# Update on Water Quality Conditions below Glen Canyon Dam
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## Introduction

Water-quality monitoring of Glen Canyon Dam releases, in the tailrace below the dam, has demonstrated progressively lower dissolved oxygen (DO) concentrations and increasing specific conductance (SC) during the month of February 2007, indicating increasing influence of deep water in the reservoir affecting dam releases. The mean daily DO concentration in dam releases was approximately 8.0 mg/L at the beginning of the month (77% of saturation); however, the concentration reached 4.4 mg/L (42% of saturation) on February 28, with instantaneous measurements reaching as low as 3.7 mg/L. It is uncertain how long this trend will continue. By comparison, mean daily tailrace DO concentrations reached a minimum of 3.9 mg/L on September 29, 2005.

## Monitoring Methods

The Grand Canyon Monitoring and Research Center has YSI Model 6920 multi-parameter sondes measuring continuous (20-minute intervals) water temperature, specific conductance, pH, dissolved oxygen, and turbidity at three locations in the Glen Canyon Dam tailwater: inside the draft tubes of the Glen Canyon Dam generators (CRDT), in the tailrace approximately 100 m downstream of Glen Canyon Dam below the river outlet works (CRBD), and at Lees Ferry on a mid-channel buoy slightly upstream of the Lees Ferry boat ramp. The tailrace location, CRBD, is connected to a data collection platform, accessible by telephone, which was installed in September of 2005. The CRDT and CRLF locations are visited monthly for servicing, calibration and data retrieval. The next visit will be March 5, 2007.

Depth profiles of water-quality parameters are collected in the Glen Canyon Dam forebay, approximately 2.4 km upstream of Glen Canyon Dam, on a monthly basis, using a Hydrolab Surveyor 3/H20 multi-parameter sonde. Recent forebay profiles were collected on January 25, 2007 (**Figure 1**) and February 15, 2007 (**Figure 2**). The next forebay sampling is scheduled concurrently with a full reservoir survey during the week of March 11, 2007

## Lake Powell Conditions

**Figure 1** shows conditions through the water column of the reservoir forebay on January 25, 2007. At this time, the surface of the reservoir (epilimnion) had mixed to the depth of the penstocks, approximately 40 m. Epilimnetic DO concentrations were approximately 8.5 mg/L, SC was approximately 725 µS/cm. The hypolimnion, or bottom layer of the reservoir was fairly uniform from a depth of 62 m to the bottom. Hypolimnetic DO concentration was approximately 1.7 mg/L near the bottom to 2.7 mg/L at 75 m. DO at

the upper boundary of the hypolimnion was 2.6 mg/L at 62 m. The entire water column was nearly isothermal with temperatures ranging between 7.9 ºC to 8.5 ºC; however, the lake was stratified due to the differences in SC. There was an intermediate zone of relatively well-oxygenated water residing below the penstock level and separating the mixed epilimnion from the hypolimnion.

**Figure 2** shows conditions in the reservoir forebay on February 15, 2007. At this time, the intermediate zone below the penstock depth had essentially been evacuated, and penstocks were withdrawing water from the thin transition zone between the epilimnion and hypolimnion. The upper boundary of the hypolimnion has moved upwards to where a DO concentration of 2.5 mg/L was observed at 51 m. This condition results in the reservoir being susceptible to internal oscillations from wind events, which can cause the surface layers of the reservoir to be moved upstream, with deeper layers being displaced upwards to be incorporated into dam releases.

## Dam Release Water-Quality

**Figure 3** shows instantaneous water-quality measurements in the Glen Canyon Dam tailwater (CRBD) since February 1, 2007. Conditions were fairly stable until approximately February 12, at which time a gradual decrease in dissolved oxygen concentrations, and a corresponding increase in SC, were observed, indicating an increasing influence of deeper reservoir water in dam releases. With the passage of a storm system on February 23, 2007, DO concentrations dropped rather dramatically by about 1 mg/L, with a corresponding jump in SC of about 50 µS/cm. Although this rapid decrease was probably the result of the February 23rd storm system, it is a part of a more long-term decrease in DO concentrations. Release temperature has remained constant throughout this period.

## Discussion

Two processes appear to be affecting the quality of reservoir releases. One is the short-term effect of weather patterns on the reservoir where the stratification boundary is very near the penstock release depth. The zone of fairly oxygenated water that existed below the penstock elevation in January 2007 has essentially been evacuated, bringing the hypoxic hypolimnion closer to the penstock release level. With the passage of storm systems on February 23-25, and again on February 28-March 1, strong SW winds created short-term oscillations (internal seiches) in the stratification patterns in Lake Powell and resulted in some of the hypoxic hypolimnion to be entrained in the releases. This is shown in the **Figure 3** as decreases in DO and increases in SC during these periods.

