Chemical Treatments for Turbidity Control: Basic Principles and Examples

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What To Do About Turbidity?

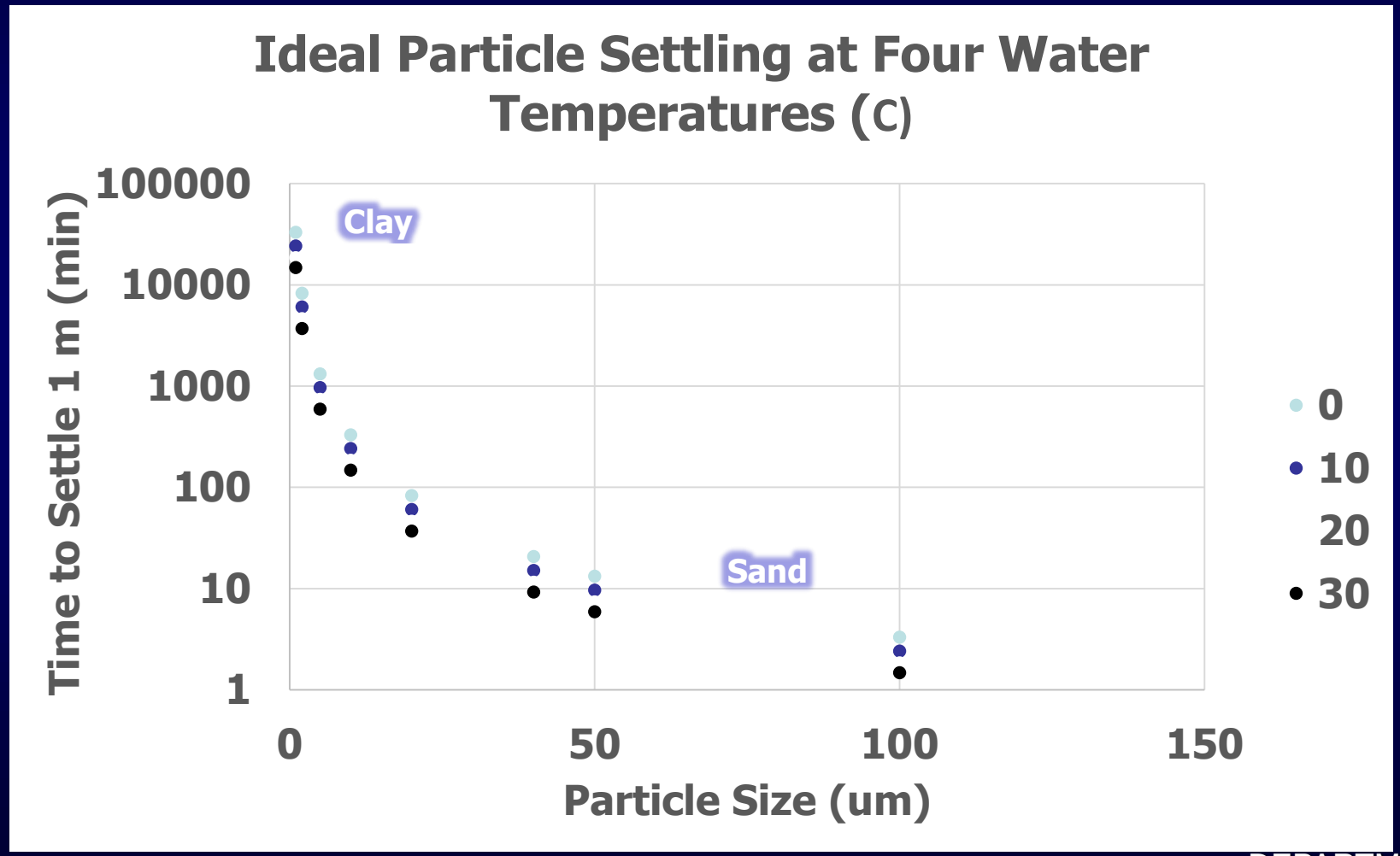
- Filter: often impractical because effective filters require maintenance (e.g. backflushing).
- Infiltrate: ideal solution (no runoff!) but often soil properties or high groundwater prevent it.
- Chemically Assisted Settling: effective, may not require much change, inexpensive.

Why is Chemical Treatment Needed (or we need really large storage basins!)

70 days

7 days

17 hours



First Step: Best Practices for Source Control

Areas not being worked will be stabilized

Water conveyances will be stabilized
(they can be main source of sediment)

