FERC Project No. 2426
South SWP Hydropower
Water Quality and Temperature Study

FIELD RESULTS AND DATA SUMMARY

March 25, 2019

Consistent with Section 5.0 of the South SWP Hydropower Revised Study Plan and as approved in the Federal Energy Regulatory Commission (FERC) Study Plan Determinations dated June 14, 2017 and September 7, 2018, the California Department of Water Resources and Los Angeles Department of Water and Power (Licensees) provide the following Field Results and Data Summary for Study 4.1.16, *Water Quality and Temperature Study* (Study), which includes work completed to date, key findings, associated data files, variances, and remaining work. The Licensees consider these data to be public.

Completed Work to Date:

The Study is complete. As required by the FERC-approved Study Plan, the Licensees have completed Step 1 (Select Water Quality Parameters), Step 2 (Select Sampling Locations), Step 3 (Collect Water Quality Samples), Step 4 (Collect Reservoir Profiles), and Step 5 (Install and Maintain Stream Temperature Loggers).

The Licensees collected water quality samples (Step 3) at nine locations throughout the Project: (1) Quail Lake near the center; (2) Quail Lake near the outlet; (3) Pyramid Lake near the dam; (4) Pyramid Lake in the William E. Warne Powerplant arm; (5) Pyramid Lake in the Piru Creek arm; (6) Pyramid reach, near the base of Pyramid Dam; (7) Pyramid reach, about 1.5 miles downstream of Pyramid Dam; (8) Pyramid reach, about 3.0 miles downstream of Pyramid Dam (near Frenchmen's Flat); and (9) Pyramid reach, upstream of Lake Piru near Blue Point Campground. At the five reservoir sampling locations in Quail Lake and Pyramid Lake, water quality samples were collected at two depths: near the surface and near the bottom. Pyramid reach samples were collected just below the surface.

Water quality samples were collected at all locations that were identified in the Study Plan in September 2017. The water quality parameters were divided into two categories: (1) basic water quality – in situ (six parameters); and (2) basic water quality – laboratory samples that included inorganic ions, nutrients, and metals (31 parameters). Each sample was collected in a laboratory-supplied clean container. Containers used during stream sampling and reservoir surface sampling were filled directly from the water, submerged approximately 6 inches below the surface while facing downstream to prevent organic material from flowing into the container. Sampling from near the bottom of the reservoir was done using a Kemmerer sampler designed for trace metals sampling. Containers for the deep water samples were filled directly from the sampler. The sampler was thoroughly cleaned with Alconox and distilled water between sample locations. While in the field and during shipping, samples requiring refrigeration were stored on ice until transferred to an appropriate laboratory refrigerator. Water samples analyzed for metals were collected using "clean hands" methods consistent with the U.S. Environmental Protection Agency's Method 1669 sampling protocol. Quality control samples, including field blanks, equipment rinses, and field duplicates, were also collected per laboratory standards.

The Licensees also collected reservoir profiles in Quail Lake and Pyramid Lake at the same locations described above. Reservoir profiles were collected quarterly for one year beginning

with the third and fourth quarters in 2017 (Quarter 3 in September 2017, and Quarter 4 in November 2017), and the first and second quarters in 2018 (Quarter 1 in February 2018, and Quarter 2 in May 2018). At each location, a Hydrolab MS5 (or similar) unit was used to collect depth, water temperature, dissolved oxygen (DO), pH, specific conductivity, and turbidity approximately every 10 feet from the surface to the bottom. Water temperature and dissolved oxygen were plotted against elevation in order to see variation over depth and season.

Finally, the Licensees installed long-term water temperature loggers at the four locations in Pyramid reach described above. Loggers were installed in late September 2017, and removed in late October 2018, which met the requirements of the Study. The loggers recorded water temperature at 15-minute intervals and were downloaded quarterly. Duplicate loggers were installed at each monitoring location for redundancy. Loggers were installed in durable housings and secured to nearby substrate to help prevent damage or loss during higher flows. Loggers were also installed discreetly, especially in areas of higher traffic (e.g., campgrounds), to prevent vandalism. The 15-minute interval water temperature data were combined to create plots and a database of daily minimum, average, and maximum water temperature for each location.

While not required by the FERC-approved Study Plan, the Licensees also collected water samples to be analyzed for *Escheriachia coli* (*E. coli*) at the request of the State Water Resources Control Board. Samples were collected at two locations in Pyramid Lake: (1) near the dam and (2) in the Piru Creek arm during five sampling events in August and September 2018. The samples were collected within a single 30-day period including samples collected over the Labor Day weekend.

Key Accomplishments/Summary of Findings to Date:

Water Quality Sampling

Water quality in Quail Lake showed little variation between locations and depths for all selected water quality parameters. The samples collected in Quail Lake were consistent with the Lahontan Regional Water Quality Control Board's (Lahontan RWQCB) Basin Plan Water Quality Objectives.