The other and more significant is the longer-term process evidenced by the gradual DO decreases and SC increases since February 12 shown in **Figure 3**. This is likely due to an underflow density current, from cold winter inflows moving along the bottom of the reservoir and displacing the hypolimnion in the forebay upwards. A distinct underflow density current near the dam has been observed each spring since 1999, with the

exception of 2006. An underflow density current was not expected this year, as its absence in 2006 indicated that the reservoir had increased in density to the point the winter inflows were expected to flow through intermediate depths in the reservoir. However, the sustained period of cold weather that was observed in January 2007, could have increased the density of the inflows to the point where a distinct underflow was possible. No underflow density current was observed during the forebay survey of February 15, 2007; however, the trend in release water quality over the past three weeks indicates that an underflow may indeed be occurring this year and has not arrived at the forebay yet. This will be verified during next reservoir sampling, March 12-17, 2007.

If an underflow density current is occurring this year, conditions could be very similar to what was observed in 2004, when there was a distinct underflow in the forebay. Reservoir elevations are similar, 3587 ft on March 1, 2004 vs. 3598 on March 1, 2007 and similar stratification patterns were observed in both years. **Figure 4** shows a sequence of forebay profiles, from at the dam, from February through April 2004, showing the influence of the underflow in displacing the hypoxic epilimnion upwards, allowing incorporation into dam releases. **Figure 5** shows the longer-term patterns in mean daily Glen Canyon Dam release water-quality, for comparison of these two periods. While DO concentrations were not as low in 2004 as current conditions, the minimum concentration in releases was not reached until April 22, 2004, indicating that current release concentrations may continue to decrease.