2nd Step: Best Practices for Sediment Control

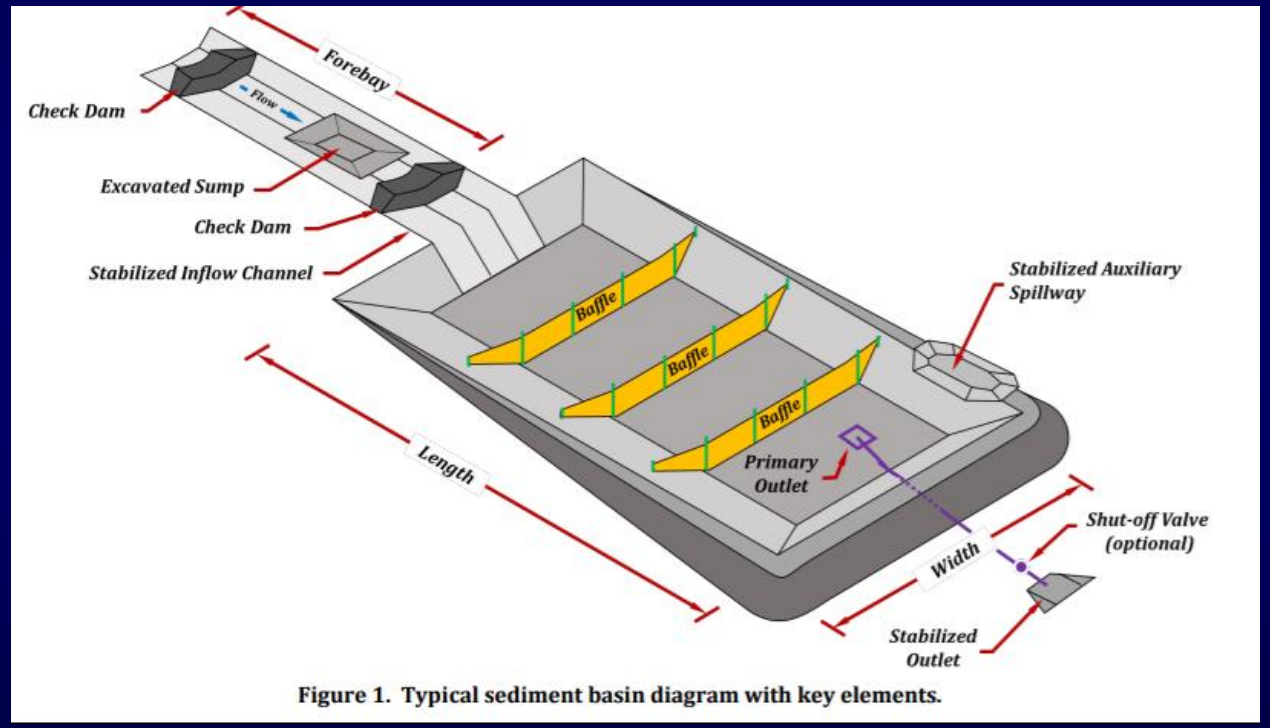


Figure 1. Typical sediment basin diagram with key elements.

IECA Standards and Practices Committee Basin

NCDOT Skimmer Basin

Chemicals Available

- Coagulants: alum, gypsum, ferric compounds
  - Overcome clay surface charge
  - Doses are in the pounds per 1,000 cu ft range
  - Can create low pH, excessive aluminum

- Flocculants: polyacrylamide, chitosan, others
  - Bind suspended solids together into flocs
  - Doses in fractions of oz per 1,000 cu ft

Early Turbidity Control Experiment

- Gypsum found to work when manually spread on basin
- Senior design student built a powder dispenser using 12V motor
- Capacity issue: could only treat about 1/3 of basin volume
- Humidity issue: gypsum turned to solid in summer…

Available Flocculant Forms

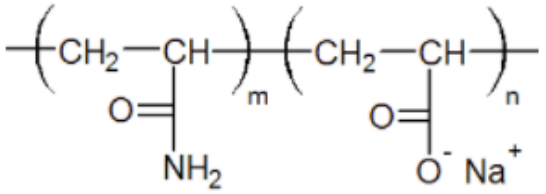
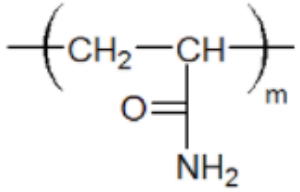
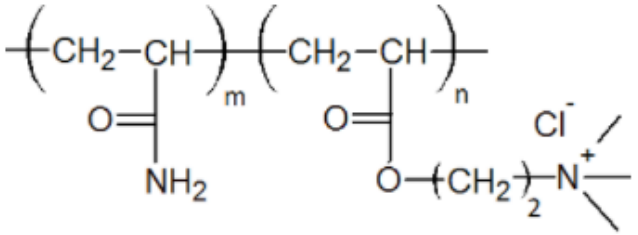
Powder

Powder-Filled Socks

Solid Block

Effervescent Tablets

PAM Forms

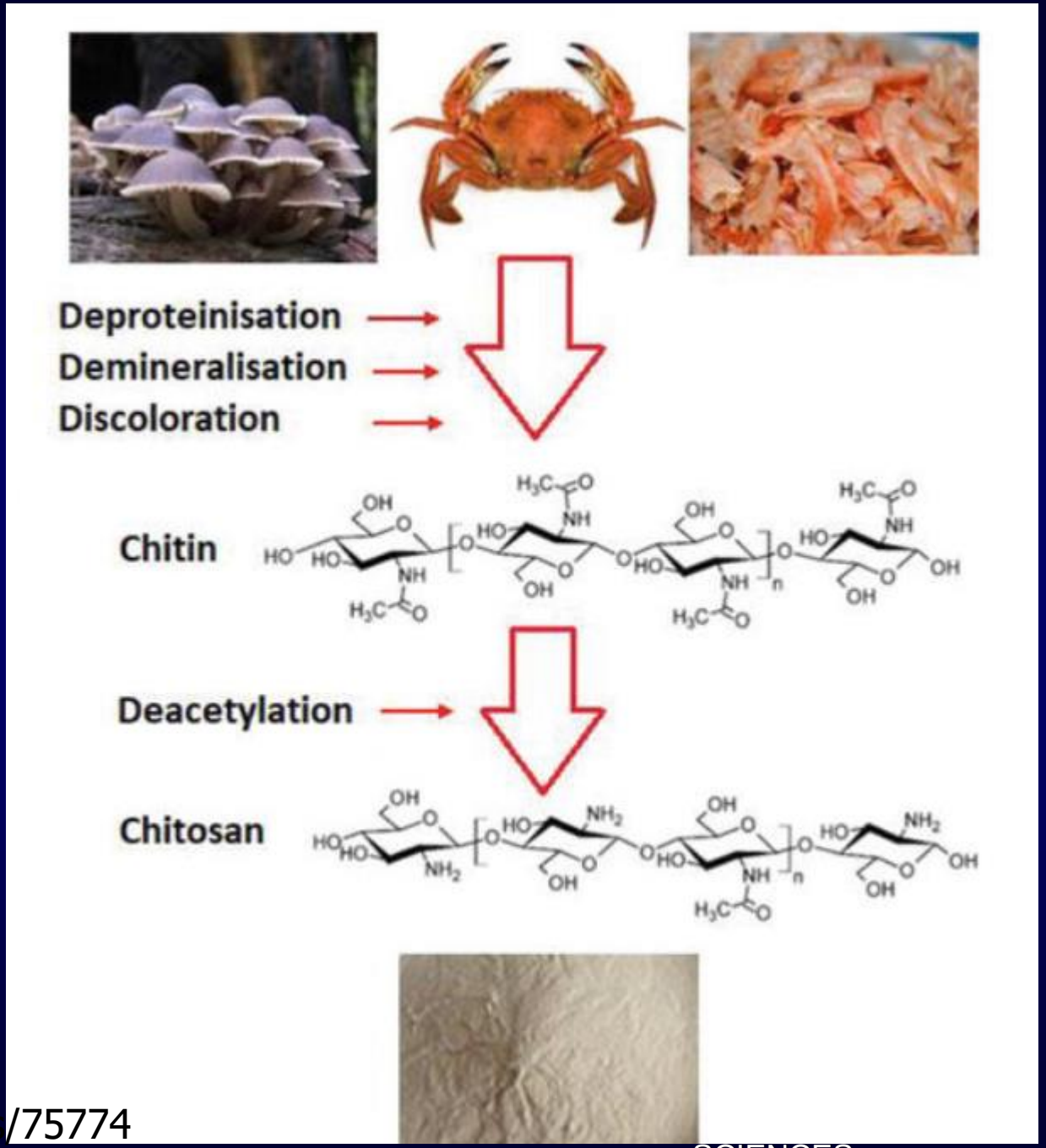
Polyacrylamide	Structure of Repeat Unit
Anionic Polyacrylicamide (APAM)	
Neutral Polyacrylamide (PAM)	
Cationic Polyacrylamide (CPAM)	

