Iron & Manganese Oxidation Cycles in a Local Drinking Reservoir

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1. INTRODUCTION

- Iron (Fe) and manganese (Mn) in drinking water can affect water quality by causing taste and odor problems.
- The EPA lists both Fe and Mn as secondary contaminants, which can present a risk to human health.
- During the summer months, thermal stratification of lakes and reservoirs can result in low dissolved oxygen in the hypolimnion (bottom waters).
- Low dissolved oxygen leads to the reduction of insoluble Fe and Mn in sediment, releasing soluble Fe and Mn into the water column.
- Hypolimnetic oxygenation systems are being increasingly used to prevent the reduction and release of soluble Fe and Mn into the water.
- ***OBJECTIVES: Determine how an oxygenation system of a local drinking water reservoir has affected Fe and Mn concentrations and compare Fe and Mn concentrations in an oxygenated reservoir to those of an unoxygenated reservoir***

2. SITE DESCRIPTION

Falling Creek Reservoir (FCR) (Figure 1)

- Primary study site
- Owned and operated by the Western Virginia Water Authority (WVWA)
- Surface Area: 1.19 x 10^{-1} km^2
- Max Depth: 9.3 m
- Thermal stratification occurs annually from May to October
- Historical issues with low dissolved oxygen (DO) during thermal stratification
- Side stream supersaturation (SSS) oxygenation system installed in 2013 (Figure 2).
- The SSS was first operational in May 2013, but was only run intermittently during stratification. Since 2016, the SSS has been fully operational during the thermal stratification period of May to October.

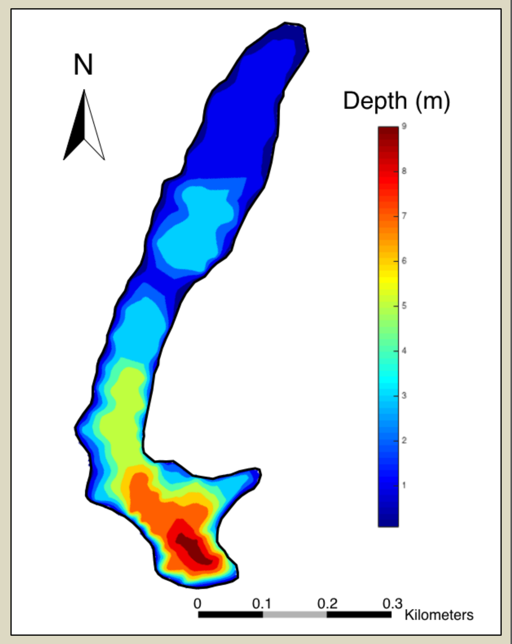

Figure 1. Falling Creek Reservoir Bathymetry (Gerling et al. 2014)

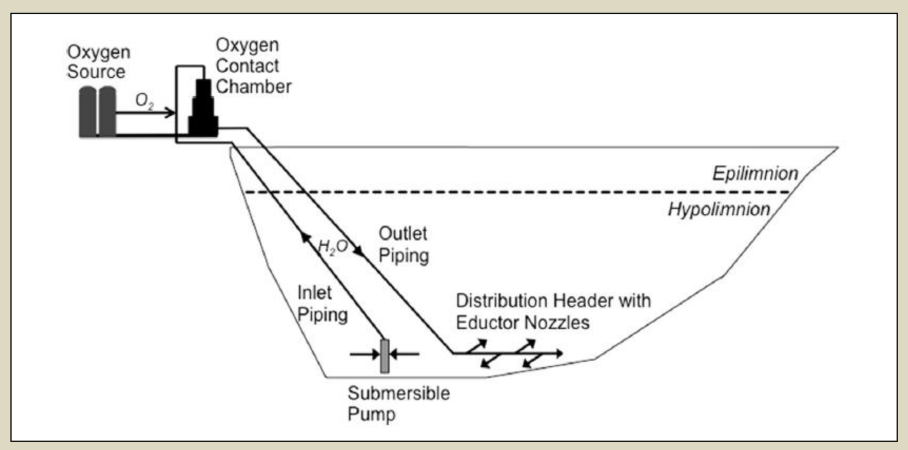

Figure 2. Schematic of side stream supersaturation system (SSS) in Falling Creek Reservoir. (Gerling et. al, 2014)

