WRANE
Water Research, Assessment and Networking Ecosystem

What's in Water?

Geochemical Evaluation

Presented by: Dr. Tracy Quan

How is water evaluated geochemically?

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Outline

1. Why is water so (chemically) wonderful?
2. What are the conventional geochemical measurements to evaluate water?
    - pH
    - Alkalinity
    - Total dissolved solids (TDS)
    - Ions and salinity
    - Dissolved gases
    - Organic compounds

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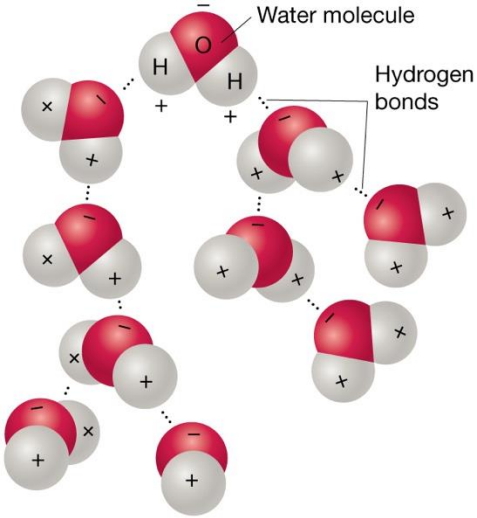
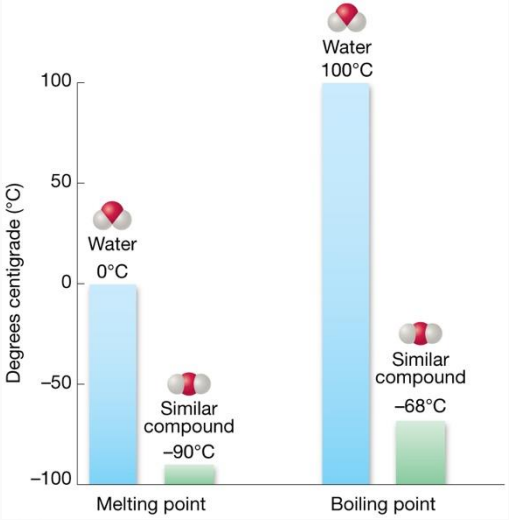
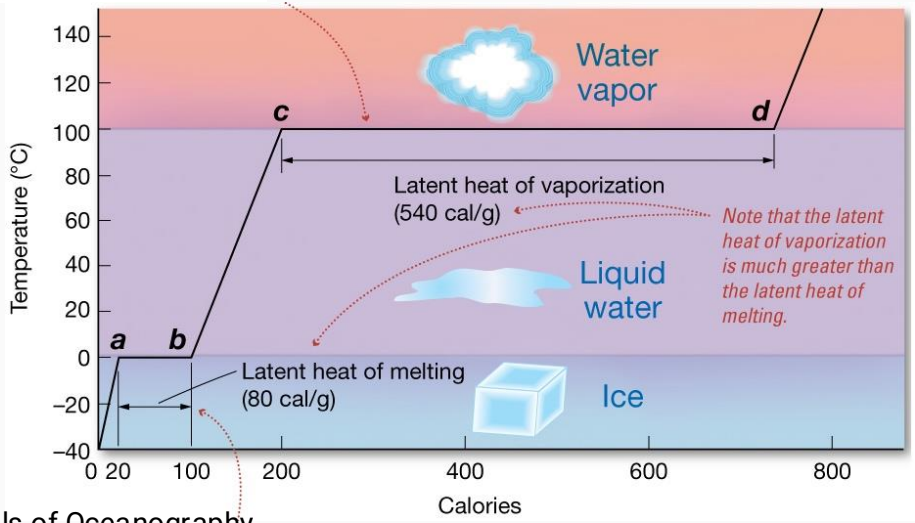
The Wonderful Water Molecule

- Polarity stabilizes dissolved ions
- Formation of Hydrogen bonds between water molecules give it stability and important properties
- High heat capacity stores energy, allows transport, drives climate



