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A Comparison of Potential Mixes in Two Southeastern Lakes: Lake Jocassee, SC and Carters Lake, GA



Introduction to Limnology Research BIOSC 4940

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Background:

Meromixis: A lake that does not mix completely.

Mixolimnion: Upper fresh water that is subjected to mixing and possibly temperature stratification.

Monimolimnion: Deep and normally greater density layer that does not mix and may be anoxic.

Chemocline: The layer of rapid chemical change that separates the mixed and unmixed layers of a meromictic lake.

Monomictic: A lake that only mixes once a year. Usually occurs during the fall and winter with spring and summer stratification.

Relative Depth: $Z_r (\%) = [(Z_{max}) (\sqrt{\pi})] / [20VA_0]$

Introduction:

In the Southeast United States most lakes tend to be warm monomictic lakes, mixing during one season each year. However, under circumstances of great relative depth, lakes may tend towards meromictic conditions. In this case the bottom layer of the lake, or the monimolimnion, never mixes completely. Carter's Lake in Chatsworth, Georgia was created in 1977 after the creation of Carter's Dam, and is an example of a meromictic lake. Lake Jocassee is a reservoir located in Salem, South Carolina on the Savannah River Basin. The reservoir was created in 1973 upon the completion of The Jocassee Pumped Storage Hydroelectric Station. Like Carter's Lake, Lake Jocassee is very deep and large, and has the possibility of behaving as a meromictic lake. Past data suggests that Lake Jocassee behaves more frequently as a warm monomictic lake while occasionally not mixing completely. We wanted to further study Lake Jocassee's morphometry to dig deeper into the possibility of meromixis within the lake by looking at the level of mixing in the Winter of 2014.

Methods:

The first step in determining mixing is to find the area of the lake. We obtained a map of Lake Jocassee and cut the lake into 8 segments. We measured out a 2 km square using the map scale and divided it by 2 to get how many planimeter units were in a km. We planimeted the surface areas of each segment and the subsequent areas of every 50 ft depth increments. We converted the measurements we got at each depth to km² using the square as the conversion unit and added each depth together. We also performed the cut-and-weigh method to compare the values.

We used the same square first to see how much the 2km² weighed. Again we divided it by 2 in order to see how much 1 km weighed. We proceeded by cutting out the different depths of the lake segment, weighed them, and converted them to km. The graphs can be seen in the results.

To get the thermal and chemical profile of Jocassee, we went to the deepest part and lowered sensors down to the bottom and back up again. The sensors collected data every second. The results can also be seen in the results section.

Data:

