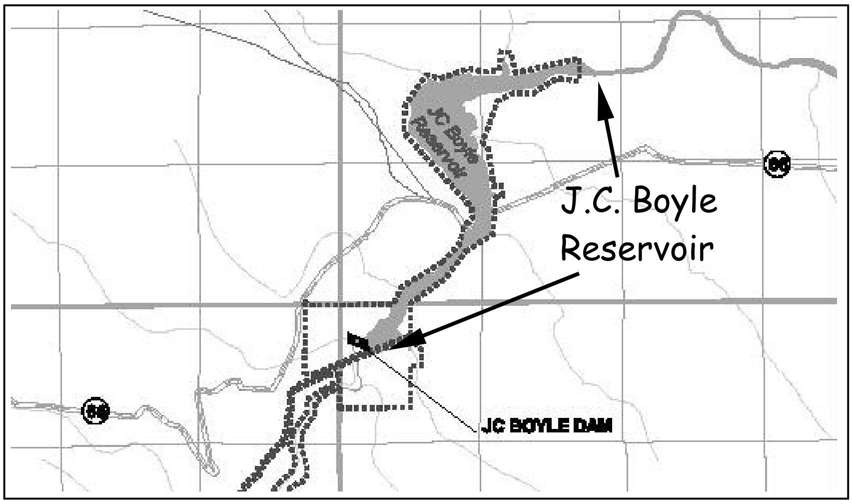
4. J.C. Boyle Reservoir

Reservoir Location and Characteristics

The J.C. Boyle reservoir includes the portion of the mainstem Klamath River from J.C. Boyle dam (RM 224.7) to the upper end of the J.C. Boyle reservoir (RM 228) near the mouth of Spencer Creek.



J.C. Boyle Reservoir Physical and Operational Characteristics			
Impoundment length (miles)	3.3	Normal full pool elevation (ft msl)	3793.5
Impoundment length (RM)	224.7-228	Normal minimum pool elevation (ft msl)	3788.0
Surface area (acres)	420	Normal annual operating fluctuation (ft)	5.5
Maximum / mean depth (ft)	40 / 8.3	Average daily operating fluctuation (ft)	2.0
Total storage capacity (ac-ft)	3,495	Normal active storage capacity (ac-ft)	1,724
Total retention time (days)		Active storage retention time (days)	
At 710 cfs	2.5	At 710 cfs	1.2
At 1600 cfs (□mean flow)	1.1	At 1600 cfs (□mean flow)	0.5
At 10,000 cfs (extreme event)	0.2	At 10,000 cfs (extreme event)	0.1

Dam Characteristics and Flow Control Structures

- J.C. Boyle dam characteristics are listed in the adjacent table.
- Diversion intake withdraws water from about the top (surface) 30 feet of reservoir.
- Spill occurs primarily when reservoir inflows exceed about 3,000 cfs (i.e., hydraulic turbine capacity).

J.C. Boyle Dam Characteristics	
Dam type: *Earthfill*	
Dam overall length (ft)	714
Dam crest elevation (ft msl)	3800
Dam height (ft)	68
Spillway type: *Ogee with 3 gates*	
Spillway length (ft)	117
Spillway crest elevation (ft msl)	3781.5
Diversion intake type: *Concrete tower with four 11.5'-wide openings*	
Diversion intake crest elevation (ft msl)	3762
Diversion intake full pool depth (ft)	31.5
Diversion intake min. pool depth (ft)	26

- J.C. Boyle dam is equipped with a pool and weir fish ladder. An automated gate maintains a constant flow into the ladder, and an auxiliary water supply system assures that a total of 80 cfs is provided as attraction flow at the ladder entrance.
- A FERC-stipulated minimum flow requirement of 100 cfs is maintained below the dam.