Beaverdam Reservoir (BVR) (Figure 3)

- Reference reservoir
- Owned and operated by the Western Virginia Water Authority (WVWA)
- Surface Area: 3.9 x 10^{-1} km^2
- Max Depth: 13.5 m
- Thermal stratification occurs annually from May to October
- Historical issues with low dissolved oxygen (DO) during thermal stratification
- No oxygenation system
- Acts as primary inflow to FCR

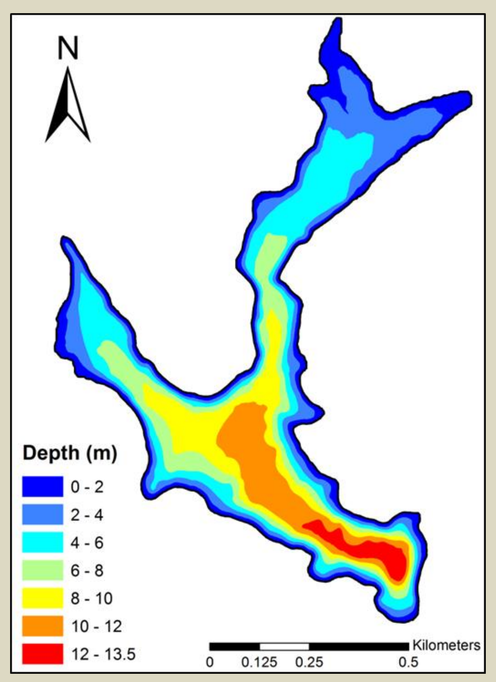

Figure 3. Beaverdam Reservoir Bathymetry (McClure 2016)

3. METHODS

- Samples were collected weekly from each reservoir for 6 weeks (Mid June – Late July) to measure total and soluble Fe and Mn concentrations.
- Samples were collected along a depth profile (FCR: 0.1 1.6, 3.8. 5.0, 8.0 m below the surface; BVR: 0.1, 3.0, 6.0, 9.0, 11.0 m below the surface).
- Soluble metal samples were filtered using a 0.45 µm nylon filter.
- Samples were directly poured from a 4L Van Dorn water sampler into 15 mL centrifuge tubes.
- Samples were preserved using trace metal grade nitric acid.
- Samples were analyzed for Fe and Mn using an Inductively Coupled Plasma Optical Emission Spectrometer (ICP-OES).

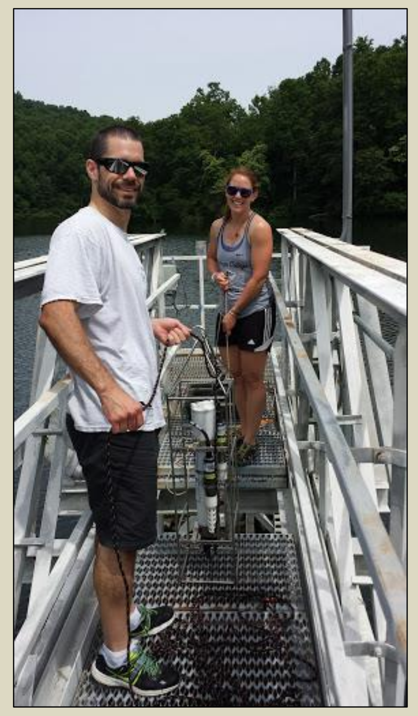

Figure 4. Water sampling at FCR.

4. RESULTS: IRON

- Fe concentrations for FCR (Figure 5) and BVR (Figure 6) from 2014-2017.
- Oxygenation intermittent in 2014, continuous in 2015 (with exception of one week in June) and in 2016 and 2017.