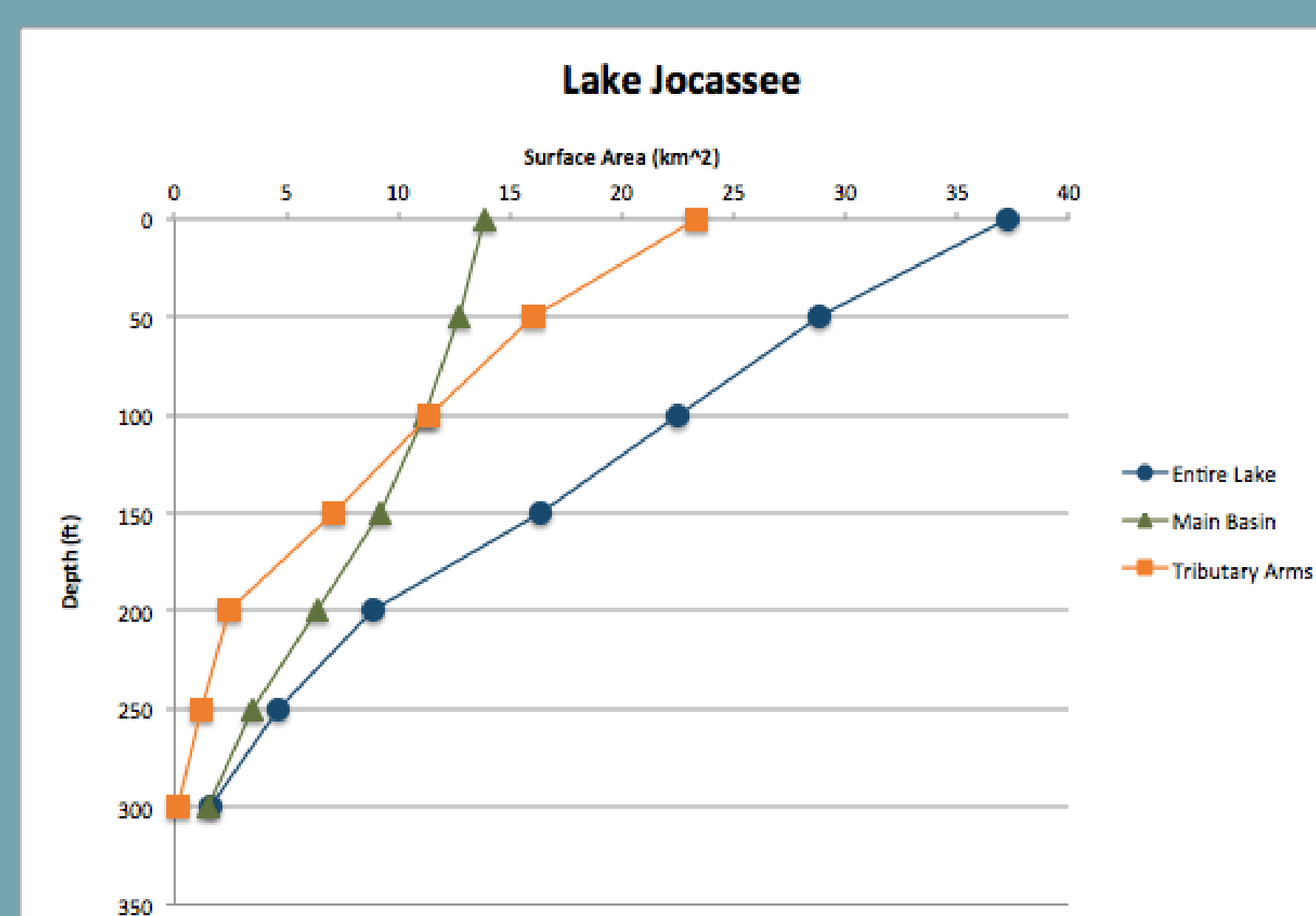


Figure 1: The hypsograph of the entire lake and the main basin for each respective lake section

