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Impact of WTRs in a Saturated Bioretention System

Troy Membrere

Cara J. Poor

University of Portland, poor@up.edu

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Impact of WTRs in a Saturated Bioretention System

Troy Membrere and Cara Poor, Ph.D., P.E. Shiley School of Engineering.

Objectives

To evaluate equilibrium chemistry in bioretention systems with water treatment residuals (WTRs) under saturated conditions.

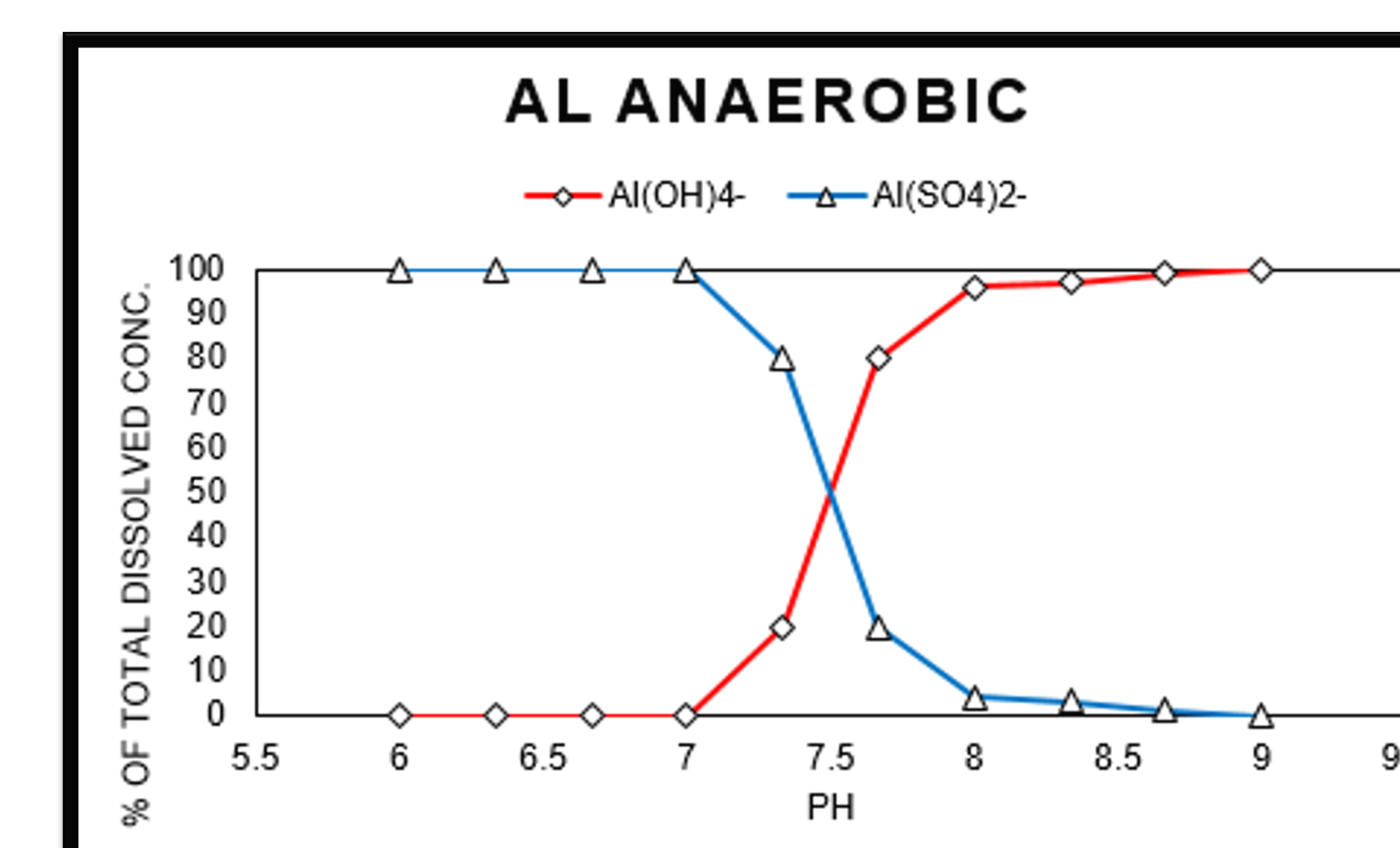