Accutely toxic in unbound form (clean water)

http://polymerdatabase.com/polymer%20classes/Polyacrylamide%20type.html

Chitosan Polymer

- Derived from chitin, which is derived from crab/shrimp shells primarily
- Accutely toxic in unbound form (not in muddy water)



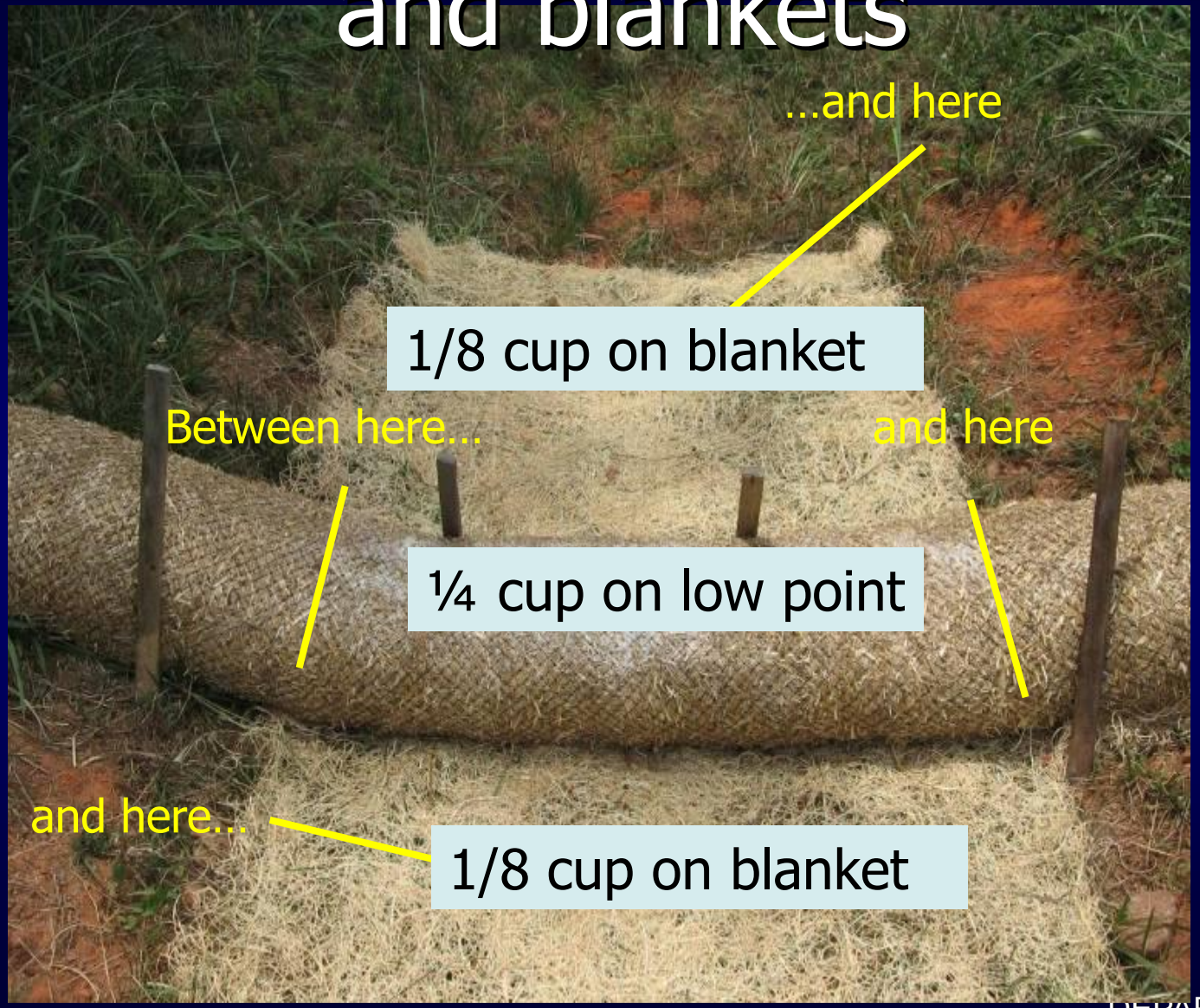
https://www.intechopen.com/chapters/75774

Jar Test: Ideal Flocculation Example

Should test you soil or muddy water with flocculants before selecting one.

