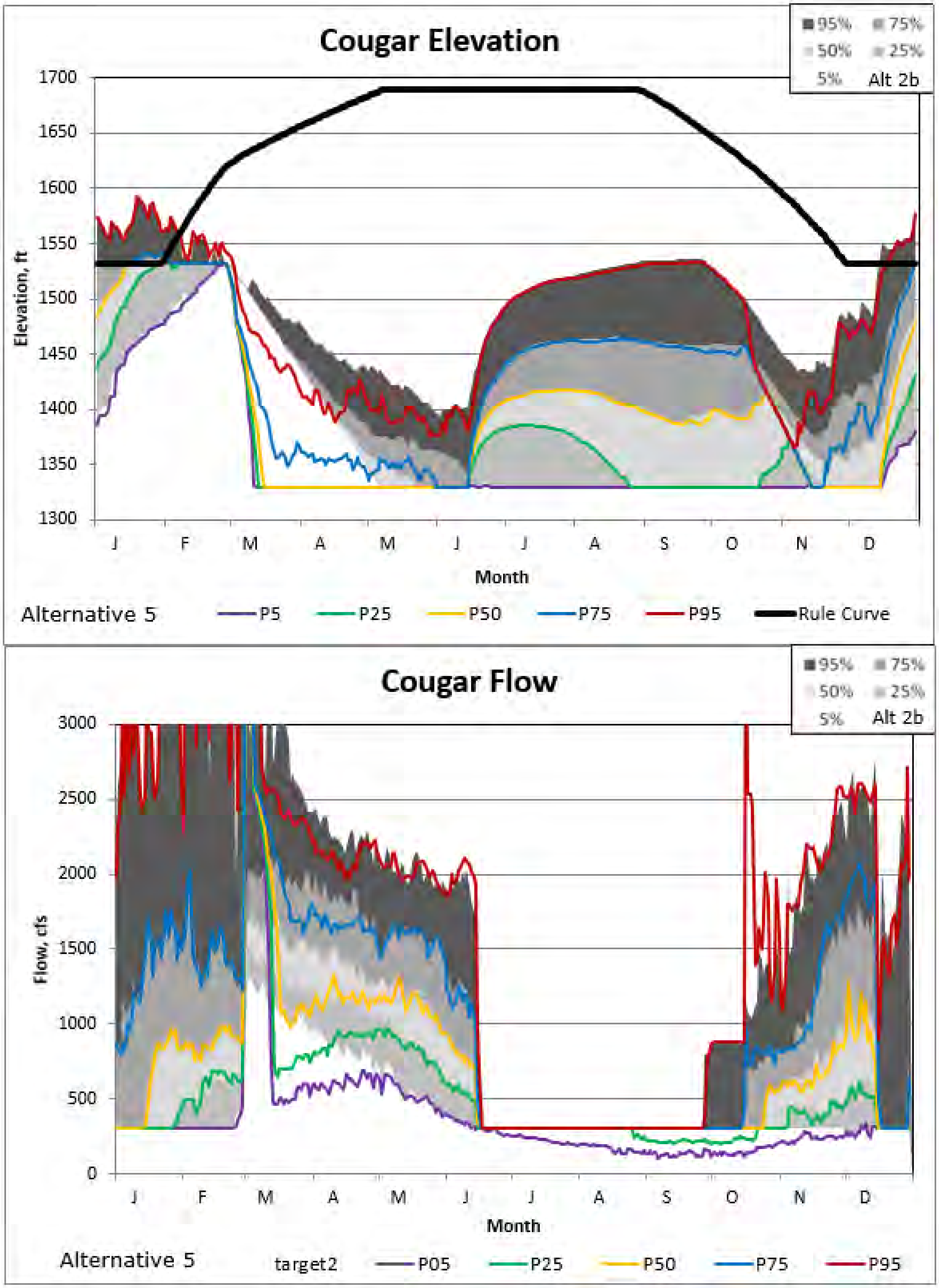


Figure 5-166. Cougar Alternative 5 / 2b Non-Exceedance Plot

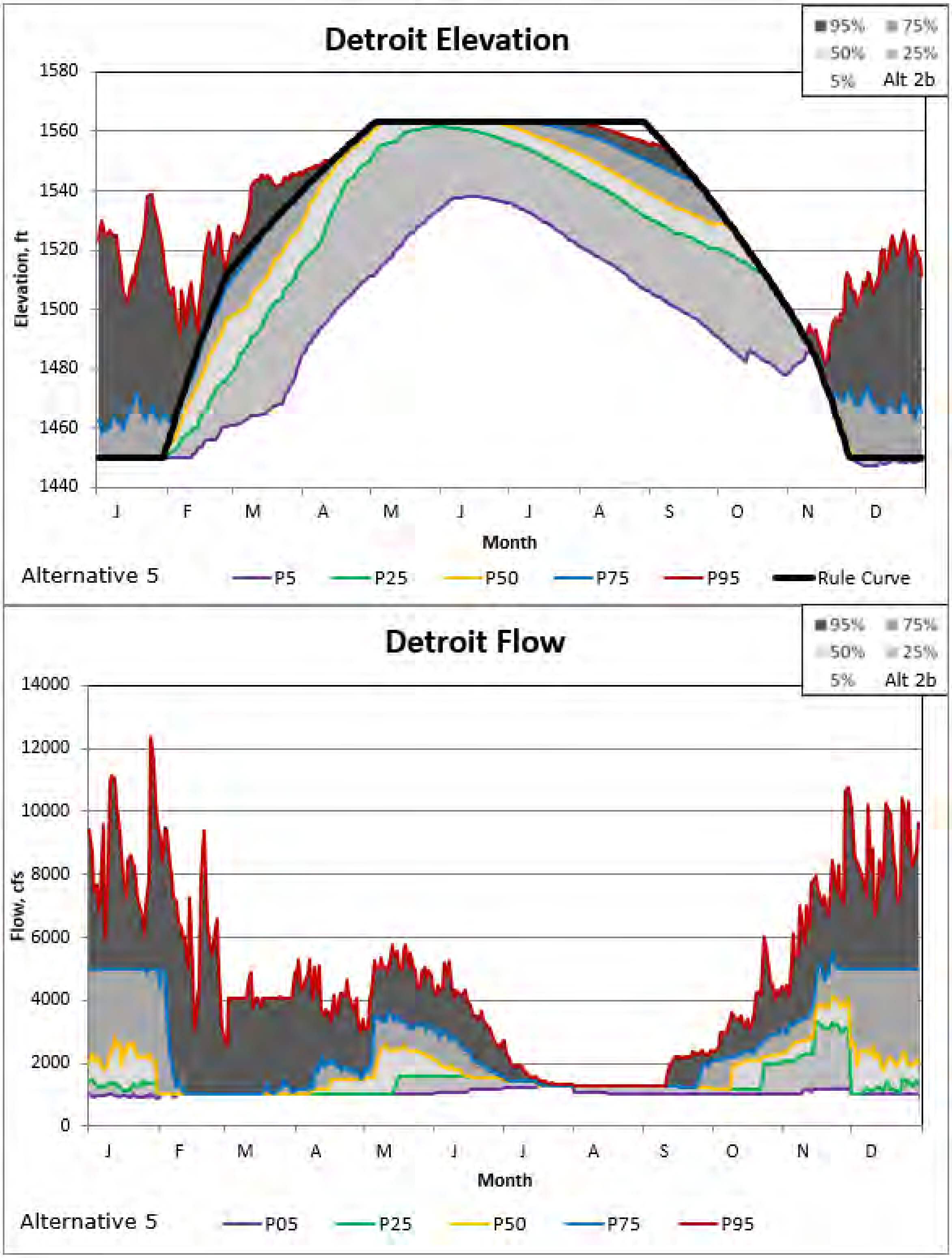


Figure 5-167. Detroit Alternative 5 / 2b Non-Exceedance Plot

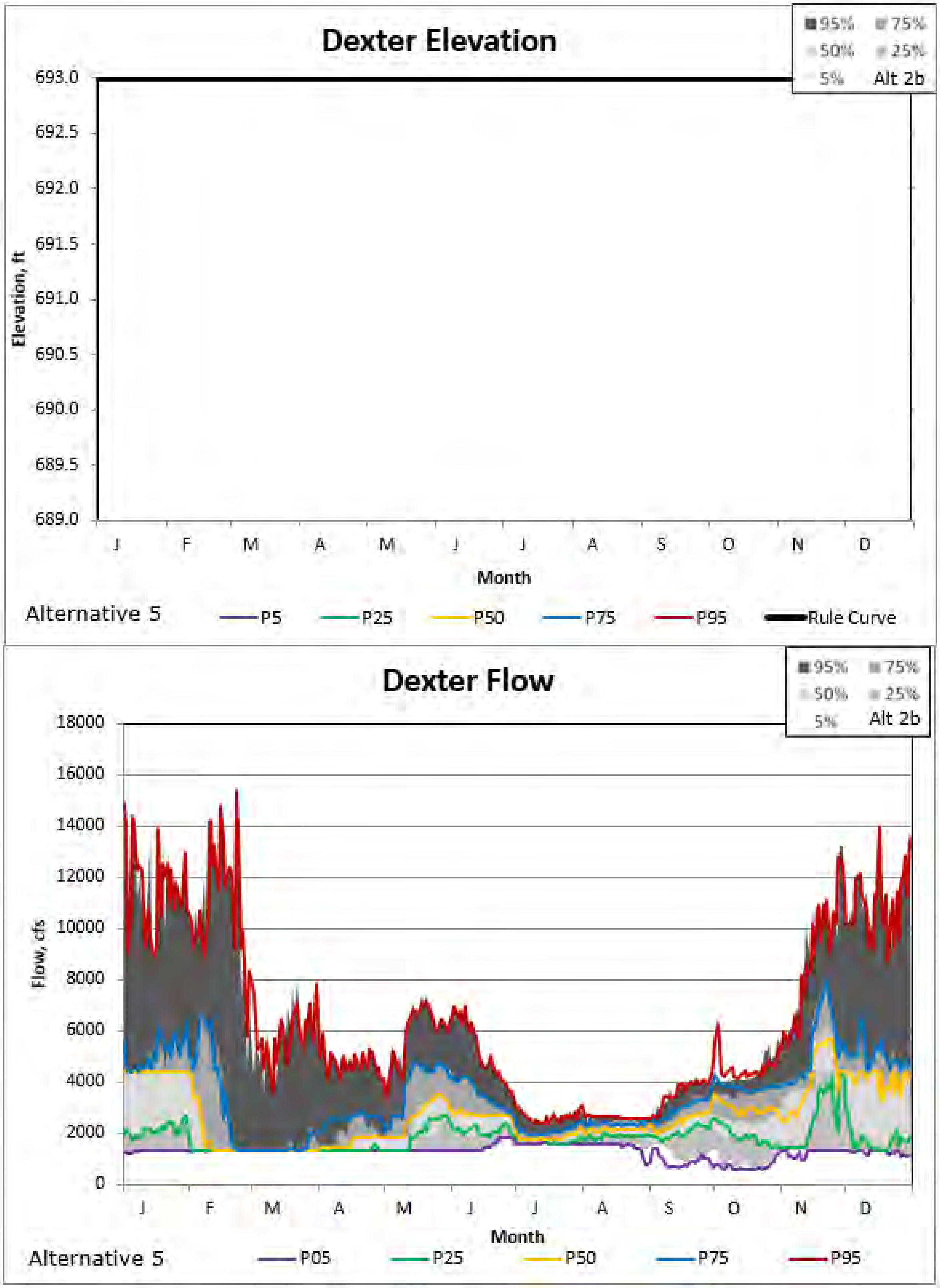


Figure 5-168. Dexter Alternative 5 / 2b Non-Exceedance Plot

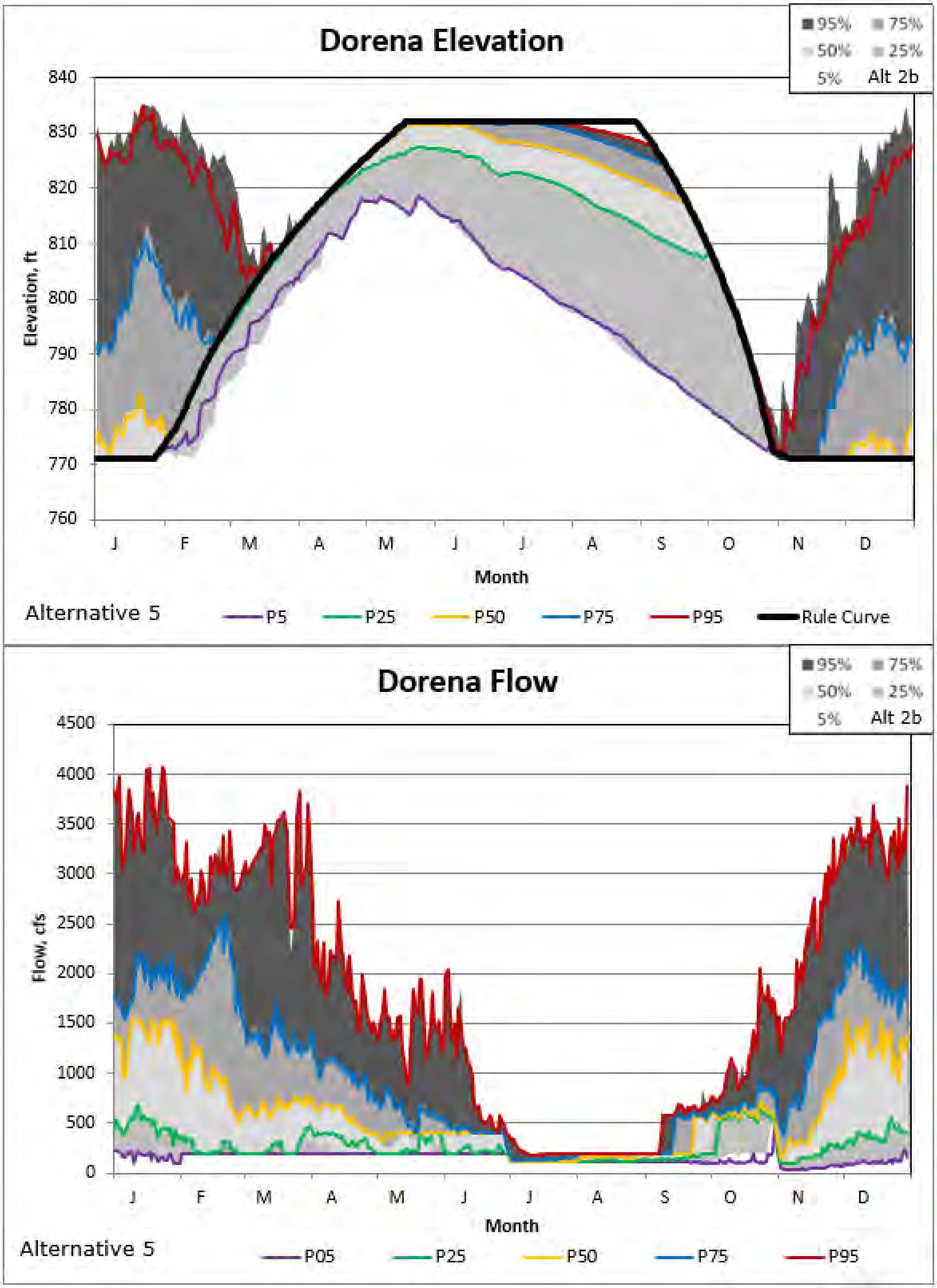


Figure 5-169. Dorena Alternative 5 / 2b Non-Exceedance Plot

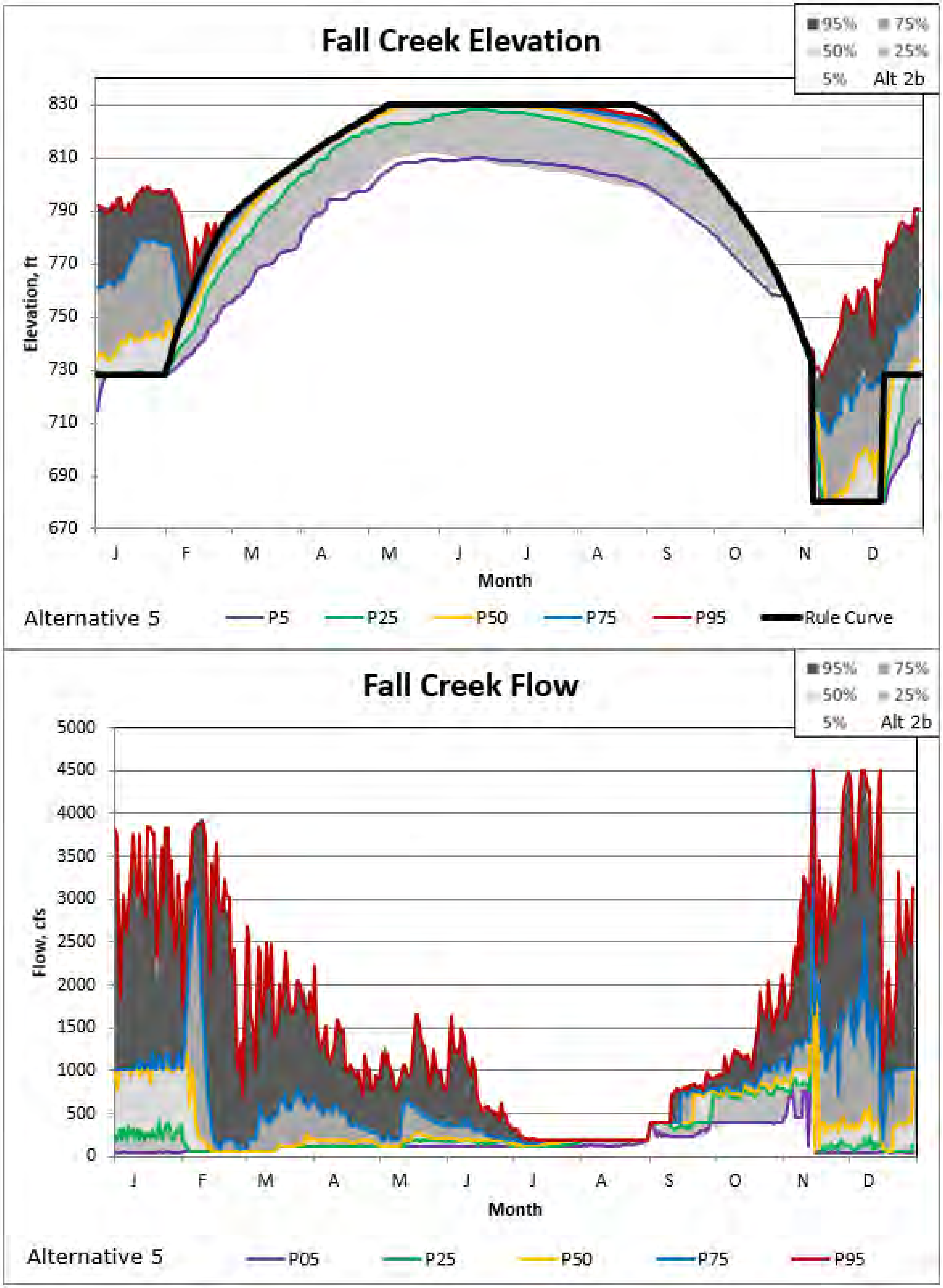


Figure 5-170. Fall Creek Alternative 5 / 2b Non-Exceedance Plot

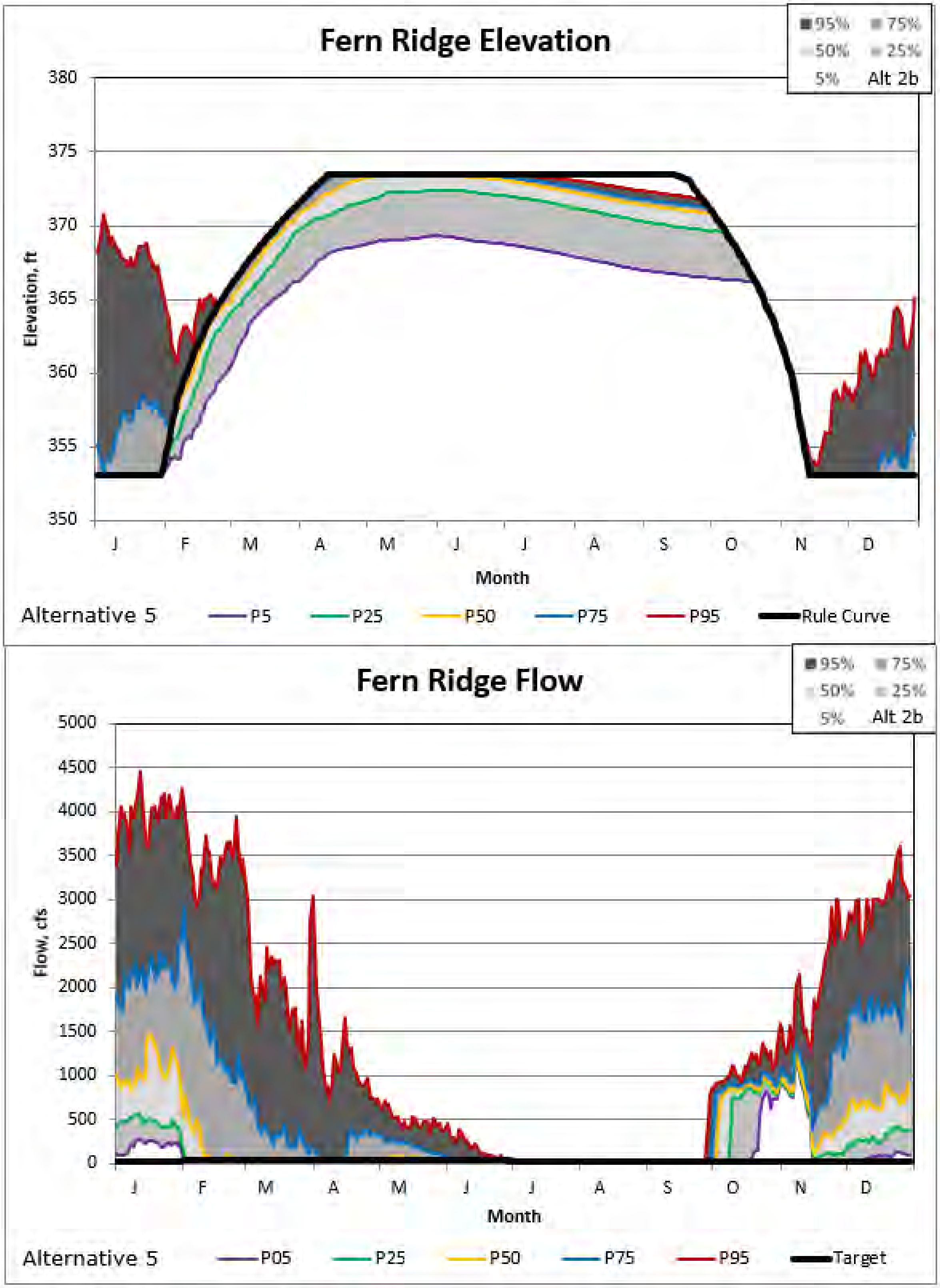


Figure 5-171. Fern Ridge Alternative 5 / 2b Non-Exceedance Plot

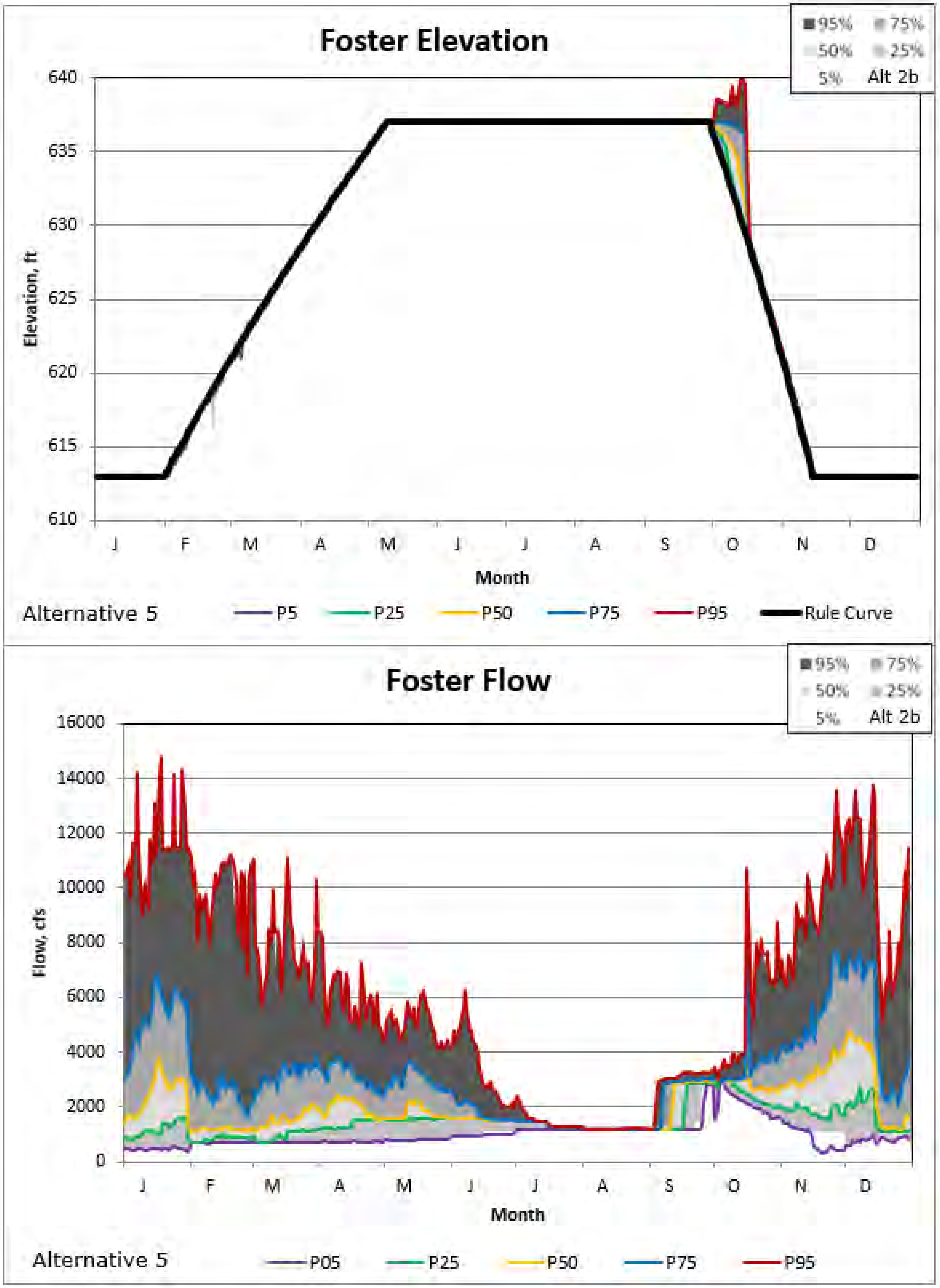


Figure 5-172. Foster Alternative 5 / 2b Non-Exceedance Plot

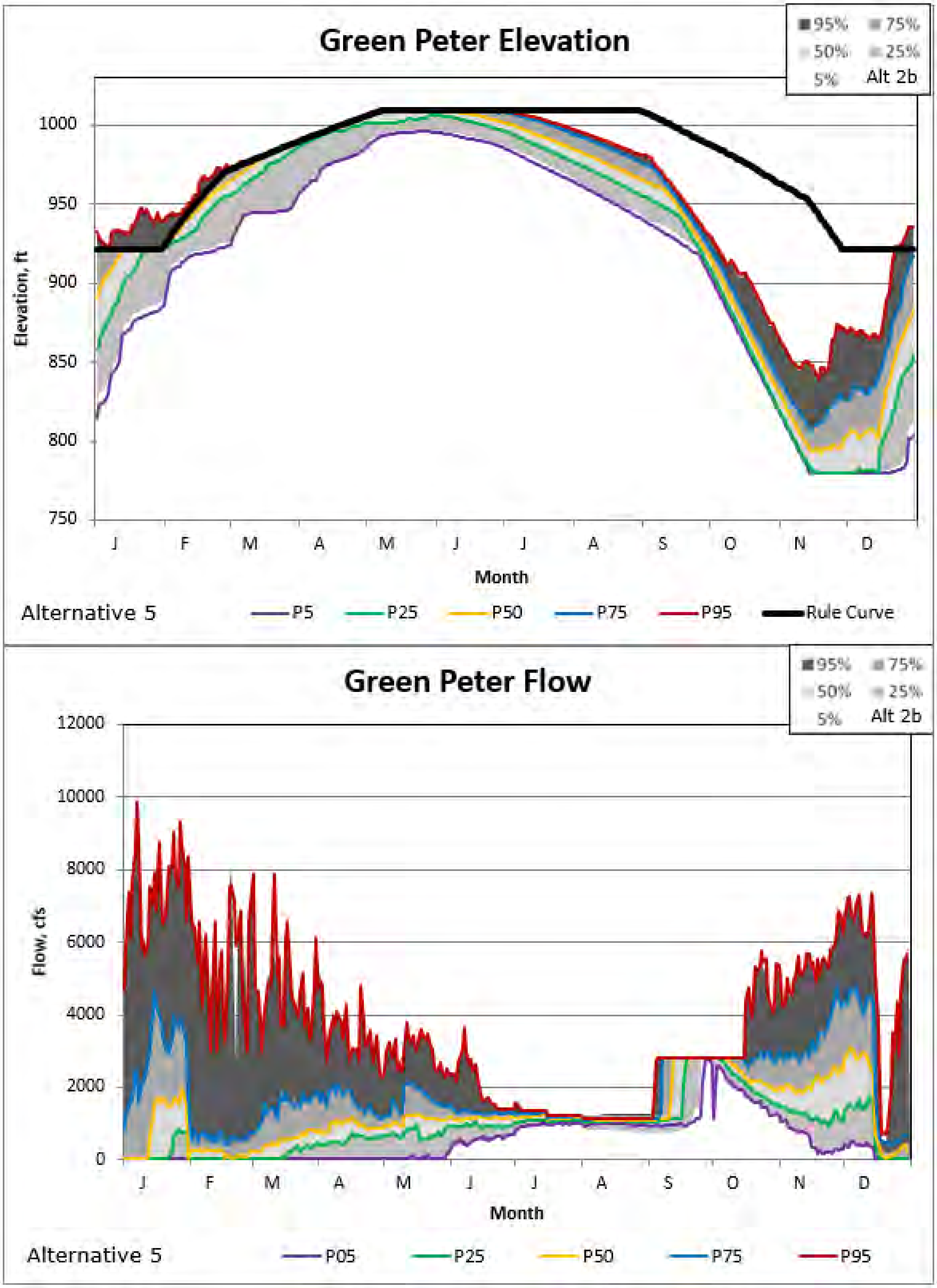


Figure 5-173. Green Peter Alternative 5 / 2b Non-Exceedance Plot

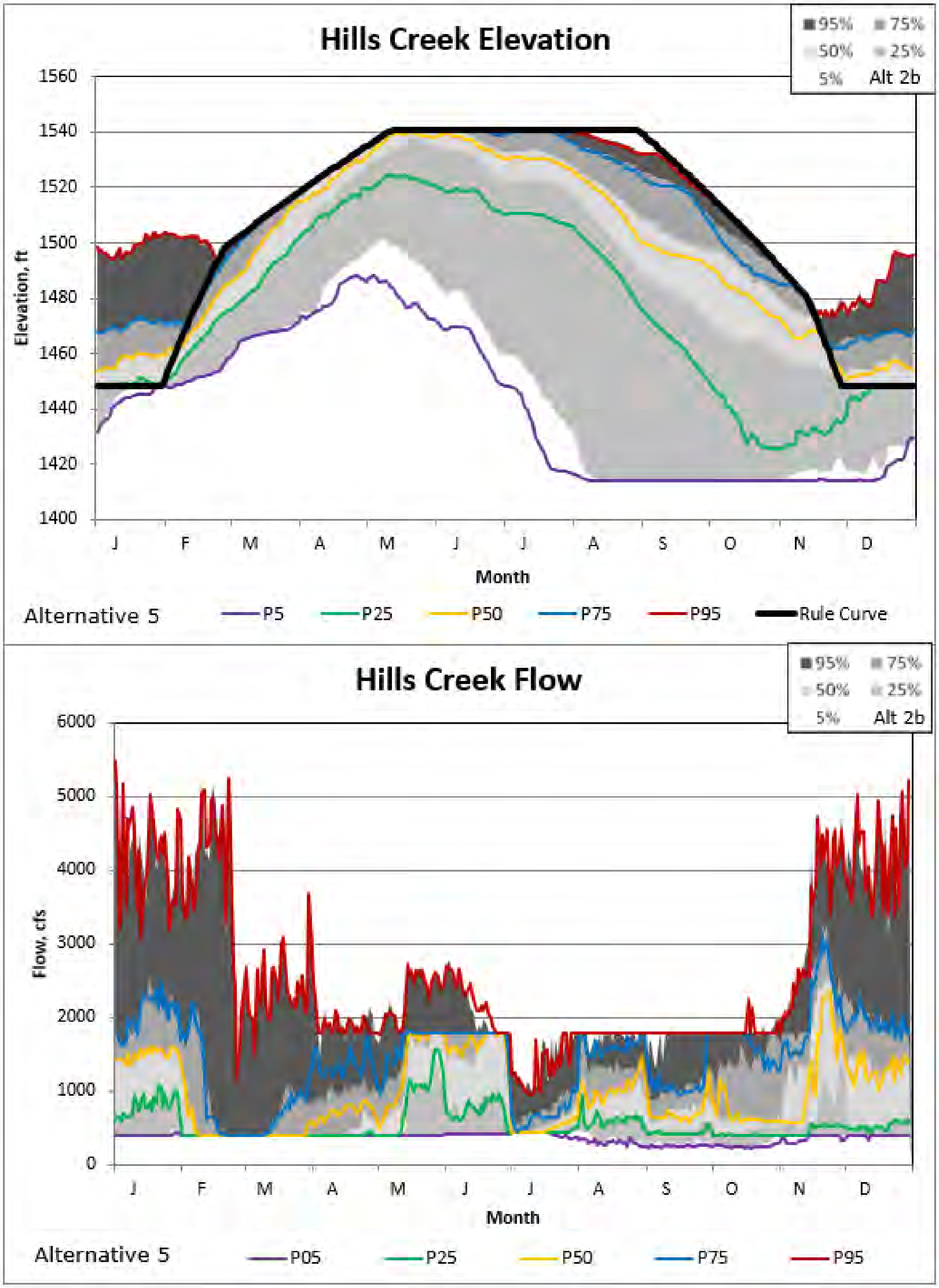


Figure 5-174. Hills Creek Alternative 5 / 2b Non-Exceedance Plo

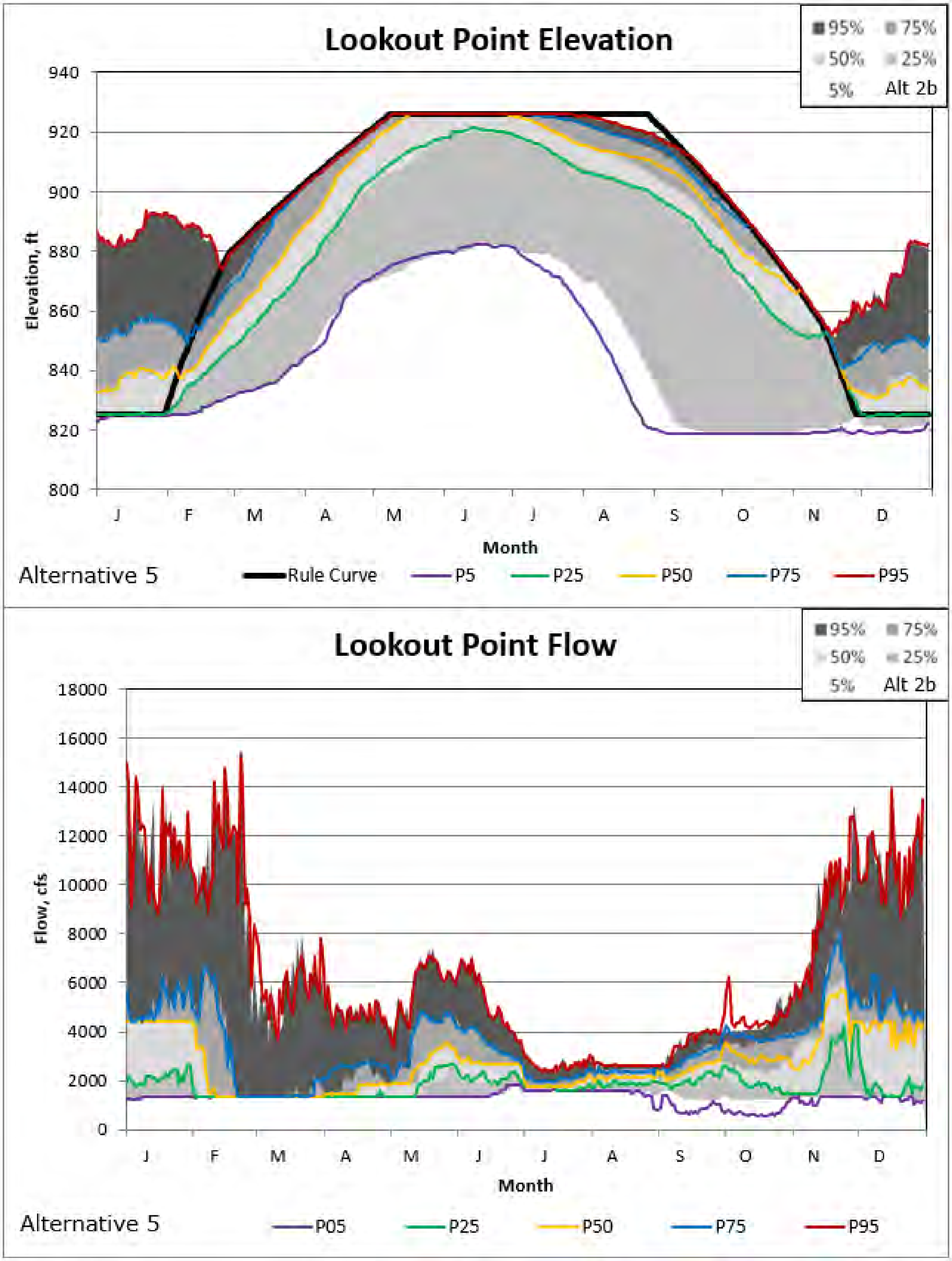


Figure 5-175. Lookout Point Alternative 5 / 2b Non-Exceedance Plot

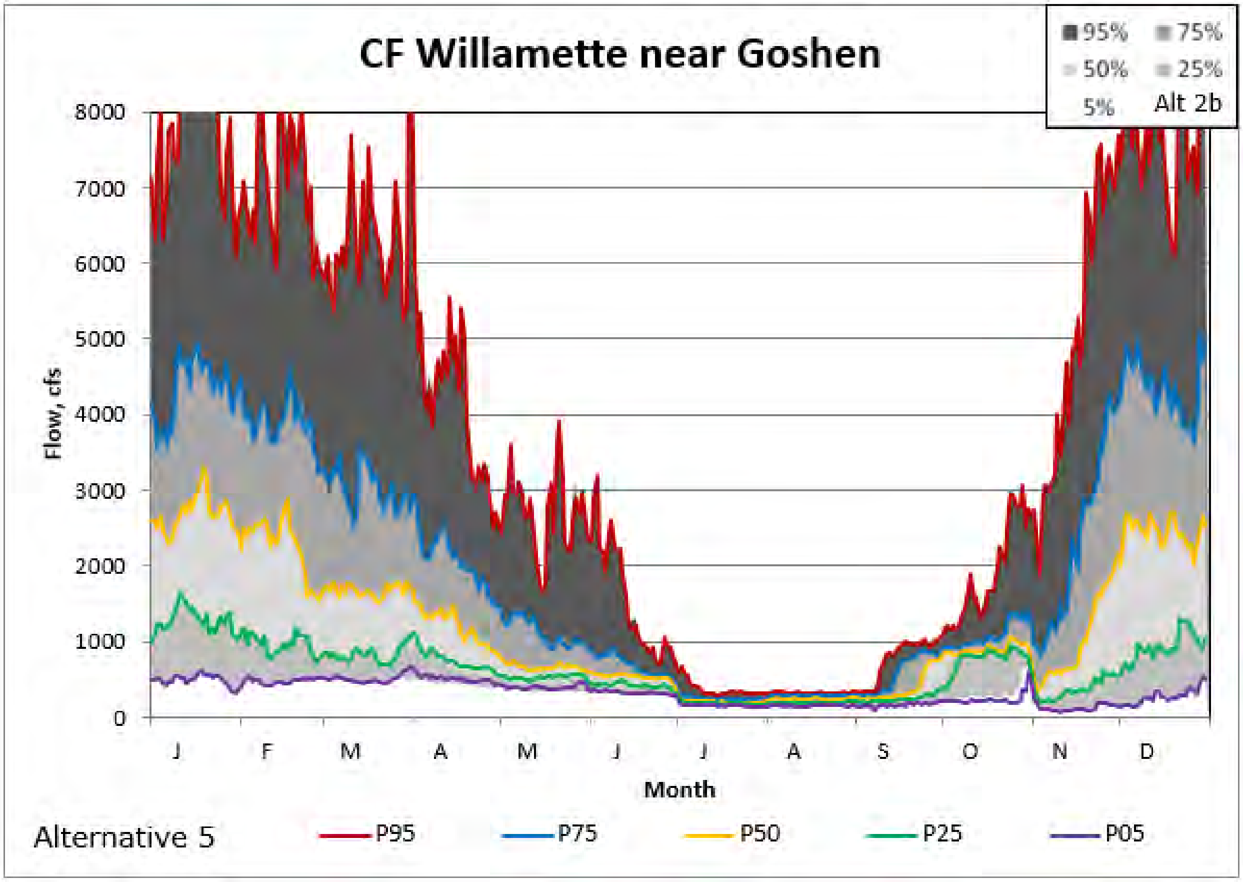


Figure 5-176. Goshen Alternative 5 / 2b Non-Exceedance Plot

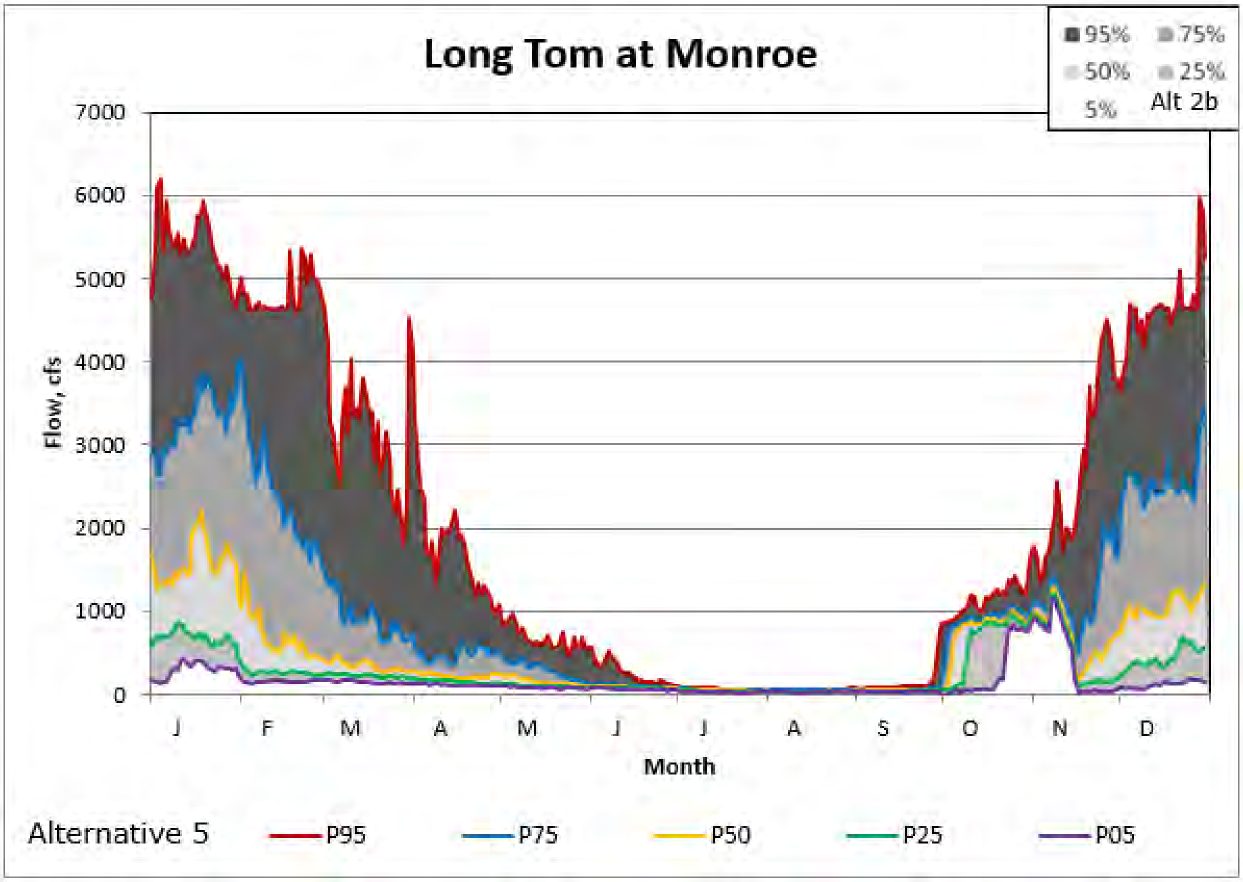


Figure 5-177. Monroe Alternative 5 / 2b Non-Exceedance Plot

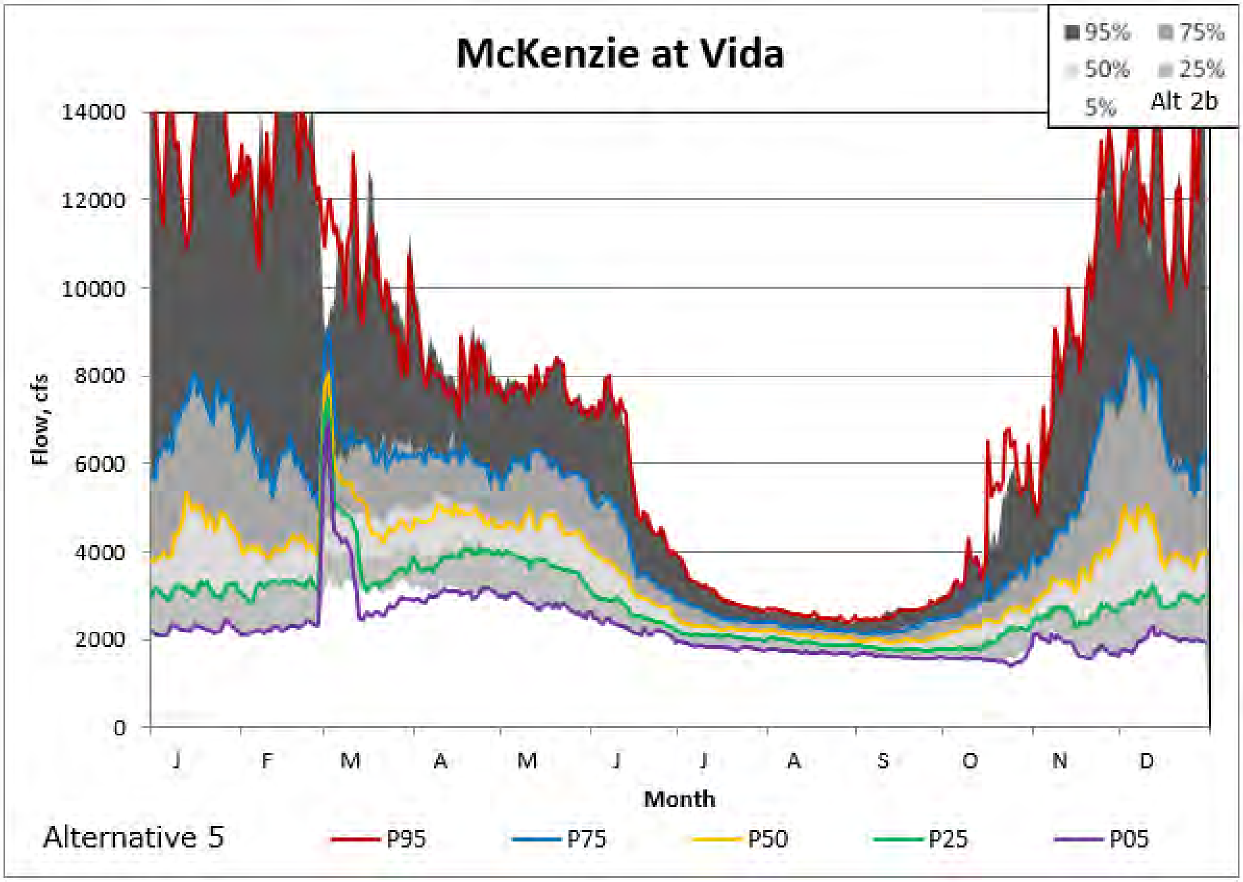


Figure 5-178. Vida Alternative 5 / 2b Non-Exceedance Plot

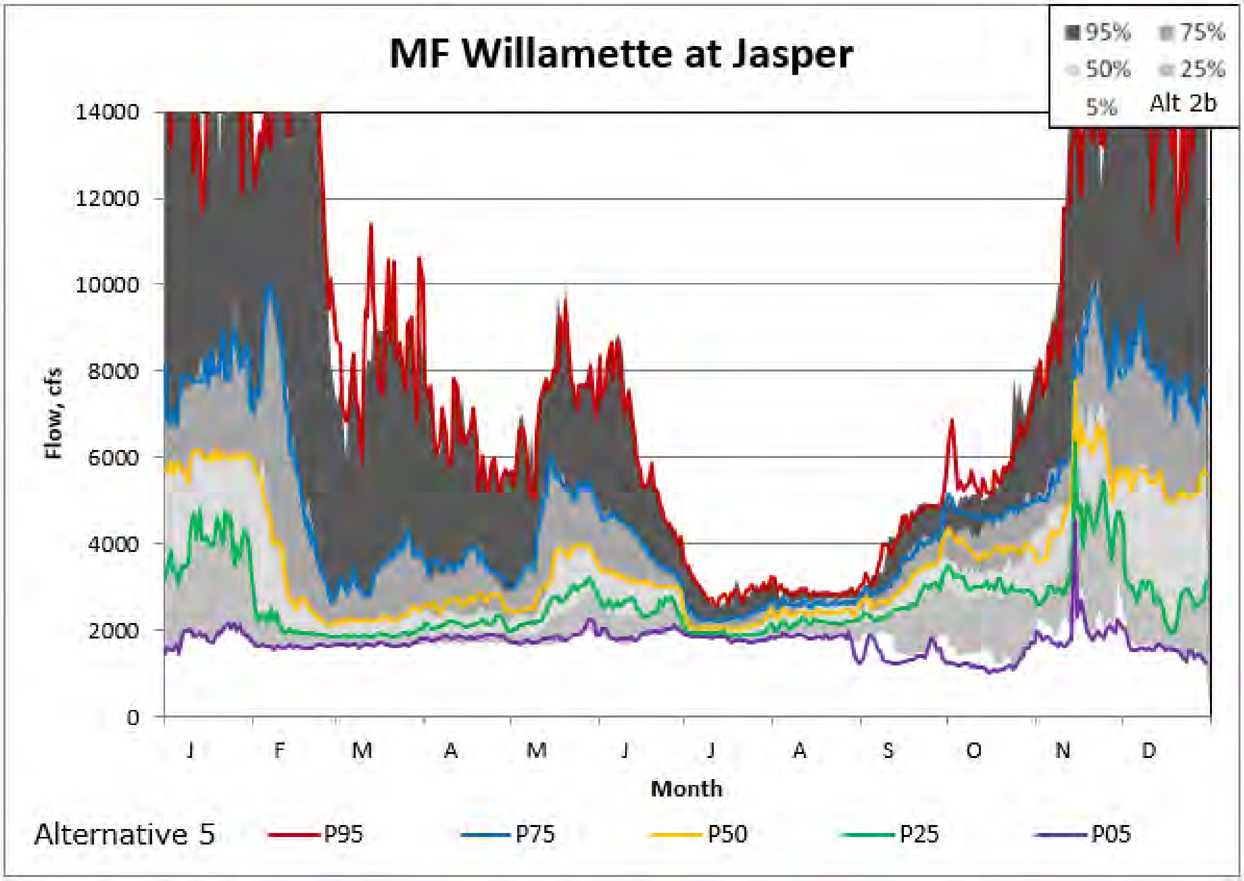


Figure 5-179. Jasper Alternative 5 / 2b Non-Exceedance Plot

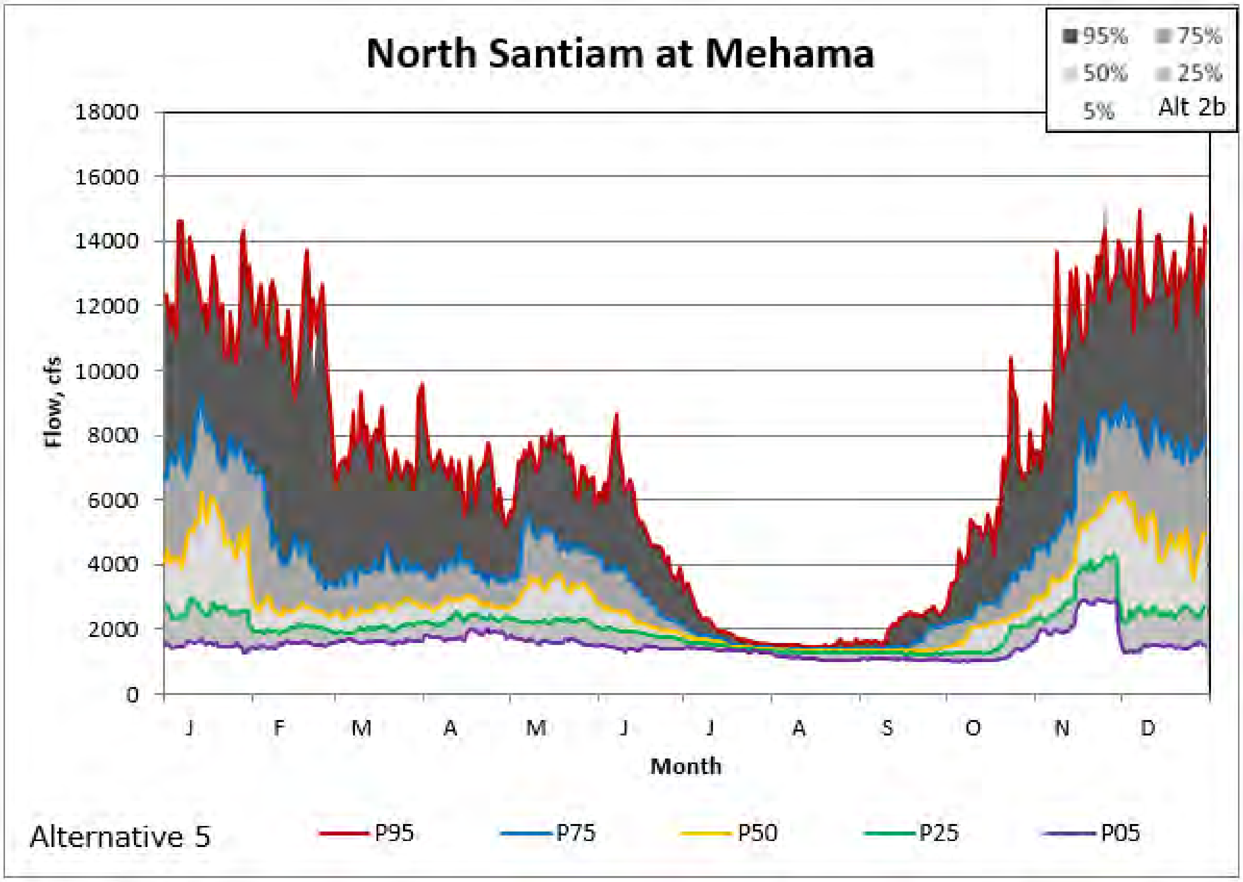


Figure 5-180. Mehama Alternative 5 / 2b Non-Exceedance Plot

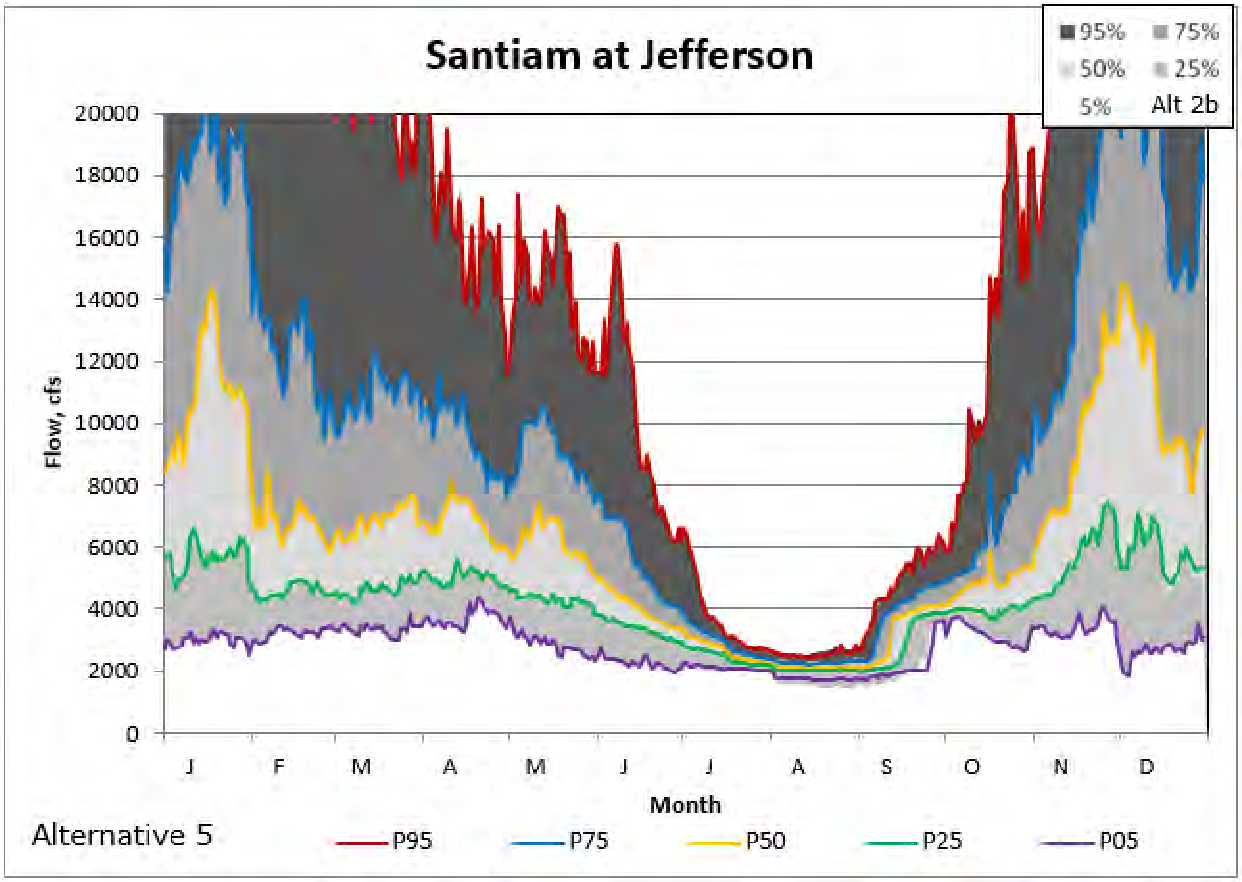


Figure 5-181. Jefferson Alternative 5 / 2b Non-Exceedance Plot

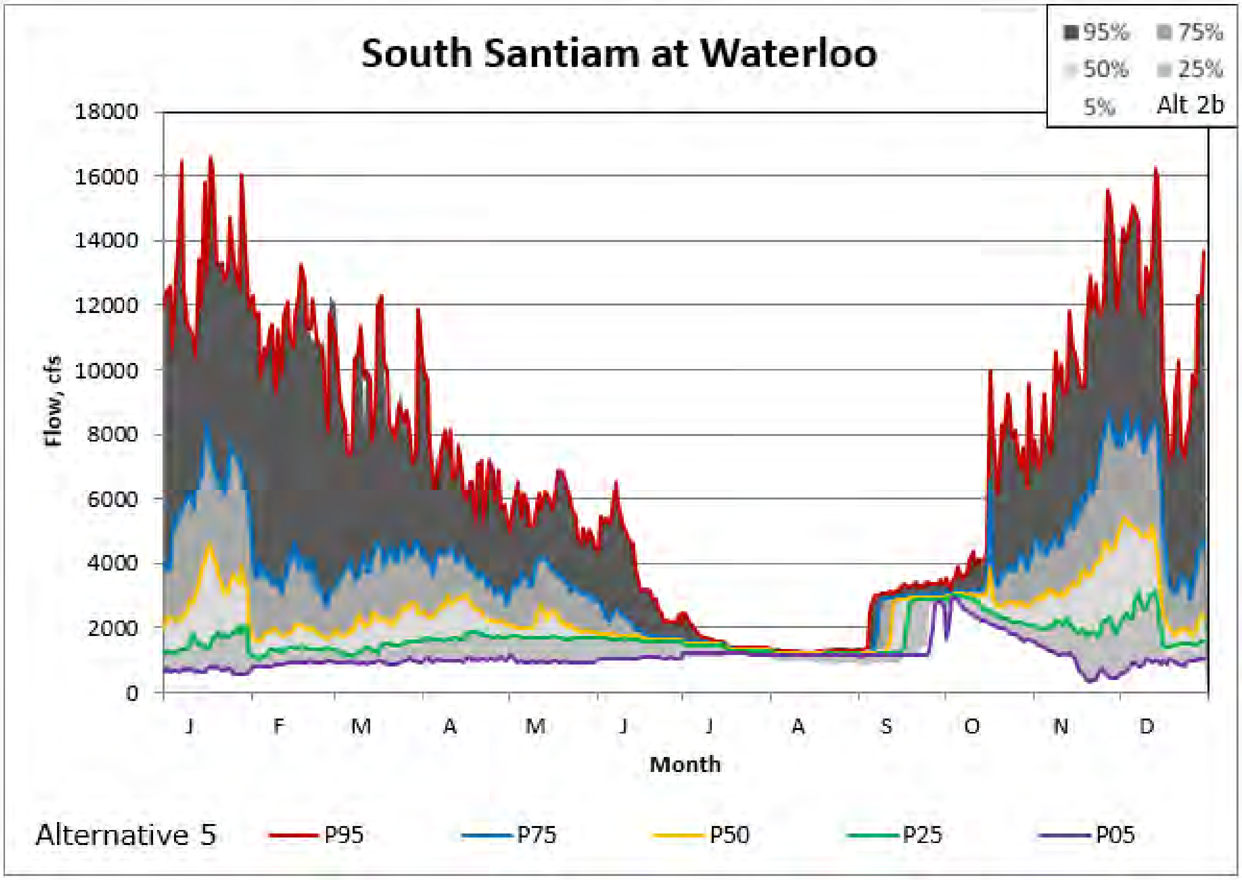


Figure 5-182. Waterloo Alternative 5 / 2b Non-Exceedance Plot

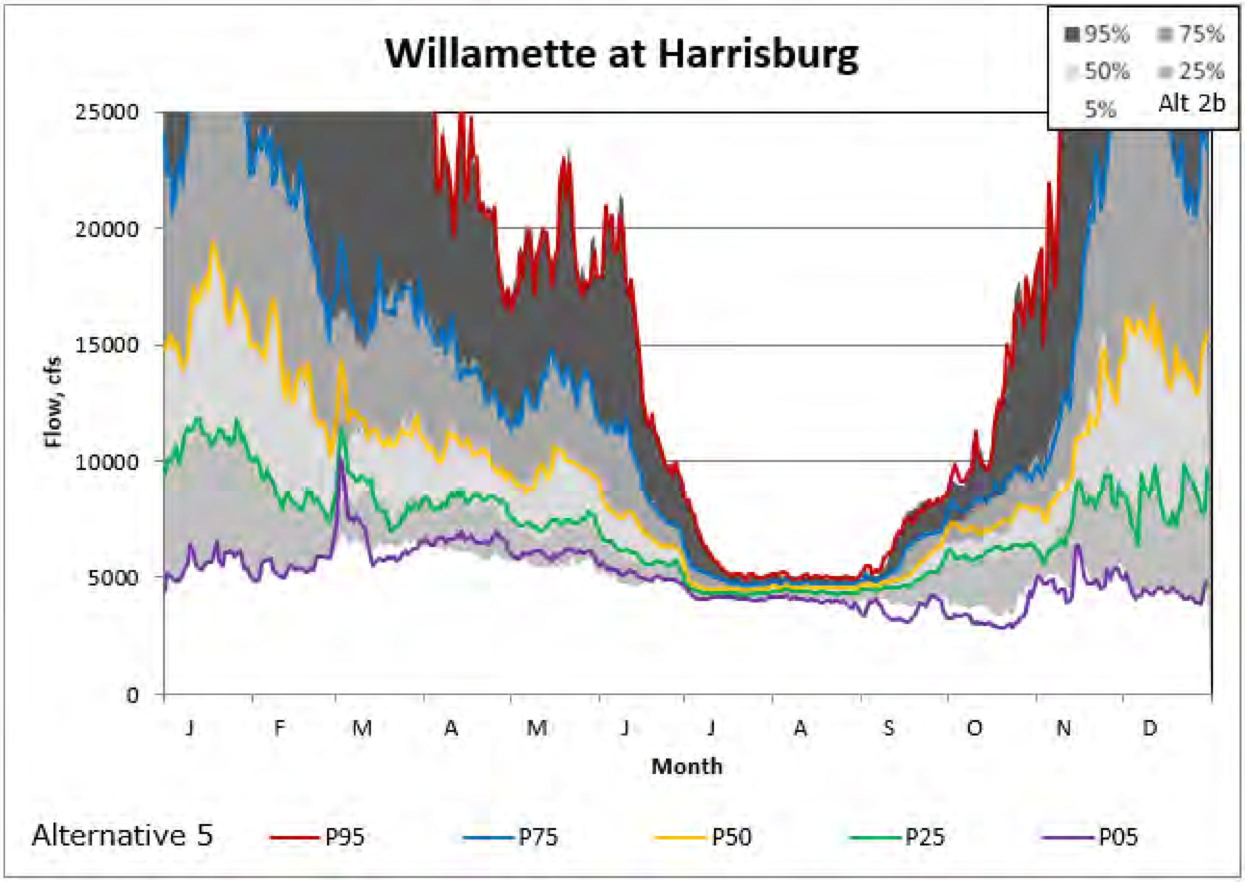


Figure 5-183. Harrisburg Alternative 5 / 2b Non-Exceedance Plot

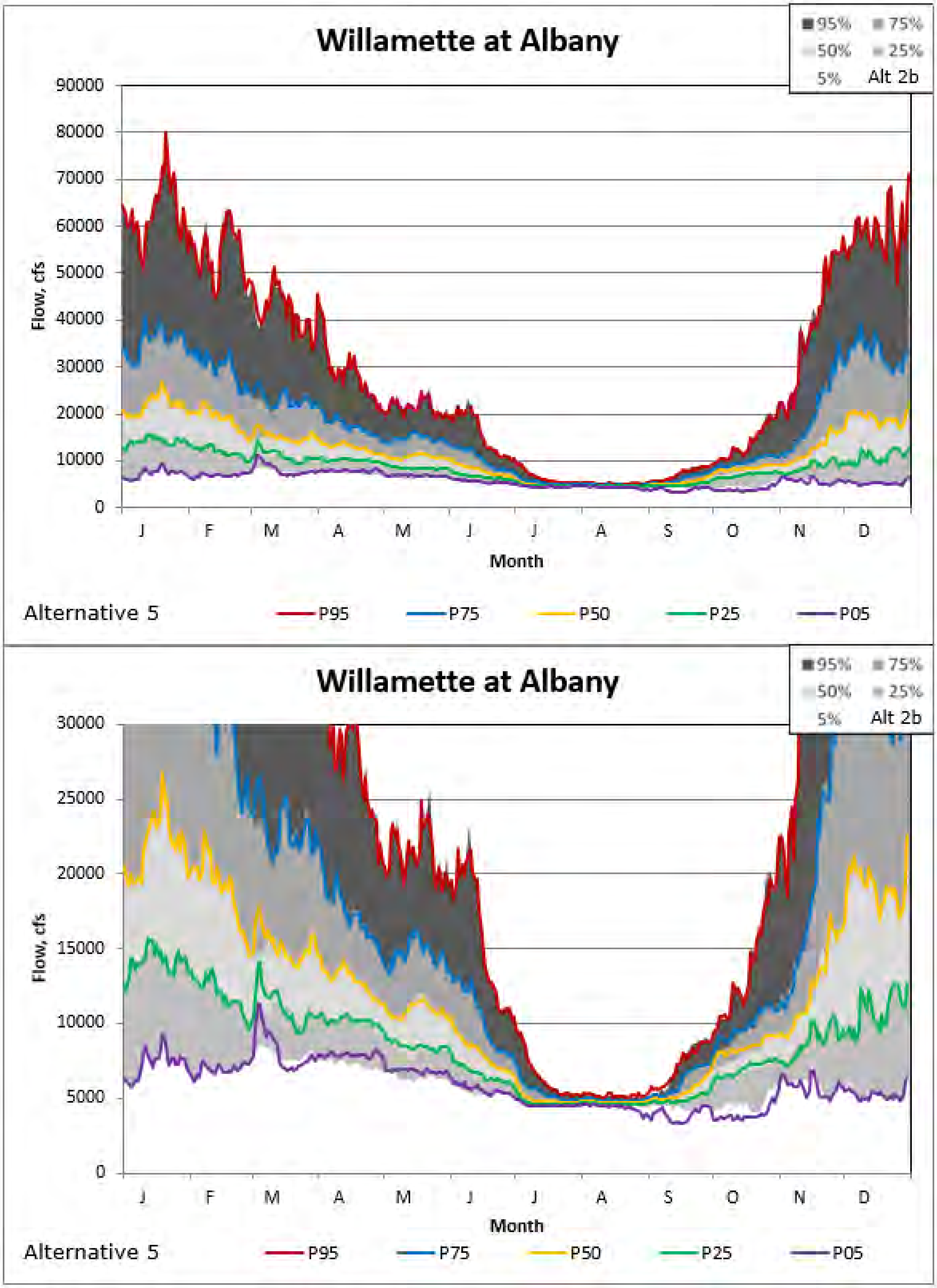


Figure 5-184. Albany Alternative 5 / 2b Non-Exceedance Plot

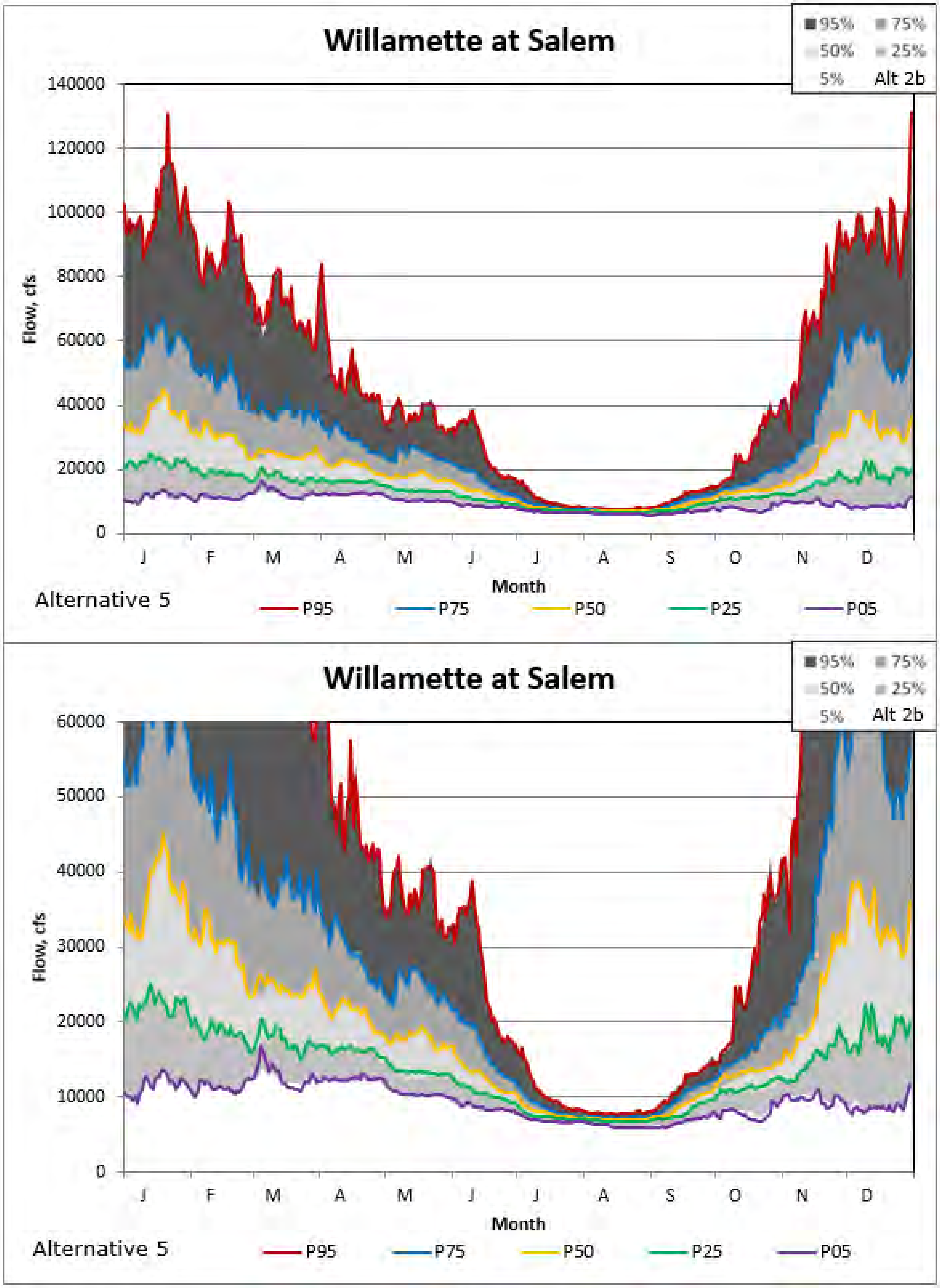


Figure 5-185. Salem Alternative 5 / 2b Non-Exceedance Plot

5.10 ALTERNATIVE 5/ALTERNATIVE 2B WY 2009-2019 PLOTS

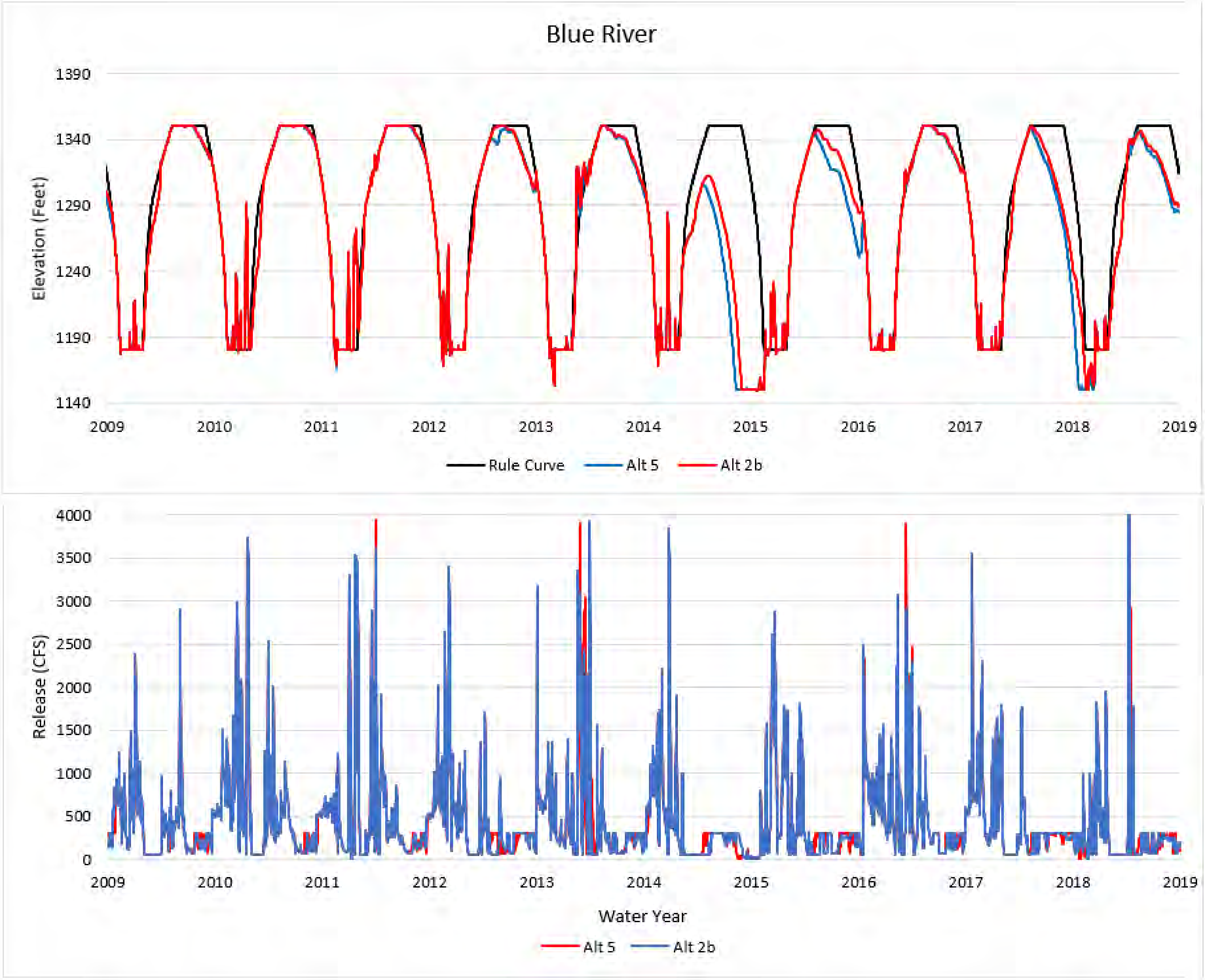


Figure 5-186. Blue River Alternative 5/2b WY 2009-2019 Plot

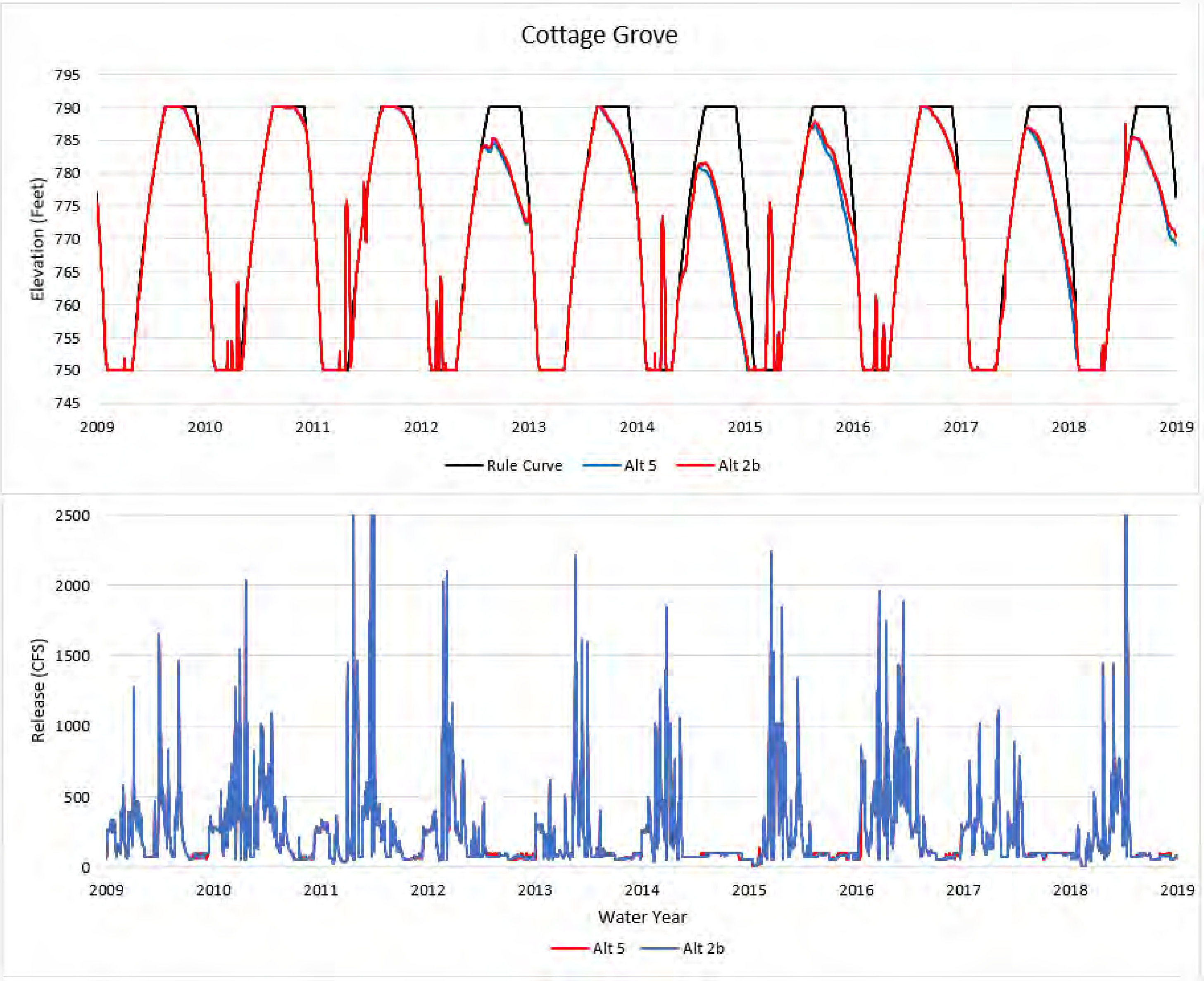


Figure 5-187. Cottage Grove Alternative 5/2b WY 2009-2019 Plot

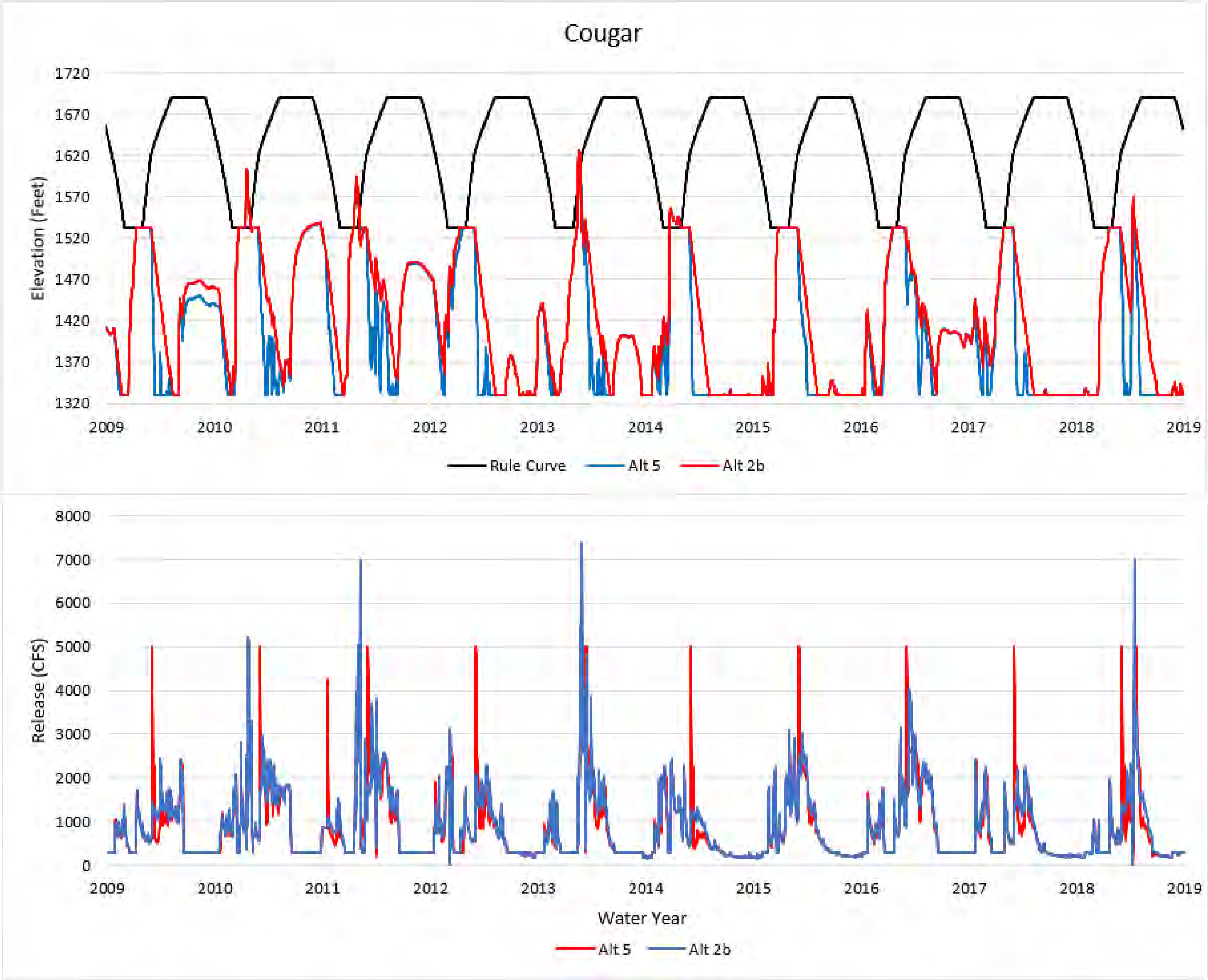


Figure 5-188. Cougar Alternative 5/2b WY 2009-2019 Plot

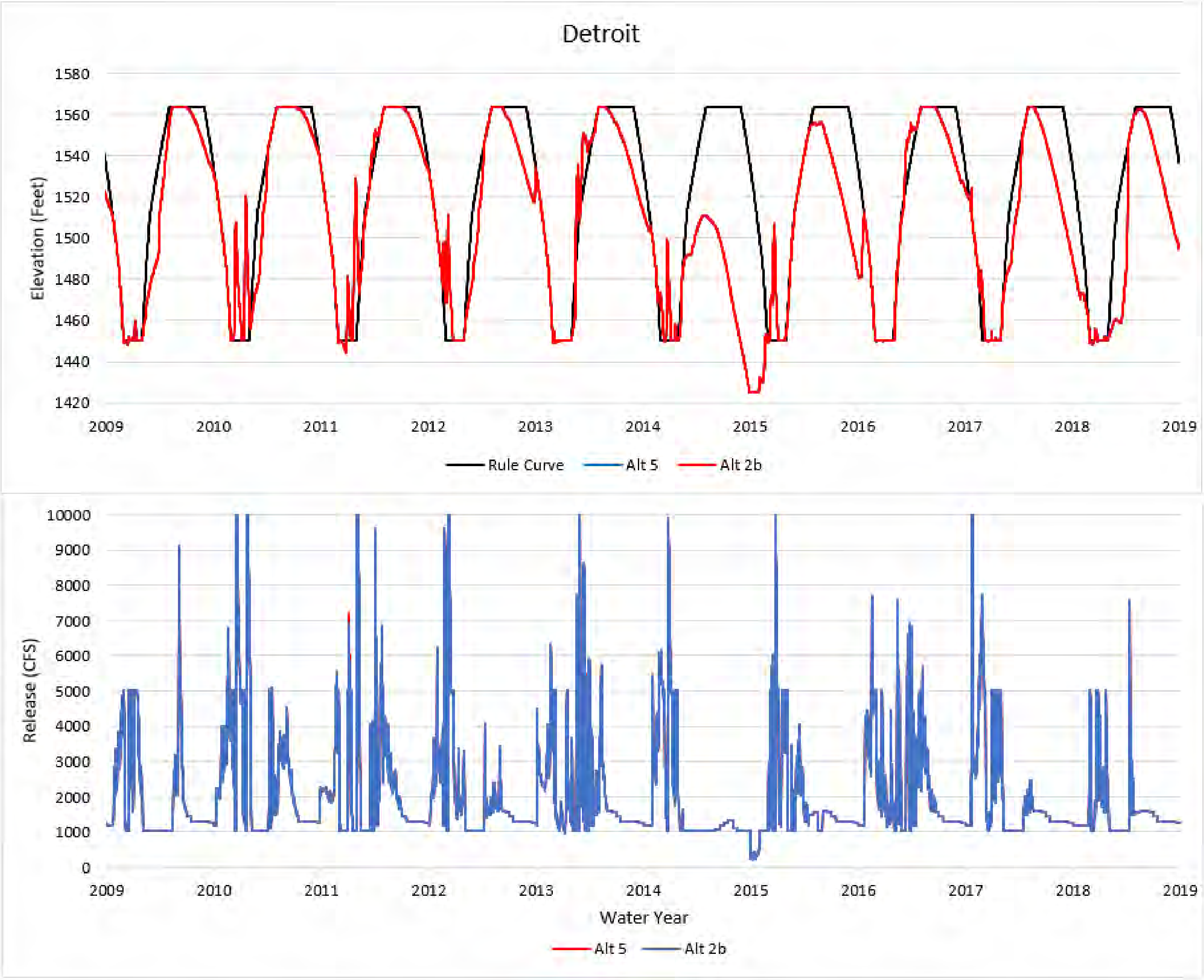


Figure 5-189. Detroit Alternative 5/2b WY 2009-2019 Plot

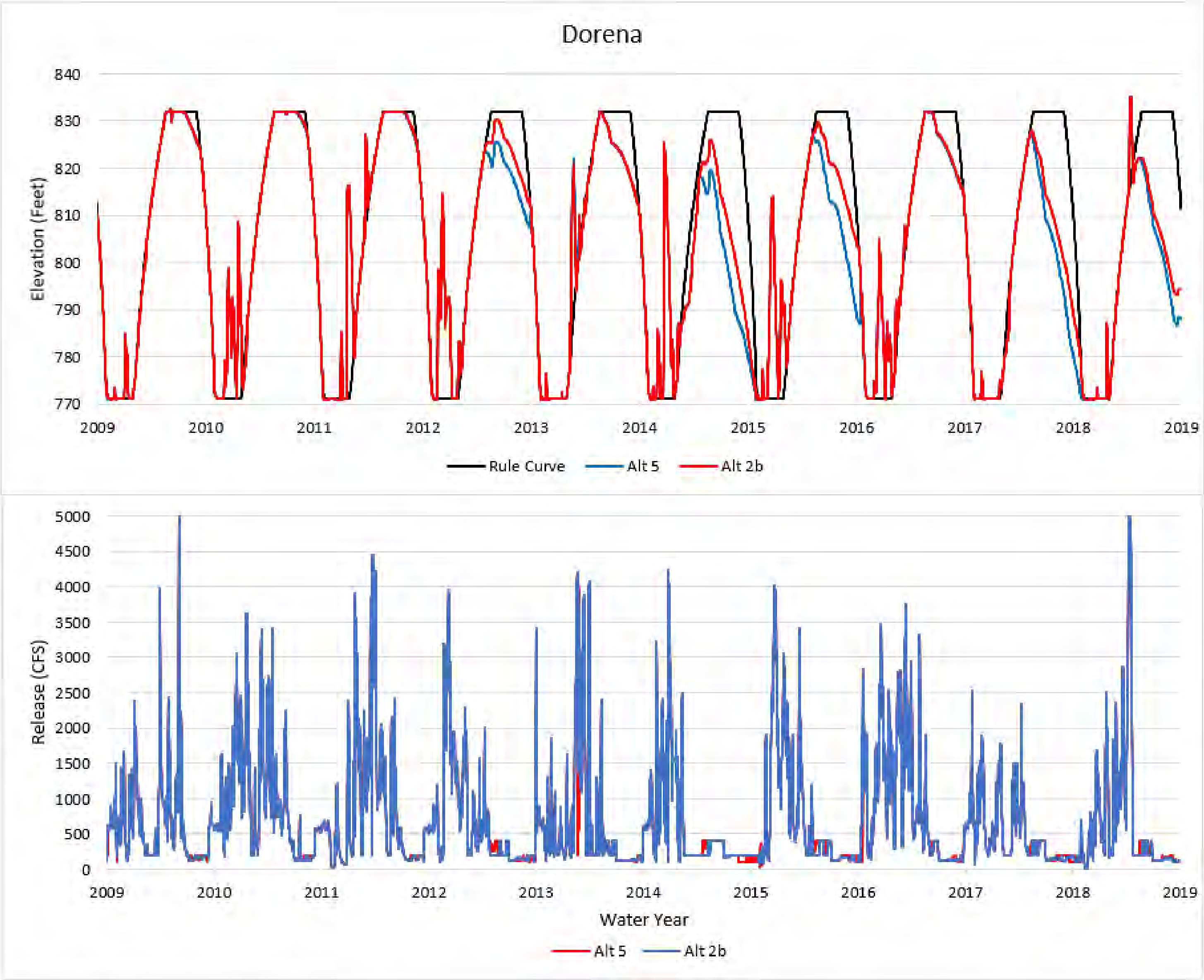


Figure 5-190. Dorena Alternative 5/2b WY 2009-2019 Plot

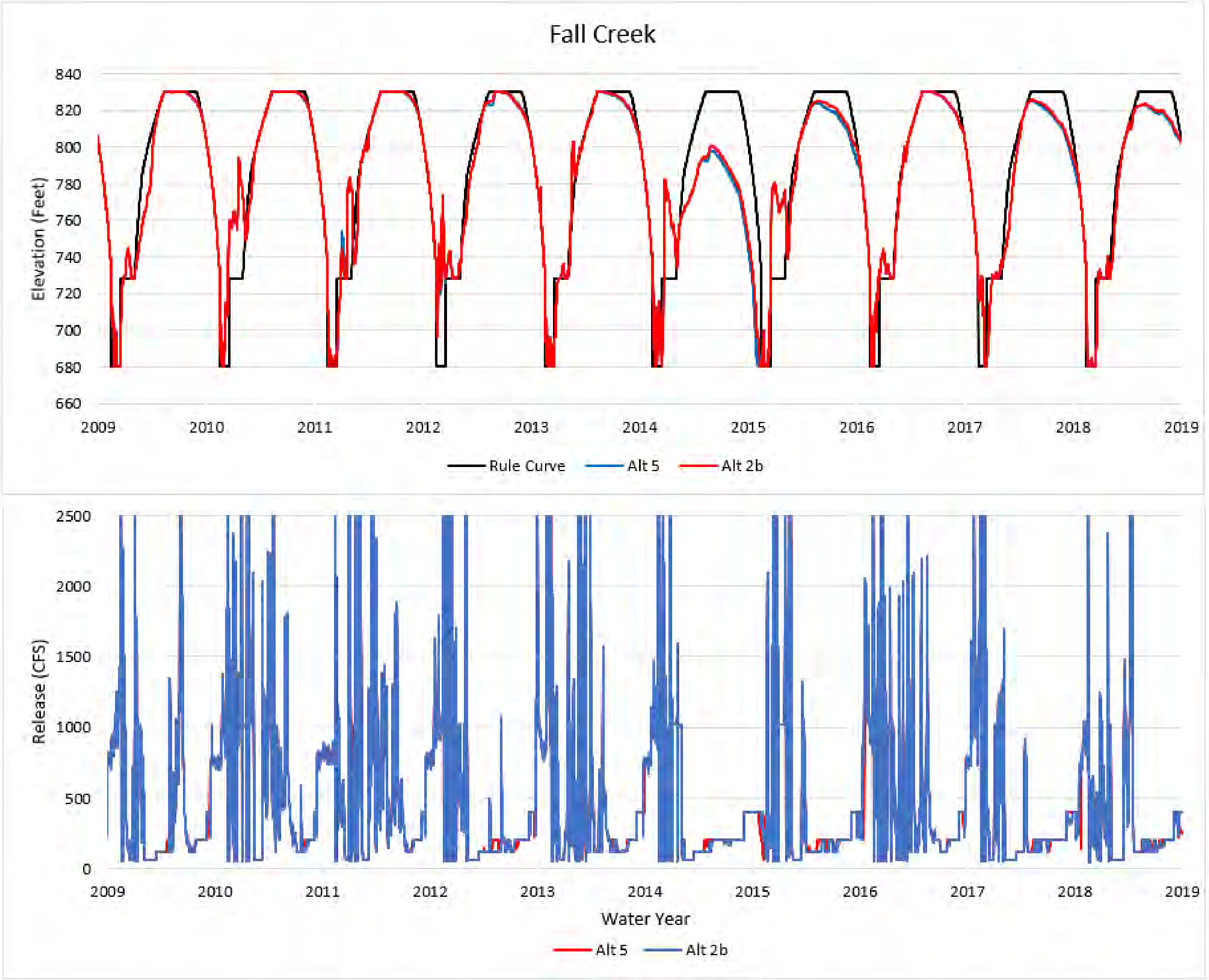


Figure 5-191. Fall Creek Alternative 5/2b WY 2009-2019 Plot

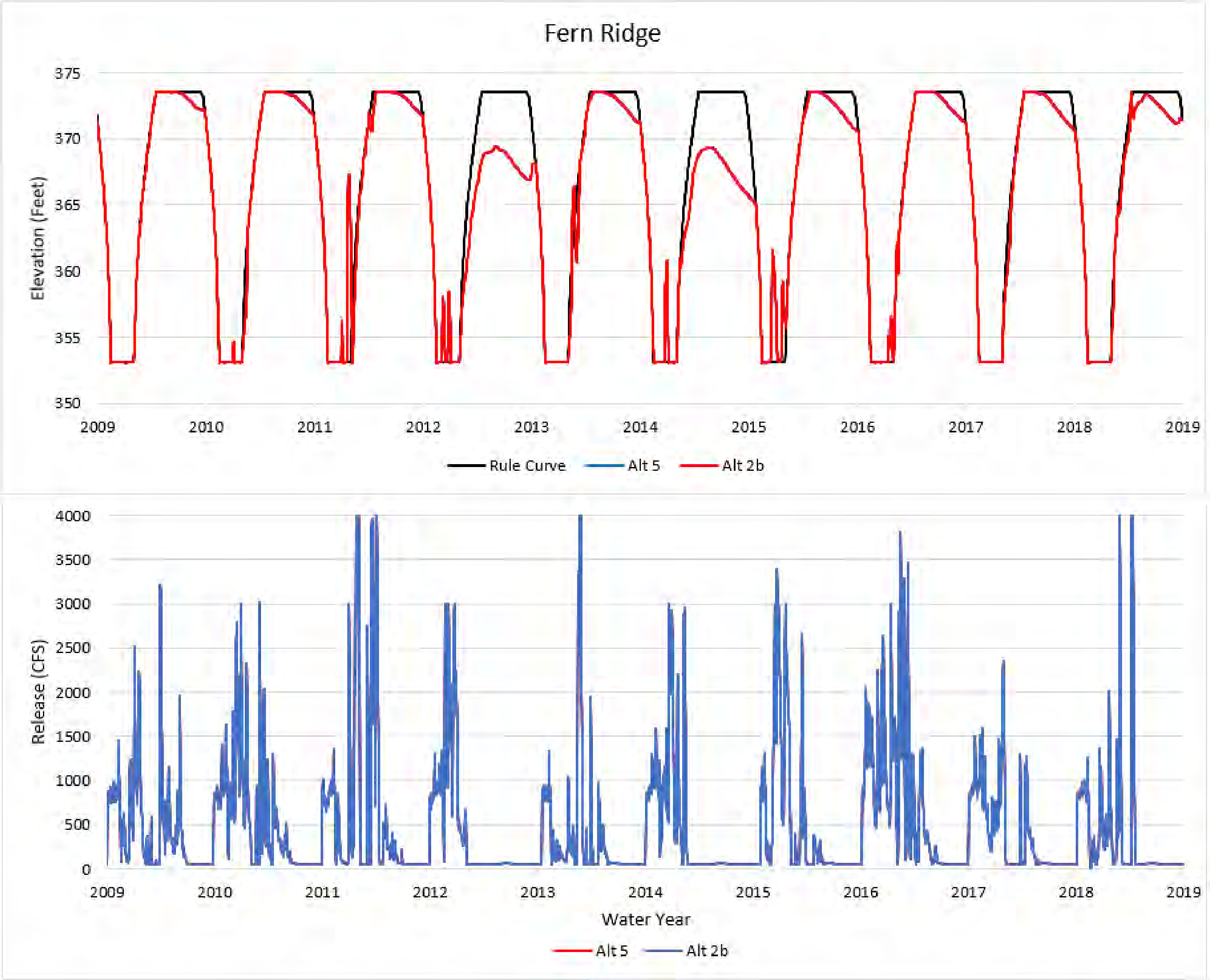


Figure 5-192. Fern Ridge Alternative 5/2b WY 2009-2019 Plot

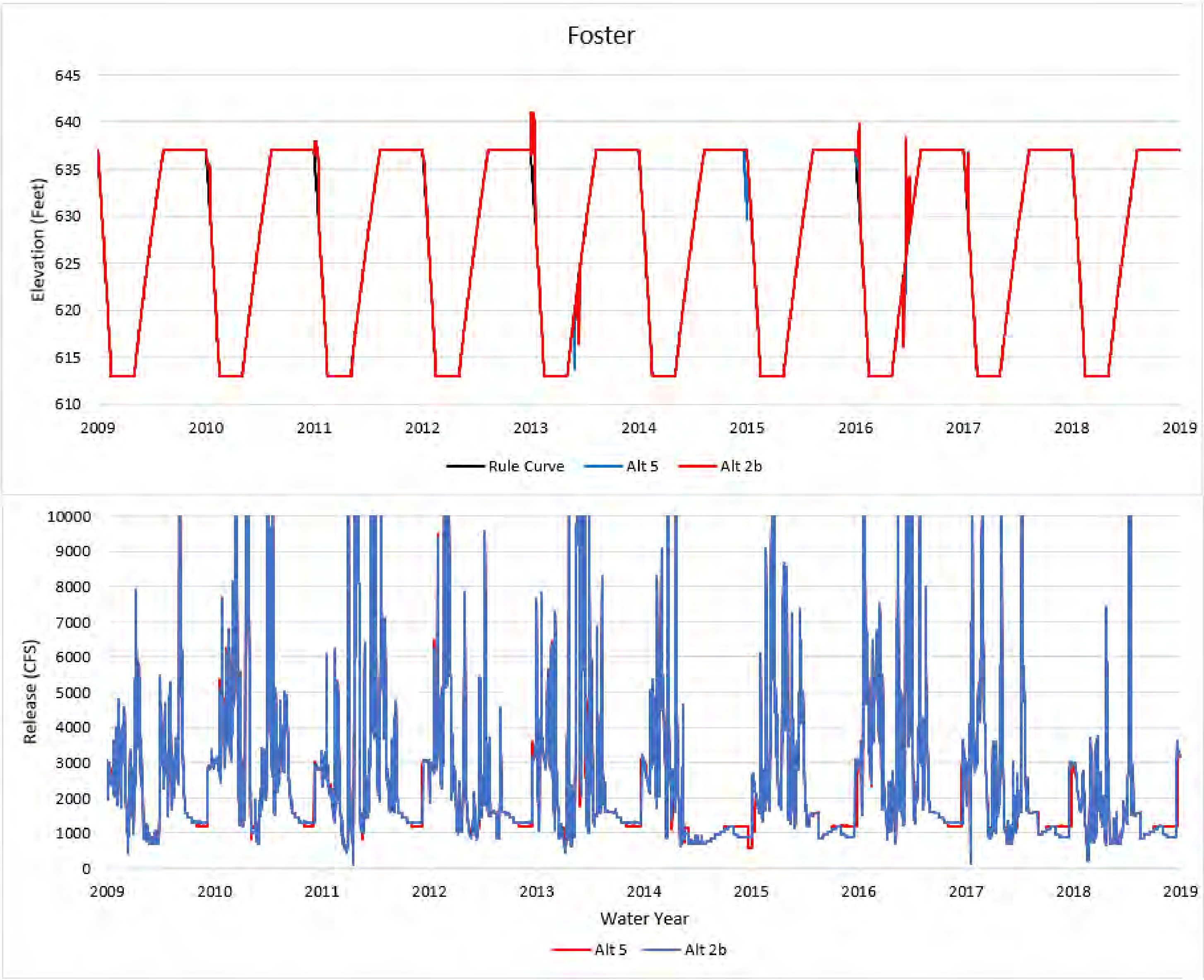


Figure 5-193. Foster Alternative 5/2b WY 2009-2019 Plot

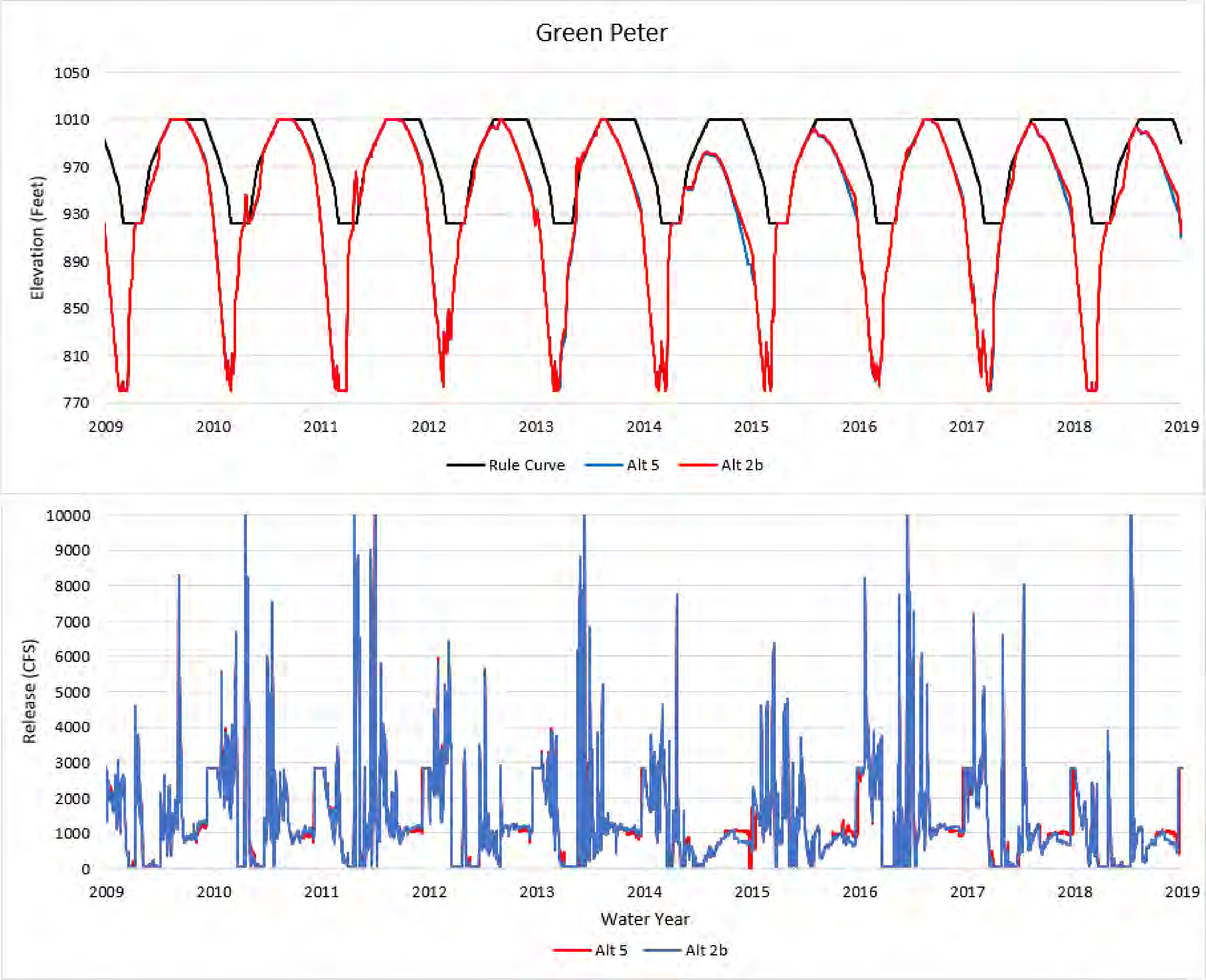


Figure 5-194. Green Peter Alternative 5/2b WY 2009-2019 Plot

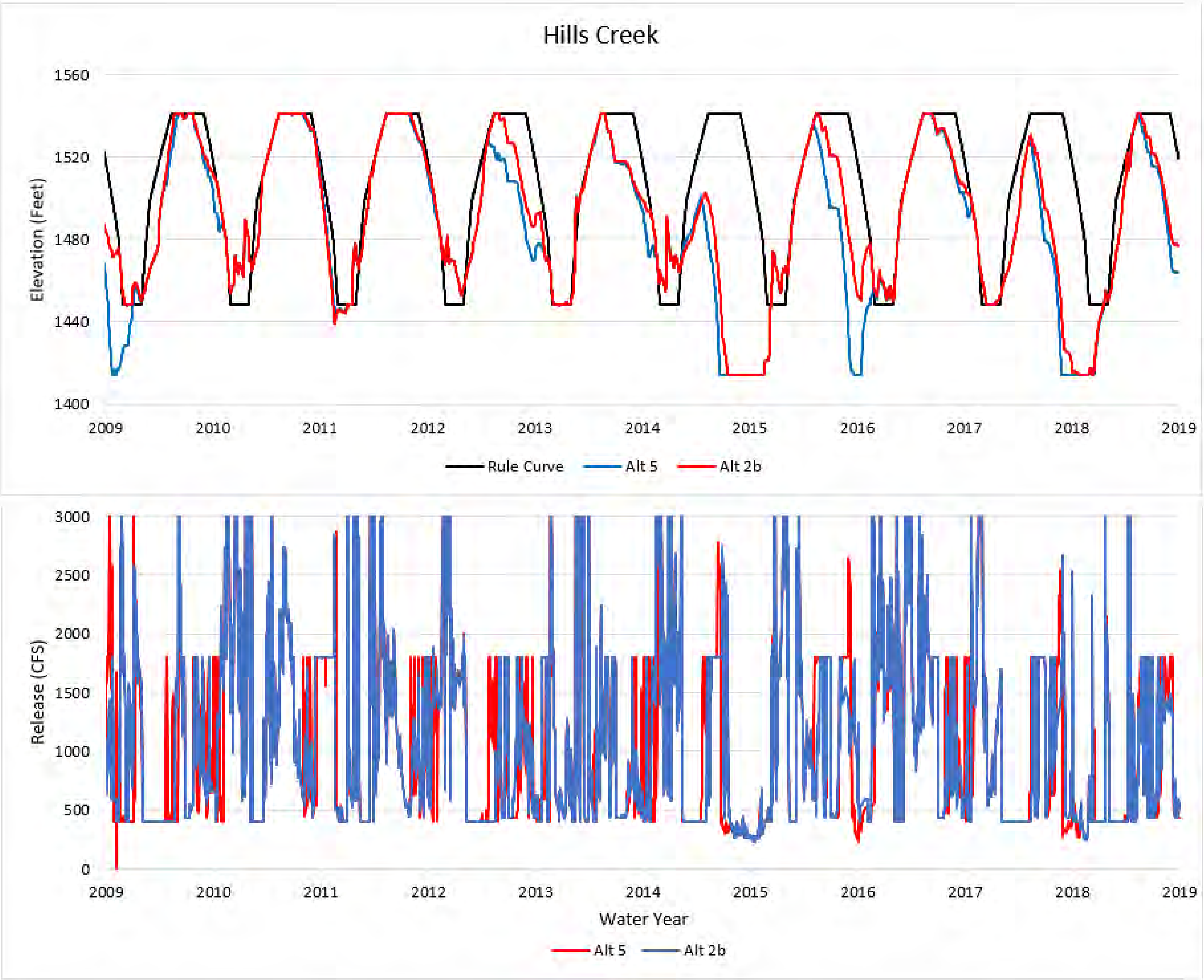


Figure 5-195. Hills Creek Alternative 5/2b WY 2009-2019 Plot

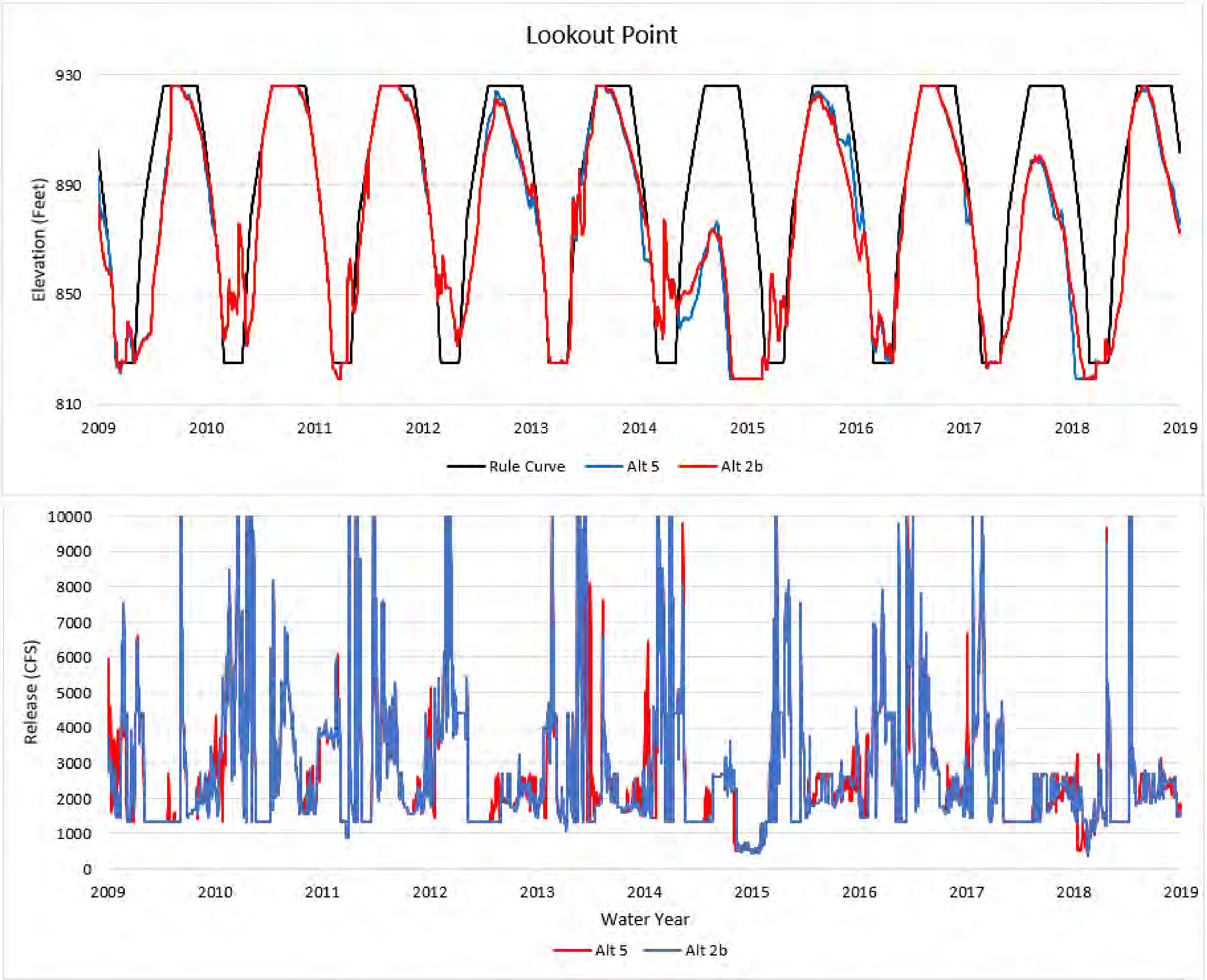


Figure 5-196. Lookout Point Alternative 5/2b WY 2009-2019 Plot

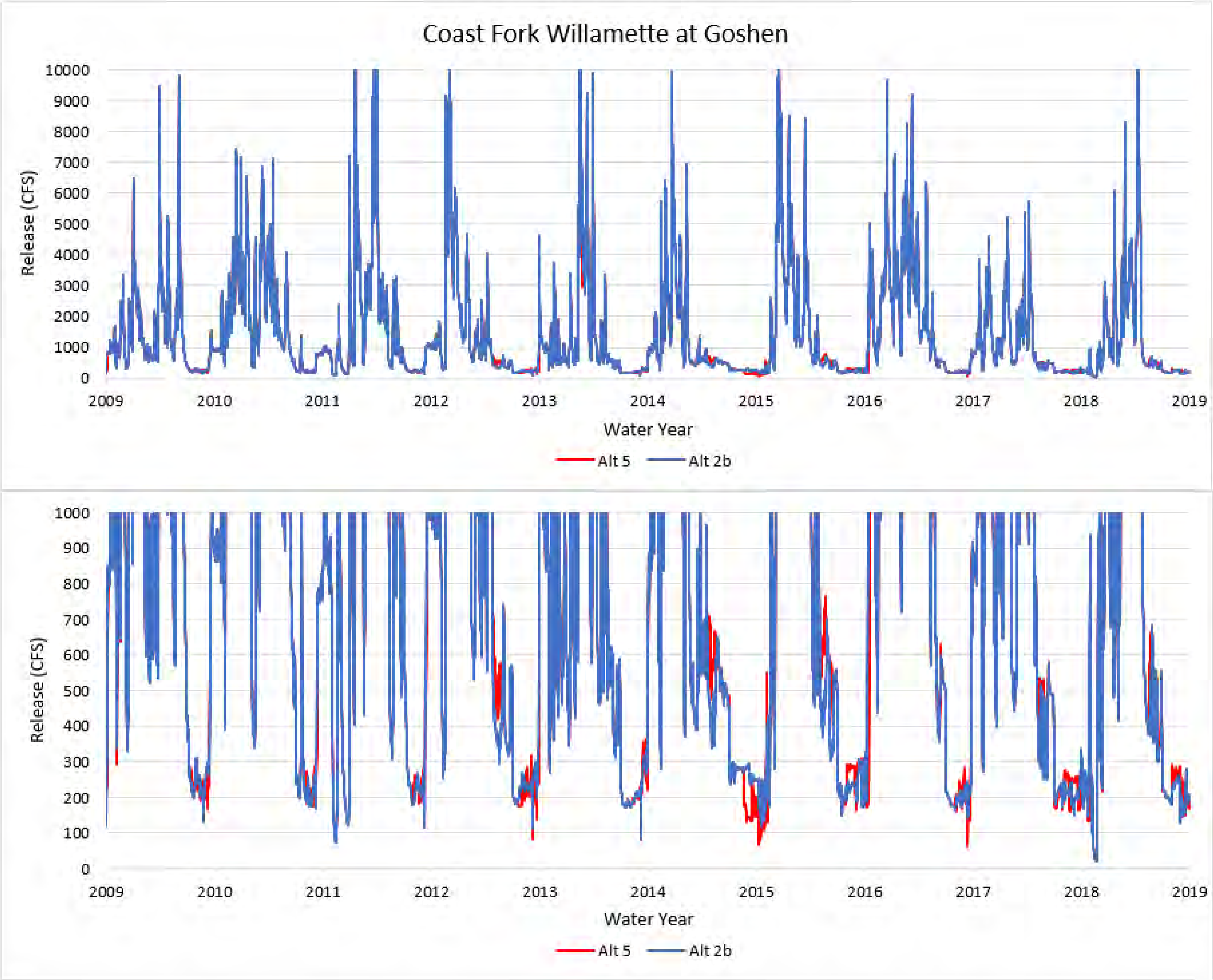


Figure 5-197. Goshen Alternative 5/2b WY 2009-2019 Plot

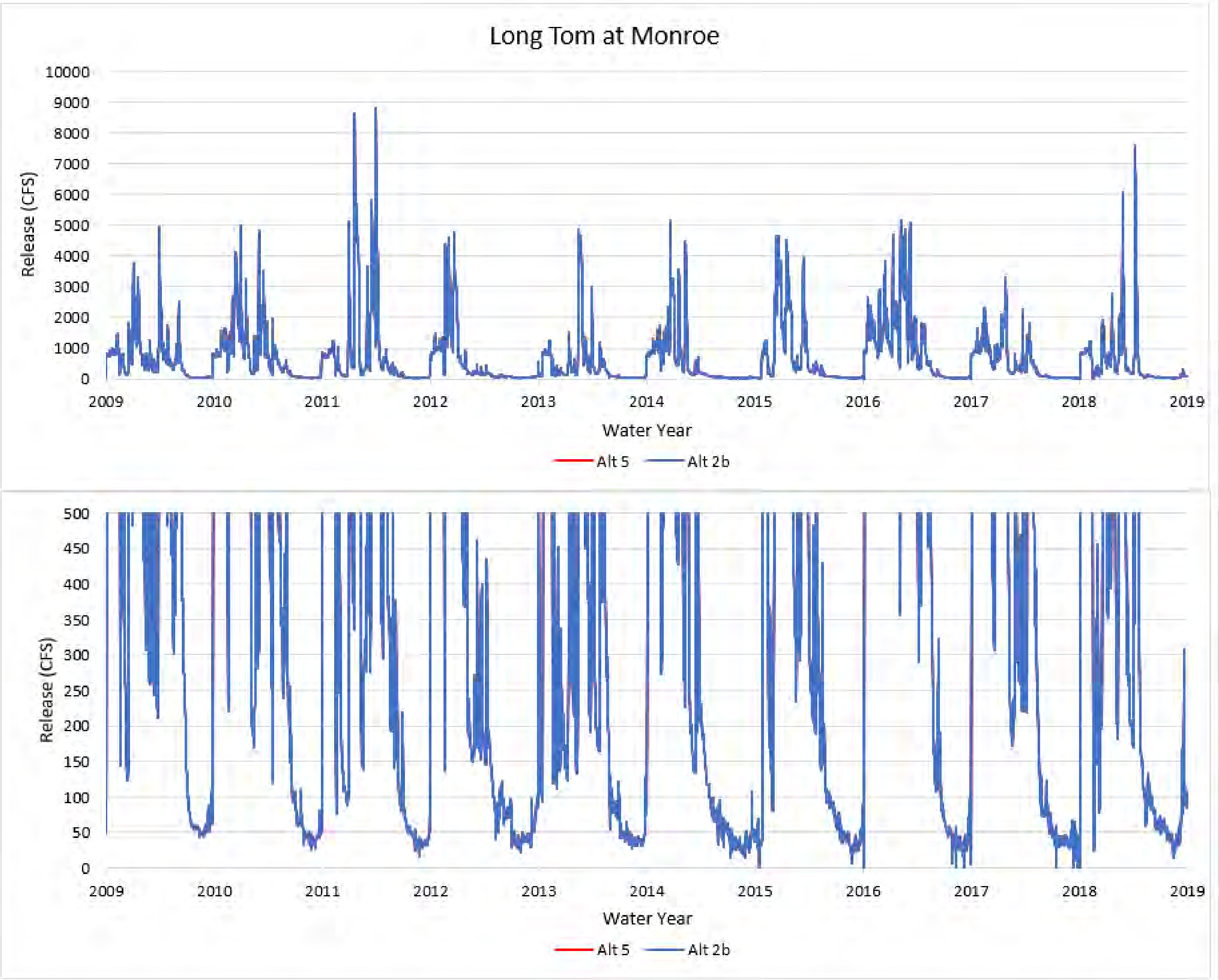


Figure 5-198. Monroe Alternative 5/2b WY 2009-2019 Plot

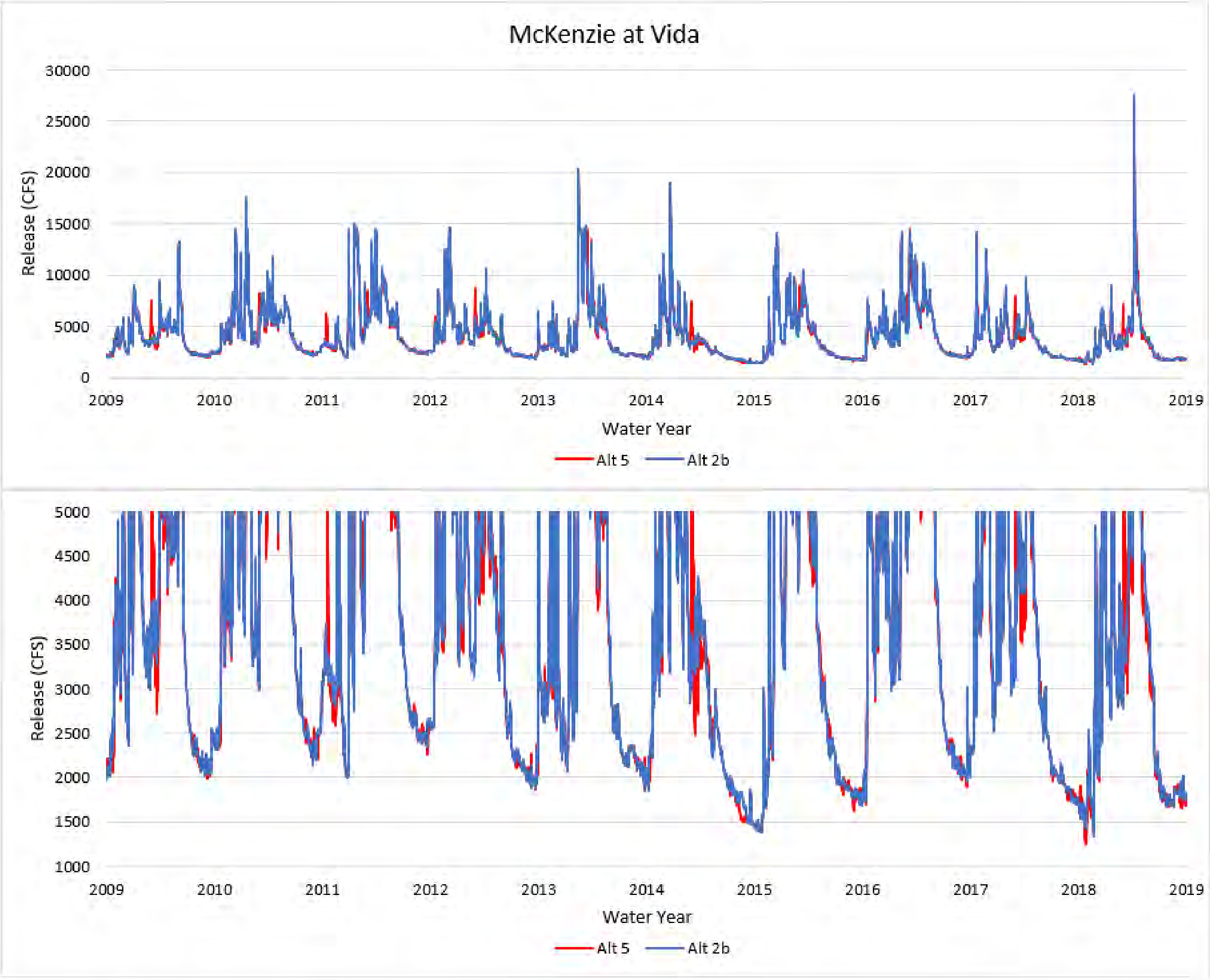


Figure 5-199. Vida Alternative 5/2b WY 2009-2019 Plot

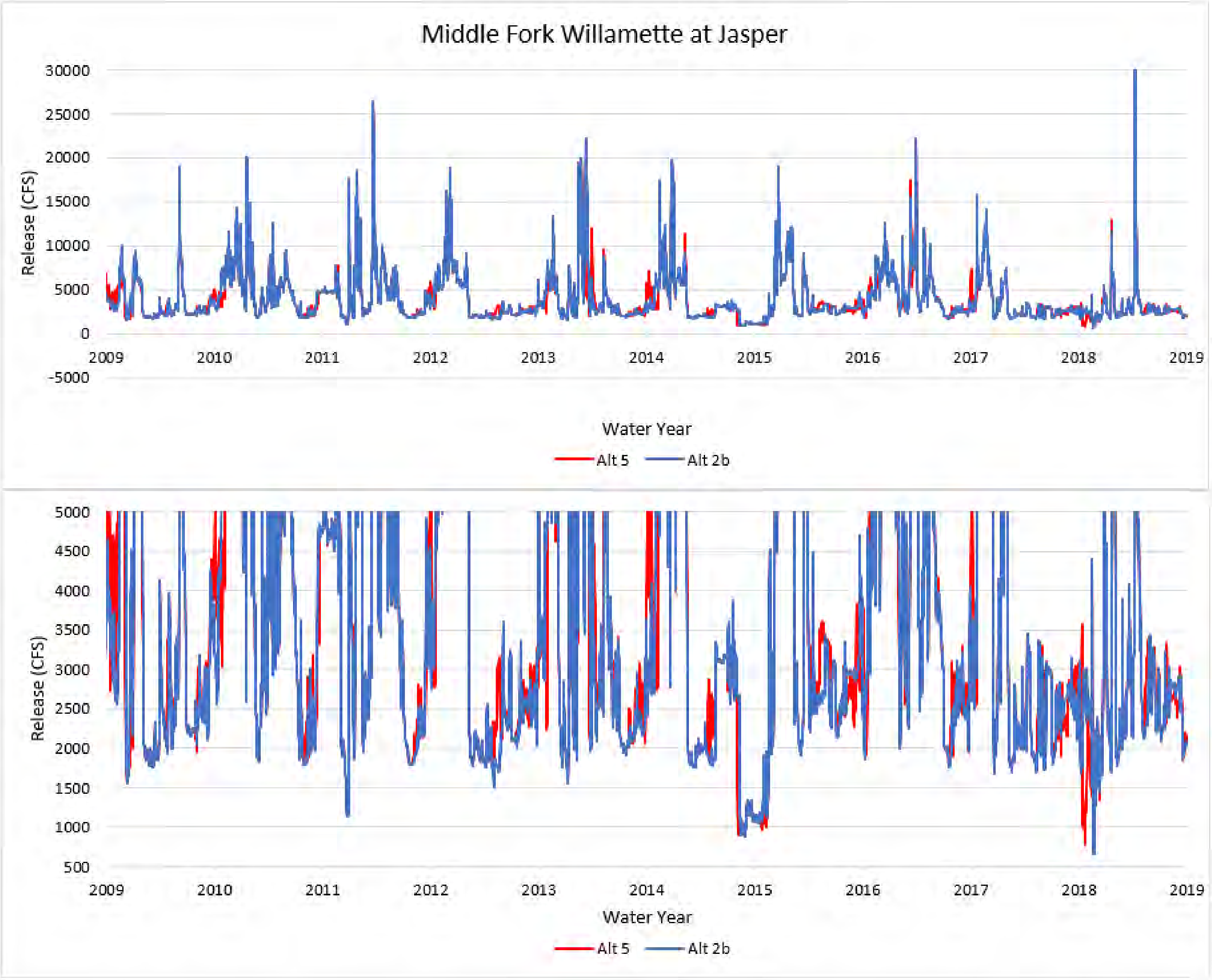


Figure 5-200. Jasper Alternative 5/2b WY 2009-2019 Plot

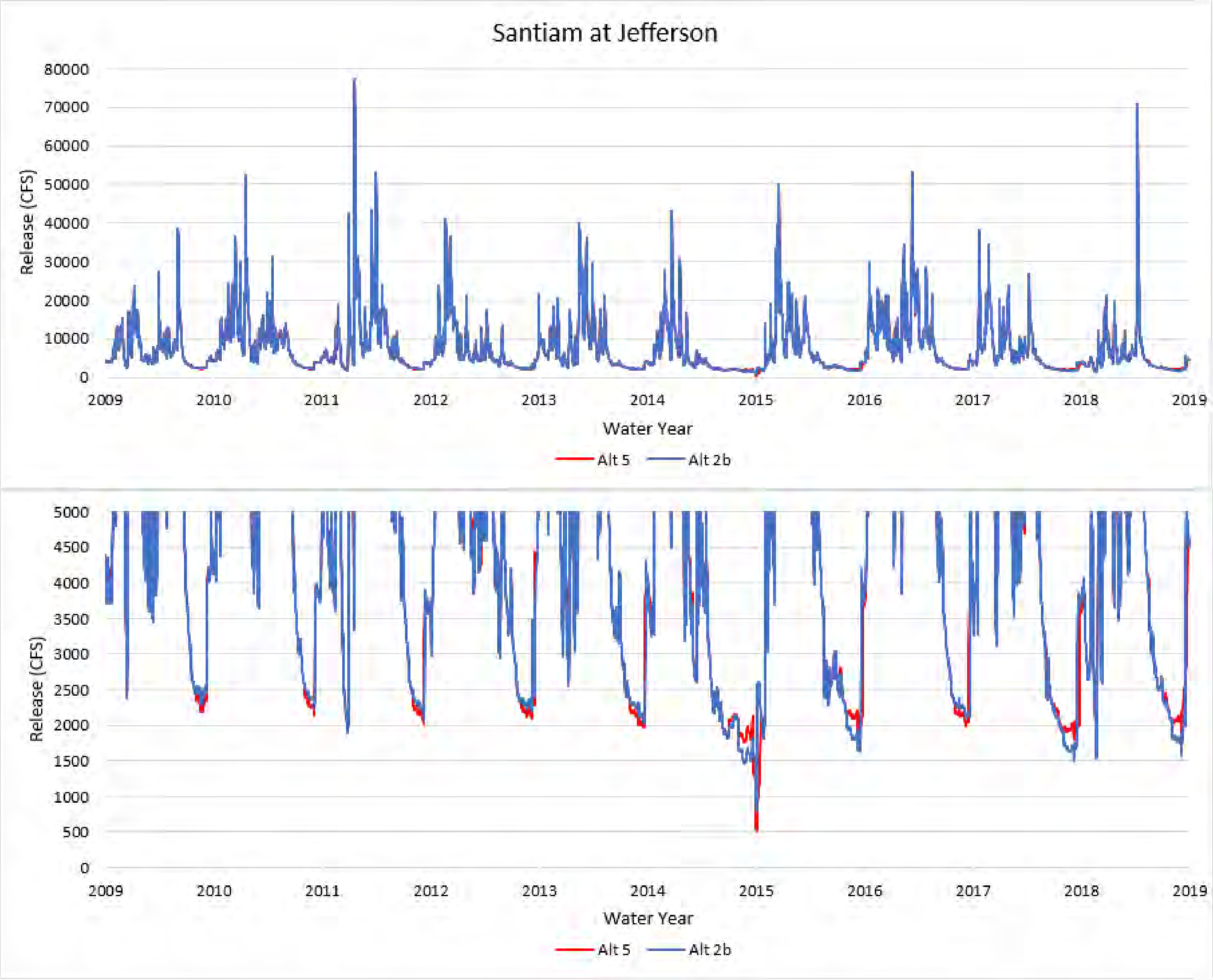


Figure 5-201. Jefferson Alternative 5/2b WY 2009-2019 Plot

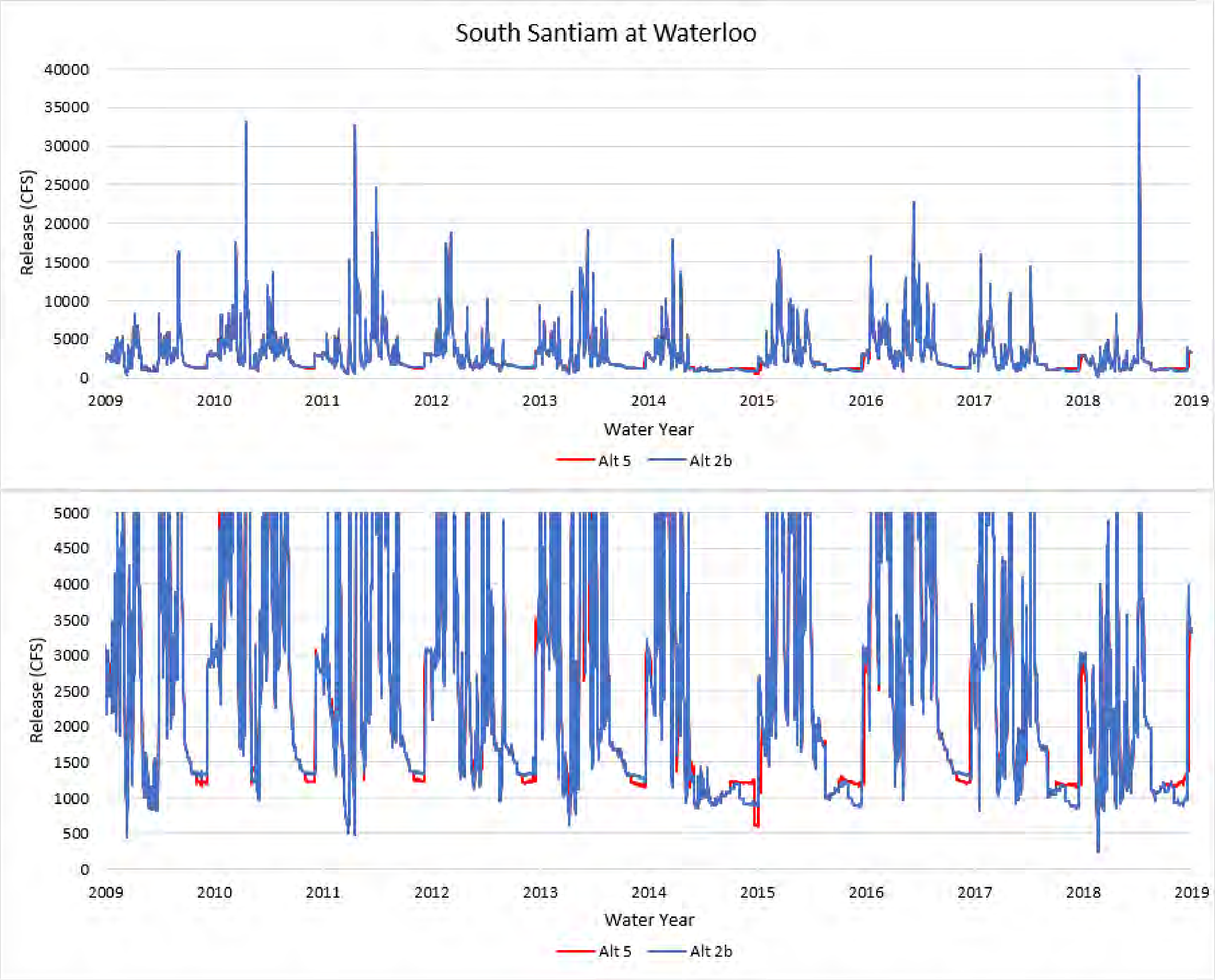


Figure 5-202. Waterloo Alternative 5/2b WY 2009-2019 Plot

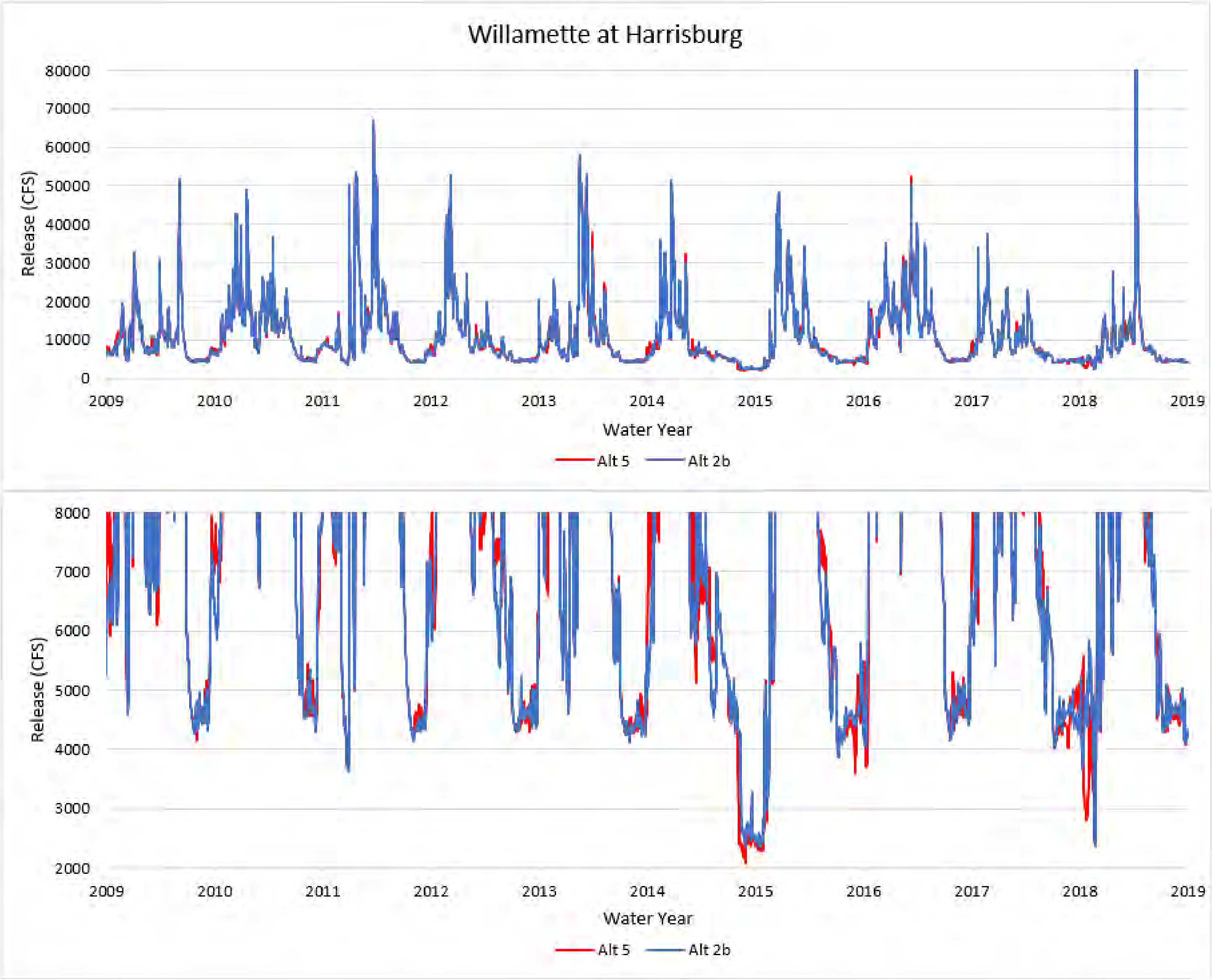


Figure 5-203. Harrisburg Alternative 5/2b WY 2009-2019 Plot

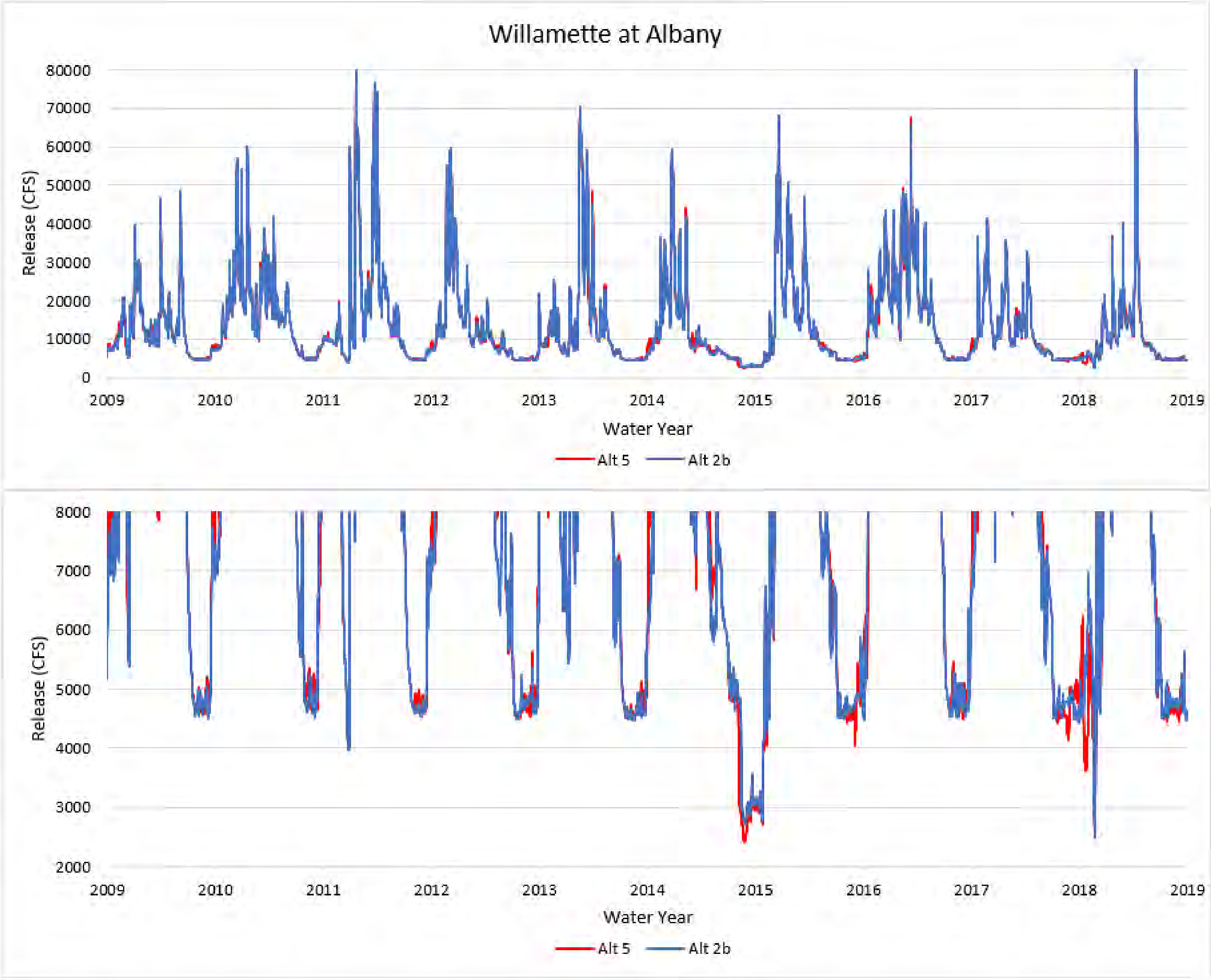


Figure 5-204. Albany Alternative 5/2b WY 2009-2019 Plot

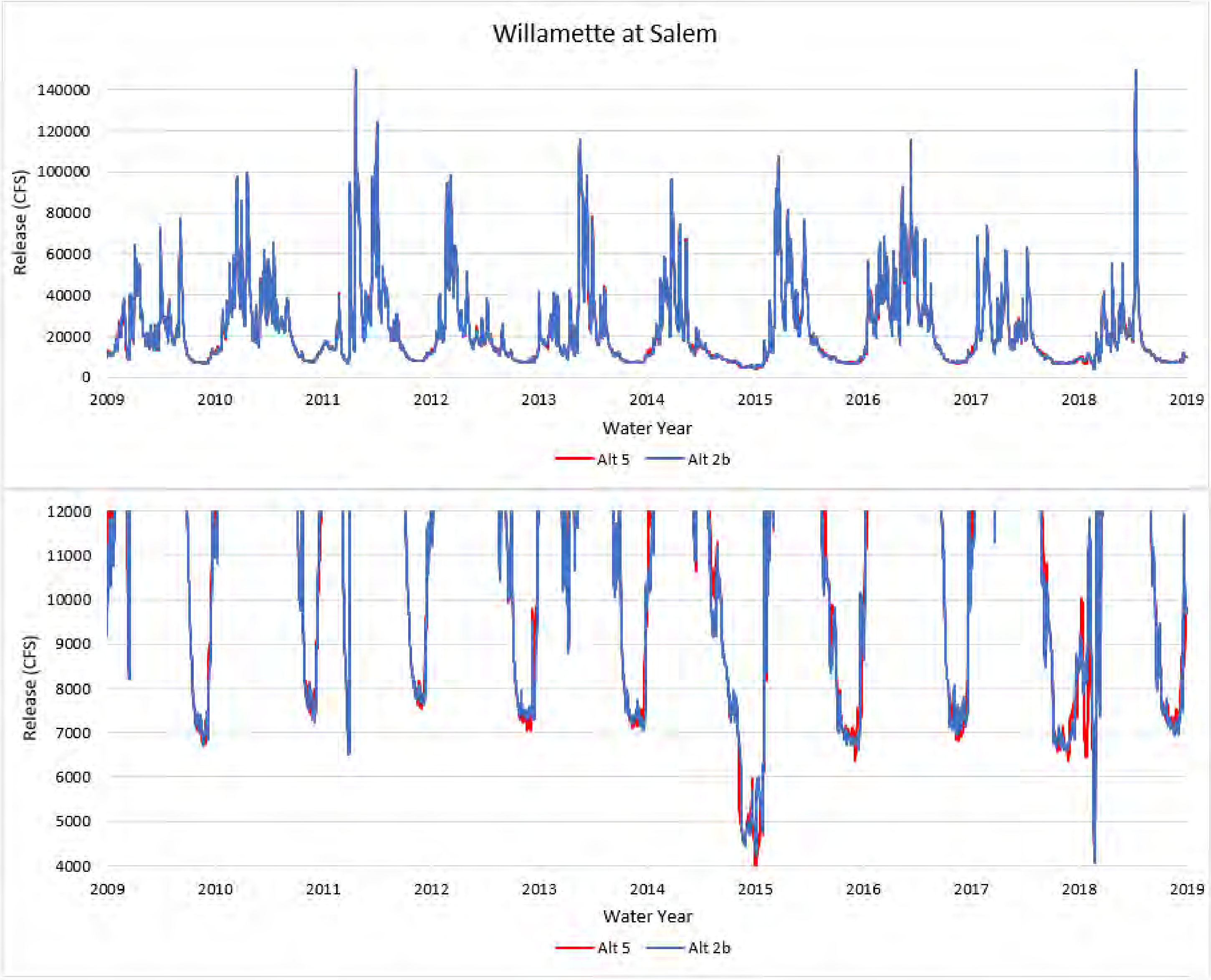


Figure 5-205. Salem Alternative 5/2b WY 2009-2019 Plot

6 QUALITATIVE ASSESSMENT OF CLIMATE CHANGE IMPACTS TO HYDROLOGY

Climate change impacts, and methodology and assumptions below, draw on the climate change projection and trend information provided in the climate change appendices (F1 and F2).

This is a qualitative assessment of the effects of climate change on the water surface elevation in the WVS reservoirs (“storage”) and the total downstream flow including unregulated flow (“flow”) at each listed control point. The primary inputs to the assessment are the storage and flow exceedance charts (Section 5) and climate change ‘natural flow’ box and whisker plots broken out by month (Figure B-6-2 - Figure B-6-13). Additional information came from the precipitation projections and DSS ResSim outputs, though these were used less frequently.

The hydrology climate change assessment is divided by WVS and the downstream control points. Each location and alternative, including the NAA, has a projection of the climate change effects. These qualitative descriptions are “Much More”, “More”, “Similar”, “Less”, and “Much Less” (Figure B-6-1). The descriptions are based on engineering judgment and generally a descriptor of the percent difference for the alternative under climate change.

