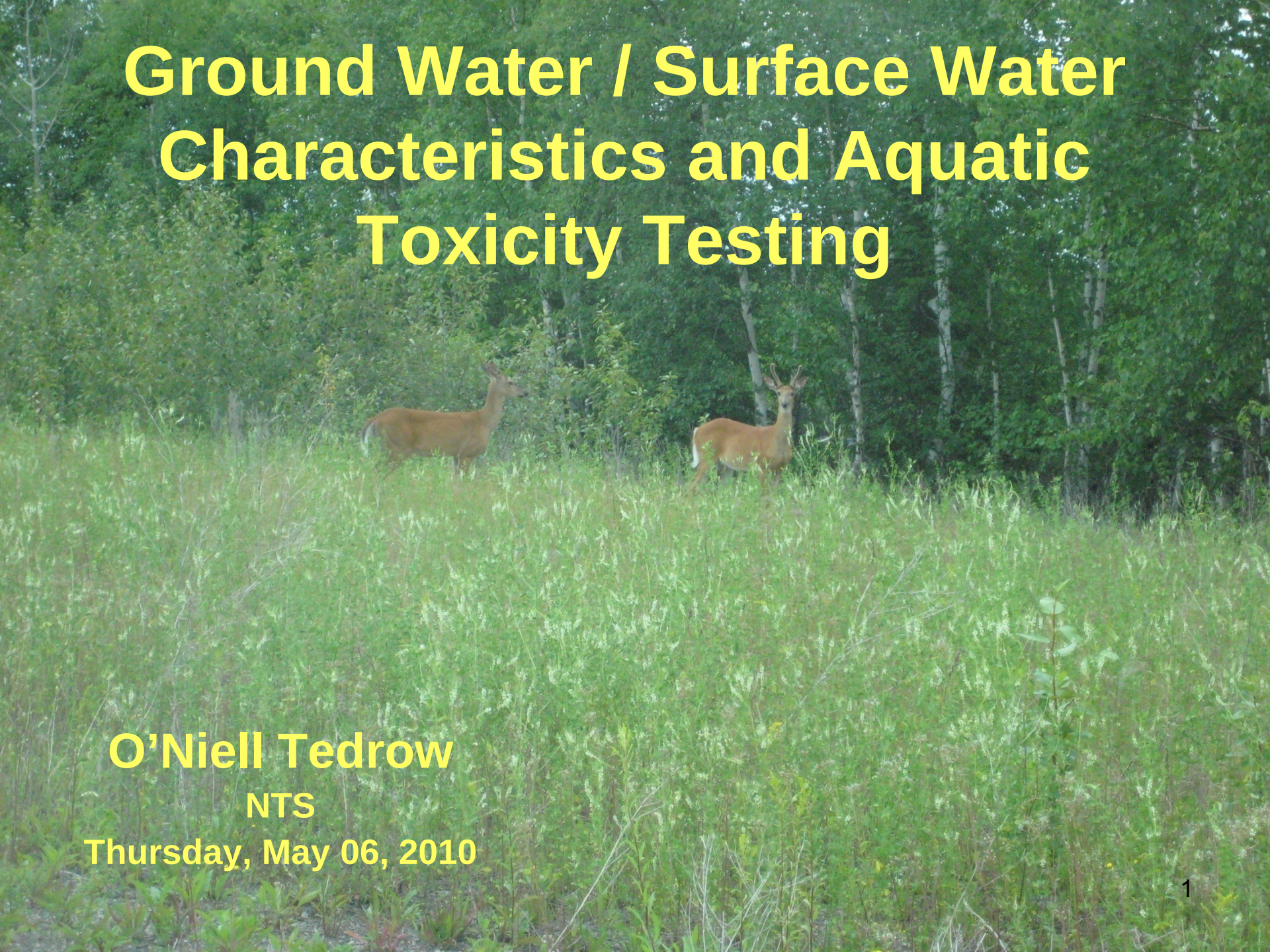
Ground Water / Surface Water Characteristics and Aquatic Toxicity Testing