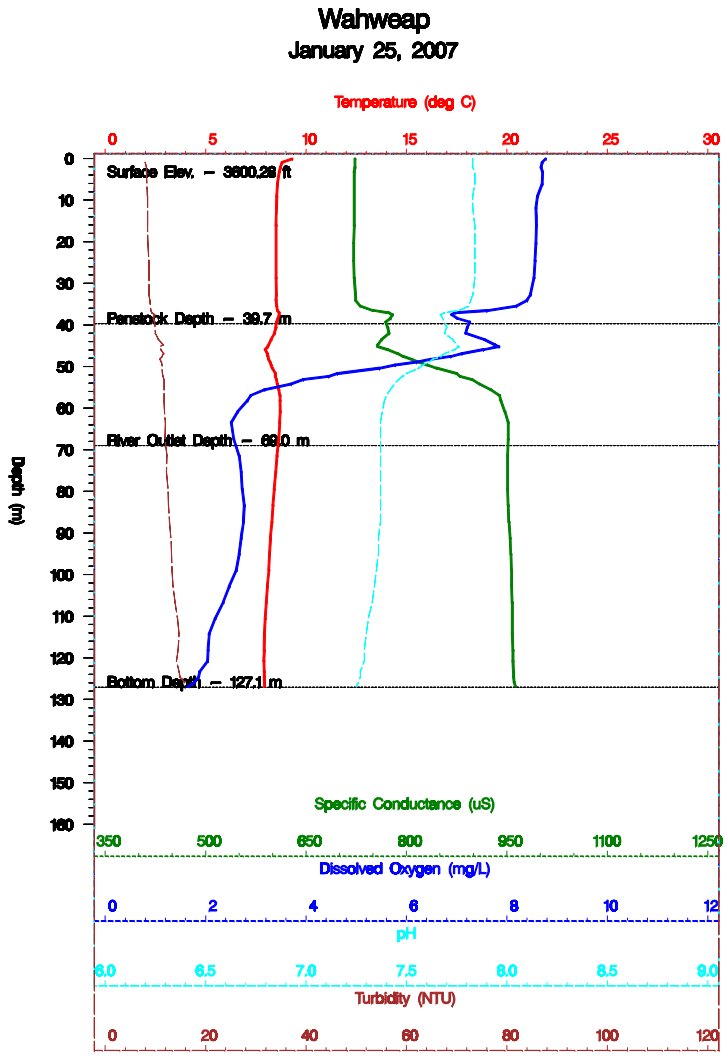


Figure 1. Forebay conditions, January 25, 2007

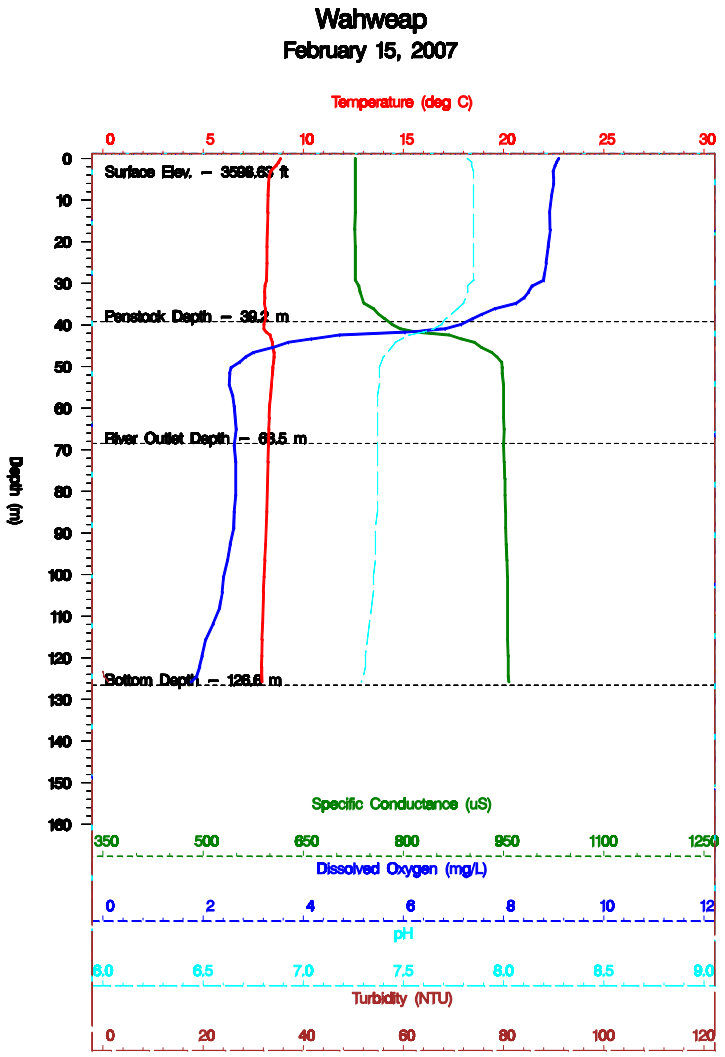


Figure 2. Forebay conditions, February 15, 2007