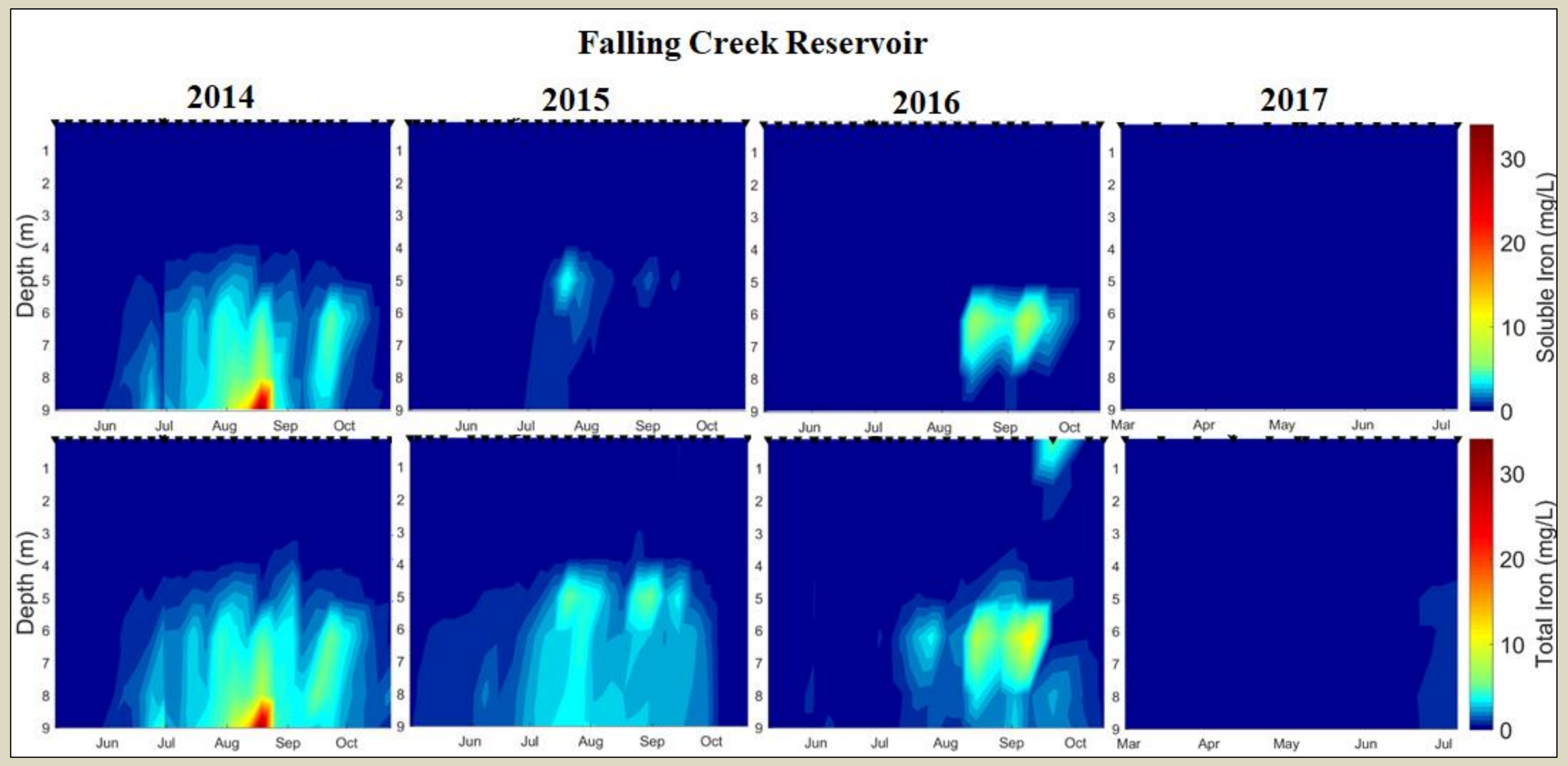

Figure 5. Soluble Fe (top) and total Fe (bottom) concentrations in FCR during the summer months from 2014-2017. Color scale on right shows concentrations. Sampling dates shown as black triangles on top of figure. Concentrations between sampling dates interpolated using Matlab. Note that the 2017 dataset goes only until mid-July.