Water quality in Pyramid Lake showed little variation between locations and depths for all the parameters sampled. Two of the six water quality samples collected in Pyramid Lake were inconsistent with the Los Angeles Regional Water Quality Control Board's (Los Angeles RWQCB) Water Quality Control Plan for the Los Angeles Region (Basin Plan) Water Quality Objective of 5 milligrams per liter (mg/L) or greater for DO. The DO concentrations were 3.23 mg/L and 3.81 mg/L, and both occurred in samples collected in the hypolimnion of Pyramid Lake near the dam and in the Piru Creek arm in September 2017 when a slight thermocline was present. DO concentrations measured in the bottom 60 feet of the reservoir during the third quarter reservoir profile had values ranging from 4.77 mg/L to 0 mg/L.

Water quality in Pyramid reach below Pyramid Dam showed greater variability versus the reservoir samples. The total concentrations of alkalinity, barium, and total dissolved solid levels increased farther downstream of Pyramid Dam. Levels of organic carbon and phosphorous decreased with distance from Pyramid Dam. Concentrations of antimony, beryllium, cadmium, chromium, lead, and silver remained below laboratory detection limits throughout Pyramid reach samples. None of the samples collected in Pyramid reach were inconsistent with Los Angeles

RWQCB's Basin Plan Water Quality Objectives.

Licensees collected water samples in Pyramid Lake near the dam and in the Piru Creek arm to be analyzed for *E. coli* . (Table 1). The results were consistent across all sampling dates and locations. Total coliform measured over the maximum reporting limit (2,419.6 most probable number [MPN]/100mL) for 10 of the 12 samples with the remaining two measuring at 1,300 MPN/100mL and 1,200 MPN/100mL. *E. coli*, which was the parameter of interest during sampling, measured below the laboratory's method reporting limit of 1 MPN/100mL for 11 of the 12 samples. The one measurable result was 1 MPN/100mL.

Table 1. *E. coli* sampling results for two locations in Pyramid Lake, 2018

Sample Date	Sample Time	# Positive Wells		MPN/100 mL		Presence/Absence (P/A)	
		E. coli Small	*E. coli* Large	Total Coliform[1]	*E. coli*[2]	Total Coliform	*E. coli*
Site 1 - near Pyramid Dam							
8/21/18	13:20	ND	ND	>2,419.6	<1	P	A
8/28/18[3]	12:51	ND	ND	>2,419.6	<1	P	A
8/28/18[3]	12:51	ND	ND	>2,419.6	<1	P	A
9/1/18	10:07	ND	ND	>2,419.6	<1	P	A
9/4/18	13:31	ND	ND	>2,419.6	<1	P	A
9/11/18	12:52	ND	ND	1,300	<1	P	A
Site 2 - Piru Creek Arm							
8/21/18	12:50	ND	ND	>2,419.6	<1	P	A
8/28/18[3]	11:50	ND	ND	>2,419.6	<1	P	A
8/28/18[3]	11:50	1	ND	>2,419.6	1	P	P
9/1/18	9:42	ND	ND	>2,419.6	<1	P	A
9/4/18	13:40	ND	ND	>2,419.6	<1	P	A
9/11/18	13:37	ND	ND	1,200	<1	P	A

[1] 2,419.6 MPN/100mL is the maximum recorded value of the test conducted.
[2] 1 MPN/100mL is the method reporting limit for the test. Result of "< 1" are values less than the laboratory reporting limit.
[3] Two samples were collected at each location on 8/28/18 to serve as a duplicate sample for quality assurance protocols.
Key:
> = Greater than
< = Less than
MPN = Most probable number
mL = milliliters
P = Presence
A = Absence
ND = Non Detection

Reservoir Profiles

Considering Quail Lake's shallow depth (less than 30 feet deep at normal maximum water surface elevation [NMWSE]), no thermocline or other patterns typical of deeper lakes and reservoirs were detected. Water temperature and DO profiles are shown in Figures 1 and 2, respectively. The DO concentrations were consistent with the Lahontan RWQCB's Basin Plan Water Quality Objective. Specific conductivity ranged between 214 microsiemens per centimeter (µS/cm) and 547 µS/cm over all depths and sample events. pH ranged between 7.69

and 8.52 over all depths and sample events. Quail Lake was at or near its NMWSE at the time of the data collection.