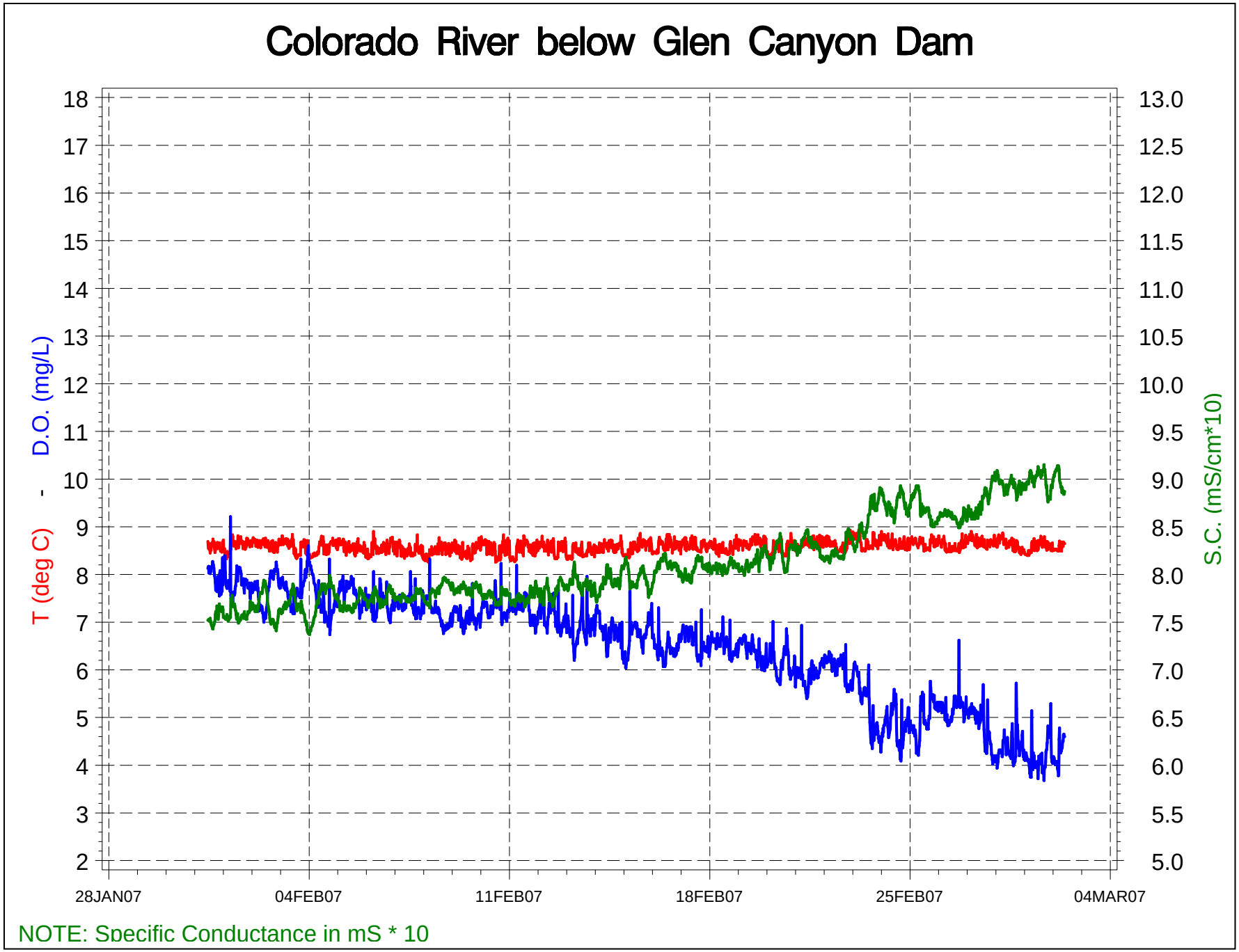


Figure 3. Glen Canyon Dam release water-quality since February 1, 2007

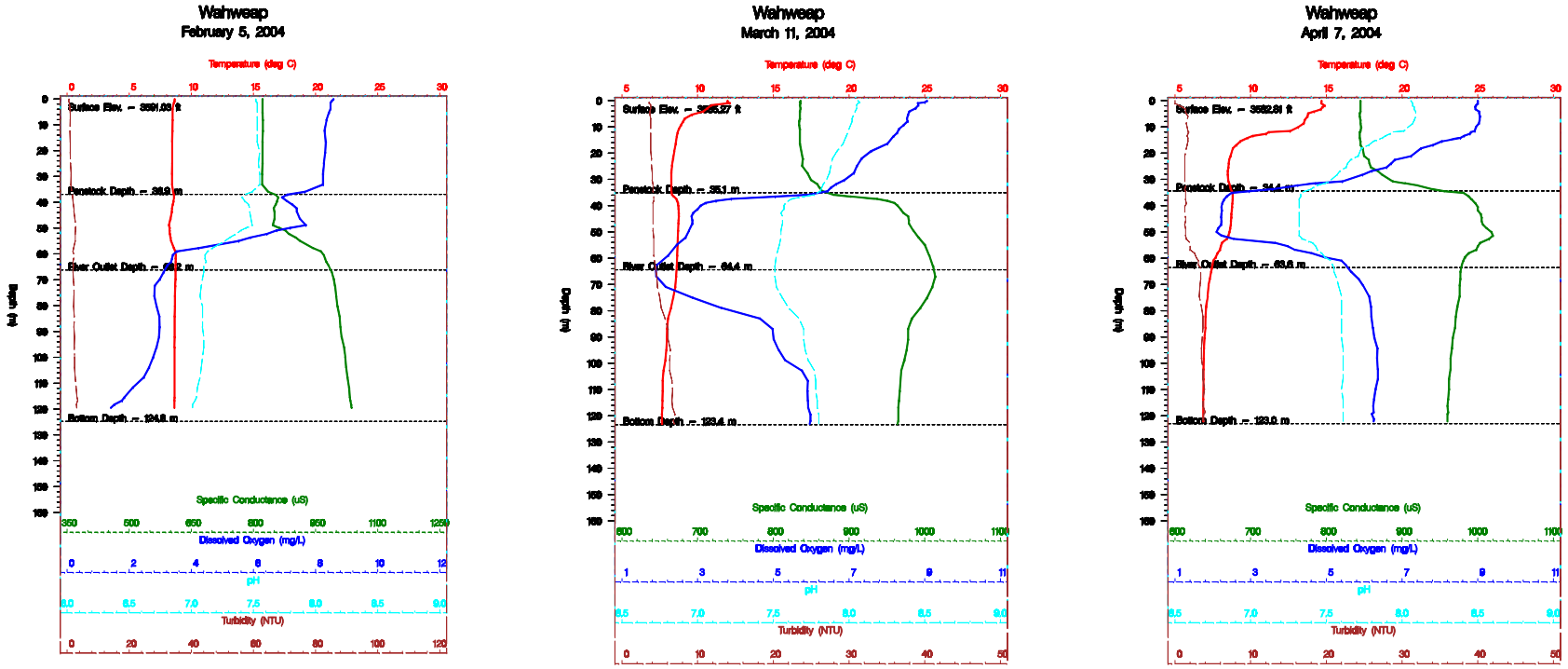