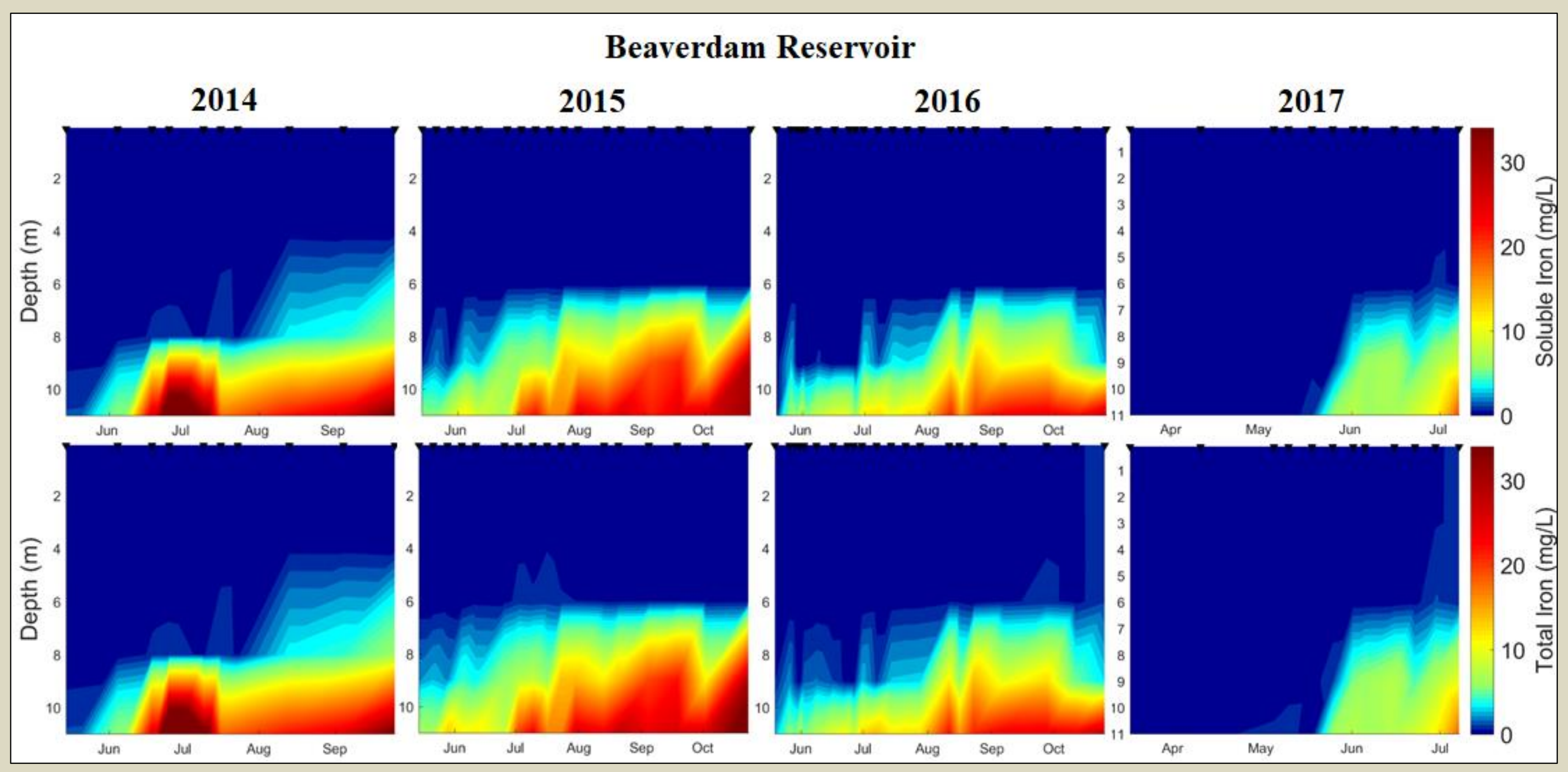

Figure 6. Soluble Fe (top) and total Fe (bottom) concentrations in BVR during the summer months from 2014-2017. Color scale on right shows concentrations. Sampling dates shown as black triangles on top of figure. Concentrations between sampling dates interpolated using Matlab. Note that the 2017 dataset goes only until mid-July.

4. RESULTS: MANGANESE

- Mn concentrations for FCR (Figure 7) and BVR (Figure 8) from 2014-2017.
- Oxygenation intermittent in 2014, continuous in 2015 (with exception of one week in June) and in 2016 and 2017.