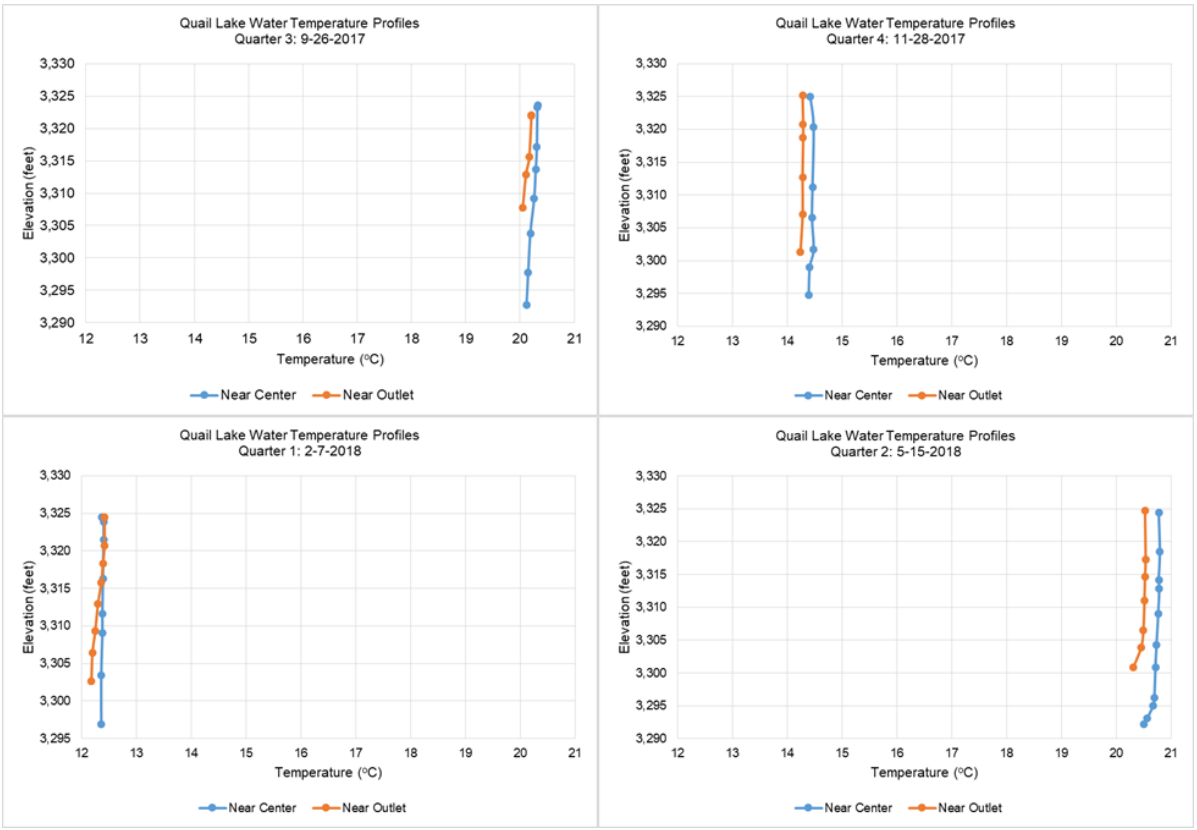
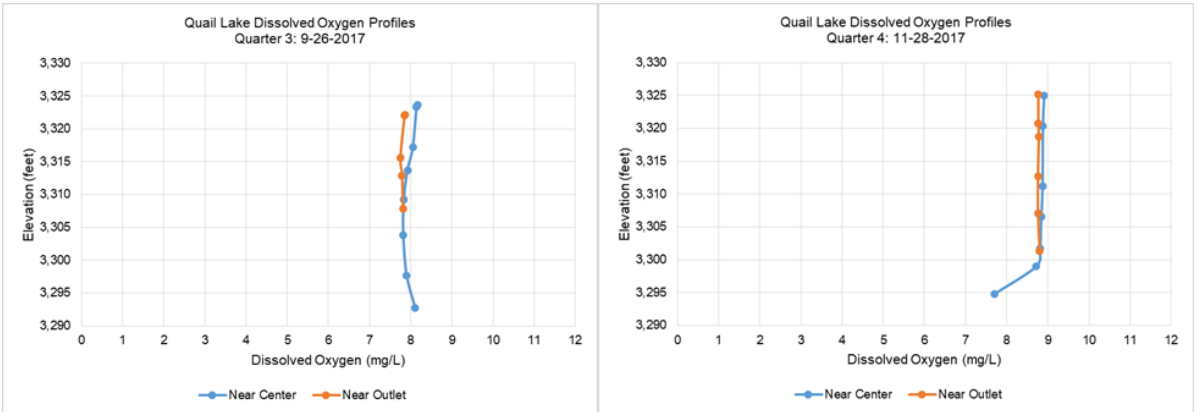


Figure 1. Quarterly Water Temperature Profiles for Two Locations in Quail Lake, 2017-2018