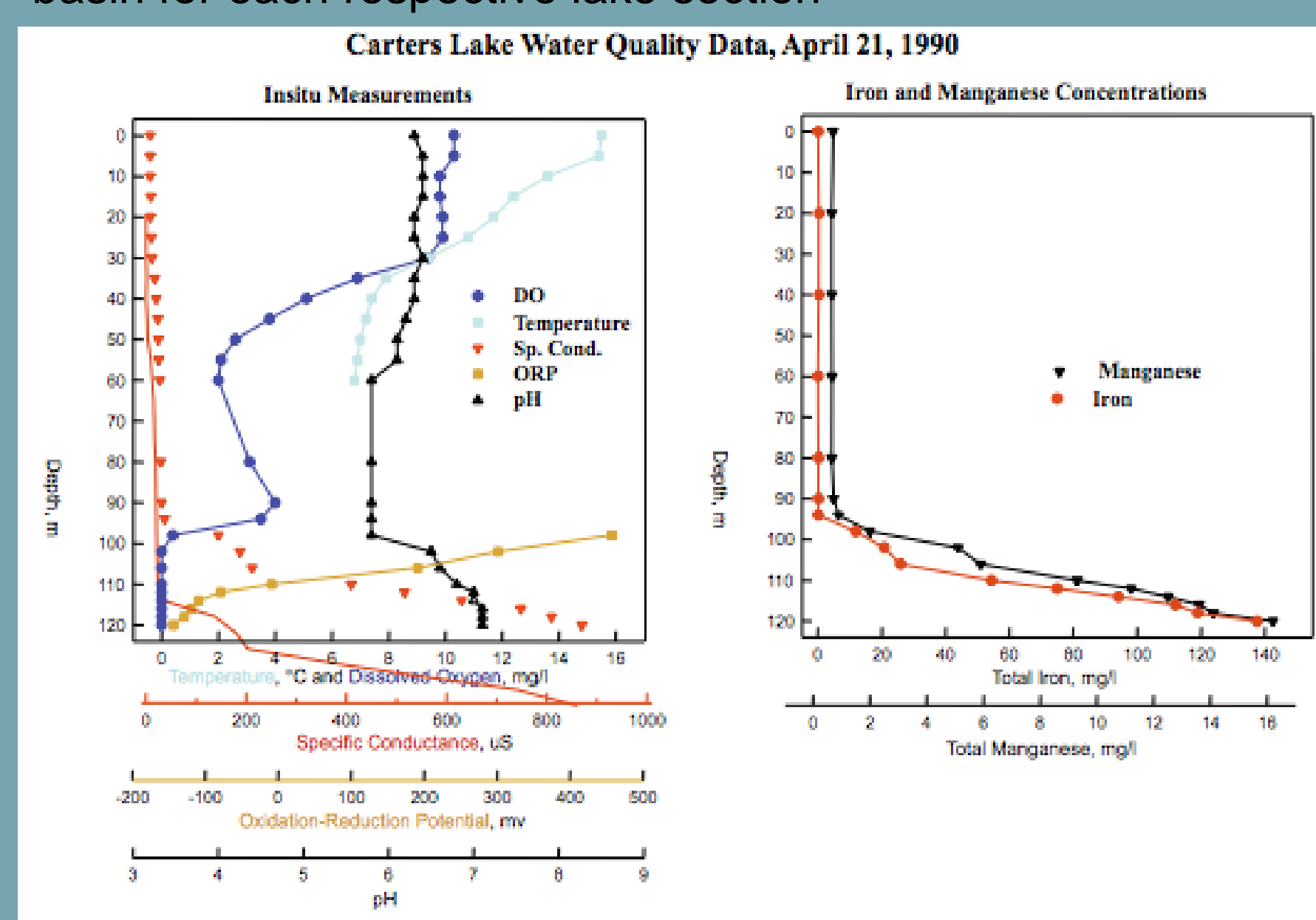


Figure 3: The thermal and chemical profiles of Carters lake from 1990.

	Lake Jocassee	Lake Jocassee Main Basin	Carters Lake	Carters Lake to Max Mixing Depth
Relative Depth	$1.328 \times 10^{-3}\%$	$2.178 \times 10^{-3}\%$	$4.113 \times 10^{-3}\%$	$2.216 \times 10^{-3}\%$