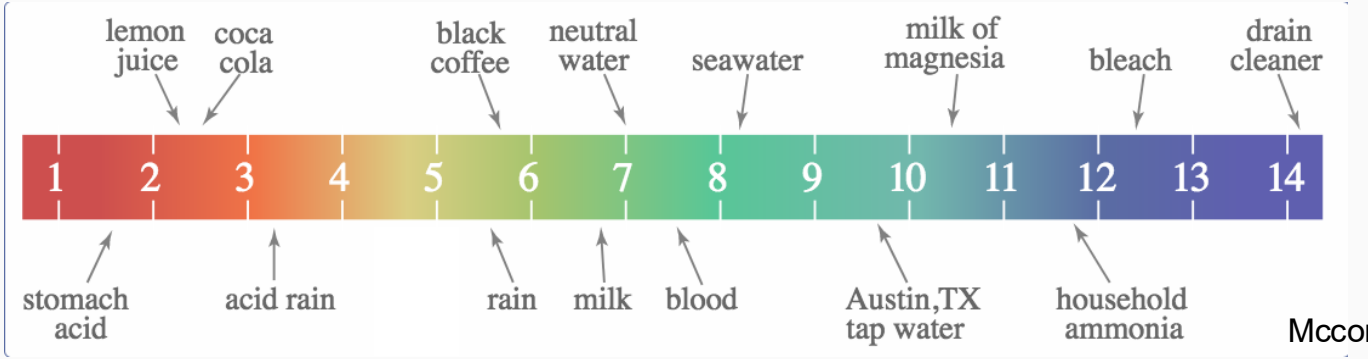




Trujillo and Thurman, Essentials of Oceanography

pH: a Master Variable

- pH = -log[H^+] = -log[H_3O^+]
- Most natural waters pH ~5.5-8.5
  - Acid mine drainage pH ~2.5-5.5
  - Alkaline waters pH >9