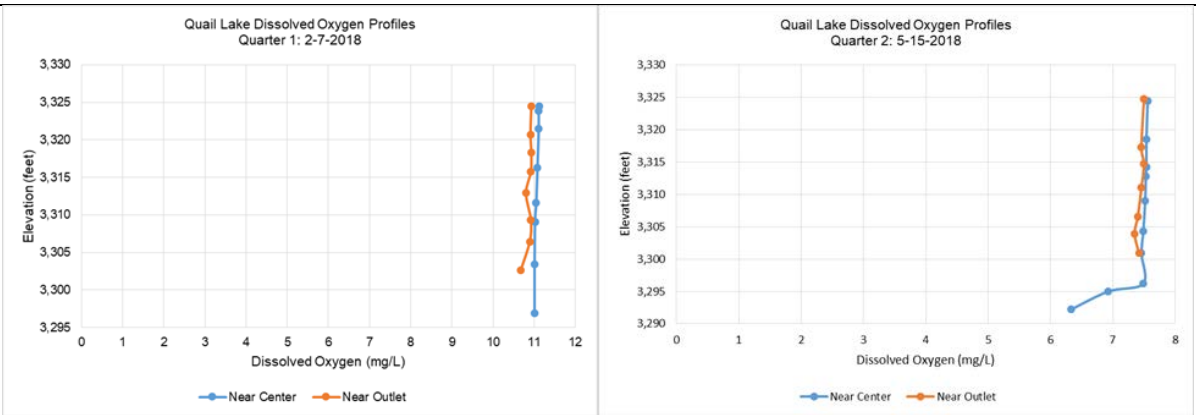


Figure 2. Quarterly Dissolved Oxygen Profiles for Two Locations in Quail Lake, 2017-2018

Surface water temperatures in Pyramid Lake ranged between 11 degrees Celsius (°C) and 23°C depending on the time of year and sample location. In general, there was no thermocline detected during the sampling events, except for a slight one during the third quarter sample (September 2017) (Figure 3). Surface DO concentrations ranged between 5.4 mg/L and 10.6 mg/L. DO concentrations tended to stay consistent throughout the water column. The only exception was the third quarter sample (September 2017), when DO concentrations reached near zero at a depth of 260 feet (Figure 4). pH values ranged between 6.7 and 8.5 across all depths, locations, and sample events. Specific conductivity ranged between 194 µS/cm and 506 µS/cm across all depths, locations, and sample events. Turbidity ranged from 0.5 Nephelometric Turbidity Units (NTU) to 30.4 NTU across all depths and locations, and was greatest near the bottom of the reservoir.

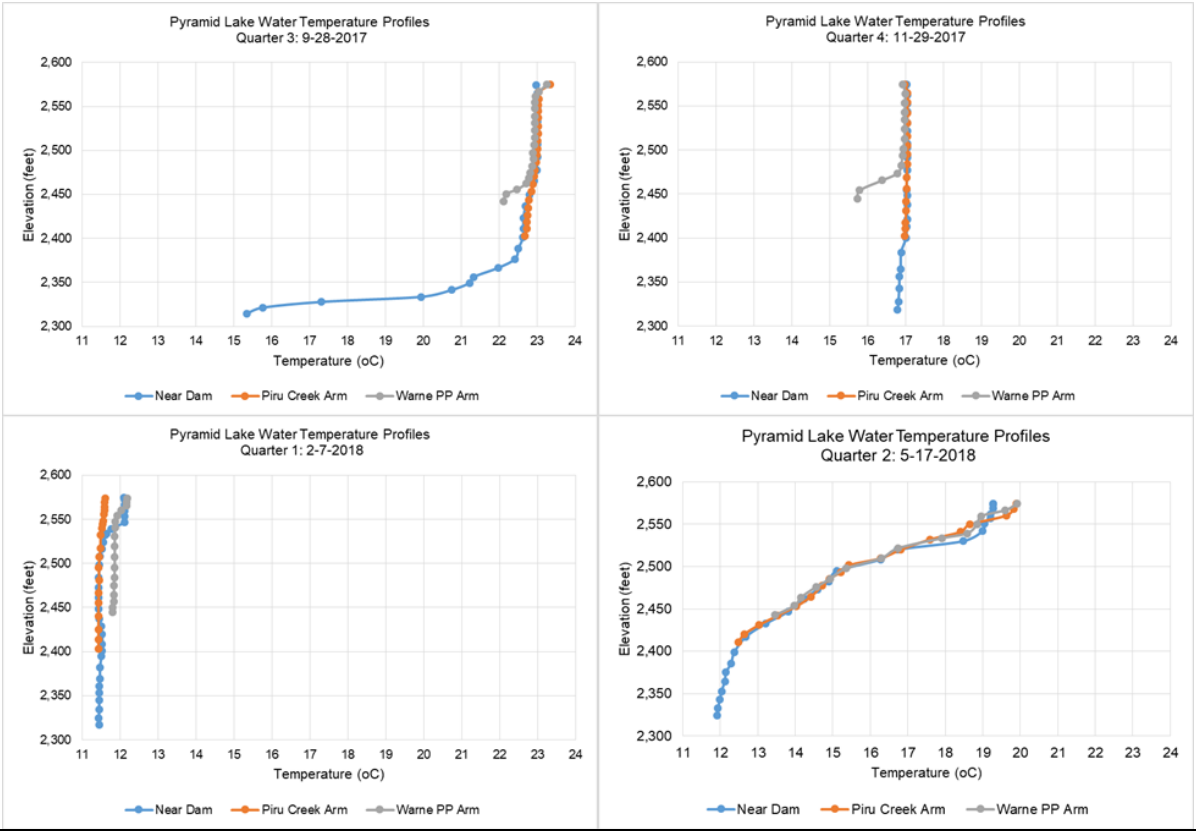


Figure 3. Water Temperature Profiles at Three Locations in Pyramid Lake, Quarterly 2017-2018