Figure 5: The respective relative depths of Lake Jocassee and Carters lake

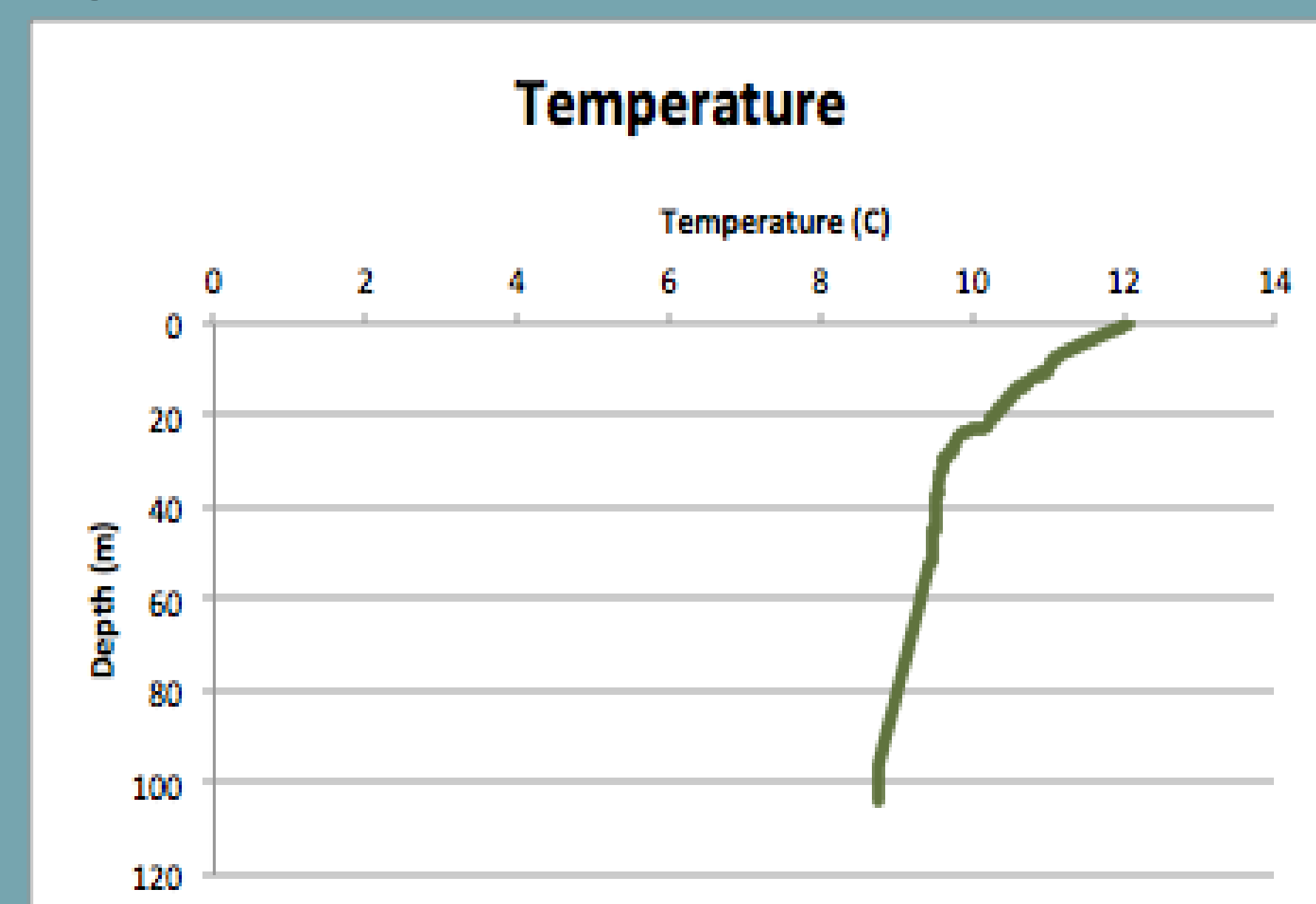


Figure 6: Temperature of Lake Jocassee on 2/22/2015 showing the beginning of stratification early in spring of 2015.

