Testimony of Stephen Grinnell, P.E. of MWH regarding the State Water Resources Control Boards January 10-13, 2006 Hearing on the Yuba County Water Agency Extension Petition

1. My testimony is on the hydrology of the Yuba River for water year 2006 through 2007. I have completed analyses to determine the expected range of flow and water temperatures of the lower Yuba River under several sets of flow requirements which are detailed in this testimony. I have also analyzed the amounts of YCWA diversion deliveries for irrigation, and the potential for shortages in deliveries in Yuba County for 2007 under these flow requirements. I am a registered Civil Engineer in the State of California and my statement of qualifications has been submitted to the SWRCB with this testimony. (See exhibit YCWA-2.)

Analysis Results and Conclusions

2. The results of my analyses include a series of average monthly Yuba River flow exceedance probability plots for two locations, at the Smartville Gage and at the Marysville Gage, for two scenarios. The two scenarios are summarized in paragraph 4 of this testimony. The flow exceedance probability plots are in Appendix B of the Initial Study/Negative Declaration for the YCWA Extension Petition (exhibit YCWA-9) and are included in this testimony in Attachment A. My analysis also includes a series of monthly average Yuba River water temperature exceedance probability plots resulting from the average monthly flows for the two scenarios. The water temperature exceedance probability plots also are in Appendix B of the Initial Study/Negative Declaration for the extension petition and are included in this testimony in Attachment A.

3. In addition to determining expected flows and temperatures of the lower Yuba River I simulated 83 years of historical hydrology to analyze the potential increased risk of diversion delivery shortage that would occur in 2007 if YCWA had to comply in 2006 with the SWRCB RD-1644 Long Term flow requirements and the flow schedules of the Lower Yuba River Accord (LYR Accord), whichever is the higher requirement on any particular day, as compared to the risk of diversion delivery shortage that would occur in 2007 if YCWA had to comply in 2006 with the SWRCB RD-1644 Interim flow requirements and the flow schedules specified in exhibit 1 to the Fisheries Agreement For 2006 Lower Yuba River Pilot Program, of the Lower Yuba River Accord. (The Fisheries Agreement For 2006 Lower Yuba River Pilot Program is exhibit YCWA-7. The flow schedules in exhibit 1 to this agreement are referred to in this testimony as the "LYR Accord" flow schedules.) Both scenarios used operations to meet RD-1644 Long Term flow requirements in 2007. The results of this analysis show that if YCWA were required to meet the RD-1644 Long Term flows in addition to the LYR Accord flows in 2006, then the carryover storage in New Bullards Bar Reservoir on September 30, 2006 would

be reduced by an average of 30,000 acre-ft, if the 2006 water year were in the driest 20% of all years simulated, and would be reduced by from 40,000 to 70,000 acre-ft, if the 2006 water year were in the driest 10% of all years simulated. This range of reduction in carryover storage, if it were to occur, would result in shortages that could not be replaced with groundwater pumping by farmers in Yuba County if the 2007 water year were in about the 20% driest of all water years simulated.

Discussion

4. Yuba County Water Agency plans to implement a pilot program in 2006. The planned pilot program will change flows in the Yuba River below Englebright Dam. Because of the widely varying hydrology of the Yuba River from year to year, and because the 2006 water year is unknown at this time, the water year could result in a wide range of hydrologic conditions. An analysis has been conducted to examine the potential range of hydrologic conditions that could result under the two flow scenarios listed below as scenarios A and B.

A. Determination of the range and probability of occurrence of flows and temperatures in the Lower Yuba River that would occur without a pilot program and with YCWA operations to comply with the SWRCB RD-1644 Long Term flow requirements.

B. Determination of the range and probability of occurrence of flows and temperatures in the Lower Yuba River that would occur with the proposed pilot program, with YCWA operations to comply with the SWRCB RD-1644 Interim flow requirements and the flow schedules of the LYR Accord, whichever is the higher requirement on any particular day.

5. The YCWA 2006 pilot program will be accomplished by operating the Yuba River Development Project (YRDP) facilities to comply with one of 6 flow schedules in the LYR Accord flow schedules. The specific flow schedule that will be followed in 2006 will be determined using the North Yuba Index, which is the sum of the volume of active storage that remained in New Bullards Bar Reservoir on September 30, 2005 plus the total inflow volume to New Bullards Bar Reservoir in 2006. The amount of active storage in New Bullards Bar Reservoir on September 30, 2005 was 474,999 acre-ft (total storage of 708,999 - 234,000 minimum FERC license storage). New Bullards Bar total inflow for 2006 is calculated by adding the measured inflow from October 1, 2005 to the present date plus the forecasted inflow volume for the remainder of the 2006 water year. Complete descriptions of the North Yuba Index, and the LYR Accord flow schedules were provided as exhibits to the YCWA 2006 transfer petition filed with the SWRCB. Table 1 is a listing of the LYR Accord flow schedules for the Marysville Gage and the Smartville Gage.

Table 1. Instream Flow Schedules.

Marysville Gage (cfs)

Schedule	OCT		NOV	DEC	JAN	FEB	MAR	APR		MAY		JUN		JUL	AUG	SEP	Total Annual Volume (AF)
	1-15	16-31	1-30	1-31	1-31	1-29	1-31	1-15	16-30	1-15	16-31	1-15	16-30	1-31	1-31	1-30	
1	500	500	500	500	500	500	700	1000	1000	2000	2000	1500	1500	700	600	500	574200
2	500	500	500	500	500	500	700	700	800	1000	1000	800	500	500	500	500	429066
3	500	500	500	500	500	500	500	700	700	900	900	500	500	500	500	500	398722
4	400	400	500	500	500	500	500	600	900	900	600	400	400	400	400	400	361944
5	400	400	500	500	500	500	500	500	600	600	400	400	400	400	400	400	334818
6	350	350	350	350	350	350	350	350	500	500	400	300	150	150	150	350	232155

* Indicated flows represent average volumes for the specified time period. Actual flows may vary from the indicated flows according to established criteria.
* Indicated Schedule 6 flows do not include an additional 30 TAF available from groundwater substitution to be allocated according to established criteria.

Smartville Gage (cfs)

Schedule	OCT		NOV	DEC	JAN	FEB	MAR	APR		MAY		JUN		JUL	AUG	SEP	Total Annual Volume (AF)
	1-15	16-31	1-30	1-31	1-31	1-29	1-31	1-15	16-30	1-15	16-31	1-15	16-30	1-31	1-31	1-30	
A	700	700	700	700	700	700	700	700	-	-	-	-	-	-	-	700	-
B	600	600	600	550	550	550	550	600	-	-	-	-	-	-	-	500	-

* Schedule A used with Schedules 1, 2, 3 and 4 at Marysville.
* Schedule B used with Schedules 5 and 6 at Marysville.

6. An additional part of the LYR Accord is an end–of-September target storage in New Bullards Bar reservoir of 650,000 acre-ft, which is 55,000 acre-ft lower than the operational target of 705,000 acre-ft previously used by YCWA, which is part of the operational conditions agreed to with PG&E in the 1966 YCWA-PG&E Power Purchase Agreement. This lower storage target for the end of September results in increased releases from storage during the summer months of wetter years when storage is relatively high and storage operations govern the release schedule from New Bullards Bar Reservoir.

7. A part of the 2006 Pilot Program is a water transfer. Transfer water will be provided to the Delta for export by DWR by YCWA releasing water that would have otherwise been stored without the operations to meet the LYR Accord flow schedules or to meet the end-of-September storage target. Supplemental transfer water may also be released if YCWA decides to released water from storage by further reducing storage beyond that required to meet the flow schedules and target storage of the LYR Accord and the flows that would occur in the absence of the transfer. Additional transfer flows could also be released to the Delta if YCWA and Member Units decide to implement a groundwater substitution program in 2006. However, neither a supplemental surface water transfer nor a groundwater substitution program is included in the modeling described in this testimony and these flows are not included in the flow exceedance probability plots or the water temperature exceedance probability plots.

8. YCWA proposes to meet the flow schedules of the LYR Accord while continuing to meet the RD-1644 Interim flow requirements. In all months of most years, the LYR Accord flow is higher than the corresponding RD-1644 Interim flow requirement. However, this does not always occur. For example, part of the simulation of 83 years of historical hydrology included the year 1966, which is a Below Normal year under the Yuba River Index of RD-1644, and is a

Schedule 2 year under the North Yuba Index of the LYR Accord. The flows required for the months of April to September for these two flow standards are listed in Table 2. The resulting flow requirement that YCWA would implement is also listed as the result of the higher of the two requirements, determined for each day.

Table 2. Flow Requirements at Marysville Gage (cfs)

	April			May	June			July			August	September	
Flow Requirement	1 to 15	15 to 20	21 to 30	1 to 31	1	2 to 15	16 to 30	1	2	3 to 31	1 to 31	1 to 14	15 to 30
RD-1644 Interim	500	500	1000	1500	1050	800	800	560	390	250	250	250	250
LYR Accord	700	700	800	1000	800	800	500	500	500	500	500	500	500
Result	700	700	1000	1500	1050	800	800	560	500	500	500	500	500

Surface Water Modeling Description

9. The YCWA YRDP facilities were simulated using the Lower Yuba River Basin Model (LYRBM) developed by MWH for modeling the lower Yuba River. The model operates on a monthly time-step, and uses inflows that are a result of modeling historical hydrology routed through the Yuba River upper basin facilities which have been simulated to operate under current operational constraints. This upper basin simulation was completed using an HEC-5 model developed by Bookman Edmonston Engineering for the 2001 SWRCB Lower Yuba River hearings.

10. The HEC-5 model results are used as inputs to the LYRBM. These results define the monthly inflows to New Bullards Bar Reservoir, Englebright Reservoir, and flows from Deer Creek for 1922 through 2004. The primary operational objectives for reservoir operations in the LYRBM are flood control, agricultural water supply, power generation and instream flows. The features modeled by the LYRBM include New Bullards Bar Reservoir, Englebright Reservoir, the Lower Yuba River between Englebright Dam and Daguerre Point Dam, diversions at Daguerre Point Dam and the Lower Yuba River from Daguerre Point Dam to Marysville. The LYRBM has been verified by comparing results from this model against the results of the HEC-5 Yuba Basin model, which was reviewed by DWR for the 2001 SWRCB hearings.

11. The LYRBM simulation includes operations for several sets of requirements for the lower Yuba River and New Bullards Bar Reservoir. These sets of requirements include the following:

- Federal Energy Regulatory Commission (FERC) License for Yuba River Development Project

- 1966 Pacific Gas & Electric (PG&E) Power Purchase Contract (when implemented in the model)
- Flood Control Agreement Between YCWA and the U.S. Army Corps of Engineers
- 1993 Narrows I FERC License
- Yuba County Water Agency Water Right Permits and Member Unit Contracts
- Lower Yuba River Accord (when implemented in the model)
- RD-1644 flow requirements (Interim or Long Term flow schedules as selected)
- Minimum monthly power generation (set at 18,500 Megawatt-hours for all scenarios)
- Target storage operating line (varies by scenario)

12. New Bullards Bar Reservoir is the major storage facility of the YRDP and the primary operational feature of the LYRBM. The reservoir has a total storage capacity of 966,000 acre-feet with a minimum pool of 234,000 acre-feet, leaving 732,000 acre-feet of operable storage. A portion of the storage capacity, 170,000 acre-feet, is reserved from September through April for flood control. Releases from New Bullards Bar Reservoir are made through the Colgate Powerhouse, with a release capacity of 3,700 cubic feet per second (cfs), the dam's bottom outlet, or a gated spillway.

13. Englebright Reservoir has a total storage capacity of 70,000 acre-feet, but this capacity normally is used only for day-to-day regulation of flows. Englebright Reservoir receives flows from New Bullards Bar Reservoir and flows from the Middle and South Yuba Rivers. Releases are made through the Narrows I and II powerhouses, with a combined capacity of 4,170 cfs and over an uncontrolled spillway. Because the LYRBM operates on a monthly time-step, Englebright Reservoir storage is not simulated and all inflows to the reservoir are simulated as being released within the same time step. New Bullards Bar Reservoir operations take into consideration Englebright Reservoir inflows from the Middle and South Yuba Rivers and the Narrows I and II powerhouses capacities to obtain release amounts to meet downstream demands for each time-step.

14. The lower Yuba River refers to the 24-mile section of the river between Englebright Dam and the confluence with the Feather River south of Marysville. Instream flow requirements are specified on the lower Yuba River at the Smartville Gage immediately below Englebright Dam, and at the Marysville Gage near the confluence of the Yuba and Feather Rivers.

15. Daguerre Point Dam controls water elevations for irrigation diversions into the Hallwood-Cordua Canal (North Canal) and South Yuba Canal (South Canal). Browns Valley Irrigation District diverts water at its Pumpline Diversion Facility, approximately 1 mile upstream from Daguerre Point Dam. Cordua Irrigation District, Hallwood Irrigation Company, and Ramirez Water District receive water via North Canal from the north side of the Yuba River just upstream from the north abutment of Daguerre Point Dam. Brophy Water District, South Yuba Water

District, and Dry Creek Mutual Water Company receive water via the South Canal from the south side of the Yuba River just upstream from the south abutment of Daguerre Point Dam. For the LYRBM, all of these diversions are assumed to occur at Daguerre Point Dam.

Modeling the Lower Yuba River for 2006

16. For the 2006 Pilot Program, the LYRBM simulates water year 2006 (October 2005 through September 2006) and the 2007 water year (October 2006 through September 2007) using a Monte Carlo simulation. Because the sequence of hydrologic conditions in 2006 or 2007 cannot be predicted at this time, the Monte Carlo simulation uses historical conditions of each two-water-year pair from 1922 to 2004 to represent a range of historical hydrology with the starting reservoir conditions for water year 2006 and current operational constraints as listed above. Therefore, 83 two-year series of monthly hydrologic conditions are modeled and results are calculated. In other words, 1922 and 1923 hydrology are used for 2006 and 2007, then 1923 and 1924 hydrology are used for 2006 and 2007, then 1924 and 1925 and so on. For the 2006 water year, the starting storage condition (September 30, 2005 New Bullards Bar storage) modeled was 708,000 acre-feet. Using this starting condition for each simulation period, the Monte Carlo LYRBM simulates lower Yuba River flows for 24 months, using the 24 months of historical inflows for each of the 83 time periods of 1922 through 2004 as described above, generating a range of hydrologic conditions for the 2006 and 2007 water years varying from very wet to very dry. This range of possible outcomes then is used to statistically identify the potential occurrence of reservoir and river conditions for 2006. For the analysis to determine flows, temperatures and transfer storage and releases, only the months of April 2006 to February 2007 in the extension petition request period are used from the modeling.

17. Modeling results from the Monte Carlo simulation provide information about lower Yuba River operations, including reservoir storage, power generation, flows at Smartville, diversions from Daguerre Point Dam, and flows at Marysville. The flow results for the lower Yuba River are, in turn, used with a temperature model to predict the ranges of temperatures expected on the Lower Yuba River, as discussed below.

18. Surface water modeling for the Lower Yuba River 2006 transfer involved three alternative flow and operational scenarios:

- RD-1644 Long Term flow requirements
- Lower Yuba River Accord Flow and related requirements, where the RD-1644 Interim flow requirements are also complied with
- Lower Yuba River Accord Flow and related requirements, where the RD-1644 Long Term flow requirements are also complied with (this scenario is used for determination of

diversion delivery shortage risk under the LYR Accord combined with RD-1644 Long Term versus transfer amounts under the LYR Accord combined with RD-1644 Interim)

19. All three alternatives include the present level of demands for diversions from Daguerre Point Dam. One of the operational constraints of the YRDP and modeled is to attempt to protect against drought conditions and the potential for diversion delivery shortage. This is accomplished by maintaining a storage amount (carryover storage) on September 30 in New Bullards Bar Reservoir that would ensure providing at least 50 percent of local diversion demands in the following year, if the following year were to have 1-in-100-year drought conditions. This carryover storage amount is used to determine when and how much shortage in diversion deliveries would be imposed in the current year to maintain storage at the required carryover storage amount.

20. For the LYR Accord in 2006, the starting storage amount, used for the North Yuba Index, is already known, and therefore the probabilities of occurrence of the various flow schedules are based on the probabilities of different inflow volumes into New Bullards Bar Reservoir during the 2006 water year. The 2005 water year was very wet, and the 2005 YCWA-DWR transfer operations did not take place before September 30, 2005 because of Delta conditions. Therefore, YCWA operated to meet a September 30, 2005 target of 705,000 acre-ft, and actual storage was at 708,999 acre-ft on September 30, 2005. The amount of active storage in New Bullards Bar Reservoir therefore was 474,999 acre-ft. This amount of storage is well above the maximum amount of September 30th storage that would typically be reached under long term LYR Accord implementation, and is well above the range of storages resulting from simulations used to determining the North Yuba River Index value thresholds for the six flow schedules. Because of the high storage amount for calculating the North Yuba Index for 2006, the probability of occurrence of the various schedules for 2006 is skewed heavily toward the wetter schedules. For example, the LYR Accord flow schedules and North Yuba Index were designed so that either a schedule 4, 5, 6 or a Conference Year (the drier year flow schedules) would occur with a 15 percent probability. In contrast, for the 2006 water year, the probability that one of these schedule years will occur is 8.9 percent. Additionally, although it was statistically possible to have a conference year in 2006, the inflow into New Bullards Bar Reservoir would have had to be less than 25,001 acre-ft for this to occur. As of late December 2005, more than this amount of inflow already has occurred, so a Conference Year in 2006 is not possible. Table 3 shows the probability of occurrence for the LYR Accord schedules for 2006, using the active storage of 474,999 acre-ft to calculate the North Yuba Index and the statistical probability of New Bullards Bar Reservoir Inflow**.**

Table 3. Probability of Occurrence of LYR Accord Schedules for 2006

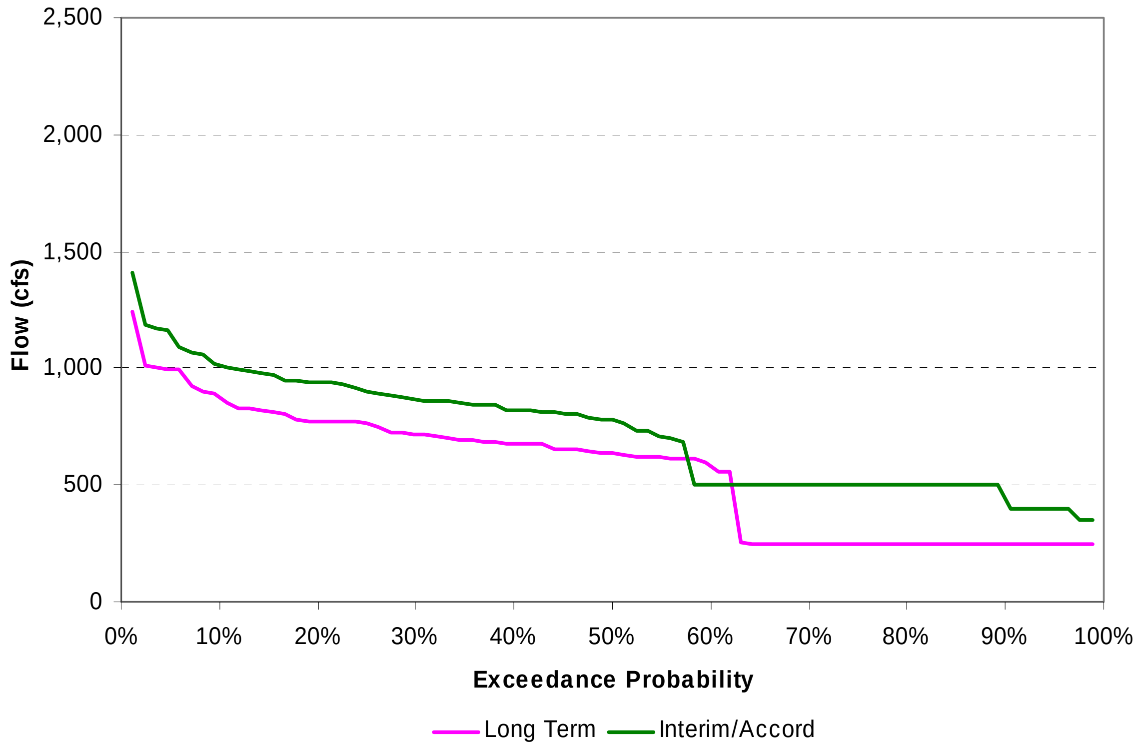
North Yuba Index	Percent	Schedule	% Exceedance
500	0.4%	Conf.	
693	2.0%	6	99.6%
820	3.0%	5	97.7%
920	3.5%	4	94.7%
1,040	5.5%	3	91.1%
1,400	21.8%	2	85.7%
> 1,400	63.9%	1	63.9%
Total	100%		

Simulation Results

21. The results of the Monte Carlo simulation are 83 separate series of monthly New Bullards Bar Reservoir storage values and flows in the Lower Yuba River. For each month (April 2006 through February 2007), the 83 values from the Monte Carlo simulation are ranked in order from highest to lowest and plotted against exceedance probability. Plotting position (rank/(1+ n), where n = 83) is used to determine exceedance probability. Figure 1 is an example of the results of flow exceedances for a single month (September 2006), simulated for the 83 years of hydrologic conditions, for the two flow requirement scenarios to be compared. Results for the months April 2006 through February 2007 are attached to this testimony as Attachment A. The two scenarios are labeled in the plots as "Long Term", representing the results of the flow analysis for simulated operations to RD-1644 Long Term flow requirements; and "Interim/Accord", representing the results of the flow analysis for simulated operations for the combination of the LYR Accord and the RD-1644 Interim flow requirements, with each day’s requirement being the greater of the LYR Accord requirement and the RD-1644 Interim requirement for that day.