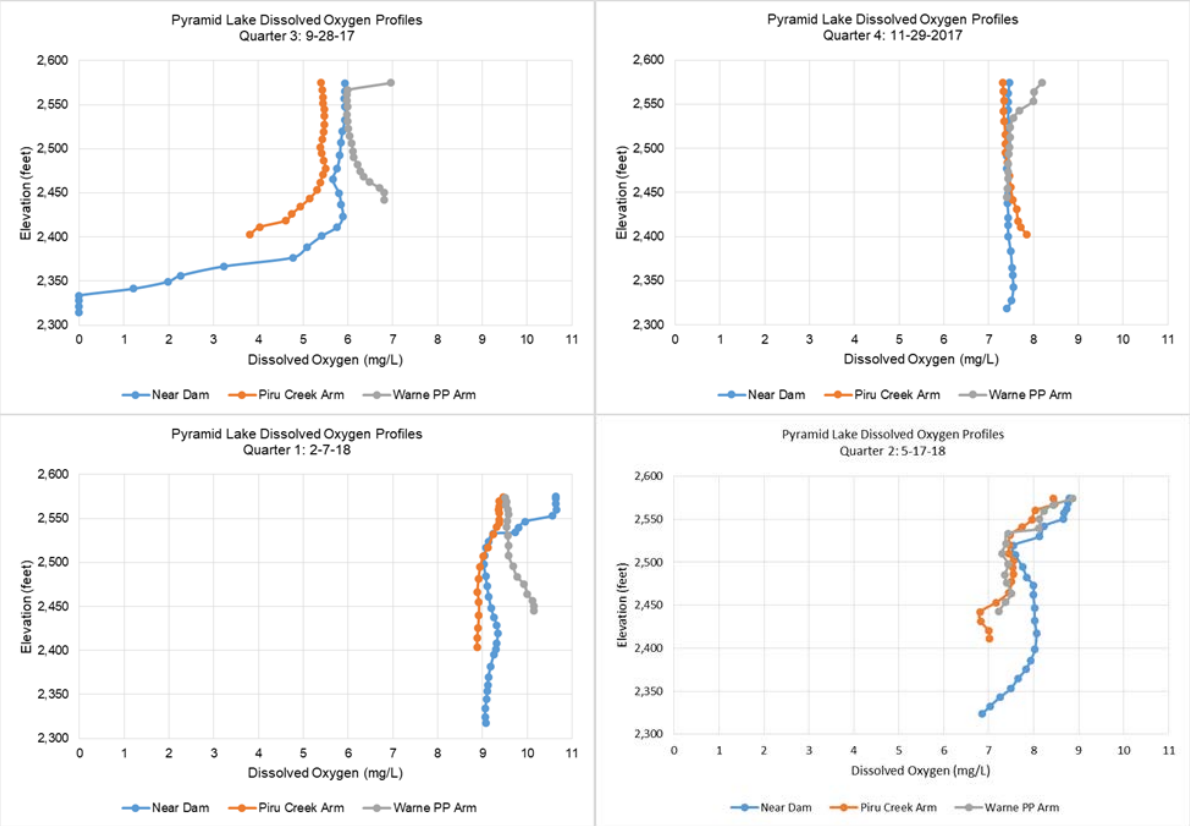


Figure 4. Dissolved Oxygen Profiles at Three Locations in Pyramid Lake, Quarterly 2017-2018

Water Temperature Monitoring

Water temperatures in Pyramid reach varied daily and seasonally at all locations. Water temperatures downstream of Pyramid Dam ranged between 10°C and just over 20°C, but showed very little diurnal fluctuation due to the consistent releases from Pyramid Dam (see Figure 5).