A few basic assumptions:

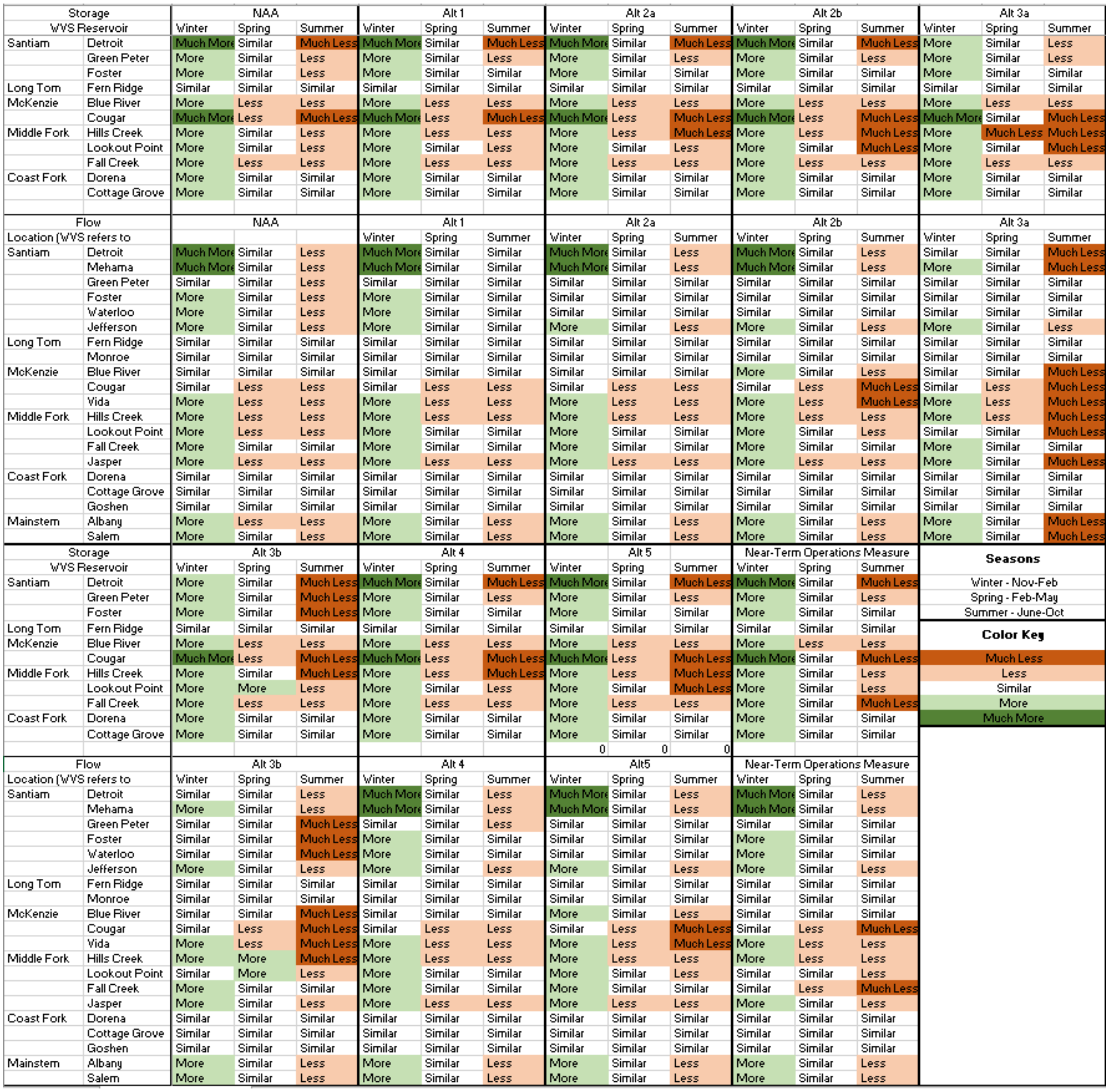
- Flow attenuates and accumulates as it goes downstream. In other words, as the river moves away from a dam, flow changes will become milder unless the input flows are similarly affected.
- Downstream flow targets are prioritized over reservoir storage. If a reservoir has storage available in an alternative, it will use it to meet downstream flow targets even if it requires a significant drop in reservoir storage.
- Reservoirs that already draft to a minimum elevation in an alternative would not alter their operations earlier in the year within each alternative framework to store more water prior to the summer.
- Winter includes November through February.
- Spring includes February through May. The overlap with winter is necessary as the WVS reservoirs start filling in February and the month is a significant factor in whether the system reaches maximum conservation pool or not.
- Summer includes June through October.
- Each alternative is compared to itself in the climate change assessment. The central question is, “how would the projected flow changes affect the alternative baseline?”
- Each determination is for all water year types. Changes to exceedance lines are generally compared to the like box and whisker plot (i.e. the P05 line in the exceedance graphs is more heavily influenced by the P10 plot than the P90 plot).

- Since there is an upper limit to storage (maximum conservation pool) where additional inflow does not increase available storage later in the year, drier years often control the determination even if wetter years would be similar between the baseline and climate projection. Since wetter years may be similar and drier years would be drier, the overall determination would be "Less" or "Much Less".

Winter flow volumes are projected to increase for most of the WVS. Although the ResSim model is not a flood operations model, the volume that each project regulates during the winter is approximately correct. If the baseline exceedance charts show that the reservoir is regularly nearly the top of available storage, additional releases would be required with the greater flow projected. Reservoirs that stay lower in the baseline have more freedom to increase storage during the winter and keep regulated downstream flows similar.

Spring flow volumes are projected to be similar in the climate change projections for the WVS, but flows will likely be distributed earlier in the year. February and March are projected to have higher flows, whereas lower flows are projected in April and May. The determinations use a combination the filling season of each reservoir, the percentage of time it fills in the baseline, and its sensitivity to generally earlier flows. The spring season is often a matter of engineering judgment.

Summer flow volumes are projected to decrease for most of the WVS, with particularly big changes in higher elevation basins with more snow melt. Reservoirs will have to release more water to meet downstream flow targets as local inflows will be less. If reservoirs have stored water available in the baseline alternative, they will try to meet downstream flow targets. It is difficult to project if or when a particular project would run out of stored water. A flow location is generally assigned a "Much Less" only if the storage in the alternative baseline already runs out.



Storage		NAA			Alt 1			Alt 2a			Alt 2b			Alt 3a		
WVS Reservoir		Winter	Spring	Summer	Winter	Spring	Summer	Winter	Spring	Summer	Winter	Spring	Summer	Winter	Spring	Summer
Santiam	Detroit	Much More	Similar	Much Less	Much More	Similar	Much Less	Much More	Similar	Much Less	Much More	Similar	Much Less	More	Similar	Less
	Green Peter	More	Similar	Less	More	Similar	Less	More	Similar	Less	More	Similar	Less	More	Similar	Less
	Foster	More	Similar	Less	More	Similar	Similar	More	Similar	Similar	More	Similar	Similar	More	Similar	Similar
Long Tom	Fern Ridge	Similar	Similar	Similar	Similar	Similar	Similar	Similar	Similar	Similar	Similar	Similar	Similar	Similar	Similar	Similar
McKenzie	Blue River	More	Less	Less	More	Less	Less	More	Less	Less	More	Less	Less	More	Less	Less
	Cougar	Much More	Less	Much Less	Much More	Less	Much Less	Much More	Less	Much Less	Much More	Less	Much Less	Much More	Similar	Much Less
Middle Fork	Hills Creek	More	Similar	Less	More	Less	Less	More	Less	Much Less	More	Less	Much Less	More	Much Less	Much Less
	Lookout Point	More	Similar	Less	More	Similar	Less	More	Similar	Less	More	Similar	Much Less	More	Similar	Much Less
	Fall Creek	More	Less	Less	More	Less	Less	More	Less	Less	More	Less	Less	More	Less	Less
Coast Fork	Dorena	More	Similar	Similar	More	Similar	Similar	More	Similar	Similar	More	Similar	Similar	More	Similar	Similar
	Cottage Grove	More	Similar	Similar	More	Similar	Similar	More	Similar	Similar	More	Similar	Similar	More	Similar	Similar

Flow		NAA			Alt 1			Alt 2a			Alt 2b			Alt 3a		
Location (WVS refers to					Winter	Spring	Summer	Winter	Spring	Summer	Winter	Spring	Summer	Winter	Spring	Summer
Santiam	Detroit	Much More	Similar	Less	Much More	Similar	Similar	Much More	Similar	Less	Much More	Similar	Less	Similar	Similar	Much Less
	Mehama	Much More	Similar	Less	Much More	Similar	Similar	Much More	Similar	Less	Much More	Similar	Less	More	Similar	Much Less
	Green Peter	Similar	Similar	Less	Similar	Similar	Similar	Similar	Similar	Similar	Similar	Similar	Similar	Similar	Similar	Similar