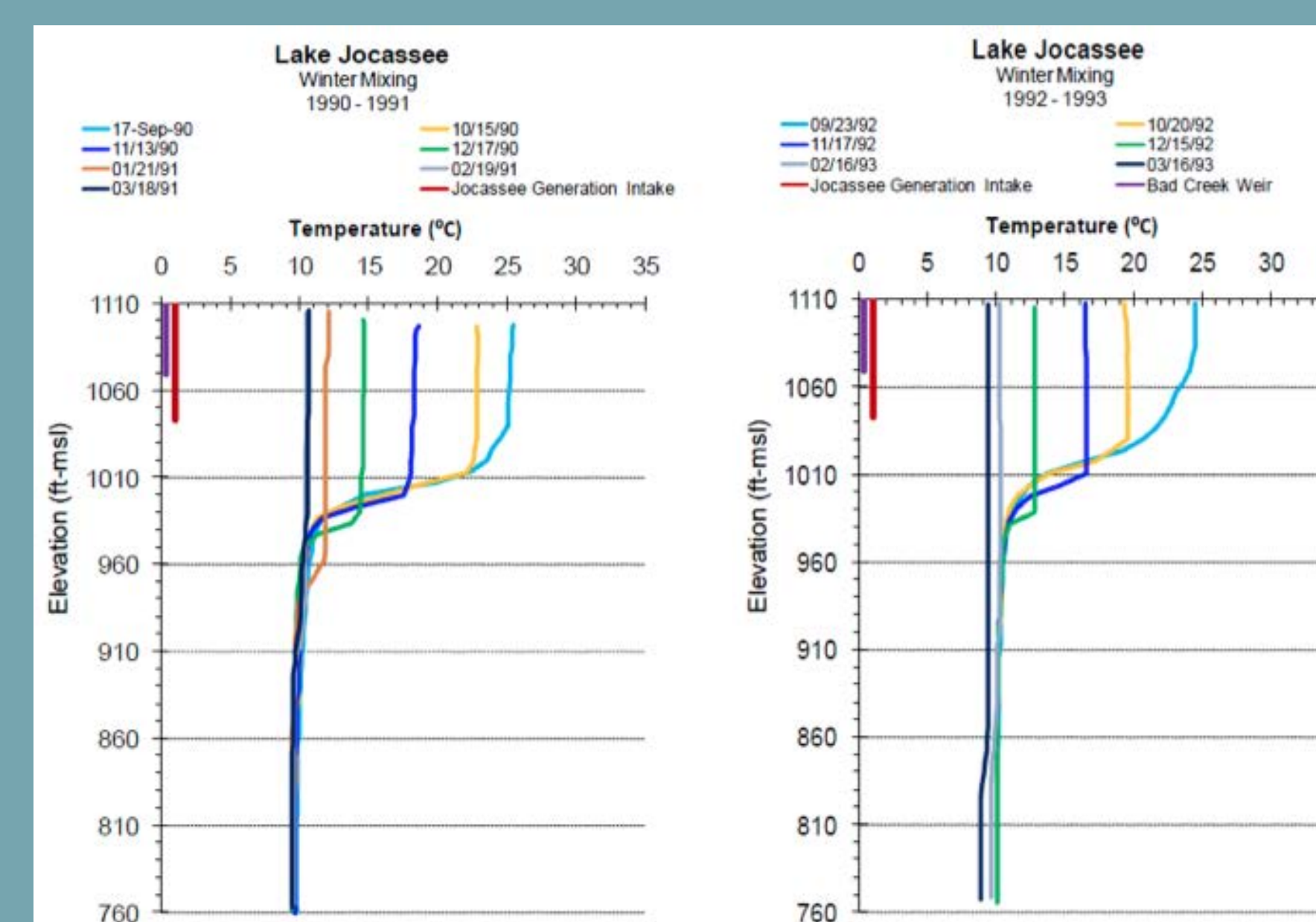


Figure 2: The thermal profile for a year of complete (1992-1993) and incomplete (1990-1991) mixing.