22. The exceedance plot of Figure 1 has the percent probability that the flow is expected to be exceeded for the month on the X axis and has the monthly average flow on the Y axis. For any given flow, the plot can be read across from the Y axis to the scenario line of interest and then down to the resulting percentage of years during which the flow would be expected to be met or exceeded. Conversely, for any given percentage probability selected from the X axis, the plot can be read up to the selected scenario and then across to the Y axis to determine the flow that will be met or exceeded during the selected percentage of years. For example, from Figure 1 for flow at Marysville for September 2006, the flow of 500 cfs will be met or exceeded during 90% of years for Interim/Accord operations versus during only 62% of years for RD-1644 Long Term operations.

Figure 1.: Exceedance Probability of Yuba River Flow at Marysville for September 2006



Lower Yuba River Temperature Modeling

23. Temperature modeling of the lower Yuba River focuses on predicting temperatures at two locations on the Lower Yuba River: at Daguerre Point Dam and at the Marysville Gage. The purpose of the analysis is to determine the relative effect of flow on water temperature for the two locations of interest. This analysis provides a relative comparison of the estimated water temperatures that would occur with the 2006 Pilot Program versus the estimated water termperatures that would occur under the RD-1644 Long Term requirements without the Pilot Program. For the temperature model, water temperatures at Daguerre Point Dam and the Marysville gage are simulated on a monthly basis.

24. Temperature modeling analysis for the SWRCB 2000 hearings showed that the main variables for prediction of water temperature in the Lower Yuba River are the release temperature at Narrows II powerhouse, located below Englebright Reservoir, the Marysville air temperature, and the flow of the Lower Yuba River.

25. Temperatures for the analysis are calculated using flow output results from the LYRBM. These flows are used in a multivariate linear statistical model to calculate temperatures. The multivariate linear statistical model was determined through regression analysis on available historical flow and temperature data. A significant amount of temperature data has been collected

since 1999 on the Lower Yuba River. Before 1999, very little temperature data were available for the Daguerre Dam location. The new Daguerre Dam temperature data have allowed for regression analysis of this information to develop a statistical model for predicting temperatures at Daguerre Dam, which previously was done in an indirect manner and a less accurate approach. The new data also have provided greater insight into the relative influence of flow, air temperature and other influences, such as Yuba Goldfield flow returns to the Yuba River, on water temperature at the Marysville Gage.

26. Development of the statistical temperature model is done using daily data. Because of the strong influence of release temperature on water temperature at Daguerre Dam and Marysville Gage, the regressions use the Narrows II release temperature as an upstream condition. Both regressions were determined using historical daily data for 1999 through 2005. Flow results from the LYRBM are for the period of 1922 to 2004. Available temperature data for the two variables besides flow that are used in the statistical model are the Narrows II temperature release and the Marysville air temperature. Because of a lack of available historical daily data (or monthly data for Narrows II releases) for the full period of record, the Narrows II release temperature and Marysville air temperatures used in the temperature prediction are defined as a single series of 12 monthly values. These values are the historical average monthly Narrows II release temperature and Marysville daily mean air temperatures. These 12 month series of values are used for all scenarios modeled. As a result, all variation in water temperature from one scenario to another is a result of the flow amount variation.

Daguerre Point Dam Water Temperature

27. As previously described, Daguerre Point Dam is approximately 12 miles downstream of Englebright Dam. The terrain for this reach of the river varies significantly, changing from a steep, narrow gorge near Englebright Dam, to a wide, flat, open area near Daguerre Point. Also, multiple accretions and depletions exist between Englebright and Daguerre Point, including Deer Creek, Dry Creek, and the Yuba River Goldfields. While a flow gage is present at the mouth of Deer Creek, there are very limited temperature data below Smartville and no flow gages below Deer Creek except for the Marysville gage.

28. Historical data used for developing a statistical model of water temperatures at Daguerre Point Dam include the Yuba River flow at the Smartville gage, Narrows II release temperature, Daguerre Point Dam water temperature, and Marysville air temperature. Daily data for these variables are available from 1999 through 2005. Regression equations are used to relate Daguerre Point Dam water temperature to flow at the Smartville gage, Narrows II release temperature, and air temperature at Marysville.

29. The statistical temperature model resulting from regression analysis use a single set of coefficients for all months. The independent variables for the model are: Narrows II release temperature, flow at Smartville, and average monthly air temperature at Marysville. The representative equation has the form:

DGP = 0.83 * (N2) + 0.16*(Air) -7.79E-5*(YRS)

Where:

DGP = Water temperature at Daguerre Point Dam (degrees Fahrenheit)

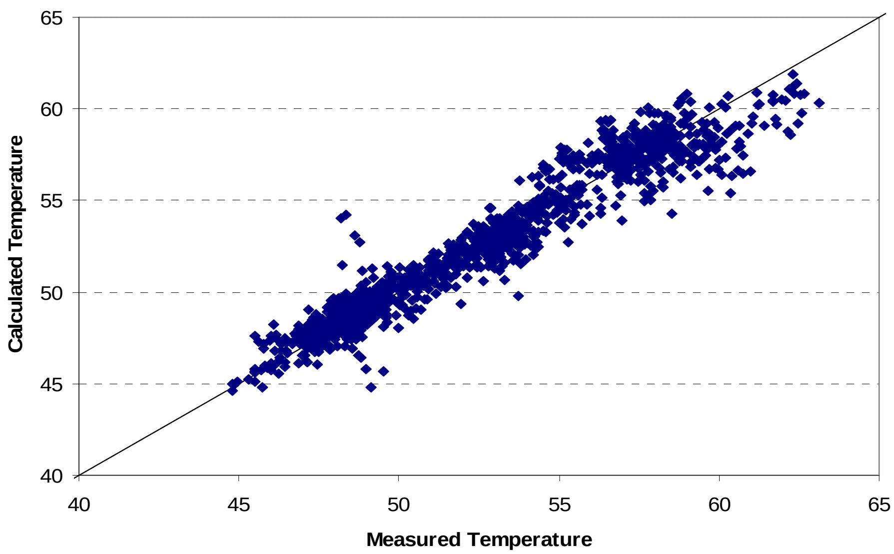
N2 = Release temperature of Narrows II powerhouse (degrees Fahrenheit)

Air = Air temperature at Marysville (degrees Fahrenheit)

YRS = Flow at Smartville (cfs)

30. As shown in the equation, the Narrows II release temperature has the strongest influence on water temperatures at Daguerre Dam, with a 0.83 coefficient. This relationship has an R-squared value of 0.95. Figure 2 is a scatter plot of the calculated daily water temperature at Daguerre Point Dam versus the measured daily water temperature.

Figure 2. Measure Daguerre Point Dam Daily Water temperature Versus Calculated Daily Water Temperature



Marysville Gage Water Temperature

31. The Marysville gage is approximately 6 miles downstream from Daguerre Point Dam. The river in this reach is relatively wide and flat, with very little cover or shade. Few accretions or depletions are present in this reach. Because of diversions at Daguerre Point Dam, the flow

below Daguerre Point Dam to the confluence with the Feather River is lower than the flow above the dam. For predicting the temperature at Marysville gage, a two-step process needs to be used. First, the temperature at Daguerre is calculated for a time step as described above. Then this temperature is used as the upstream release temperature for calculating the Marysville Gage flow temperature. For simplification, and to reduce error in the analysis, rather than predicting a temperature at Daguerre and then using this as an input to the prediction for temperature at Marysville, the variables for predicting the Daguerre temperature are used directly in the regression analysis for determining the statistical model for the Marysville temperature and a single equation is used to calculate the Marysville Gage water temperature.

32. Available historical data for developing a statistical model of water temperature at the Marysville gage included Daguerre Point Dam water temperature, Marysville air temperature, Yuba River flow at the Marysville gage, and Marysville water temperature. Daily historical data are available from 1999 to 2005. Analysis is similar to that described for Daguerre Point Dam water temperature. The general representative equation has the form:

MRY = A * (N2) + B*(Air) + C*(YRS)+D*(MRYF)

Where:
MRY = Water temperature at Marysville gage (degrees Fahrenheit)
N2 = Release temperature of Narrows II powerhouse (degrees Fahrenheit)
Air = Air temperature at Marysville (degrees Fahrenheit)
YRS = Yuba River flow at Smartville gage (cfs)
MRYF = Yuba River flow at Marysville gage (cfs)

33. As indicated by the equation, the variables for the Daguerre Point Dam water temperature prediction (Narrows II release temperature, flow at Smartville and Marysville air temperature) are included in the variables for the Marysville Gage water temperature prediction.

34. Observation of the relationship between flows and temperatures shows a reduction in influence of flows on water temperatures as flows increase. Therefore, a linear regression providing a singular linear relationship between flow and temperature will tend to overestimate predicted water temperature at high flows and underestimate water temperatures at low flows. To capture this nonlinear effect in a simplified quasi-linear relationship, different sets of coefficients are used for Marysville Gage flows above and below a transition flow, where the flow-temperature relationship weakens. Analysis showed that the most accurate use of a transition point for Marysville Gage flow varied by month in order to maintain continuity as different Narrows II temperatures and Marysville air temperatures are used for each month. Transition flow points were determined through iteration of 50 cfs intervals to ensure no sudden changes in temperature prediction occur for a small increase or decrease in flow at the transition point.

Figure 3 is an example of the relationship between Marysville Gage flow and Marysville Gage temperature for a given release temperature and a given Marysville air temperature. Table 4 shows the two sets of coefficients for prediction of the Marysville Gage water temperature and Table 5 shows the monthly Marysville Gage transition flow rate used to determine which equation to is applied to each time step.

Figure 3. Relationship of Flow versus Temperature at the Marysville Gage for August

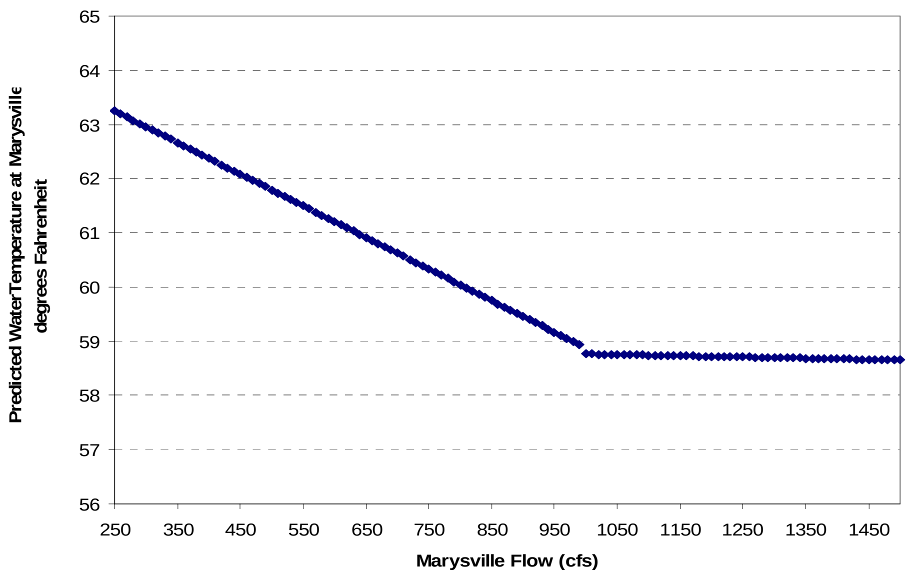


Table 4. Coefficients for Water Temperatures at Marysville Gage

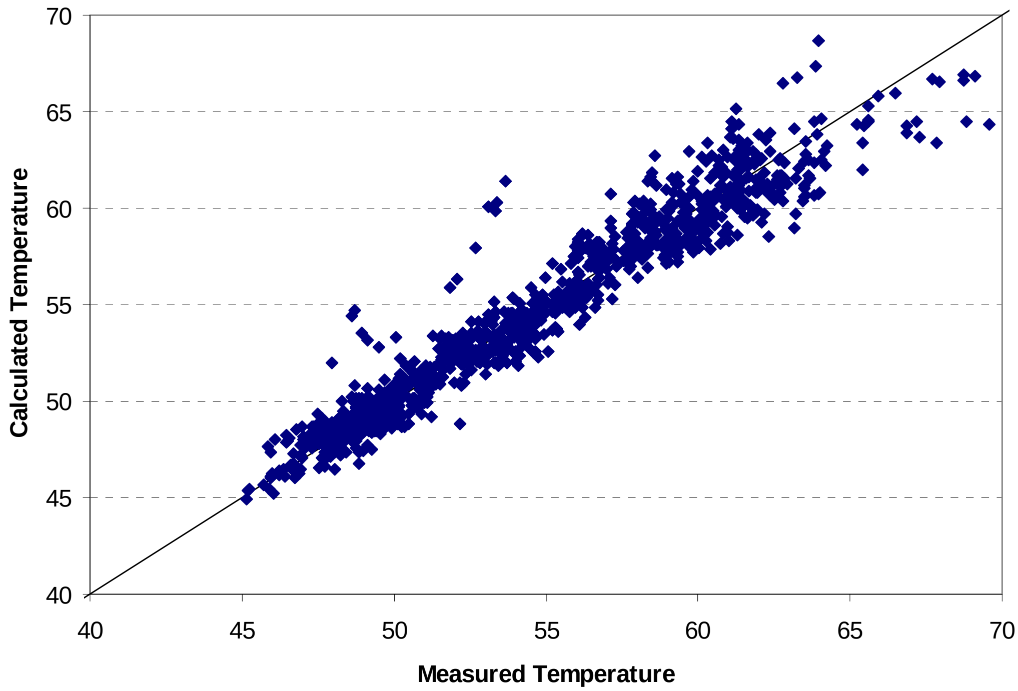
	A	B	C	D
Flow < Q	0.76	0.30	2.73E-4	-6.11E-3
Flow > Q	0.81	0.20	-3.23E-4	9.30E-5

Table 5. Transition Flow Rates for Calculating Water Temperatures at Marysville Gage

Month	Flow (Q) (cfs)
January	450
February	550
March	550
April	650
May	900
June	950
July	1,050
August	1,000
September	950
October	750
November	550
December	450

35. The resulting temperature predictions, when compared to measured temperatures for the Marysville Gage flow, have an R-squared value of 0.95. Figure 4 is a scatter plot of the calculated daily water temperature at Marysville Gage versus the measured daily water temperature using the equation and two sets of coefficients and transition flows listed above.

Figure 4. Measure Marysville Gage Daily Water temperature Versus Calculated Daily Water Temperature

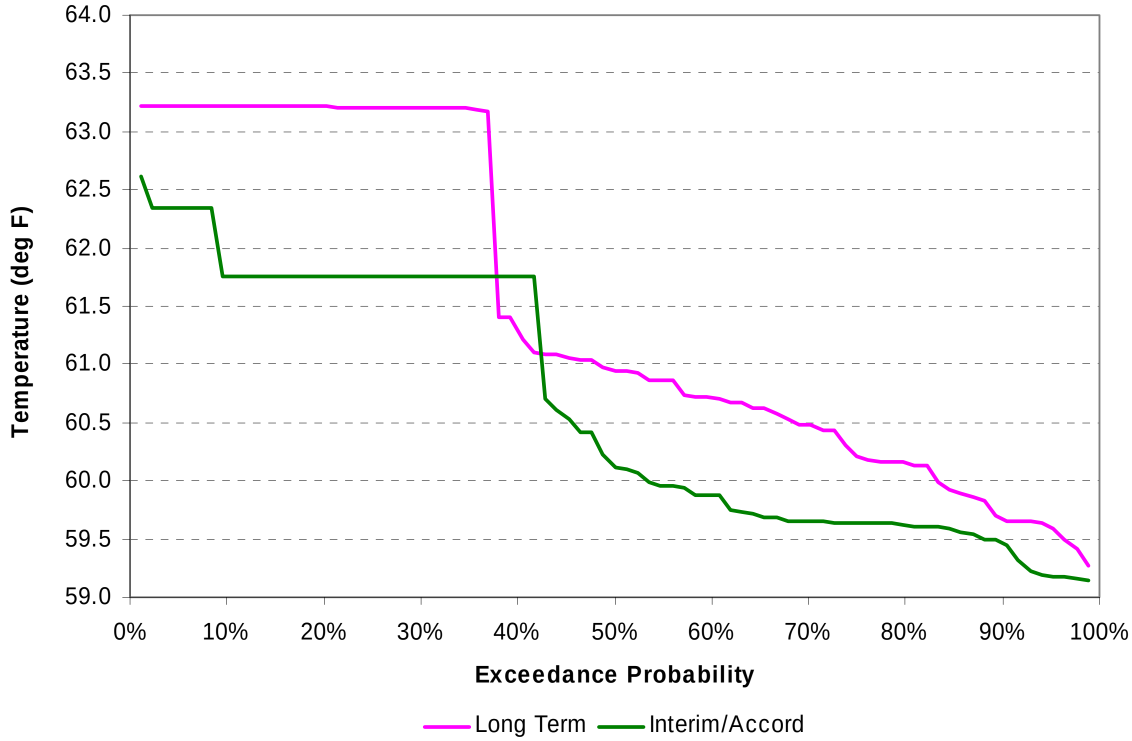


36. The results of the temperature modeling are shown in Attachment A as exceedance probability plots each month of April 2006 through February 2007 for the two flow scenarios. The two scenarios are labeled in the plots as "Long Term", representing the results of the temperature analysis for simulated operations to RD-1644 Long Term flow requirements; and "Interim/Accord", representing the results of the temperature analysis for simulated operations for the combination of the LYR Accord and the RD-1644 Interim flow requirements, with each day’s requirement being the greater of the LYR Accord requirement and the RD-1644 Interim requirement for that day. Figure 5 is a plot of the exceedance probability of water temperature at the Marysville Gage for September 2006.

37. The exceedance plot of Figure 5 has the percent probability that the water temperature is expected to be exceeded for the month on the X axis and has the monthly water temperature on the Y axis. For any given temperature, the plot can be read across from the Y axis to the scenario line of interest and then down to the resulting percentage of years that the temperature would be

expected to be met or exceeded. Conversely, for any given percentage probability selected from the X axis, the plot can be read up to the selected scenario and then across to the Y axis to determine the temperature that will be met or exceeded the selected percentage of years. For example, from Figure 5 for flow at Marysville for September 2006, the temperature of 62 degrees will be met or exceeded during 9% of years for Accord and Interim operations versus during 38% of years for RD-1644 Long Term operations.

Figure 5. Exceedance Probability of Yuba River Water Temperature at Marysville for September 2006



Impacts of Operating to RD-1644 Long Term in 2006 with the LYR Accord

38. The LYR Accord flow schedules were developed to maximize the use of the hydrology of the Yuba River and the capacity of YRDP facilities to provide fishery benefits and to provide water for transfer while maintaining a reliable level of water supply for local irrigation needs. If the effective date of the RD-1644 Long Term flow requirements, which presently is April 21, 2006, is not extended to March 1, 2007, then YCWA will be required to meet the RD-1644 Long Term flow requirements starting on April 21, 2006. This would require more water to be released, if 2006 is a drier water year type, than would be required to be released under the RD-1644 Interim flow requirements. The effect of these additional required releases would be to reduce September 30, 2006 storage in New Bullards Bar Reservoir in a Dry, Critical or Extreme Critical year (as defined in RD-1644), if one of these water-year types were to occur in 2006, below the levels that would occur with the RD-1644 Interim flow requirements and the LYR

Accord. The estimated September 30, 2006 storage reduction with the LYR Accord and RD-1644 Long Term flow requirements below the levels that would occur with the LYR Accord and RD-1644 Interim flow requirements averages 30,000 acre-ft for Dry, Critical and Extreme Critical years, which are about 25% of all modeled years. For about the 10% driest of all modeled years, the storage reduction would range from 40,000 acre-ft to 70,000 acre-ft. With the LYR Accord and operations to comply with the RD-1644 Long Term flow requirements, the average storage amount on September 30, 2006, if the 2006 water year is in the 10% driest years, would be 410,000 acre-ft.