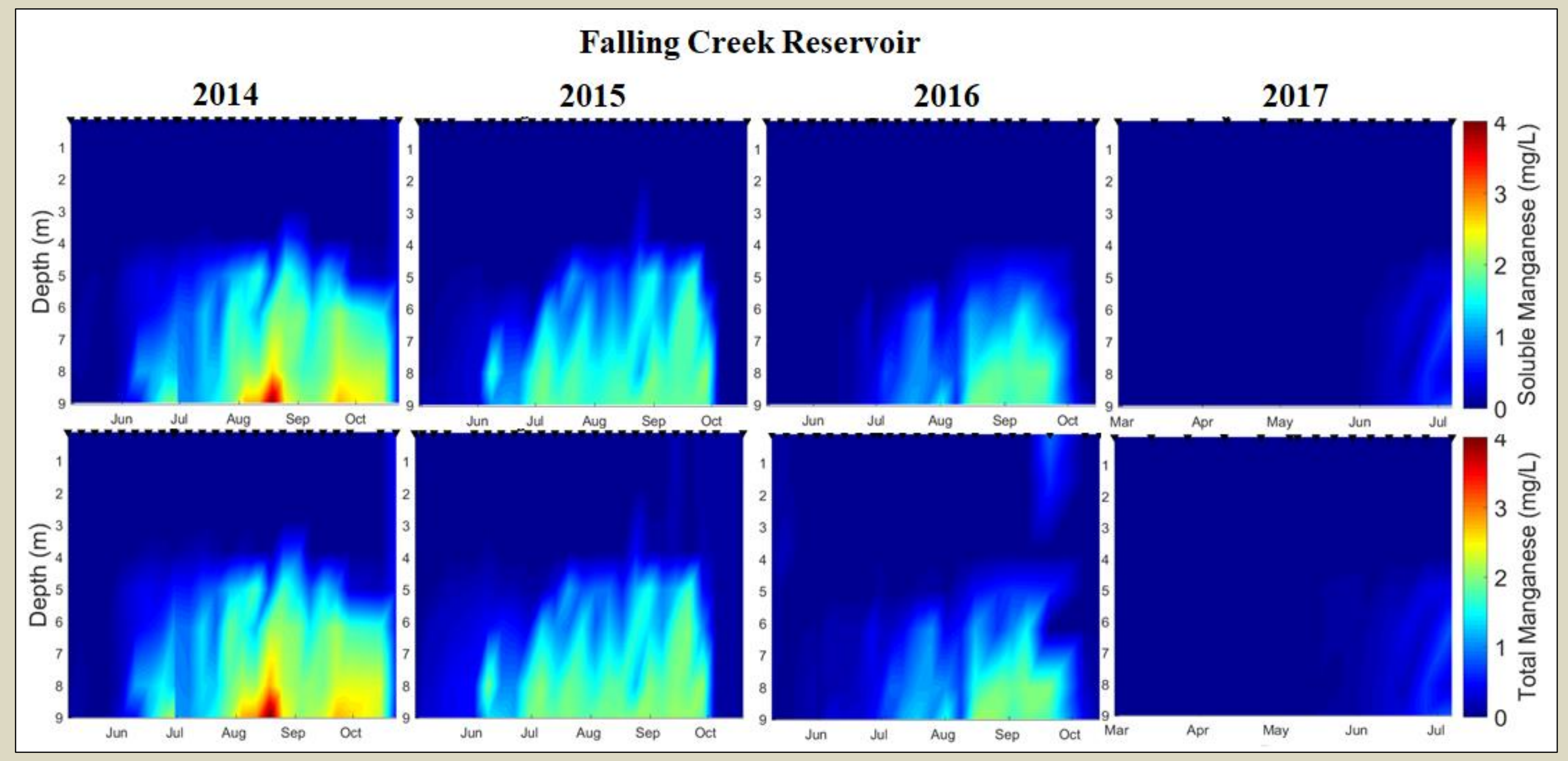

Figure 7. Soluble Mn (top) and total Mn (bottom) concentrations in FCR during the summer months from 2014-2017. Color scale on right shows concentrations. Sampling dates shown as black triangles on top of figure. Concentrations between sampling dates interpolated using Matlab. Note that the 2017 dataset goes only until mid-July.