O'Niell Tedrow

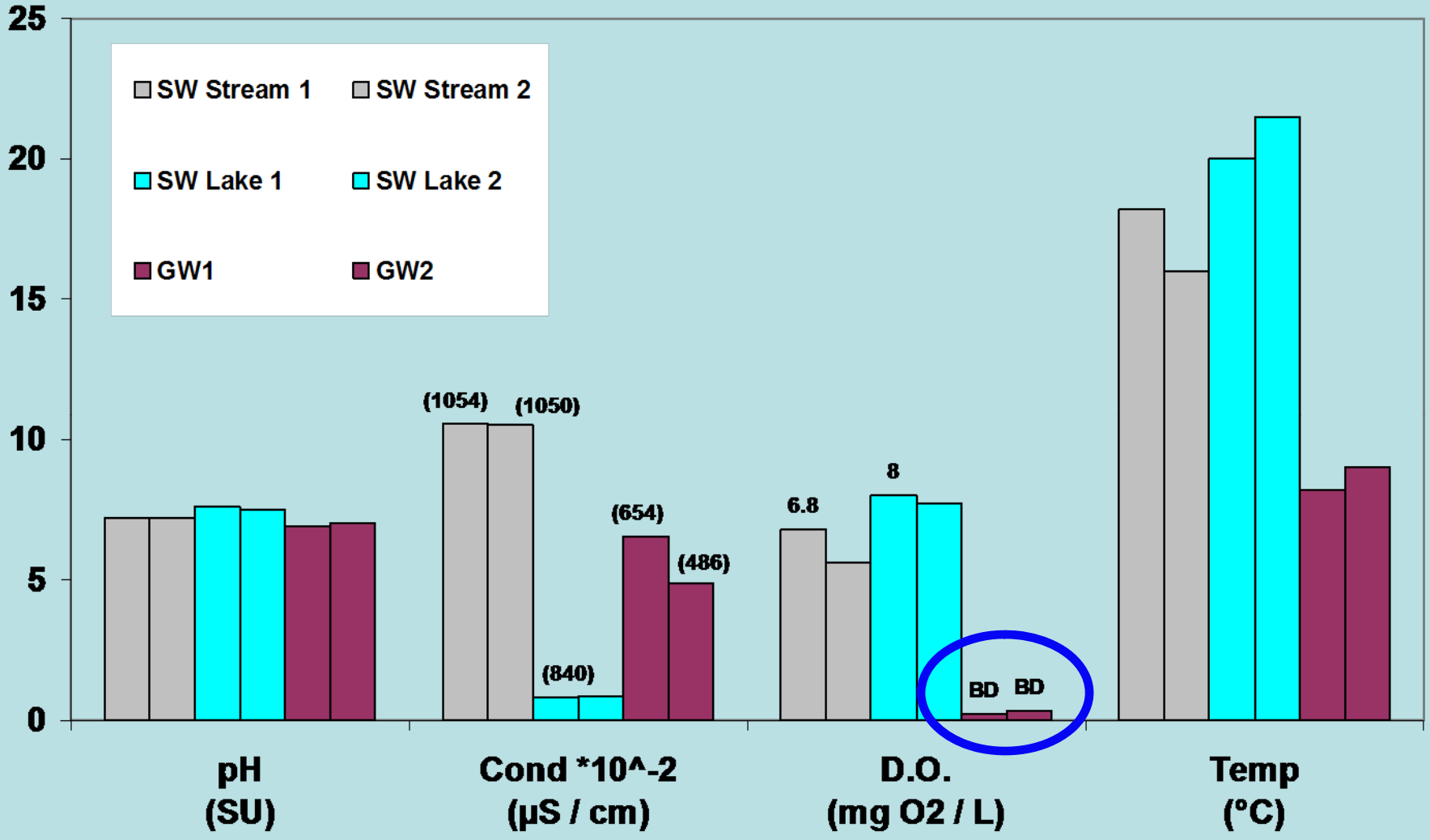
NTS

Thursday, May 06, 2010

Overview

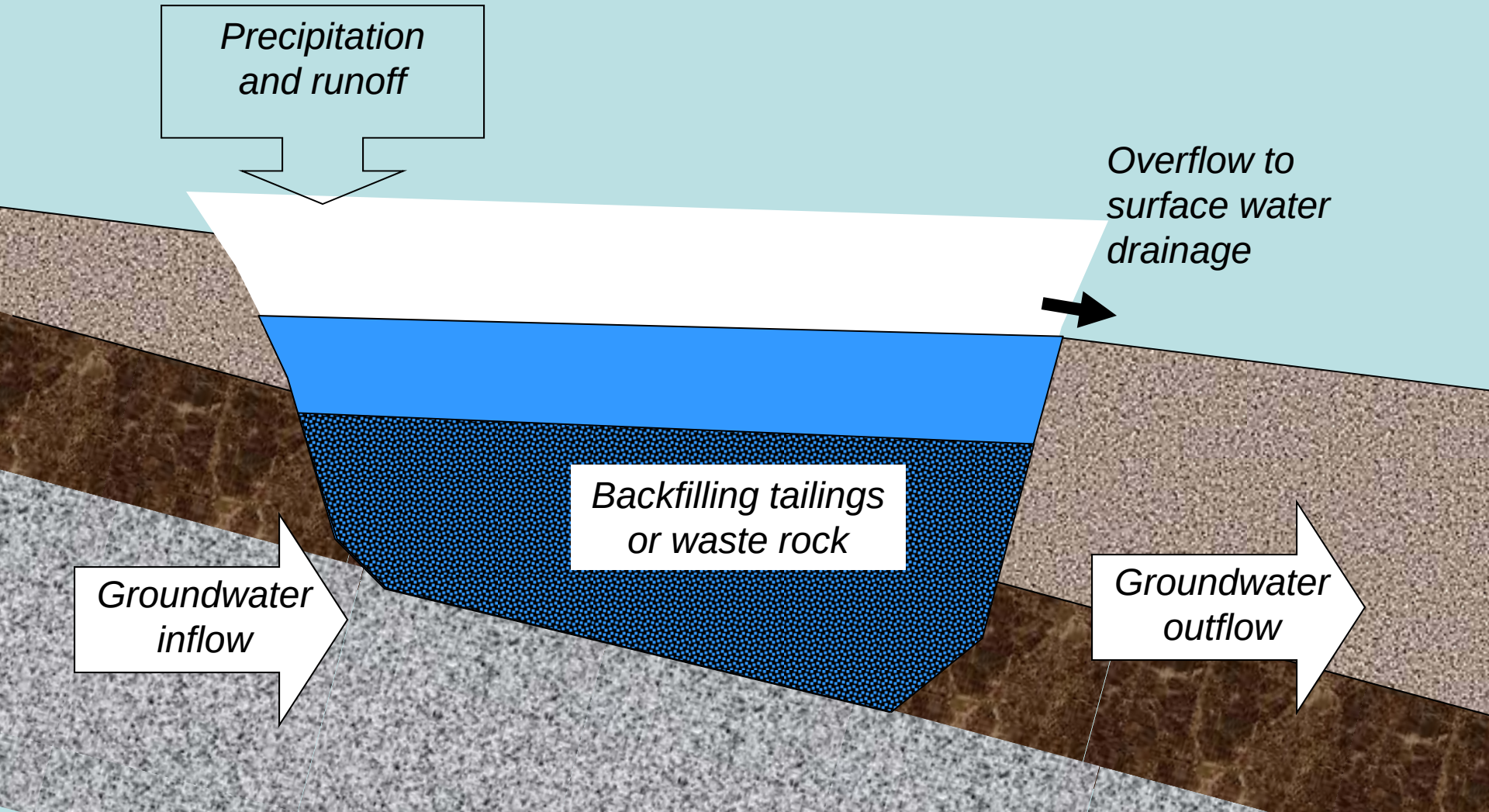
- GW / SW Characteristics
  - Influences on Toxicity Tests
- Introduce “Toxicology”
- Definitions
  - Exposures / responses
    - Form matters (!)
  - Toxicity Tests (“Chronic” vs. “Acute”)
  - Data interpretation / conclusions
- Potential Sources of Error
- Recap: Points of Interest

GW vs. SW Characteristics



*BD = Below Detection.