Passive Dosing: Add ½ cup flocculant to ditches/diversions

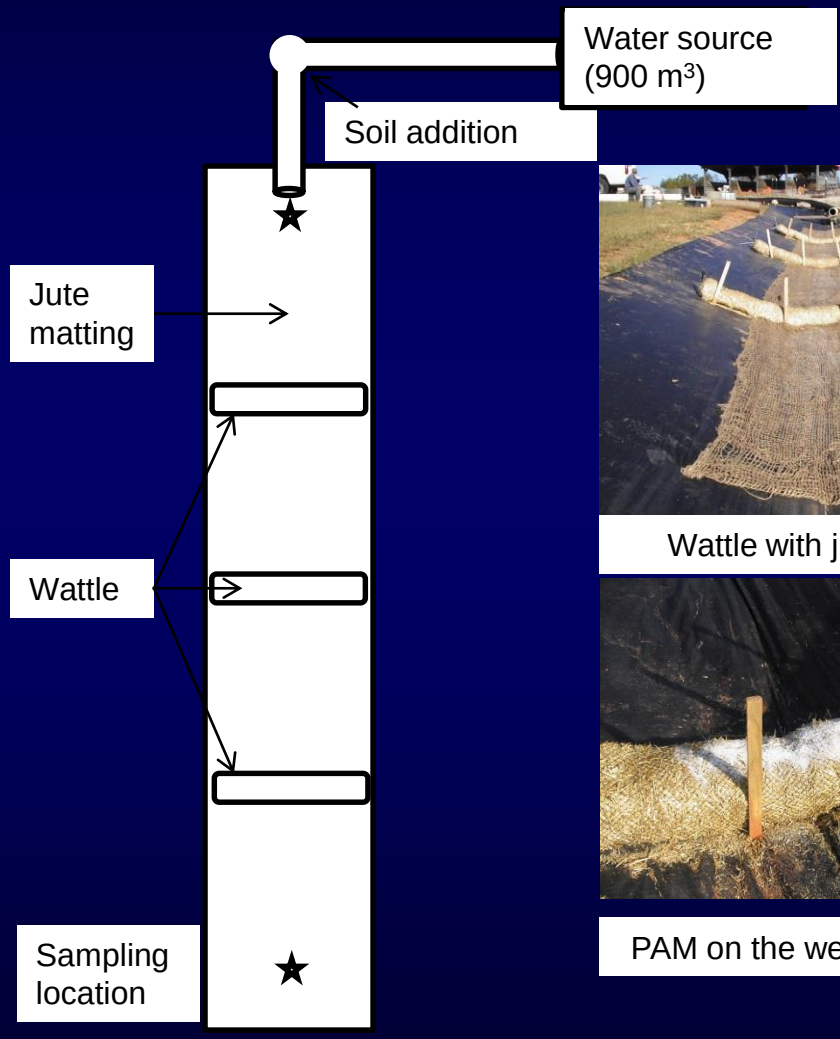
Distribution of ½ cup flocculant to wattles and blankets



Examples: Add flocculant treatment to ditches/diversions

Natural fiber materials work well due to the high surface area for holding the PAM powder.