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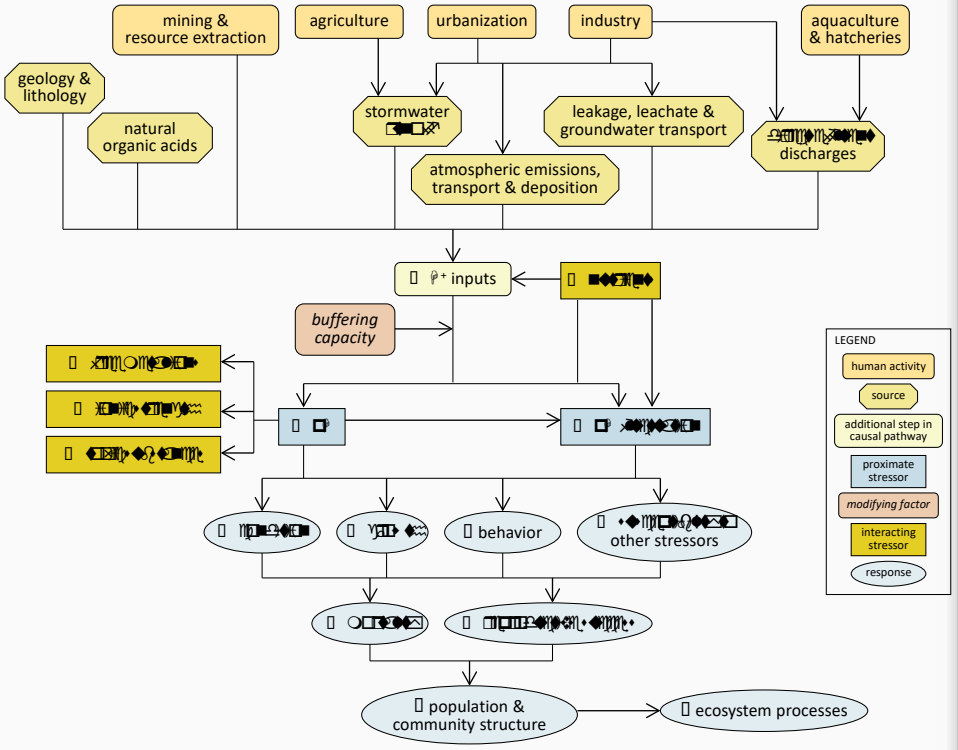
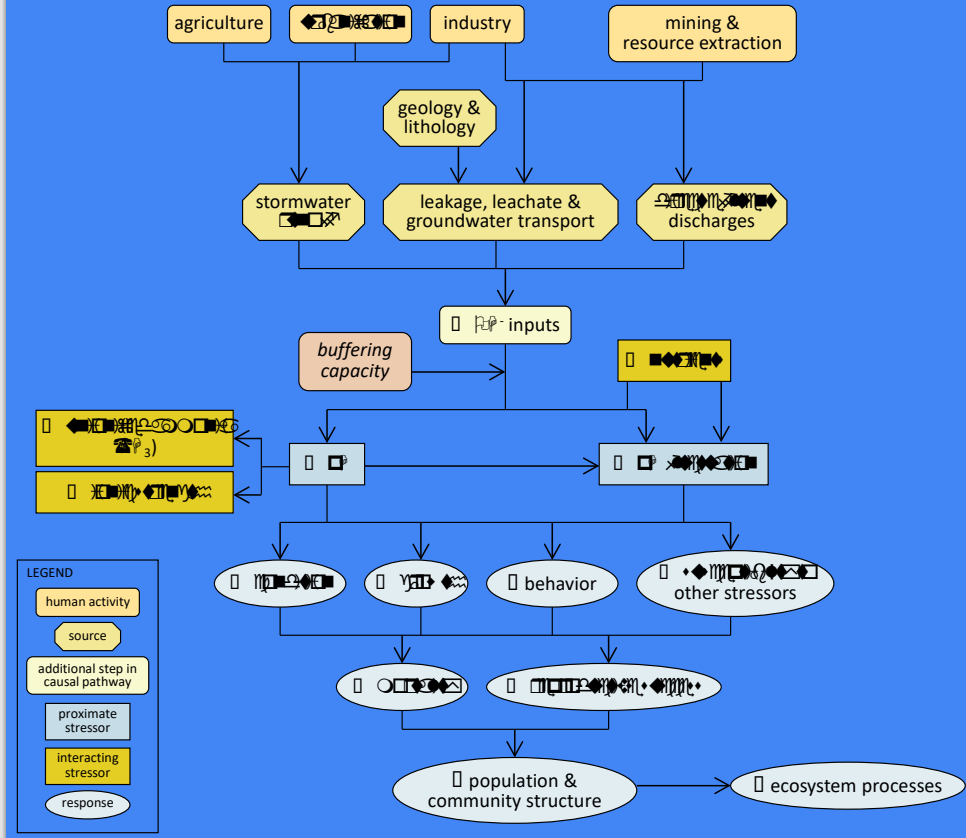
Low pH