39. Using a September 30, 2006 storage amount of 410,000 acre-ft, the LYRBM was used to simulate conditions in the 2007 water year, with operations to comply with RD-1644 Long Term flow requirements, and no LYR Accord operations. The results of simulation of the historical hydrology of 1922 through 2004 for these starting conditions indicate about a 30% chance of shortages greater than 40,000 acre-ft in deliveries to YCWA's Member Units during 2007. The average shortage amount, in the water-year types in which a shortage occurs, is estimated to be 173,000 acre-ft, or about 50% of the diversion demand for YCWA's deliveries to its Member Units.

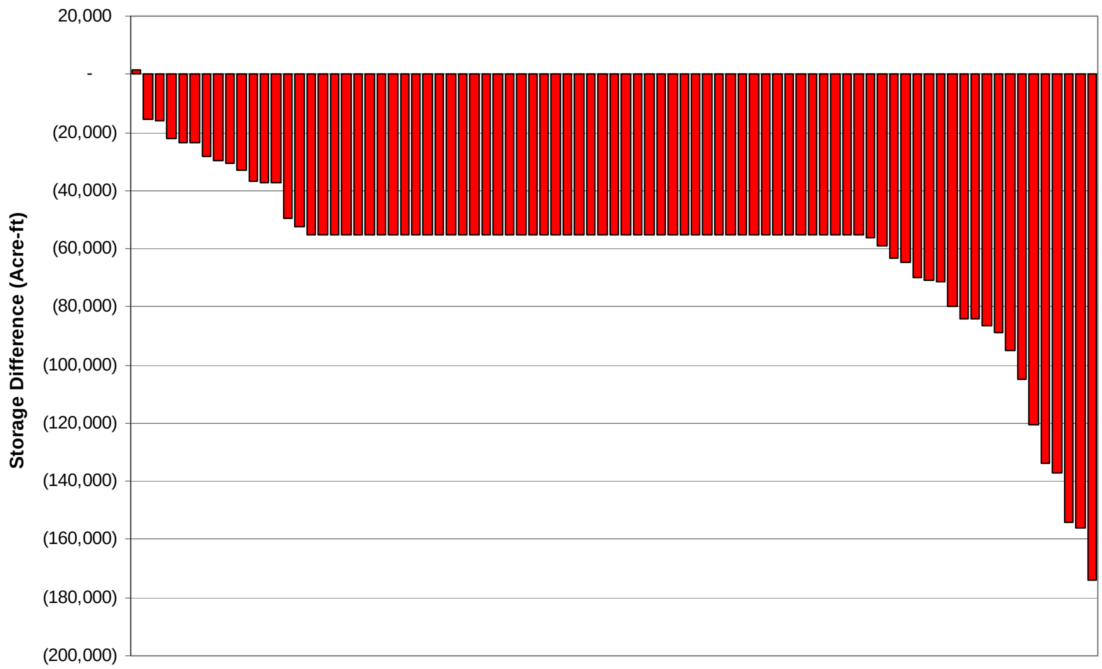
40. YCWA, in cooperation with its Member Units, has been developing a conjunctive use program that would be used to support the LYR Accord during drought conditions. Although this analysis has assumed that the LYR Accord would not be implemented in 2007 and that YCWA would operate only to the RD-1644 Long Term flow requirements, the pumping capacity of the conjunctive use program nevertheless would be available to attempt to meet water supply shortages. However, the total estimated groundwater pumping capacity for irrigation in the Member Units' service areas is about 100,000 to 120,000 acre-ft. Therefore, any shortage amount above 100,000 acre-ft would not be able to be replaced with groundwater. For the simulation described above, the diversion delivery shortage would be greater than 100,000 acre-ft in about 20% of all modeled years when the September 30, 2006 storage was 410,000 acre-ft. Based on the simulation results, the additional storage reduction resulting from operations to comply with RD-1644 Long Term flow requirements in 2006 with LYR Accord operations, which range from 40,000 to 70,000 acre-ft in the 10% driest years, could not be made up through groundwater pumping in 2007 if shortages of more than 100,000 acre-ft were to occur.

Risks of Operating to LYR Accord in 2006 and to RD-1644 Long Term in 2007

41. For all years except for one, the LYR Accord operations with complying to RD-1644 Interim flow requirements in 2006 result in substantially lower storage in New Bullards Bar Reservoir at the end of September 2006 than operations to comply only with RD-1644 Long Term flow requirements. The difference in end of September 2006 storage between these two scenarios is shown in Figure 6. The figure plots the difference between the RD-1644 Long Term end of

September 2006 storage in New Bullards Bar Reservoir and the LYR Accord end of September 2006 storage in New Bullards Bar Reservoir on the y axis and the 83 simulated years of hydrology are ranked from smallest to largest difference along the x axis. As shown in Figure 6, the storage difference is almost always equal to or greater than 55,000 acre-ft and has a maximum difference of just under 180,000 acre-ft.

Figure 6. Difference in New Bullards Bar Reservoir end of September 2006 Storage resulting from operations to RD-1644 Long Term versus operations to LYR Accord and RD-1644 Interim flow requirements



42. The LYR Accord flow schedules were derived to maximize flows in the lower Yuba River using a combination of natural runoff and storage in New Bullards Bar Reservoir. The LYR Accord was designed to be a multi-year program that maximized the use of storage in drier years by accounting for lower storage in the following year through the use of the North Yuba Index, which includes a term for the active storage carried over from the previous year. This approach allows for the maximal use of storage to best meet all needs of the lower Yuba River. With the LYR Accord flow schedules in effect in 2006 and without the implementation of the LYR Accord's North Yuba Index, LYR Accord flow schedules, and other LYR Accord components, such as the conjunctive use program, in 2007, and instead having to comply with RD-1644 Long Term flow requirements in 2007, the risk of shortages as described above would be very substantial.

Attachment A

Exceedance Probability Plots for flow and Temperature at Marysville Gage and Smartville for April 2006 to February 2007

Figure X-1: Exceedance Probability of Yuba River Flow at Smartville for April, 2006

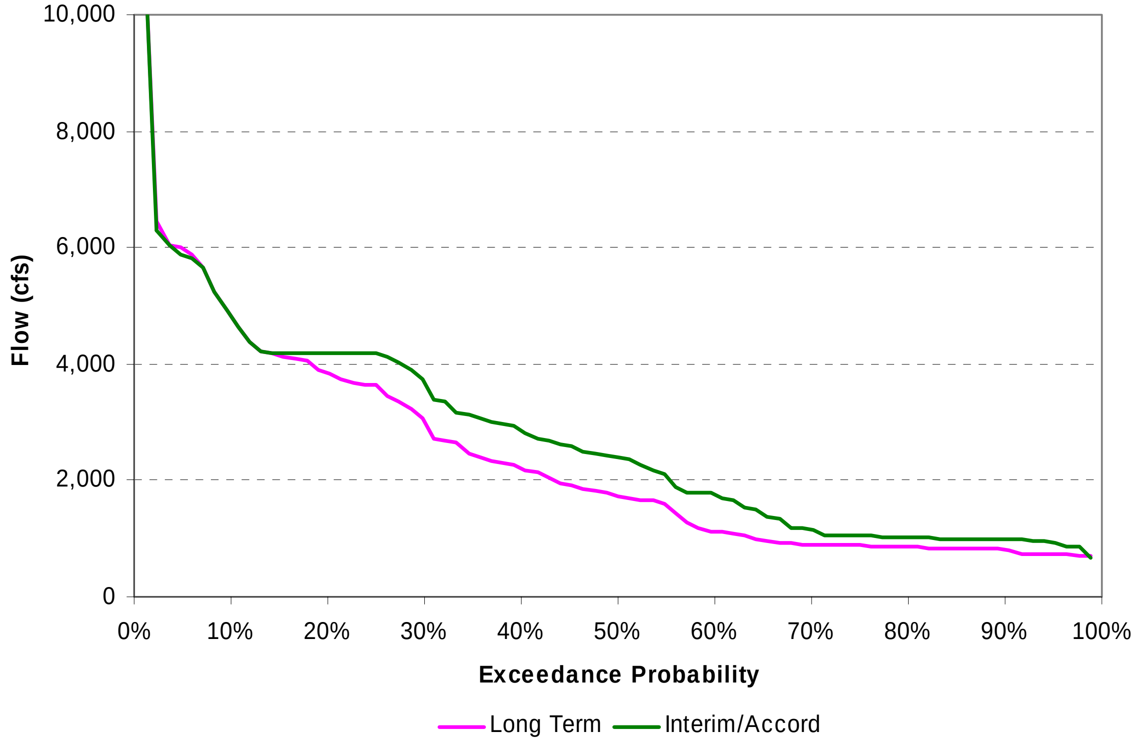


Figure X-2: Exceedance Probability of Yuba River Flow at Marysville for April, 2006

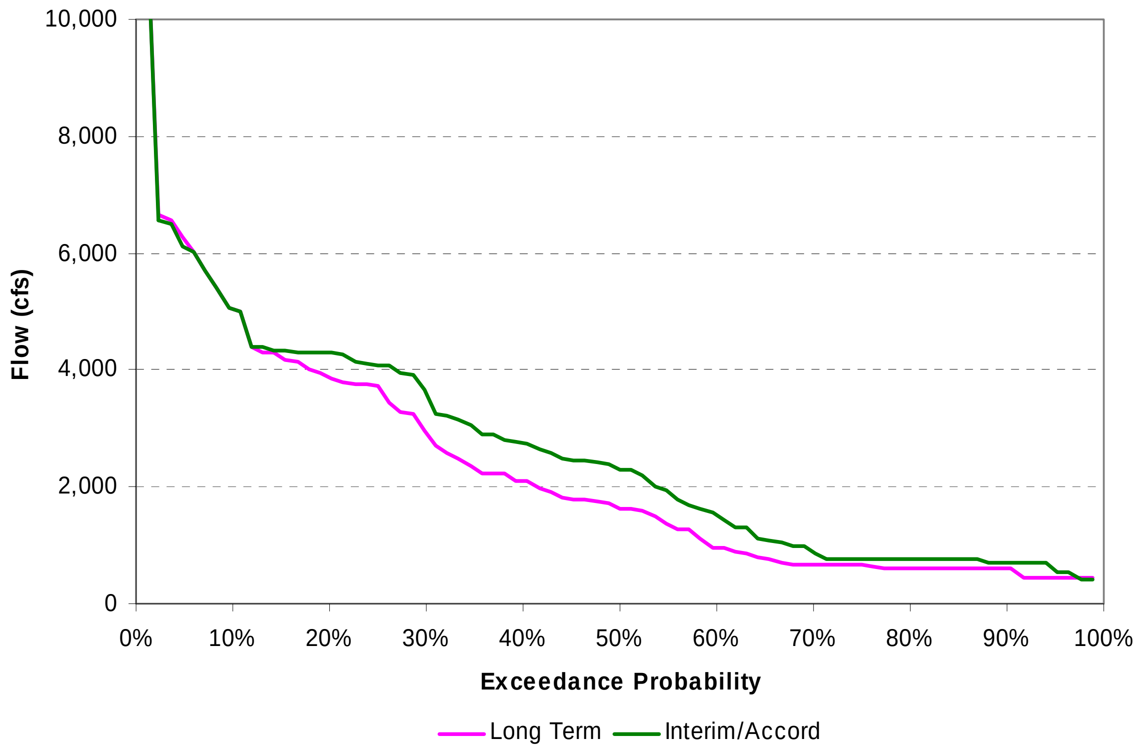


Figure X-3: Exceedance Probability of Yuba River Flow at Smartville for May, 2006

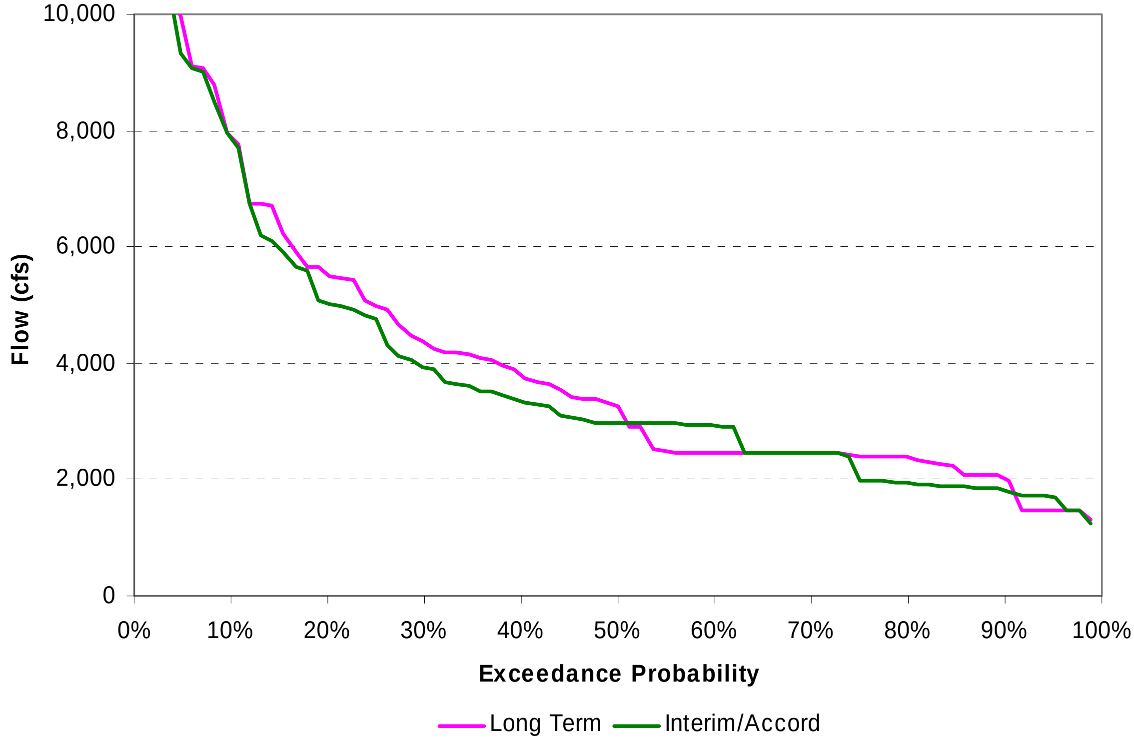


Figure X-4: Exceedance Probability of Yuba River Flow at Marysville for May, 2006

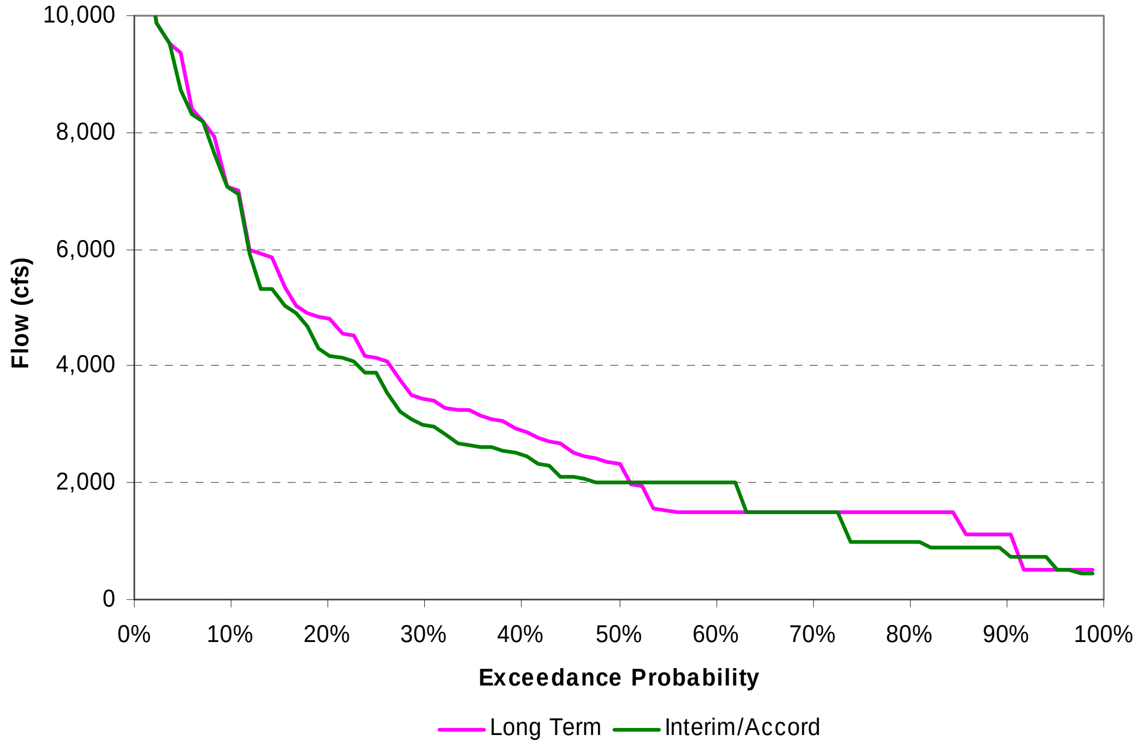


Figure X-5: Exceedance Probability of Yuba River Flow at Smartville for June, 2006

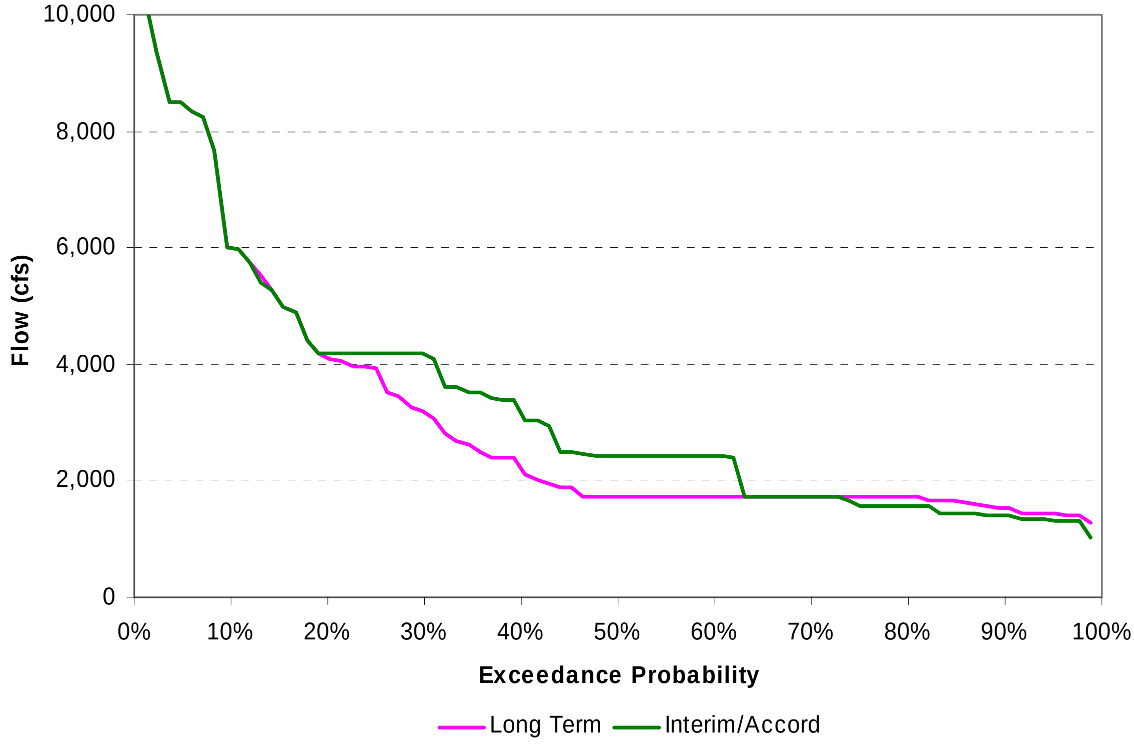


Figure X-6: Exceedance Probability of Yuba River Flow at Marysville for June, 2006

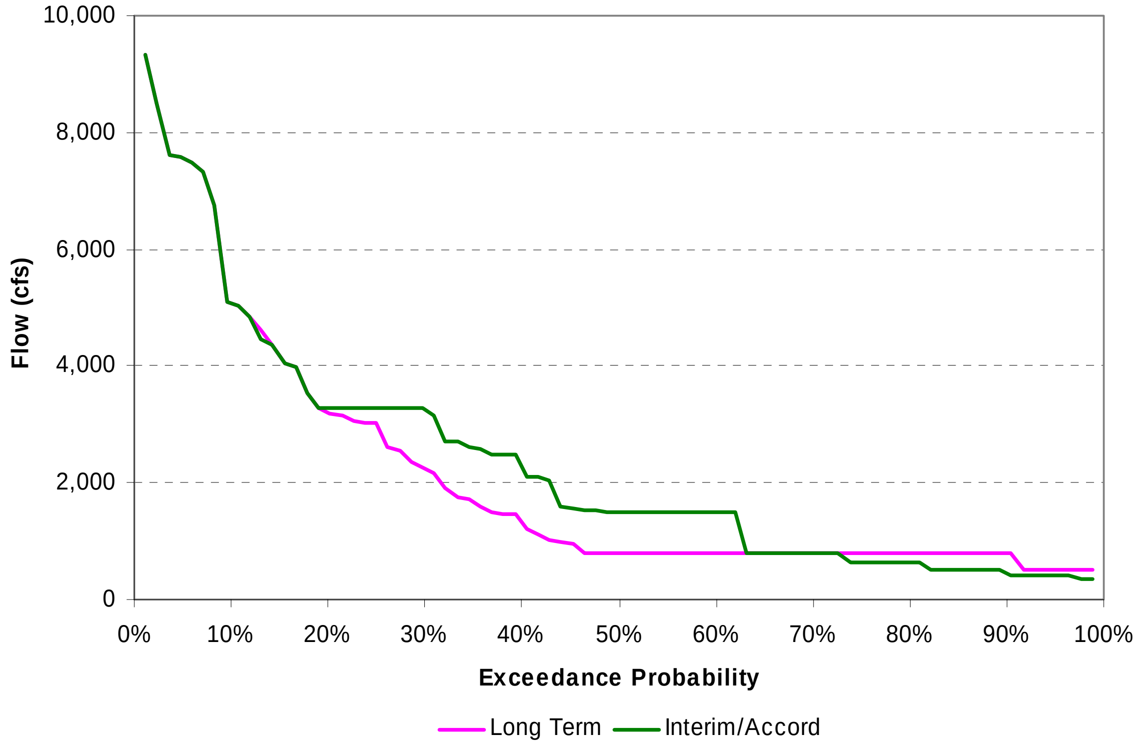


Figure X-7: Exceedance Probability of Yuba River Flow at Smartville for July, 2006