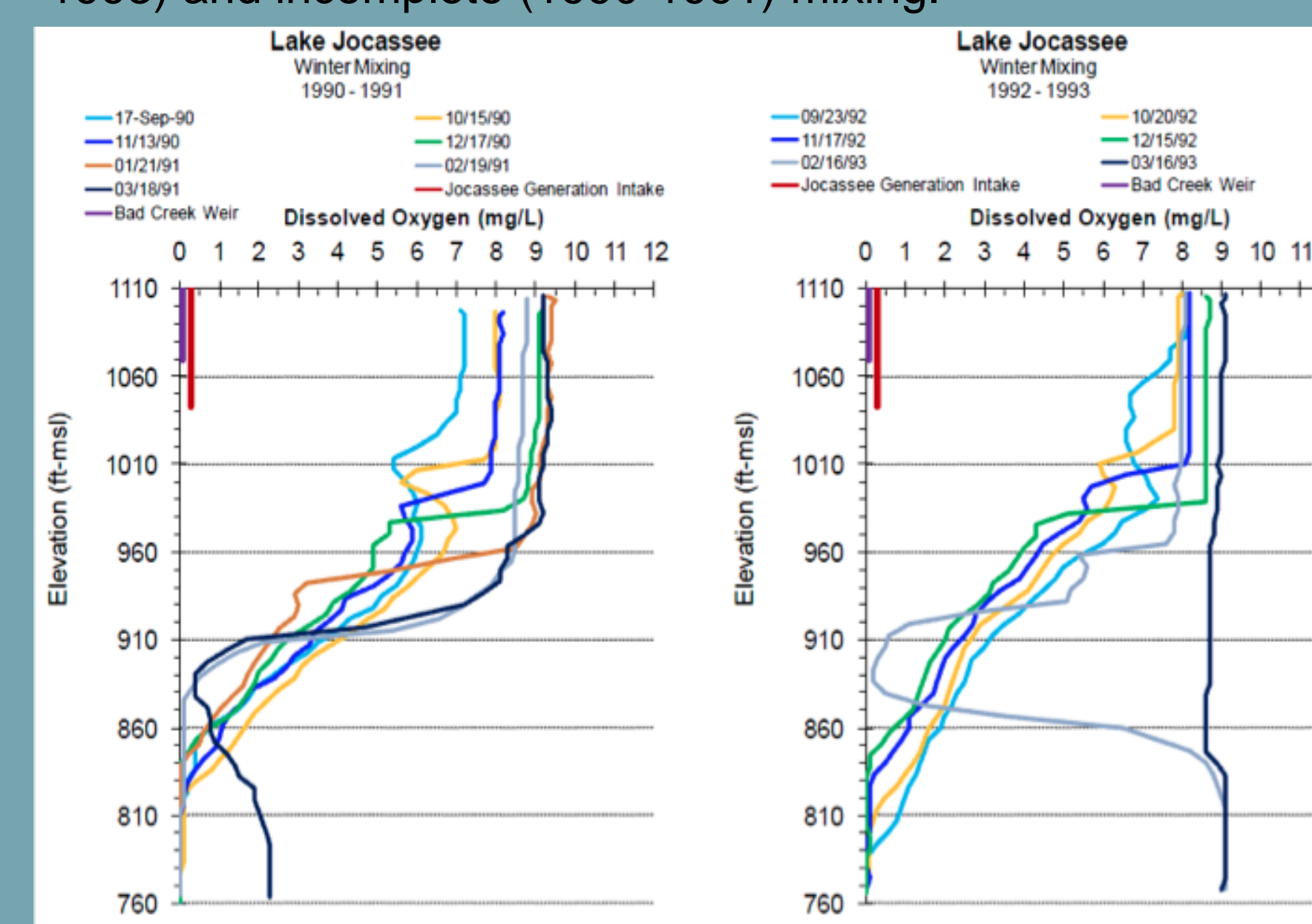


Figure 4: The dissolved oxygen profile for a year of complete (1992-1993) and incomplete (1990-1991) mixing.