High pH



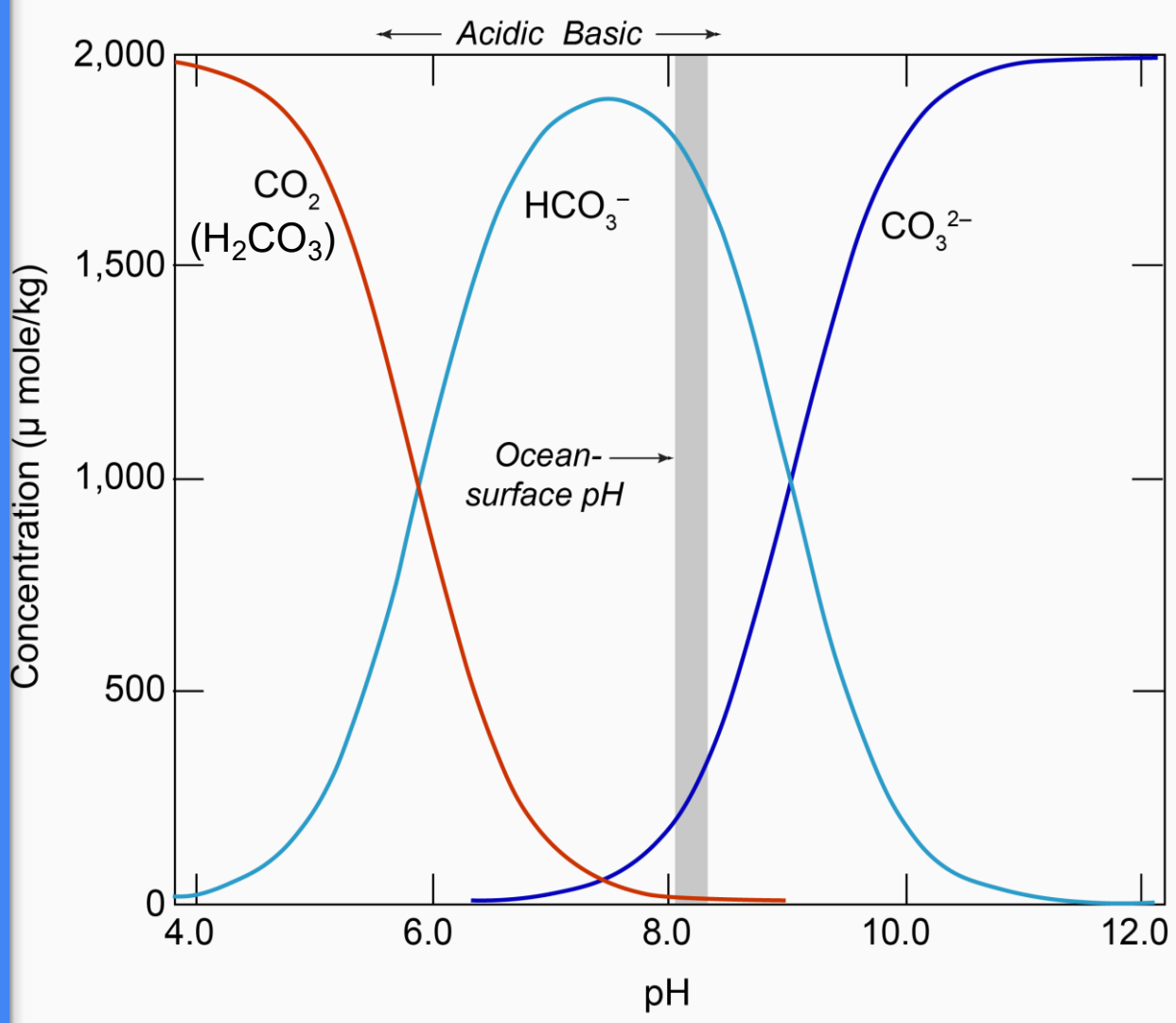
EPA Conceptual Models

Alkalinity

- Alkalinity = $-M_{H+} + M_{HCO3-} + 2M_{CO32-} + M_{OH-} + M_{B(OH)4-} + M_{H3SiO4-} + M_{HS-} + M_{Organic\ anions}$ ····
- Represents the buffering capacity of a water body
  - Strong acids will convert anions to uncharged species
  - Strong bases will convert uncharged species to anions
- Keeps the pH relatively steady