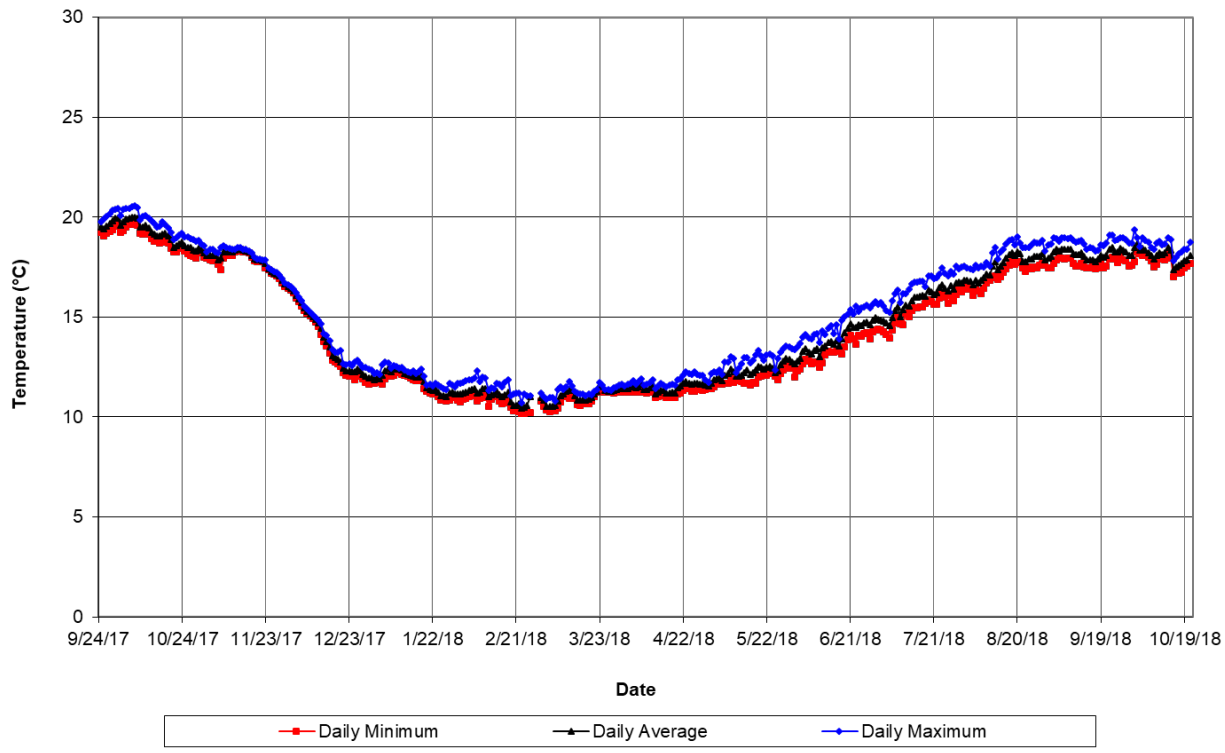


Figure 5. Daily Minimum, Average, And Maximum Water Temperatures at Pyramid reach Downstream of Pyramid Dam

Water temperatures further downstream of Pyramid Dam showed more seasonal and diurnal variation compared to the station near the dam. The two monitoring locations 1.5 and 3.0 miles downstream of Pyramid Dam had very similar water temperatures, ranging between 6°C and 28.5°C (Figures 6 and 7). Despite the Licensees' efforts to have no data gaps (e.g., duplicate loggers, hidden from the public, robust housing), there is a data gap of 96 days (February 8, 2018 to May 14, 2018) at the location 3.0 miles downstream of Pyramid Dam, near Frenchmen's Flat (Figure 7), due to vandalism of the loggers. When the monitoring location was visited on May 14, 2018, both loggers were gone and one broken housing was found. Missing loggers were replaced with new loggers during the same site visit in order to continue data collection and were moved to a more secluded location. Water temperatures observed at the monitoring stations 1.5 and 3.0 miles below Pyramid Dam were very similar, with 98 percent of the daily average temperatures within 1°C and 65 percent of the daily average temperatures within 0.5°C.