	Foster	More	Similar	Less	More	Similar	Similar	Similar	Similar	Similar	Similar	Similar	Similar	Similar	Similar	Similar
	Waterloo	More	Similar	Less	More	Similar	Similar	Similar	Similar	Similar	Similar	Similar	Similar	Similar	Similar	Similar
	Jefferson	More	Similar	Less	More	Similar	Similar	More	Similar	Less	More	Similar	Less	More	Similar	Less
Long Tom	Fern Ridge	Similar	Similar	Similar	Similar	Similar	Similar	Similar	Similar	Similar	Similar	Similar	Similar	Similar	Similar	Similar
	Monroe	Similar	Similar	Similar	Similar	Similar	Similar	Similar	Similar	Similar	Similar	Similar	Similar	Similar	Similar	Similar
McKenzie	Blue River	Similar	Similar	Similar	Similar	Similar	Similar	Similar	Similar	Similar	More	Similar	Less	Similar	Similar	Much Less
	Cougar	Similar	Less	Less	Similar	Less	Less	Similar	Less	Less	Similar	Less	Much Less	Similar	Less	Much Less
	Vida	More	Less	Less	More	Less	Less	More	Less	Less	More	Less	Much Less	More	Less	Much Less
Middle Fork	Hills Creek	More	Less	Less	More	Less	Less	More	Less	Less	More	Less	Less	More	Less	Much Less
	Lookout Point	More	Less	Less	More	Similar	Similar	More	Similar	Similar	More	Similar	Less	Similar	Similar	Much Less
	Fall Creek	More	Similar	Similar	More	Similar	Similar	More	Similar	Similar	More	Similar	Similar	More	Similar	Similar
	Jasper	More	Less	Less	More	Less	Less	More	Less	Less	More	Less	Less	More	Similar	Much Less
Coast Fork	Dorena	Similar	Similar	Similar	Similar	Similar	Similar	Similar	Similar	Similar	Similar	Similar	Similar	Similar	Similar	Similar
	Cottage Grove	Similar	Similar	Similar	Similar	Similar	Similar	Similar	Similar	Similar	Similar	Similar	Similar	Similar	Similar	Similar
	Goshen	Similar	Similar	Similar	Similar	Similar	Similar	Similar	Similar	Similar	Similar	Similar	Similar	Similar	Similar	Similar
Mainstem	Albany	More	Less	Less	More	Similar	Less	More	Similar	Less	More	Similar	Less	More	Similar	Much Less
	Salem	More	Similar	Less	More	Similar	Less	More	Similar	Less	More	Similar	Less	More	Similar	Much Less

Storage		Alt 3b			Alt 4				Alt 5		Near-Term Operations Measure		
WVS Reservoir		Winter	Spring	Summer	Winter	Spring	Summer	Winter	Spring	Summer	Winter	Spring	Summer
Santiam	Detroit	More	Similar	Much Less	Much More	Similar	Much Less	Much More	Similar	Much Less	Much More	Similar	Much Less
	Green Peter	More	Similar	Much Less	More	Similar	Less	More	Similar	Less	More	Similar	Less
	Foster	More	Similar	Much Less	More	Similar	Similar	More	Similar	Similar	More	Similar	Similar
Long Tom	Fern Ridge	Similar	Similar	Similar	Similar	Similar	Similar	Similar	Similar	Similar	Similar	Similar	Similar
McKenzie	Blue River	More	Less	Less	More	Less	Less	More	Less	Less	More	Less	Less
	Cougar	Much More	Less	Much Less	Much More	Less	Much Less	Much More	Less	Much Less	Much More	Similar	Much Less
Middle Fork	Hills Creek	More	Similar	Much Less	More	Less	Much Less	More	Less	Much Less	More	Similar	Less
	Lookout Point	More	More	Less	More	Similar	Less	More	Similar	Much Less	More	Similar	Less
	Fall Creek	More	Less	Less	More	Less	Less	More	Less	Less	More	Similar	Much Less
Coast Fork	Dorena	More	Similar	Similar	More	Similar	Similar	More	Similar	Similar	More	Similar	Similar
	Cottage Grove	More	Similar	Similar	More	Similar	Similar	More	Similar	Similar	More	Similar	Similar
								0	0	0			

Flow		Alt 3b			Alt 4			Alt5			Near-Term Operations Measure		
Location (WVS refers to		Winter	Spring	Summer	Winter	Spring	Summer	Winter	Spring	Summer	Winter	Spring	Summer
Santiam	Detroit	Similar	Similar	Less	Much More	Similar	Less	Much More	Similar	Less	Much More	Similar	Less
	Mehama	More	Similar	Less	Much More	Similar	Less	Much More	Similar	Less	Much More	Similar	Less
	Green Peter	Similar	Similar	Much Less	Similar	Similar	Less	Similar	Similar	Similar	Similar	Similar	Similar
	Foster	Similar	Similar	Much Less	More	Similar	Similar	Similar	Similar	Similar	More	Similar	Similar
	Waterloo	Similar	Similar	Much Less	More	Similar	Similar	Similar	Similar	Similar	More	Similar	Similar
	Jefferson	More	Similar	Less	More	Similar	Less	More	Similar	Less	More	Similar	Less
Long Tom	Fern Ridge	Similar	Similar	Similar	Similar	Similar	Similar	Similar	Similar	Similar	Similar	Similar	Similar
	Monroe	Similar	Similar	Similar	Similar	Similar	Similar	Similar	Similar	Similar	Similar	Similar	Similar
McKenzie	Blue River	Similar	Similar	Much Less	Similar	Similar	Similar	More	Similar	Less	Similar	Similar	Similar
	Cougar	Similar	Less	Much Less	Similar	Less	Less	Similar	Less	Much Less	Similar	Less	Much Less
	Vida	More	Less	Much Less	More	Less	Less	More	Less	Much Less	More	Less	Less
Middle Fork	Hills Creek	More	More	Much Less	More	Less	Less	More	Less	Less	More	Less	Less
	Lookout Point	Similar	More	Less	More	Similar	Similar	More	Similar	Less	Similar	Similar	Less
	Fall Creek	More	Similar	Similar	More	Similar	Similar	More	Similar	Similar	Similar	Less	Much Less
	Jasper	More	Similar	Less	More	Less	Less	More	Less	Less	More	Similar	Less
Coast Fork	Dorena	Similar	Similar	Similar	Similar	Similar	Similar	Similar	Similar	Similar	Similar	Similar	Similar
	Cottage Grove	Similar	Similar	Similar	Similar	Similar	Similar	Similar	Similar	Similar	Similar	Similar	Similar
	Goshen	Similar	Similar	Similar	Similar	Similar	Similar	Similar	Similar	Similar	Similar	Similar	Similar
Mainstem	Albany	More	Similar	Less	More	Similar	Less	More	Similar	Less	More	Similar	Less
	Salem	More	Similar	Less	More	Similar	Less	More	Similar	Less	More	Similar	Less