Operations

- J.C. Boyle is generally scheduled and operated in a peaking mode when river flows are less than about 3,000 cfs (i.e., hydraulic turbine capacity). This generally occurs throughout the year outside the spring months when flows are highest (Figures 4-1 and 4-2).
- Daily peaking is accomplished by regulating daily inflow with the J.C. Boyle reservoir. Off-peak inflows are stored in the reservoir, raising the reservoir water level. During peaking, the reservoir is drawn down to augment inflows and allow operation of the turbine-generators at high loads near peak efficiency (Figure 4-3). Daily inflows can be fully regulated with a 2-foot reservoir water level fluctuation.
- One or both of the turbine-generators are typically started in the morning to early afternoon and ramped up to best efficiency or full load

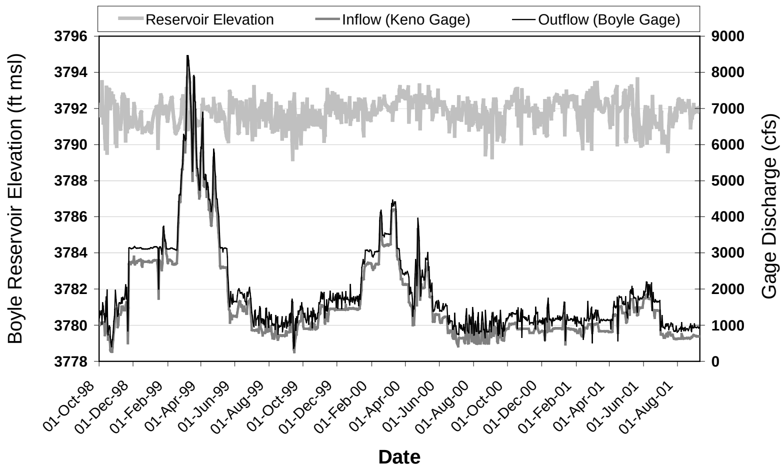


Figure 4-1
Daily Average Boyle Reservoir Elevation, and Estimated Reservoir Inflow and Outflow for WYs 1999-2001

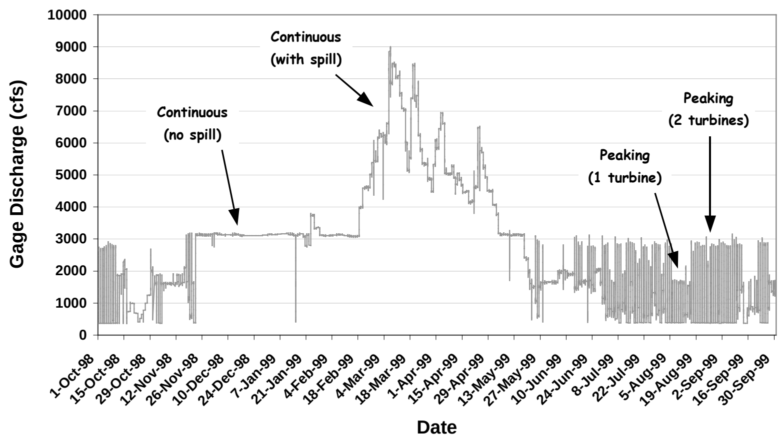


Figure 4-2
Hourly Discharge Below the J.C. Boyle Powerhouse WY 1999

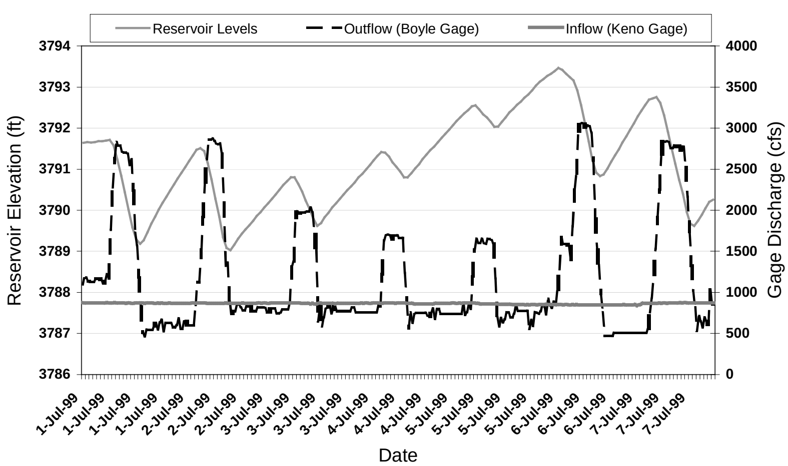


Figure 4-3
Hourly J.C. Boyle Reservoir Elevations, and Reservoir Inflow and Outflow During July 1-7, 1999