Figure 4. Glen Canyon Dam forebay profiles, February to April 2004

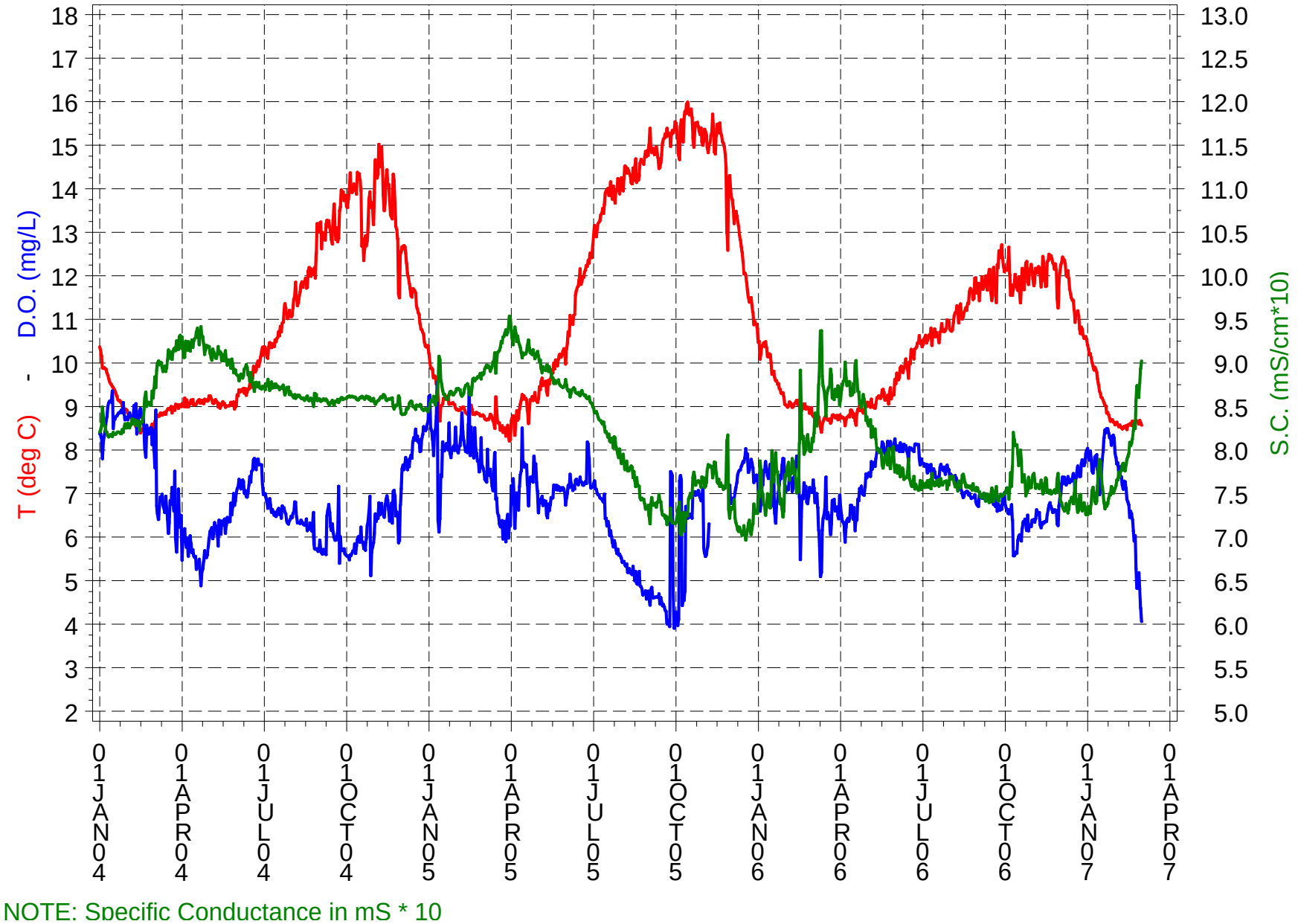


Figure 5. Mean daily Glen Canyon Dam release water quality, 2004 to 2007