Seasons
Winter - Nov-Feb
Spring - Feb-May
Summer - June-Oct

Color Key
Much Less
Less
Similar
More
Much More

Figure 6-1. Climate Change Effects Matrix

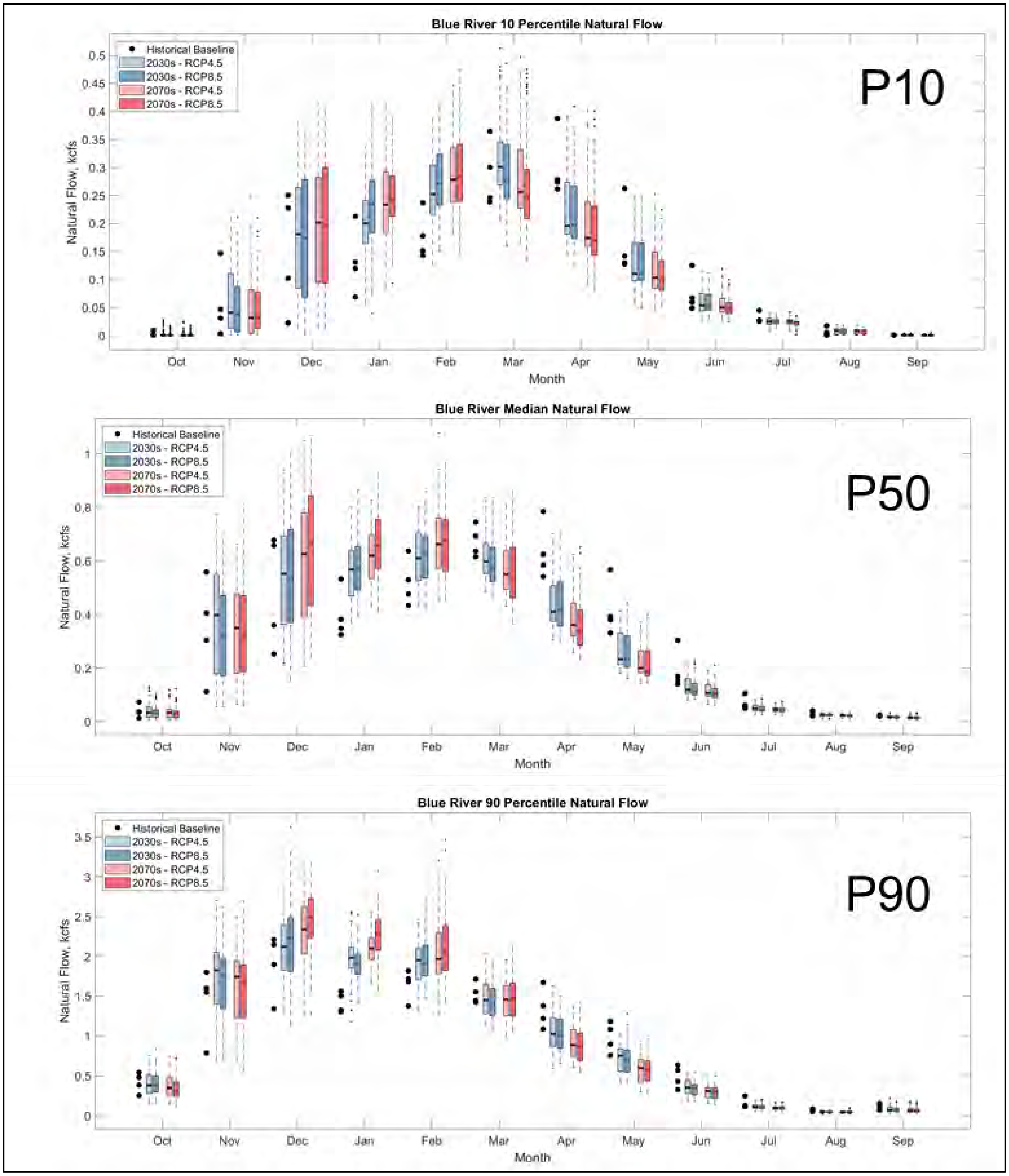


Figure 6-2. Blue River Climate Change Projections

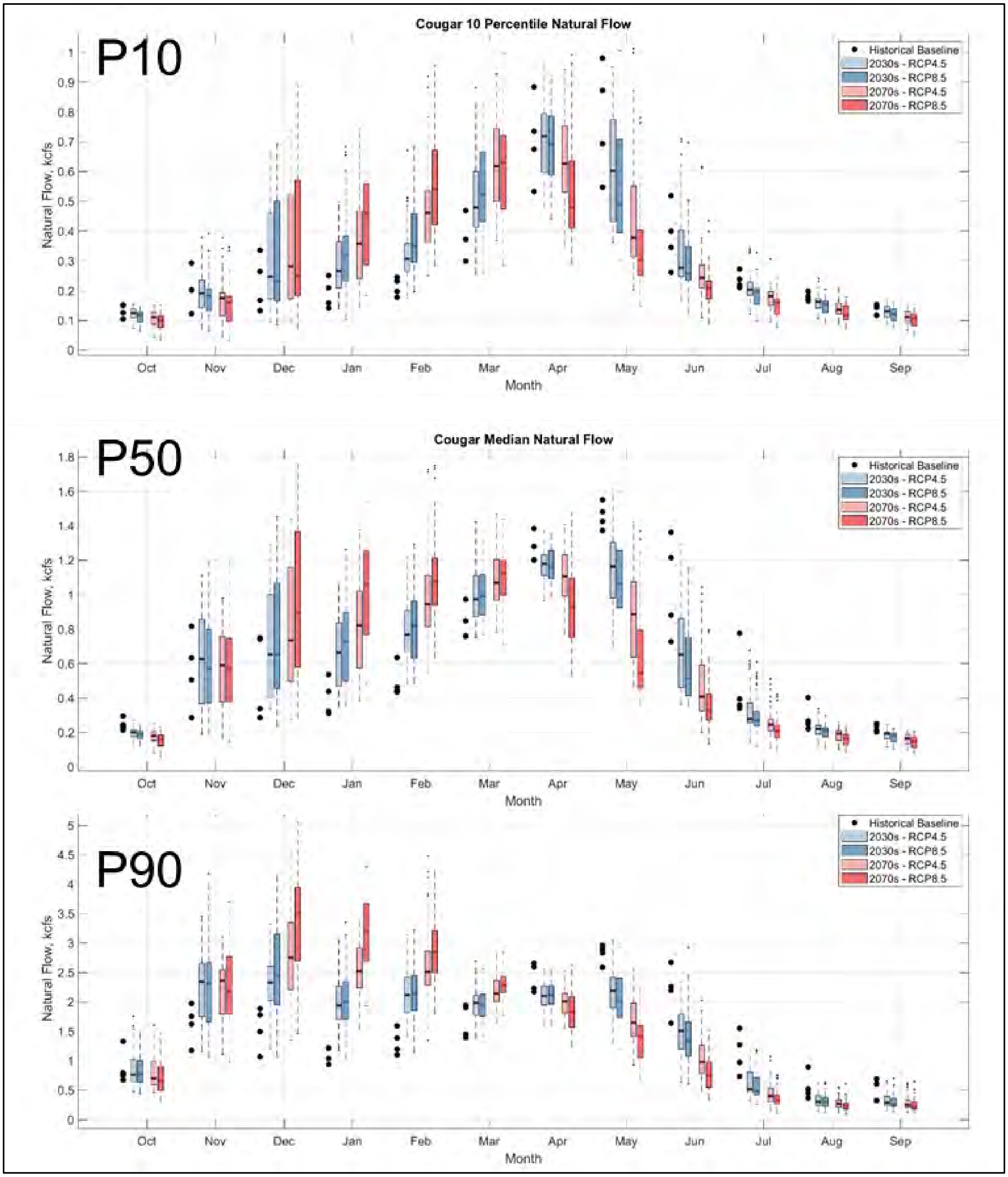


Figure 6-3. Cougar Climate Change Projections

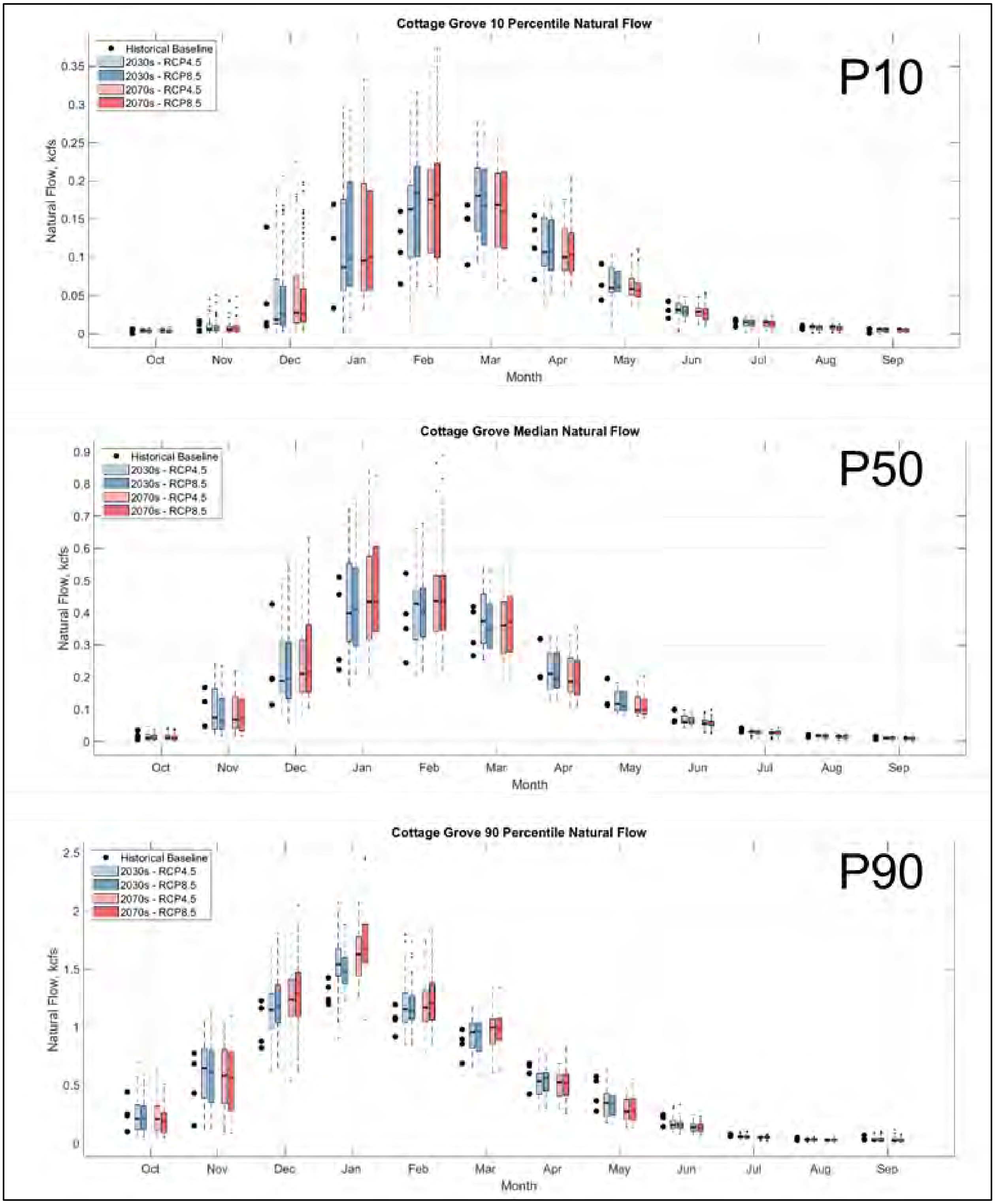


Figure 6-4. Cottage Grove Climate Change Projections

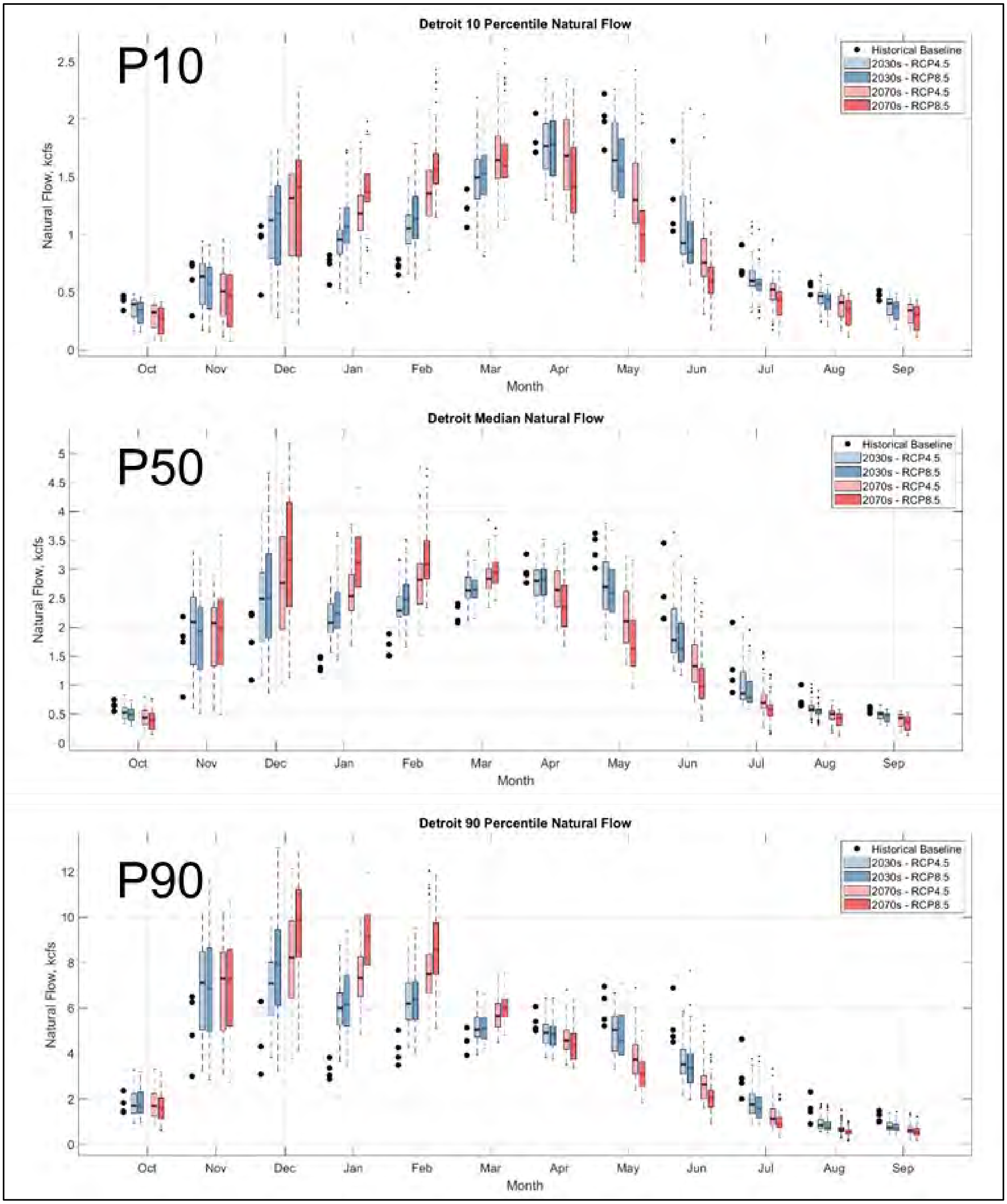


Figure 6-5. Detroit Climate Change Projections

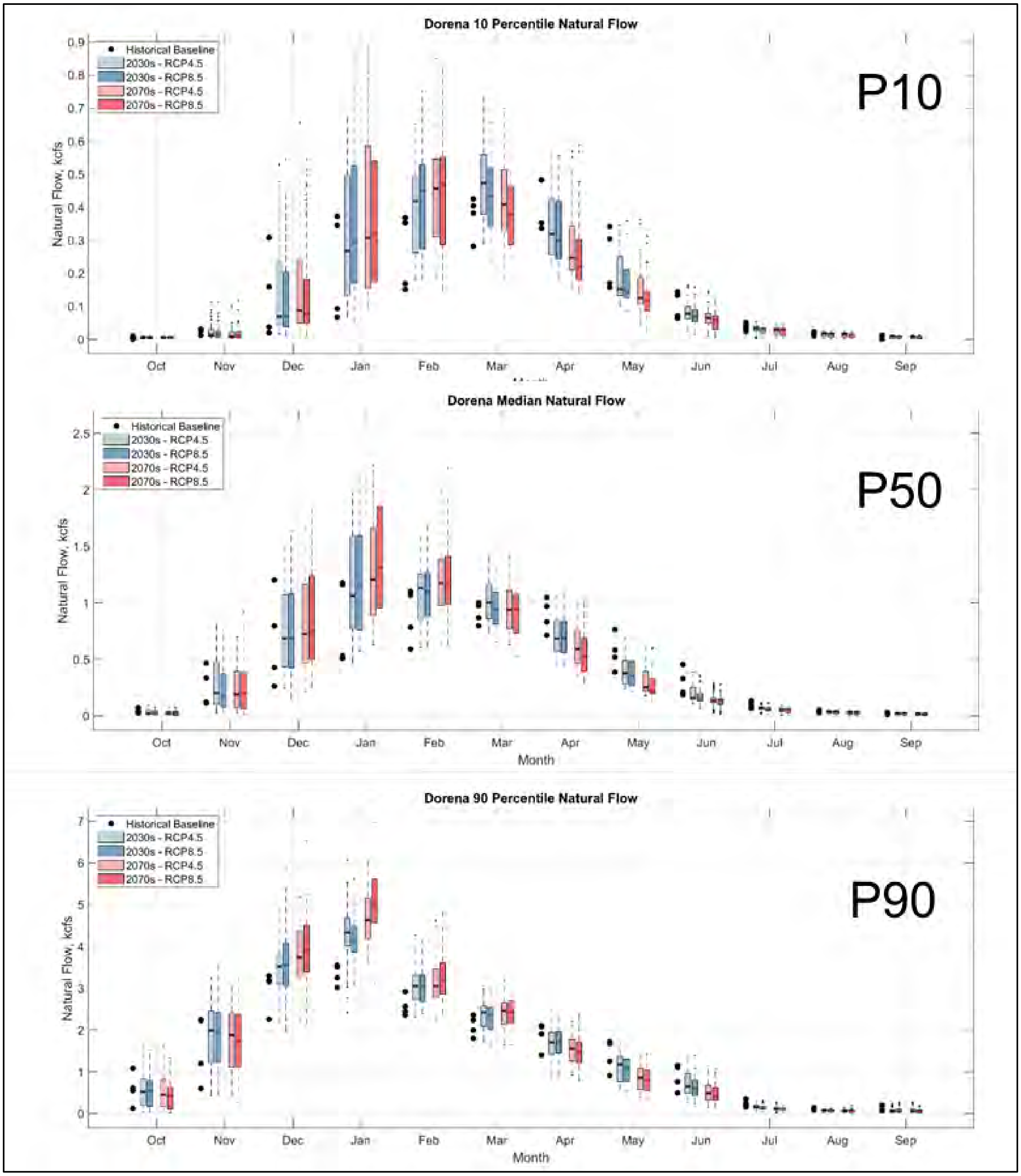


Figure 6-6. Dorena Climate Change Projections

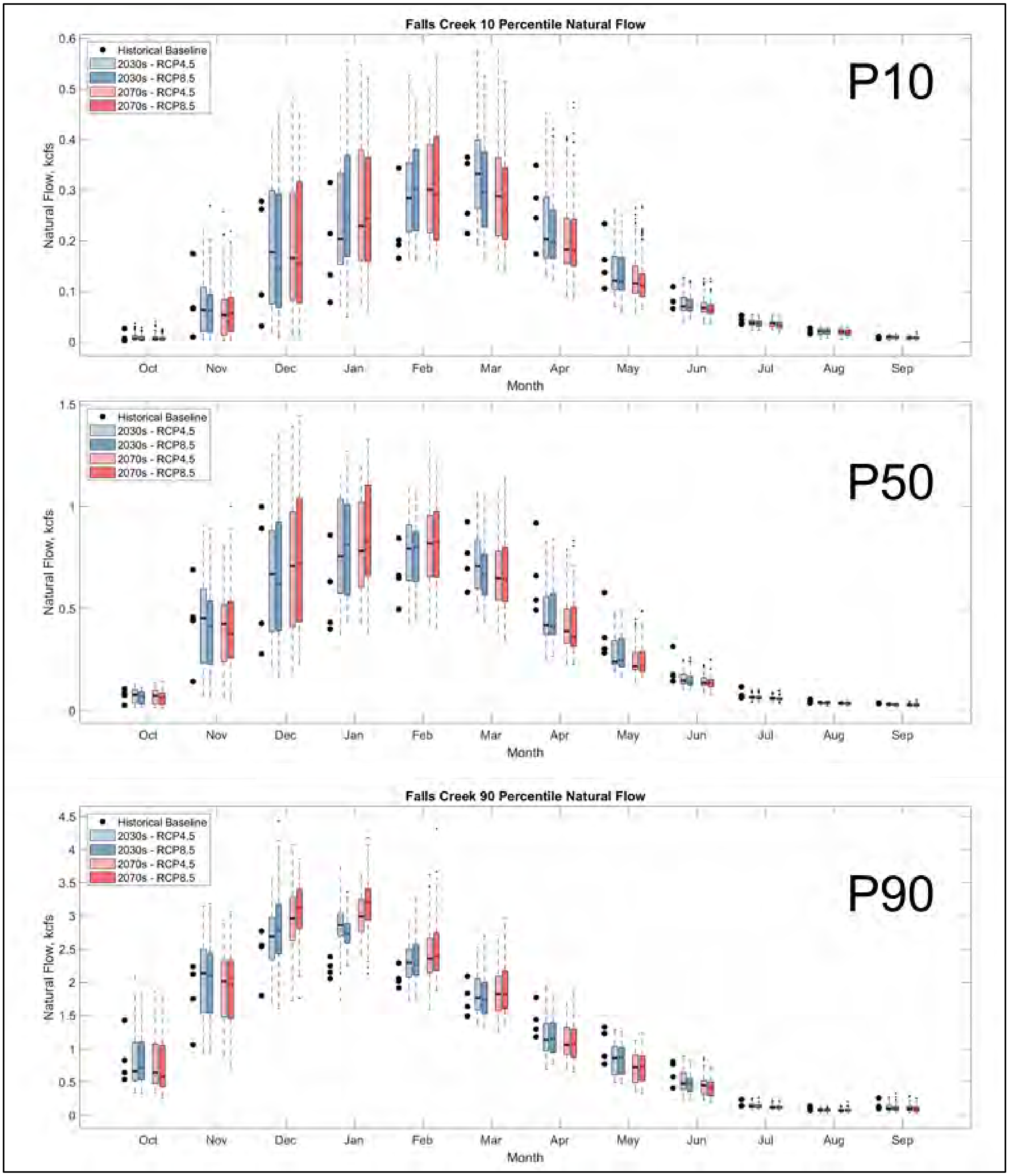


Figure 6-7. Fall Creek Climate Change Projections

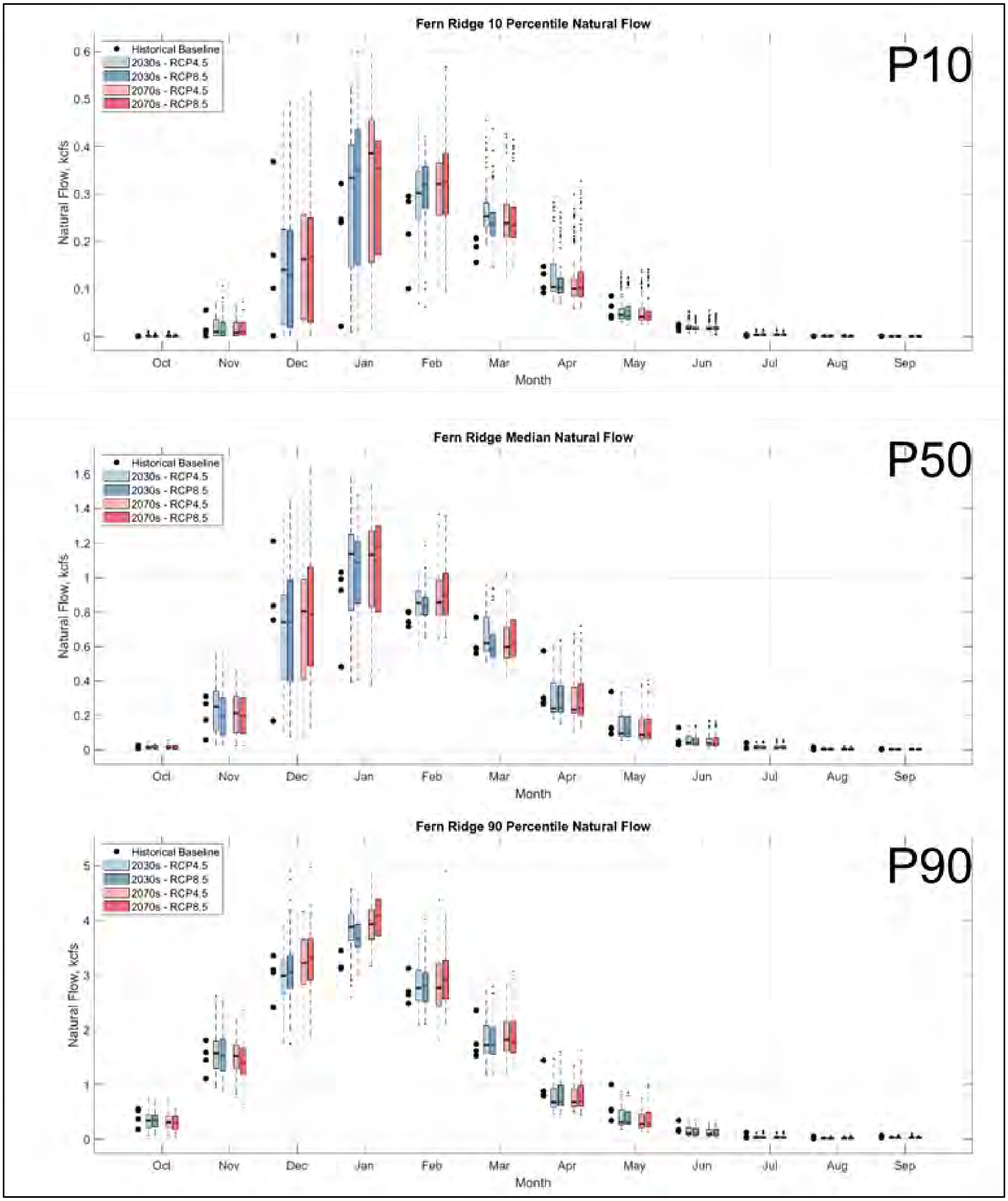


Figure 6-8. Fern Ridge Climate Change Projections

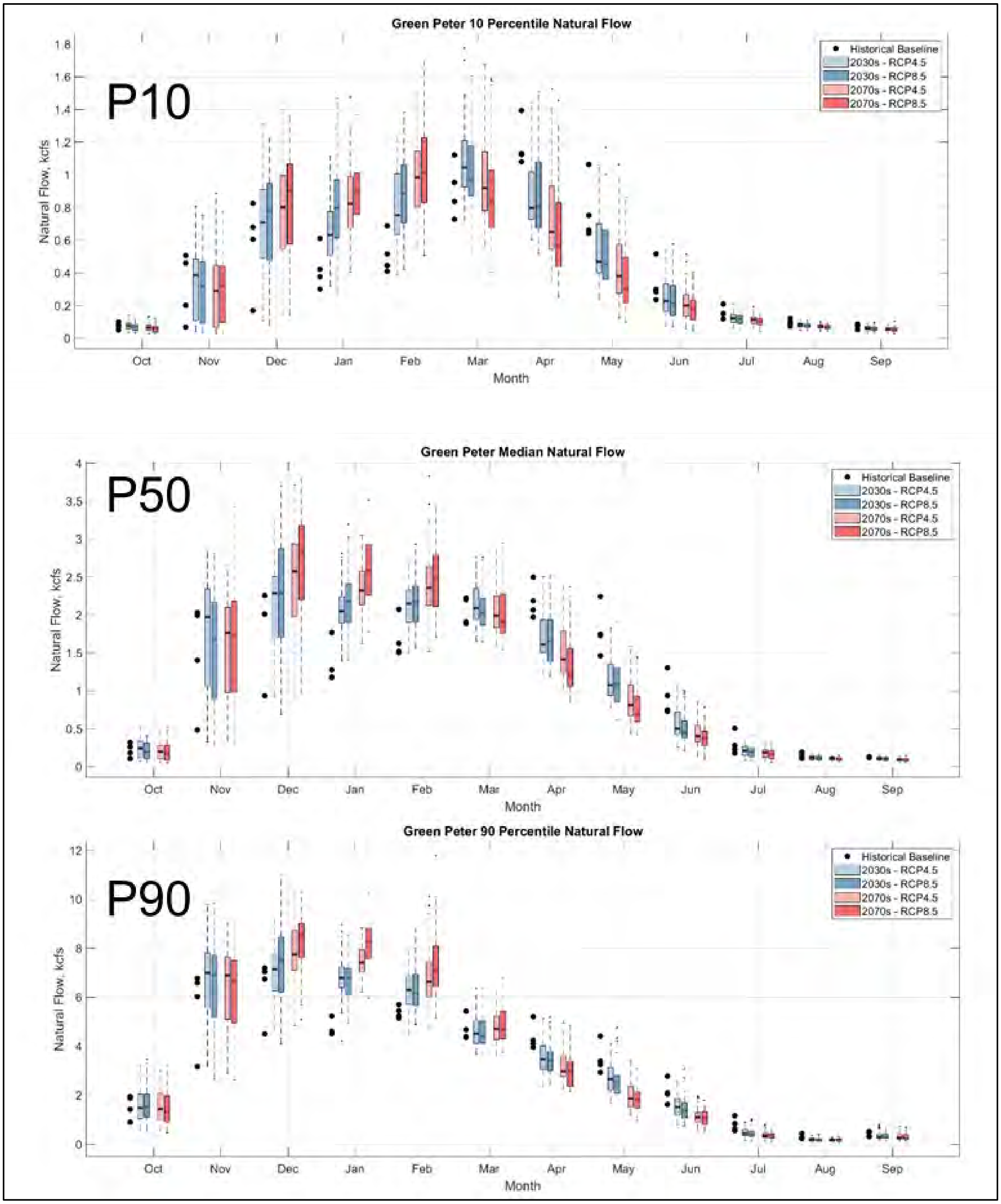


Figure 6-9. Green Peter Climate Change Projections

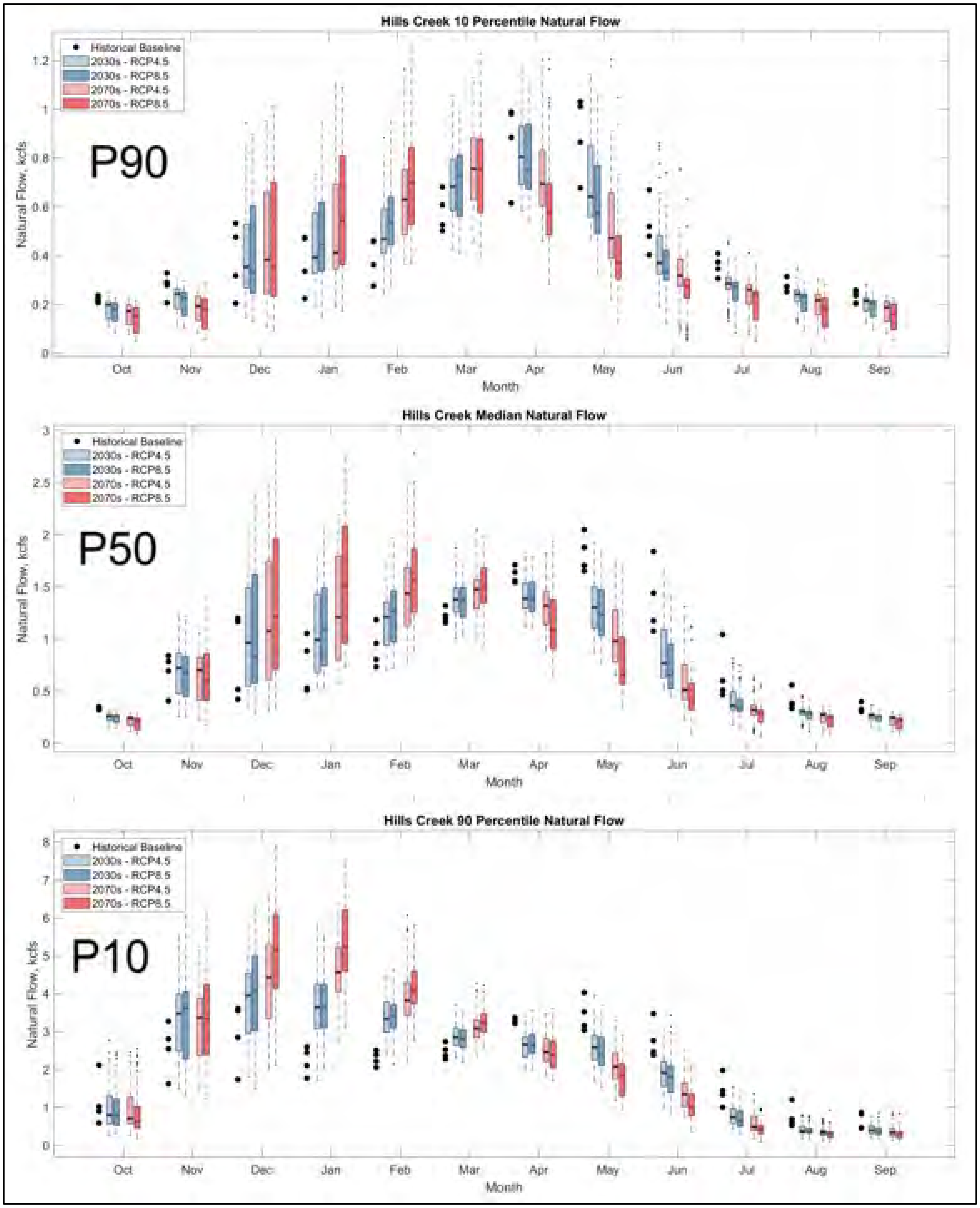


Figure 6-10. Hills Creek Climate Change Projections

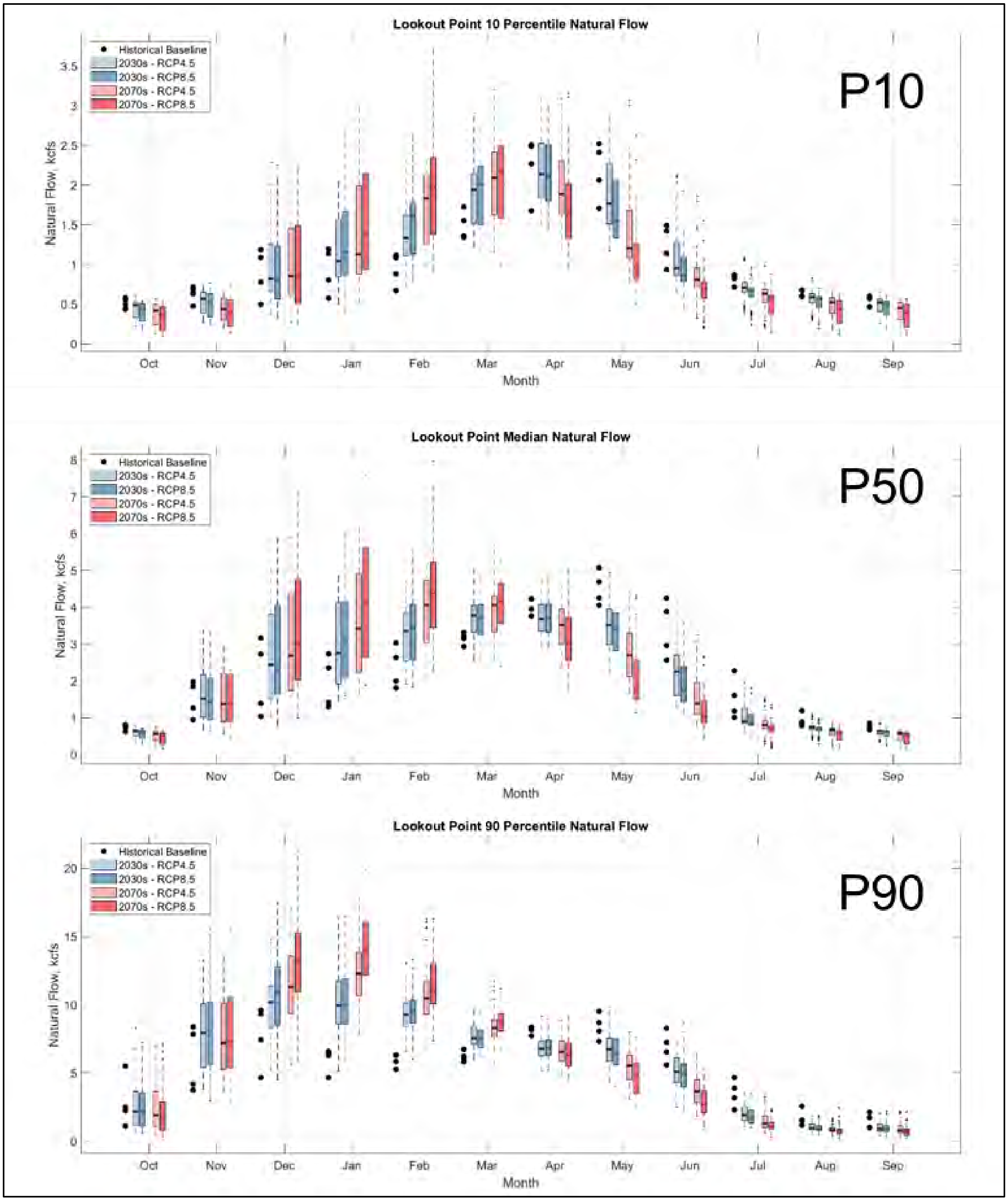


Figure 6-11. Lookout Point Climate Change Projections

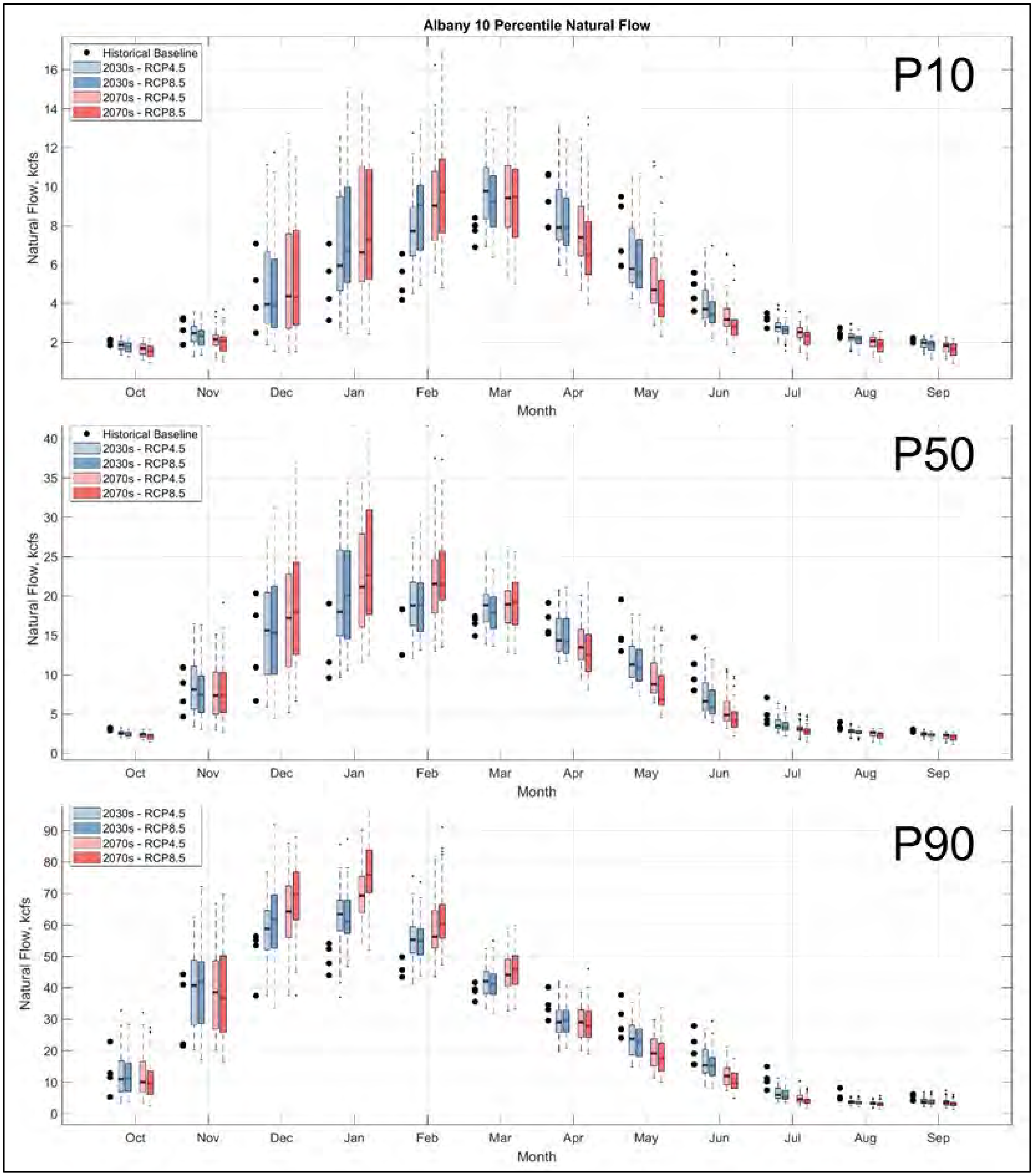


Figure 6-12. Albany Climate Change Projections

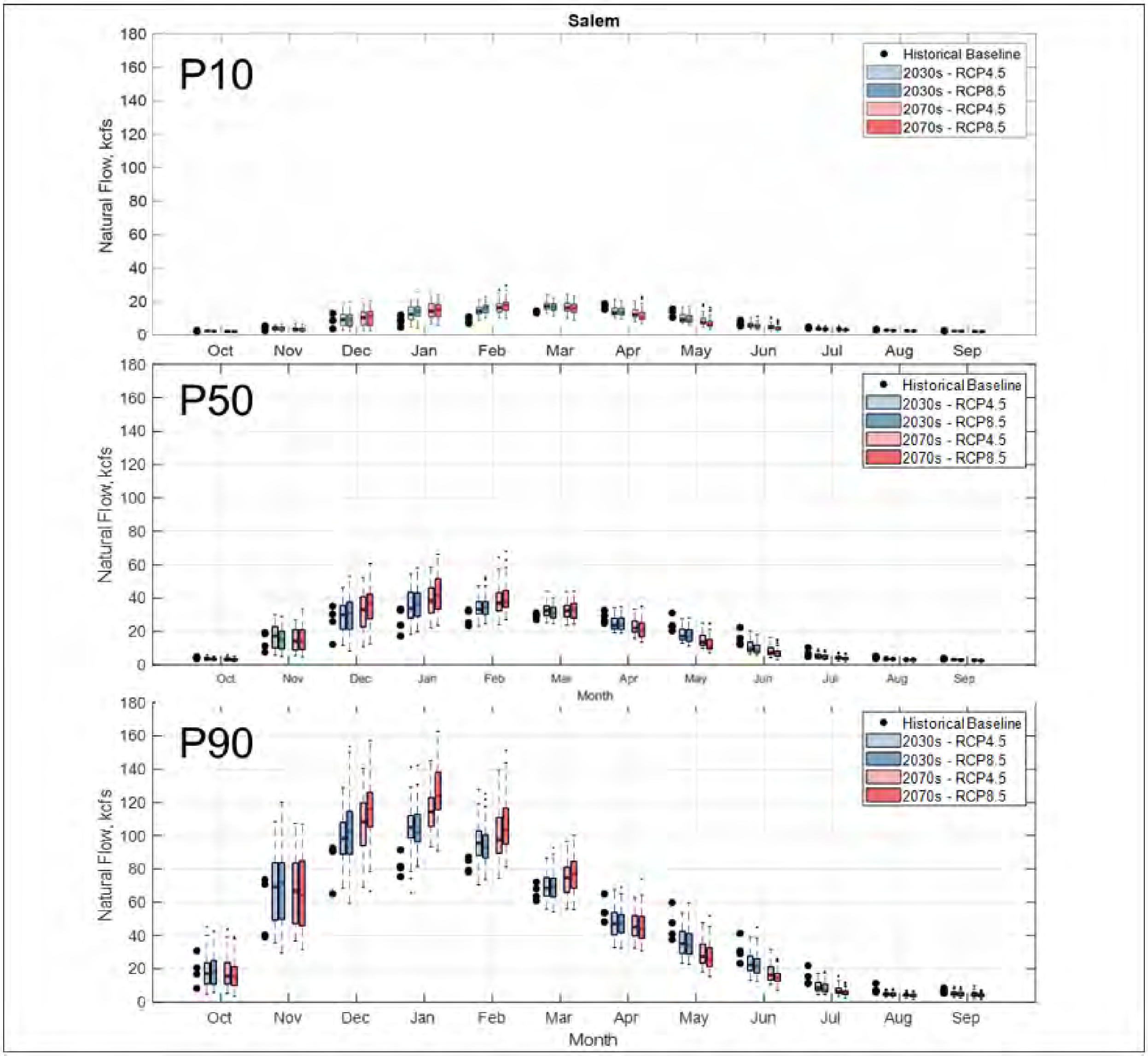


Figure 6-13. Salem Climate Change Projections

7 INCREASE IN CONSERVATION STORAGE ASSOCIATED WITH NOT DRAWING DOWN WHEN ABOVE THE RULE CURVE FOR 14 DAYS DURING REFILL AT WVP RESERVOIRS

Allowing for storm events that raise pool levels above the rule curve during spring refill to be stored instead of drafted over a 14 day period prior to meeting the rule curve was proposed as an measure for evaluation. This analysis identifies potential increases in conservation storage associated with the proposed operation and provides rationale for the screening of this measure.

Current project constraints require WVP reservoirs to draft to the rule curve within 7-10 days of the flow at a downstream control point receding below regulation stage. Allowing water to be stored above the rule curve for a longer period during spring refill, up to 14 days, offers reservoir operators even greater flexibility to store spring storm events and increase conservation season storage.

Extending the period of time pool elevations remain above the rule curve during spring refill results in prolonged periods of reduced flood storage resulting in increased flood risk. Reservoirs store water during high precipitation events to reduce flows downstream, resulting in higher pool elevations. The higher the pool elevation, the smaller rain event required to raise the pool to elevations where uncontrolled releases are required. An analysis of impacts to flood risk management (FRM) would be required if benefits to conservation storage encourage further consideration of this measure.

Methods:

Increased conservation storage associated with storing water above the rule curve for 14 days following a storm event was investigated using the HEC-ResSim model. The model applies reservoir operational rules under various hydrologic conditions to simulate regulated in stream flow and reservoir elevations throughout the basin. The Willamette basin HEC-ResSim model includes all thirteen WVP reservoirs along with the operational rules and constraints at each location, which are designed to achieve both project-specific and system-wide objectives as specified in the project and system Water Control Manuals.

The alternative operation is modeled by creating a reservoir zone identical in slope to the rule curve that precedes the rule curve by 14 days and defining a rule in the new zone that does not permit the reservoir to draw down (Figure B-7-1 -A). Reservoir elevations will only rise in this zone if inflows exceed maximum outflows which are constrained by downstream control point flows, physical outlet maximum flows, and calibration flows determined to match typical operations. When reservoir elevations rise above the new zone reservoirs will draft up to maximum flows until reaching the no draw down zone. The No-Action alternative is similarly modeled with a 7-day period of no drawdown preceding the spring refill curve (Figure B-7-1 -B).

In current operations, reservoir operators receive forecasts of future rain events. Reservoir operators will draft to the rule curve as quickly as possible after a storm event if another storm event is forecasted. ResSim does not utilize forecasting. As a result, when back-to-back events with inflows that exceed maximum outflows occur in the alternative operation, reservoir elevations may remain above the rule curve significantly longer than 14 days in the alternative simulation. As a result, observed increases in storage resulting from the alternative operation may be larger than what it would be in real time operations, particularly in adequate and abundant water years, but less so in insufficient and deficit water years which are of the greatest concern. For these reasons, increases in storage resulting from alternative operations were only reported in Insufficient and Deficit water years.

Impacts to conservation storage were evaluated by comparing the storage volume observed on the date of target maximum storage at each WVP reservoir resulting from the alternative simulation and no-action simulation in Insufficient and Deficit water years. Table B-7-1 indicates the flow in cubic feet per second (cfs) that can be sustained over 30 days by releasing stored volume in increments of kilo acre-feet (kaf) to help contextualize the significance of increases in storage. For context, One kaf of storage can sustain releases of 17 cfs for 30 days.

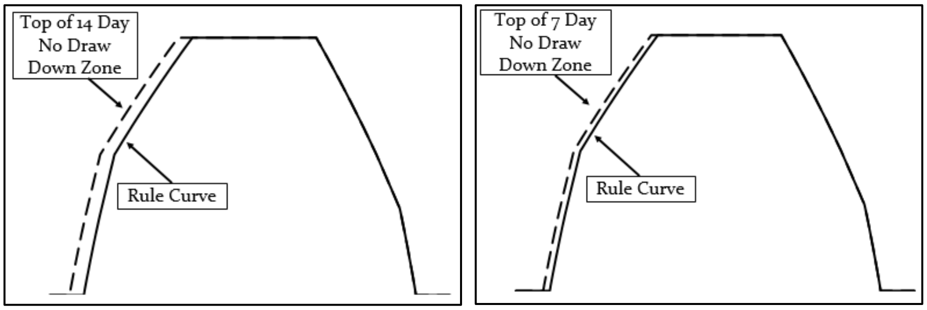


Figure 7-1. Figure 1 – Alternative (a) and no – action (b) no draw down zones

Table 7-1. kaf converted to cfs sustainable over 30 days

KAF	CFS Sustained for 30 Days	KAF	CFS Sustained for 30 Days	KAF	CFS Sustained for 30 Days	KAF	CFS Sustained for 30 Days	KAF	CFS Sustained for 30 Days
1	17	16	268	31	520	46	782	61	1,023
2	34	17	285	32	537	47	799	62	1,040
3	50	18	302	33	553	48	816	63	1,057
4	67	19	319	34	570	49	833	64	1,073
5	84	20	335	35	587	50	850	65	1,090
6	101	21	352	36	604	51	867	66	1,107
7	117	22	369	37	620	52	884	67	1,124
8	134	23	386	38	637	53	901	68	1,140
9	151	24	402	39	654	54	918	69	1,157
10	168	25	419	40	671	55	935	70	1,174
11	184	26	436	41	688	56	952	71	1,191
12	201	27	453	42	704	57	969	72	1,207
13	218	28	470	43	721	58	986	73	1,224
14	235	29	486	44	738	59	1,003	74	1,241
15	252	30	503	45	755	60	1,020	75	1,258

Results and Conclusions:

Table B-7-2 shows increases in system conservation storage associated with the alternative operation in Insufficient and Deficit water years. Table B-7-3 shows average increases at individual reservoirs. Pool elevations do not rise above the rule curve during spring refill in some Deficit water years and so benefits in those years are not realized. Increases in system storage are observed in all Insufficient water years. Tables and plots detailing increases at individual reservoirs are provided.