output. The unit(s) are maintained at near-constant load, ramped back down later in the day, and shut off at night.

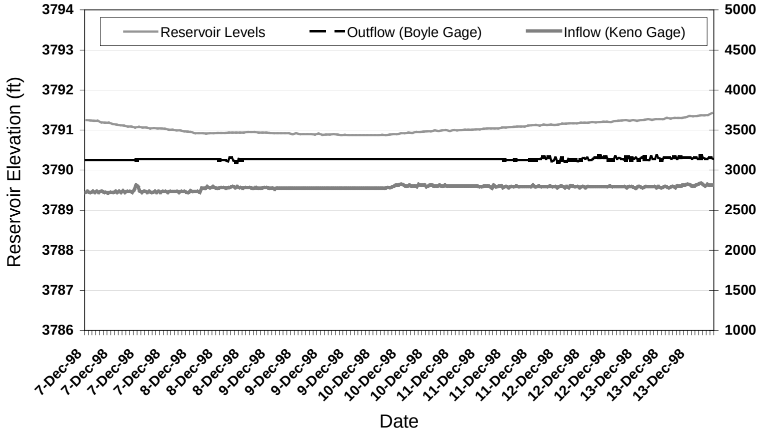


Figure 4-4
Hourly J.C. Boyle Reservoir Elevations, and Reservoir Inflow and Outflow During December 7-13, 1998

- The principal operating constraints imposed on the extent of peaking operation are the available inflow, the limits on changes in flow rate (i.e., ramp rate) to 9 inches in river stage per hour (approximately 250 cfs per hour)[1], and the available active storage in the reservoir.

Limnological Description and Water Quality Trends

- J.C. Boyle reservoir is the smallest of PacifiCorp's three mainstem reservoirs. J.C. Boyle reservoir has relatively short flow retention rates (about 1 day at the average flow of 1600 cfs, and about 2.5 days at 700 cfs). Due to its short flow retention rates and rather narrow, channeled basin, J.C. Boyle reservoir combines features of both riverine and lacustrine environments.

Figure 4-5
Surface And Bottom Temperatures In JC Boyle Reservoir: May 26 To November 14, 2000. All Temperatures In Degrees Celsius.

- Short flow retention rates in J.C. Boyle reservoir also results in only very weak, if any, vertical stratification of water temperatures (Figures 4-5 and 4-6). Weak stratification occurs mostly during summer months, when surface waters are consistently 2-3°C warmer than bottom temperatures (Figure 4-5). Even during the summer, the weak thermal stratification is often interspersed with times of isothermal, well-mixed conditions. These isothermal, well-mixed conditions are likely due to operations-related short-term increases in flow.

[1] As measured at the USGS gage station approximately ½ mile below the J.C. Boyle powerhouse.

- Although vertical stratification of water temperatures in JC Boyle reservoir during summer is mostly weak, dissolved oxygen progressively decreases, and becomes hypoxic to anoxic, especially at depth (Figure 4-6).