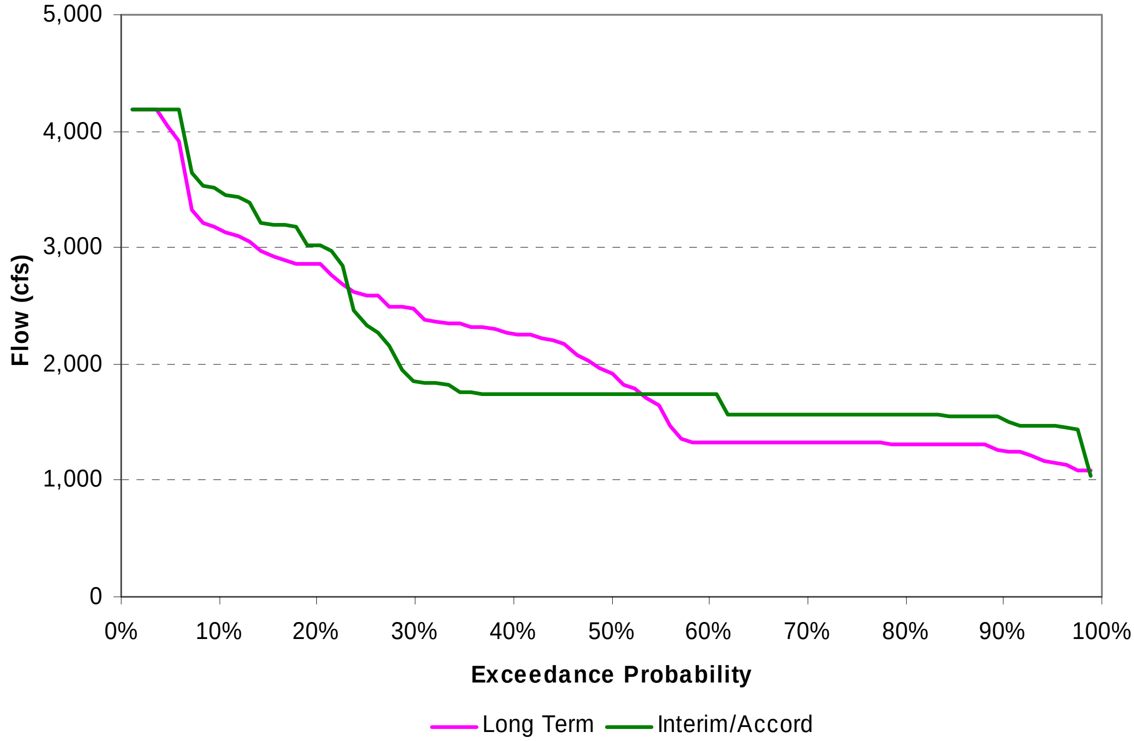


Figure X-8: Exceedance Probability of Yuba River Flow at Marysville for July, 2006

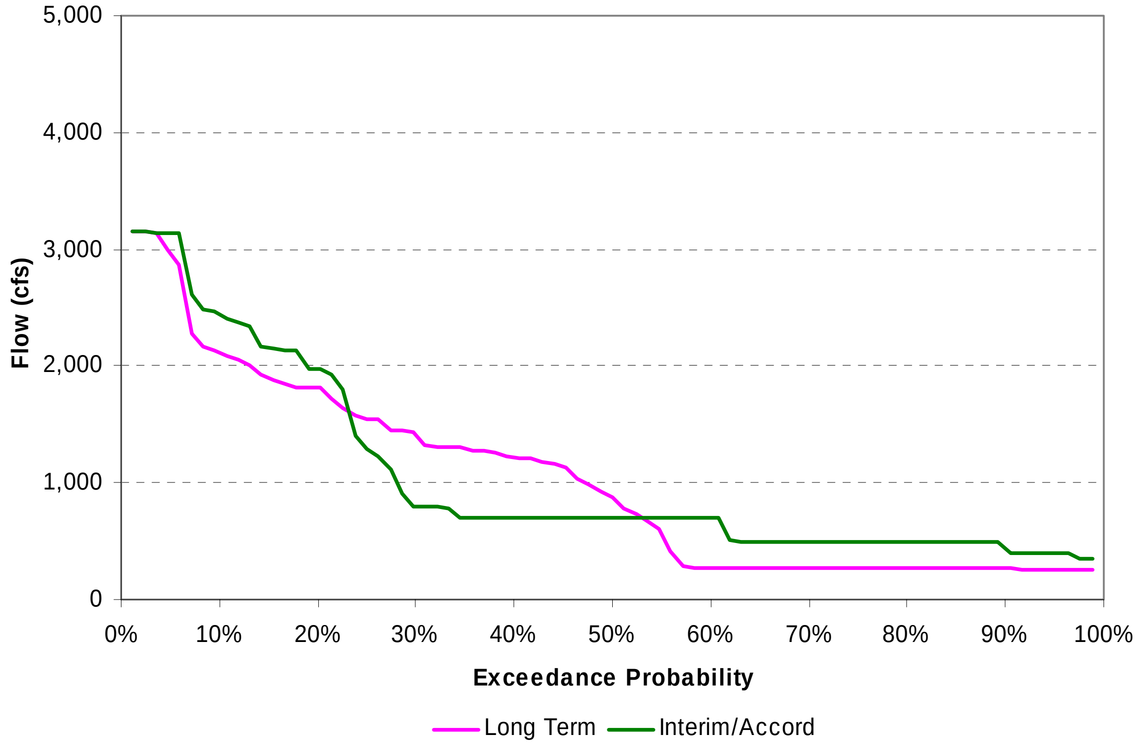


Figure X-9: Exceedance Probability of Yuba River Flow at Smartville for August, 2006

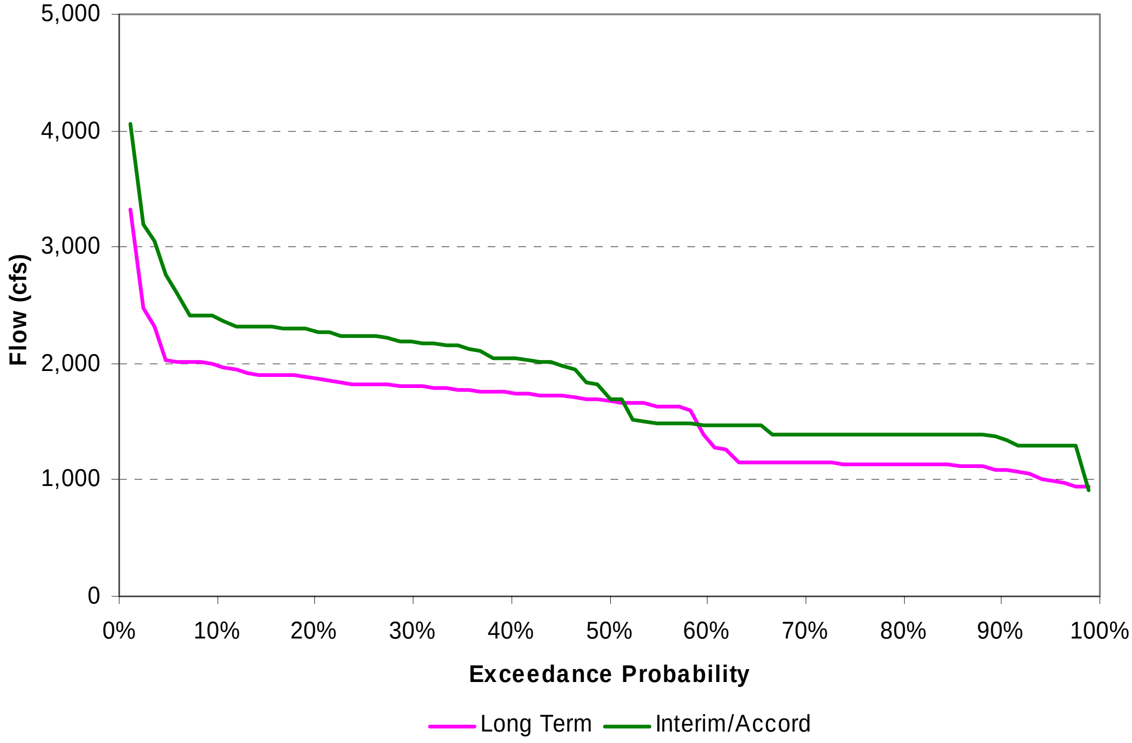


Figure X-10: Exceedance Probability of Yuba River Flow at Marysville for August, 2006

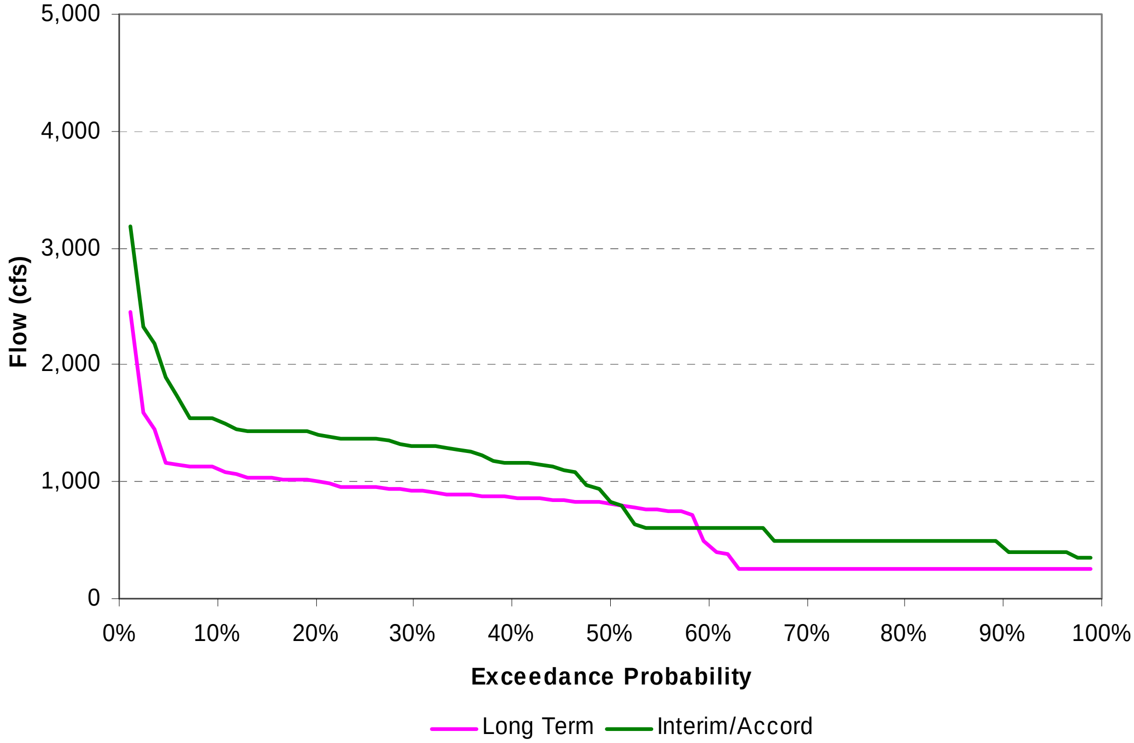


Figure X-11: Exceedance Probability of Yuba River Flow at Smartville for September, 2006

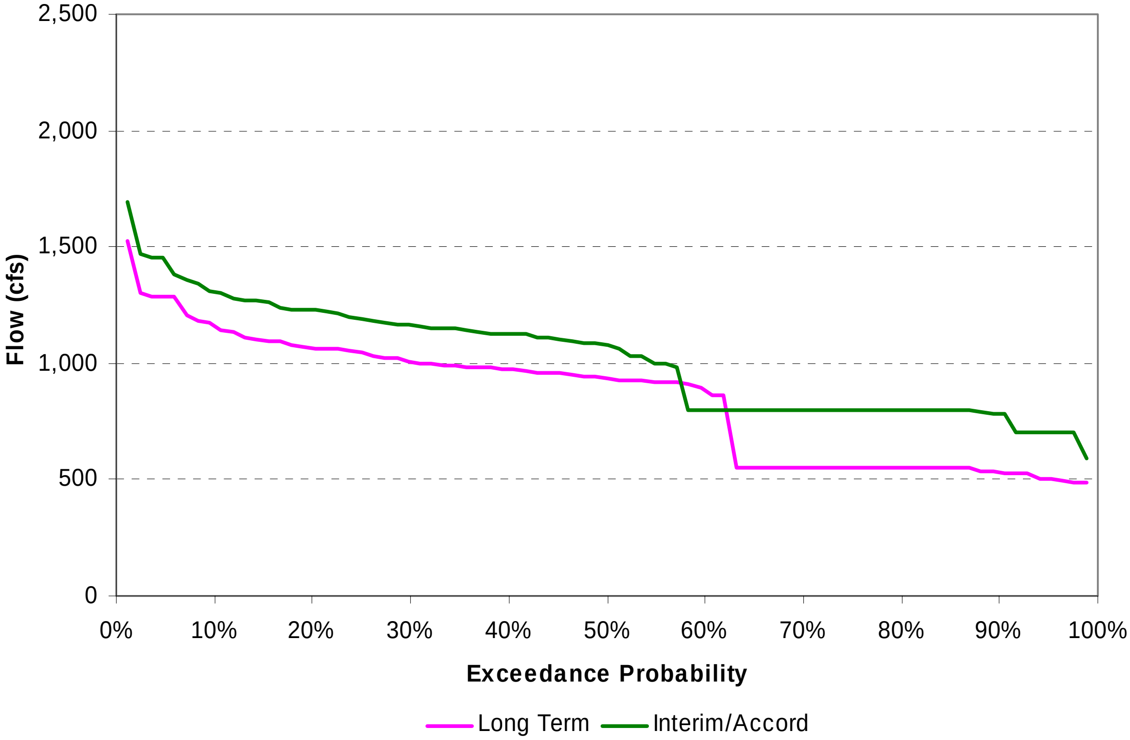


Figure X-12: Exceedance Probability of Yuba River Flow at Marysville for September, 2006

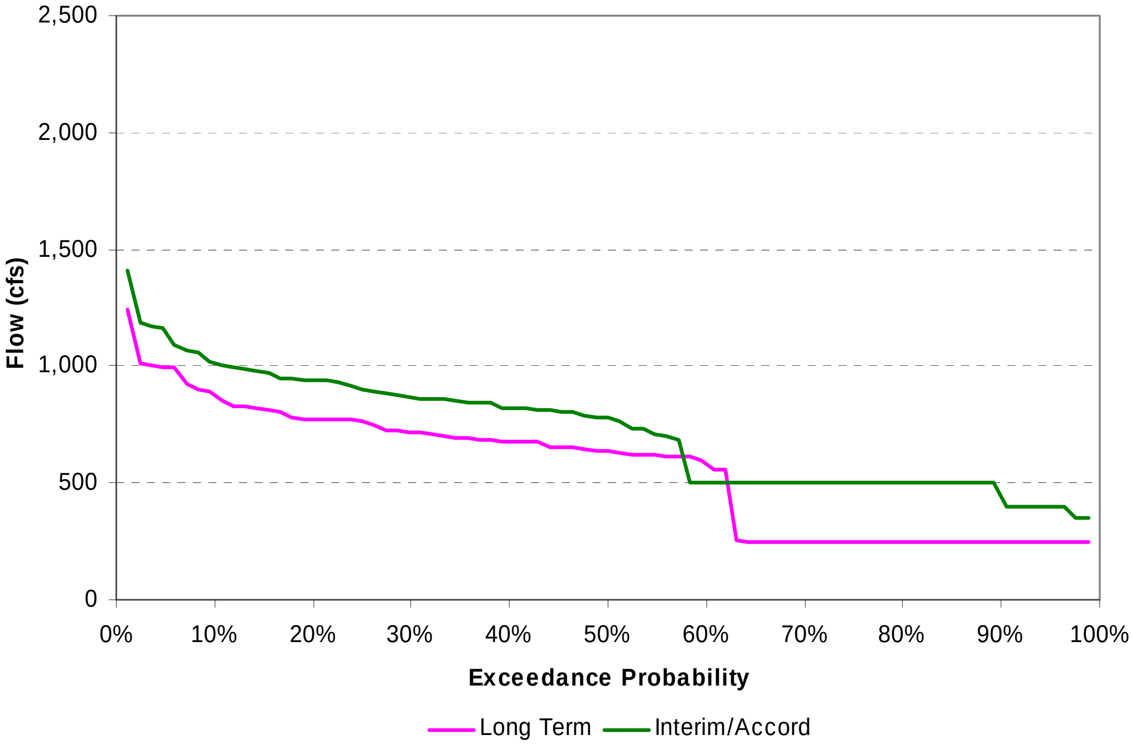


Figure X-13: Exceedance Probability of Yuba River Flow at Smartville for October, 2006

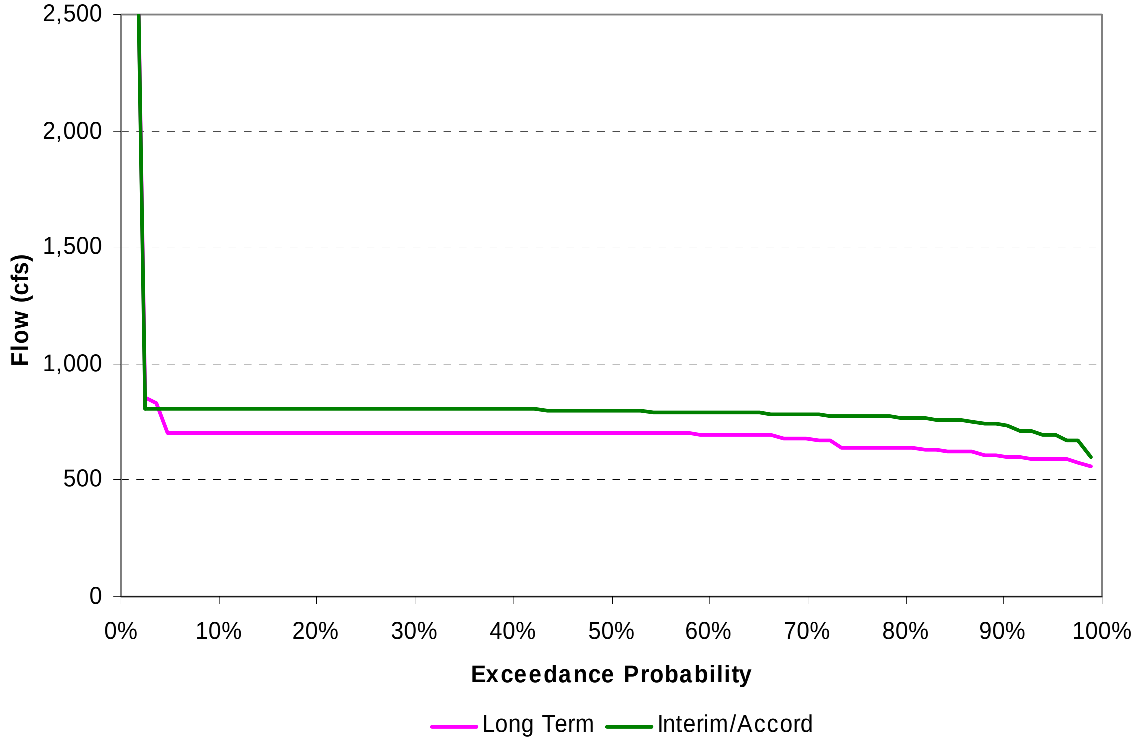


Figure X-14: Exceedance Probability of Yuba River Flow at Marysville for October, 2006