Table 7-2. increases in system conservation storage associated with alternative operations in insufficient and deficit water years

Year	1944	1965	1967	1968	1978	1987	1992	1994
KAF	6.4	27.5	25.3	7.2	28.3	1.0	9.7	9.2
Year	1941	1942	1973	1977	2001	2015		
KAF	7.0	0.0	56.3	0.0	1.1	6.7		
System		**Legend**		Insufficient	Deficit			

Table 7-3. Mean increase in conservation storage associated with alternative operations in Insufficient and Deficit water years

Reservoir	Insufficient (8 years)		Deficit (6 years)	
	# Years W/Increase	Average Increase (kaf)	# Years W/Increase	Average Increase (kaf)
Blue River	1	0.2	1	0.1
Cottage Grove	2	0.4	1	0.0
Cougar	4	3.1	2	0.6
Detroit	3	2.4	2	2.2
Dorena	3	2.1	3	1.1
Fall Creek	6	2.2	4	1.9
Fern Ridge	1	1.4	0	0.0
Green Peter	3	0.7	2	4.8
Hills Creek	0	0.0	0	0.0
Lookout Point	2	1.9	1	1.1
System	8	14.3	4	11.9

Additional Figures and Tables:

Blue River:

Table 7-4. May Increase in conservation storage associated with alternative operations at Blue River in Insufficient and Deficit years

Year	1944	1965	1967	1968	1978	1987	1992	1994
KAF	0.0	0.0	1.8	0.0	0.0	0.0	0.0	0.0
Year	1941	1942	1973	1977	2001	2015		
KAF	0.0	0.0	0.7	0.0	0.0	0.0		
Blue River		**Legend**		Insufficient	Deficit			

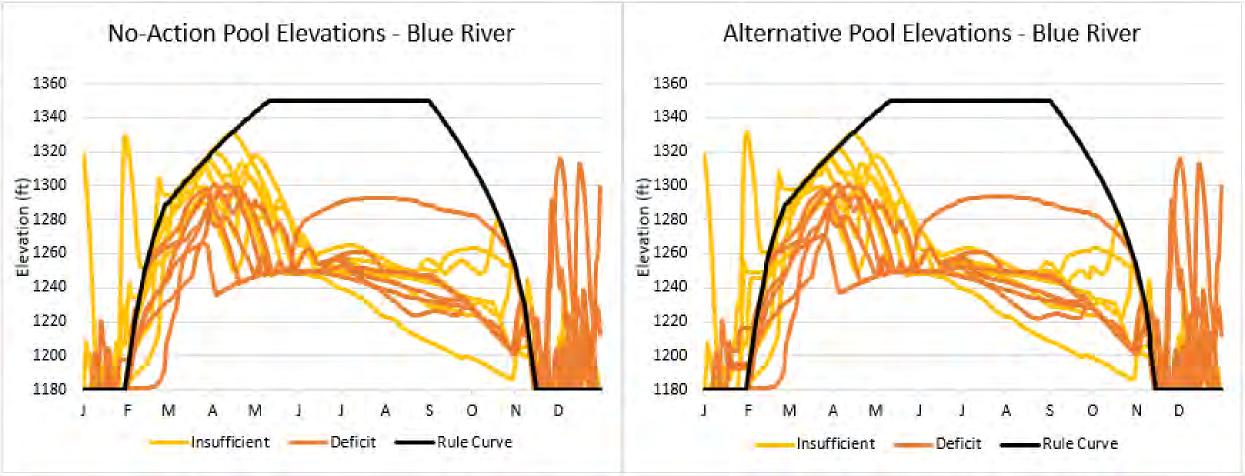


Figure 7-2. Blue River No-Action and Alternative operations pool elevations in Insufficient and Deficit water years

Cougar:

Table 7-5. 10 May Increase in conservation storage associated with alternative operations at Cougar Insufficient and Deficit years

Year	1944	1965	1967	1968	1978	1987	1992	1994
KAF	0.0	7.9	11.9	0.0	2.0	0.0	0.0	2.6
Year	1941	1942	1973	1977	2001	2015		
KAF	0.2	0.0	3.5	0.0	0.0	0.0		
Cougar		**Lenend**		Abundant	Adequate			

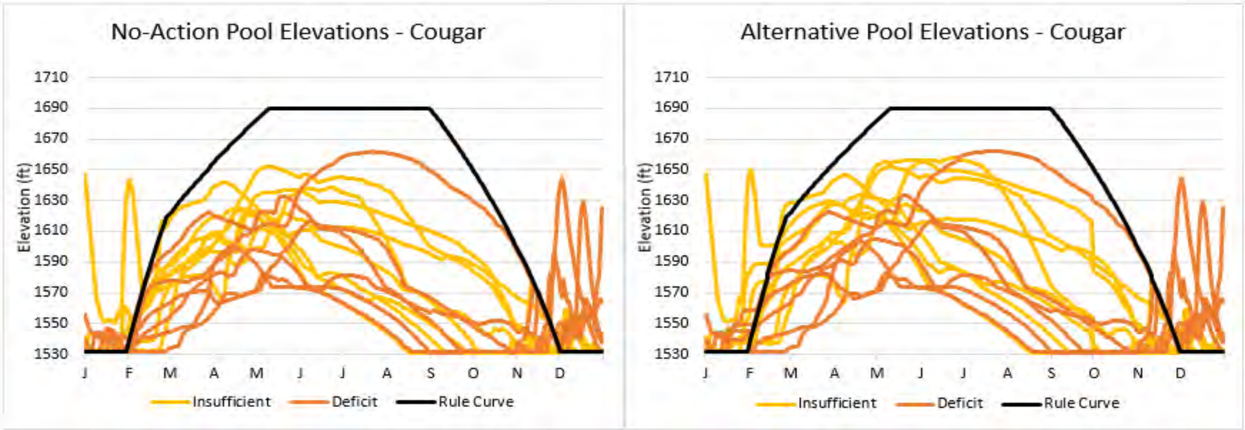


Figure 7-3. Cougar No-Action and Alternative operations pool elevations in Insufficient and Deficit water years

Cottage Grove:

Table 7-6. May Increase in conservation storage associated with alternative operations at Cottage Grove

Year	1944	1965	1967	1968	1978	1987	1992	1994
KAF	1.5	0.0	Fill	0.0	0.0	0.0	0.0	1.4
Year	1941	1942	1973	1977	2001	2015		
KAF	0.0	Fill	0.0	0.0	0.0	0.1		
Cottage Grove		**Legend**		Insufficient	Deficit			

*Fill indicates that the reservoir filled under baseline conditions

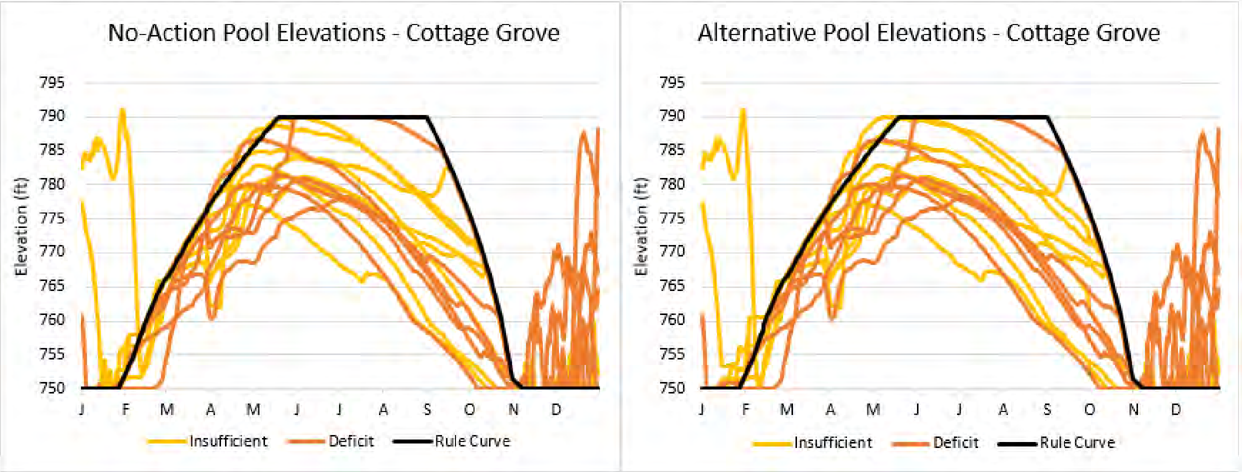


Figure 7-4. Cottage Grove No-Action and Alternative operations pool elevations in Insufficient and Deficit water years

Detroit:

Table 7-7. May Increase in conservation storage associated with alternative operations at Detroit

Year	1944	1965	1967	1968	1978	1987	1992	1994
KAF	0.0	3.9	11.6	3.6	0.0	0.0	0.0	0.0
Year	1941	1942	1973	1977	2001	2015		
KAF	0.3	0.0	12.8	0.0	0.0	0.0		
Detroit		**Legend**		Insufficient	Deficit			

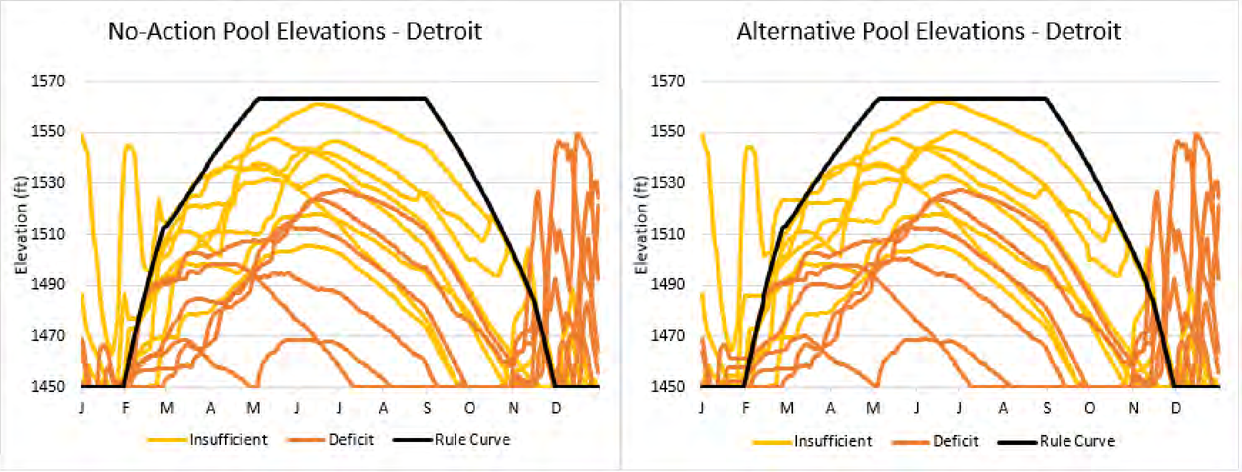


Figure 7-5. Detroit No-Action and Alternative operations pool elevations in Insufficient and Deficit water years

Dorena:

Table 7-8. May Increase in conservation storage associated with alternative operations at Dorena

Year	1944	1965	1967	1968	1978	1987	1992	1994
KAF	4.3	0.0	Fill	0.0	0.0	0.0	8.8	3.6
Year	1941	1942	1973	1977	2001	2015		
KAF	0.1	Fill	4.1	Fill	0.0	2.5		
Dorena		**Legend**		Insufficient	Deficit			

*Fill indicates that the reservoir filled under baseline conditions

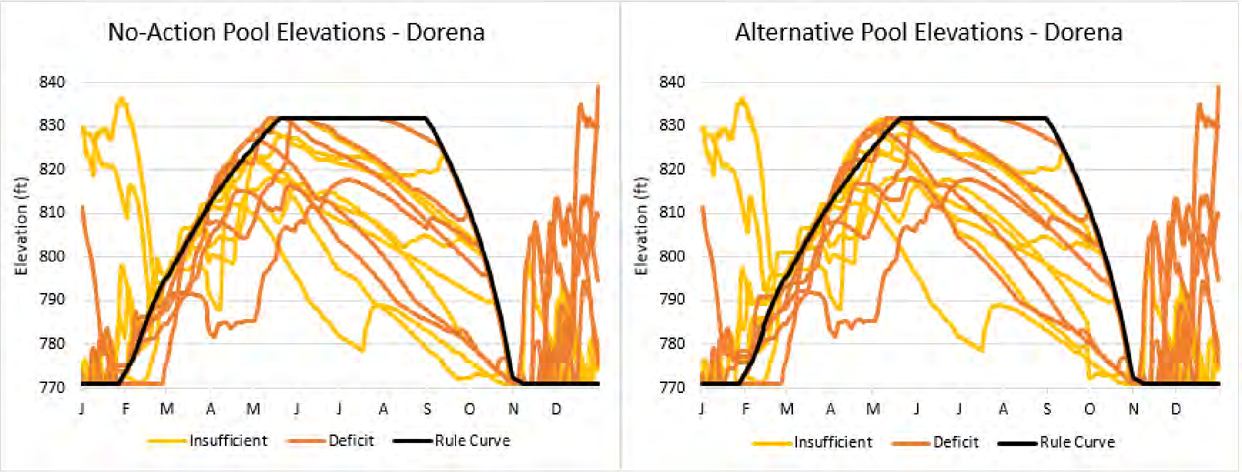


Figure 7-6. Dorena No-Action and Alternative operations pool elevations in Insufficient and Deficit water years

Fall Creek:

Table 7-9. May Increase in conservation storage associated with alternative operations at Fall Creek

Year	1944	1965	1967	1968	1978	1987	1992	1994
KAF	Fill	3.2	Fill	1.9	8.5	1.0	0.9	1.6
Year	1941	1942	1973	1977	2001	2015		
KAF	6.4	Fill	2.9	Fill	1.1	0.9		
Fall Creek		**Legend**		Insufficient	Deficit			

*Fill indicates that the reservoir filled under baseline conditions

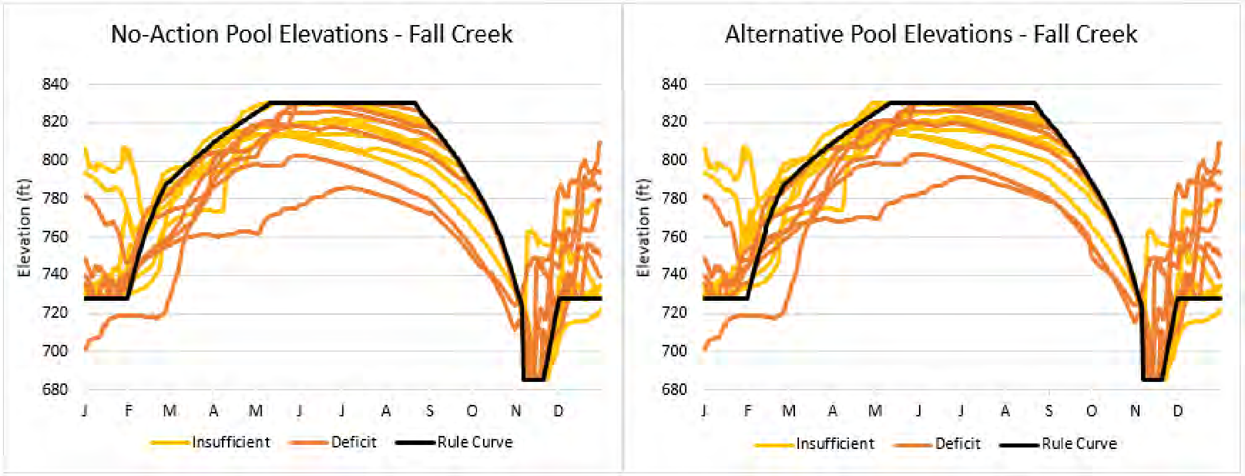


Figure 7-7. Fall Creek No-Action and Alternative operations pool elevations in Insufficient and Deficit water years

Fern Ridge:

Table 7-10. April Increase in conservation storage associated with alternative operations at Fern Ridge

Year	1944	1965	1967	1968	1978	1987	1992	1994
KAF	0.0	11.5	Fill	0.0	0.0	0.0	0.0	0.0
Year	1941	1942	1973	1977	2001	2015		
KAF	0.0	0.0	0.0	0.0	0.0	0.0		
Fern Ridge		**Legend**		Insufficient	Deficit			

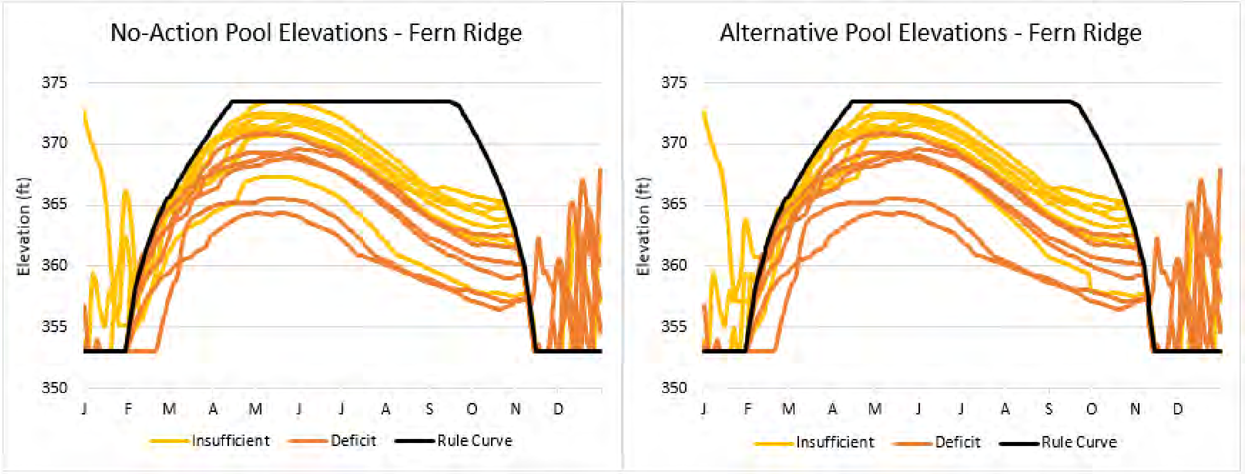


Figure 7-8. Fern Ridge No-Action and Alternative operations pool elevations in Insufficient and Deficit water years

Green Peter:

Table 7-11. May Increase in conservation storage associated with alternative operations at Green Peter

Year	1944	1965	1967	1968	1978	1987	1992	1994
KAF	0.0	0.9	Fill	1.7	3.4	0.0	0.0	0.0
Year	1941	1942	1973	1977	2001	2015		
KAF	0.0	0.0	25.4	Fill	0.0	3.2		
Green Peter		Legend		Insufficient	Deficit			

*Fill indicates that the reservoir filled under baseline conditions

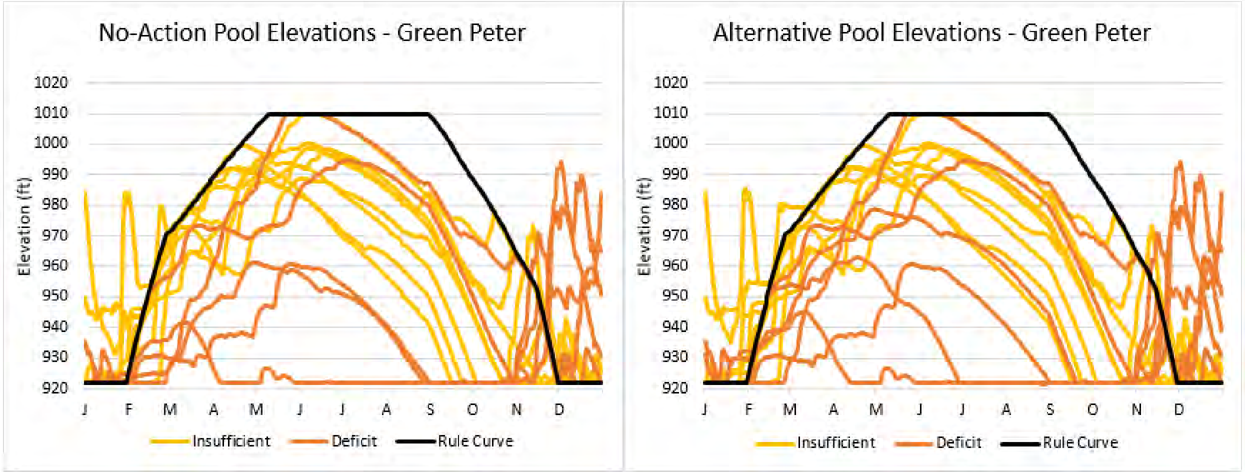


Figure 7-9. Green Peter No-Action and Alternative operations pool elevations in Insufficient and Deficit water years

Hills Creek:

Table 7-12. May 15 Increase in conservation storage associated with alternative operations at Hills Creek

Year	1944	1965	1967	1968	1978	1987	1992	1994
KAF	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Year	1941	1942	1973	1977	2001	2015		
KAF	0.0	0.0	0.0	0.0	0.0	0.0		
Hills Creek		**Legend**		Insufficient	Deficit			

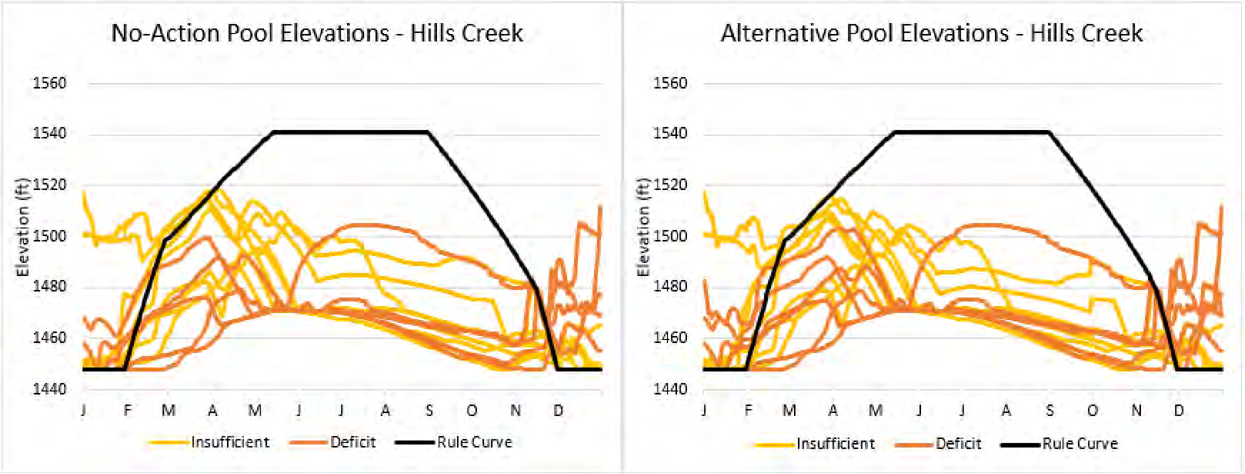


Figure 7-10. Hills Creek No-Action and Alternative operations pool elevations in Insufficient and Deficit water years

Lookout Point:

Table 7-13. May Increase in conservation storage associated with alternative operation at Lookout Point

Year	1944	1965	1967	1968	1978	1987	1992	1994
KAF	0.6	Fill	Fill	0.0	14.4	0.0	0.0	0.0
Year	1935	1941	1942	1973	1977	2001	2015	
KAF	0.0	0.0	0.0	6.9	0.0	0.0	0.0	
Lookout Point		**Legend**		Insufficient	Deficit			

*Fill indicates that the reservoir filled under baseline conditions

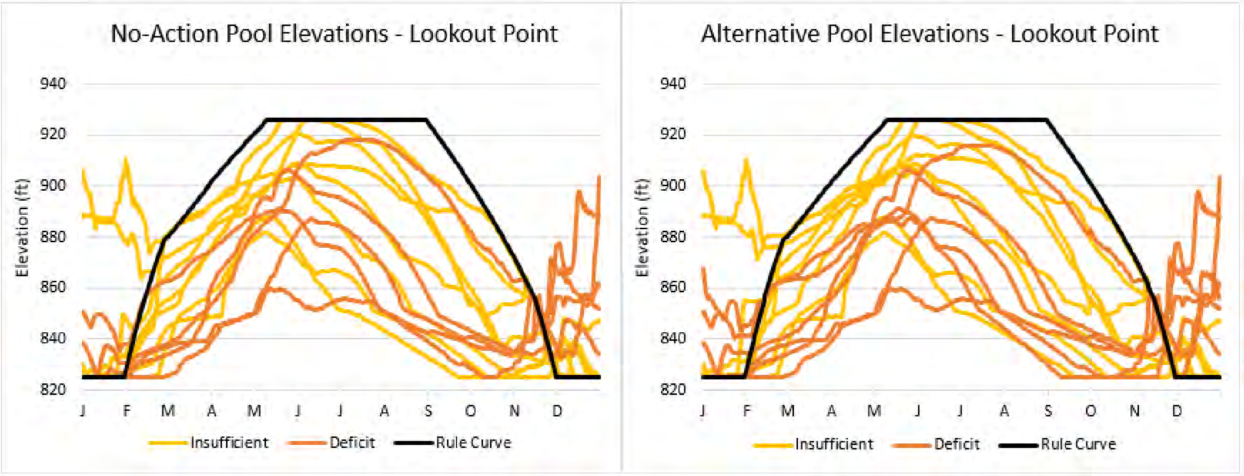


Figure 7-11. Lookout Point No-Action and Alternative operations pool elevations in Insufficient and Deficit water years

8 FLOOD RISK ASSOCIATED WITH HOLDING WILLAMETTE VALLEY RESERVOIRS WITH SECONDARY FLOOD STORAGE AT THE TOP OF THE SECONDARY FLOOD POOL DURING THE WINTER – 1964 AND 1996 CASE STUDY

Targeting the top of the secondary flood pool at Willamette Valley Project (WVP) reservoirs in the winter instead of the minimum conservation elevation, with the goal of increasing the magnitude of spring refill, has been proposed as a measure for evaluation as part of the Willamette Valley System (WVS) Environmental Impact Statement (EIS) study. Six WVP reservoirs have secondary flood pools. Figure B-8-1 identifies the secondary flood storage and total maximum conservation storage at each reservoir. This analysis aims to identify potential impacts to flood risk management (FRM) associated with the proposed alternative operation.

A reduction in winter flood storage is associated with an increase in flood risk. Reservoirs store water during high precipitation events to reduce flows downstream, resulting in higher pool elevations. The higher the pool elevation, the smaller rain event required to raise the pool to elevations where uncontrolled releases are required.

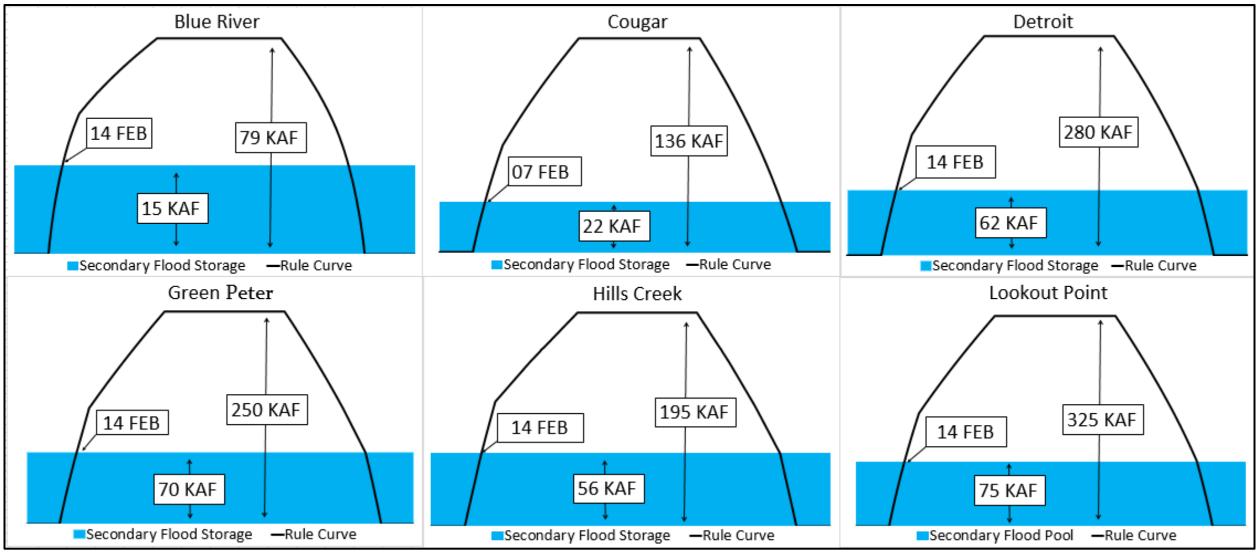


Figure 8-1. Secondary flood storage at Willamette Valley reservoirs

Methods:

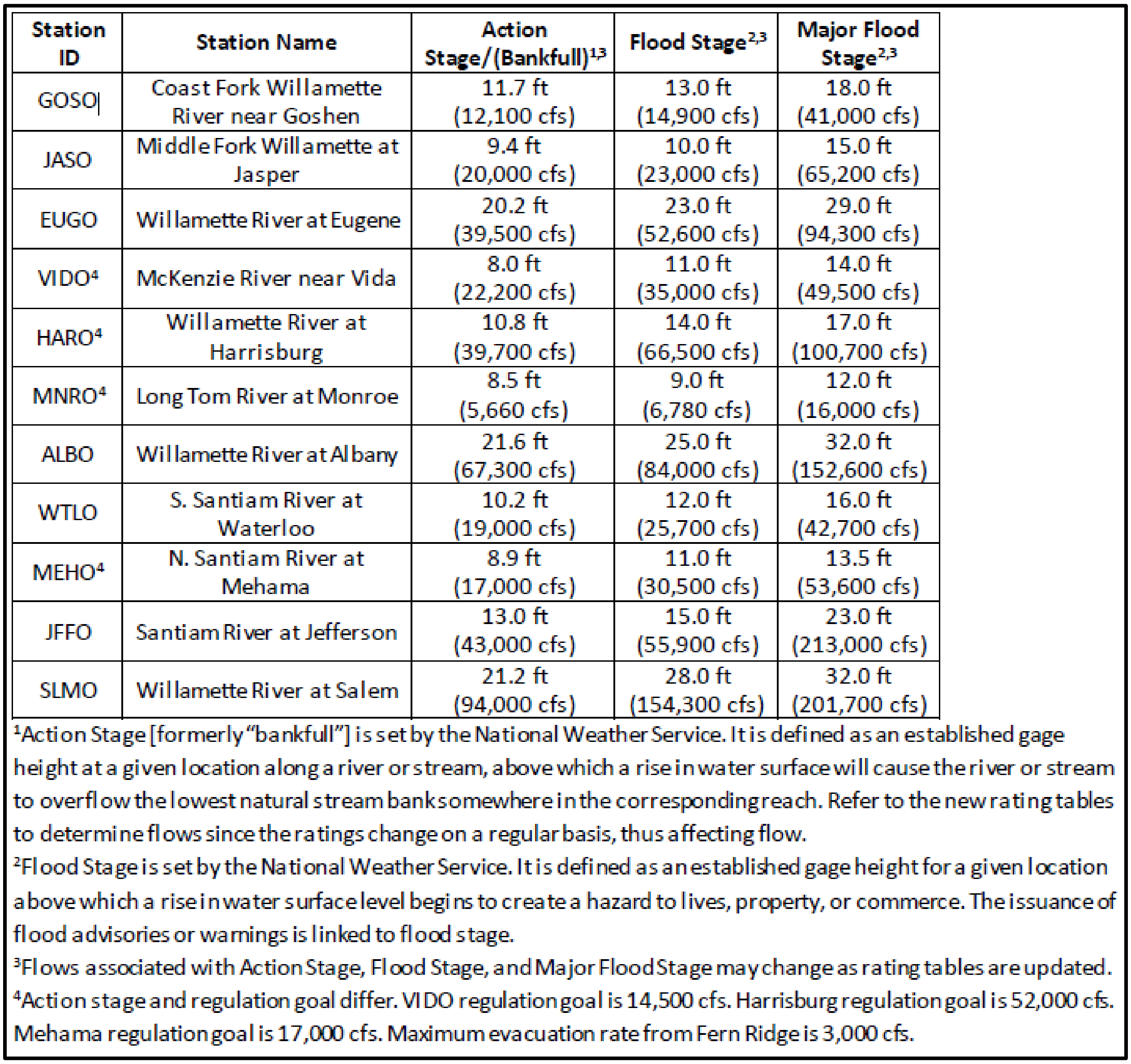
Increases in flood risk associated with targeting the top of the secondary flood pool at Cougar, Detroit, Green Peter, Lookout Point, Hills Creek, and Blue River reservoirs during the winter are investigated using the HEC-ResSim model and Flood Insurance Study (FIS) watershed. The model applies reservoir operational rules under various hydrologic conditions to simulate regulated flow and reservoir elevations throughout the basin. The Willamette basin HEC-ResSim model includes all thirteen WVP reservoirs, along with the operational rules and constraints at each location, which are designed to achieve both project-specific and system-wide objectives as specified in the project and system Water Control Manuals. The FIS watershed uses a 3-hour simulation time step and hourly ramping rates to model flood operations.

The FIS watershed is best suited for single flood event modeling under baseline conditions. Small changes in reservoir operations can lead to model instability unless care is taken to choose the appropriate simulation start and end dates. This is due in large part to the short simulation time step of 3 hours, which makes the simulation more sensitive to small changes, but also helps capture peak flows and reservoir elevations. For this reason, only the 1964 and 1996 high water events are modeled as part of this analysis.

The 1964 event was a basin wide rain on snow event occurring in mid-December.. The 1964 event was chosen as a case study because it is known to have impacted all sub basins with reservoirs with secondary flood pools and is well known to reservoir regulators.

The 1996 event was also a rain on snow event occurring in late January and early February. The 1996 event most heavily impacted the Santiam sub basin relative to other sub basins in the larger Willamette basin. The 1996 event was chosen as a case study because it occurred within recent memory, occurred under current levels of flood risk protection, and spanned the transition from winter flood operations to spring refill.

Evaluation of the impacts to flood risk management associated with targeting the top of the secondary flood pools at Cougar, Detroit, Green Peter, Lookout Point, Hills Creek, and Blue River reservoirs during the winter is carried out by comparing plots showing reservoir elevations and control point regulation flows from the no-action baseline simulation and the secondary flood pool alternative simulation. Willamette basin control point regulation flows are provided in Figure B-8-2.



Station ID	Station Name	Action Stage/(Bankfull)[1,3]	Flood Stage[2,3]	Major Flood Stage[2,3]
GOSO|	Coast Fork Willamette River near Goshen	11.7 ft (12,100 cfs)	13.0 ft (14,900 cfs)	18.0 ft (41,000 cfs)
JASO	Middle Fork Willamette at Jasper	9.4 ft (20,000 cfs)	10.0 ft (23,000 cfs)	15.0 ft (65,200 cfs)
EUGO	Willamette River at Eugene	20.2 ft (39,500 cfs)	23.0 ft (52,600 cfs)	29.0 ft (94,300 cfs)
VIDO[4]	McKenzie River near Vida	8.0 ft (22,200 cfs)	11.0 ft (35,000 cfs)	14.0 ft (49,500 cfs)
HARO[4]	Willamette River at Harrisburg	10.8 ft (39,700 cfs)	14.0 ft (66,500 cfs)	17.0 ft (100,700 cfs)
MNRO[4]	Long Tom River at Monroe	8.5 ft (5,660 cfs)	9.0 ft (6,780 cfs)	12.0 ft (16,000 cfs)
ALBO	Willamette River at Albany	21.6 ft (67,300 cfs)	25.0 ft (84,000 cfs)	32.0 ft (152,600 cfs)
WTLO	S. Santiam River at Waterloo	10.2 ft (19,000 cfs)	12.0 ft (25,700 cfs)	16.0 ft (42,700 cfs)
MEHO[4]	N. Santiam River at Mehama	8.9 ft (17,000 cfs)	11.0 ft (30,500 cfs)	13.5 ft (53,600 cfs)
JFFO	Santiam River at Jefferson	13.0 ft (43,000 cfs)	15.0 ft (55,900 cfs)	23.0 ft (213,000 cfs)
SLMO	Willamette River at Salem	21.2 ft (94,000 cfs)	28.0 ft (154,300 cfs)	32.0 ft (201,700 cfs)

[1] Action Stage [formerly "bankfull"] is set by the National Weather Service. It is defined as an established gage height at a given location along a river or stream, above which a rise in water surface will cause the river or stream to overflow the lowest natural stream bank somewhere in the corresponding reach. Refer to the new rating tables to determine flows since the ratings change on a regular basis, thus affecting flow.

[2] Flood Stage is set by the National Weather Service. It is defined as an established gage height for a given location above which a rise in water surface level begins to create a hazard to lives, property, or commerce. The issuance of flood advisories or warnings is linked to flood stage.

[3] Flows associated with Action Stage, Flood Stage, and Major Flood Stage may change as rating tables are updated.

[4] Action stage and regulation goal differ. VIDO regulation goal is 14,500 cfs. Harrisburg regulation goal is 52,000 cfs. Mehama regulation goal is 17,000 cfs. Maximum evacuation rate from Fern Ridge is 3,000 cfs.

Figure 8-2. Flood Regulation Goals at Willamette Projects

<u>Results and Discussion:</u>

The December 1964 flood in the Willamette basin is attributed to warm rain melting snow on frozen ground. Many of the WVP reservoirs were not operating at full flood storage potential when the flood occurred. Lookout Point is a notable exception, which filled to full pool in an effort to regulate downstream flows according to historic elevation and discharge records. In reservoir simulations, where all reservoirs are regulating in accordance with current operations, all reservoirs reach full pool in the no-action baseline simulation, spill to prevent overtopping, and release flows that exceed regulation stages downstream. Consequently, reservoirs in the alternative simulation storing water in the secondary flood pool reach full pool sooner and spill for a longer duration releasing an additional volume approximately equal to their secondary flood pools. Consequently, downstream flooding is increased.

All control points in the Willamette basin exceeded regulation stages in the baseline and all control points below reservoirs with secondary flood pools exceeded regulation stages by greater magnitudes or for longer durations as a result of alternative operations. Most notably, Harrisburg exceeded major flood stage for days in the alternative instead of hours in the baseline (figure 2), and flows at Waterloo exceeded major flood stage in the alternative while only exceeding flood stage in the baseline (figure 3). Peak flows at Salem were no higher in the alternative, but the duration of peak flows above major flood stage was increased by several days (figure 4). Plots comparing alternative operation and baseline reservoir elevations for all reservoirs with secondary flood pools and control point flows downstream of these reservoirs resulting from the 1964 high water event are provided in the appendices.

To provide additional context, the 1996 event was also modeled with alternative operations. The 1996 event was also a rain on snow event that impacted the Santiam basin more than any other sub basin in the larger Willamette basin. Green Peter very nearly reaches full pool in the baseline simulation. Model results suggest targeting the top of the secondary flood pool at Green Peter in 1996 would result in the reservoir reaching full resulting in releases raising flows at Waterloo to above flood stage and approaching major flood stage. Green Peter pool elevations during the 1996 event are shown in figure 5, and control point flows at Waterloo are shown in figure 6.

The probability a large event will be basin wide or impact a particular sub basin is beyond the scope of this study, which is intended only to use known large events in the period of record to demonstrate the flood risk implications of decreasing winter flood storage. These provide examples of flood inducing storms occurring in mid-winter (1964) and early refill season (1996) where increases in the magnitude and duration of flows above regulation stages are anticipated to occur as a result of targeting the secondary flood pool in the winter.