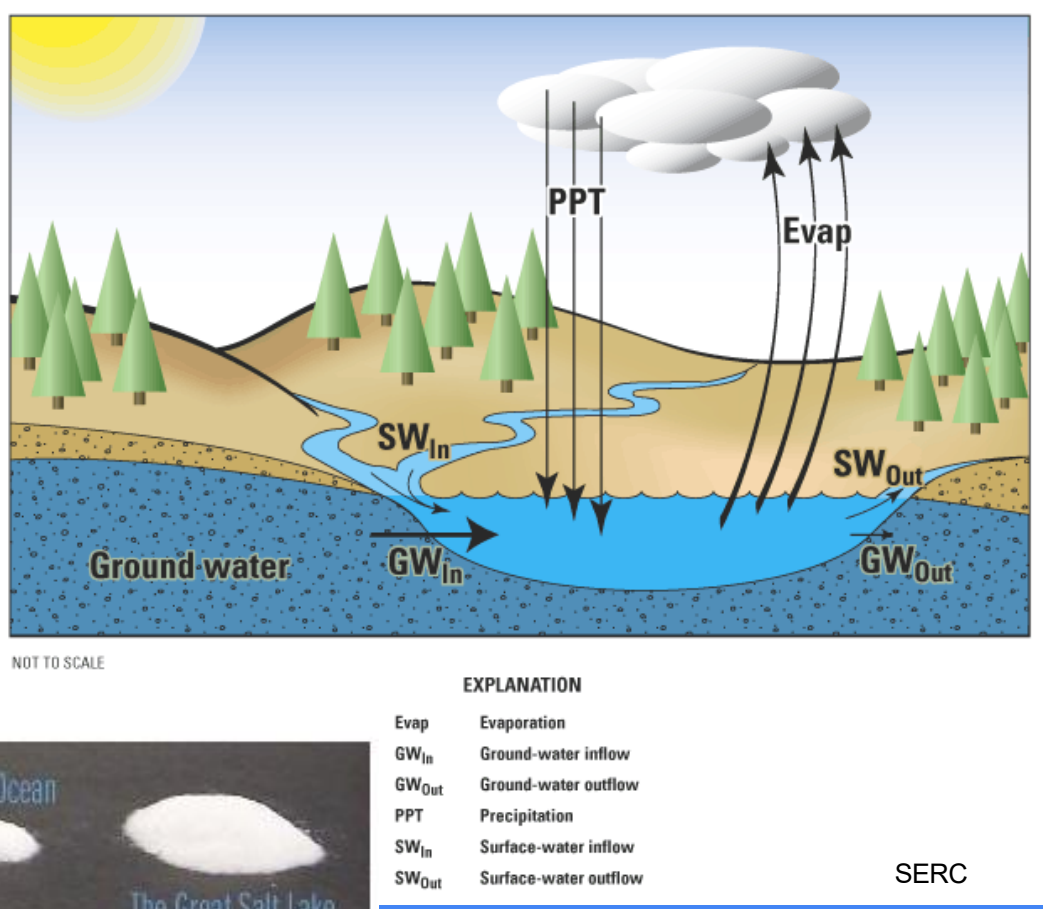
Carbonate Alkalinity

- CO_2 from the atmosphere dissolves in water, forming the carbonate buffer system
- At natural water pH, bicarbonate ion (HCO_3^-) is the dominant form
  - Uptakes H^+ to form carbonic acid (H_2CO_3)
  - Releases H+ to form carbonate ion (CO_3^{2-})



TDS = Total Dissolved Solids

Any material dissolved in water, including ions, gases, organic compounds, metals, contaminants