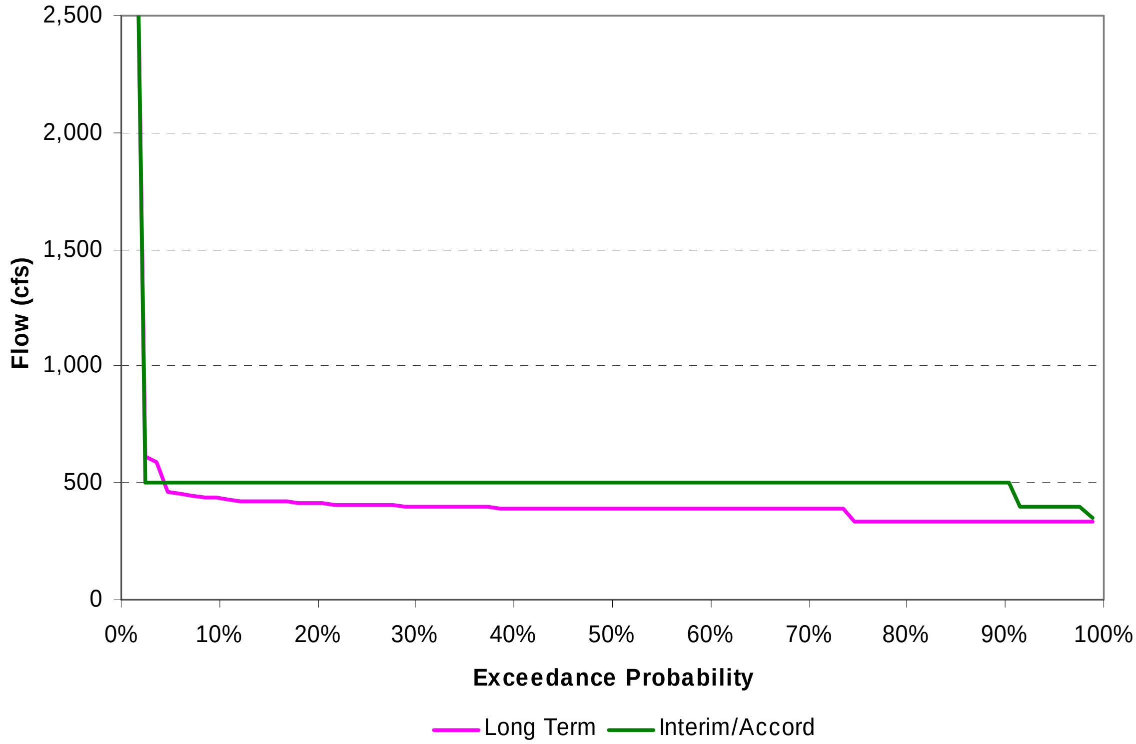


Figure X-15: Exceedance Probability of Yuba River Flow at Smartville for November, 2006

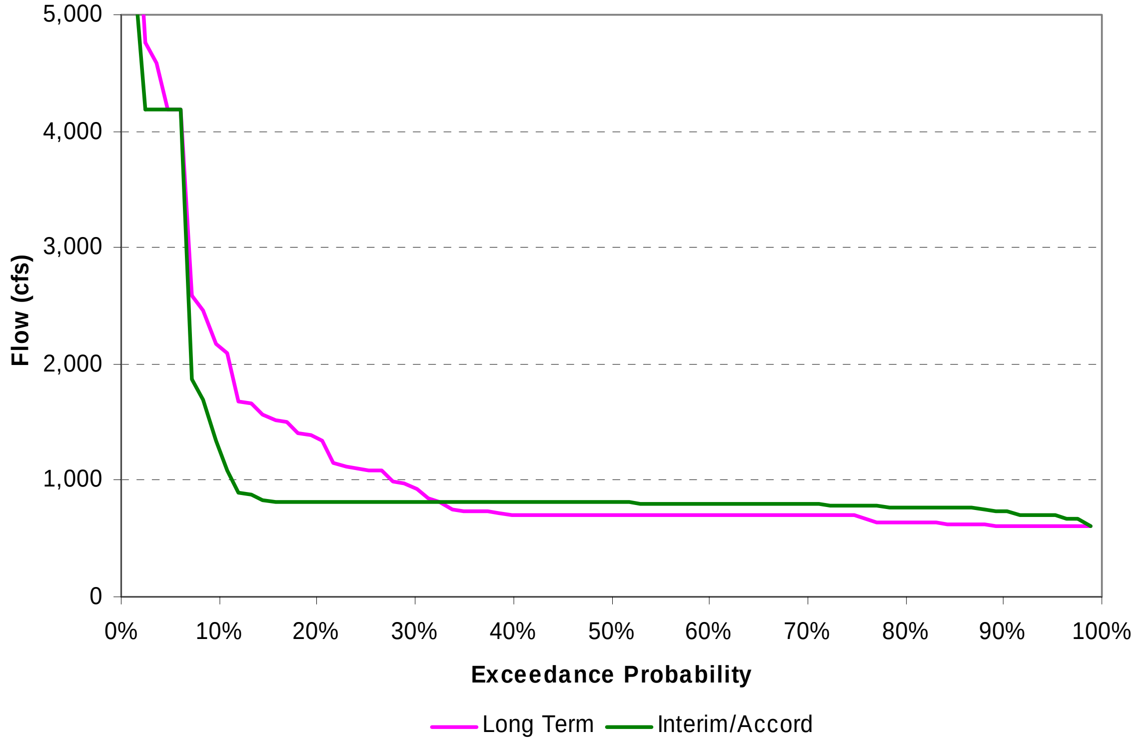


Figure X-16: Exceedance Probability of Yuba River Flow at Marysville for November, 2006

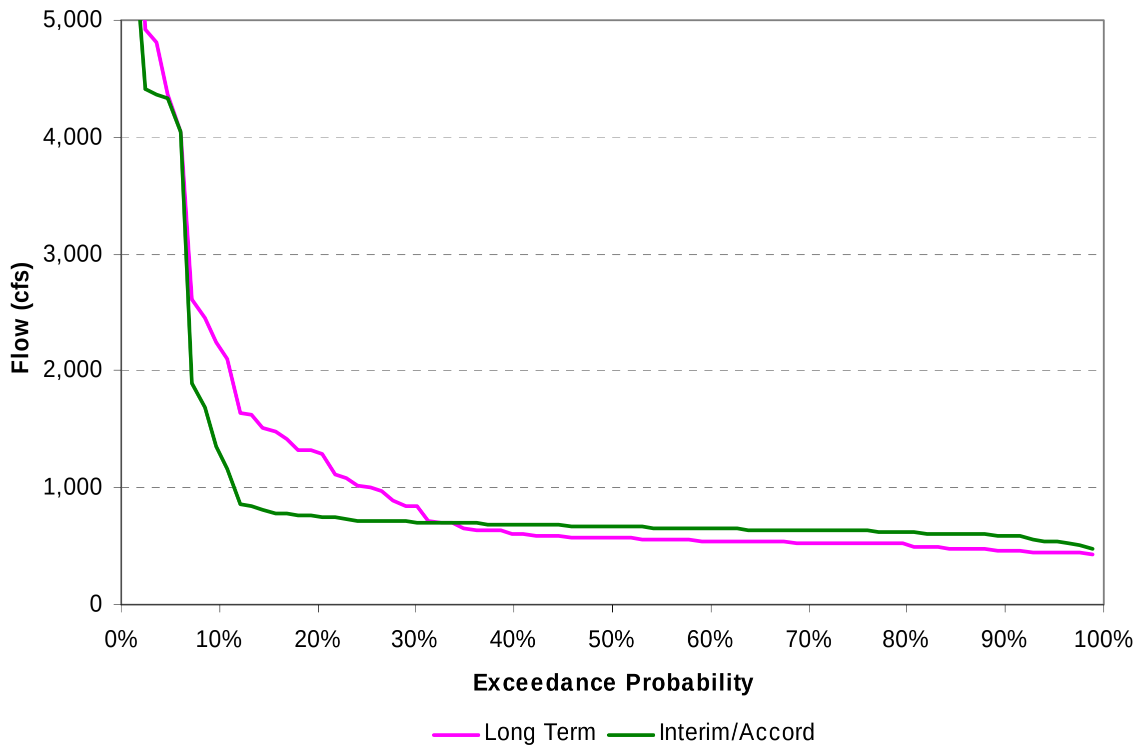


Figure X-17: Exceedance Probability of Yuba River Flow at Smartville for December, 2006

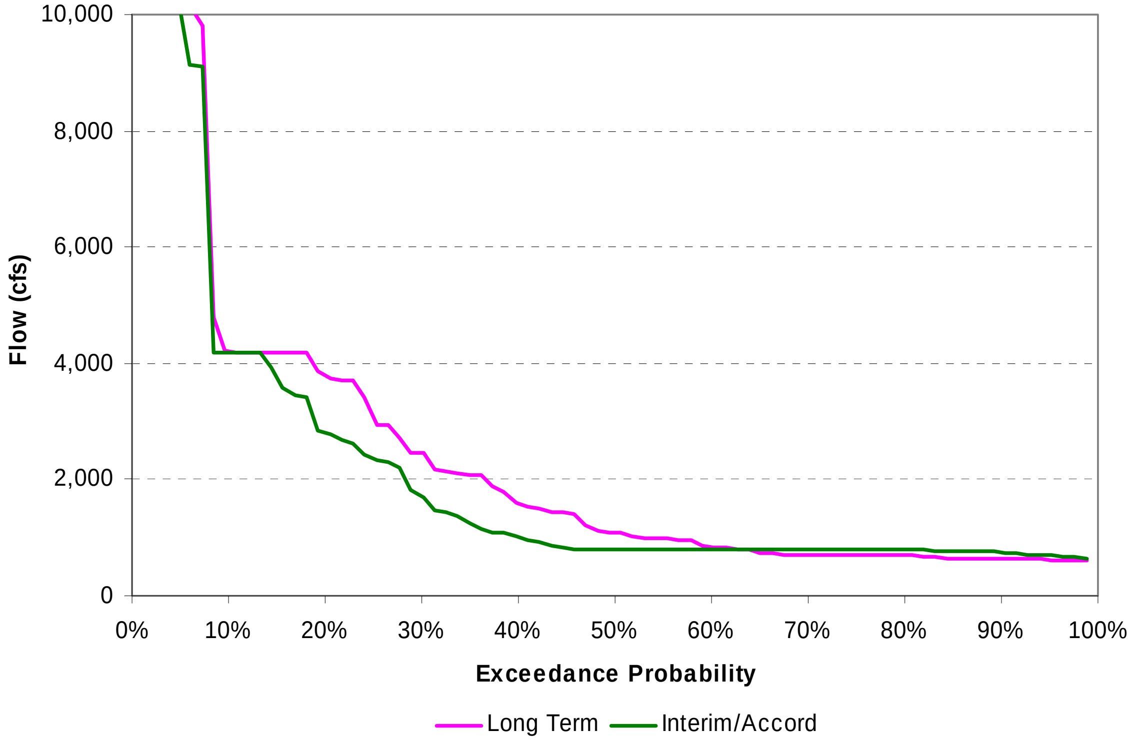


Figure X-18: Exceedance Probability of Yuba River Flow at Marysville for December, 2006

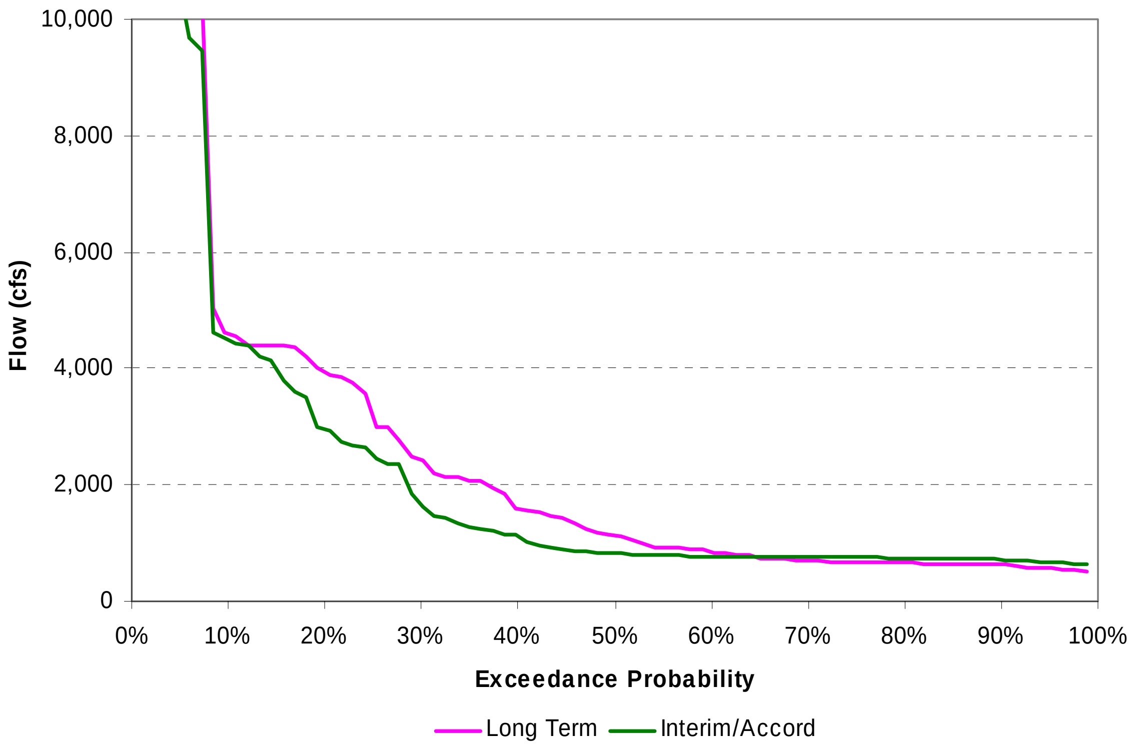


Figure X-19: Exceedance Probability of Yuba River Flow at Smartville for January, 2007

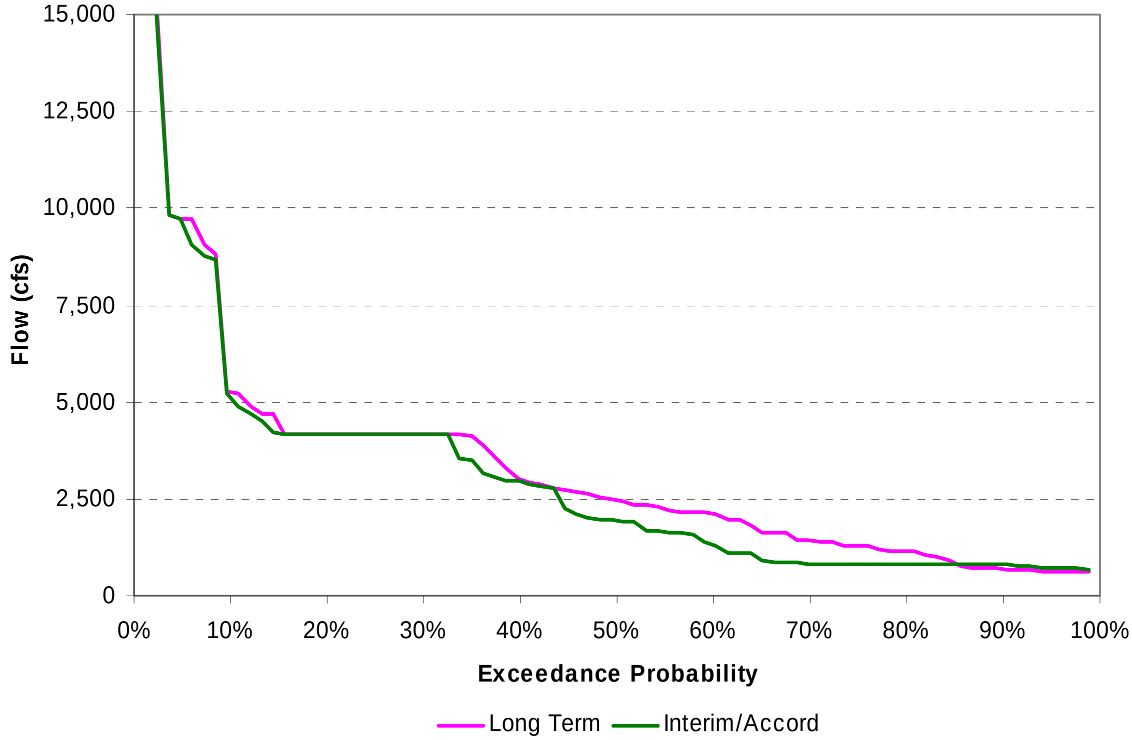


Figure X-20: Exceedance Probability of Yuba River Flow at Marysville for January, 2007

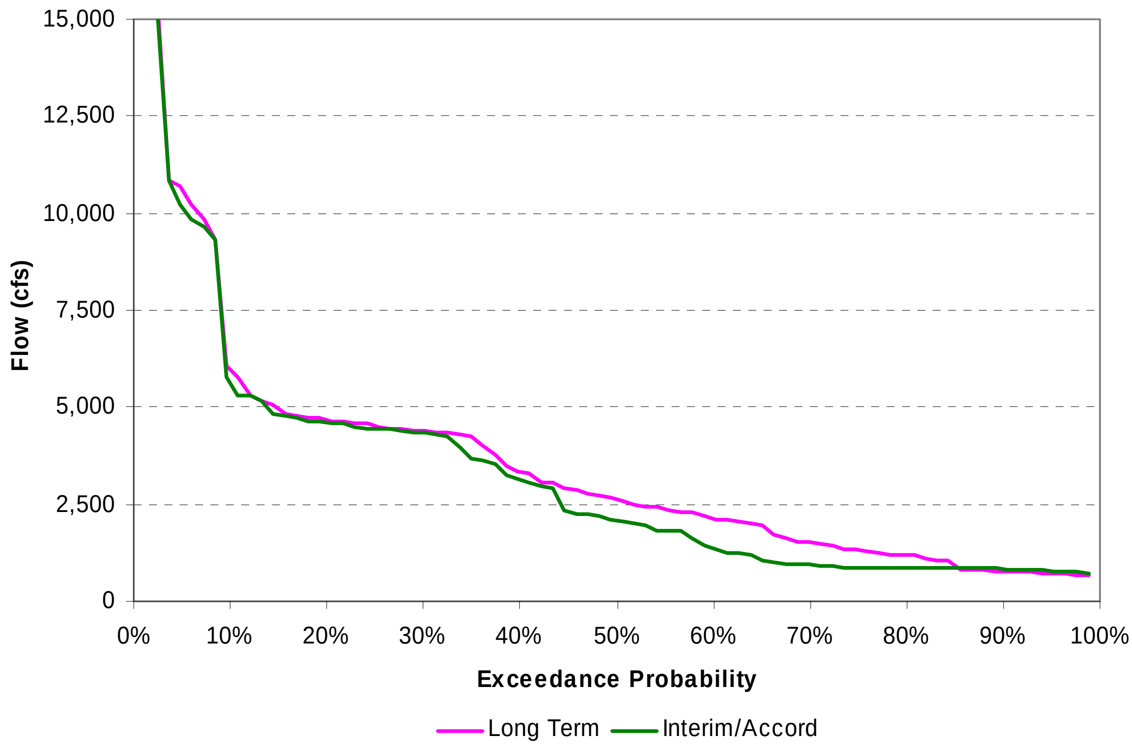


Figure X-21: Exceedance Probability of Yuba River Flow at Smartville for February, 2007

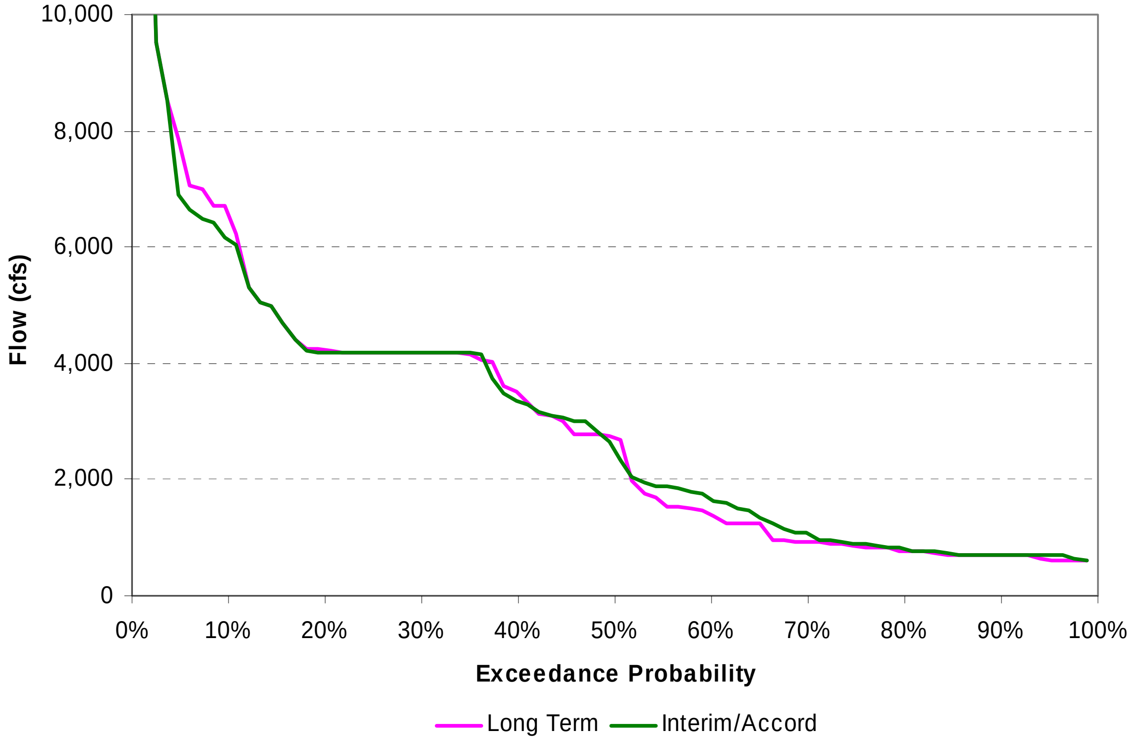


Figure X-22: Exceedance Probability of Yuba River Flow at Marysville for February, 2007