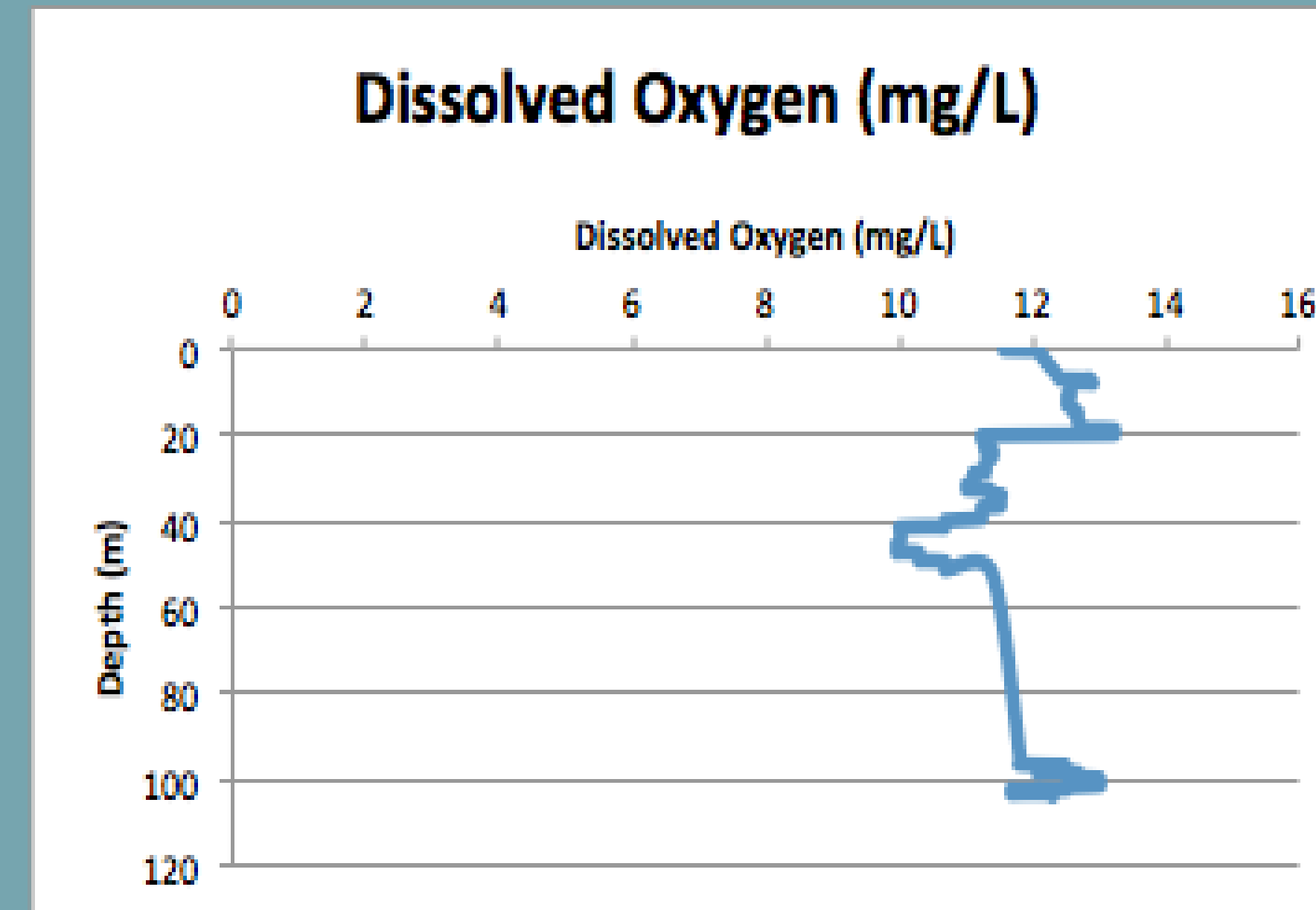
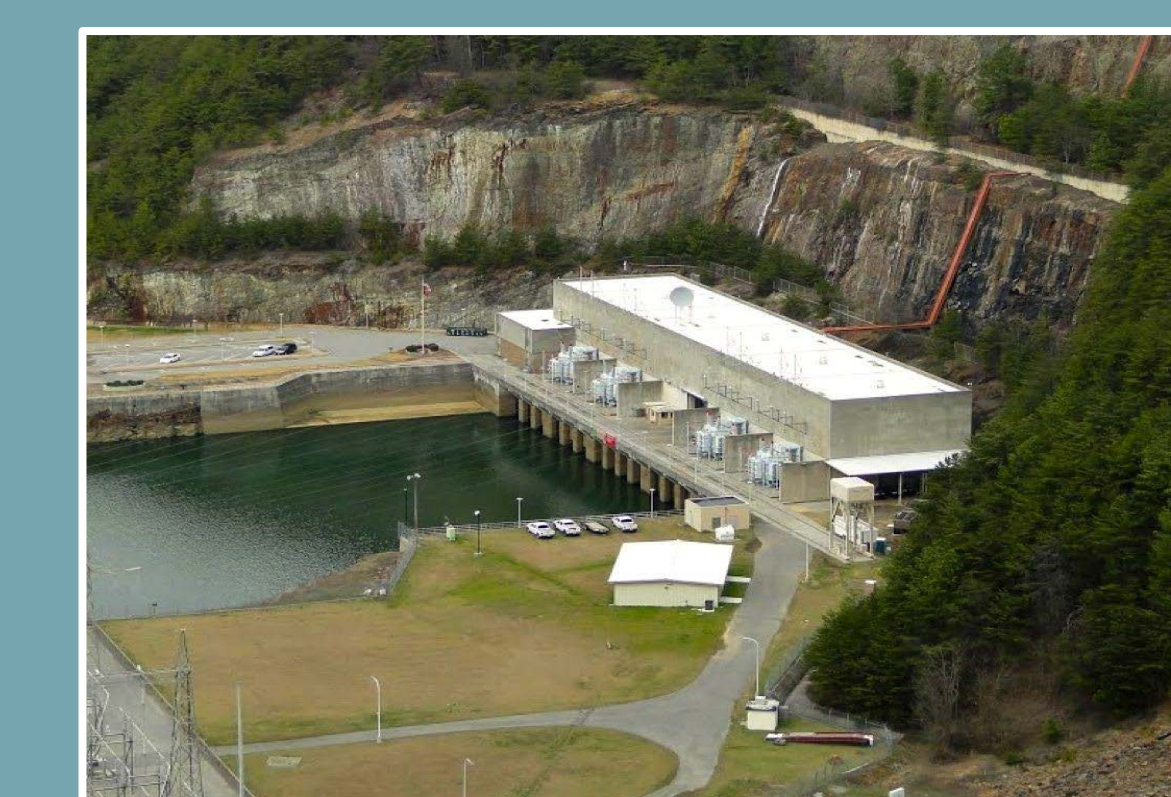
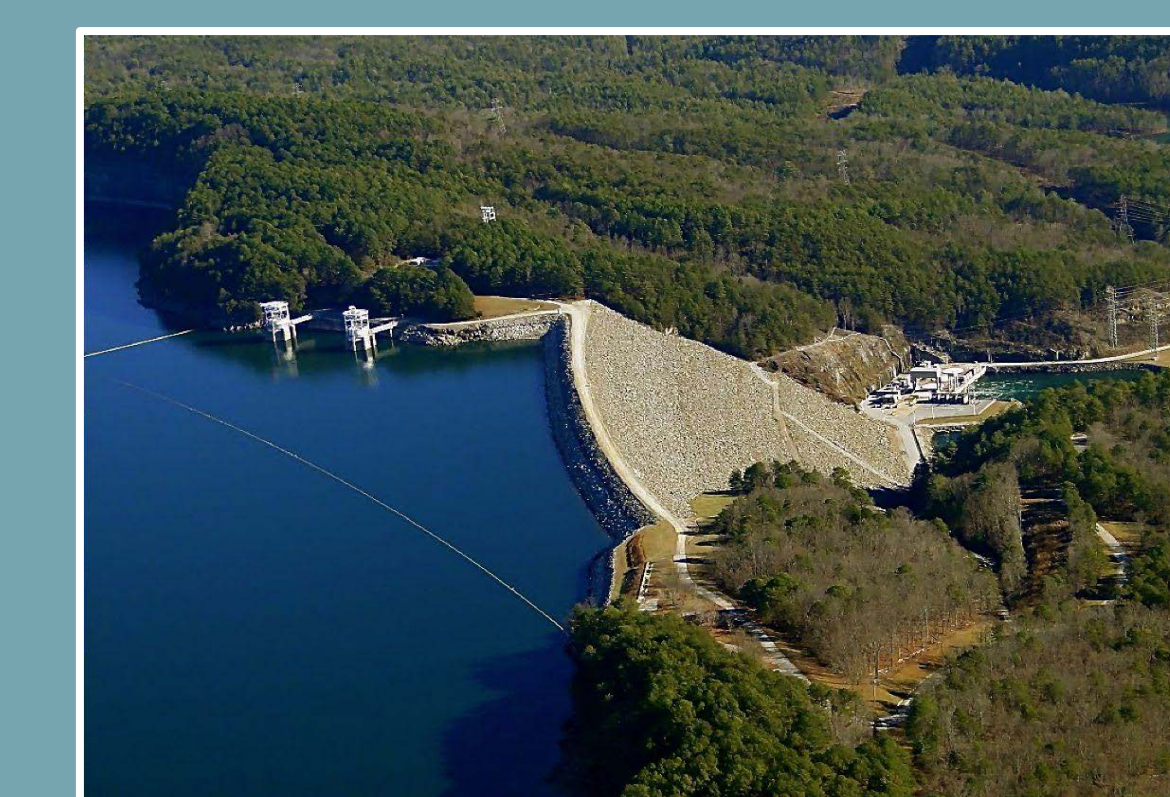