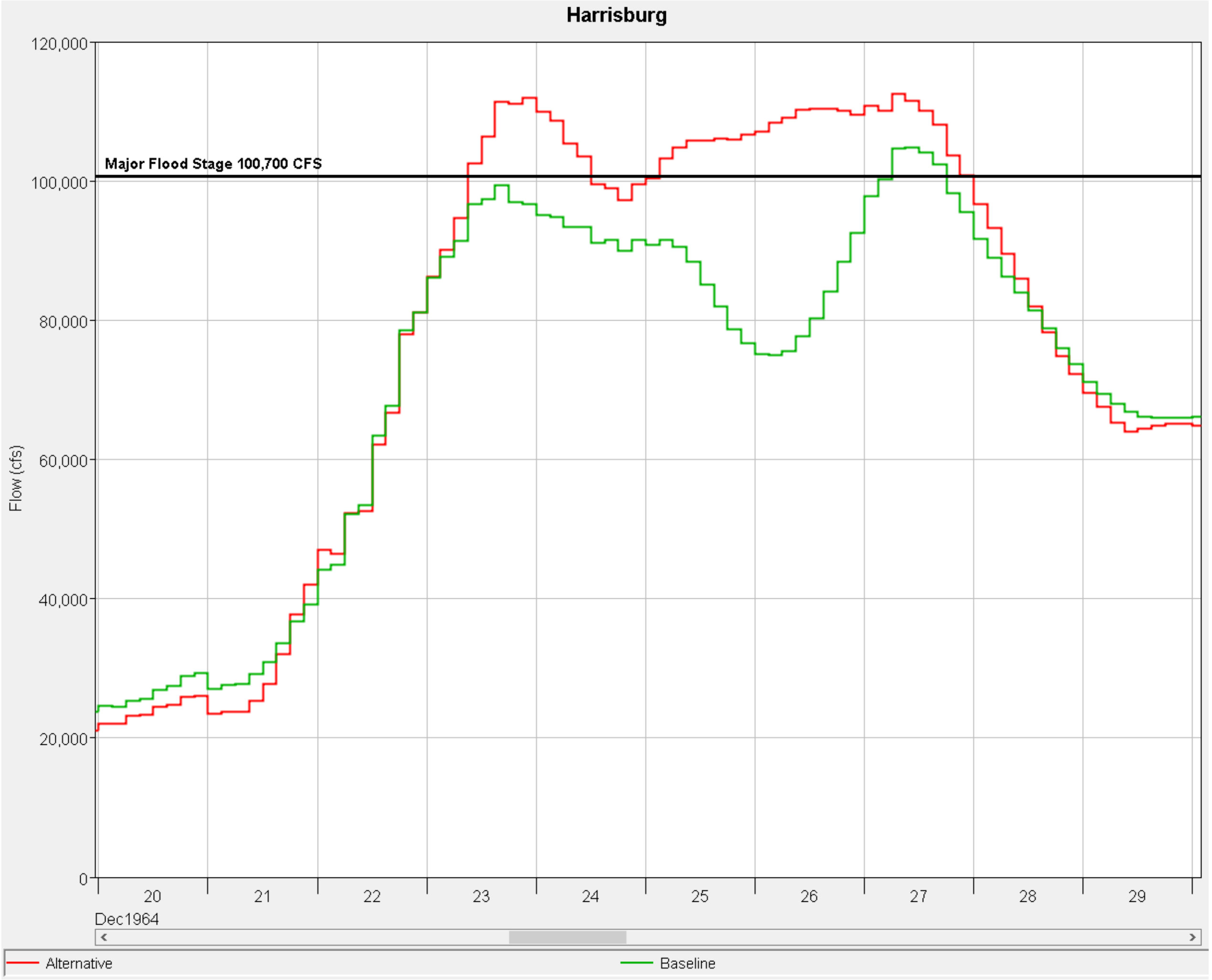


Figure 8-3. Willamette at Harrisburg, Dec 1964

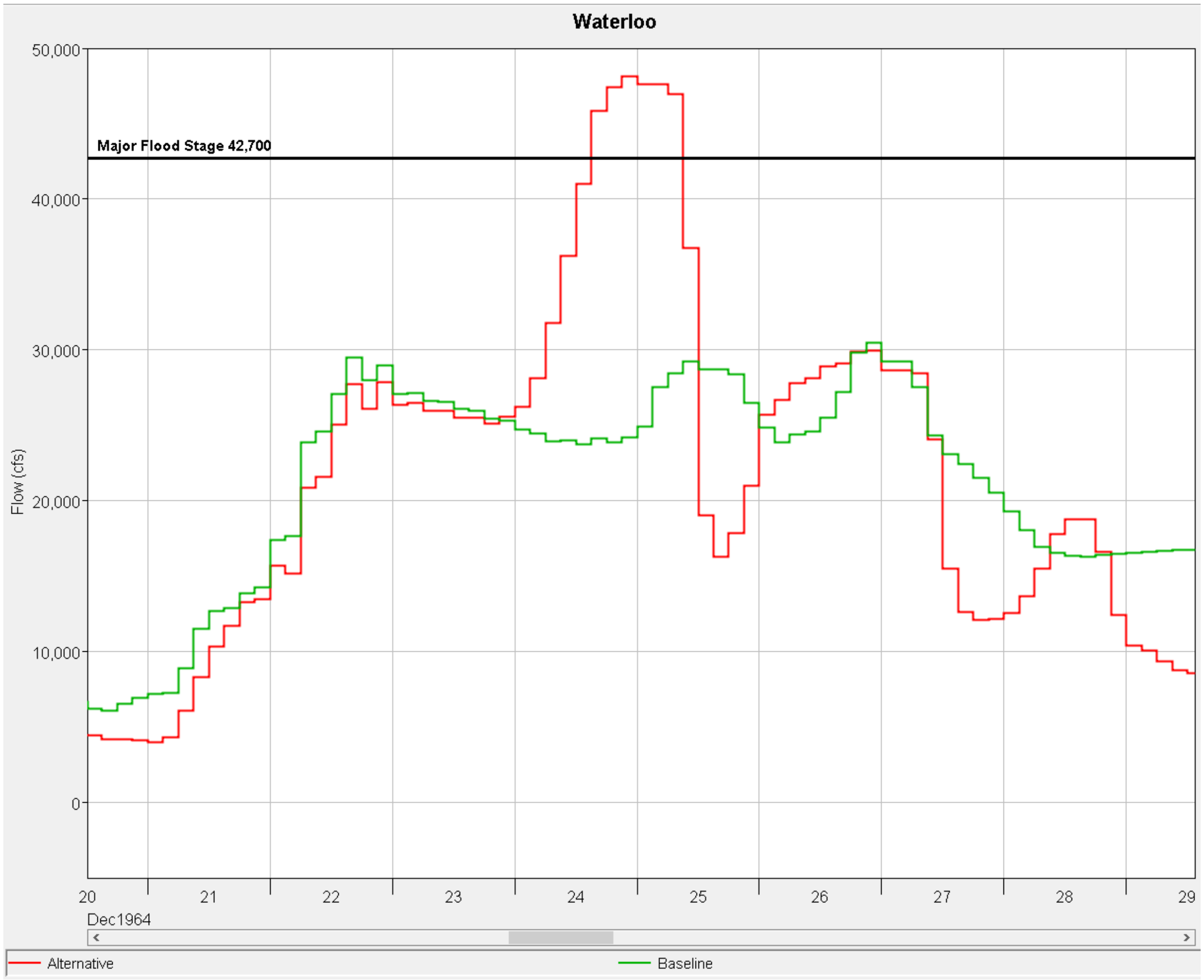


Figure 8-4. South Santiam at Waterloo Dec 1964

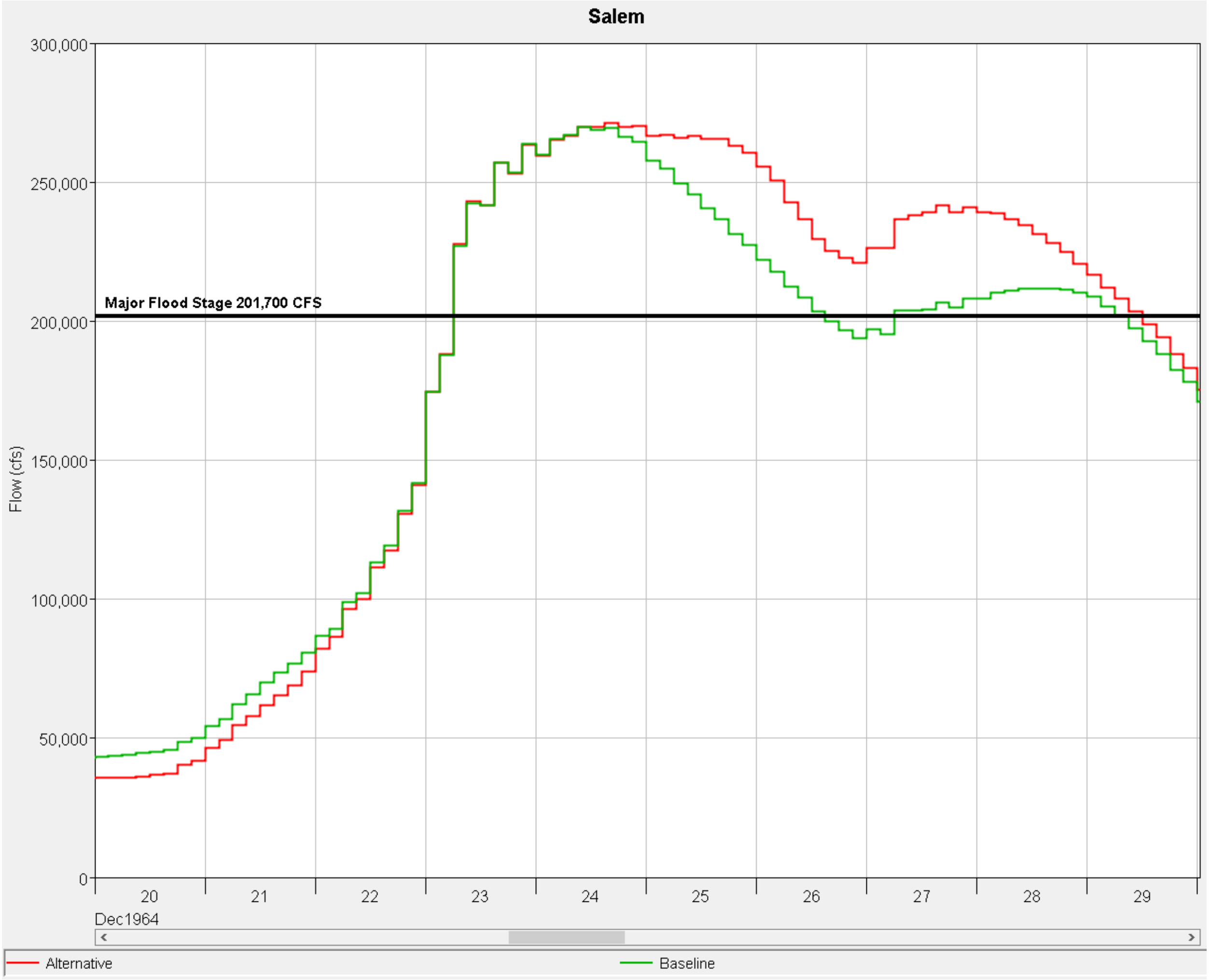


Figure 8-5. Willamette at Salem, Dec 1964

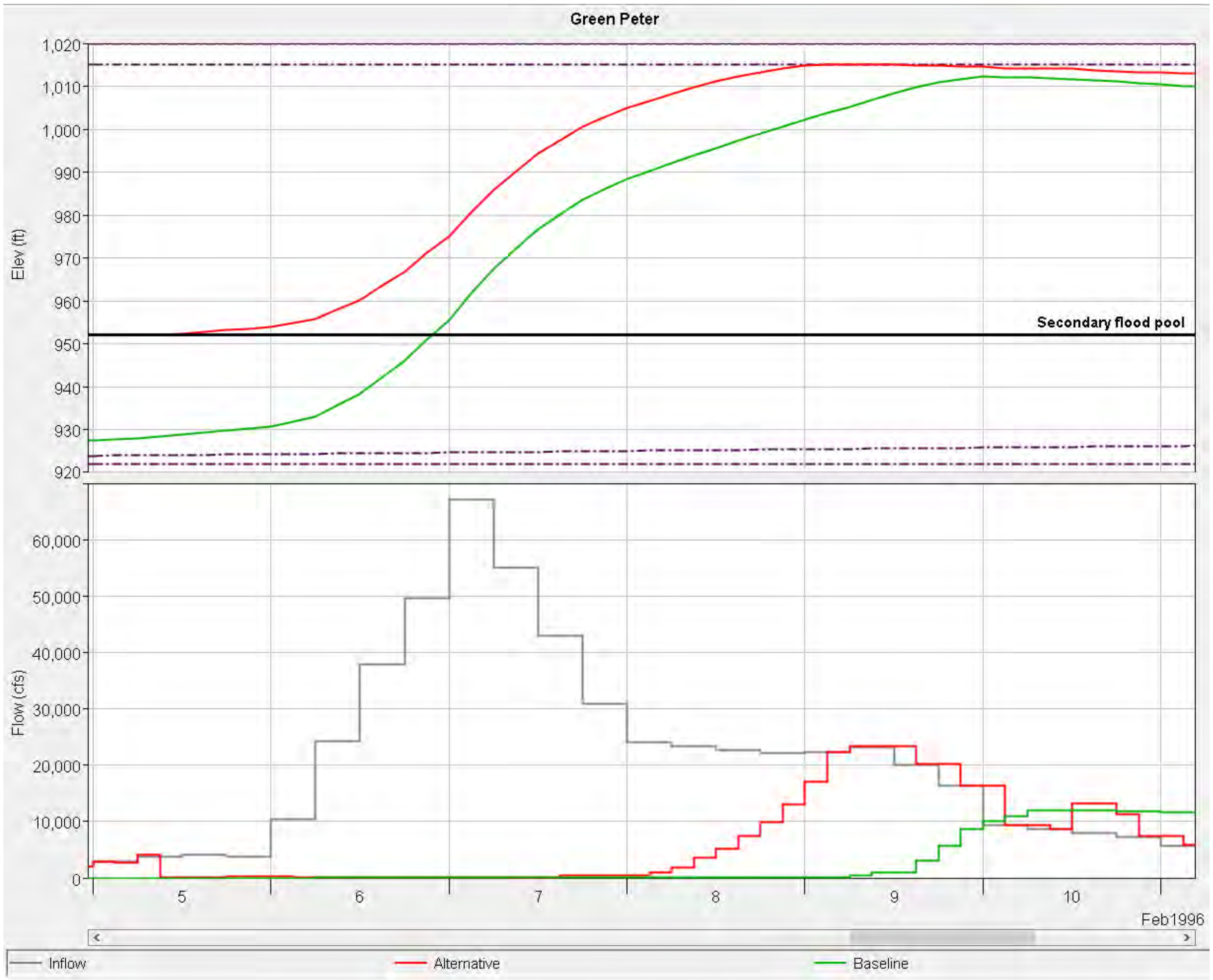


Figure 8-6. Green Peter Reservoir, Feb 1996

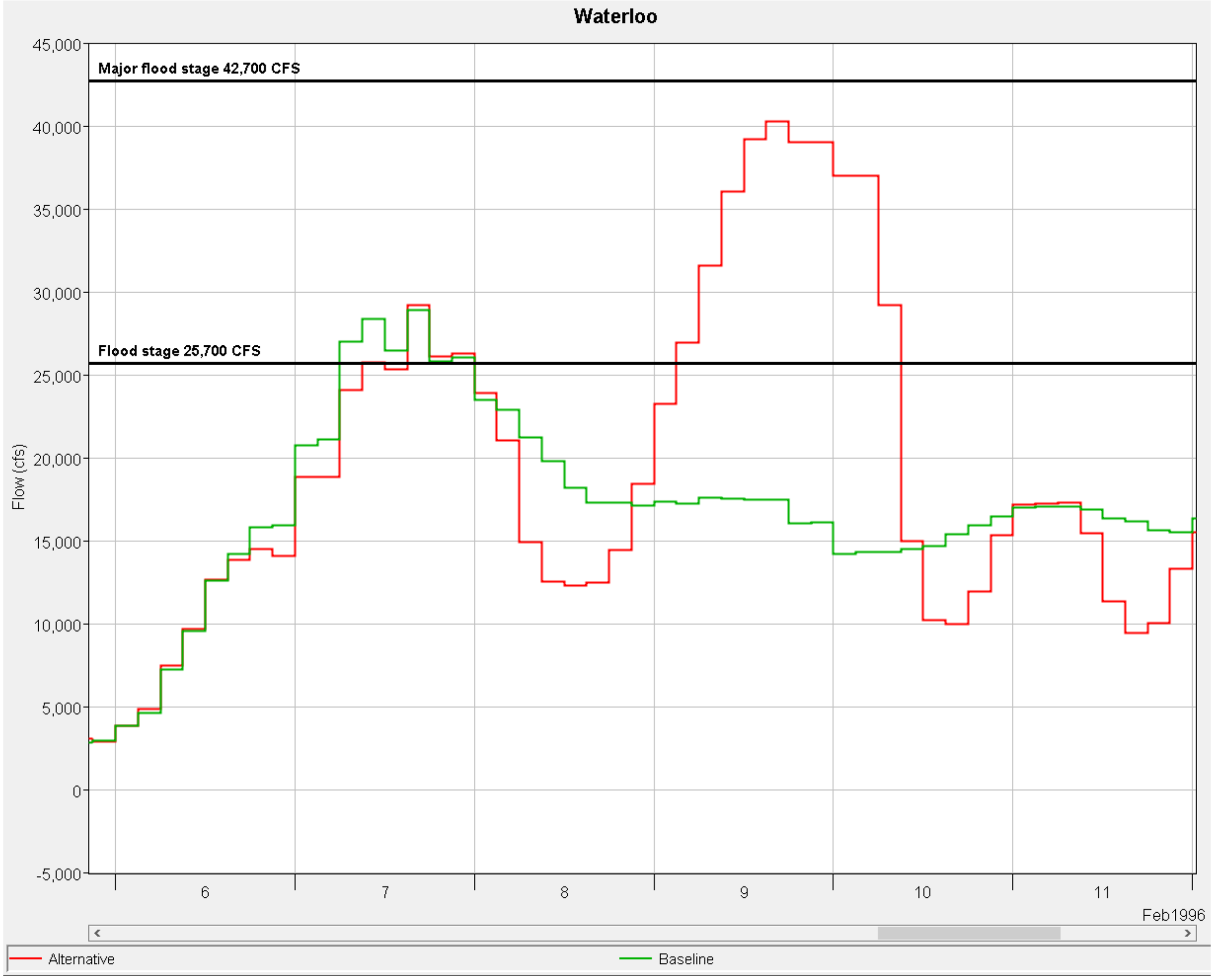


Figure 8-7. South Santiam at Waterloo, Feb 1996

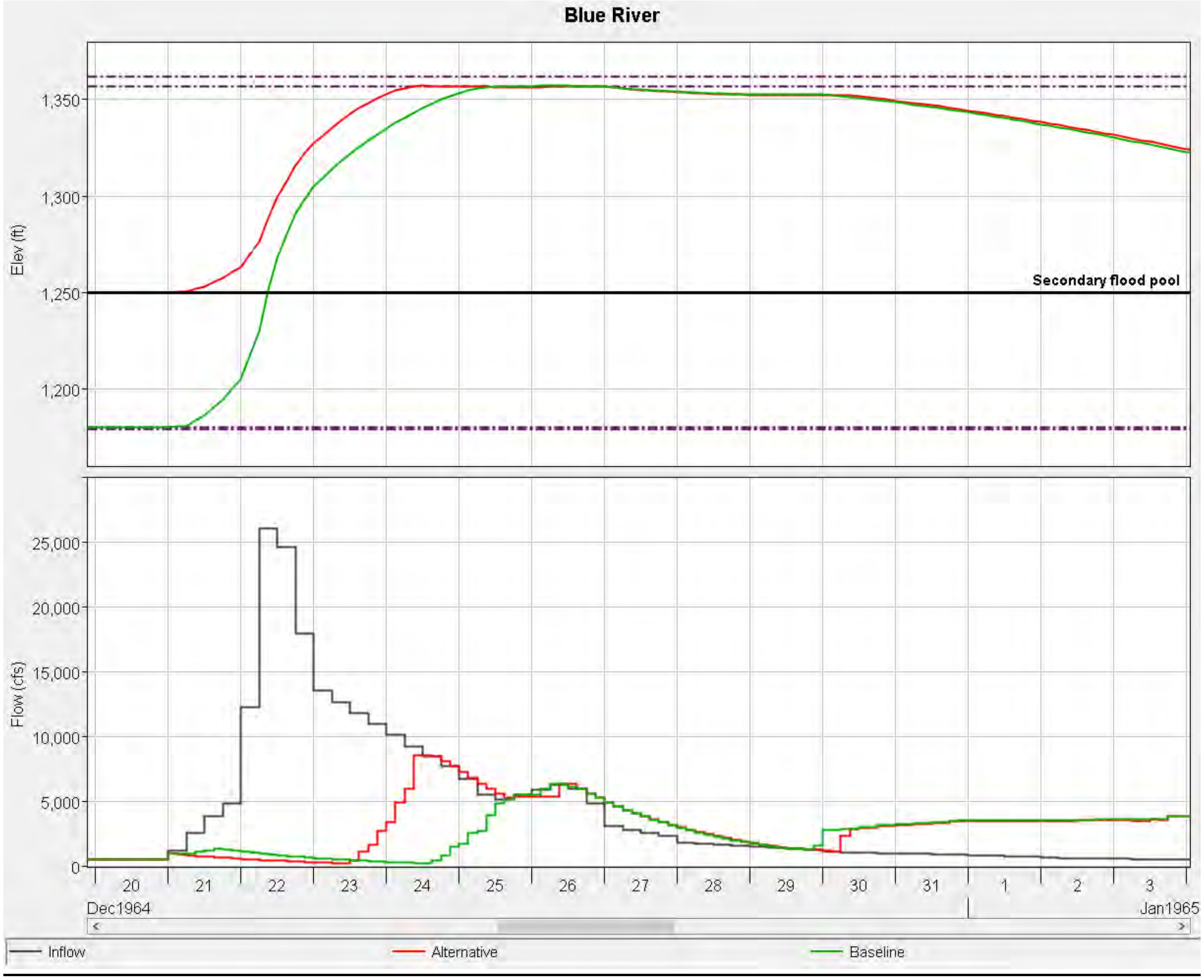


Figure 8-8. Blue River, Dec 1964

Figure 8-9. Cougar, Dec 1964

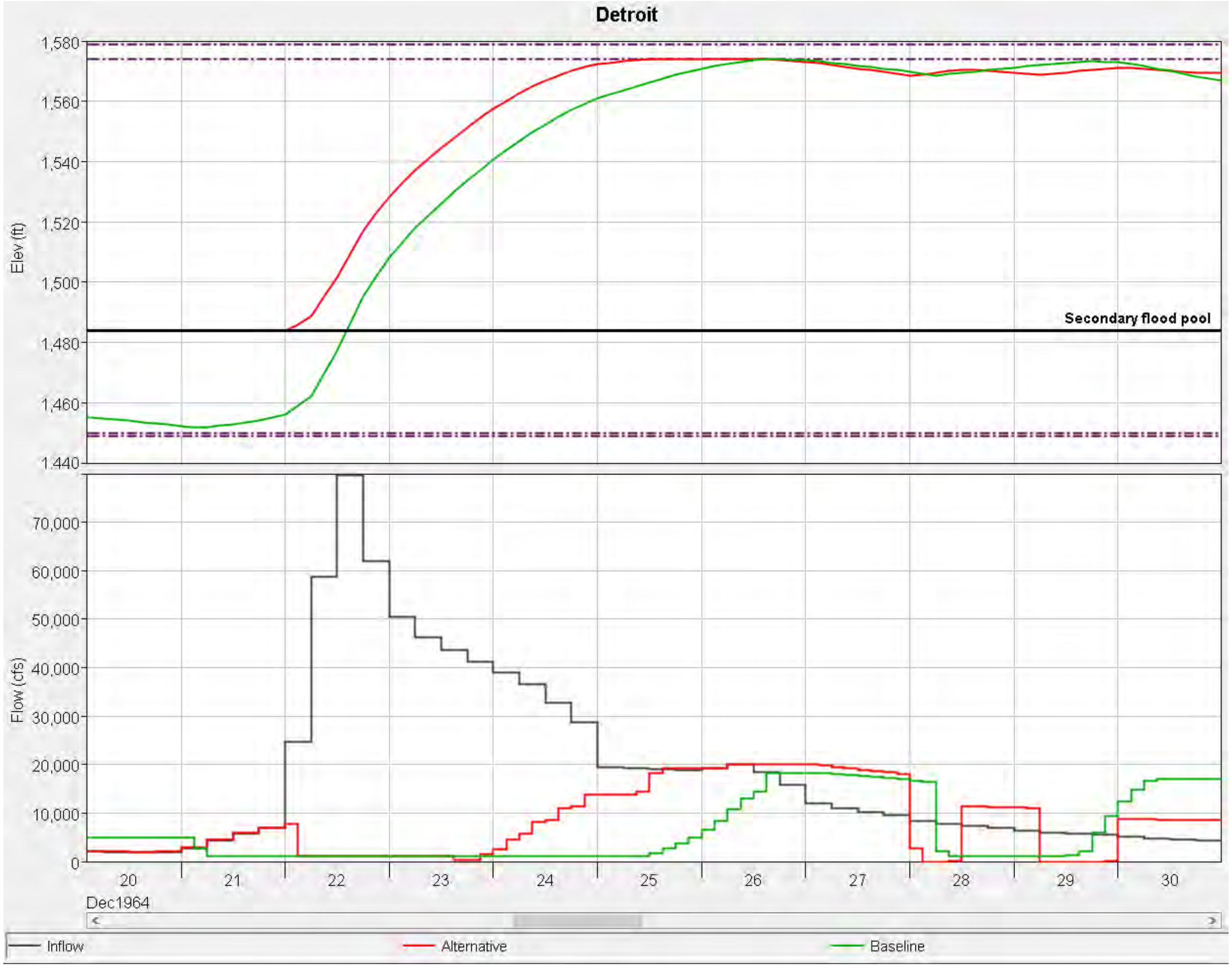


Figure 8-10. Detroit, Dec 1964

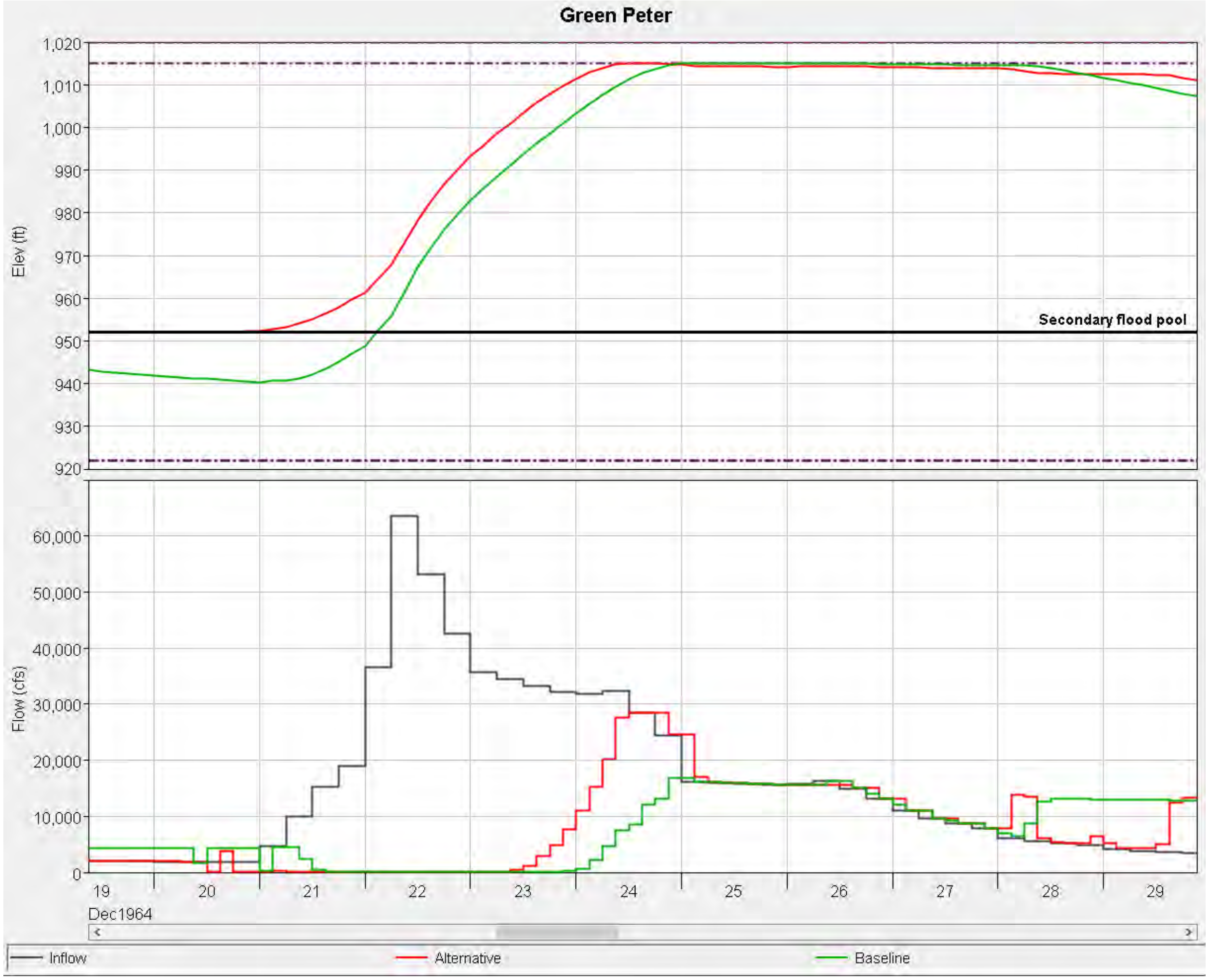


Figure 8-11. Green Peter, Dec 1964

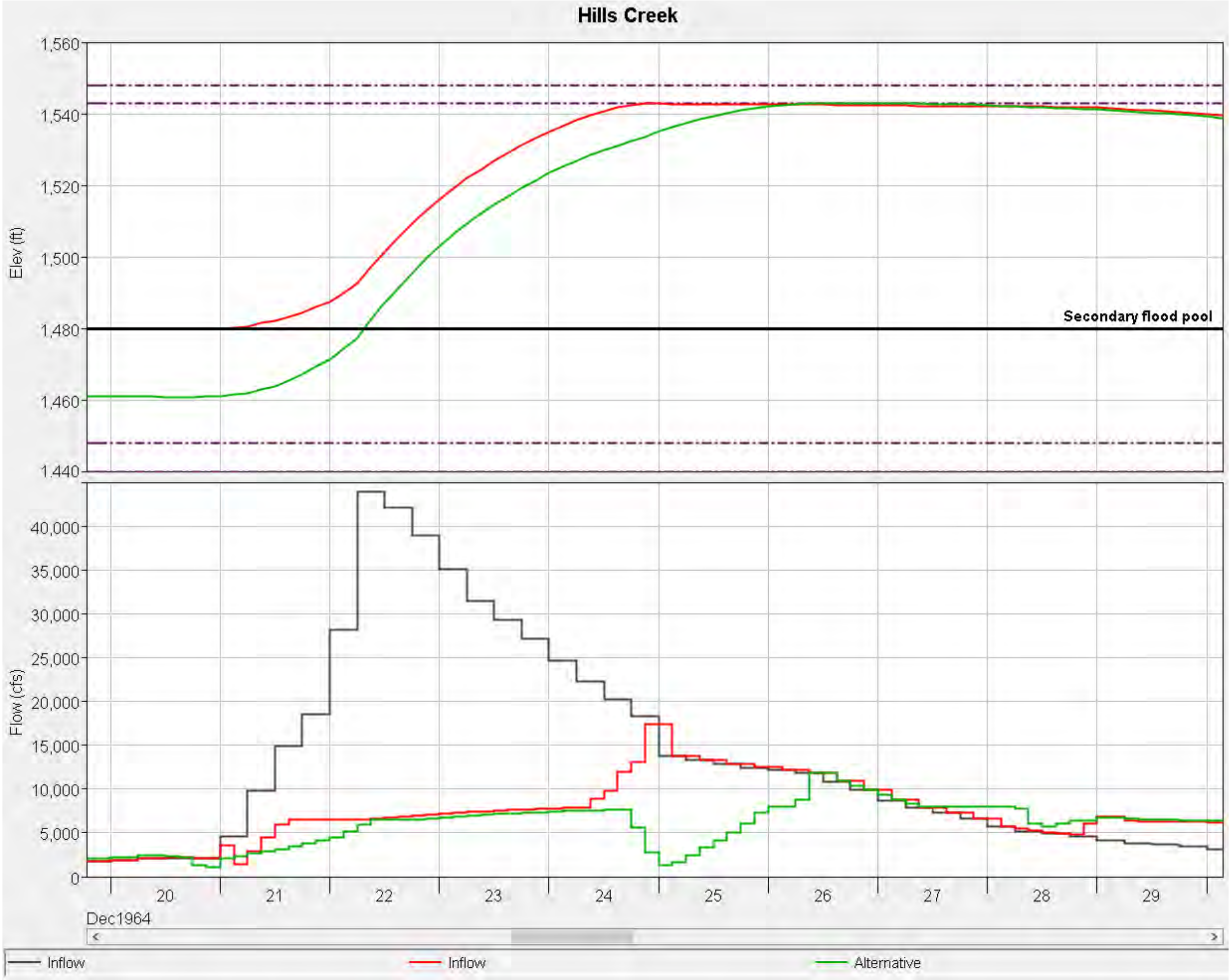


Figure 8-12. Hills Creek, Dec 1964

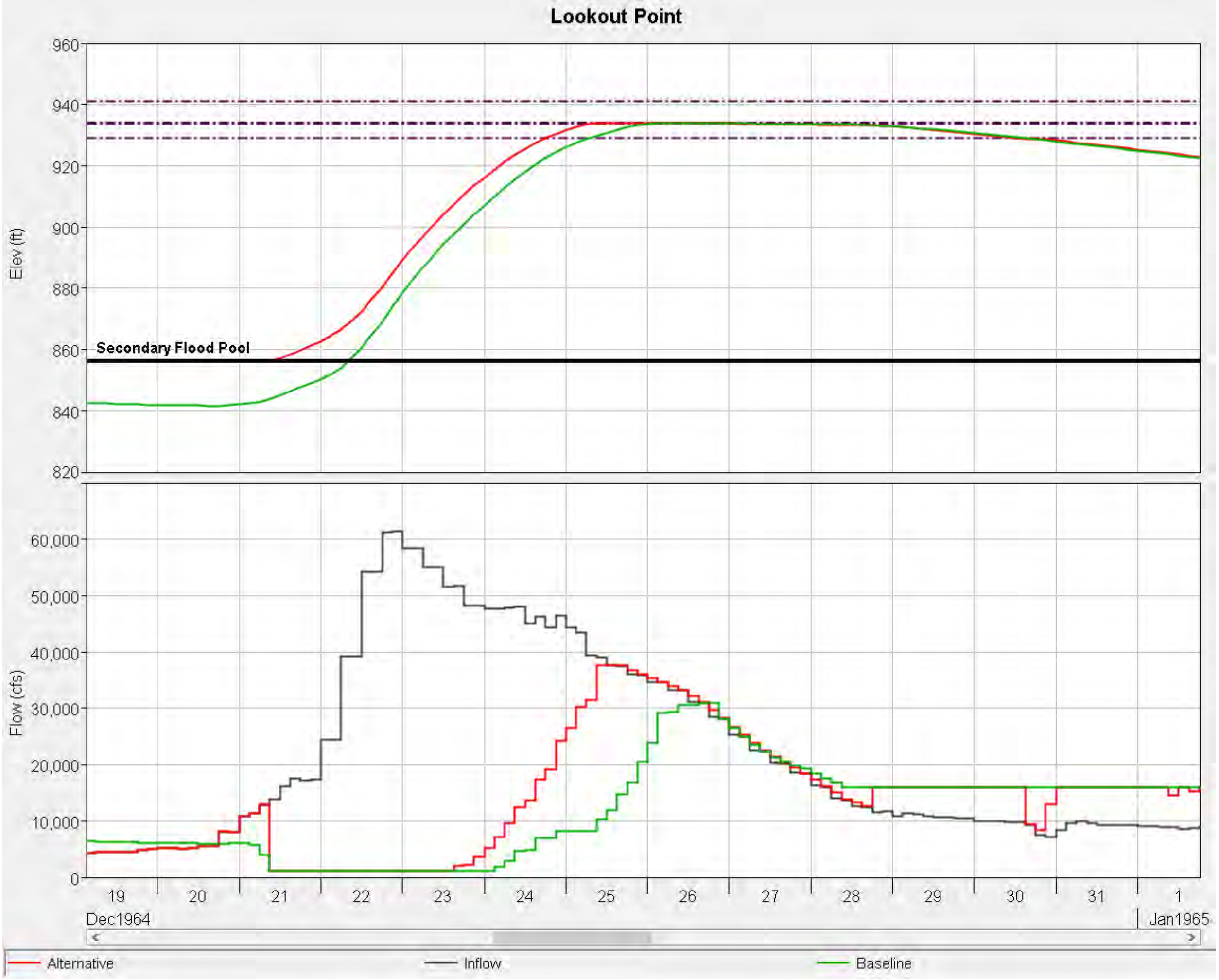


Figure 8-13. Lookout Point, Dec 1964

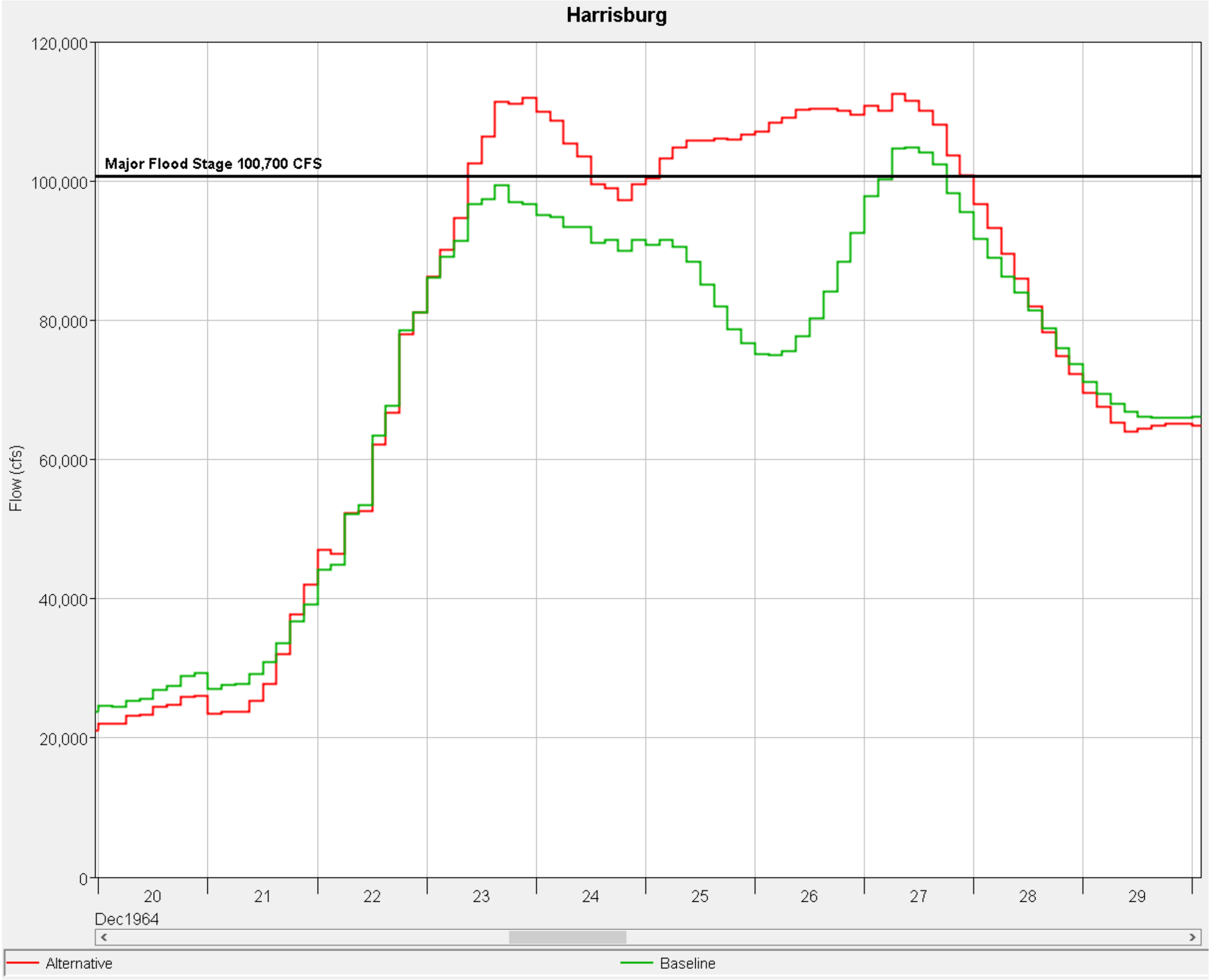


Figure 8-14. Harrisburg, Dec 1964

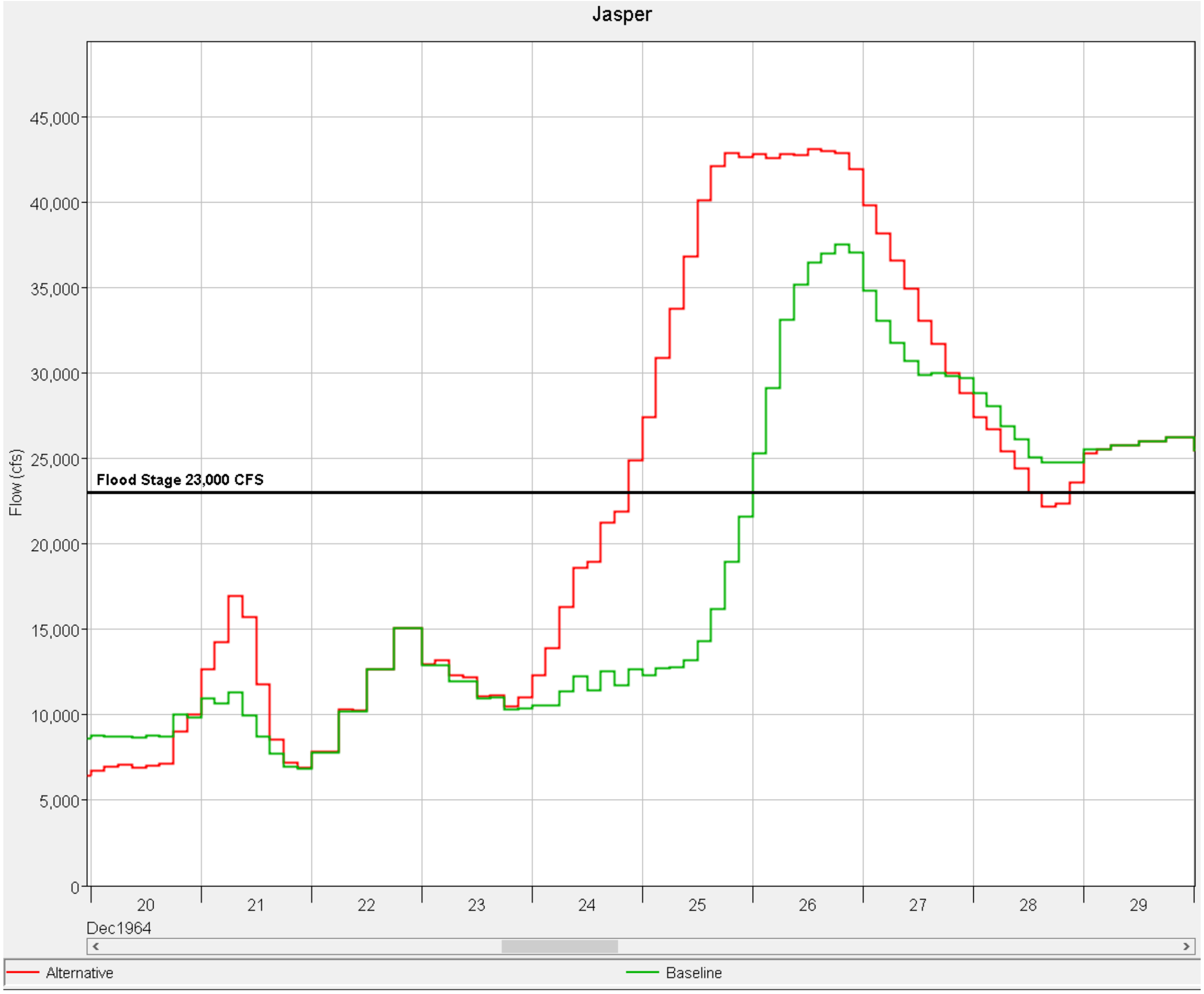


Figure 8-15. Jasper, Dec 1964

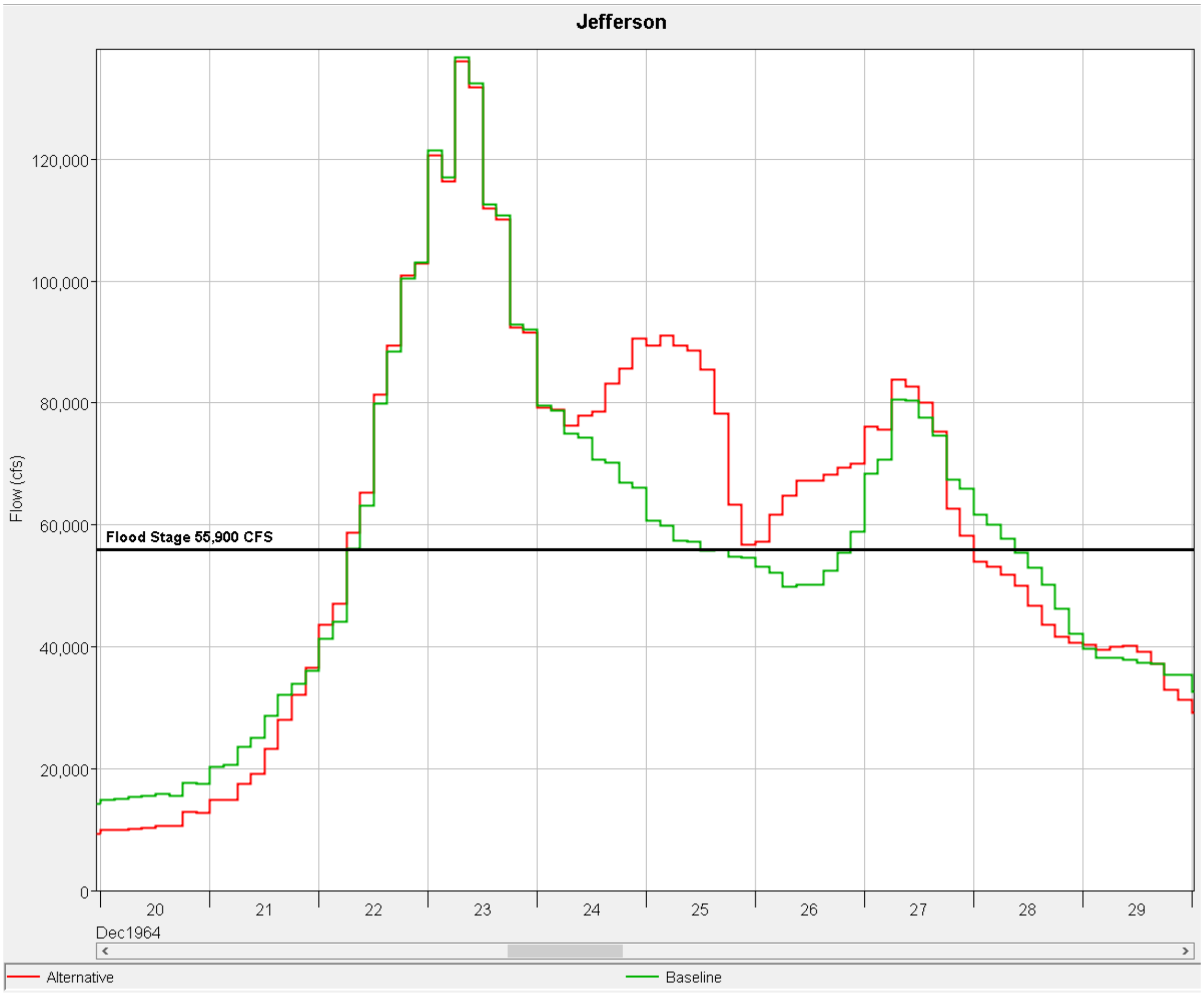


Figure 8-16. Jefferson, Dec 1964

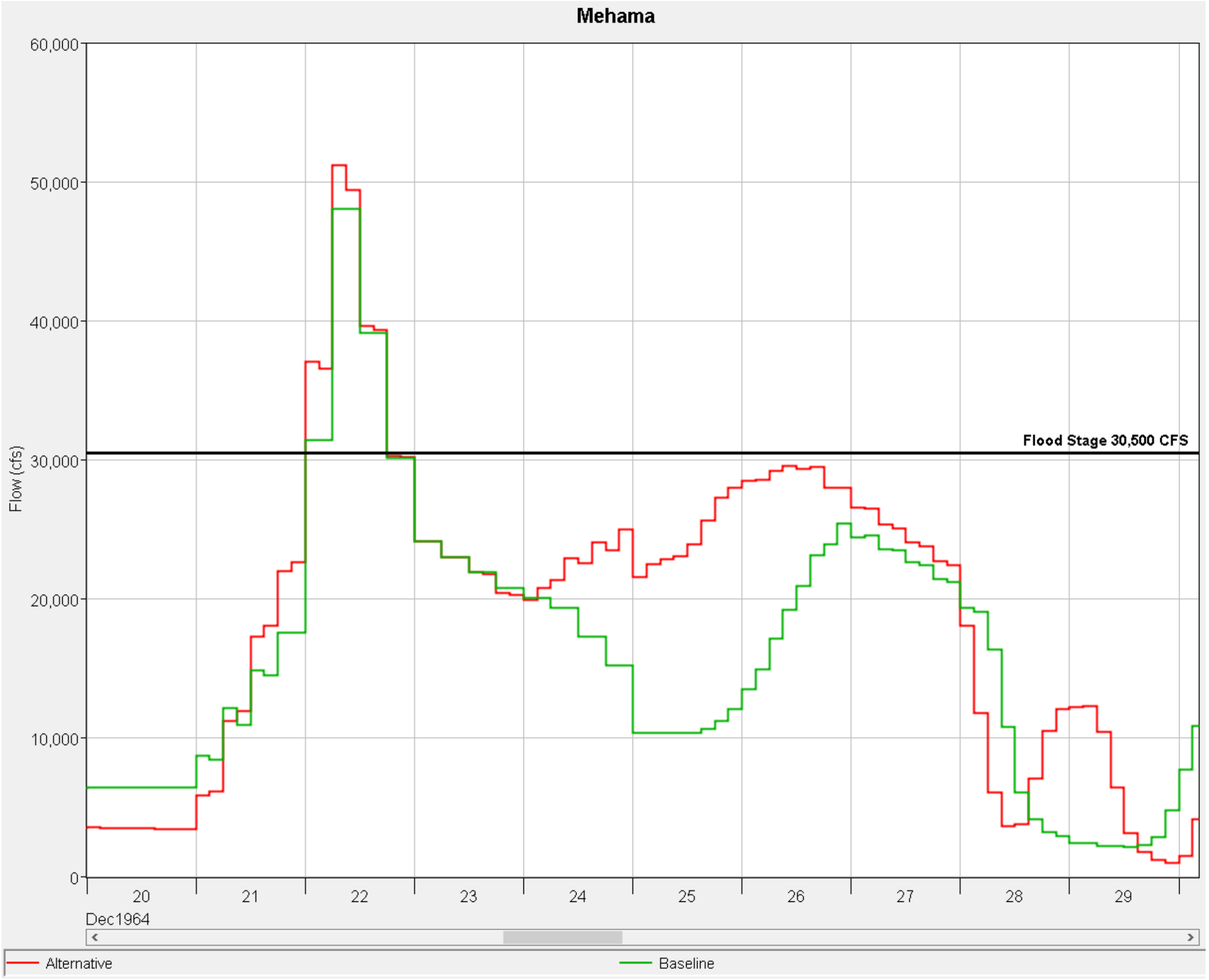


Figure 8-17. Mehama, Dec 1964

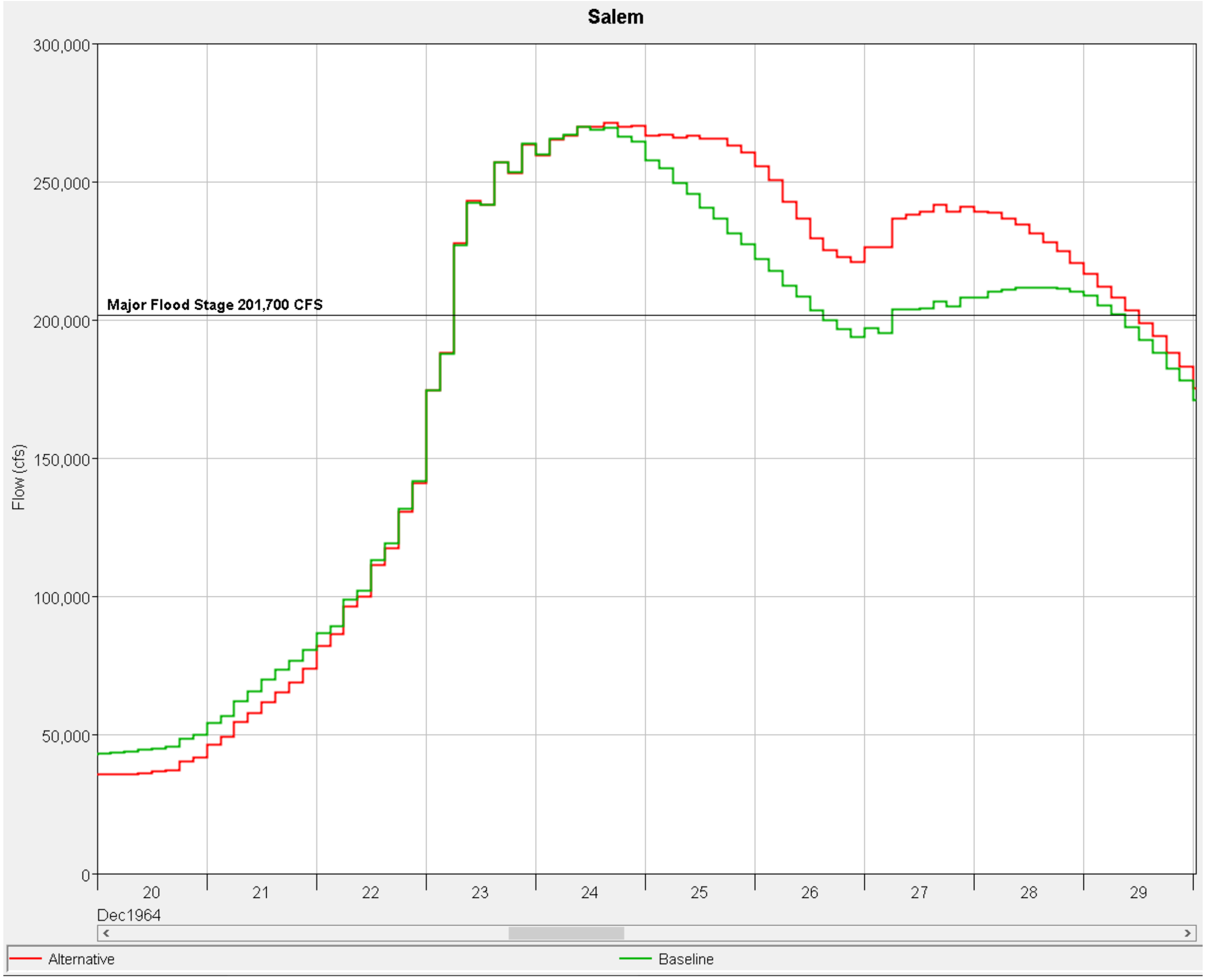


Figure 8-18. Salem, Dec 1964

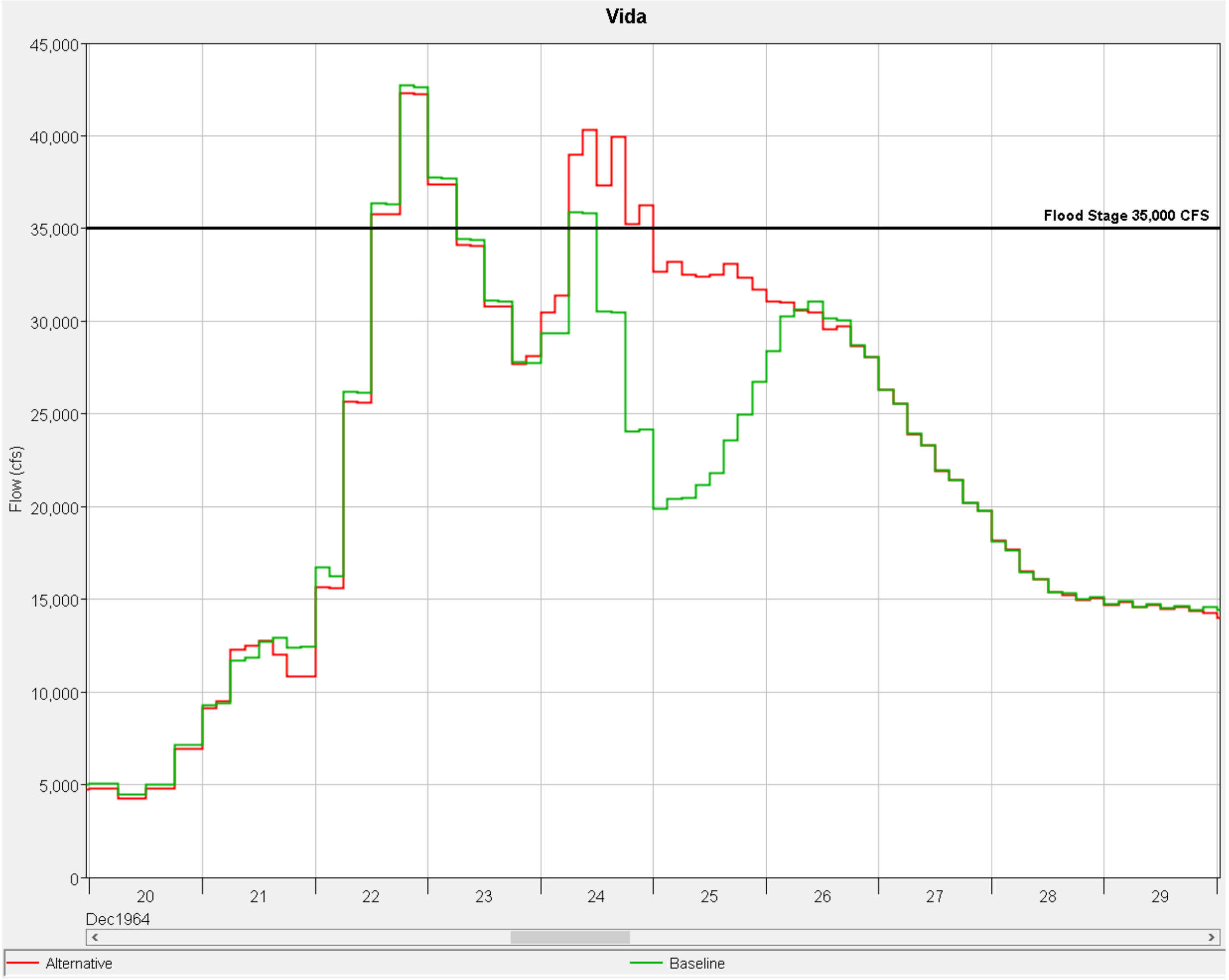


Figure 8-19. Vida, Dec 1964

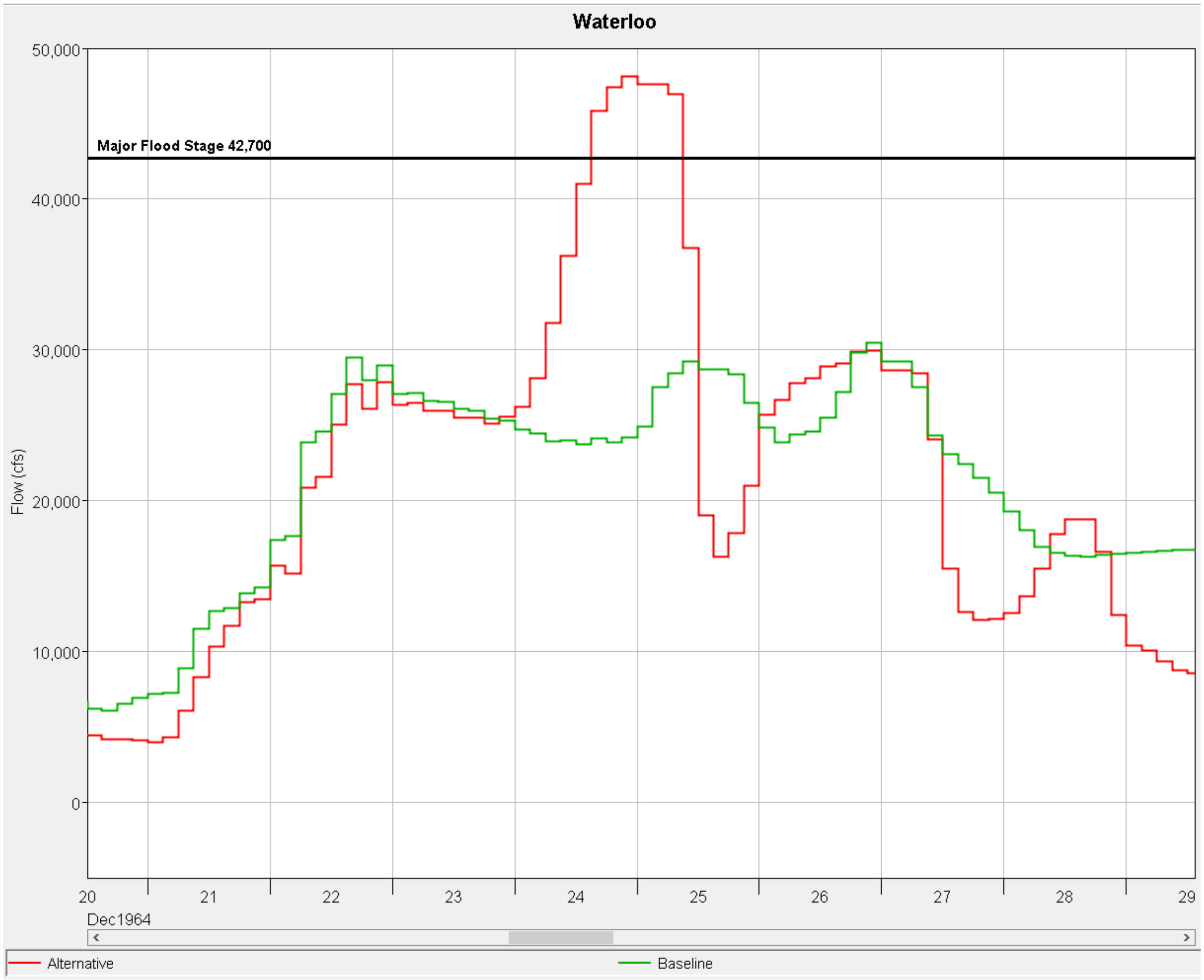


Figure 8-20. Waterloo, Dec 1964

9 INCREASES IN CONSERVATION STORAGE ASSOCIATED WITH TARGETING THE TOP OF THE SECONDARY FLOOD POOL DURING THE WINTER AT WVP RESERVOIRS

Targeting the top of the secondary flood pool at Willamette Valley Project (WVP) reservoirs in the winter instead of the minimum conservation elevation, with the goal of increasing the magnitude of spring refill, has been proposed as an measure for evaluation. This analysis identify potential increases in conservation storage associated with the proposed alternative operation.

Six WVP reservoirs have secondary flood pools. Figure 1 identifies the secondary flood storage and total maximum conservation storage at each reservoir. The proposed alternative will likely guarantee spring refill to the top of the secondary flood pool by the date indicated in Figure B-9-1. This will result in higher maximum conservation season storage in years when reservoirs do not fill to the guide curve after the dates indicated in Figure B-9-1 under current operations.

A reduction in winter flood storage is associated with an increase in flood risk. Reservoirs store water during high precipitation events to reduce flows downstream, resulting in higher pool elevations. The higher the pool elevation, the smaller rain event required to raise the pool to elevations where uncontrolled releases are required. An analysis of impacts to flood risk management (FRM) will be required if benefits to conservation storage encourage further consideration of this measure.

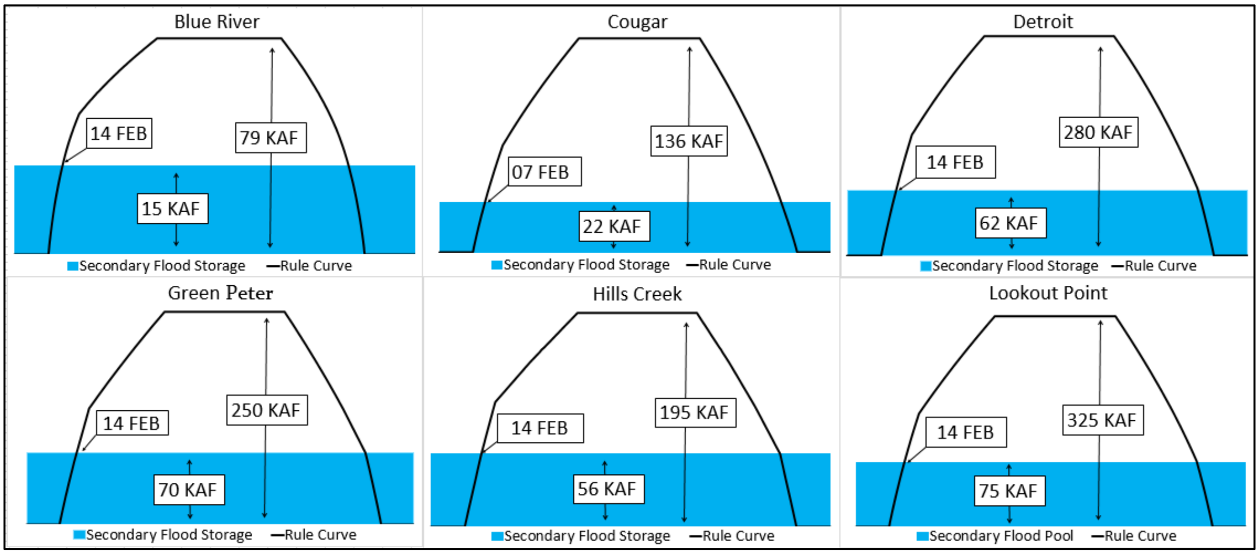


Figure 9-1. Secondary flood storage at Willamette Valley reservoirs

Methods:

Increases on conservation storage associated with targeting the top of the secondary flood pool at Cougar, Detroit, Green Peter, Lookout Point, Hills Creek, and Blue River reservoirs during the winter are investigated using the HEC-ResSim model. The model applies reservoir operational rules under various hydrologic conditions to simulate regulated in stream flow and reservoir elevations throughout the basin. The Willamette basin HEC-ResSim model includes all thirteen WVP reservoirs along with the operational rules and constraints at each location, which are designed to achieve both project-specific and system-wide objectives as specified in the project and system Water Control Manuals.

Operational conditions and requirements are simulated using historical hydrology over a period of 84 years (1935-2019) on a daily time step. Increases in conservation storage associated with alternative operations will be evaluated by comparing the storage volume observed on 01 April resulting from the alternative simulation compared to the no-action-alternative (NAA) simulation in years when the reservoir does not reach the rule curve above the secondary flood pool in the NAA.

WVS EIS target minimum flows below WVP reservoirs in the baseline NAA are defined to meet 2008 NMFS BiOp flow targets and forecasted 2050 withdrawals previously defined by the Willamette Basin Review (USACE, 2019). Alternate minimum flow regimes may be considered in

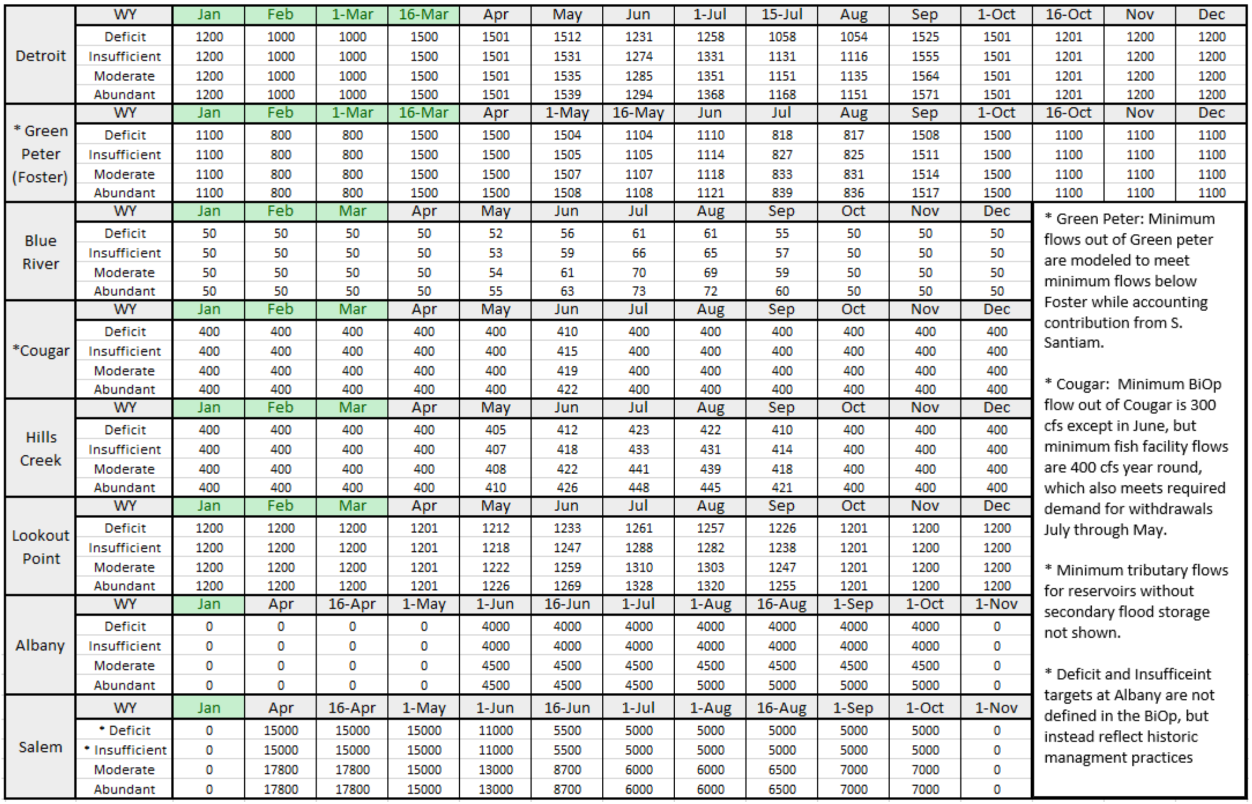
WVS EIS alternatives. Early conservation season storage assessed on 01 April provides a meaningful snapshot of storage available to supplement conservation season minimum flows while not being impacted by future minimum flow requirements that may change in WVS EIS alternatives and specifically measures impacts to system storage before minimum flow requirements at Salem come into effect. Prioritization of the quantity of water drafted from individual reservoirs to supplement flows at Salem and Albany are determined by logic attempting to maintain distributed system storage in ResSim and will not be consistent between the baseline and alternative simulations.

If elevations reach the rule curve after exceeding the secondary flood pool elevation in the NAA then no benefit from the alternative operation is anticipated. Therefore, differences in reservoir storage between the NAA and alternative on 01 April were assigned a value of zero if the NAA reaches the rule curve after having exceeded the secondary flood pool elevation. The maximum increase in storage that can be attributed to the alternative operation is the storage capacity of the secondary flood pool. If model results show larger increases due to unforeseen discrepancies between the two model runs, those values were edited to indicate a storage increase equal to the storage capacity of the secondary flood pool.

In some years storage increases in the alternative may be limited by the rule curve but not in the NAA. If this occurs after 01 April then 01 April storage differences may overestimate the benefit of the alternative operation. However, a different flow regime in a future WVS EIS alternative may prevent this from occurring and so values will not be edited when this occurs. When this scenario is identified its occurrence will be indicated in the results.

WVS EIS baseline Minimum flows by water year type are presented in Table B-9-1. Minimum flows shown are a composite of 2008 NMFS BiOp flow targets and releases required to meet forecasted 2070 Willamette Basin Review withdrawals. Minimum flows after 01 January affecting 01 April storage are highlighted in green. Table B-9-2 indicates the flow in cubic feet per second (cfs) that can be sustained over 30 days by releasing stored volume in increments of kilo acre-feet (kaf) to help make the connection between stored water and potential releases.

Table 9-1. Minimum flows required to meet BiOp and projected 2070 withdrawals



Detroit	WY	Jan	Feb	1-Mar	16-Mar	Apr	May	Jun	1-Jul	15-Jul	Aug	Sep	1-Oct	16-Oct	Nov	Dec
	Deficit	1200	1000	1000	1500	1501	1512	1231	1258	1058	1054	1525	1501	1201	1200	1200
	Insufficient	1200	1000	1000	1500	1501	1531	1274	1331	1131	1116	1555	1501	1201	1200	1200
	Moderate	1200	1000	1000	1500	1501	1535	1285	1351	1151	1135	1564	1501	1201	1200	1200
	Abundant	1200	1000	1000	1500	1501	1539	1294	1368	1168	1151	1571	1501	1201	1200	1200
* Green Peter (Foster)	WY	Jan	Feb	1-Mar	16-Mar	Apr	1-May	16-May	Jun	Jul	Aug	Sep	1-Oct	16-Oct	Nov	Dec
	Deficit	1100	800	800	1500	1500	1504	1104	1110	818	817	1508	1500	1100	1100	1100
	Insufficient	1100	800	800	1500	1500	1505	1105	1114	827	825	1511	1500	1100	1100	1100
	Moderate	1100	800	800	1500	1500	1507	1107	1118	833	831	1514	1500	1100	1100	1100
	Abundant	1100	800	800	1500	1500	1508	1108	1121	839	836	1517	1500	1100	1100	1100
Blue River	WY	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec			
	Deficit	50	50	50	50	52	56	61	61	55	50	50	50			
	Insufficient	50	50	50	50	53	59	66	65	57	50	50	50			
	Moderate	50	50	50	50	54	61	70	69	59	50	50	50			
	Abundant	50	50	50	50	55	63	73	72	60	50	50	50			
*Cougar	WY	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec			
	Deficit	400	400	400	400	400	410	400	400	400	400	400	400			
	Insufficient	400	400	400	400	400	415	400	400	400	400	400	400			
	Moderate	400	400	400	400	400	419	400	400	400	400	400	400			
	Abundant	400	400	400	400	400	422	400	400	400	400	400	400			
Hills Creek	WY	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec			
	Deficit	400	400	400	400	405	412	423	422	410	400	400	400			
	Insufficient	400	400	400	400	407	418	433	431	414	400	400	400			
	Moderate	400	400	400	400	408	422	441	439	418	400	400	400			
	Abundant	400	400	400	400	410	426	448	445	421	400	400	400			
Lookout Point	WY	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec			
	Deficit	1200	1200	1200	1201	1212	1233	1261	1257	1226	1201	1200	1200			
	Insufficient	1200	1200	1200	1201	1218	1247	1288	1282	1238	1201	1200	1200			
	Moderate	1200	1200	1200	1201	1222	1259	1310	1303	1247	1201	1200	1200			
	Abundant	1200	1200	1200	1201	1226	1269	1328	1320	1255	1201	1200	1200			
Albany	WY	Jan	Apr	16-Apr	1-May	1-Jun	16-Jun	1-Jul	1-Aug	16-Aug	1-Sep	1-Oct	1-Nov			
	Deficit	0	0	0	0	4000	4000	4000	4000	4000	4000	4000	0			
	Insufficient	0	0	0	0	4000	4000	4000	4000	4000	4000	4000	0			
	Moderate	0	0	0	0	4500	4500	4500	4500	4500	4500	4500	0			
	Abundant	0	0	0	0	4500	4500	4500	5000	5000	5000	5000	0			
Salem	WY	Jan	Apr	16-Apr	1-May	1-Jun	16-Jun	1-Jul	1-Aug	16-Aug	1-Sep	1-Oct	1-Nov			
	* Deficit	0	15000	15000	15000	11000	5500	5000	5000	5000	5000	5000	0			
	* Insufficient	0	15000	15000	15000	11000	5500	5000	5000	5000	5000	5000	0			
	Moderate	0	17800	17800	15000	13000	8700	6000	6000	6500	7000	7000	0			
	Abundant	0	17800	17800	15000	13000	8700	6000	6000	6500	7000	7000	0			

* Green Peter: Minimum flows out of Green peter are modeled to meet minimum flows below Foster while accounting contribution from S. Santiam.

* Cougar: Minimum BiOp flow out of Cougar is 300 cfs except in June, but minimum fish facility flows are 400 cfs year round, which also meets required demand for withdrawals July through May.

* Minimum tributary flows for reservoirs without secondary flood storage not shown.

* Deficit and Insufficeint targets at Albany are not defined in the BiOp, but instead reflect historic managment practices

Table 9-2. kaf converted to cfs sustainable over 30 days

KAF	CFS Sustained for 30 Days	KAF	CFS Sustained for 30 Days	KAF	CFS Sustained for 30 Days	KAF	CFS Sustained for 30 Days	KAF	CFS Sustained for 30 Days
1	17	16	268	31	520	46	782	61	1,023
2	34	17	285	32	537	47	799	62	1,040
3	50	18	302	33	553	48	816	63	1,057
4	67	19	319	34	570	49	833	64	1,073
5	84	20	335	35	587	50	850	65	1,090
6	101	21	352	36	604	51	867	66	1,107
7	117	22	369	37	620	52	884	67	1,124
8	134	23	386	38	637	53	901	68	1,140
9	151	24	402	39	654	54	918	69	1,157
10	168	25	419	40	671	55	935	70	1,174
11	184	26	436	41	688	56	952	71	1,191
12	201	27	453	42	704	57	969	72	1,207
13	218	28	470	43	721	58	986	73	1,224
14	235	29	486	44	738	59	1,003	74	1,241
15	252	30	503	45	755	60	1,020	75	1,258

<u>Results:</u>

Blue River:

Table B-9-3 indicates the estimated increase in maximum conservation storage resulting from guaranteeing refill to the top of the secondary flood pool during spring refill at Blue River. The secondary flood pool volume at Blue River is 15 kaf, which is approximately 20% of the total 75 kaf of conservation storage capacity.

Blue River reservoir fills nearly all Abundant water years in the baseline and therefore cannot realize a benefit from the alternative operations. Blue River rarely fills in adequate water years, but the reservoir does fills to the rule curve after exceeding the secondary flood pool elevation in the baseline, and so no benefit from the alternative operation is realized. Increases in storage are observed in 38% (3 of 8) Insufficient water years with an average increase of 1.1 kaf, which is equivalent to 18 cfs released over 30 days. Increases are realized in 67% (4 of 6) deficit water years with a median increase of 6.4 kaf, which is equivalent to 107 cfs released over 30 days.

Benefits in 2005 decrease significantly later in the season as a result of Blue River drafting to stay below the rule curve in the alternative while pool elevations rise in the baseline.