Influences on GW / SW
Characteristics: Non-Active Mine Pit



Toxicity Test Influences

- pH
  - Elemental speciation / bioavailability
    - Example: Cu, carbonate speciation
- Dissolved Oxygen (D.O.)
  - Can the test organisms breathe?
    - 4.0 mg O_2 / L minimum for aquatic toxicity tests (EPA 2002)
- Conductivity (related to TSS / TDS)
  - Impair reproduction (*C. dubia*)
  - Influence growth and survival (*P. promelas*)

Introduction: Toxicology

- **Toxicology**: Scientific study of exposures and organism responses to those exposures (i.e., stimulus-response)
- **Everything may be "Toxic"**
  - Form, Concentration / Intensity, Duration, Frequency, Route
- **Exposures**
  - Define / measure exposure
- **Responses**: Lethal and non-lethal
  - Lethal = mortality
  - Non-lethal = reproduction, growth, development, abilities

Example:

≠

Organisms Used in Toxicity Tests

Ceriodaphnia dubia- “Water Flea”.
• Age used = ≤ 16 hours old (neonates).
• Adult = 1mm in “size”; neonates are much smaller, transparent.

Pimephales promelas- “Fathead minnow”.
• Age used = ≤ 24 hours old (fry).
• Fry = ~2-5mm long; transparent except for eye and digestive tract.

Definitions: Toxicity Tests

- **Chronic**:
  - Long-term exposure; ~ 1/10 of the organism's life expectancy (EPA 1991)
  - Study lasting >90 days, or a large part of the organism's life expectancy (Natl. Inst. Health 2009)
- **Chronic Toxicity (Test)**: experiment consisting of exposures lasting ~ 1/10 of an organism's life expectancy (EPA 1991)
- **Acute Toxicity (Test)**: stimulus potent enough to cause response(s) 48-96h following exposure (EPA 1991)
- **Toxic**: poisonous; capable of causing death, serious debilitation (Merriam-Webster 2009)
- **Toxin**: an unstable, "poisonous" compound produced metabolically by a living organism (Merriam-Webster 2009)

Problem?...Mitigation

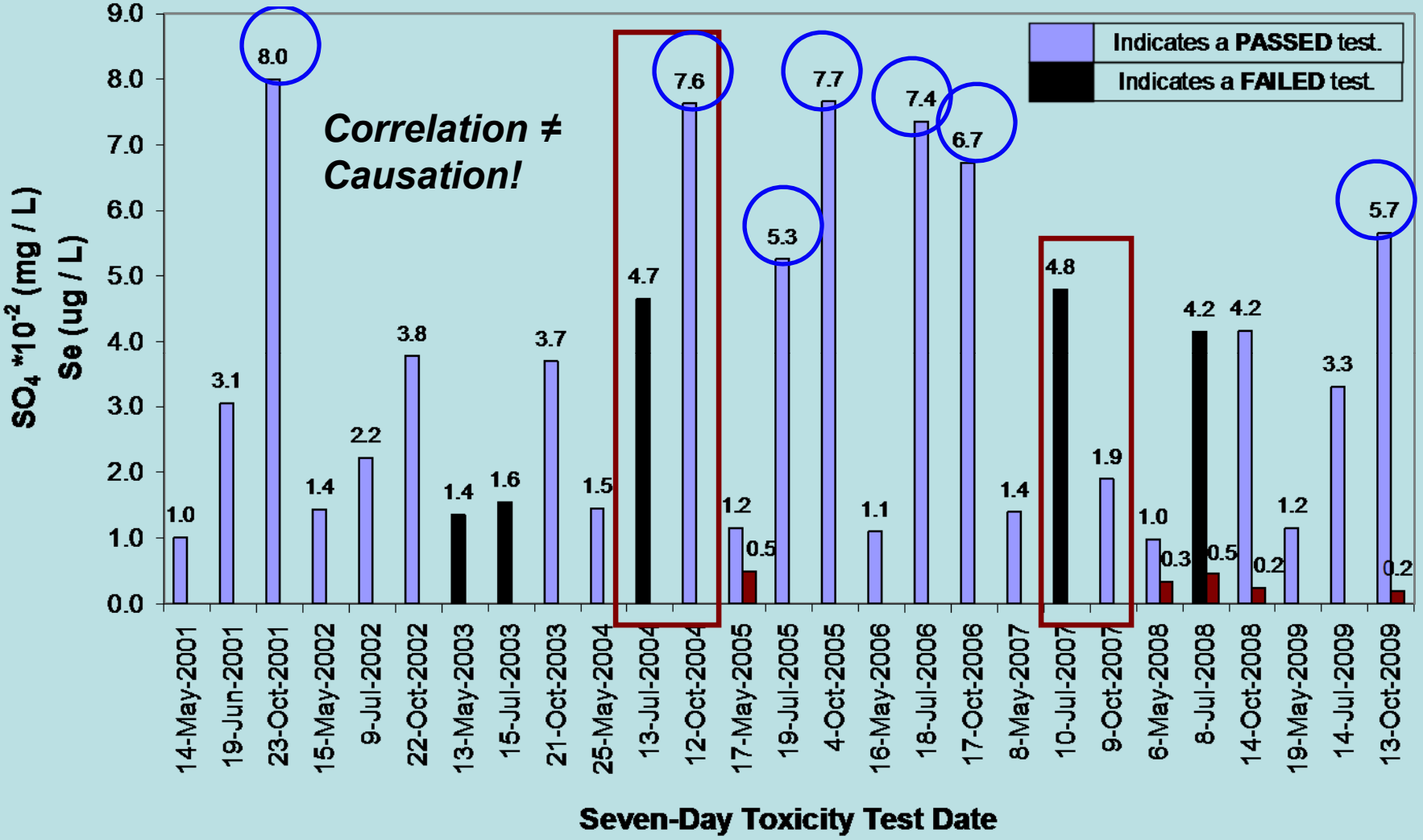
- Research / Statistics = likely influence(s) of observed toxicity
- Can be very costly (tens of thousands of $$)
- Not guaranteed to “fix” problem(s) indefinitely
- Site / water specific