Testing Flocculation Methods



Wattle with jute matting

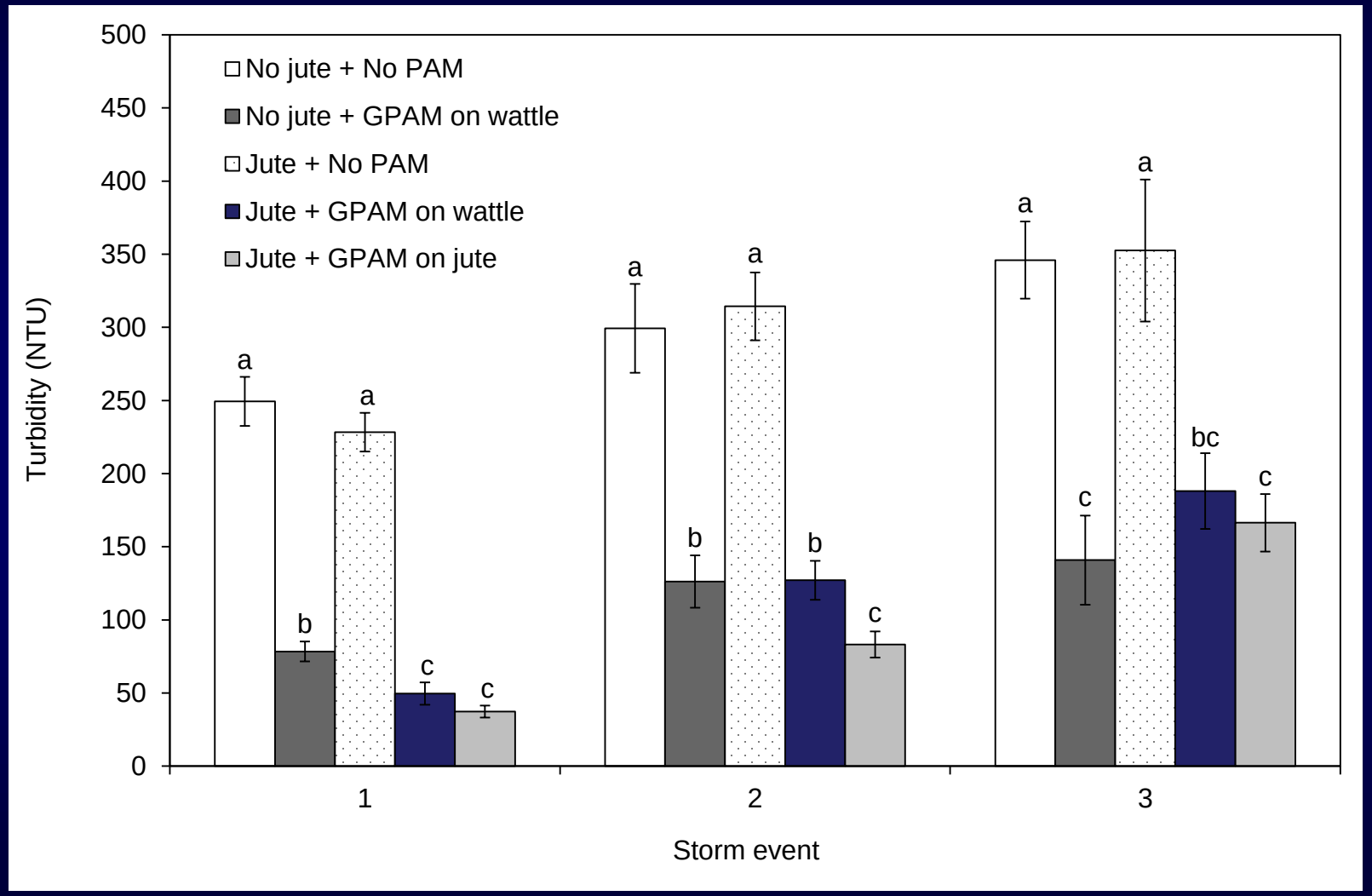
Wattle without jute matting

PAM on the weir of wattle

PAM on jute matting

Flocculant Added

Results: Turbidity Reduction Regardless of Introduction Method



Different letters within an event indicates statistically significant differences

Passive Dosing Tests: PAM on Check Dams

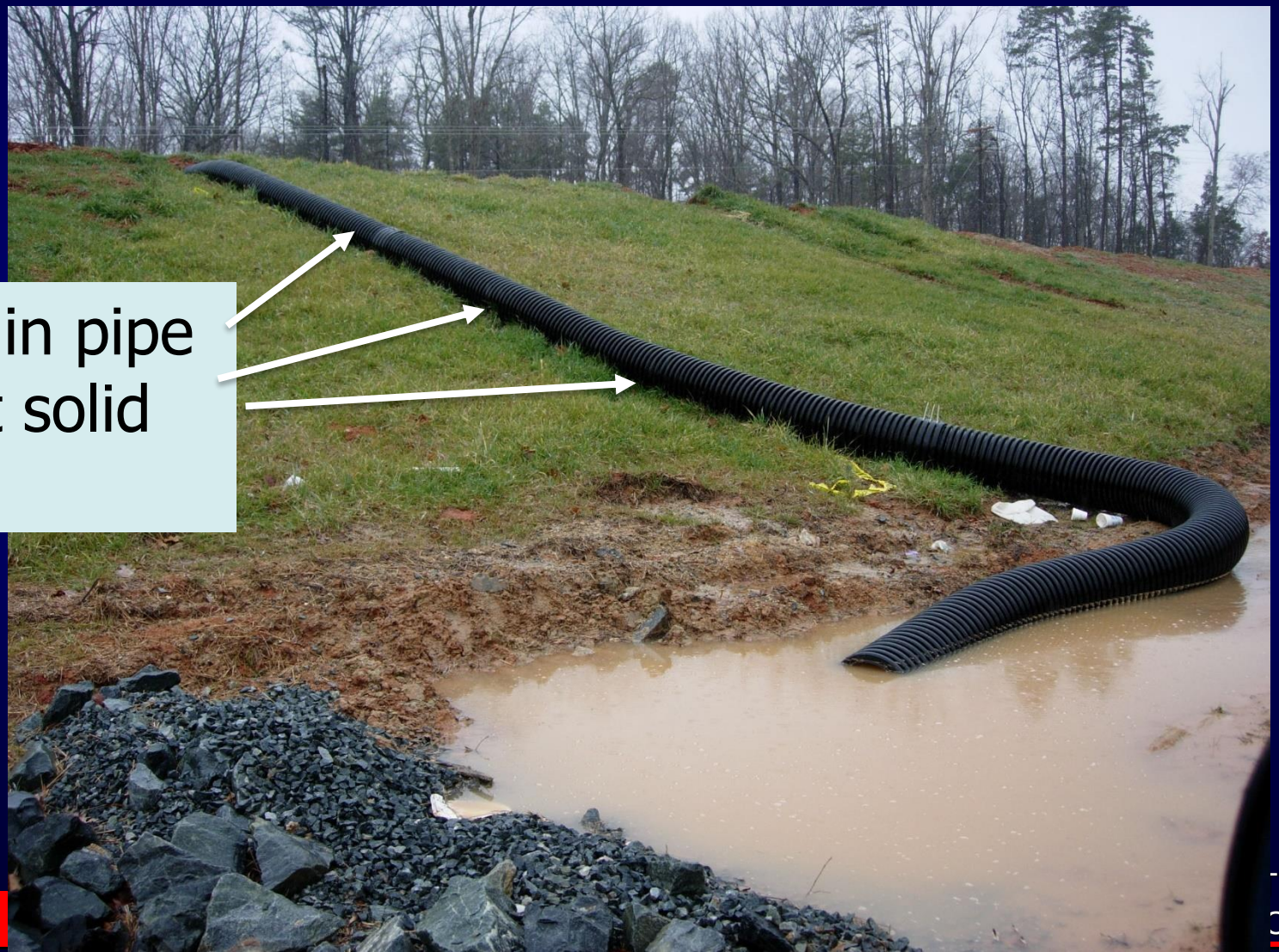
- All done at NCSU

Authors	Year	Number of Check Dams	Slope (%)	Turbidity Reduction Relative to No PAM (%)
Kang et al.	2013	3 (excelsior wattle, rock, rock w/ blanket)	5-7	>75
Kang et al.	2014	3 excelsior	7	>66 (>88 basin exit)
Kang et al.	2014	3 excelsior, with or without jute blanket	7	58-67 (Particle size increased 10X)
McLaughlin et al.	2009	Various (construction site)	Various	64-76 (storm weighted average)

Field Tests: Check dam + pipe + PAM block

Option: Add flocculant to slope drains (esp. solid forms)

Cut holes in pipe and insert solid forms



Option: If a storm drain system is in place, put flocculants in there (again, solid forms)

Option: If a storm drain system is in place, put flocculants in there

Note how block on right is less covered up because it is above the sediment

Tiered Sediment Basin – if you have the slope

Tiered Sediment Basin – lots of slope!