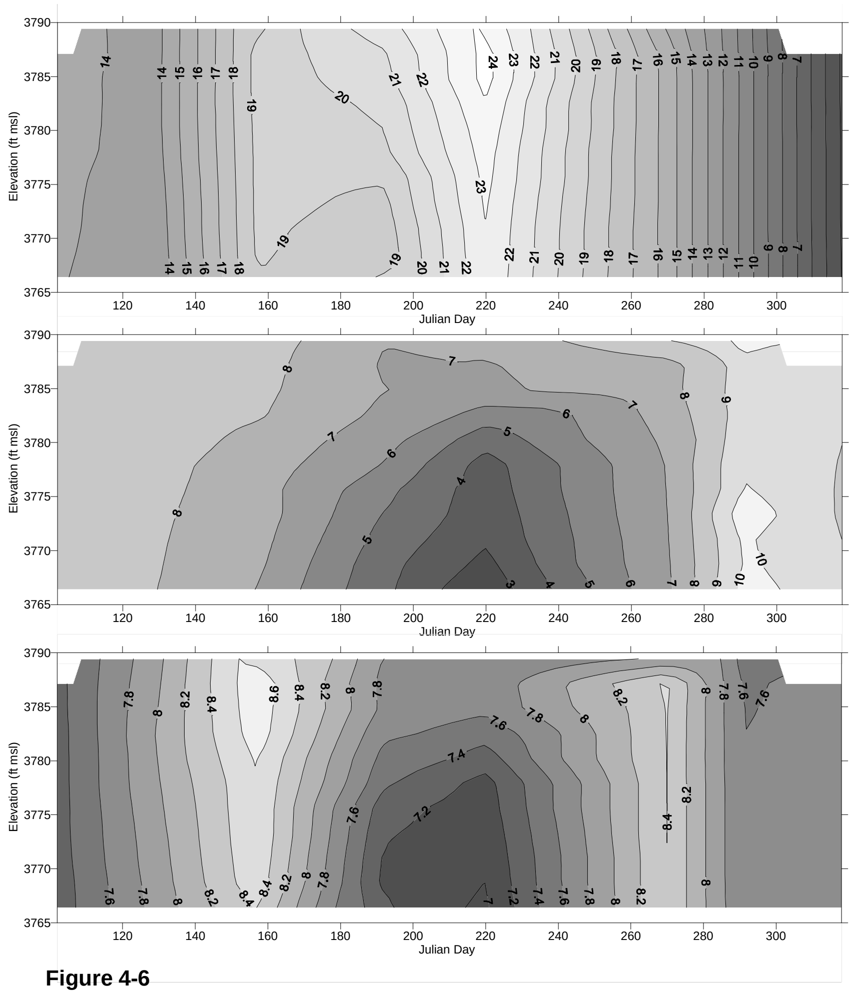


Figure 4-6
J.C. Boyle Reservoir Temperature (Top), Dissolved Oxygen (Middle), and pH (Bottom) Isolpleths: April – November 2000.

- The ranges of values for nutrient data collected in 1996 and 1997 are shown in the Figure 4-7 box plot. Nutrient values are relatively high, supporting conditions that are consistent with a highly productive system dominated by cyanophytes (blue-green algae).

- Annual trends in the abundance of algal nutrients are shown in the Figure 4-8 scatter plot. Total Kjeldahl nitrogen (TKN) concentration increases throughout the year, as does ammonia. Total nitrate concentration is low in the spring, reaches a peak in July and then decreases in late summer. Phosphorus shows an annual cycle similar to nitrogen although the magnitude of variation is smaller.

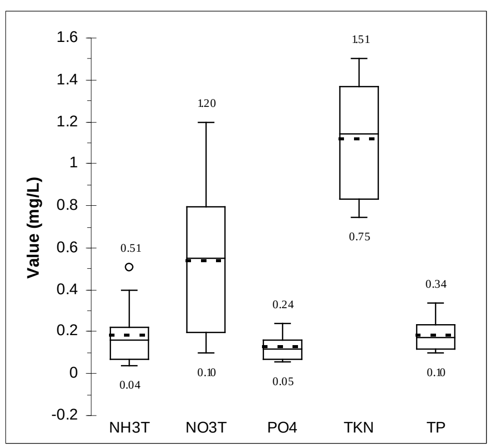


Figure 4-7
Boxplots Of Nutrient Data Collected In JC Boyle Reservoir In 1996 And 1997

- Specific conductance also shows a seasonal cycle, increasing from lower values in the spring to a high value in June and then decreasing again. This could indicate the influence of high conductivity agricultural return flow, which may contribute to the observed seasonal cycle of nitrate and phosphorus.