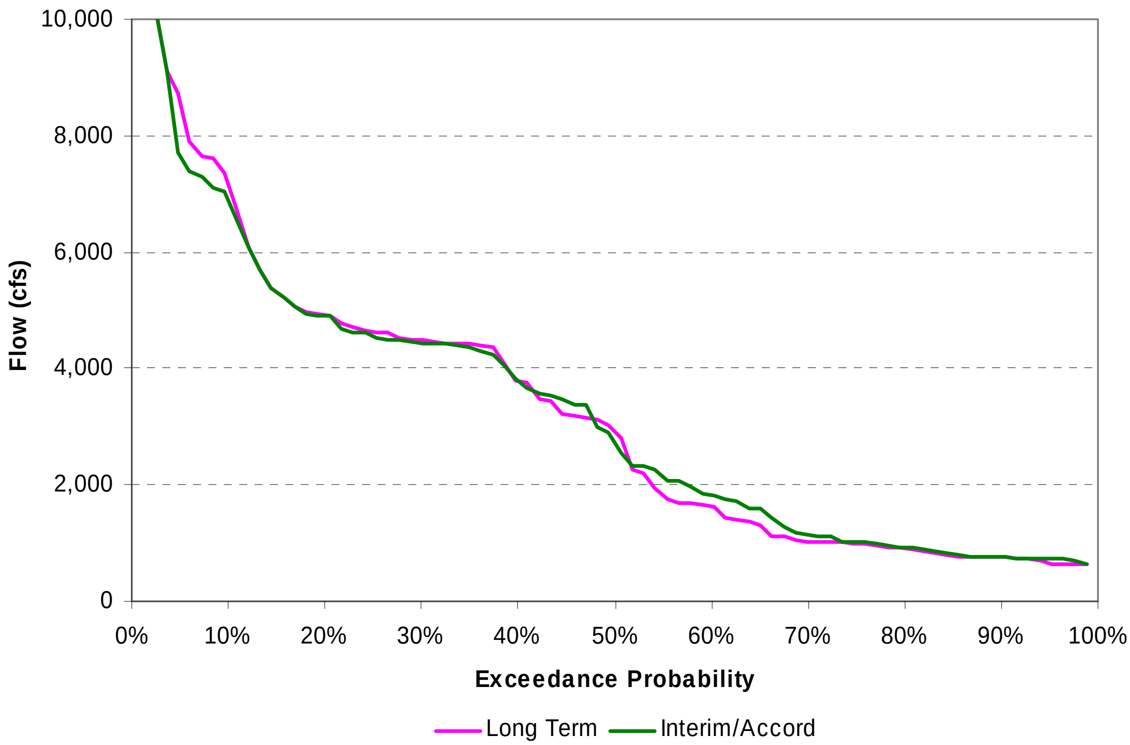


Figure Y-1: Exceedance Probability of Yuba River Water Temperature at Daguerre Point Dam for April, 2006

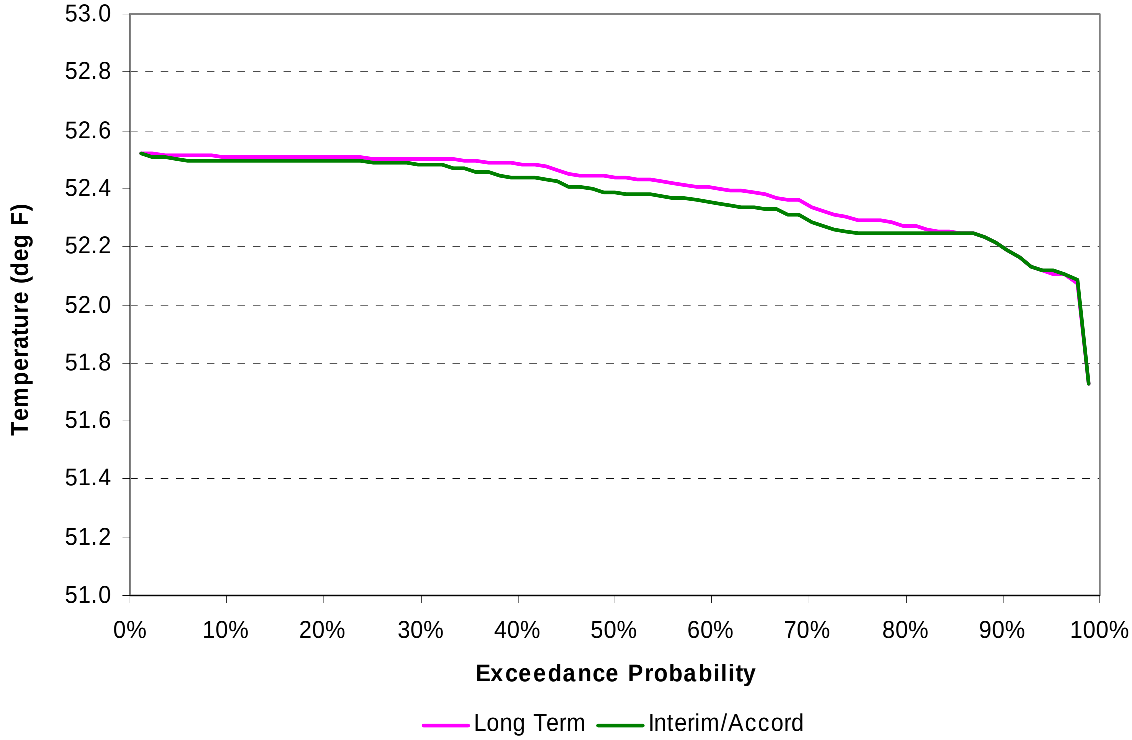


Figure Y-2: Exceedance Probability of Yuba River Water Temperature at Marysville for April, 2006

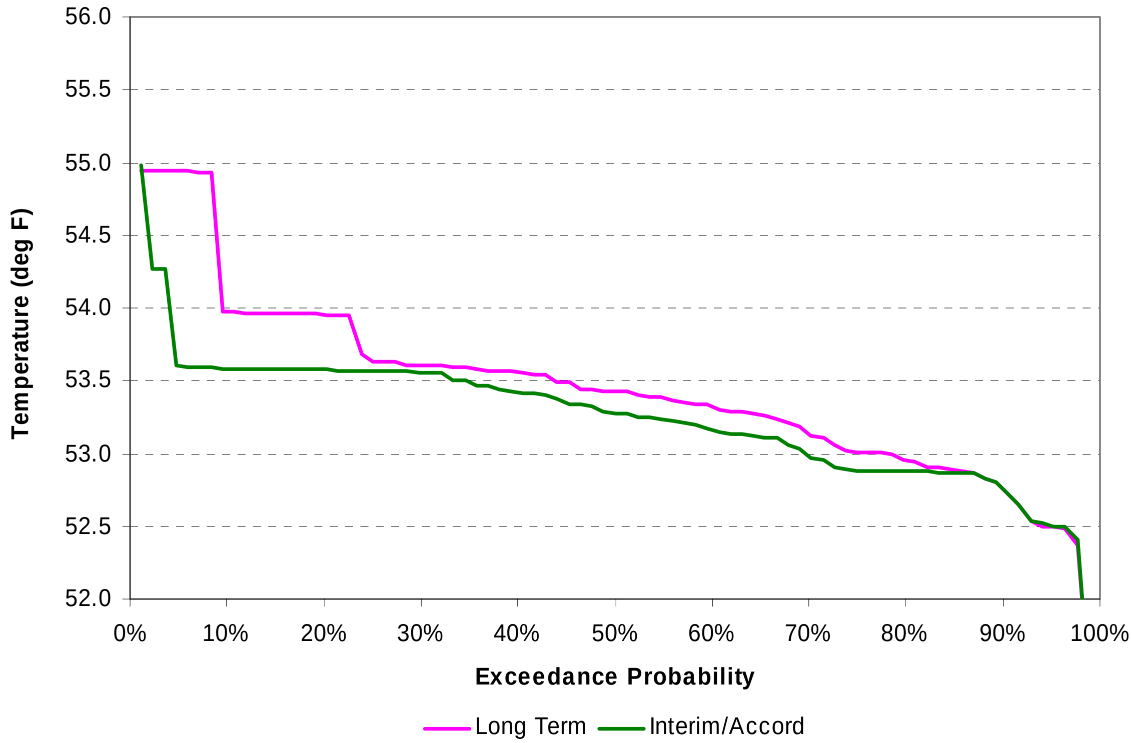


Figure Y-3: Exceedance Probability of Yuba River Water Temperature at Daguerre Point Dam for May, 2006

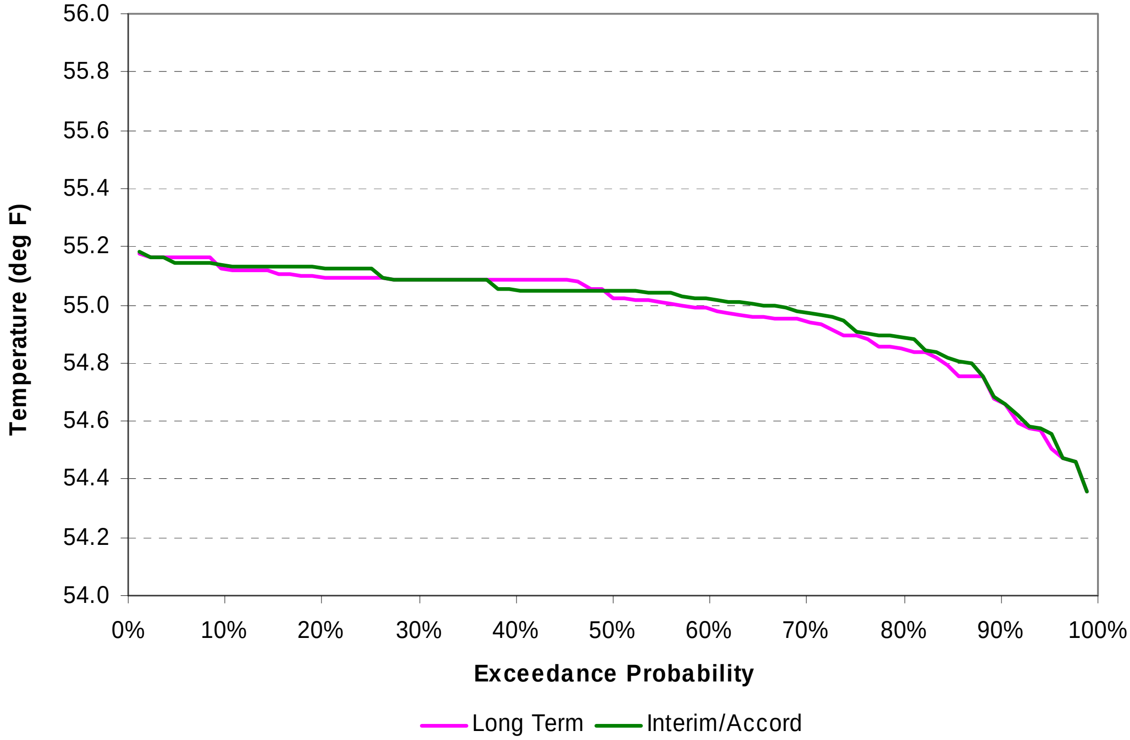


Figure Y-4: Exceedance Probability of Yuba River Water Temperature at Marysville for May, 2006

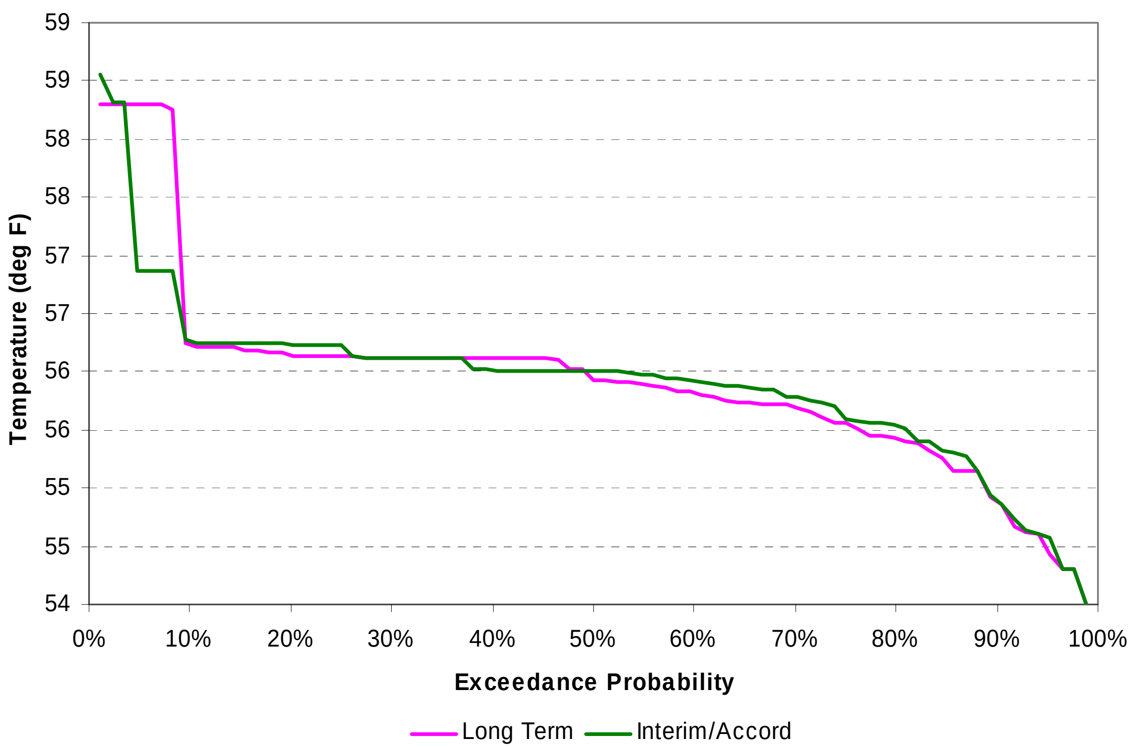


Figure Y-5: Exceedance Probability of Yuba River Water Temperature at Daguerre Point Dam for June, 2006

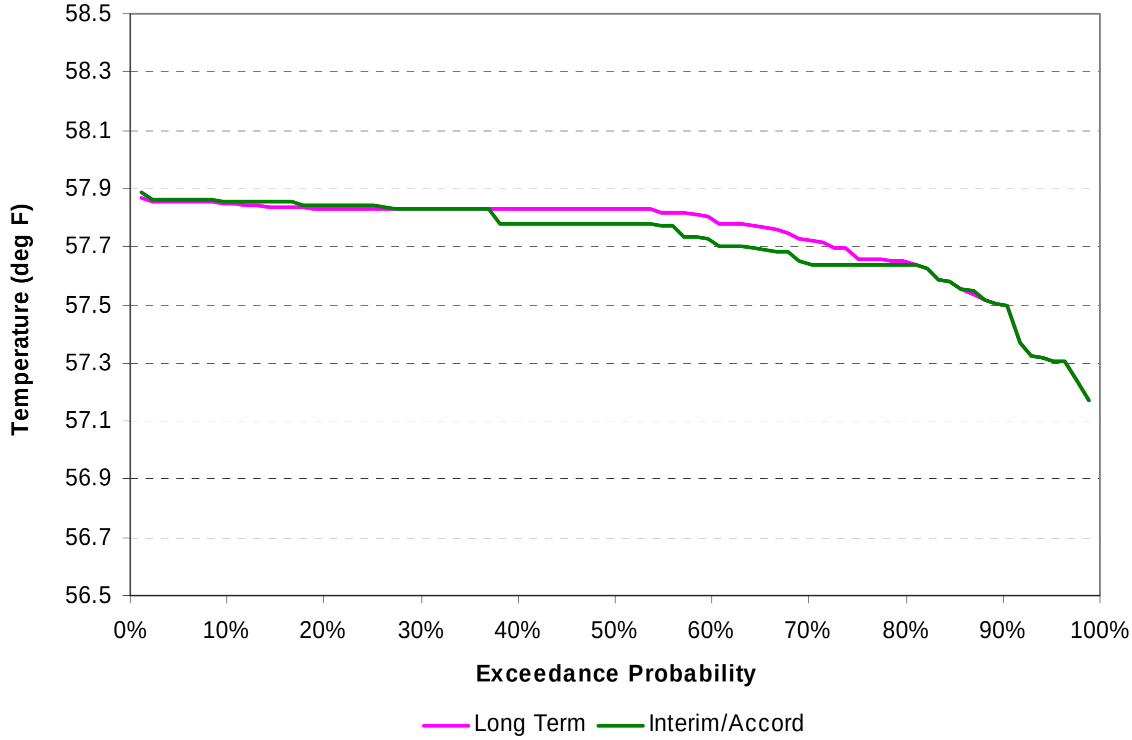


Figure Y-6: Exceedance Probability of Yuba River Water Temperature at Marysville for June, 2006

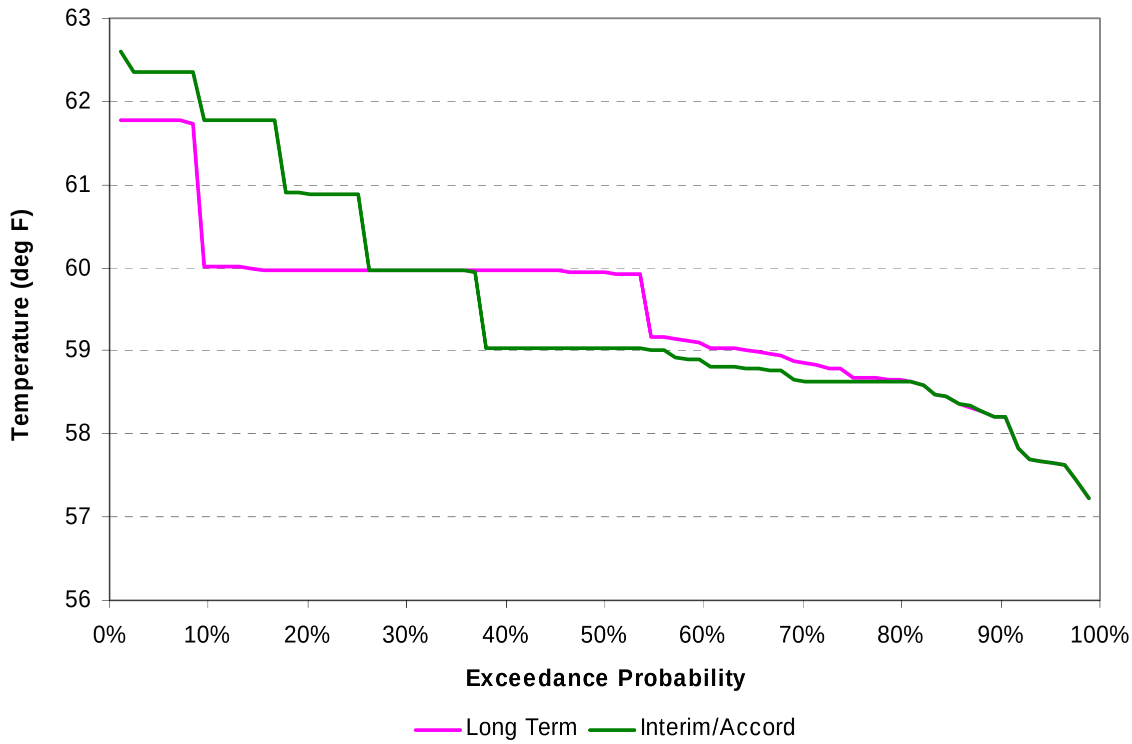


Figure Y-7: Exceedance Probability of Yuba River Water Temperature at Daguerre Point Dam for July, 2006