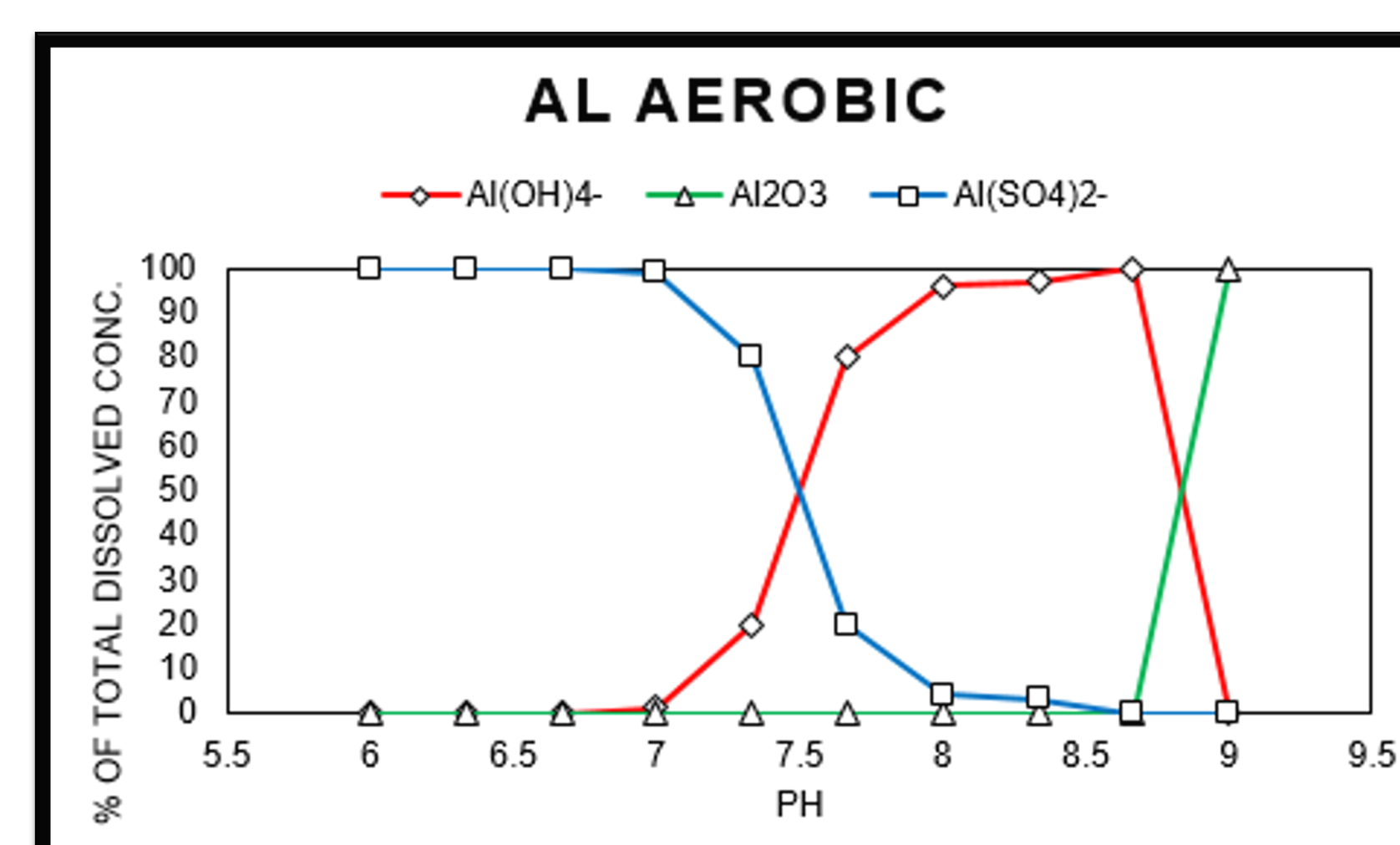
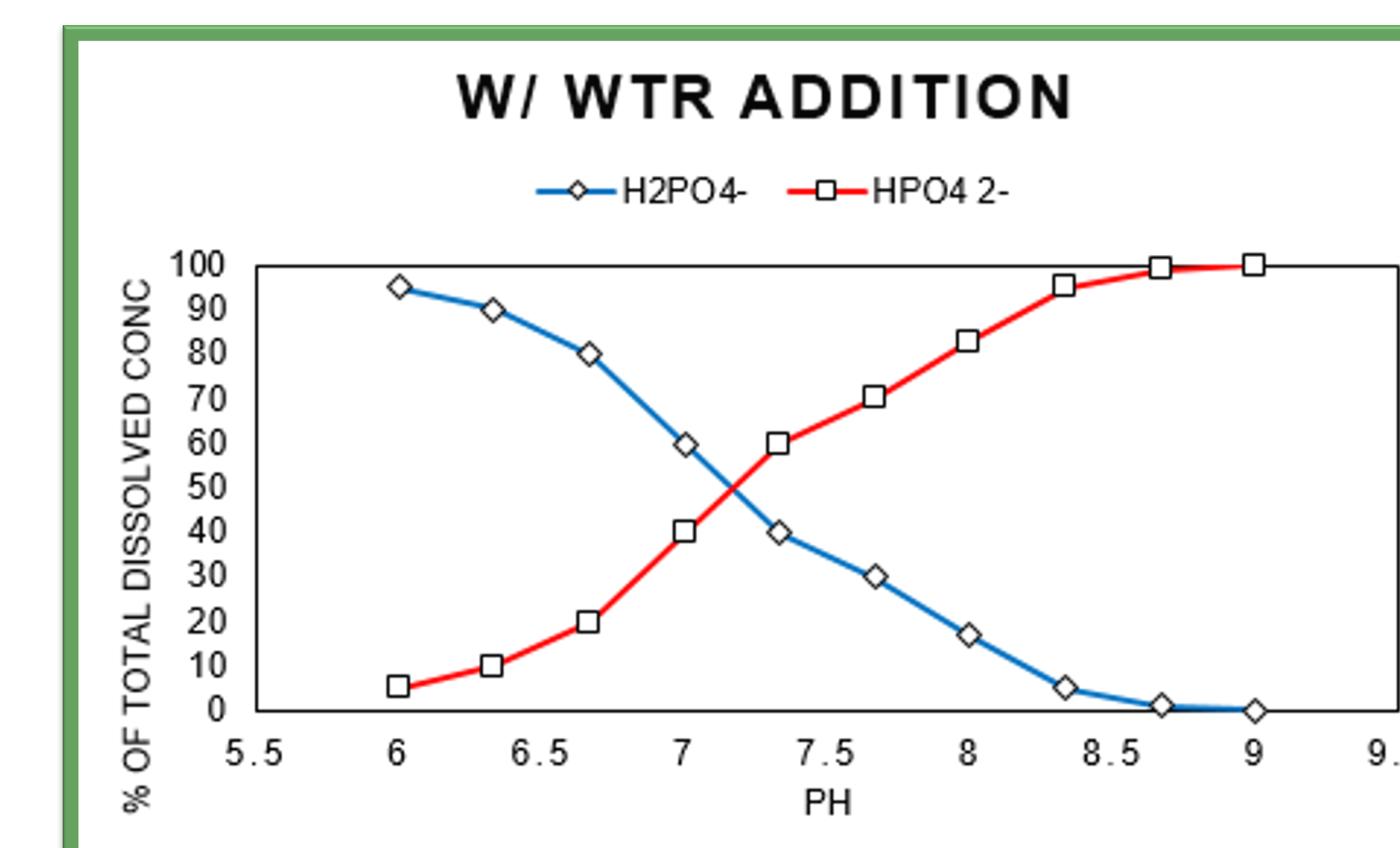
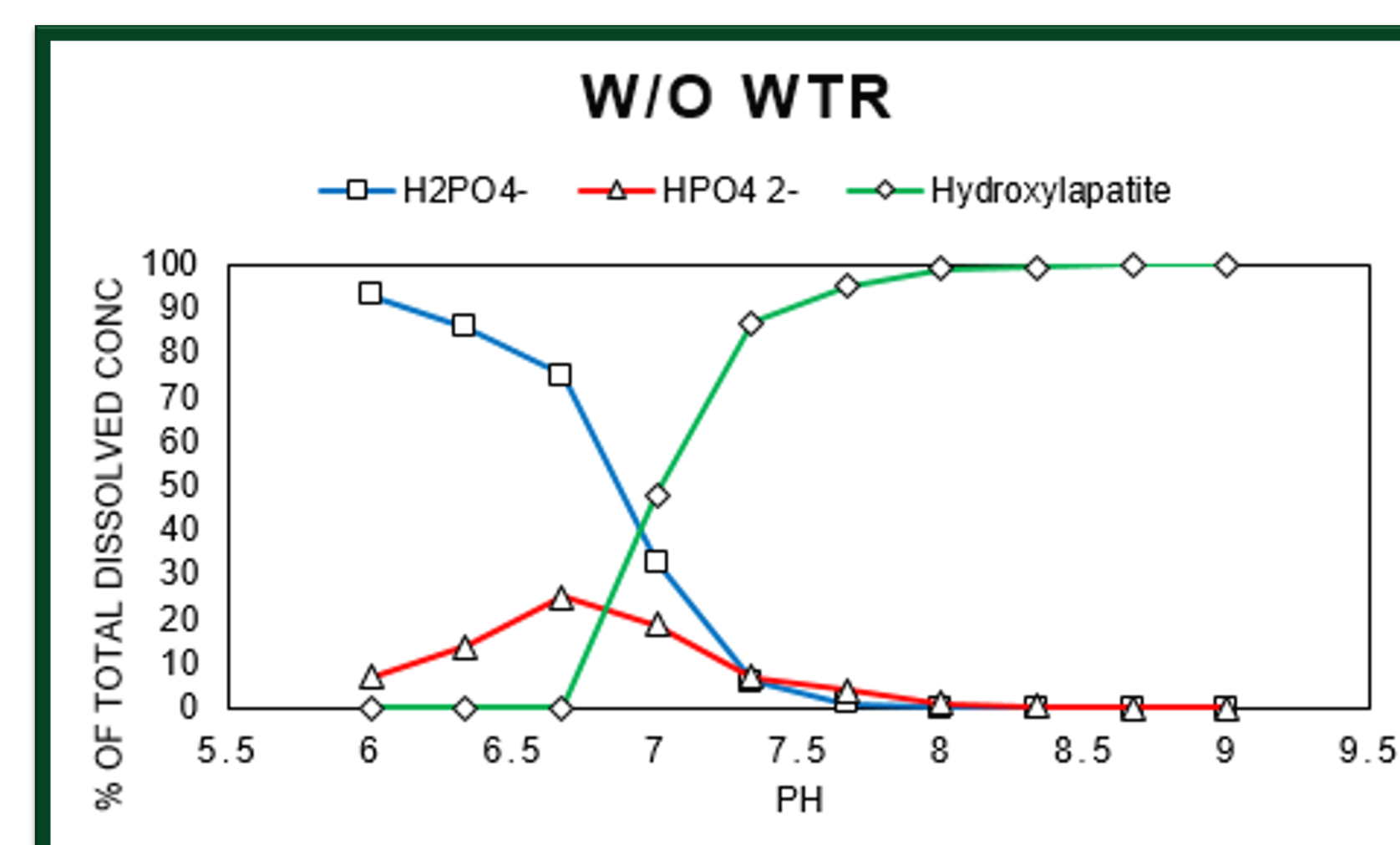