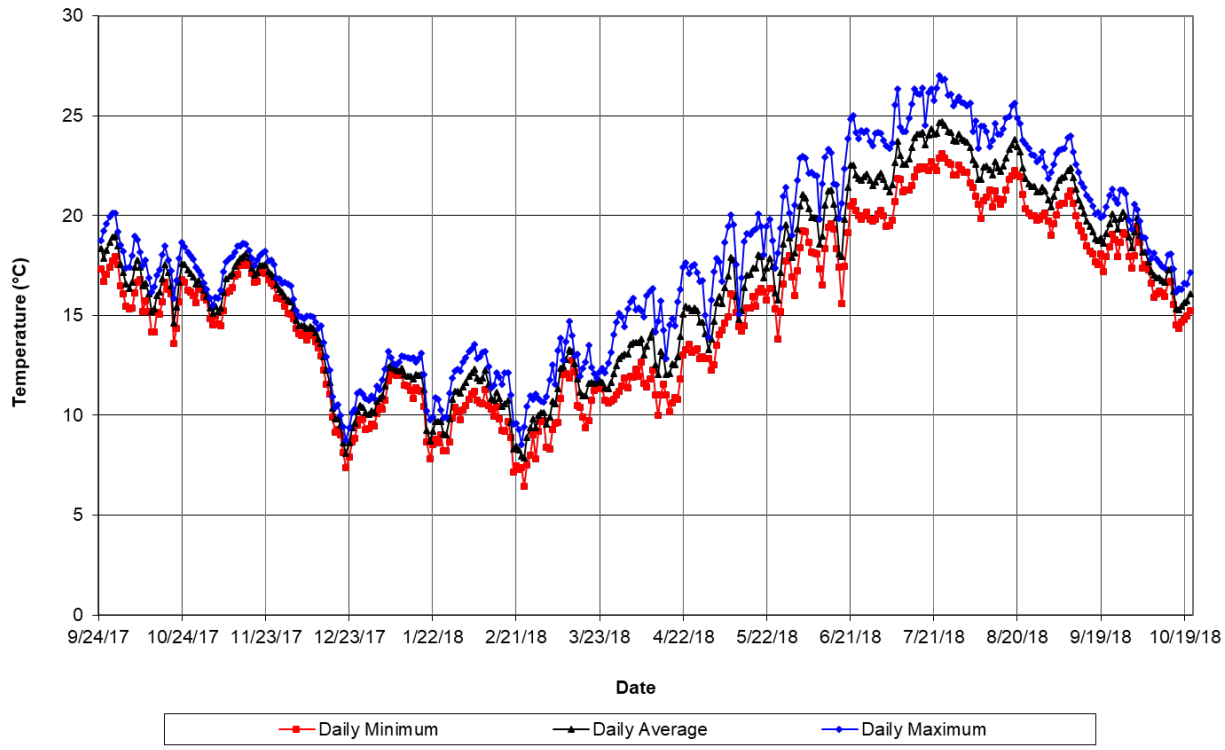
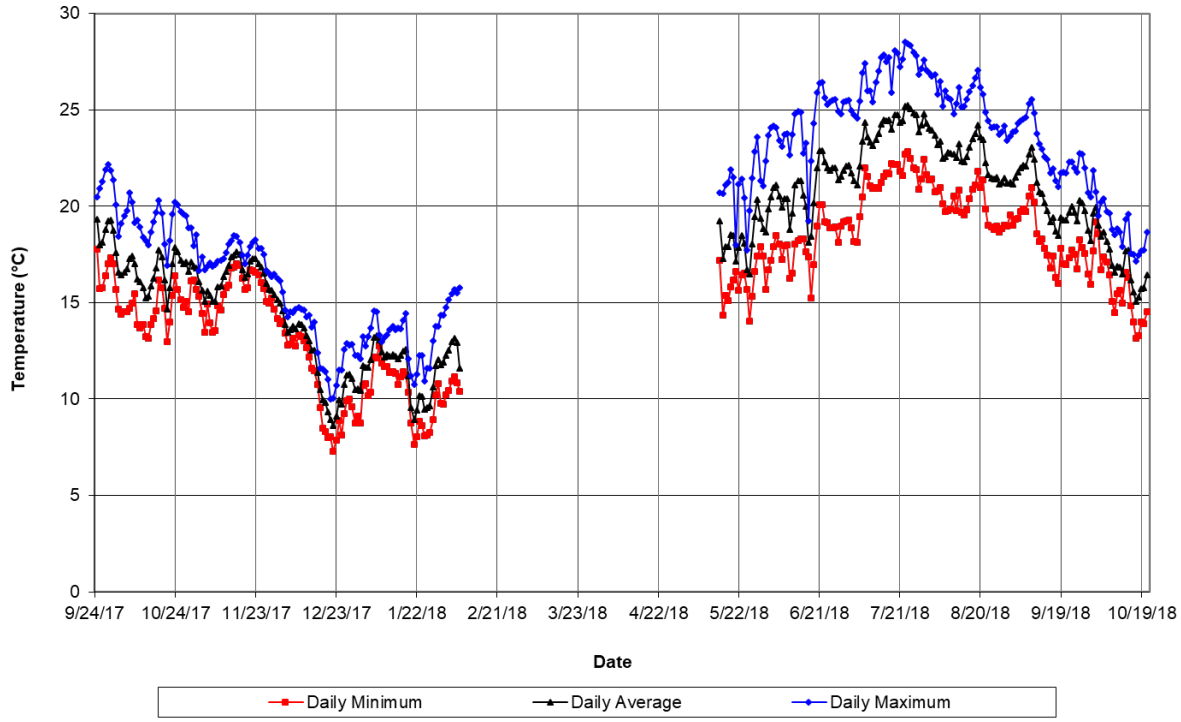


Figure 6. Daily Minimum, Average, and Maximum Water Temperatures at Piru Creek, 1.5 Miles Downstream of Pyramid Dam



Note: Data gap due to missing or malfunction data loggers.

Figure 7. Daily Minimum, Average, and Maximum Water Temperatures in Pyramid reach, 3.0 Miles Downstream of Pyramid Dam, near Frenchmen's Flat

The most downstream water temperature monitoring location was approximately 18 miles downstream of Pyramid Dam near Blue Point Campground. Water temperatures ranged between 7.9°C and 26°C, and had daily variations up to 9°C during the monitoring period (Figure 8). While the water temperatures observed at this location showed similar seasonal variation to those observed at the upstream locations, temperatures were cooler than those observed upstream.