Laboratory exposures

Laboratory predictions of organism responses

Field samples

Representative field samples



NOTE: Highest SO_4 concentrations concluded as PASSED tests based on IC_{25} and TUc. (Not defensible to use a single-factor predictor for toxicity.)

Points of Interest

- Correlation ≠ causation re: water charact's. (!)
- Statistical significance / non-significance
- Conclusions based on "support or refute hypothes(es)", not "definite cause"
- Site "A" ≠ Site "B" (!)
  - Different lakes, reservoirs; wastewaters / discharge sources, pathways and forms of constituents of concern

Example:

≠


Questions or
Comments?

References

- United States Environmental Protection Agency (EPA) 1991. *Technical support document for water quality-based toxics control*. Office of Water (EN-336); EPA/505/2-90-001.
- United States Environmental Protection Agency (EPA) 2002. *Short-term methods for estimating the chronic toxicity of effluents and receiving waters*. Fourth Edition; EPA-821-R-02-013.
- National Institute of Health (NIH) Website. http://sis.nlm.nih.gov/enviro/iupacglossary/glossaryc.html#chronicexposure.
- *(Define:Toxin)* Merriam-Webster dictionary. http://www.merriam-webster.com/dictionary/toxin.
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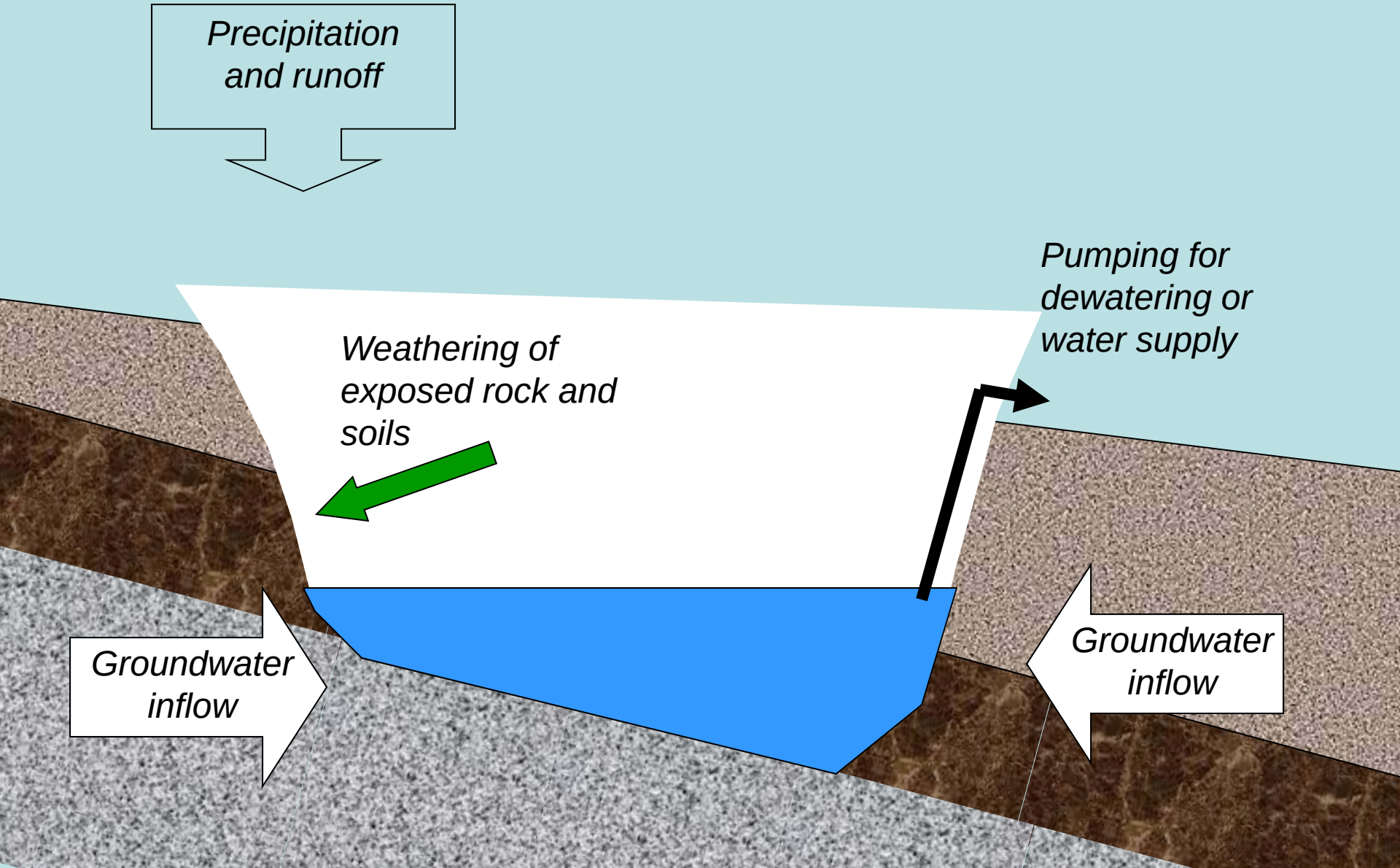
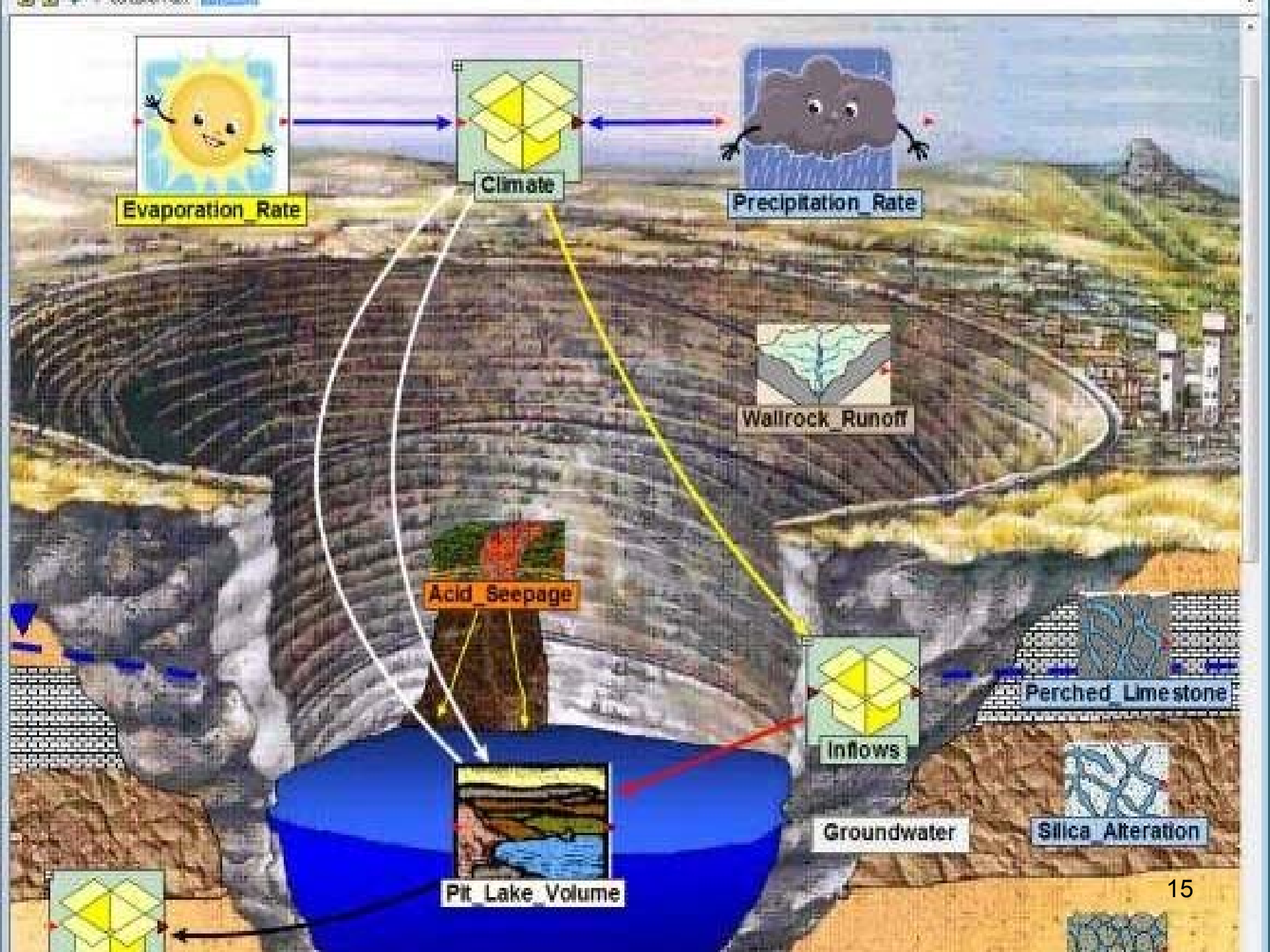
Influences on GW / SW Characteristics: Active Mine Pit

