

Internal phosphorus loading in Marion Reservoir, Kansas: a sediment core incubation study

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Introduction

Cyanobacterial harmful algal blooms (CyanoHABs) degrade water quality for recreation, drinking water supplies, and human and animal health. CyanoHABs are linked to water column nutrient concentrations sourced externally from the watershed and internally from nutrient-rich lake sediments, the latter only occurring when dissolved oxygen concentrations at the sediment-water interface are <2mg/L. CyanoHABs and total phosphorus have substantially increased in Marion reservoir since ca. 2000; however, the cause for this increase is unknown¹.

Phosphorus binds to iron, manganese, calcium, and other metals under oxic conditions and precipitates into sediments. Under anoxic conditions, metal-bound phosphorus is released into the water as orthophosphate.

Previous sediment core incubation studies from Marion Reservoir showed phosphorus release rates consistent with other hypereutrophic waterbodies^{2,3}. In this study we investigated internal nutrient (P- phosphorus) loading in Marion Reservoir, KS using a sediment core incubation method.

Methods

1. Twelve cores were collected, 4 per site (Figures 1 - 3).
2. Each core was reduced to 20cm in length, and water was replaced with 0.7µm filtered lake water.
3. All cores were incubated at 20C and bubbled with air for 24 hours to create initial oxic conditions (Figure 4).
4. Anoxic cores were bubbled with N₂ gas, Hypoxic cores were slowly bubbled with N₂ or air to maintain DO between 0.5 - 2.0mg/L, and oxic cores were bubbled with air.
5. Water samples were collected on days 1 and 6, then analyzed for orthophosphate to calculate phosphorus release rates.

$$P_{rr} = (C_t - C_0) \times \frac{V}{A}$$

P_{rr} = phosphorus release rate
 C_t = OP concentration at day t
 C_0 = OP concentration at day 0
 V = volume of water in core tube
 A = surface area of sediment core