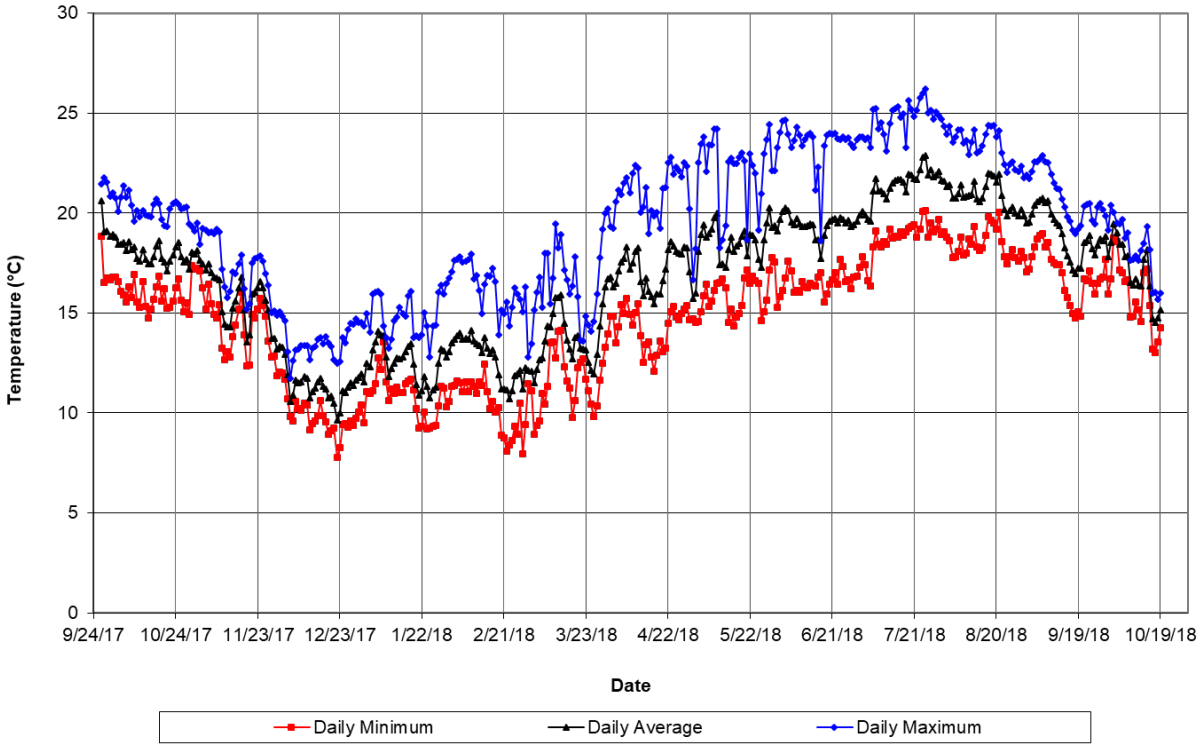


Figure 8. Daily Minimum, Average, and Maximum Water Temperatures at Pyramid reach, 18 Miles Downstream of Pyramid Dam, near Blue Point Campground

Associated Data Files *(All associated data can be found in the folder with this summary form. Note: Confidential CEII/privileged information will not be posted publicly.):*

File Name	Data Description	File Type	File Location
20181126_dwr_sswp_p2426_Project_Laboratory_Water_Quality_Data	Laboratory results for sampling at Pyramid Lake, Quail Lake, and Pyramid reach (14 locations)	Microsoft Excel	Project Website
20181126_dwr_sswp_p2426_Reservoir_Profile_Data	Raw reservoir profile data for Pyramid Lake (three locations) and Quail Lake (two locations)	Microsoft Excel	Project Website
20181126_dwr_sswp_p2426_Pyramid_Reach_Water_Temps	Raw 15-minute interval water temperature data and calculated daily minimum, average, and maximum for four locations in Pyramid reach	Microsoft Excel	Project Website

20181130_dwr_sswp_p2426_Water_Quaility_Sampling_Locations	Map of water quality sampling locations	Adobe PDF	Project Website
20181220_dwr_sswp_p2426_Laboratory_Reports	Laboratory reports from water quality sampling, including bacteria sampling	Adobe PDF	Project Website

Variances from Study Methods, Schedule, or Approach and Abnormalities in Expected Field Conditions:

There were two variances to the FERC-approved Study. The Study Plan targeted collecting one complete year of water temperature data in Pyramid reach beginning in August 2017. The Licensees installed the loggers in September 2017 and kept them installed through October 2018. This variance had no effect on the overall Study because one year of monitoring was completed; it was simply shifted by one month.

The Study Plan also envisioned “continuous recording during the entire 365 days.” At the location near Frenchmen’s Flat (approximately 3.0 miles downstream of Pyramid Dam), there is a gap in the water temperature data record from February 8, 2018 to May 14, 2018. The data gap was due to vandalism of both the primary and secondary loggers installed at this location. When the loggers were visited during the quarterly downloads on May 14, 2018, both loggers were missing and pieces of one broken housing were found nearby. New loggers were installed during the same site visit and moved to a nearby location that was more secluded. Despite this data gap, water temperature in Pyramid reach can still be characterized using the other loggers installed, including one logger located 1.5 miles upstream of the logger with the data gap.

Remaining Work:

None; the Study is complete.