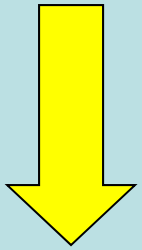



Evaporation_Rate
Climate
Precipitation_Rate
Wallrock_Runoff
Acid_Seepage
Perched_Limestone
Inflows
Groundwater
Silica_Alteration
Pit_Lake_Volume

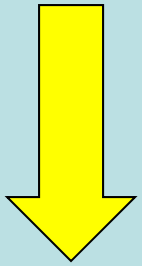
Laboratory Experimental Design

Waters used for laboratory exposures

Mod-Hard Lab Culture Water

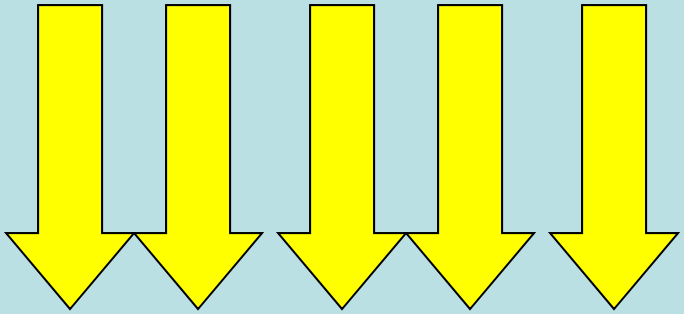


Single Exposure Concentration

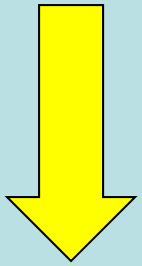


Ten Replicates

Discharge Water (%) Typical Diln. Series

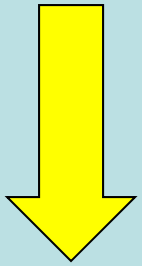


12.5 **25** **50** **75** **100**

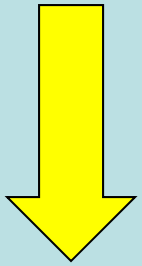


Ten Replicates / Dilution

Receiving / Diln. Water



Single Exposure Concentration

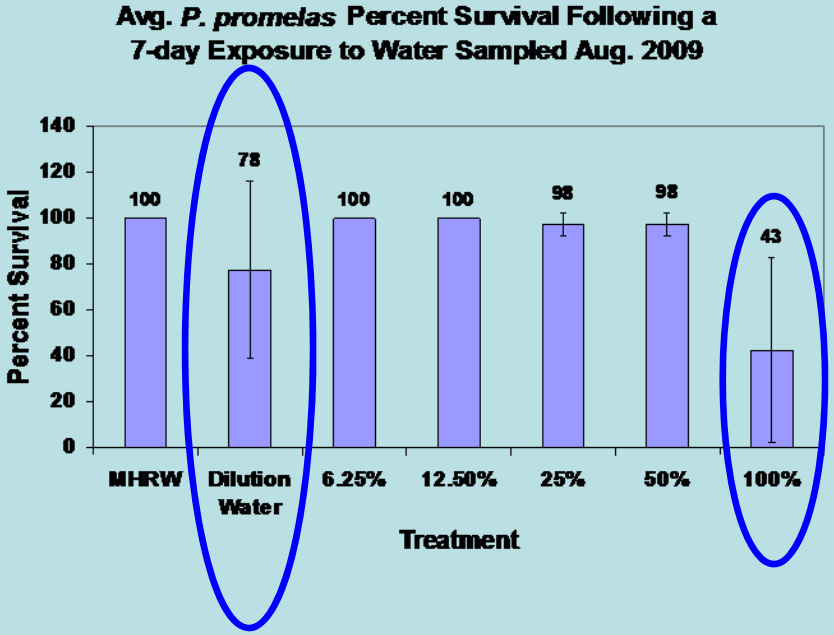


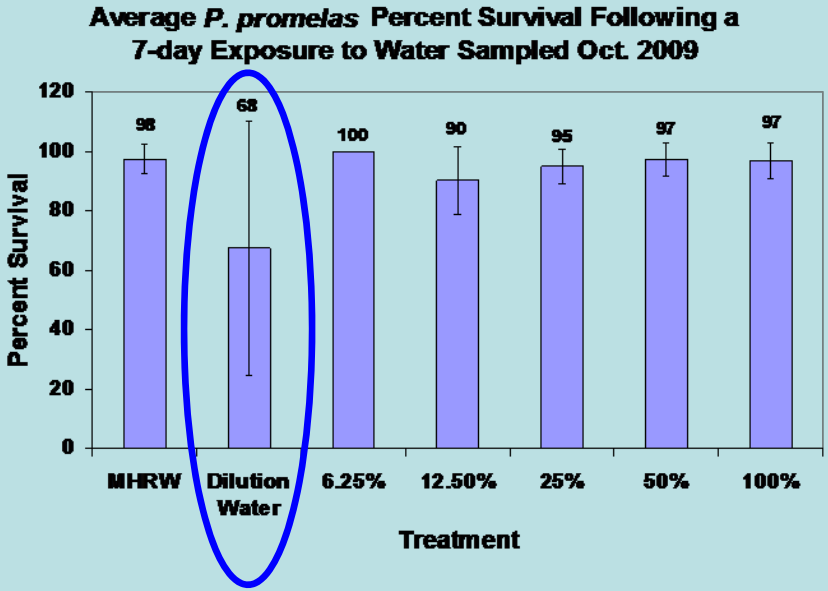
Ten Replicates

Definitions / Calculations

- **I**nhibition **C**oncentration **25 (IC25)**: the concentration of "test material" likely to cause inhibition of a non-lethal measured organism response in 25% of the tested population (EPA 2002)
- **"N**o **O**bservable **E**ffects **C**oncentration" (**NOEC**): the highest exposure concentration where adverse responses are not significantly different than non-exposed controls (EPA 2002)
- **C**hronic **T**oxicity **U**nit (**TUc**): reciprocal of the [effluent] likely to cause no observable effects to the test organisms by test conclusion (i.e., 100 / NOEC) (EPA 1991)
- **L**owest **O**bserved **E**ffects **C**oncentration (**LOEC**): the lowest exposure concentration where adverse effects are significantly different from non-exposed controls (EPA 2002)

Likely Test Contamination





- Observations from both tests indicate contamination from a source outside either the dilution or discharge water
  - **Aug. = FAIL, Oct. = PASS**
- Following contaminant observation, make arrangements with testing authority regarding:
  - Immediately communicating observations during test(s) !!
  - Test re-initiation (include discussion about historical test conclusions, cost, time)
- **!! Importance of immediate communication of observed contamination during test !!**