What about PAM Toxicity?

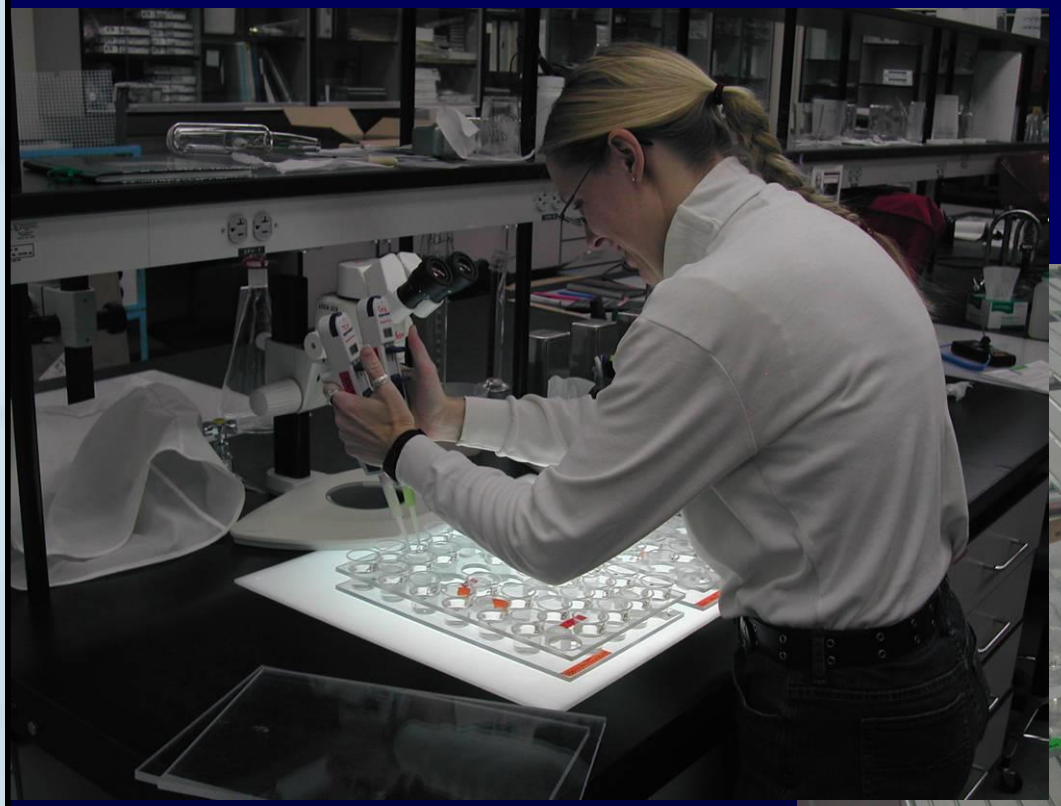
- PAM is known to be relatively non-toxic as measured by acute (24 hour) tests.
- Chronic tests (days or weeks) on fish also show low toxicity.
- Chronic tests on smaller species are most sensitive, but even these are not very sensitive to PAM.
- Recent testing on mussels also indicates low toxicity

Toxicity

Paracelsus

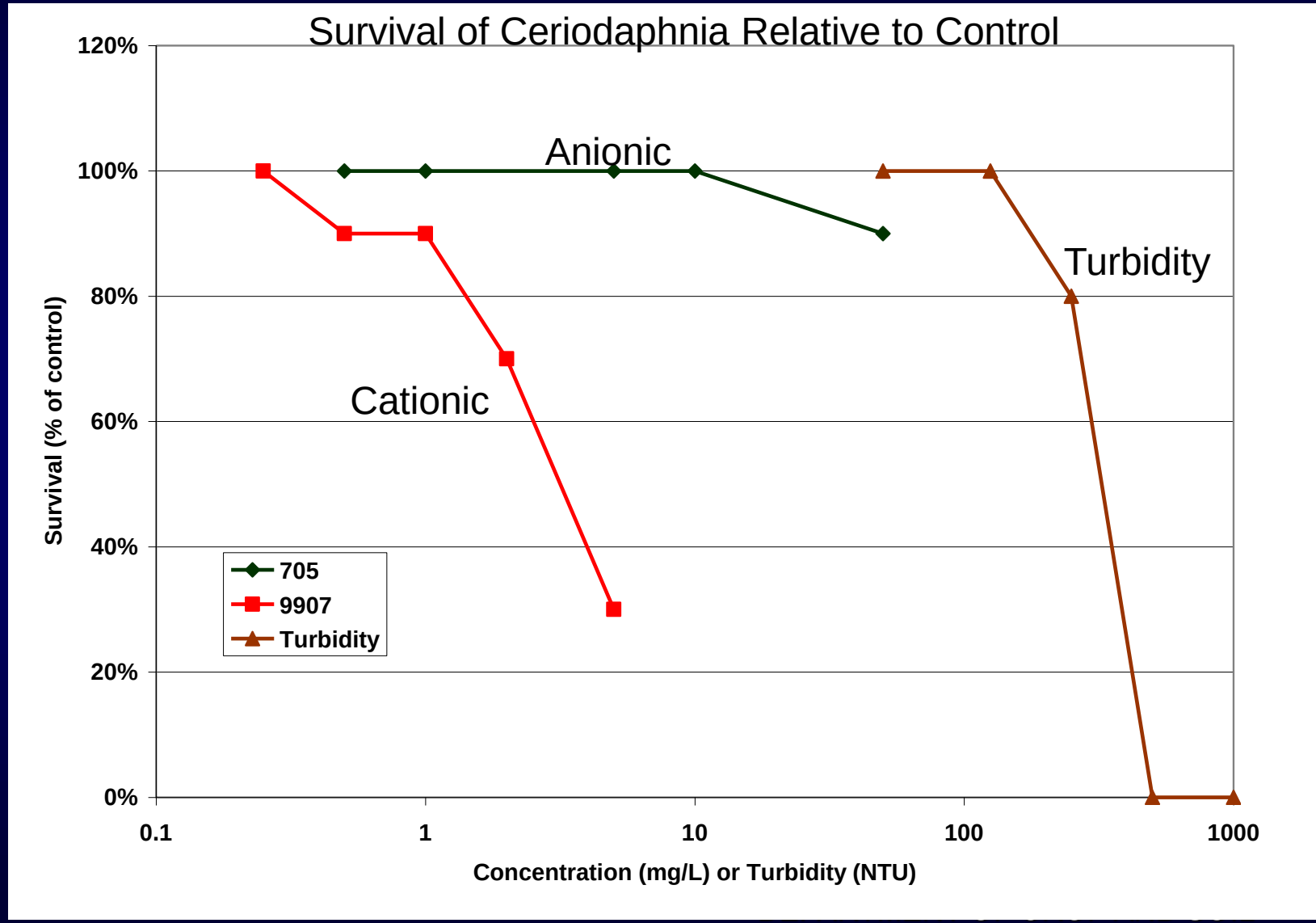
- "All things are poison and nothing is without poison, only the dose permits something not to be poisonous."
- Water can be toxic in high doses, snake venom can be medicinal in low doses.
- There is nothing inherently toxic about man-made chemicals, or non-toxic about natural chemicals