Figure 7: Dissolved Oxygen of Lake Jocassee on 2/22/2015 showing distribution of dissolved oxygen to all depths, providing no evidence for incomplete mixing in the winter of 2014-2015.



Carters Lake Powerhouse



Lake Jocassee and Dam

Conclusion and Discussion:

Based on the criteria for meromictic lakes, Lake Jocassee should be a meromictic lake due to its size and depth. However, due to the nature of the inflows and outflows of the lake, it acts as a warm monomictic lake while only occasionally failing to mix completely. Based on the minimum depth of meromixis in Carters Lake, if Lake Jocassee was only the main basin, theoretically it should be meromictic as well. There is still some uncertainty of why this happens, leading to more questions. Some of those questions are:

- What is the relationship between the depth of intake and intensity and frequency of pumped-storage?
- What discharge rate is required to promote mixing?
- What affect does Lake Jocassee tributaries have on its mixing?
- What is the optimal lake depth needed to promote mixing?
- Do operational factors affect the variability of Lake Jocassee?
- If so, what is the mechanism affecting the variability?
- How much does air and inflow temperature affect mixing?
- Does summer stratification affect winter mixing?



Sources:

Duke Energy. 2014. Comprehensive environmental, engineering, and economic impact analysis report for revising the 1968 operating agreement for the Keowee Toxaway Project. FERC No. 2503. Duke Energy Carolinas, LLC. 965 pp.

Hains, JJ, J Carroll, W Jabour, S Ashby. 1990. unpublished data for Carters Lake, GA. USACE-ERDC-TSLRF.

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