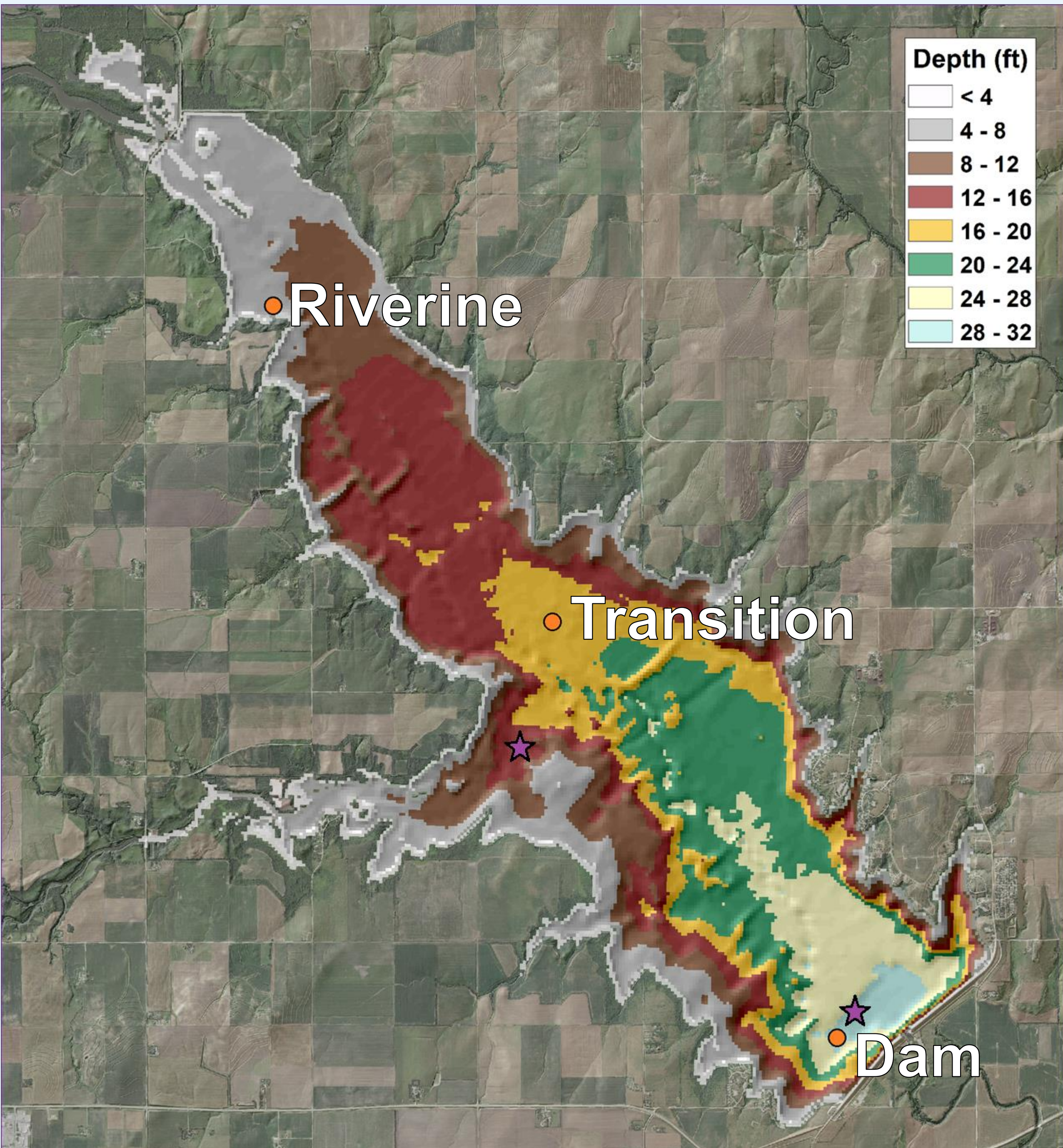


Figure 1. Map of Marion Reservoir and locations of 3 coring sites for 2020, and 2 coring sites for 2021.



Figure 2. Pulling sediment cores.