Aquatic toxicity screening: Daphnia/Ceriodaphnia



Mortality Effects (Acute Toxicity)

- Cationic toxic >1 mg/L
- Anionic not toxic up to 80 mg/L
- Turbidity toxic >250 NTU



Polyacyrlamide Aquatic Toxicity

- Wide range of values
- Generally below treatment levels
- Physical effect of viscosity
- May floc out food

Authors	Year	Product	Daphnia LC_{50} (mg/L)	
Beisenger et al.	1976	DOW AP-30	345	
Beim and Beim	1994	Anionic Magnafloc EC-10	14	(emulsion)
Acharya et al.	2010	LA-PAM	150	
Weston et al.	2009	Soilloc 100D polyacrylamide25	29 >100	- >100 for four other aquatic organisms - Oil formulations

NCSU Tests: Acute Toxicity to Mussels


museum.state.Il
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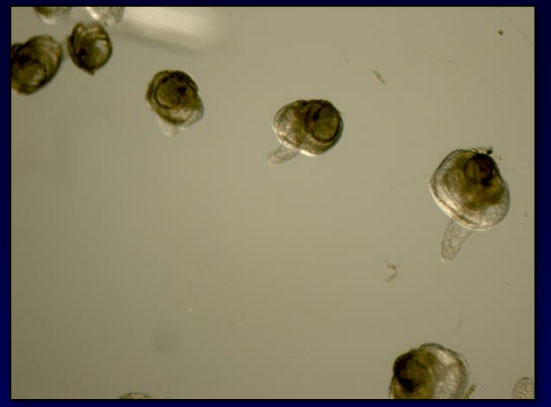
- **LC50s for freshwater species**

  Mussels (24 h– 96h LC50): 127 to >1000 mg/L



Charge Density/ Molecular Weight	Compound	Appalachian Elktoe Glochidia	Appalachian Elktoe Juvenile	Yellow Lampmussel Glochidia	Yellow Lampmussel Juvenile	Washboard Glochidia	Washboard Juvenile
Low/Very High	FLOPAM™ AN 913 VHM	>1000	>1000	>1000	>1000	>1000	>1000
Nonionic/ Moderate	FLOPAM™ FA 920	>1000	>1000	>1000	>1000	>1000	>1000
Medium/ Moderate	FLOPAM™ AN 923	>1000	330	844	127	>1000	705
Medium/High	FLOPAM™ AN 923 SH	>1000	>1000	>1000	563	>1000	>1000
Medium/Very High	FLOPAM™ AN 923VHM	>1000	>1000	>1000	>1000	>1000	>1000
Mixed	APS705	>1000	>1000	>1000	>1000	>1000	>1000

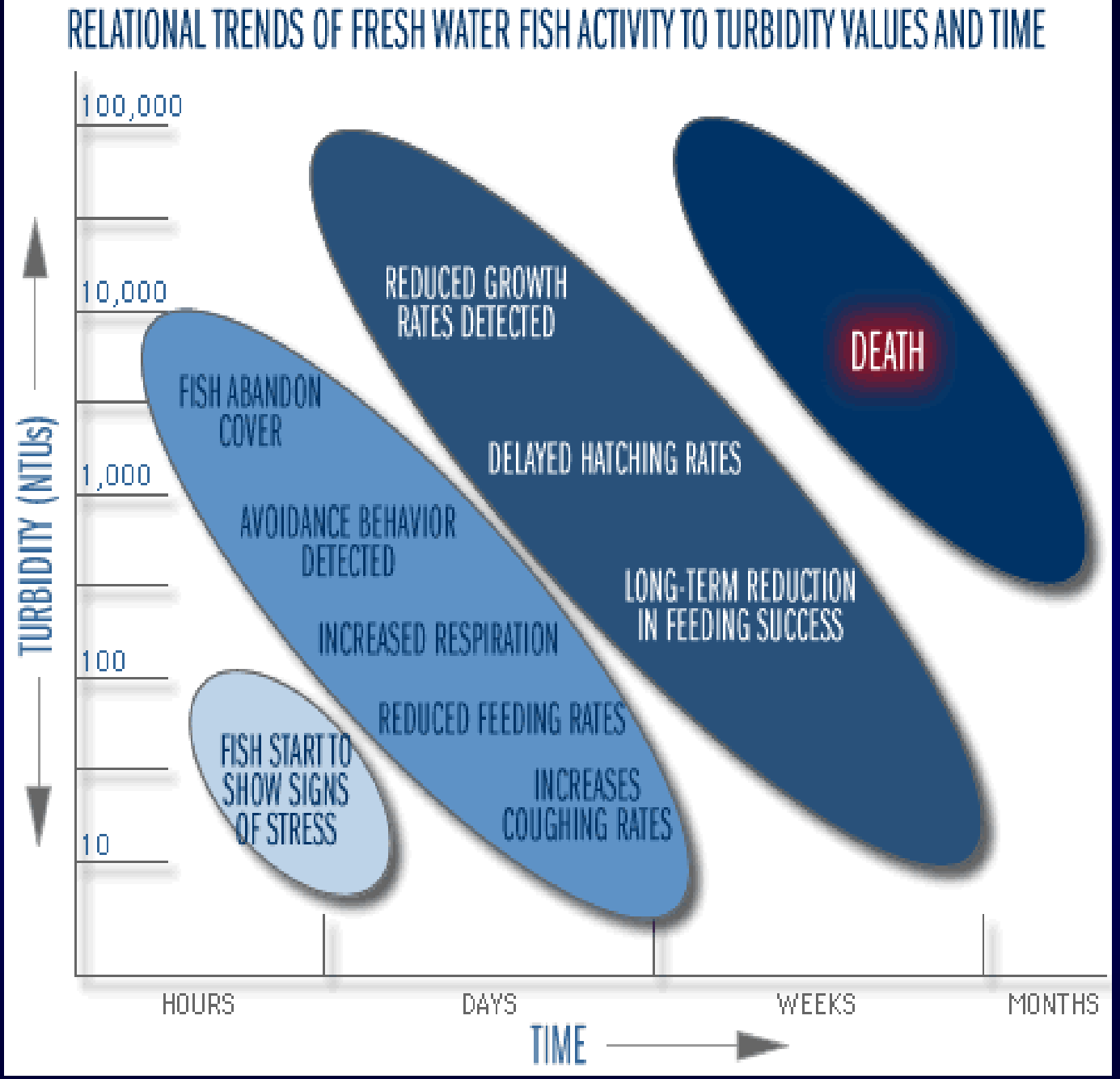
What About Acrylamide?