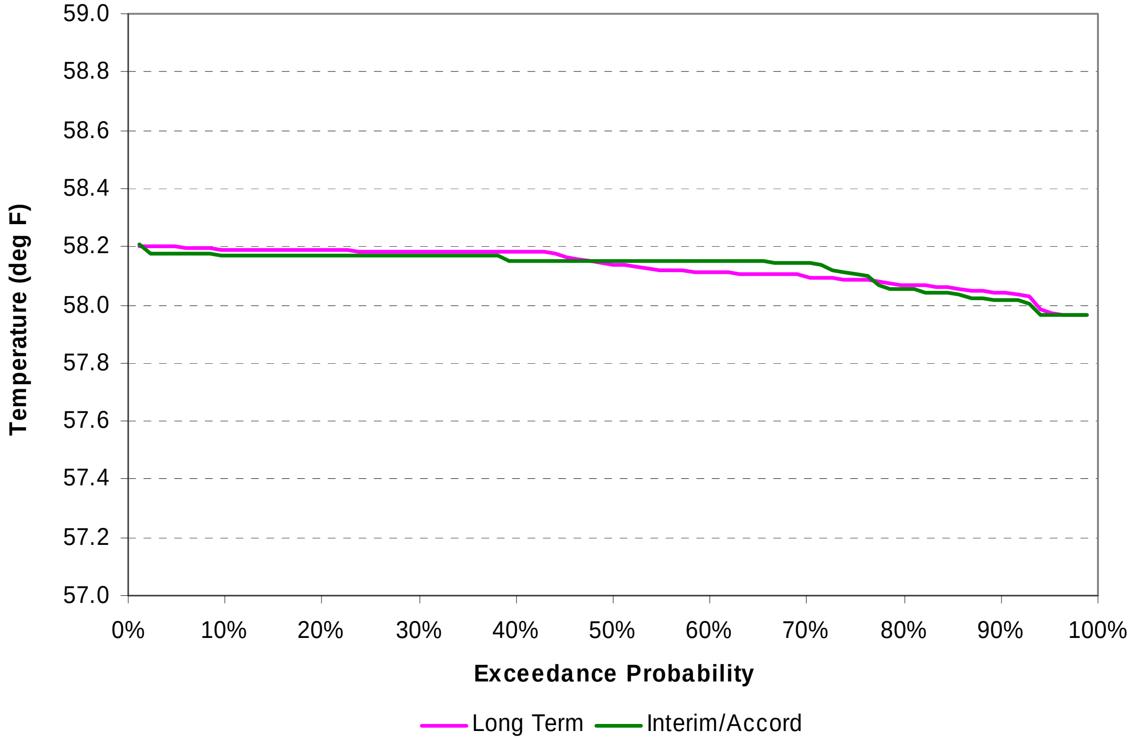


Figure Y-8: Exceedance Probability of Yuba River Water Temperature at Marysville for July, 2006

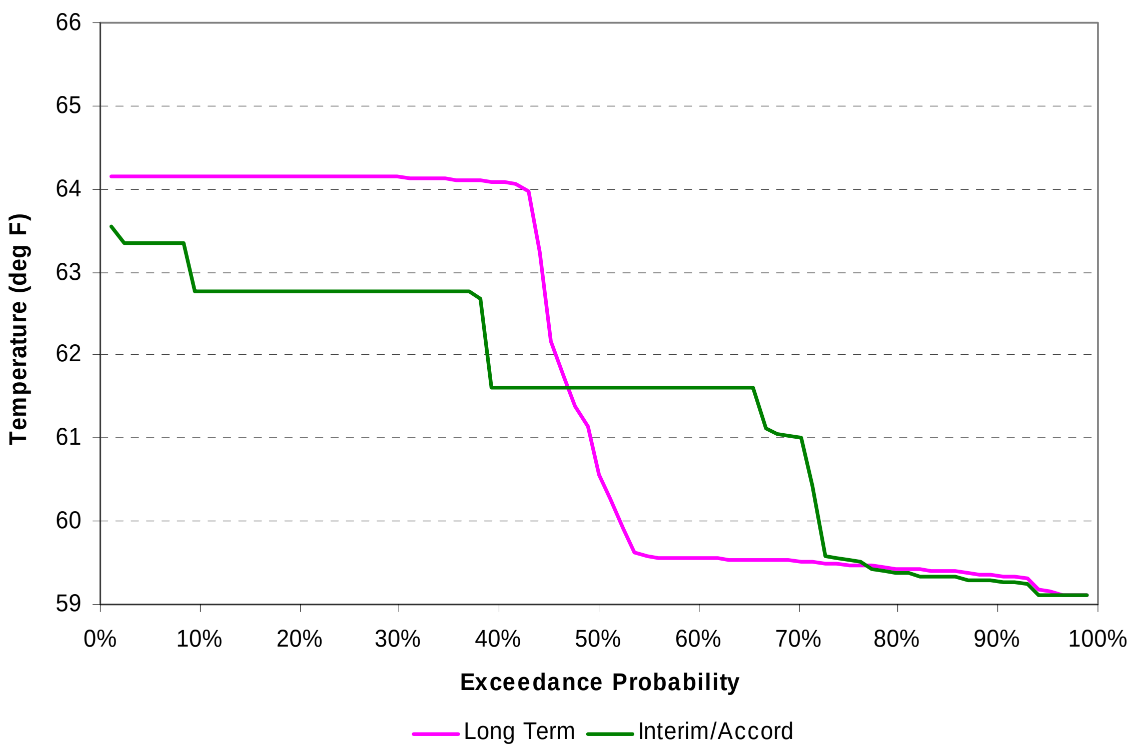


Figure Y-9: Exceedance Probability of Yuba River Water Temperature at Daguerre Point Dam for August, 2006

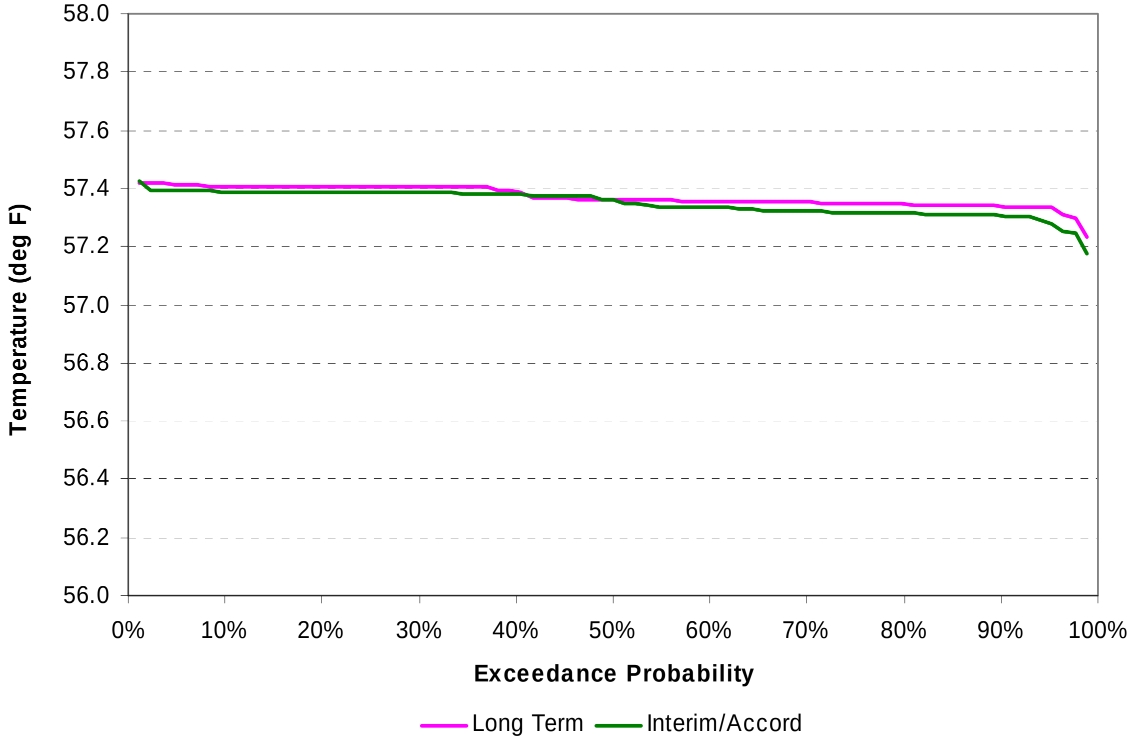


Figure Y-10: Exceedance Probability of Yuba River Water Temperature at Marysville for August, 2006

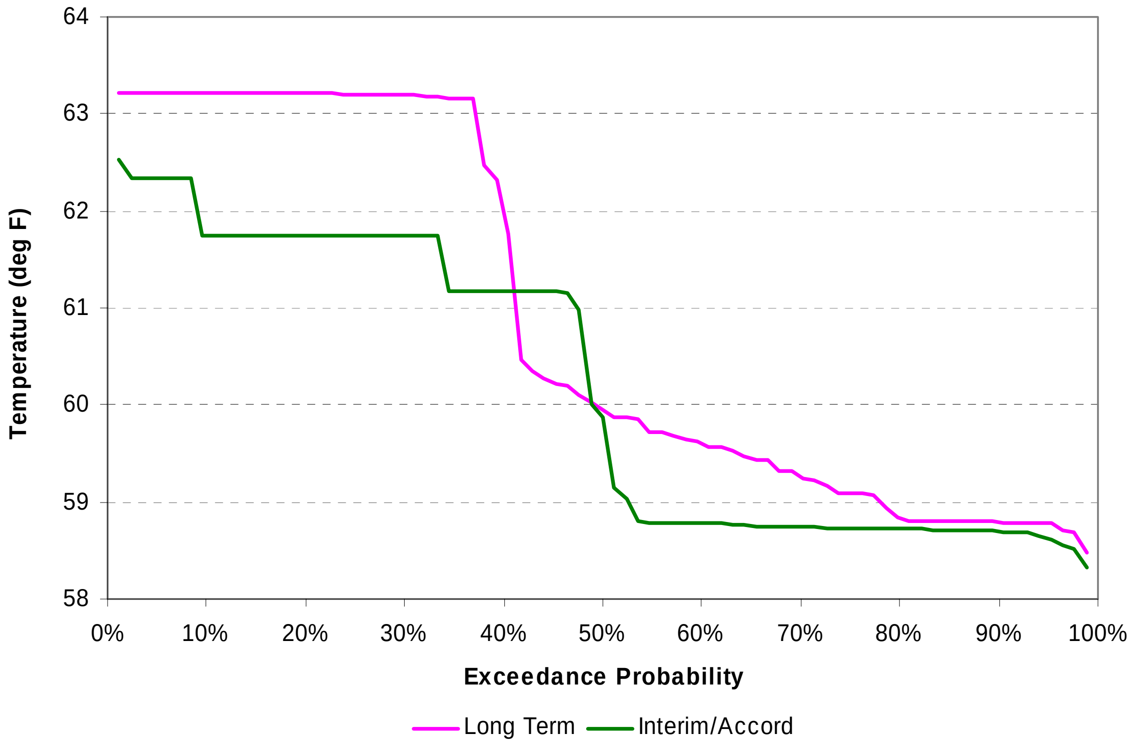


Figure Y-11: Exceedance Probability of Yuba River Water Temperature at Daguerre Point Dam for September, 2006

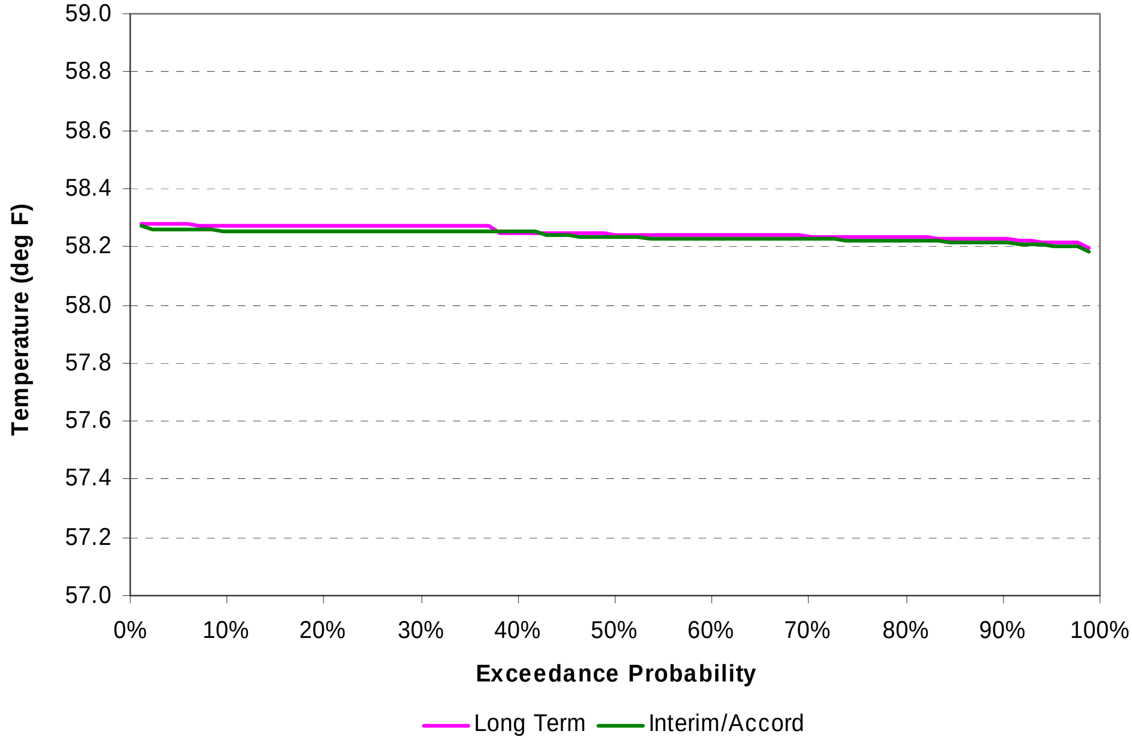


Figure Y-12: Exceedance Probability of Yuba River Water Temperature at Marysville for September, 2006

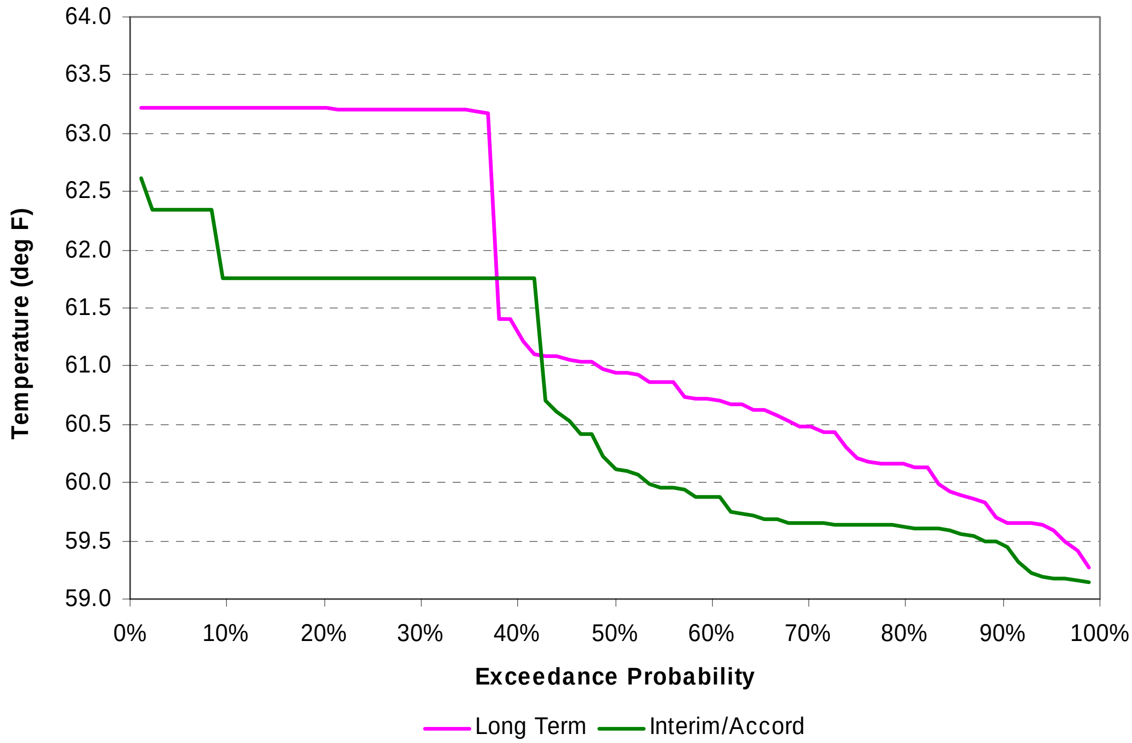


Figure Y-13: Exceedance Probability of Yuba River Water Temperature at Daguerre Point Dam for October, 2006

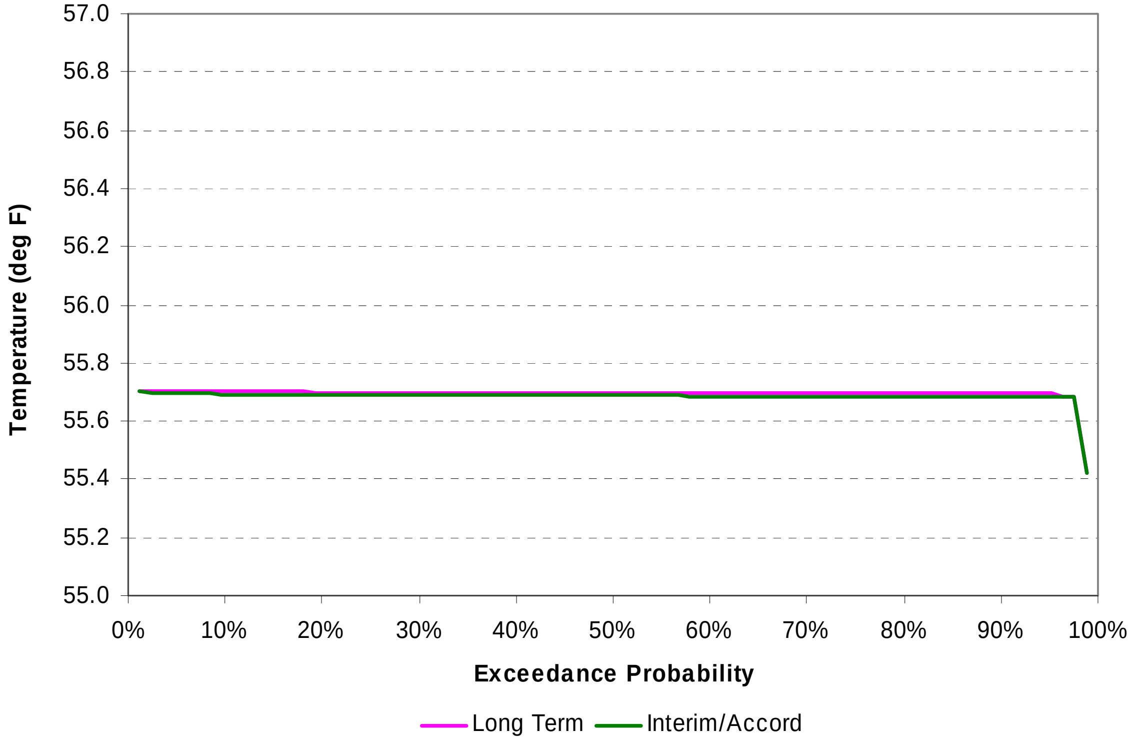


Figure Y-14: Exceedance Probability of Yuba River Water Temperature at Marysville for October, 2006

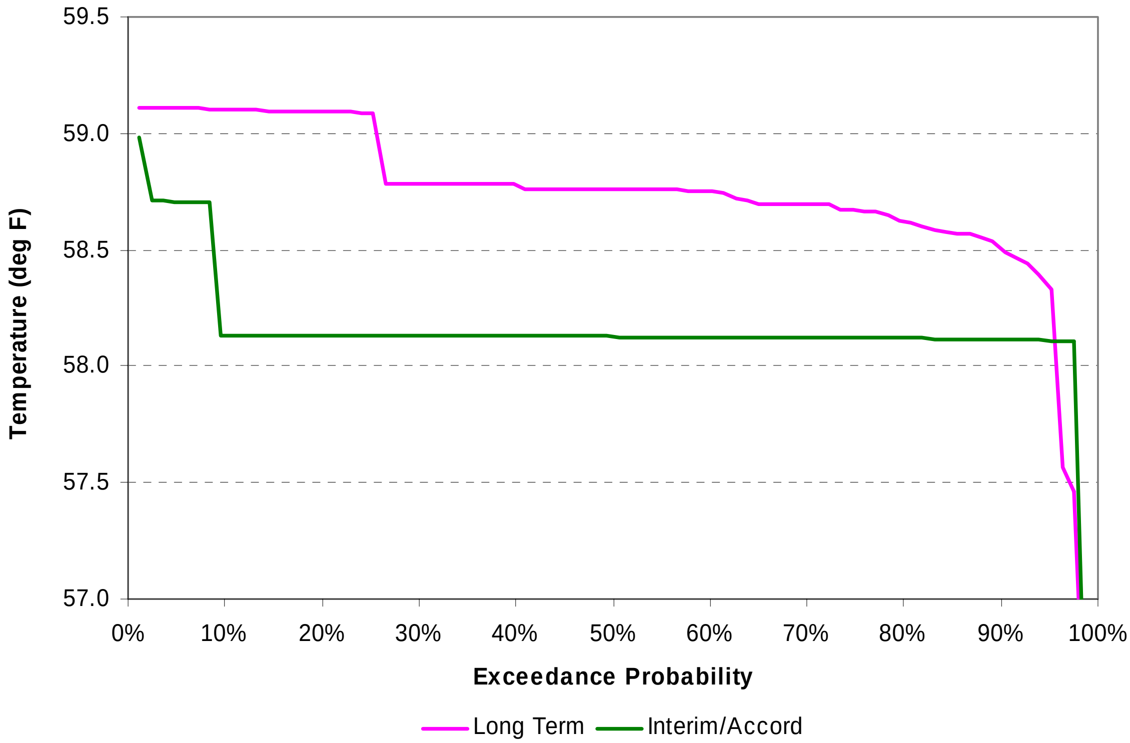


Figure Y-15: Exceedance Probability of Yuba River Water Temperature at Daguerre Point Dam for November, 2006