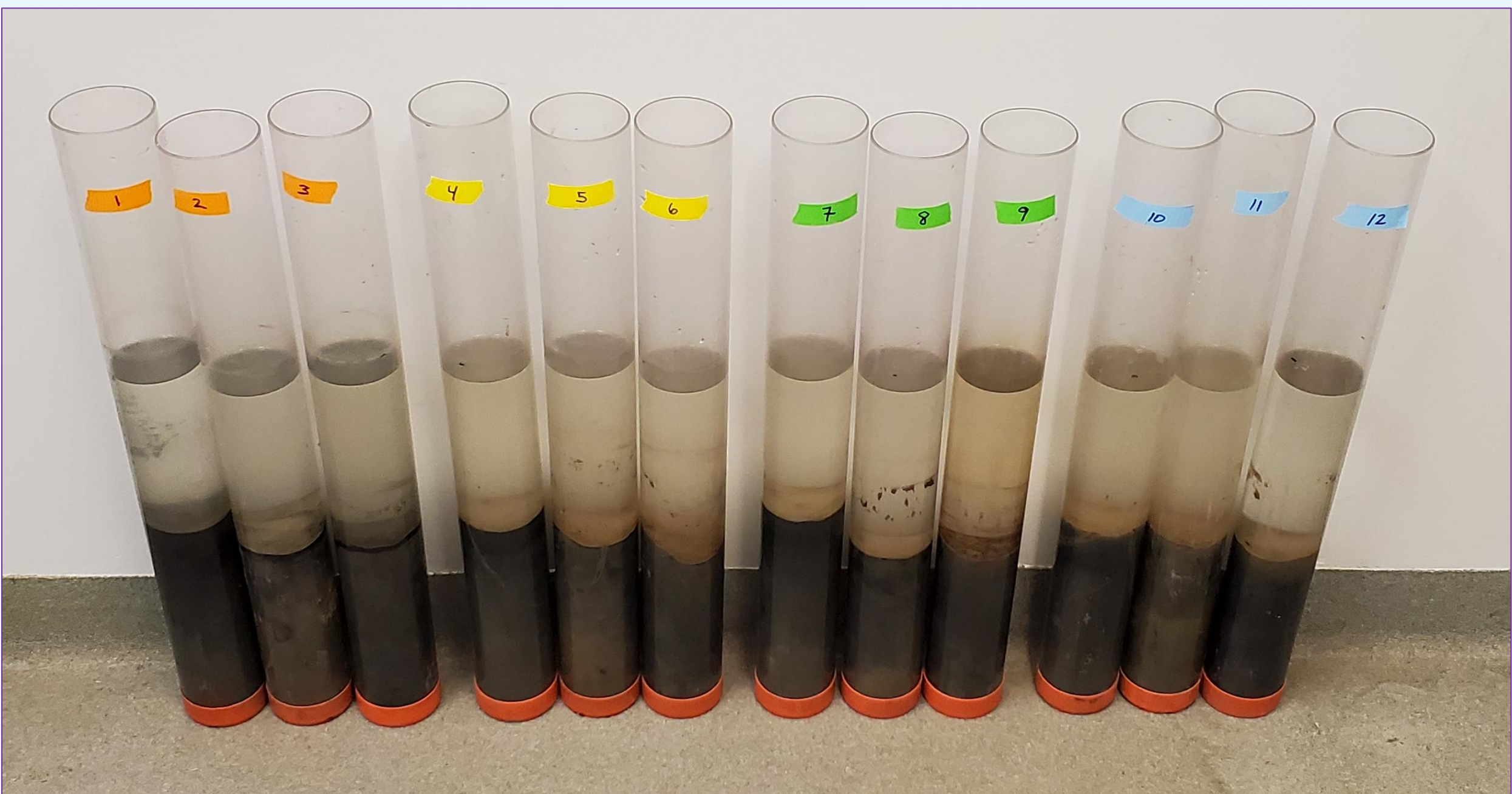


Figure 3. Core samples.



Figure 4. Cores inside incubator.

Results



Figure 5. Black sediment (iron sulfide) forms during anoxia.

The formation of FeS (iron sulfide) can be seen in anoxic cores which is indicative of sustained anaerobic conditions created in the anoxic treatments (Figure 5). Both **anoxic and hypoxic treatments showed phosphorus releasing from sediments**, whereas there was a **mixture of phosphorus release and absorption for oxic treatments** (Figure 6). **Average phosphorus release rates (Prr) under anoxic conditions were 18.6 mg P/m²/day.**

Analysis of Covariance showed that phosphorus release rates between anoxic and oxic treatments were significantly different (p-value < 0.01) while the release rates for anoxic and hypoxic showed no statistical difference (p-value = 0.433).

Conclusions

Previous studies showed P-release rates of anoxic cores were between 20.7 - 32.98 mg P/m²/day in Marion Reservoir, which was found to be similar with other hypereutrophic reservoirs in the Midwestern USA. **Our results show that Prr under anoxic conditions are consistent with previous studies** on Marion and still within the range of regional hypereutrophic reservoirs².

Internal phosphorus loading may intermittently contribute to CyanoHABs in Marion Reservoir due to discontinuous stratification events.

Given that anoxic Prr is similar to previous studies on Marion, we hypothesize that the observed increase in water column dissolved P since 2007 may be because **(1) near-bottom anoxia/hypoxia is occurring more frequently and thus increasing the total amount of P loaded into the water column annually, (2) loading of dissolved P from the watershed has increased, and/or (3) oxic internal loading is now occurring near the dam and increasing total internally loaded P annually.**

References

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Figure 6. Differences between 2007 and 2020 phosphorus release rates.