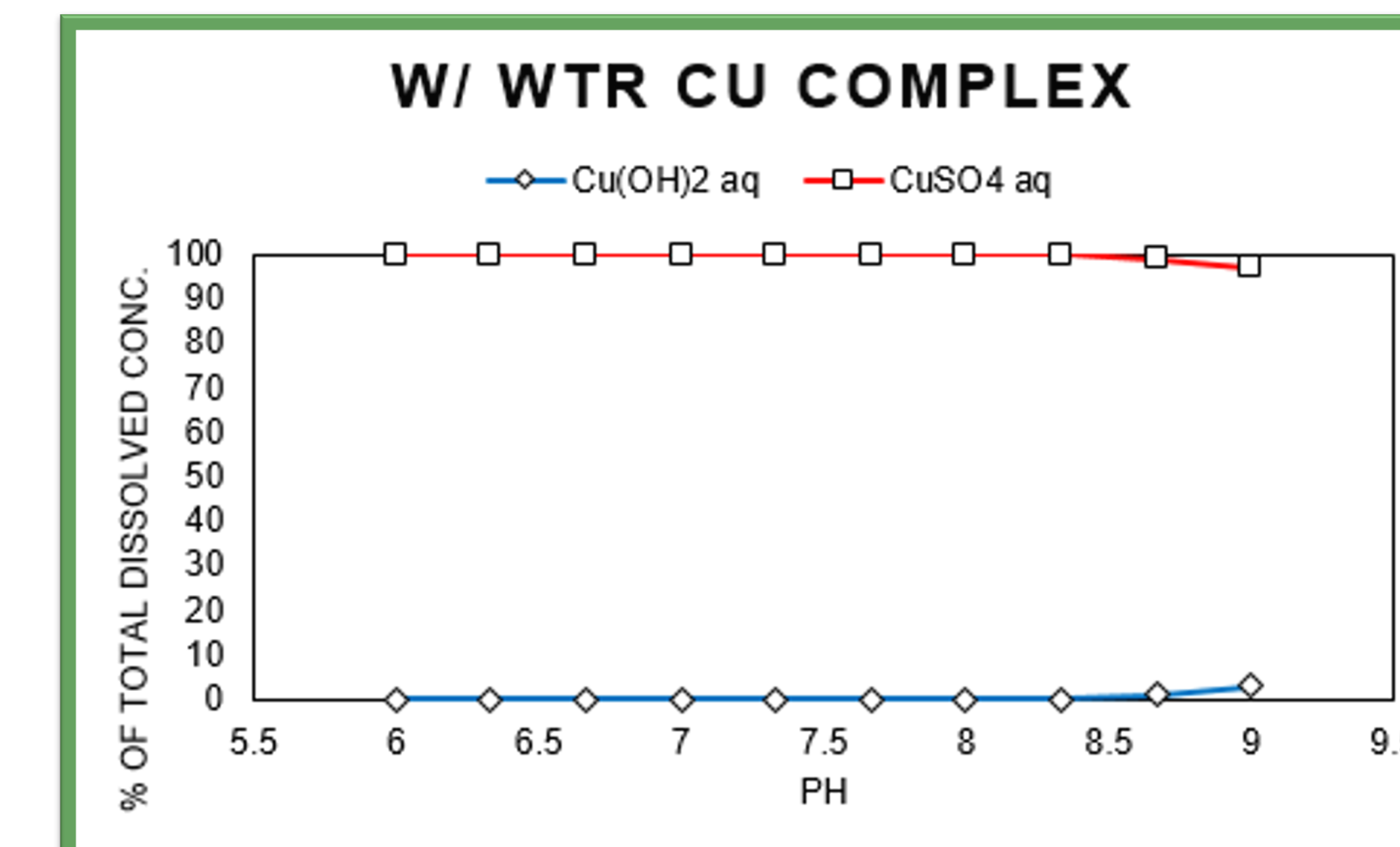
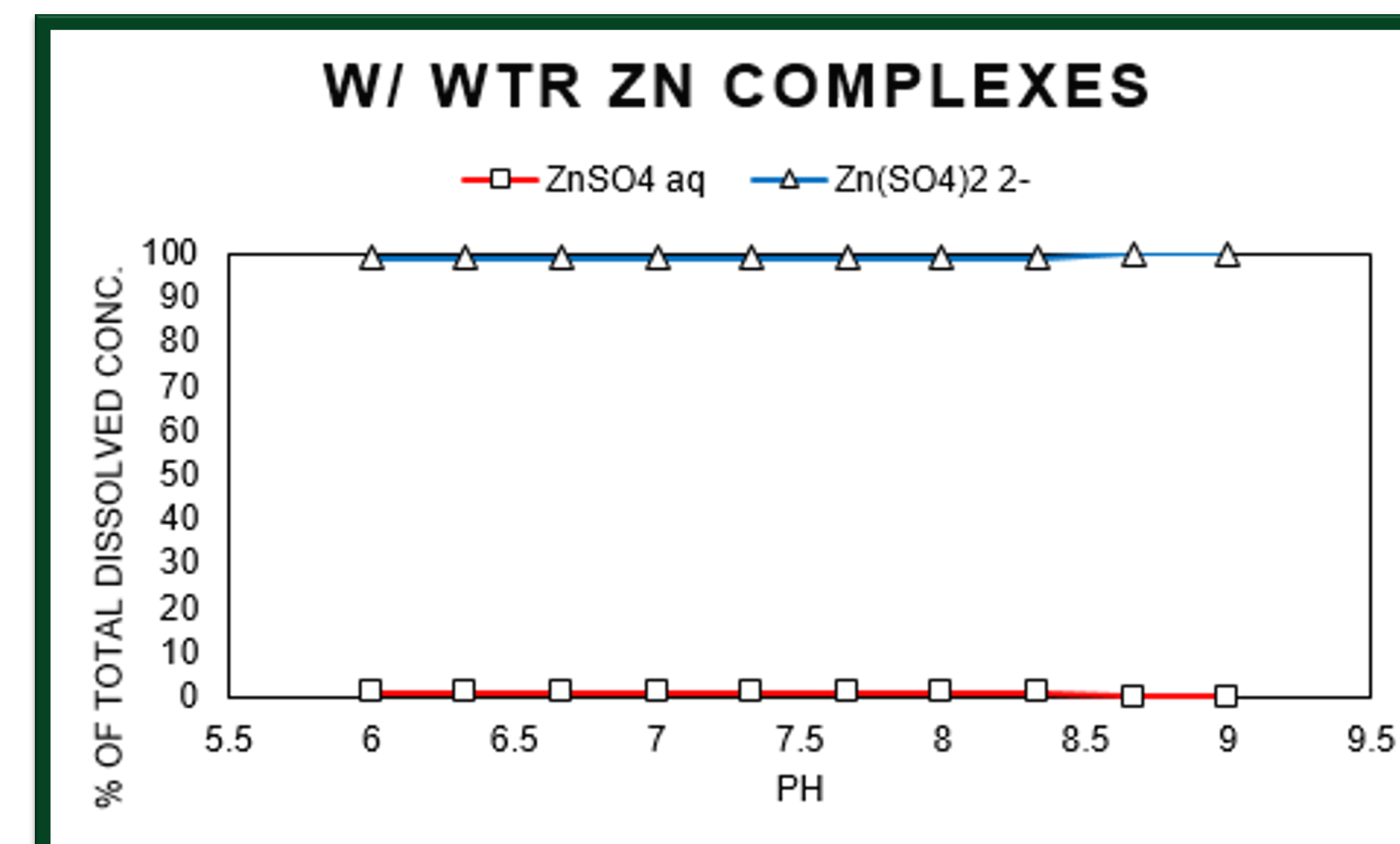
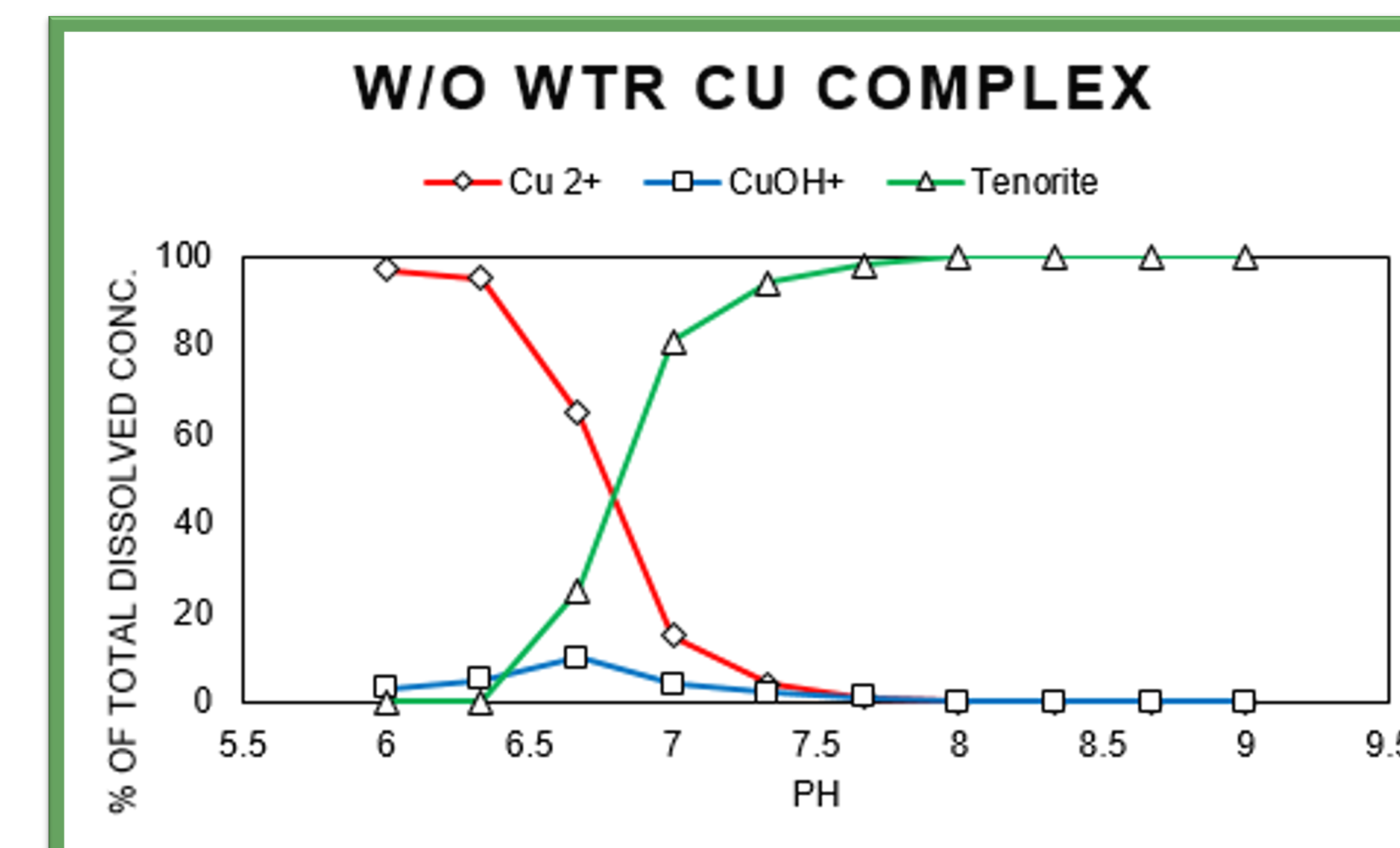