Table 9-3. April Increase in conservation storage associated with alternative operations at Blue River

Year	1936	1937	1938	1943	1945	1948	1949	1950	1951	1952
KAF	Fill	Fill	Fill	Fill	Fill	Fill	Fill	Fill	Fill	Fill
Year	1953	1955	1956	1957	1958	1960	1961	1962	1963	1969
KAF	Fill	Fill	Fill	0	0	Fill	Fill	Fill	Fill	Fill
Year	1971	1972	1974	1975	1976	1979	1982	1983	1984	1988
KAF	Fill	Fill	Fill	Fill	Fill	Fill	Fill	0	Fill	Fill
Year	1989	1991	1993	1995	1996	1997	1999	2000	2003	2008
KAF	0	Fill	Fill	Fill	Fill	Fill	Fill	0	Fill	Fill
Year	2009	2011	2012	2014	2017					
KAF	Fill	Fill	Fill	Fill	Fill					
Year	1939	1940	1946	1947	1954	1959	1964	1966	1970	1980
KAF	0	0	0	0	0	0	Fill	0	0	0
Year	1981	1985	1986	1990	1998	2002	2004	2005	2006	2007
KAF	0	0	0	0	0	0	0	12	0	0
Year	2010	2013	2016	2018	2019					
KAF	Fill	0	0	0	0					
Year	1944	1965	1967	1968	1978	1987	1992	1994		
KAF	3	0	2	0	3	0	0	0		
Year	1941	1942	1973	1977	2001	2015				
KAF	7	0	7	15	9	0				
					Legend					
BLU	Fill = Fills under baseline			Abundant	Adequate	Insufficient	Deficit			

* Increase of 0 reported if the baseline reaches the rule curve after exceeding the secondary flood pool

Cougar:

Table B-9-4 indicates the estimated increase in maximum conservation storage resulting from guaranteeing refill to the top of the secondary flood pool during spring refill at Cougar. Secondary flood pool volume at Cougar is 22 kaf, which is approximately 16% of the total 136 kaf of conservation storage capacity.

Cougar reservoir fills in 89% (40 of 45) of Abundant water years in the baseline and therefore cannot realize a benefit from the alternative operations. In the remaining 11% (5 of 45) of the abundant water years, there is no increase in storage resulting from the alternative operation. The alternative operation results in higher reservoir storage in 52% (13 of 25) adequate water years, with an average increase of 6.4 kaf which is equivalent to 107 cfs released over 30 days. The alternative operation results in higher reservoir storage in 75% (6 of 8) of Insufficient water years with an average increase of 10.2 kaf which is equivalent to 172 cfs released over 30 days. The alternative operation results in higher reservoir storage in 83% (5 of 6) of Deficit water years with an average increase of 10.3 kaf, which is equivalent to 172 cfs released over 30 days.

Increases in storage resulting from alternative operations 1966, 1985, and 1991 decrease significantly later in the season as a result of Cougar drafting to stay below the rule curve in the alternative while pool elevations rise in the baseline.

Table 9-4. April Increase in conservation storage associated with alternative operations at Cougar

Year	1936	1937	1938	1943	1945	1948	1949	1950	1951	1952
KAF	Fill	Fill	Fill	Fill	Fill	Fill	Fill	Fill	Fill	Fill
Year	1953	1955	1956	1957	1958	1960	1961	1962	1963	1969
KAF	Fill	Fill	Fill	0	0	Fill	Fill	Fill	Fill	Fill
Year	1971	1972	1974	1975	1976	1979	1982	1983	1984	1988
KAF	Fill	Fill	Fill	Fill	Fill	Fill	Fill	Fill	Fill	Fill
Year	1989	1991	1993	1995	1996	1997	1999	2000	2003	2008
KAF	0	13	Fill	Fill	Fill	Fill	Fill	Fill	Fill	Fill
Year	2009	2011	2012	2014	2017					
KAF	Fill	Fill	Fill	Fill	Fill					
Year	1939	1940	1946	1947	1954	1959	1964	1966	1970	1980
KAF	0	0	Fill	0	2	12	Fill	20	7	15
Year	1981	1985	1986	1990	1998	2002	2004	2005	2006	2007
KAF	4	22	0	0	13	0	8	22	11	0
Year	2010	2013	2016	2018	2019					
KAF	Fill	14	0	11	0					
Year	1944	1965	1967	1968	1978	1987	1992	1994		
KAF	11	0	11	0	11	8	20	22		
Year	1941	1942	1973	1977	2001	2015				
KAF	15	1	19	0	20	7				
						Legend				
CGR	Fill = Fills under baseline			Abundant	Adequate	Insufficient	Deficit			

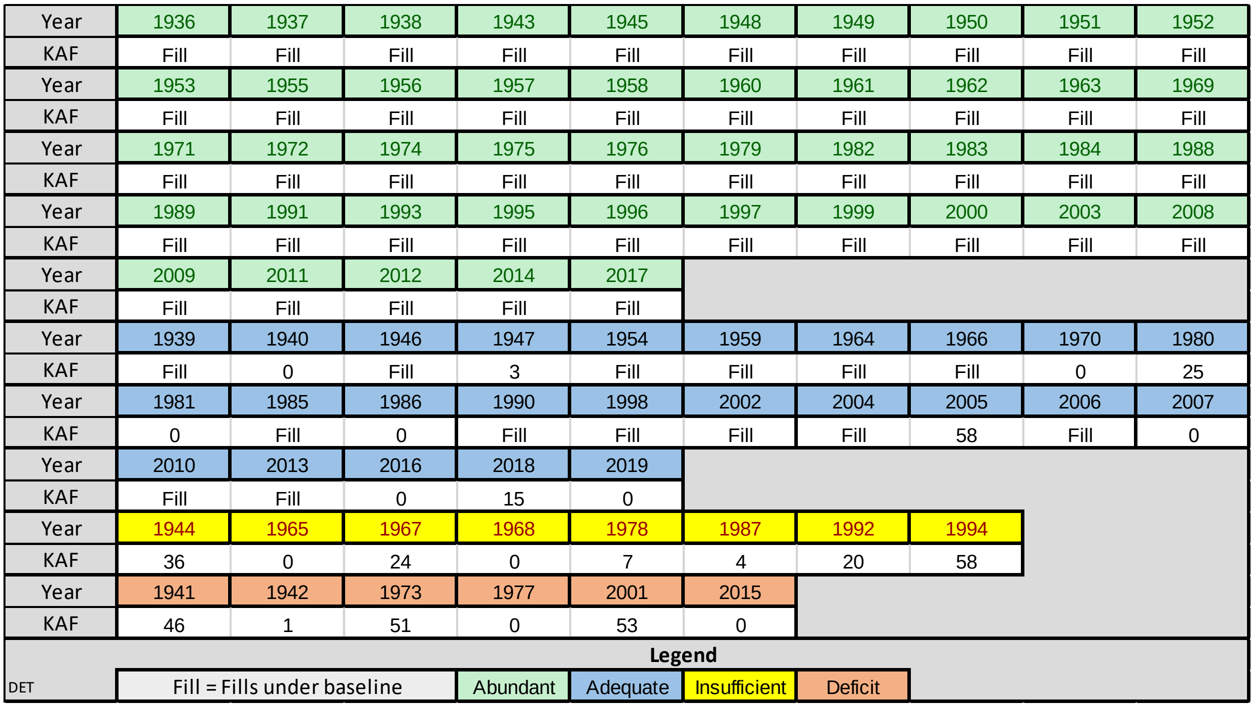
* Increase of 0 reported if the baseline reaches the rule curve after exceeding the secondary flood pool

Detroit:

Table B-9-5 indicates the estimated increase in maximum conservation storage resulting from guaranteeing refill to the top of the secondary flood pool during spring refill at Detroit. The secondary flood pool volume at Detroit is 62 kaf, which is approximately 22% of the total 280 kaf of conservation storage capacity.

Detroit reservoir fills in all Abundant water years in the baseline and therefore cannot realize a benefit from the alternative operations. The alternative operation results in higher reservoir storage in 16% (4 of 25) of Adequate water years with an average increase of 4.1 kaf, which is equivalent to 67 cfs released over 30 days. The alternative operation results in higher reservoir storage in 75% (6 of 8) of Insufficient water years with an average increase of 18.5 kaf which is equivalent to 310 cfs released over 30 days. The alternative operation results in higher reservoir storage in 67% (4 of 6) Deficit water years with a median increase of 25.2 kaf which is equivalent to 422 cfs released over 30 days.

Table 9-5. April Increase in conservation storage associated with alternative operations at Detroit



Year	1936	1937	1938	1943	1945	1948	1949	1950	1951	1952
KAF	Fill	Fill	Fill	Fill	Fill	Fill	Fill	Fill	Fill	Fill
Year	1953	1955	1956	1957	1958	1960	1961	1962	1963	1969
KAF	Fill	Fill	Fill	Fill	Fill	Fill	Fill	Fill	Fill	Fill
Year	1971	1972	1974	1975	1976	1979	1982	1983	1984	1988
KAF	Fill	Fill	Fill	Fill	Fill	Fill	Fill	Fill	Fill	Fill
Year	1989	1991	1993	1995	1996	1997	1999	2000	2003	2008
KAF	Fill	Fill	Fill	Fill	Fill	Fill	Fill	Fill	Fill	Fill
Year	2009	2011	2012	2014	2017					
KAF	Fill	Fill	Fill	Fill	Fill					
Year	1939	1940	1946	1947	1954	1959	1964	1966	1970	1980
KAF	Fill	0	Fill	3	Fill	Fill	Fill	Fill	0	25
Year	1981	1985	1986	1990	1998	2002	2004	2005	2006	2007
KAF	0	Fill	0	Fill	Fill	Fill	Fill	58	Fill	0
Year	2010	2013	2016	2018	2019					
KAF	Fill	Fill	0	15	0					
Year	1944	1965	1967	1968	1978	1987	1992	1994		
KAF	36	0	24	0	7	4	20	58		
Year	1941	1942	1973	1977	2001	2015				
KAF	46	1	51	0	53	0				
						Legend				
DET	Fill = Fills under baseline			Abundant	Adequate	Insufficient	Deficit			

* Increase of 0 reported if the baseline reaches the rule curve after exceeding the secondary flood pool

Green Peter:

Table B-9-6 indicates the estimated increase in maximum conservation storage resulting from guaranteeing refill to the top of the secondary flood pool during spring refill at Green Peter. The secondary flood pool volume at Green Peter is 70 kaf, which is approximately 28% of the total 250 kaf of conservation storage capacity.

Green Peter reservoir fills in nearly all Abundant and Adequate water years in the baseline and therefore cannot realize a benefit from the alternative operations. The alternative operation results in higher reservoir storage in 50% (4 of 8) Insufficient water years with an average increase of 7.3 kaf which is equivalent to 122 cfs released over 30 days. The alternative operation results in higher reservoir storage in 83% (5 of 6) of Deficit water years with an average increase of 35.6 kaf which is equivalent to 597 cfs released over 30 days.

Table 9-6. April Increase in conservation storage associated with alternative operations at Green Peter

Year	1936	1937	1938	1943	1945	1948	1949	1950	1951	1952
KAF	Fill	Fill	Fill	Fill	Fill	Fill	Fill	Fill	Fill	Fill
Year	1953	1955	1956	1957	1958	1960	1961	1962	1963	1969
KAF	Fill	Fill	Fill	Fill	Fill	Fill	Fill	Fill	Fill	Fill
Year	1971	1972	1974	1975	1976	1979	1982	1983	1984	1988
KAF	Fill	Fill	Fill	Fill	Fill	Fill	Fill	Fill	Fill	Fill
Year	1989	1991	1993	1995	1996	1997	1999	2000	2003	2008
KAF	Fill	Fill	Fill	Fill	Fill	Fill	Fill	Fill	Fill	Fill
Year	2009	2011	2012	2014	2017					
KAF	Fill	Fill	Fill	Fill	Fill					
Year	1939	1940	1946	1947	1954	1959	1964	1966	1970	1980
KAF	0	0	Fill	0	Fill	Fill	Fill	Fill	Fill	0
Year	1981	1985	1986	1990	1998	2002	2004	2005	2006	2007
KAF	Fill	Fill	Fill	Fill	Fill	Fill	Fill	Fill	Fill	0
Year	2010	2013	2016	2018	2019					
KAF	Fill	Fill	0	0	0					
Year	1944	1965	1967	1968	1978	1987	1992	1994		
KAF	20	0	20	0	15	0	3	0		
Year	1941	1942	1973	1977	2001	2015				
KAF	52	8	70	Fill	70	14				
						Legend				
GPR	Fill = Fills under baseline			Abundant	Adequate	Insufficient	Deficit			

* Increase of 0 reported if the baseline reaches the rule curve after exceeding the secondary flood pool

Hills Creek:

Table B-9-7 indicates the estimated increase in maximum conservation storage resulting from guaranteeing refill to the top of the secondary flood pool during spring refill at Hills Creek. The secondary flood pool volume at Hills Creek is 56 kaf, which is approximately 29% of the total 195 kaf of conservation storage.

Hills Creek reservoir fills in nearly all Abundant water years in the baseline and therefore cannot realize a benefit from the alternative operations. The alternative operation results in higher reservoir storage in 36% (9 of 25) of Adequate water years with an average increase of 8.5 kaf which is equivalent to 142 cfs released over 30 days. The alternative operation results in higher reservoir storage in 63% (5 of 8) of Insufficient water years with an average increase of 20.6 kaf which is equivalent to 344 cfs released over 30 days. The alternative operation results in higher reservoir storage in 100% (6 of 6) of Deficit water years with a median increase of 32.2 kaf, which is equivalent to 539 cfs released over 30 days.

Increases in storage resulting from alternative operations in 1959 and 1985 decrease significantly later in the season as a result of Hills Creek drafting to stay below the rule curve in the alternative while pool elevations rise in the baseline.

Table 9-7. April Increase in conservation storage associated with alternative operations at Hills Creek

Year	1936	1937	1938	1943	1945	1948	1949	1950	1951	1952
KAF	Fill	Fill	Fill	Fill	Fill	Fill	Fill	Fill	Fill	Fill
Year	1953	1955	1956	1957	1958	1960	1961	1962	1963	1969
KAF	Fill	Fill	Fill	0	0	Fill	Fill	Fill	Fill	Fill
Year	1971	1972	1974	1975	1976	1979	1982	1983	1984	1988
KAF	Fill	Fill	Fill	Fill	Fill	Fill	Fill	Fill	Fill	Fill
Year	1989	1991	1993	1995	1996	1997	1999	2000	2003	2008
KAF	0	16	Fill	Fill	Fill	Fill	Fill	Fill	0	Fill
Year	2009	2011	2012	2014	2017					
KAF	Fill	Fill	Fill	Fill	Fill					
Year	1939	1940	1946	1947	1954	1959	1964	1966	1970	1980
KAF	0	0	0	0	0	18	Fill	0	0	25
Year	1981	1985	1986	1990	1998	2002	2004	2005	2006	2007
KAF	21	31	0	6	0	0	3	51	0	0
Year	2010	2013	2016	2018	2019					
KAF	Fill	24	0	33	0					
Year	1944	1965	1967	1968	1978	1987	1992	1994		
KAF	31	0	21	0	0	13	46	54		
Year	1941	1942	1973	1977	2001	2015				
KAF	38	16	41	31	50	17				
	Legend									
HCR	Fill = Fills under baseline		Abundant	Adequate	Insufficient	Deficit				

* Increase of 0 reported if the baseline reaches the rule curve after exceeding the secondary flood pool

Lookout Point:

Table B-9-8 indicates the estimated increase in maximum conservation storage resulting from guaranteeing refill to the top of the secondary flood pool during spring refill at Lookout Point. The secondary flood pool volume at Lookout Point is 75 kaf, which is approximately 23% of the total 325 kaf of conservation storage capacity.

Lookout Point reservoir fills in nearly all Abundant and Adequate water years in the baseline and therefore cannot realize a benefit from the alternative operations. The alternative operation results in higher reservoir storage in 50% (4 of 8) of Insufficeint water years with an average observed increase of 24.9 kaf which is equivalent to 417 cfs released over 30 days. The alternative operation results in higher reservoir storage in 67% (4 of 6) of Deficit water years with an average observed increase of 33.0 kaf which is equivalent to 554 cfs released over 30 days.

Increases in storage resulting from alternative operations 1944, 2001, and 2005 decrease significantly later in the season as a result of Lookout Point drafting to stay below the rule curve in the alternative while pool elevations rise in the baseline.

Table 9-8. April Increase in conservation storage associated with alternative operation at Lookout Point

Year	1936	1937	1938	1943	1945	1948	1949	1950	1951	1952
KAF	Fill	Fill	Fill	Fill	Fill	Fill	Fill	Fill	Fill	Fill
Year	1953	1955	1956	1957	1958	1960	1961	1962	1963	1969
KAF	Fill	Fill	Fill	Fill	Fill	Fill	Fill	Fill	Fill	Fill
Year	1971	1972	1974	1975	1976	1979	1982	1983	1984	1988
KAF	Fill	Fill	Fill	Fill	Fill	Fill	Fill	Fill	Fill	Fill
Year	1989	1991	1993	1995	1996	1997	1999	2000	2003	2008
KAF	Fill	Fill	Fill	Fill	Fill	Fill	Fill	Fill	Fill	Fill
Year	2009	2011	2012	2014	2017					
KAF	Fill	Fill	Fill	Fill	Fill					
Year	1939	1940	1946	1947	1954	1959	1964	1966	1970	1980
KAF	Fill	0	Fill	Fill	Fill	Fill	Fill	Fill	Fill	Fill
Year	1981	1985	1986	1990	1998	2002	2004	2005	2006	2007
KAF	Fill	Fill	Fill	Fill	Fill	Fill	Fill	70	Fill	Fill
Year	2010	2013	2016	2018	2019					
KAF	Fill	Fill	0	54	Fill					
Year	1944	1965	1967	1968	1978	1987	1992	1994		
KAF	30	Fill	Fill	0	0	28	67	74		
Year	1941	1942	1973	1977	2001	2015				
KAF	55	0	60	20	62	0				
Legend										
LOP	Fill = Fills under baseline		Abundant	Adequate	Insufficient	Deficit				

* Increase of 0 reported if the baseline reaches the rule curve after exceeding the secondary flood pool

System:

Table B-9-9 indicates the estimated increase in conservation storage resulting from guaranteeing refill to the top of the secondary flood pool during spring refill at all six WVP reservoirs with secondary flood pools. The system secondary flood pool volume at is 300 kaf, which is approximately 19% of the total 1,590 kaf of conservation storage capacity.

WVP reservoirs fill in nearly all Abundant water years in the baseline and therefore cannot realize a benefit from the alternative operations. The alternative operation results in higher reservoir storage in 60% (15 of 25) of Adequate water years with an average observed increase of 5 kaf which is equivalent to 83 cfs released over 30 days. The alternative operation results in higher reservoir storage in 6 of 7 Insufficient water years with an average observed increase of 82.5 kaf which is equivalent to 1,383 cfs released over 30 days. The alternative operation results in higher reservoir storage in 100% (6 of 6) Insufficient water years with an average observed increase of 144 kaf which is equivalent to 2,993 cfs released over 30 days.

Increases in storage resulting from alternative operations 1944, 1959, 1966, 1985, 1991, 2001, and 2005 decrease significantly later in the season as a result of WVP reservoirs drafting to stay below the rule curve in the alternative while pool elevations rise in the baseline.

Table 9-9. April Increase in conservation storage associated with alternative operation at WVP reservoirs with secondary flood pools

Year	1936	1937	1938	1943	1945	1948	1949	1950	1951	1952
KAF	0	0	0	0	0	0	0	0	0	0
Year	1953	1955	1956	1957	1958	1960	1961	1962	1963	1969
KAF	0	0	0	0	0	0	0	0	0	0
Year	1971	1972	1974	1975	1976	1979	1982	1983	1984	1988
KAF	0	0	0	0	0	0	0	0	0	0
Year	1989	1991	1993	1995	1996	1997	1999	2000	2003	2008
KAF	0	29	0	0	0	0	0	0	0	0
Year	2009	2011	2012	2014	2017					
KAF	0	0	0	0	0					
Year	1939	1940	1946	1947	1954	1959	1964	1966	1970	1980
KAF	0	0	0	3	2	30	0	20	7	65
Year	1981	1985	1986	1990	1998	2002	2004	2005	2006	2007
KAF	26	53	0	6	13	0	11	213	11	0
Year	2010	2013	2016	2018	2019					
KAF	0	38	0	112	0					
Year	1944	1965	1967	1968	1978	1987	1992	1994		
KAF	130	0	78	0	36	53	155	208		
Year	1941	1942	1973	1977	2001	2015				
KAF	214	25	249	66	264	37				
						Legend				
System				Abundant	Adequate	Insufficient	Deficit			

* Increase of 0 reported if the baseline reaches the rule curve after exceeding the secondary flood pool

Conclusions:

The proposed alternative operation targets the top of the secondary flood pool throughout the winter with the hopes that starting refill season with a higher baseline storage will maximum conservation season storage. However, in many years the reservoirs with secondary flood pools fill to the top of the secondary flood pool by the target date even when starting from the minimum conservation elevation (Figure B-9-2-a). In other years, when starting at the secondary flood pool provides a head start on refill, the reservoirs may fill to the rule curve without the head start (Figure B-9-2-b). Increases in conservation season storage are observed in the remaining years when storage differences between the baseline and alternative resemble Figure B-9-2-c.

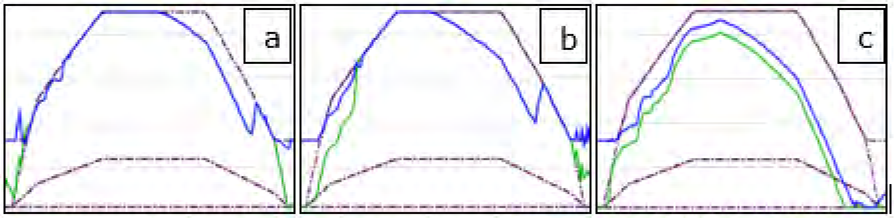


Figure 9-2. Refill scenarios – Green = Baseline, Blue = Alternative

The number of years an increase in storage is observed as a result of the alternative operations, and the median increase observed in those years is presented in table 9. In abundant water years, no significant increases in conservation storage resulting from the alternative operations are realized because reservoirs generally fill without the benefit of starting refill at the top of the secondary flood pool. In adequate water years, reservoirs rarely completely fill under normal operations, but most commonly fill to the rule curve by the end of March. Cougar is a notable exception, where increased storage resulting from alternative operations is observed in over half of Adequate water years. In Insufficient and Deficit water years, all 6 reservoirs exhibit increases in storage as a result of the alternative operations.

Average increases in Deficit water years at individual reservoirs range from 7% of maximum conservation storage capacity at Cougar to 16% of maximum conservation storage capacity Hills Creek. Average increases in system storage in insufficient years represent roughly 7% of total system storage, and 11% in Deficit years. One kaf of storage can provide a flow of 17 cfs for 30 days

If minimum flow targets remain the same as in the baseline No Action model, 01 May increases will be significantly less than 01 April increases observed in the years 1944, 1959, 1966, 1985, 1991, 2001, and 2005 which will affect the values in Table B-9-10. In these years, reservoirs fill in the alternative, but not in the baseline. Consequently, baseline storage increases while storage is drafted in the alternative. These values were not edited because alternative flow regimes that draw more water early in the season can prevent the reservoirs from filling and spilling in the alternative, and 01 April increases will remain representative of the maximum benefit to conservation season storage.

Table 9-10. -# of years with increased storage attributed to alternative operations and average increase by water year type

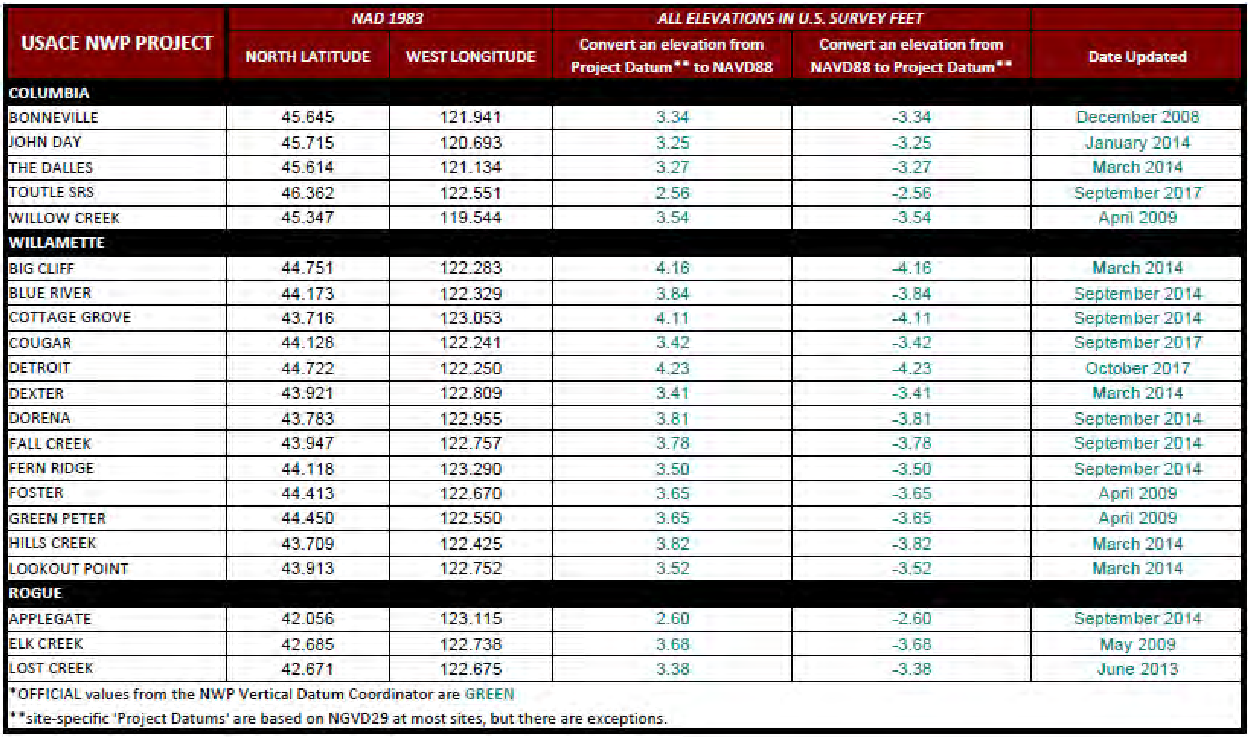
Reservoir	Abundant (45 years)		Adequate (25 years)	
	# Years W/Increase (% of year type)	Mean kaf Increase (30 day cfs equivalent)	# Years W/Increase (% of year type)	Mean kaf Increase (30 day cfs equivalent)
Blue River	0 (0)	0 (0)	1 (4)	0.5 (8)
Cougar	1 (2)	0.3 (5)	13 (52)	6.4 (107)
Detroit	0 (0)	0 (0)	4 (16)	4.1 (67)
Green Peter	0 (0)	0 (0)	0 (0)	0 (0)
Hills Creek	1 (2)	0.4 (7)	9 (36)	8.5(142)
Lookout Point	0 (0)	0 (0)	2 (8)	5.0 (83)
System	1 (2)	0.7 (12)	15 (60)	24.3(408)
Reservoir	Insufficient (8 years)		Deficit (6 years)	
	# Years W/Increase (% of year type)	Mean kaf Increase (30 day cfs equivalent)	# Years W/Increase (% of year type)	Mean kaf Increase (30 day cfs equivalent)
Blue River	3 (38)	1.1 (18)	4 (67)	6.4 (107)
Cougar	6 (75)	10.2(172)	5 (83)	10.3 (172)
Detroit	6 (75)	18.5 (310)	4 (67)	25.2 (422)
Green Peter	4 (50)	7.3 (122)	5 (83)	35.6 (597)
Hills Creek	5 (63)	20.6 (344)	6 (100)	32.2 (539)
Lookout Point	4 (50)	24.9 (417)	4 (67)	33.0 (554)
System	6 (75)	82.5 (1,383)	6 (100)	142 (2,393)

* Increases observed on 01 April. Increase of 0 reported if the baseline reaches the rule curve after exceeding the secondary flood pool

10 WVP WATER CONTROL DIAGRAMS

This section contains water control diagrams which include the authorized conservation season target and other pertinent elevations. Elevations are in project datum which is very nearly the same as NGVD29 at most projects. Table B-10-1 shows conversions between project datums and NAVD88.

Table 10-1. Project Datum Conversions



USACE NWP PROJECT	NAD 1983		ALL ELEVATIONS IN U.S. SURVEY FEET		
	NORTH LATITUDE	WEST LONGITUDE	Convert an elevation from Project Datum** to NAVD88	Convert an elevation from NAVD88 to Project Datum**	Date Updated
COLUMBIA					
BONNEVILLE	45.645	121.941	3.34	-3.34	December 2008
JOHN DAY	45.715	120.693	3.25	-3.25	January 2014
THE DALLES	45.614	121.134	3.27	-3.27	March 2014
TOUTLE SRS	46.362	122.551	2.56	-2.56	September 2017
WILLOW CREEK	45.347	119.544	3.54	-3.54	April 2009
WILLAMETTE					
BIG CLIFF	44.751	122.283	4.16	-4.16	March 2014
BLUE RIVER	44.173	122.329	3.84	-3.84	September 2014
COTTAGE GROVE	43.716	123.053	4.11	-4.11	September 2014
COUGAR	44.128	122.241	3.42	-3.42	September 2017
DETROIT	44.722	122.250	4.23	-4.23	October 2017
DEXTER	43.921	122.809	3.41	-3.41	March 2014
DORENA	43.783	122.955	3.81	-3.81	September 2014
FALL CREEK	43.947	122.757	3.78	-3.78	September 2014
FERN RIDGE	44.118	123.290	3.50	-3.50	September 2014
FOSTER	44.413	122.670	3.65	-3.65	April 2009
GREEN PETER	44.450	122.550	3.65	-3.65	April 2009
HILLS CREEK	43.709	122.425	3.82	-3.82	March 2014
LOOKOUT POINT	43.913	122.752	3.52	-3.52	March 2014
ROGUE					
APPLEGATE	42.056	123.115	2.60	-2.60	September 2014
ELK CREEK	42.685	122.738	3.68	-3.68	May 2009
LOST CREEK	42.671	122.675	3.38	-3.38	June 2013

*OFFICIAL values from the NWP Vertical Datum Coordinator are GREEN

**site-specific 'Project Datums' are based on NGVD29 at most sites, but there are exceptions.

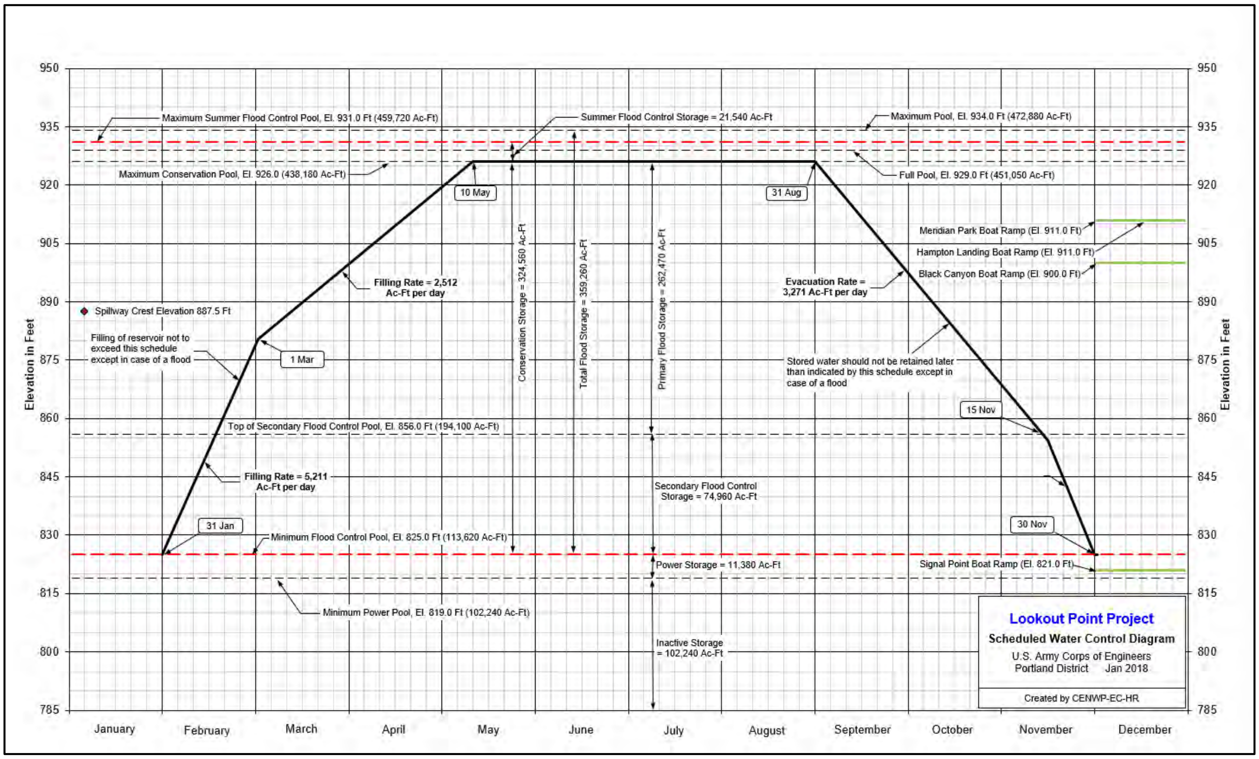


Figure 10-1. Lookout Point Water Control Diagram

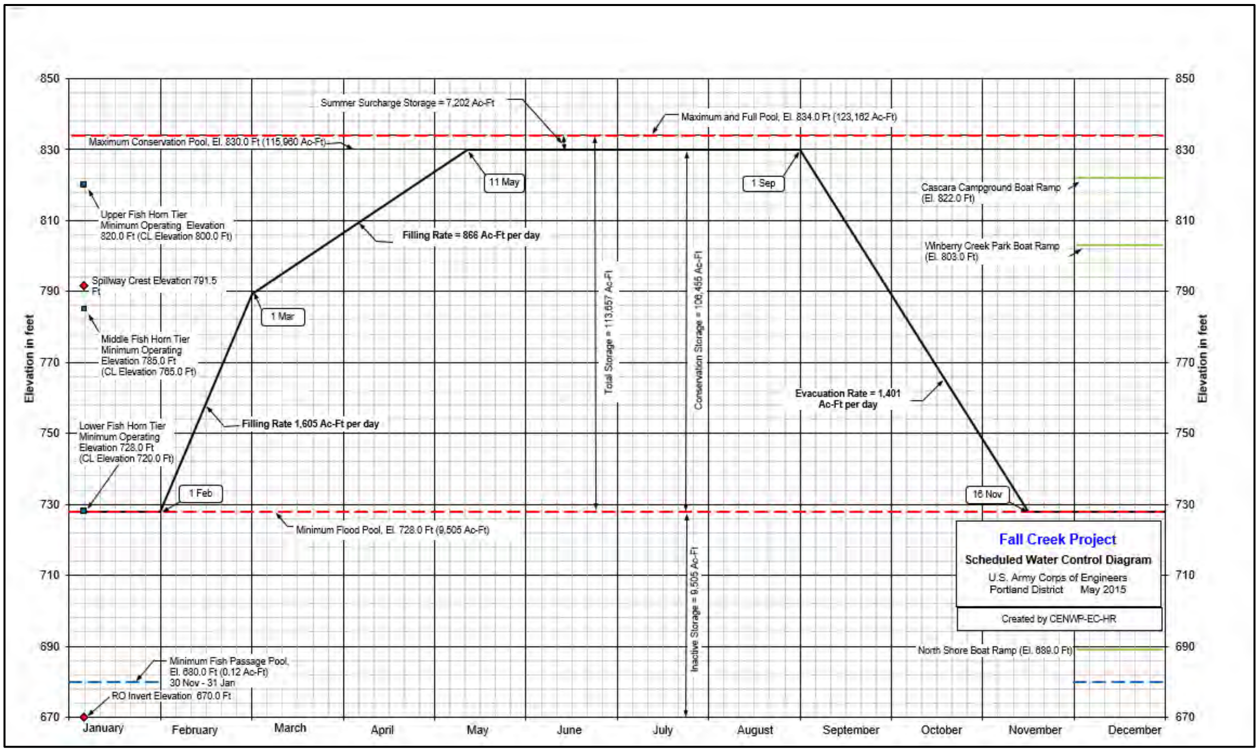


Figure 10-2. Fall Creek Water Control Diagram

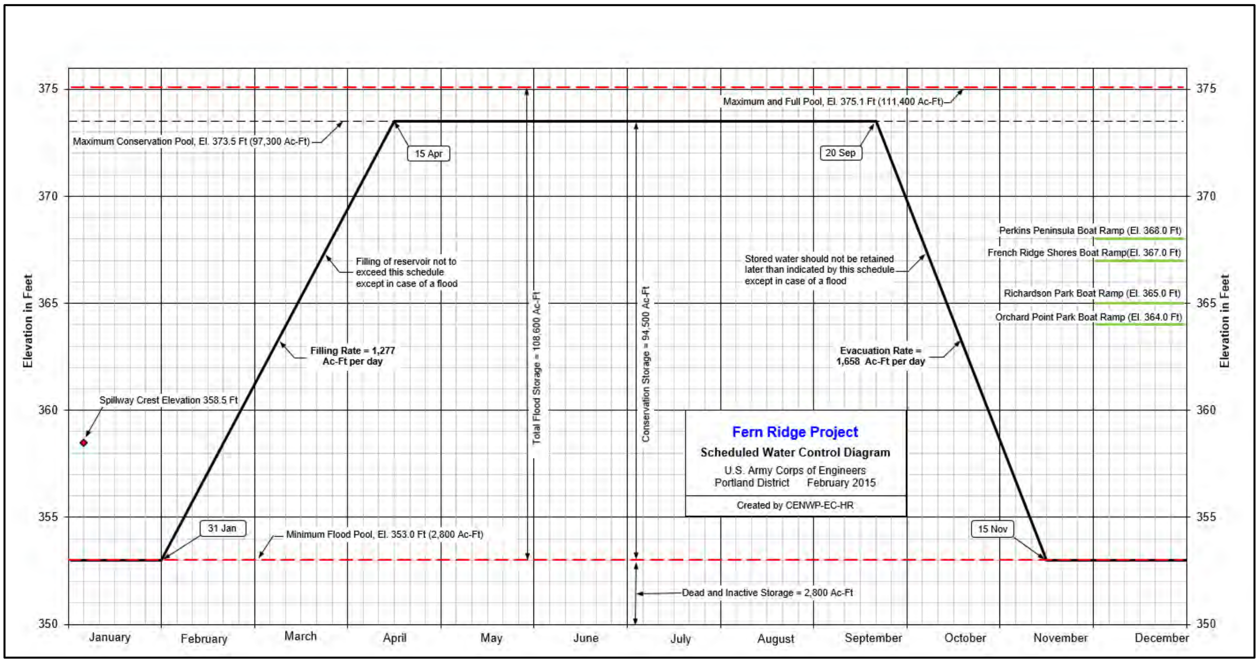


Figure 10-3. Fern Ridge Water Control Diagram

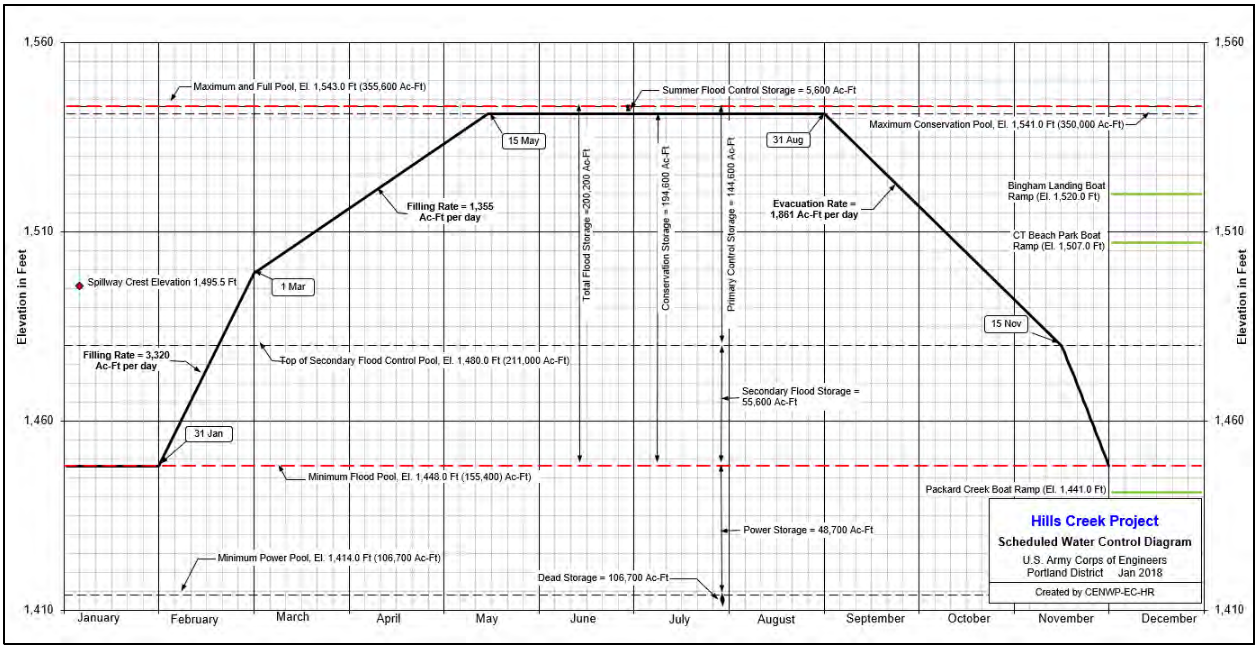


Figure 10-4. Hills Creek Water Control Diagram

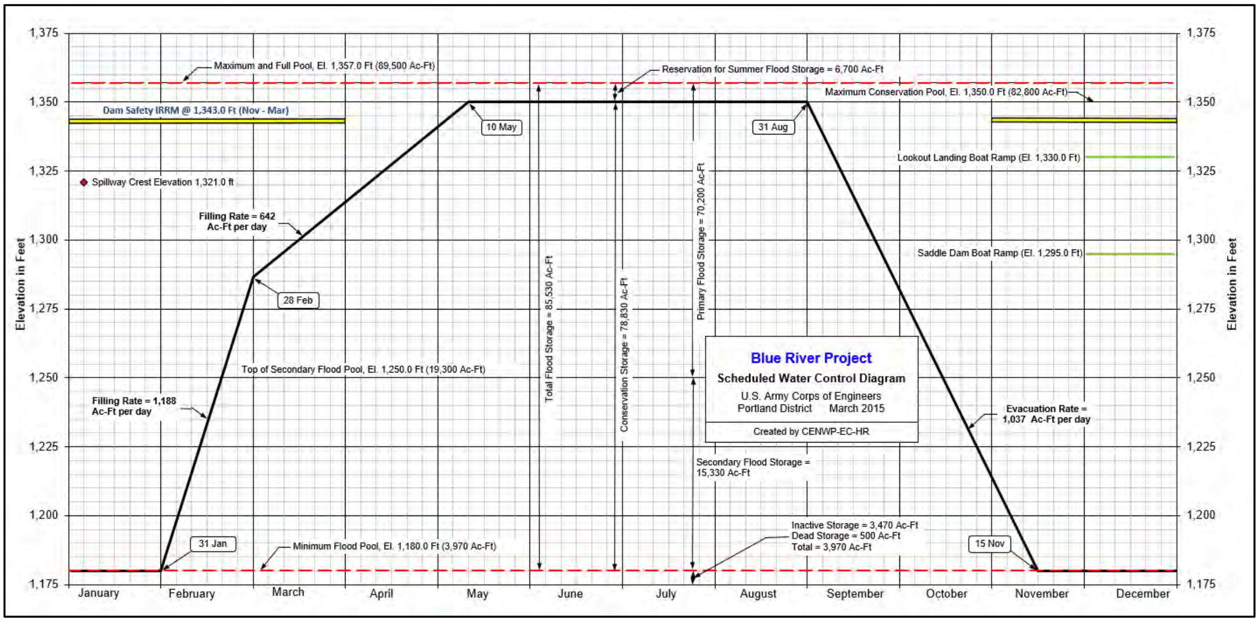


Figure 10-5. Blue River Water Control Diagram

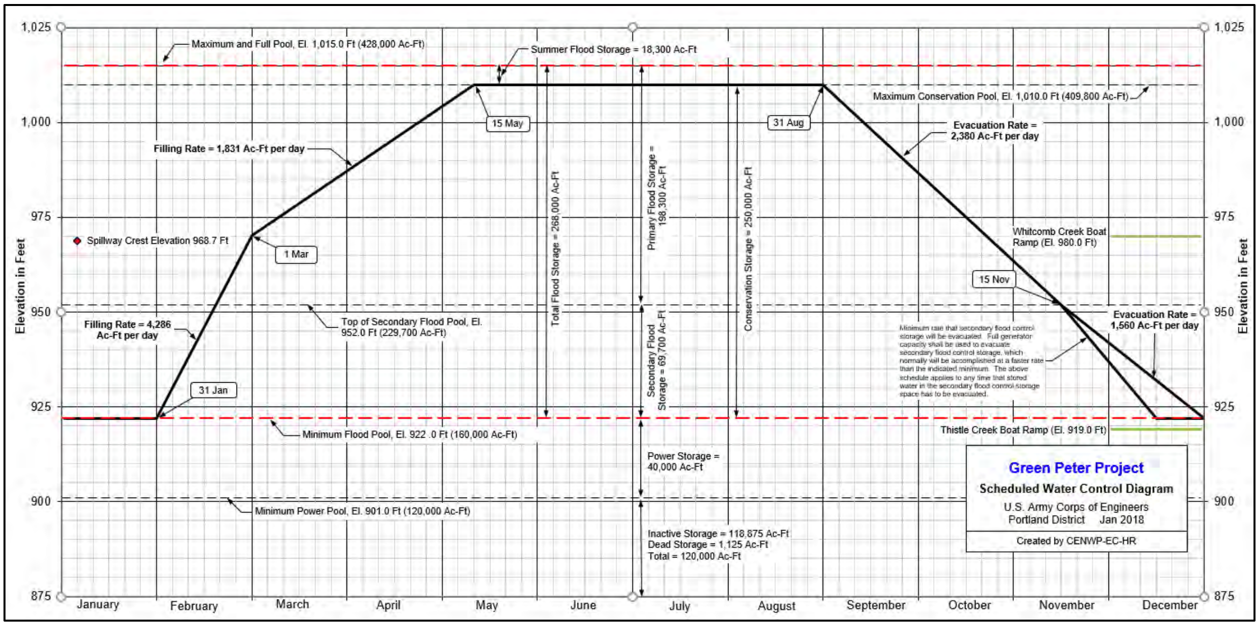


Figure 10-6. Green Peter Water Control Diagram

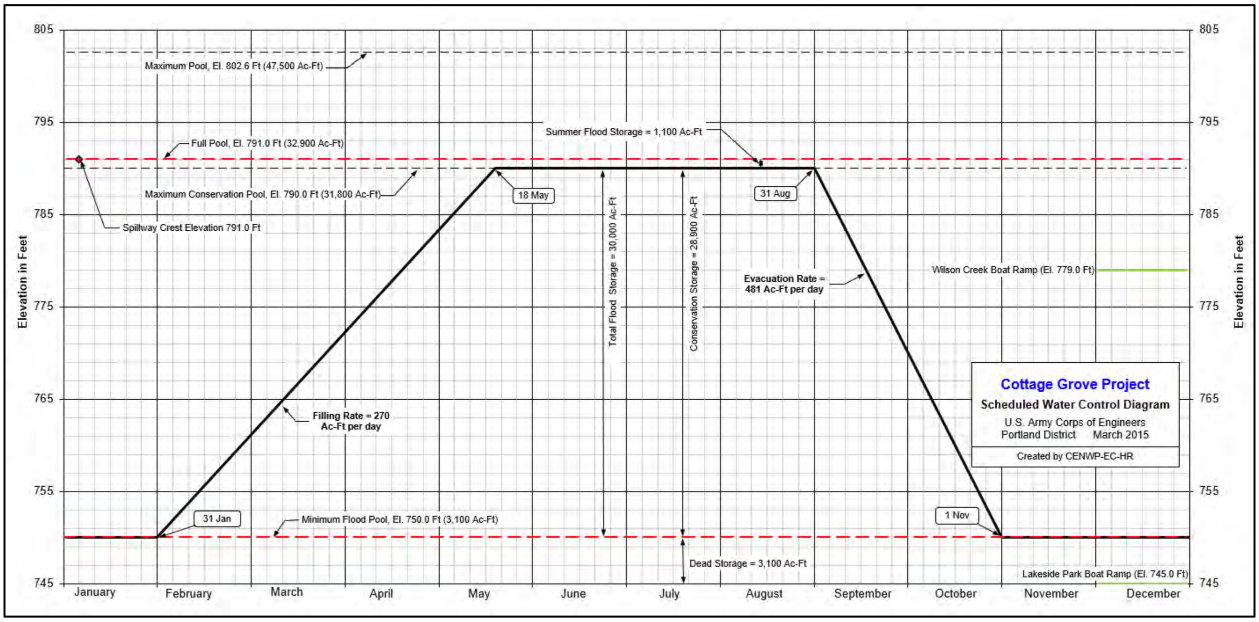


Figure 10-7. Cottage Grove Water Control Diagram

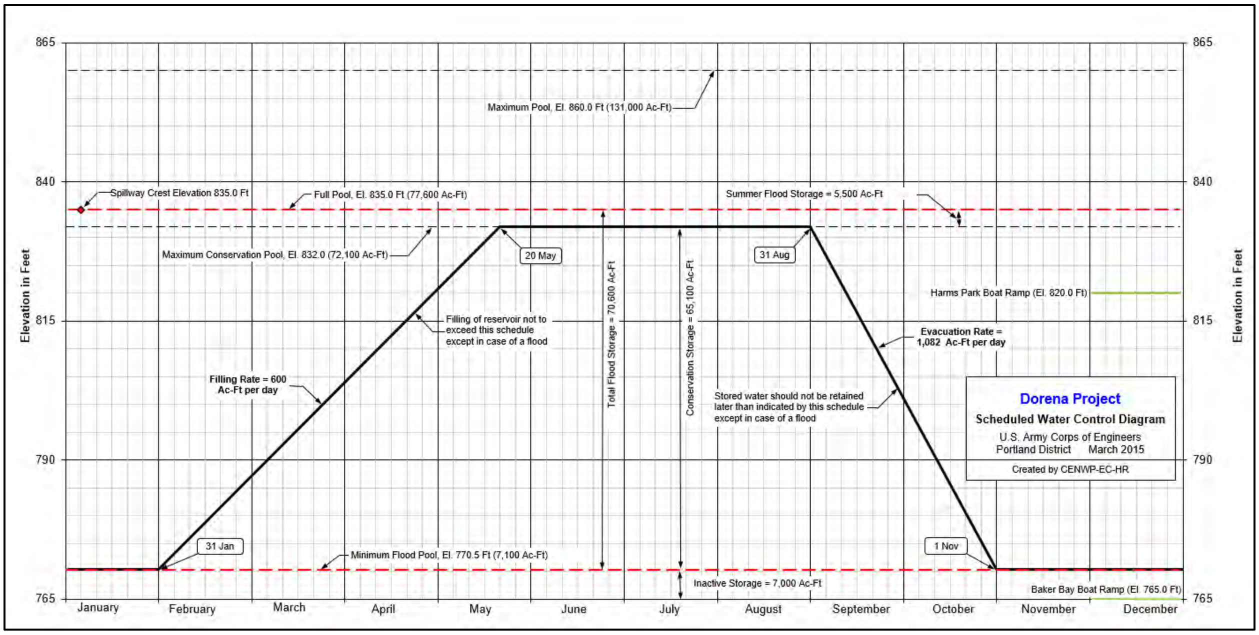


Figure 10-8. Dorena Water Control Diagram

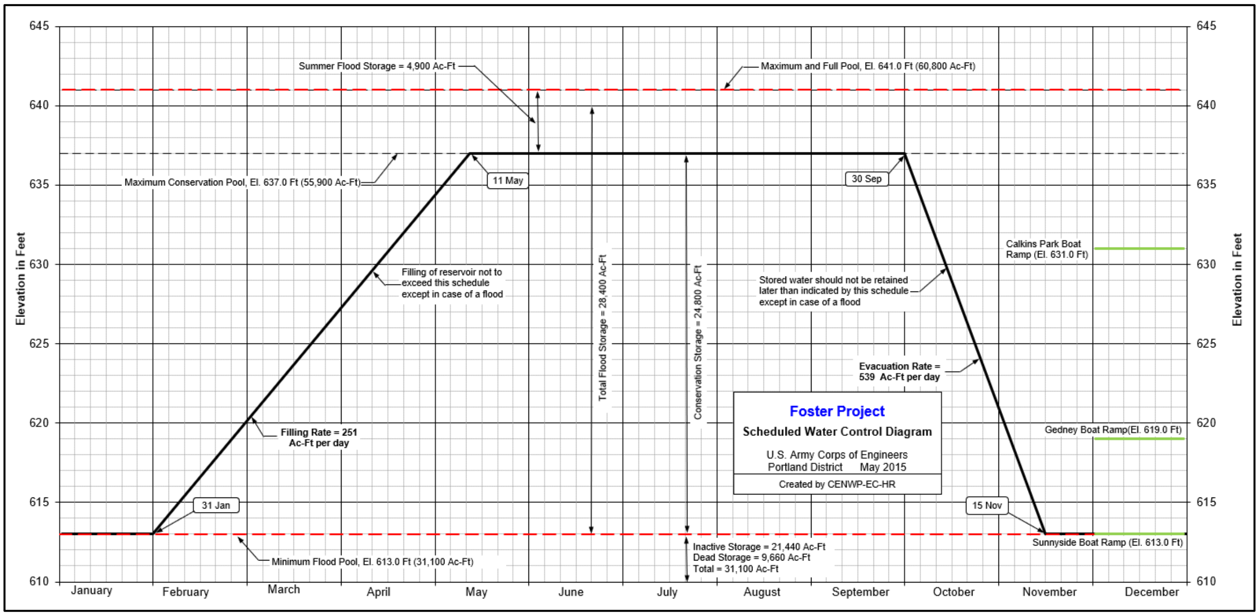


Figure 10-9.Foster Water Control Diagram

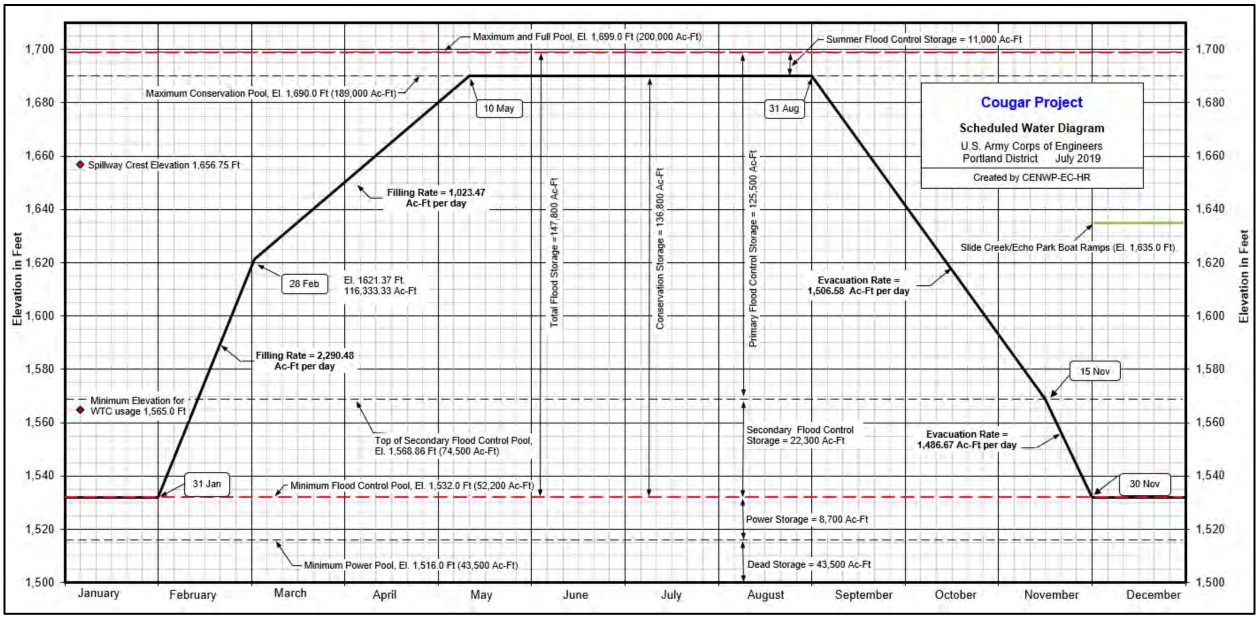


Figure 10-10. Cougar Water Control Diagram

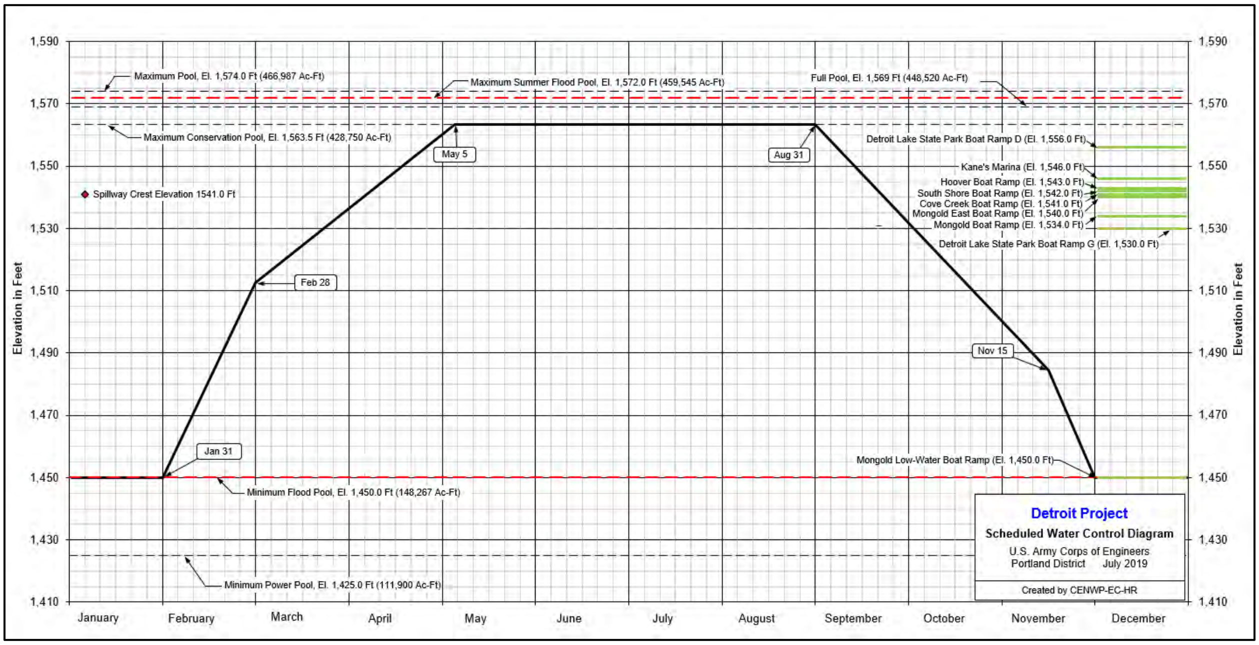


Figure 10-11. Detroit Water Control Diagram

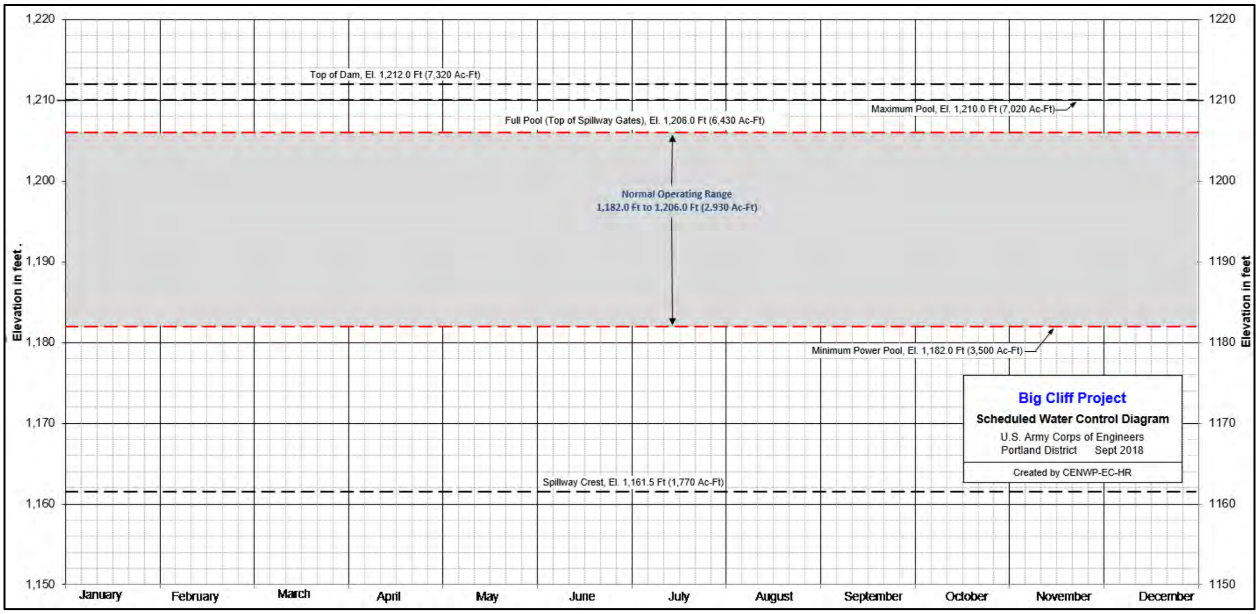


Figure 10-12. Big Cliff Water Control Diagram

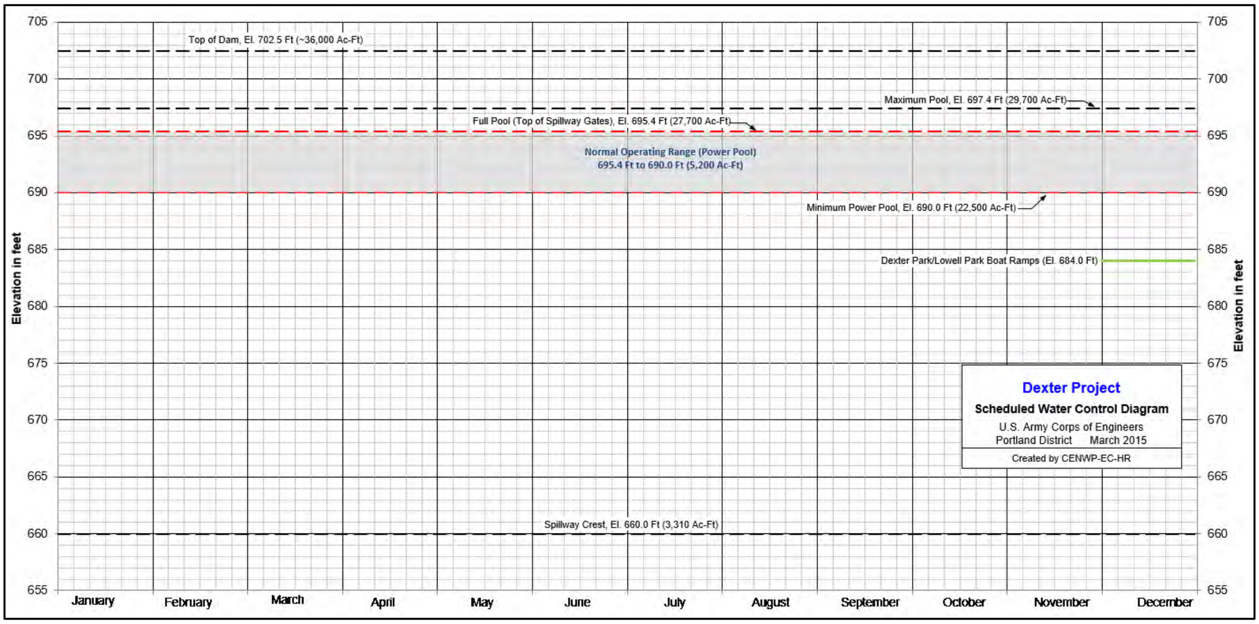


Figure 10-13. Dexter Water Control Diagram

11 BASIN DESCRIPTION SUPPLEMENTARY FIGURES

The following figures are those not included in section 3.2.1.5.2 in the main report – Unregulated and Observed Flow. All flow figures below represent water years 1935 to 2019, , with the observed data only shown for years after all upstream reservoirs had been constructed (year varies).