- Drinking water grade PAM contains <0.05% free acrylamide
- Acrylamide neurotoxicity: RfD 0.0002 mg/kg/day, or 0.014 mg/day for 70 kg person.
- Water treated at 1 mg/L has 0.0005 mg acrylamide.
- Need to drink 28 L/day…to reach the No Effect level.
- Fish LC_{50} values >100 mg/L
- PAM unlikely to release much acrylamide

Acrylamide in the Environment

- Quickly degraded in soil (half life of 1-2 days)
- Degrades in water in 2-12 days (quicker if previously exposed).
- Non-toxic at doses expected with PAM treatment (ppb).

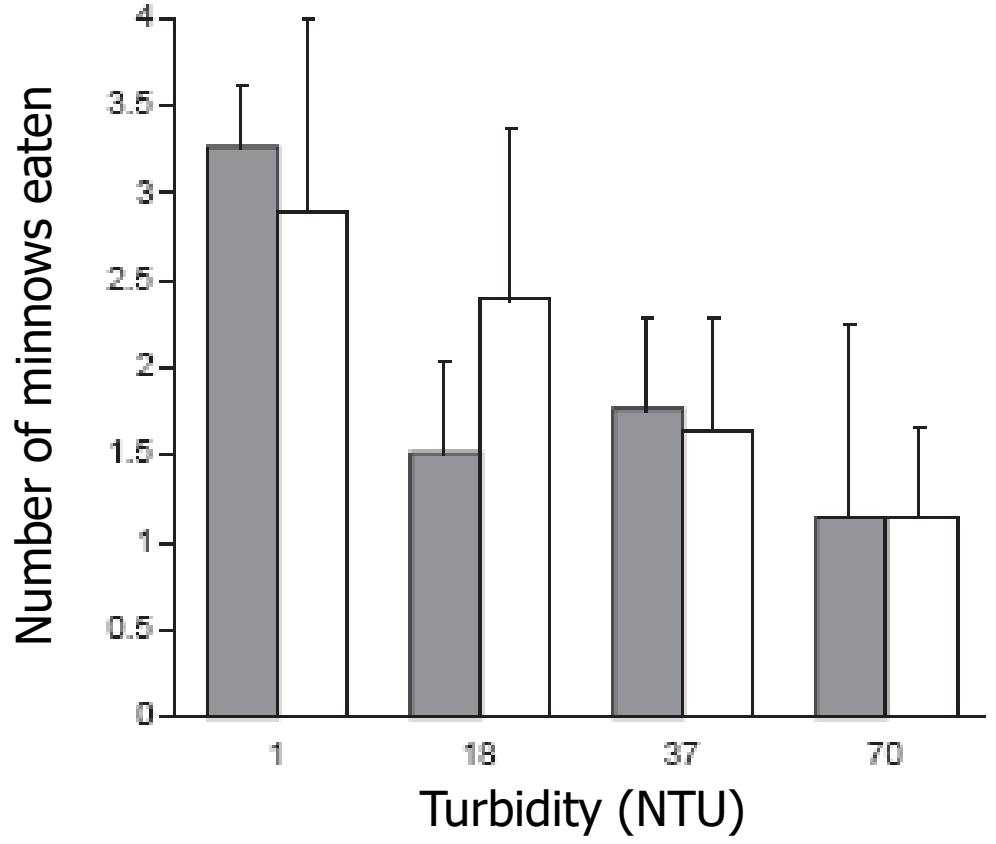
Is Turbidity Toxic? Yes!



From University of Wisconsin Extension Turbidity Fact Sheet

Turbidity Effect on Bass Feeding

Fig. 1. Comparison of the mean number of fathead minnows eaten by Cootes Paradise (shaded bars) and Rice Lake (open bars) juvenile largemouth bass during 1-h feeding trials across four levels of turbidity. Vertical bars represent ±1 SE.



Reid et al., 1999

Conclusions

- Toxicity: exposure x concentration = dose.
- Turbidity and suspended solids are toxic to aquatic organisms.
- Flocculants are not toxic at doses needed to treat turbidity (1-5 ppm).
- Treating runoff with flocculants probably reduces its toxicity (by removing sediment).

Cast of Many to Get These Projects Done!

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