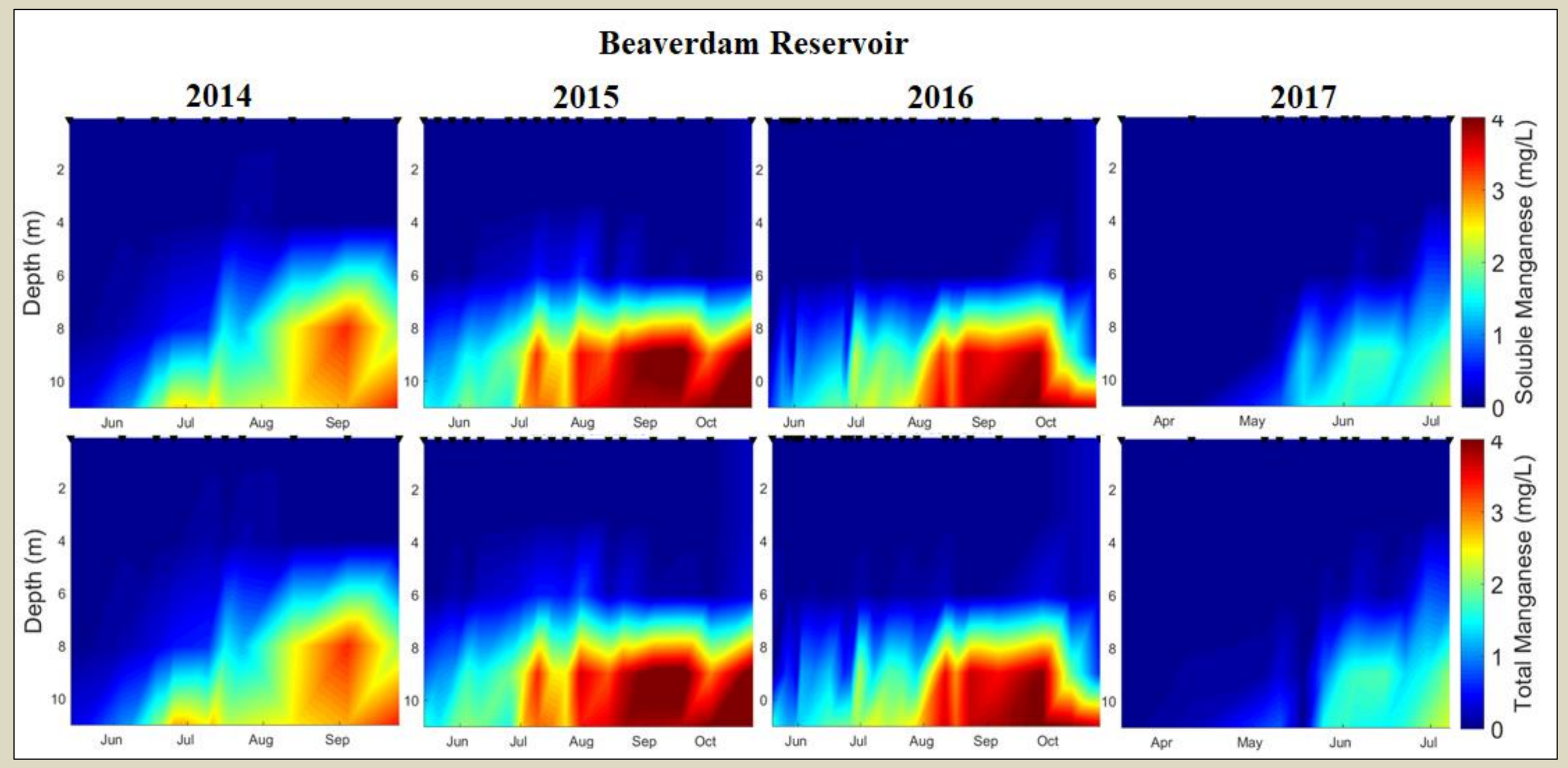

Figure 8. Soluble Mn (top) and total Mn (bottom) concentrations in BVR during the summer months from 2014-2017. Color scale on right shows concentrations. Sampling dates shown as black triangles on top of figure. Concentrations between sampling dates interpolated using Matlab. Note that 2017 dataset goes only until mid-July.

5. CONCLUSIONS

- Continuous oxygenation lowers Fe and Mn concentrations in FCR.
- Total and soluble Mn concentrations at FCR are similar each year because Mn oxidized more slowly than Fe.
- Lack of oxygenation at BVR results in biological Fe and Mn reduction in reservoir sediments, which are released as soluble metals in the water, resulting in elevated concentrations in the hypoliminion.

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