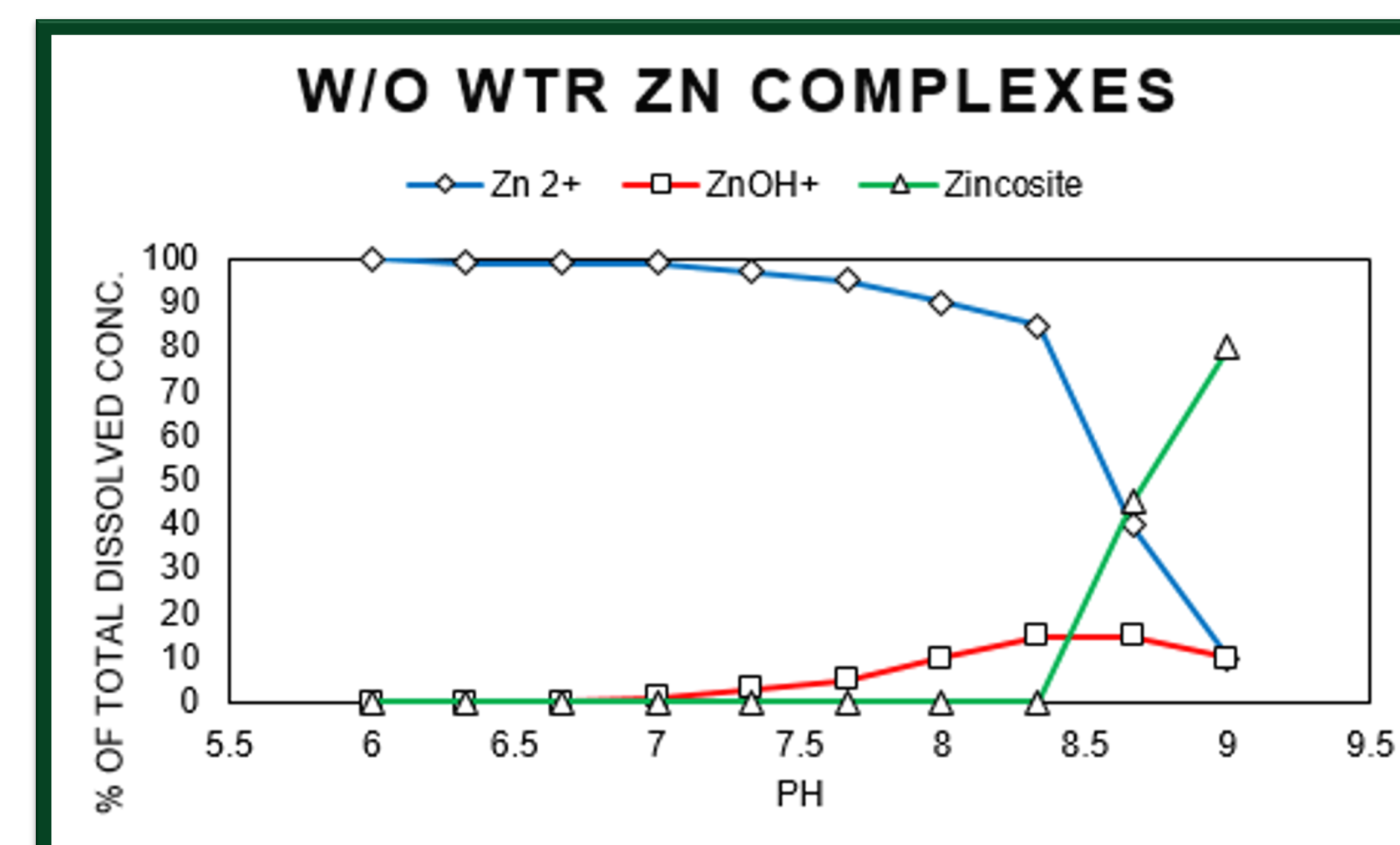
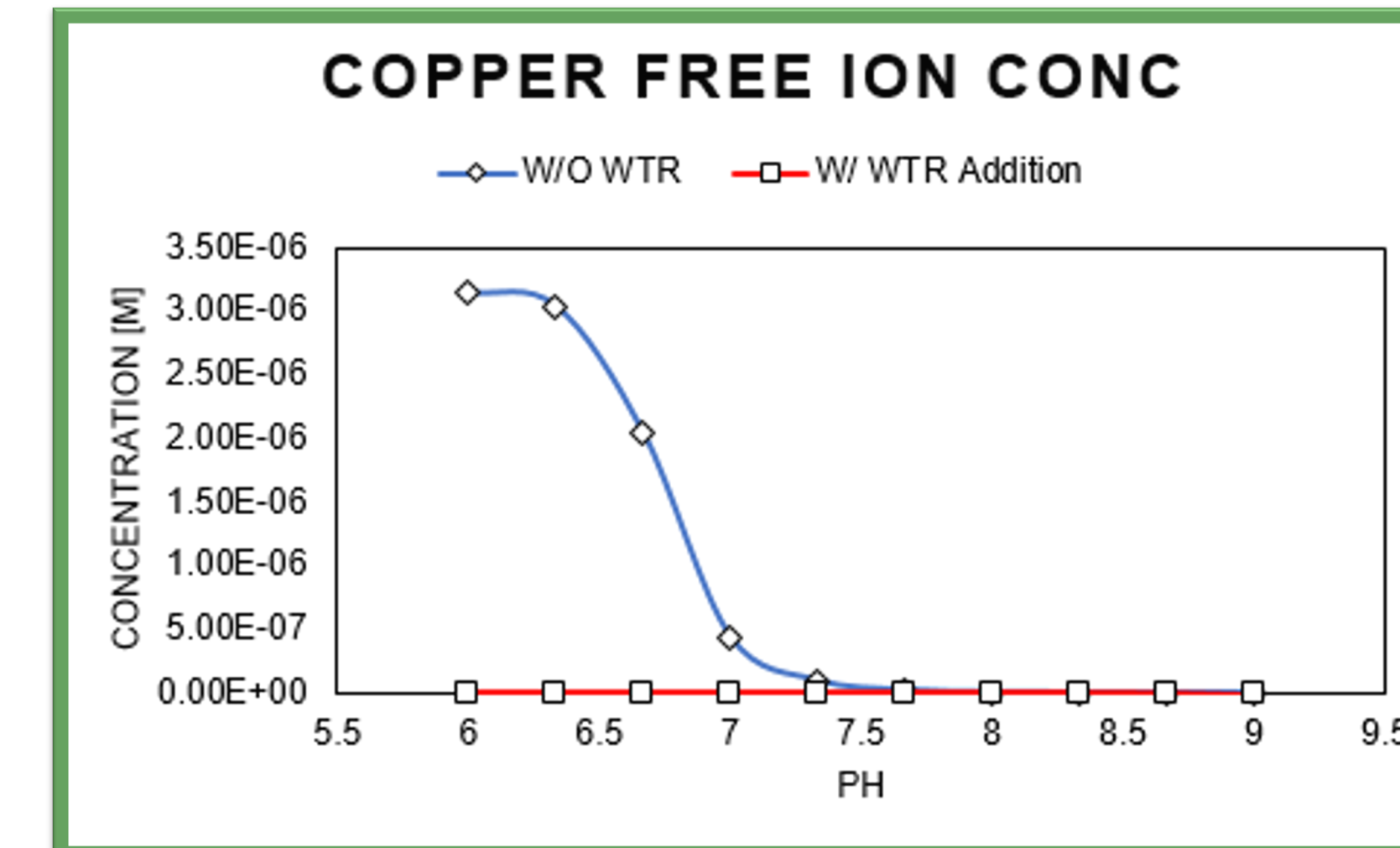
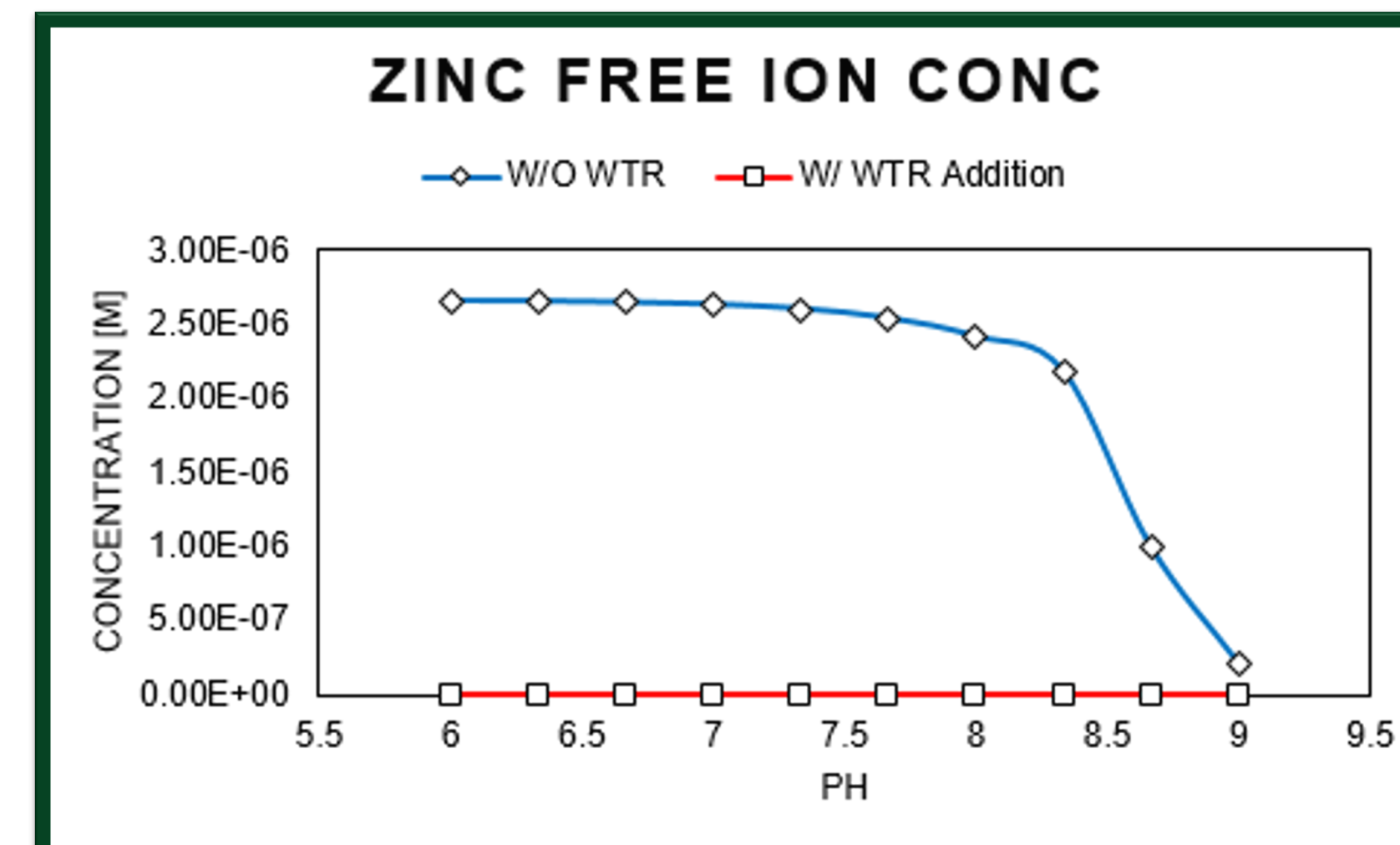
Background