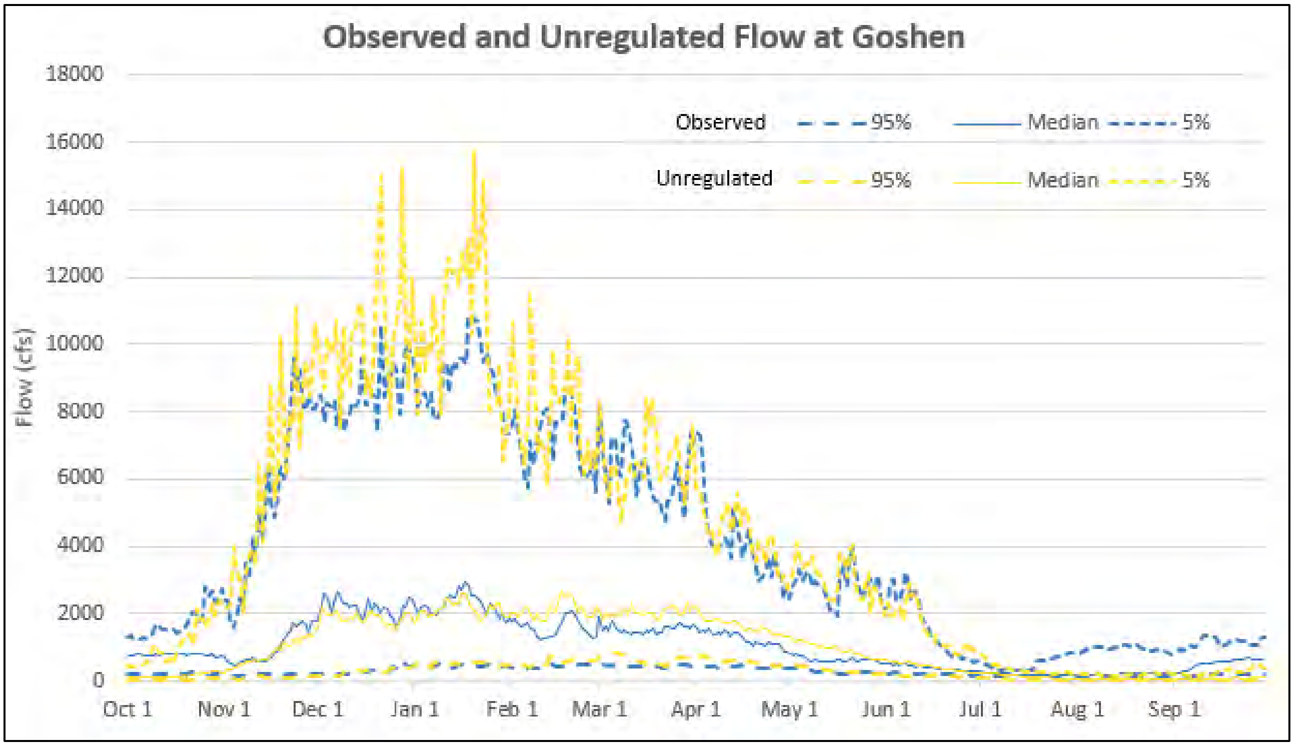


Figure 11-1. Coast Fork of the Willamette River at Goshen, OR. Flows across the water year.

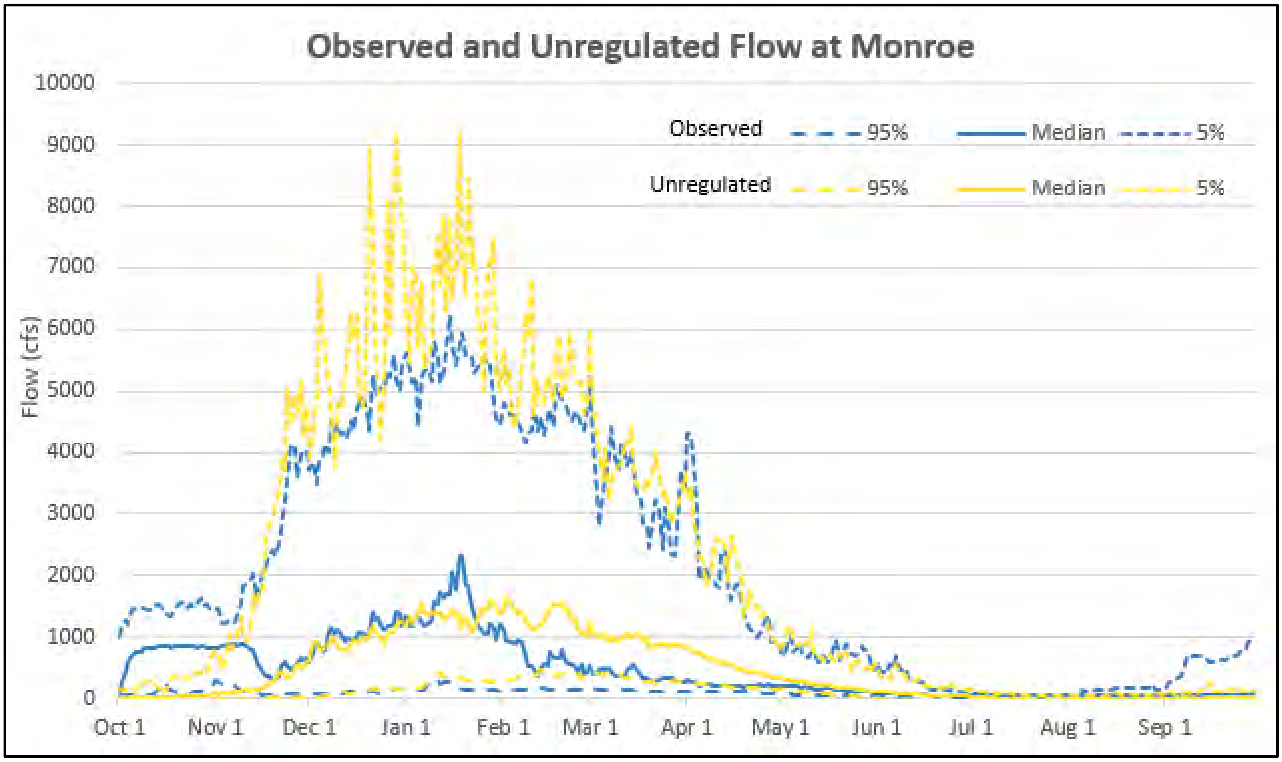


Figure 11-2. Long Tom River at Monroe, OR. Flows across the water year.

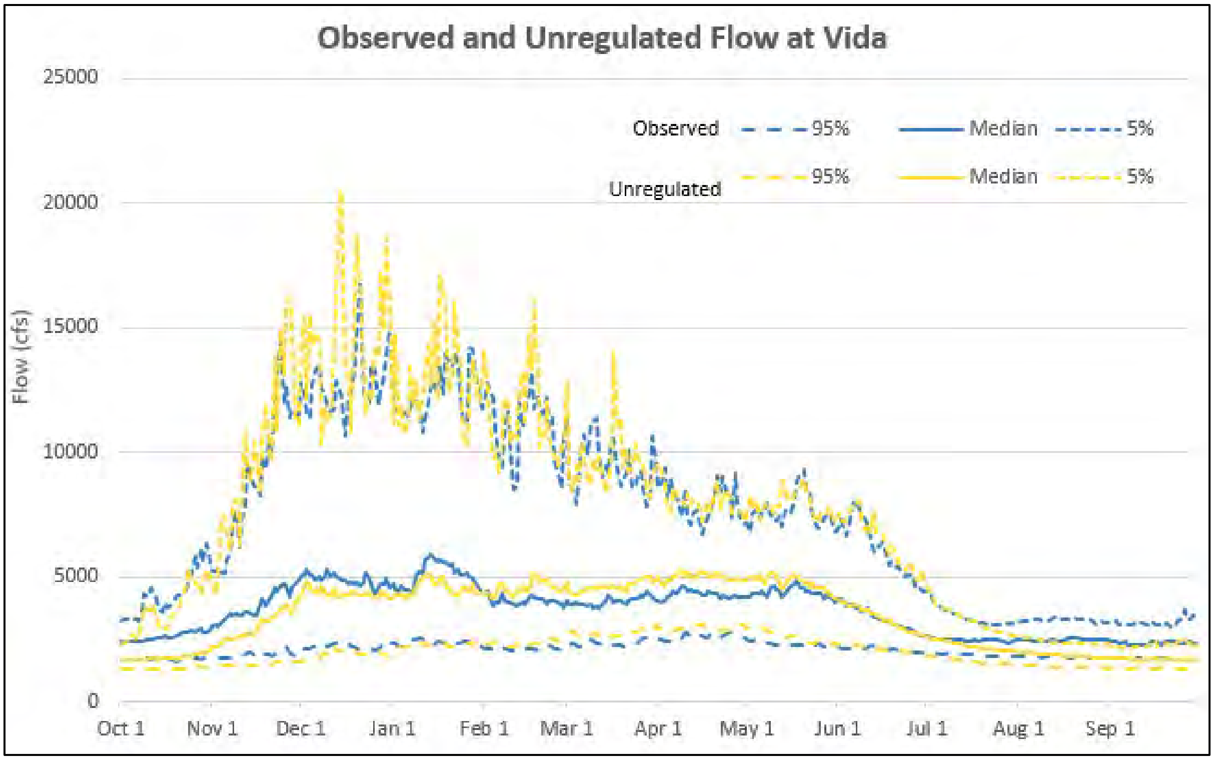


Figure 11-3. McKenzie River at Vida, OR. Flows across the water year.

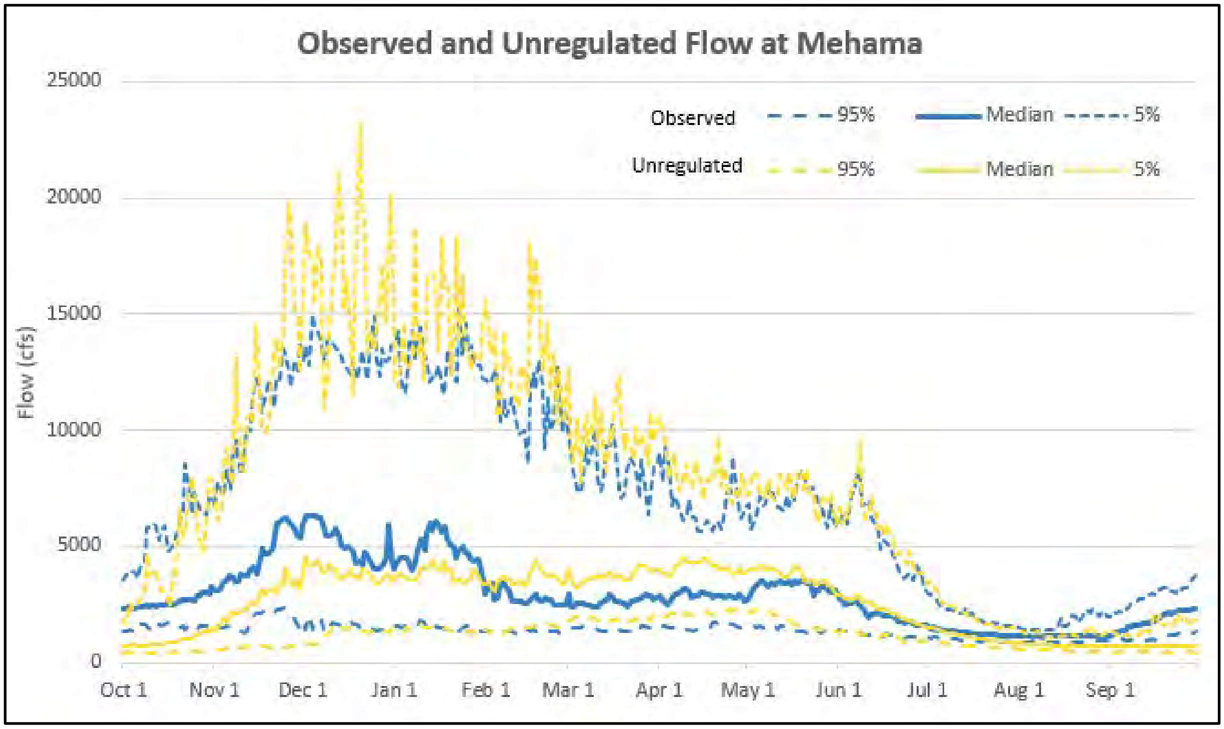


Figure 11-4. North Santiam River at Mehama, OR. Flows across the water year.

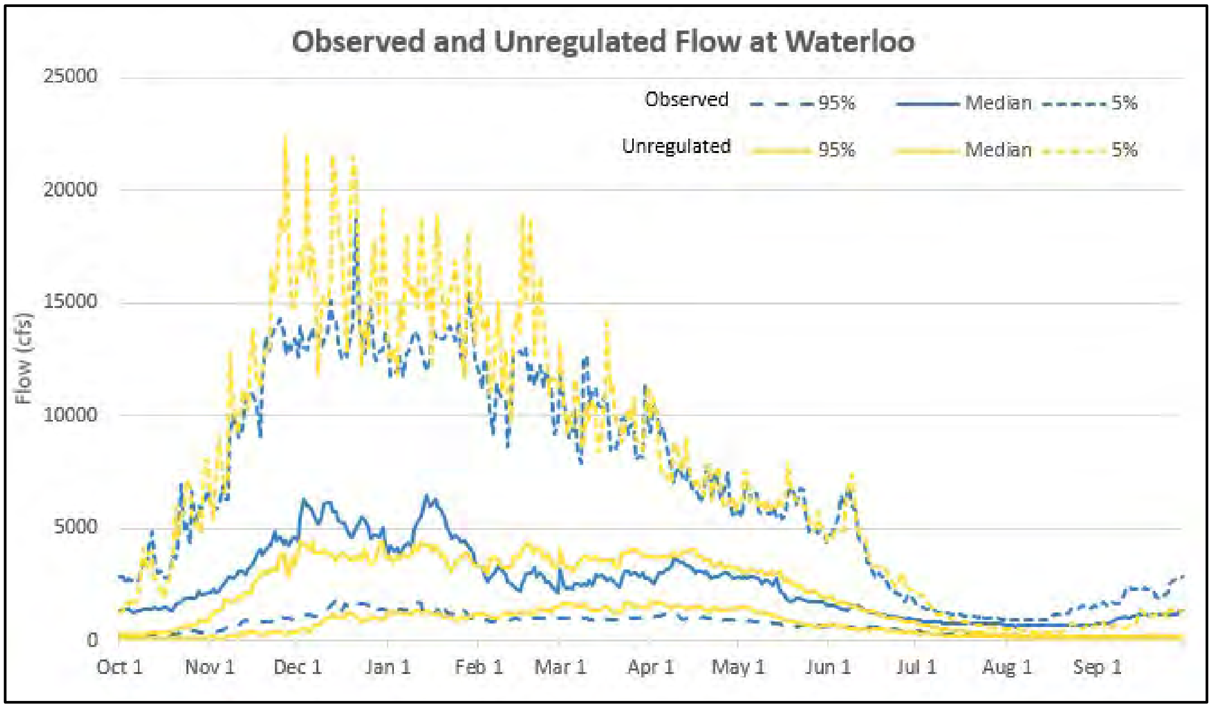


Figure 11-5. South Santiam River at Waterloo, OR. Flows across the water year.

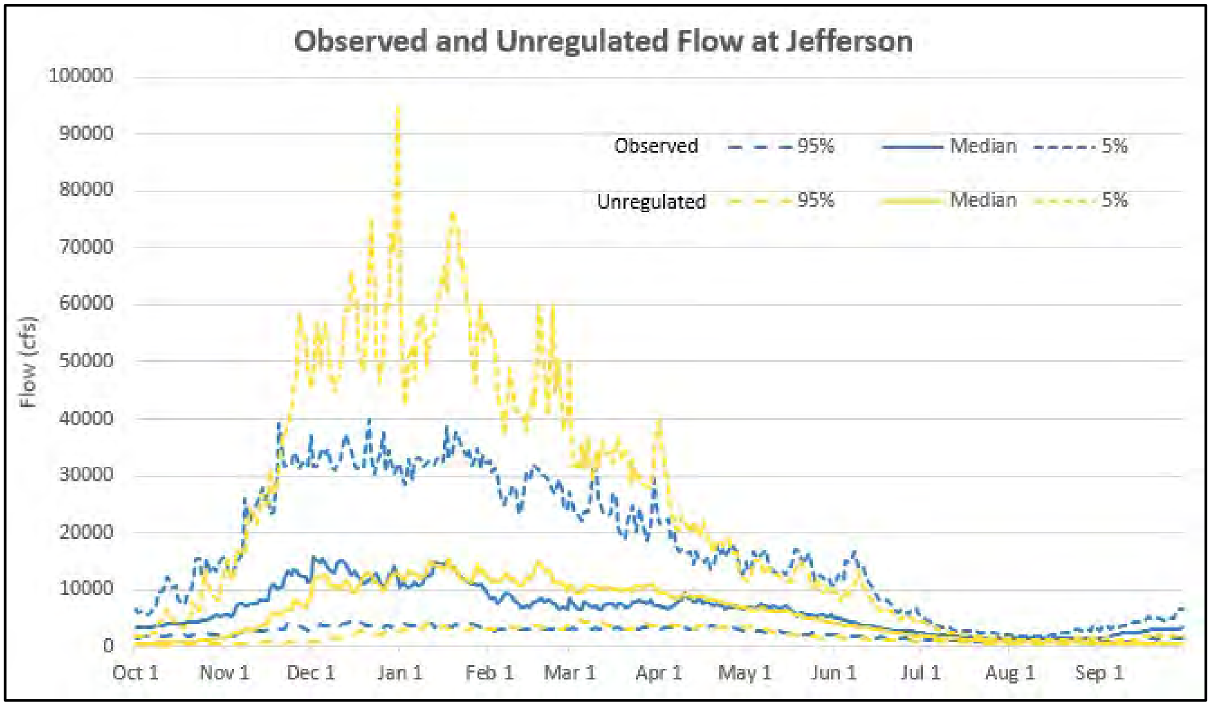


Figure 11-6. Santiam River at Jefferson, OR. Flows across the water year.

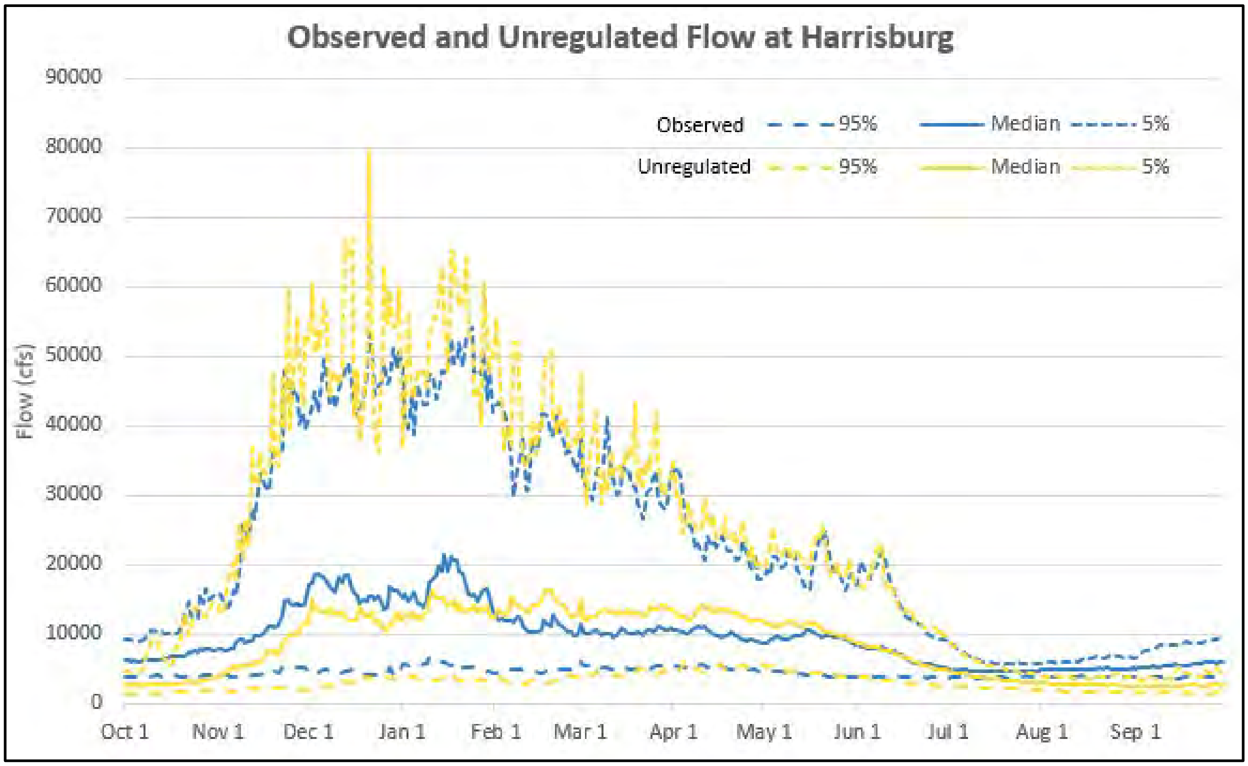


Figure 11-7. Willamette River at Harrisburg, OR. Flows across the water year.

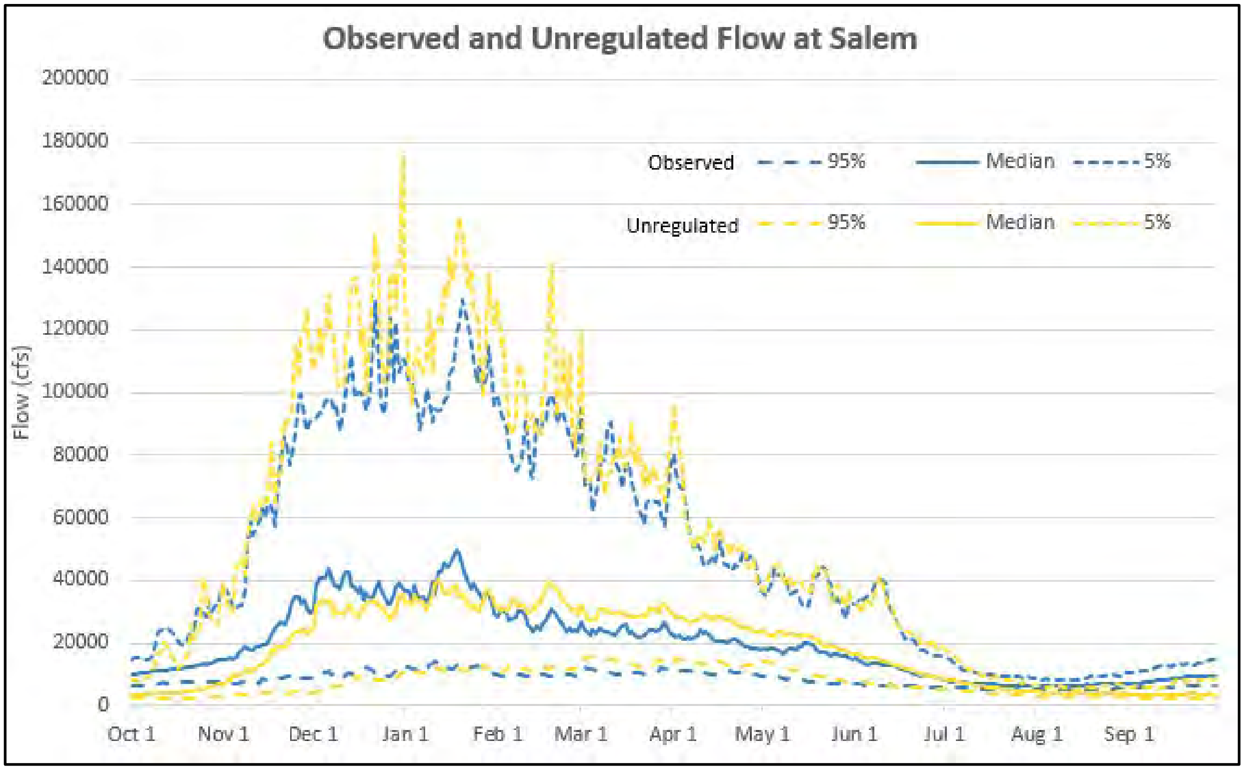


Figure 11-8. Willamette River at Salem, OR. Flows across the water year.

As noted in section 3.2.1.5.3 – of the main report – Reservoir Pool Operations, the selected prototypical years to show the range of the designations are 2011, abundant; 2015, deficit; and 2016, insufficient.

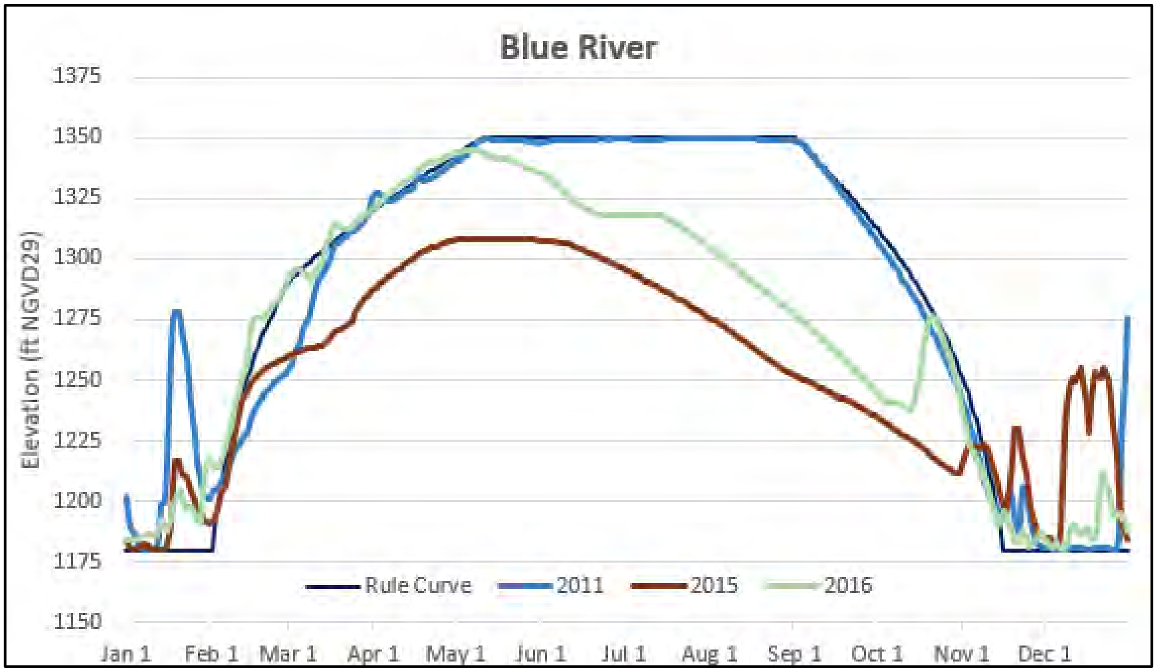


Figure 11-9. Blue River reservoir water surface elevation across 2011, 2015 and 2016.

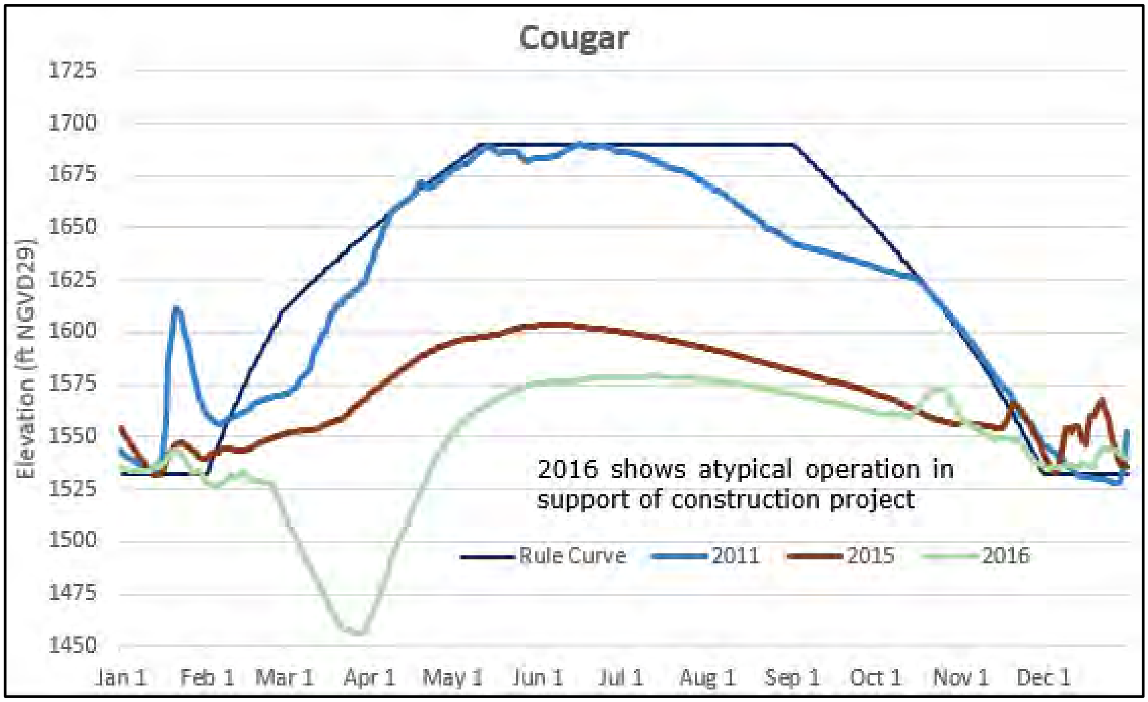


Figure 11-10. Cougar reservoir water surface elevation across 2011, 2015 and 2016.

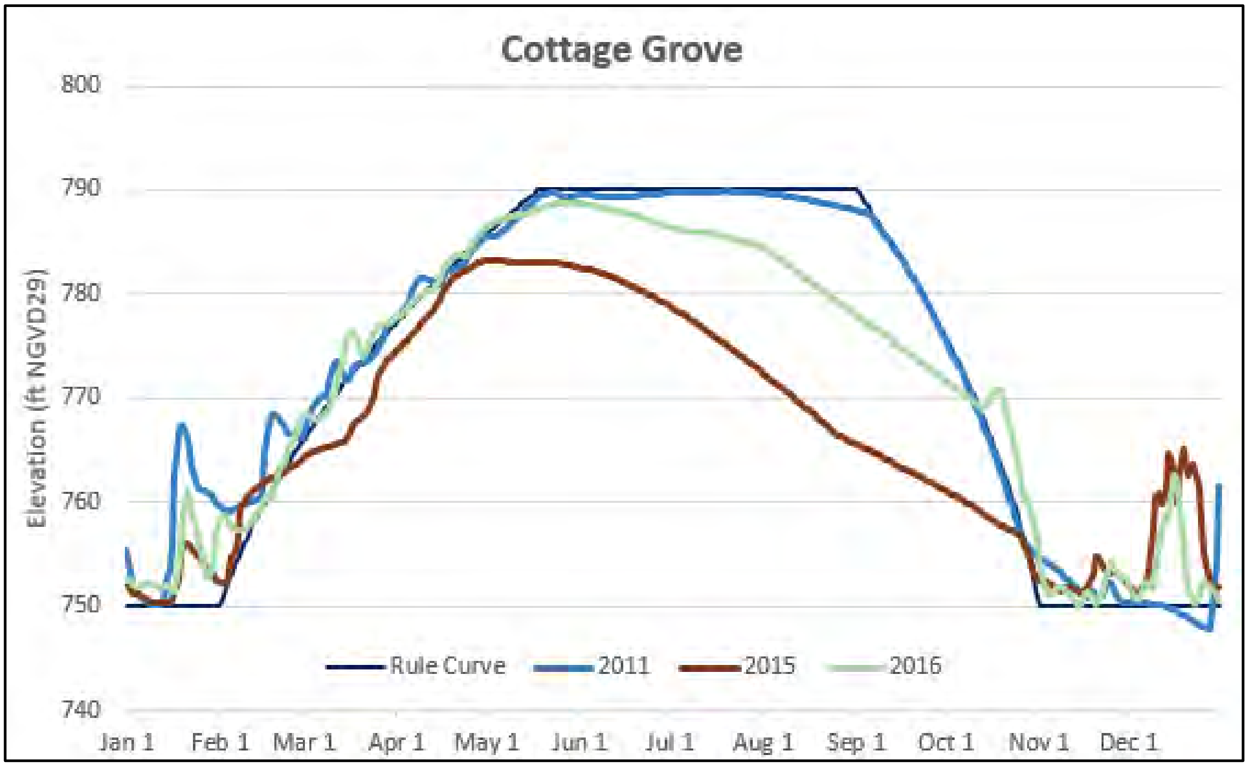


Figure 11-11. Cottage Grove reservoir water surface elevation across 2011, 2015 and 2016.

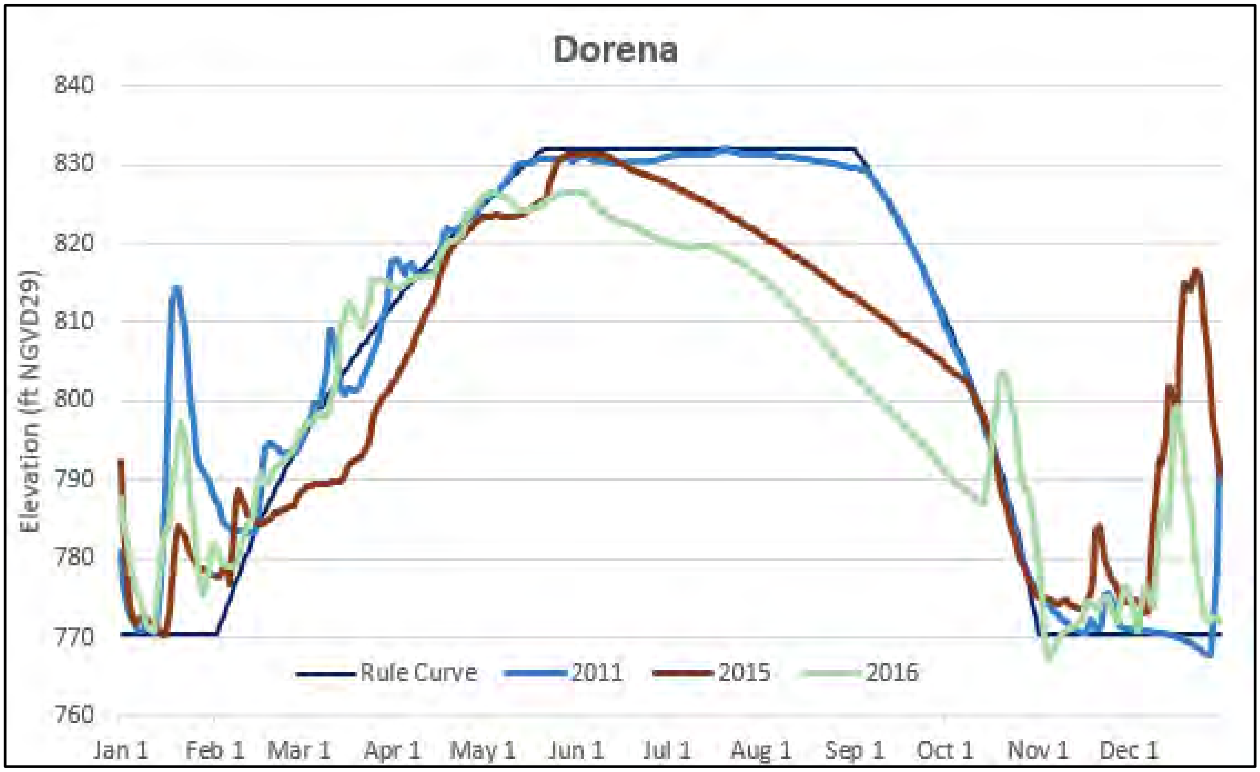


Figure 11-12. Dorena reservoir water surface elevation across 2011, 2015 and 2016.

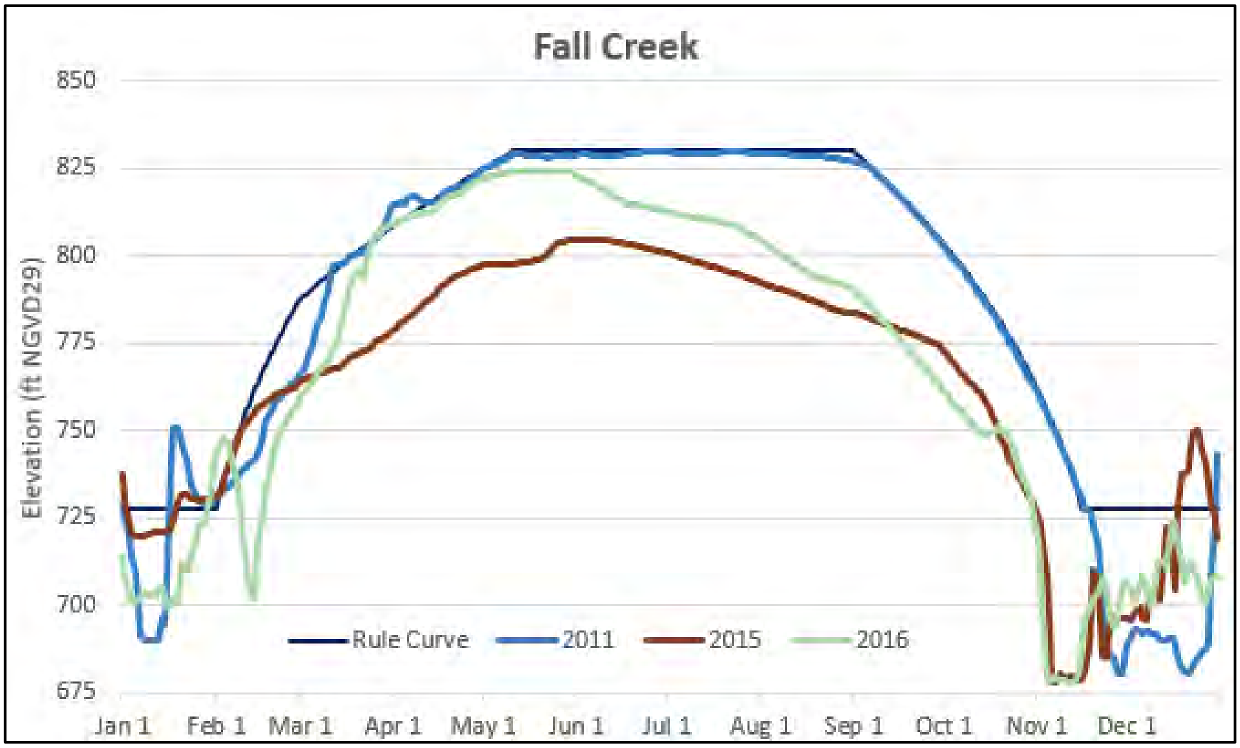


Figure 11-13. Fall Creek reservoir water surface elevation across 2011, 2015 and 2016.

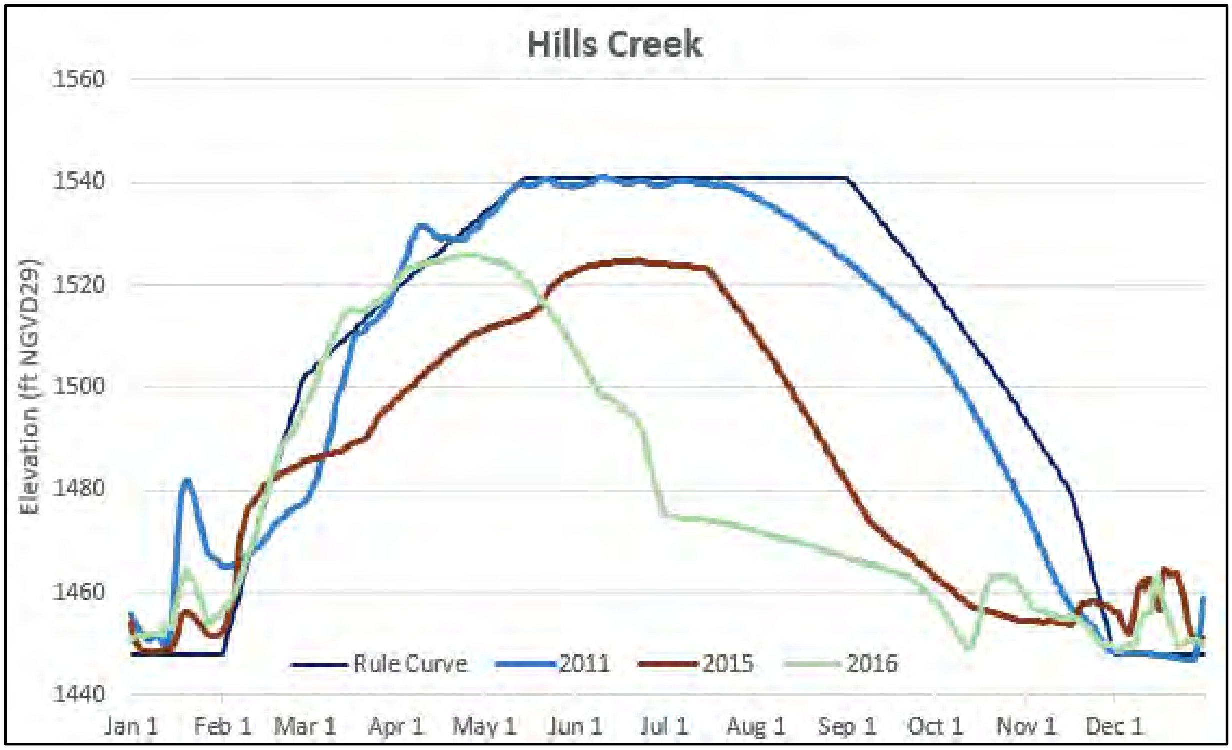


Figure 11-14. Hills Creek reservoir water surface elevation across 2011, 2015 and 2016.

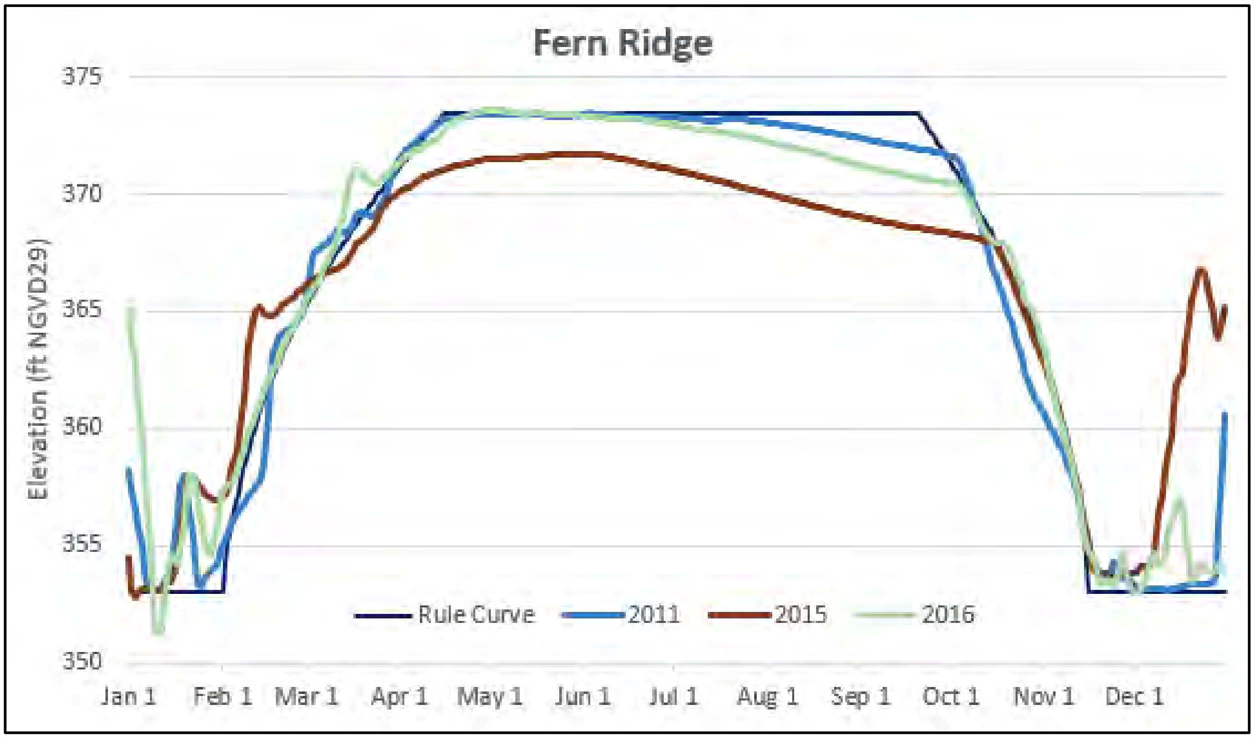


Figure 11-15. Fern Ridge reservoir water surface elevation across 2011, 2015 and 2016.

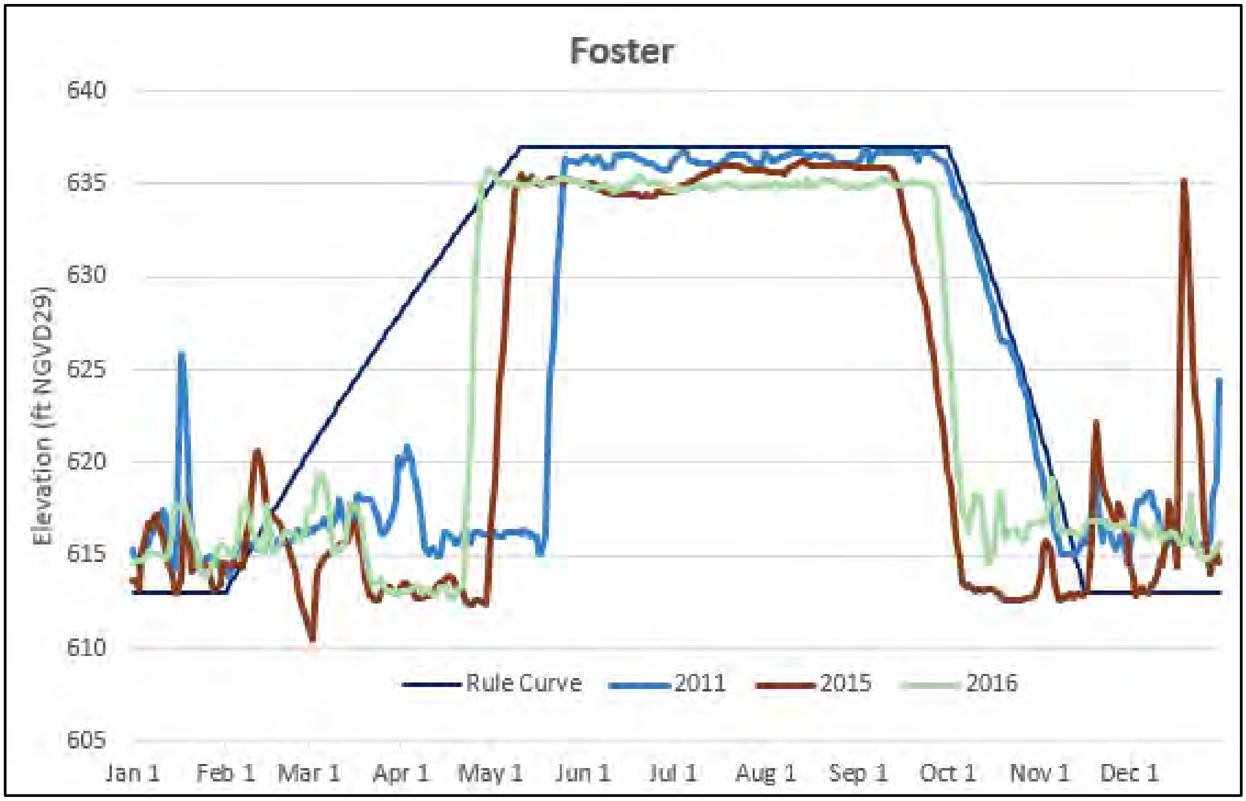


Figure 11-16. Foster reservoir water surface elevation across 2011, 2015 and 2016.

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