- The portion of the Klamath River that includes the J.C. Boyle reservoir is 303(d)-listed for water temperature, nuisance phytoplankton, and pH. Nuisance phytoplankton and high pH, along with high nutrient concentrations, indicate that algal photosynthesis and respiration processes are key factors affecting water quality conditions in J.C. Boyle reservoir.

303(d) Listed Water Quality Parameters
Water temperature
Nuisance phytoplankton
pH

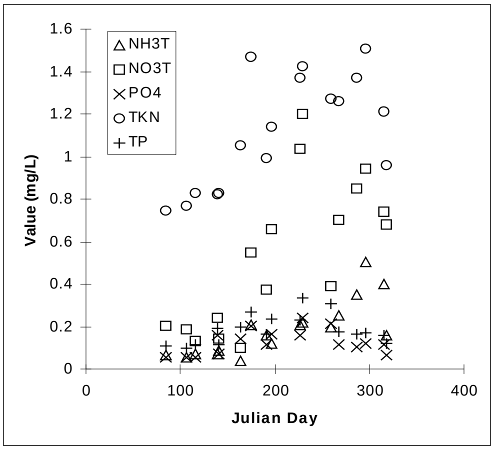


Figure 4-8
Scatterplot Of Nutrient Data Collected In JC Boyle Reservoir In 1996 And 1997 Plotted Against Day Of The Year

Available Data and Information

- **Previous WQ Monitoring (1980 to 1998)**. Monthly data was collected upstream, within, and downstream of the J. C. Boyle reservoir in 1984-85 as part of studies conducted by the City of Klamath Falls for the proposed Salt Caves Project. Since that time, little data is available for J. C. Boyle reservoir until recently. Only one site in J.C. Boyle reservoir has data prior to the start of the recent monitoring program in 1998. No metadata are available for the site, labeled Boyle-B. It is assumed that data were collected either near the dam or from the Highway 66 bridge. Water samples collected in 1996 and 1997 were analyzed for nitrogen and phosphorus. See table below.

Reach	Site Name	Sample Count	Min Date	Max Date	Source
3	Klamath River below Keno Dam	2	03/28/95	03/29/95	STORET
3	KR1 Above JCBoyle Reservoir	19	11/18/83	02/18/85	CITY OF K FALLS
4	BEP JC Boyle Reservoir at deepest point, Z = 1m	6	04/16/84	09/09/84	CITY OF K FALLS
4	BHY JC Boyle Reservoir at deepest point, Z = 7m	6	04/16/84	09/09/84	CITY OF K FALLS
4	Boyle -B (assumed to be at the dam)	17	04/25/96	11/12/97	USGS
5	KR2 Below Boyle Dam	16	03/28/84	11/18/84	CITY OF K FALLS

- **Recent WQ Monitoring (1998 to Present)**. In 1998 the USBS-Biological Resources Division (USGS-BRD) implemented a basin-wide monitoring program with support from USBR. Data were collected from Klamath Falls to below the Trinity River, as well as in the Klamath Reclamation Project and selected tributaries. This program was repeated in 1999. Throughout this period PacifiCorp monitored physical parameters in mainstem reservoirs, including J.C. Boyle reservoir. During 2000 PacifiCorp expanded monthly physical profile monitoring to include deployment of thermistors as well as grab sampling for nutrients and BOD. Thermistors provide temperature profile data near the dam. Monthly profile monitoring during April - November have been obtained for temperature, pH, dissolved oxygen, and specific conductance, and grab samples obtained from near the surface (1 meter) and near the bottom are analyzed for nitrogen, phosphorus, BOD, chlorophyll, and phytoplankton.