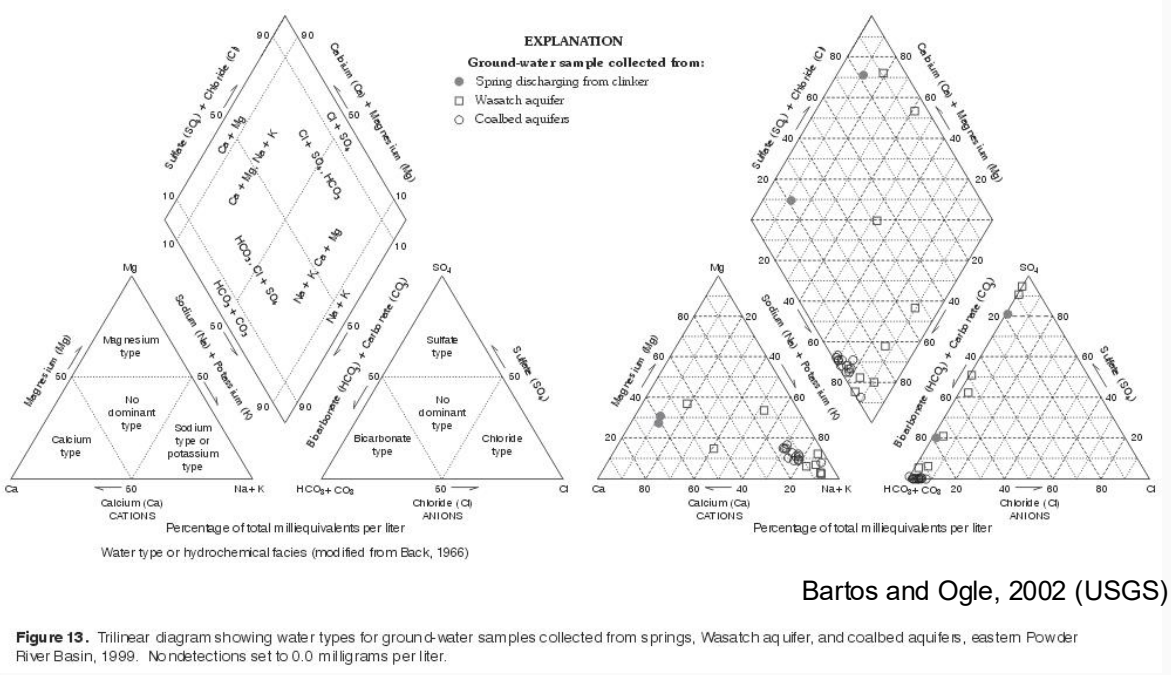


SERC

www.lakesuperiorstreams.org

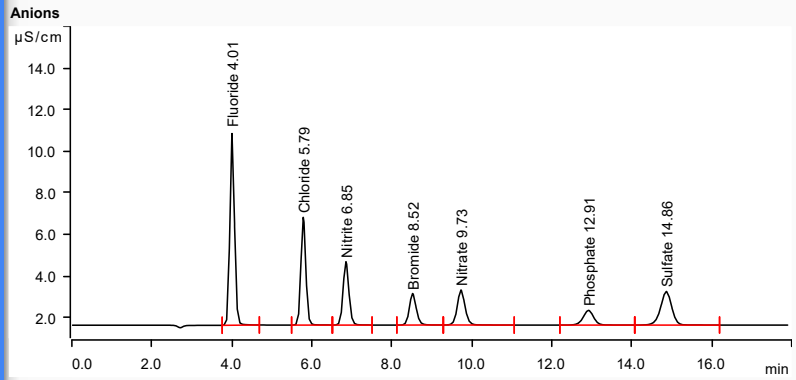
Ions

- Charged atoms/molecules
  - Most common cations are Ca^{2+}, Mg^{2+}, Na^{+}, K^{+}
  - Most common anions are HCO_3^{-}, Cl^{-}, SO_4^{2-}
- Originate from dissolution of rocks/minerals, contamination
- Serve as nutrients, form shells, also evaporite minerals
- Can be used to trace water source, biogeochemical processes, rock-water interaction



Bartos and Ogle, 2002 (USGS)

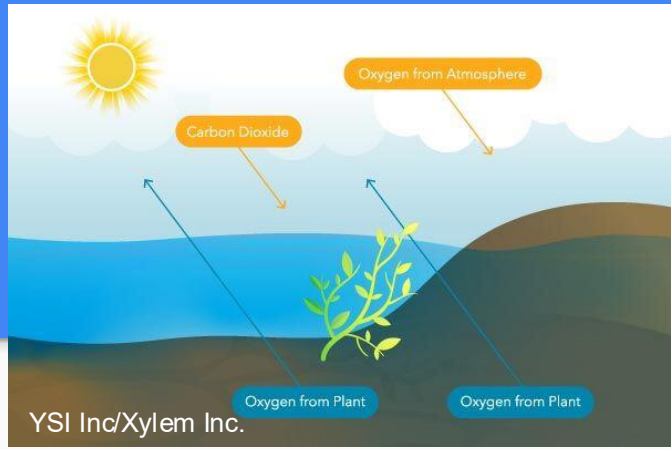
Figure 13. Trilinear diagram showing water types for ground-water samples collected from springs, Wasatch aquifer, and coalbed aquifers, eastern Powder River Basin, 1999. Nondetections set to 0.0 milligrams per liter.