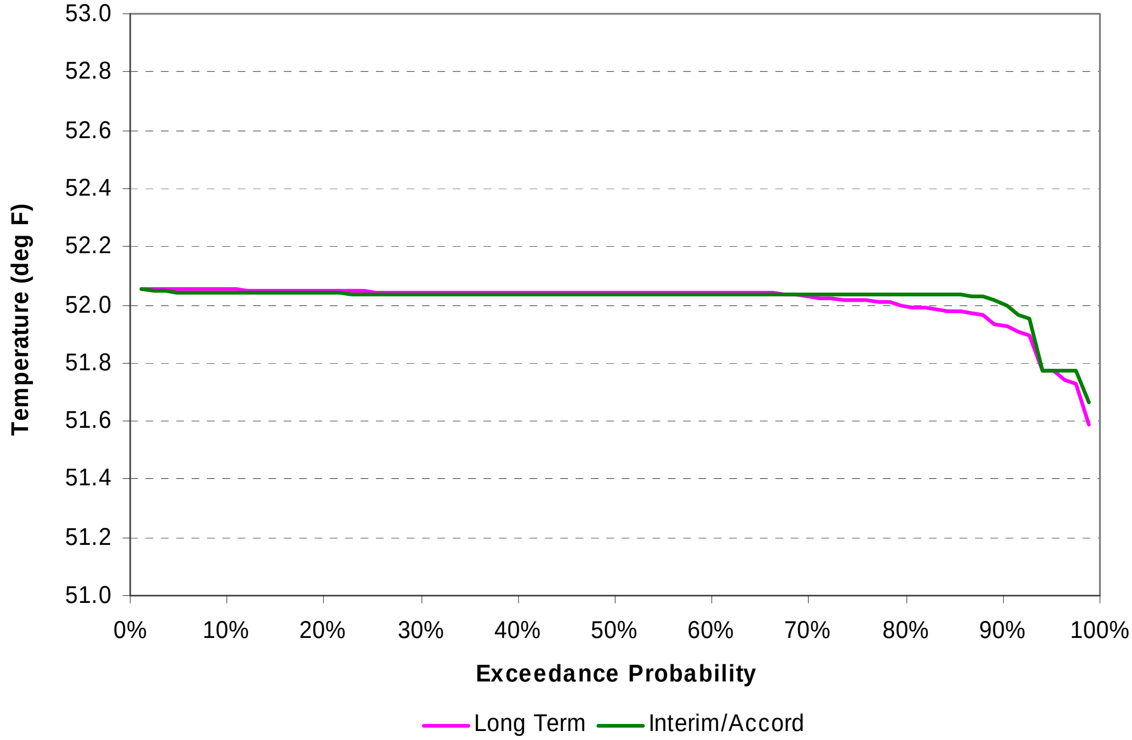


Figure Y-16: Exceedance Probability of Yuba River Water Temperature at Marysville for November, 2006

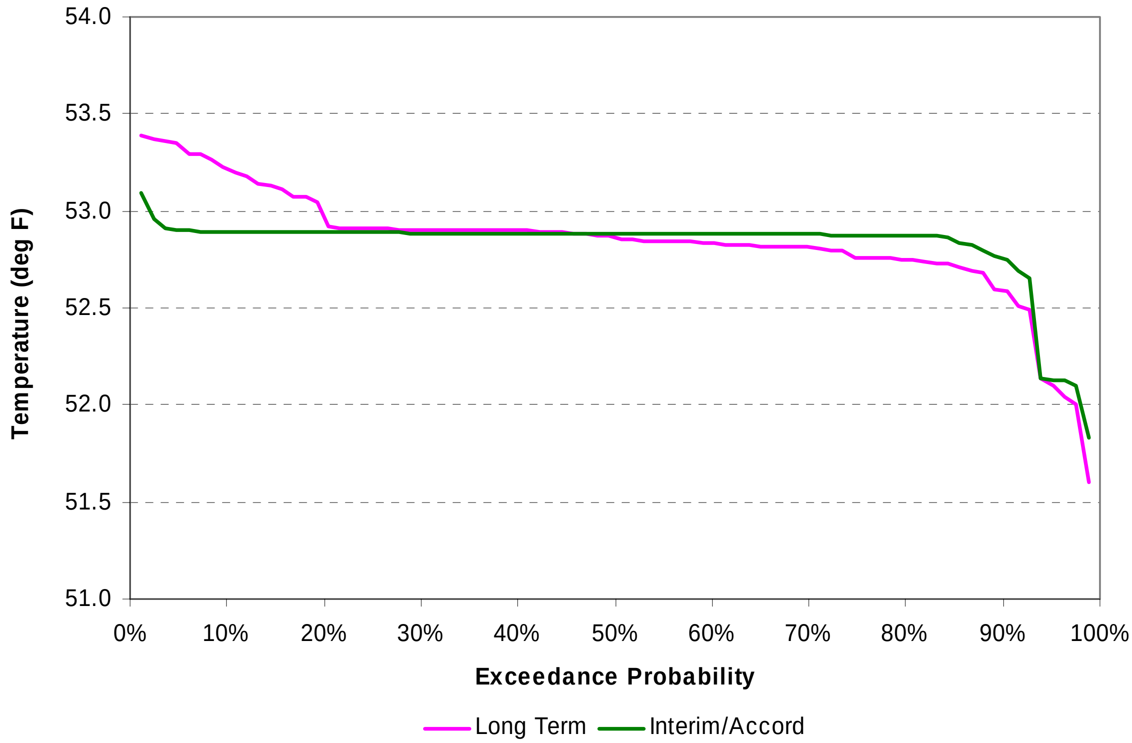


Figure Y-17: Exceedance Probability of Yuba River Water Temperature at Daguerre Point Dam for December, 2006

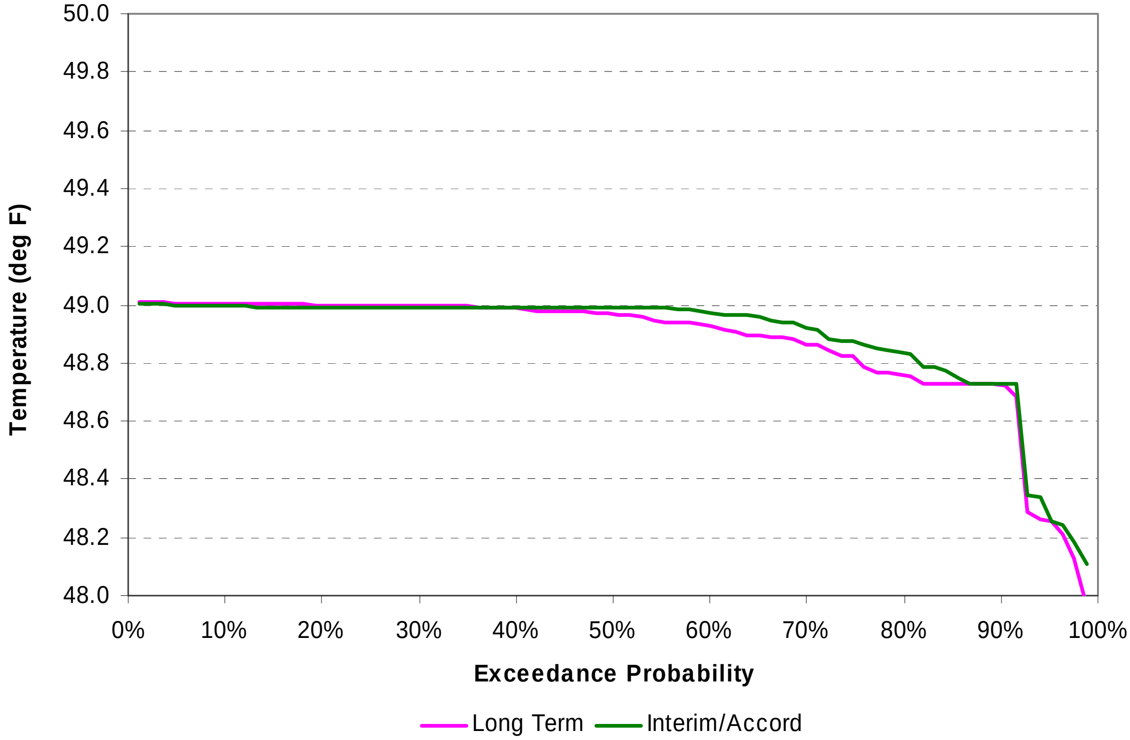


Figure Y-18: Exceedance Probability of Yuba River Water Temperature at Marysville for December, 2006

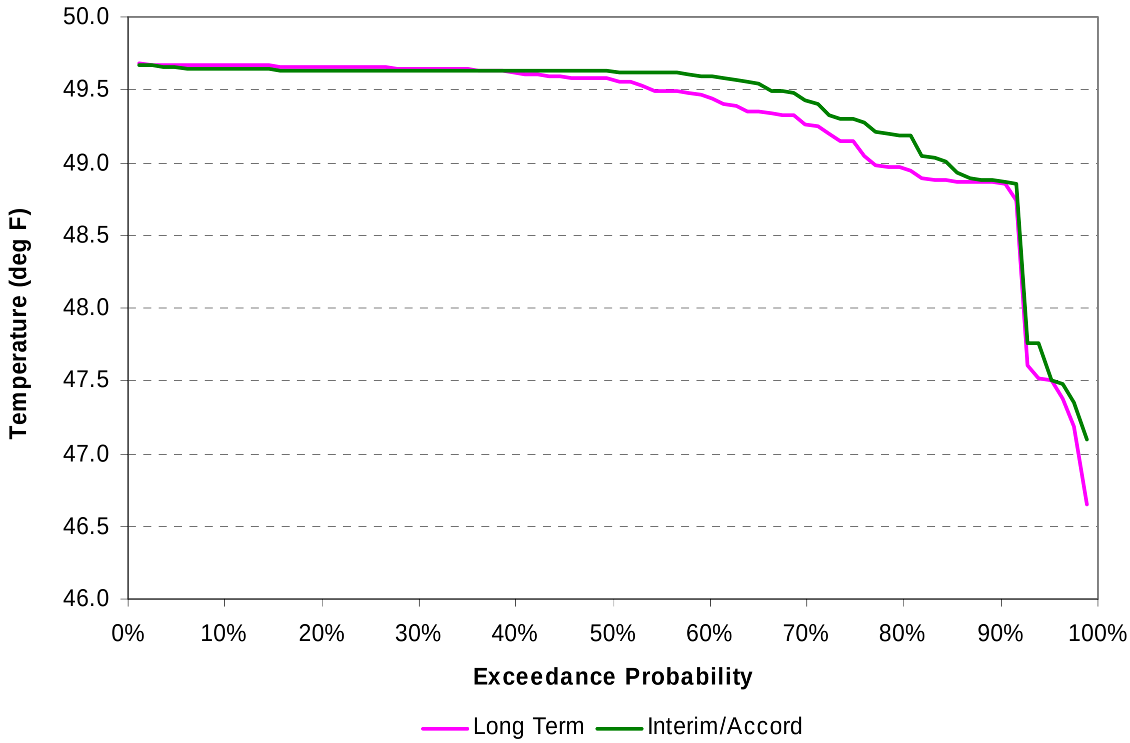


Figure Y-19: Exceedance Probability of Yuba River Water Temperature at Daguerre Point Dam for January, 2006

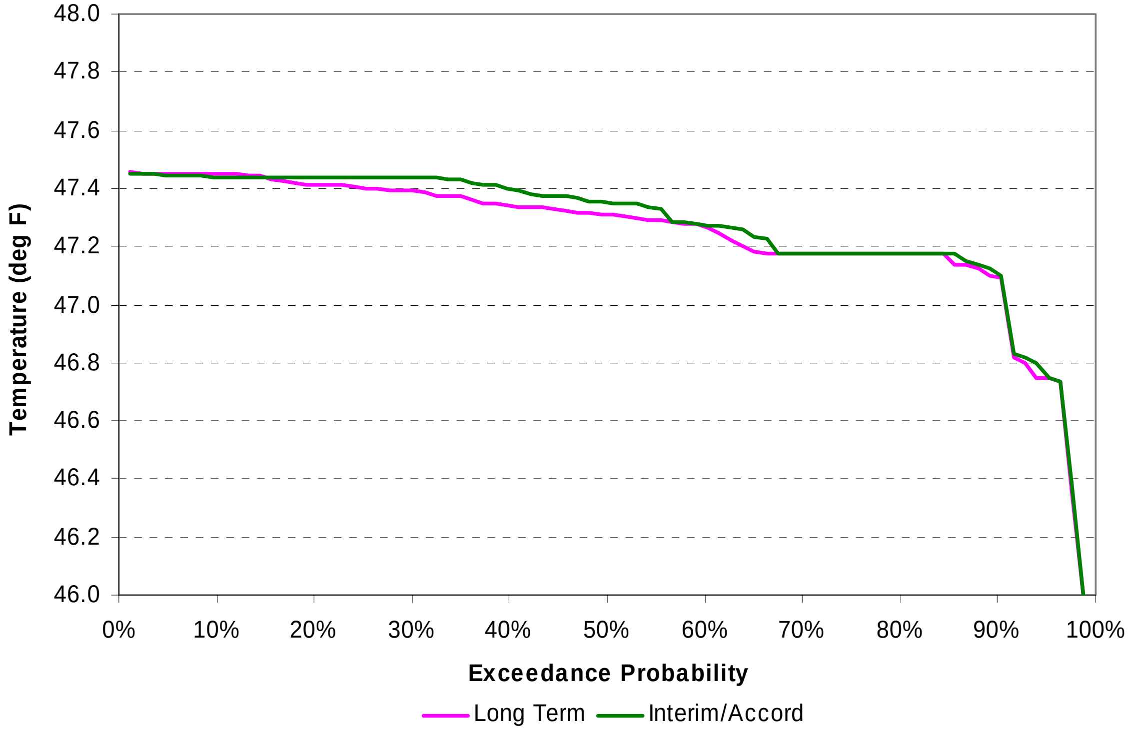


Figure Y-20: Exceedance Probability of Yuba River Water Temperature at Marysville for January, 2006

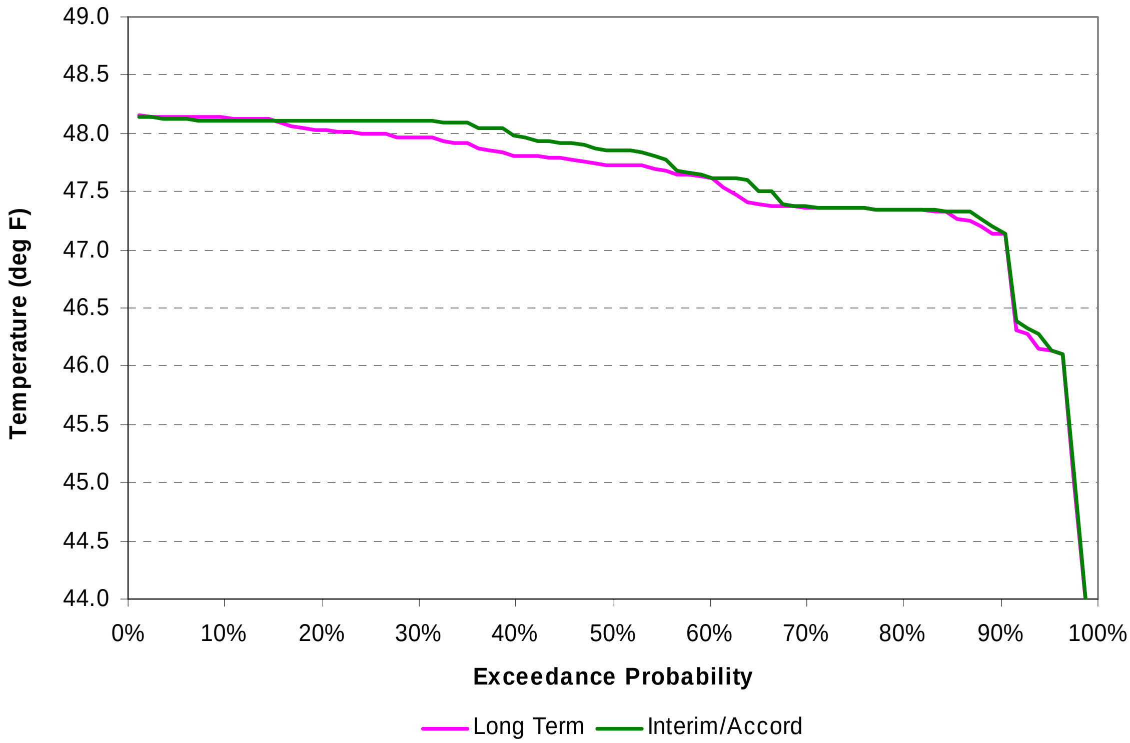


Figure Y-21: Exceedance Probability of Yuba River Water Temperature at Daguerre Point Dam for February, 2006

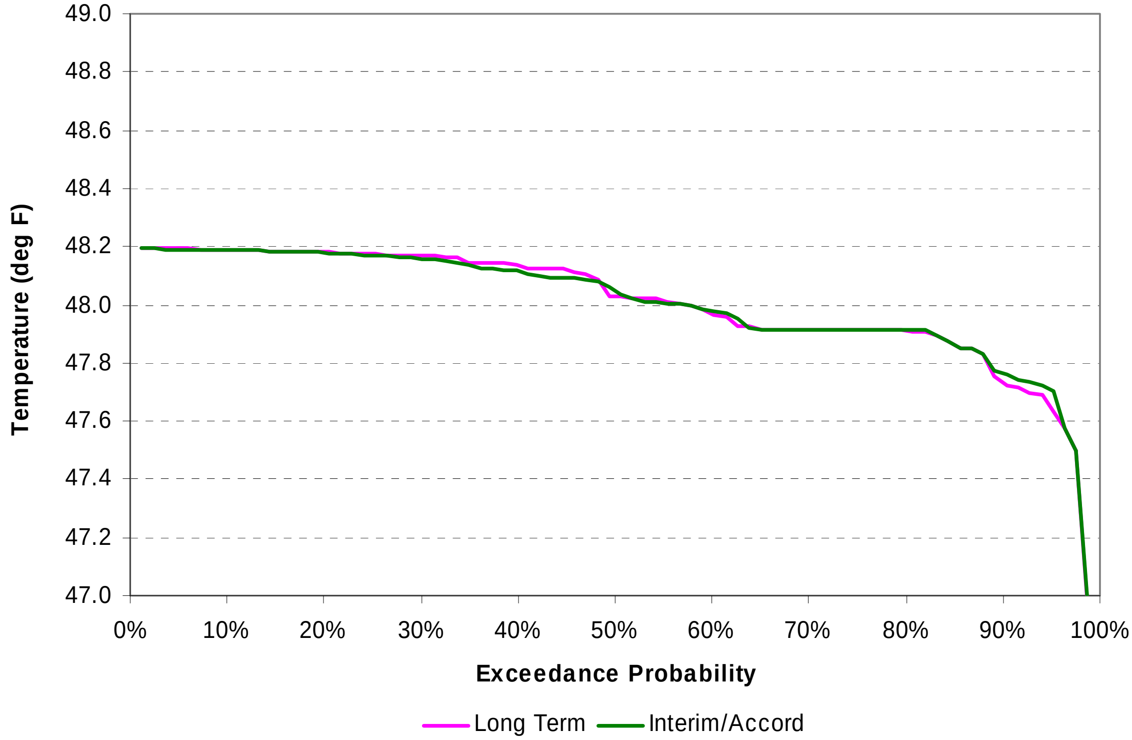


Figure Y-22: Exceedance Probability of Yuba River Water Temperature at Marysville for February, 2006