- Bioretention is a common green stormwater system used to treat urban stormwater
- However, leaching occurs within the bioretention system soil mixture – mainly phosphorus
- The saturated zone helps remove nitrate (Palmer et al., 2013)
- There is very little research into how WTRs will impact chemistry particularly for saturated conditions

Design and Methods

- MINEQL+, a chemical equilibrium modelling program, was used to create a total of four aerobic and anaerobic aquatic systems
 1. Aerobic
 2. Anaerobic
 3. Aerobic + WTR Addition
 4. Anaerobic + WTR Addition
- The urban stormwater ionic composition and concentrations mimics runoff conditions comparable to the Pacific Northwest
- To simulate the addition of a WTR, alum was introduced into the system using the chemical reaction below

$$2\text{Al}^{3+} + 3(\text{SO}_4)^{2-} \rightarrow \text{Al}_2(\text{SO}_4)_3(\text{s})$$
- Species and free ion formations of Zn, Cu, PO_4^{3-} , and Al were evaluated in the model over a range of pH



Results and Discussion

- Copper and Zinc free ion concentration was significantly higher in the systems without the WTR
- With addition to WTR, Cu and Zn sorption to sulfate was dominant
- Significant retention of PO_4^{3-} resulted with added WTRs
- Aerobic and anaerobic conditions shared similar Al free ion exchange until above a pH 8.5 where Al_2O_3 precipitates and gets removed in the soil
- The addition of WTRs with a saturated zone showed an increase in Cu and Zn complexes, reducing the free ion concentration

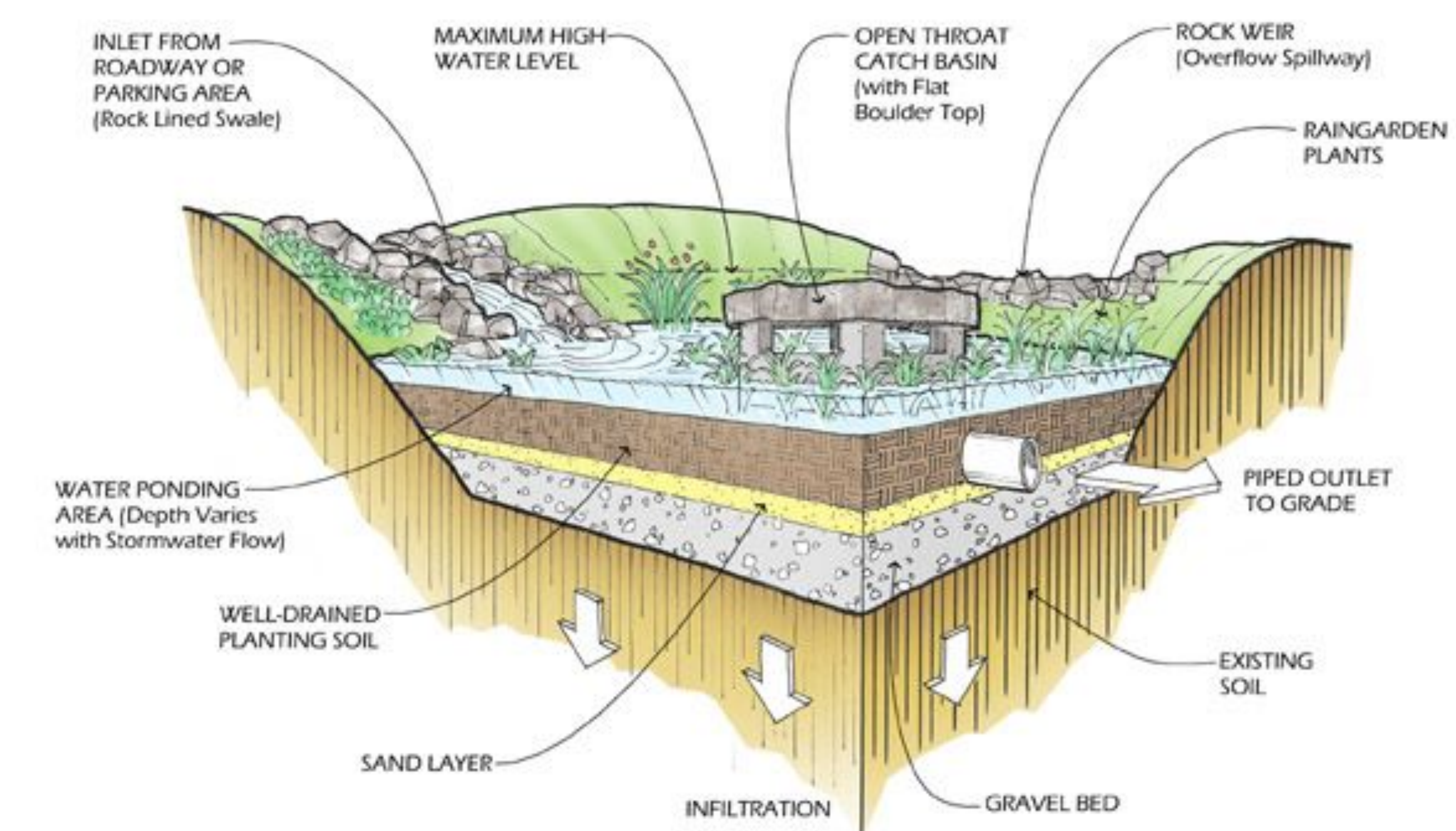
Future Work

To confirm the benefits of using a WTR in bioretention, more research and experimenting with anaerobic conditions is needed to confirm the chemical equilibrium results in this study.

Acknowledgements

We thank the Oregon Community Foundation and Shiley School of Engineering for providing funding for this project.

Cross Section of Bioretention System



Source: <https://bluegrasslawn.com/the-importance-of-bioretention-systems>

Aerobic

- O_2 available
- Equilibrated with atm @ 21% O_2

Anaerobic

- Anoxic; W/O O_2
- Partial pressure of O_2 set to 0
- Oxidation reactions were removed

Cations

Ca^{2+} K^+
 Mg^{2+} Na^+
 NH_4^+ Zn^{2+}
 Cu^{2+} Pb^{2+}

Anions

Cl^- NO_3^-
 PO_4^{3-}