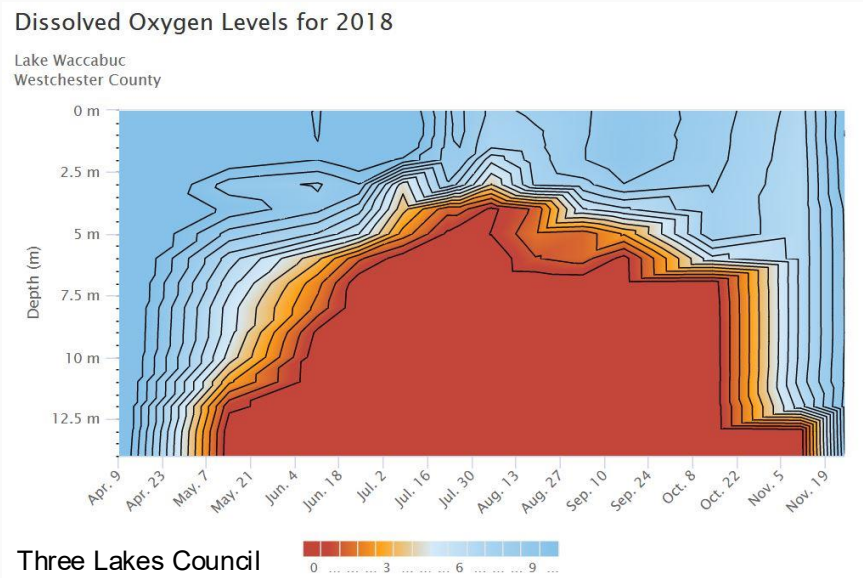


Anion standard run on ion chromatograph

Dissolved Gases

- Gas molecules dissolved in water including O_2, CO_2, methane, H_2S
  - Exchange with the atmosphere through diffusion, aeration
  - Internal sources such as photosynthesis, decomposition of organics
  - Release from sediments
- Important to health of water body
  - Dissolved O_2 a master variable
  - Stratification and anoxia



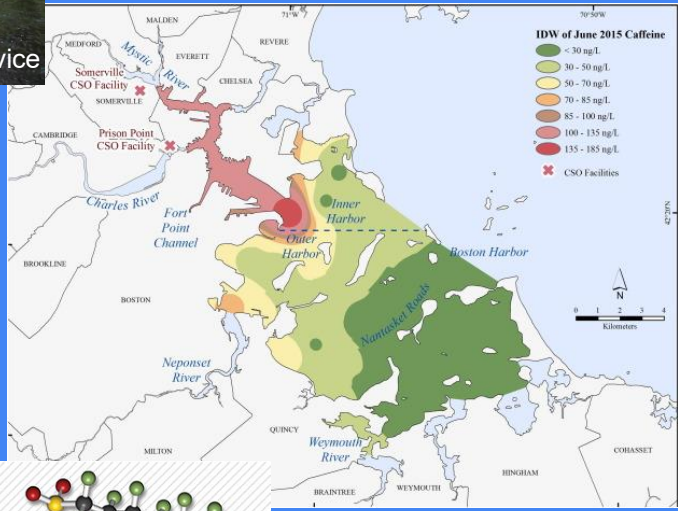


Organic Compounds

- Carbon-based compounds
- Natural organic compounds
  - Tannins, humics, dissolved organic matter
- Anthropogenic organic compounds
  - Industrial pollutants, wastewater, agrichemicals, oil spills; microplastics

Jim Mineau/Forest Service

Cantwell et al., 2016



Cook and Steinle-Darling, Water Online

Geochemical measurements can characterize a water system

Evaluate environmental conditions, biogeochemical processes, and anthropogenic influences

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Acknowledgements

Contact us:

WRANEgeo@okstate.edu

NSF grant ICER-2119861
Cas.okstate.edu/wrane/index.html

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Additional Information:

- Water Quality Information by Topic: USGS Water Science School