Turbidity Control in Pumped Water Systems

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Typical Chemical Treatment System (CTS) Situations

- **Sediment Retention Pond:** sufficient size or actual performance inadequate.
- **Soils Type:** clay content may cause high turbidity in runoff.
- **Sediment Generation Potential of Earthworks Area:** long or steep slopes
- **Use of the Earthworks Site & Construction Schedule:** haul roads, large active areas, and/or work during the rainy season.
- **Construction Dewatering:** pumped water from excavations or borrow pits may be highly turbid.

Chemical Selection Criteria

- **Treatment chemicals must be approved for use by the local or state Permitting Authority.**
- **Petroleum-based emulsions or carriers are prohibited.**
- **Treatment chemicals must have already passed aquatic toxicity testing protocols, and so do not need to be reevaluated.** Contact the appropriate Permitting Authority for a list of treatment chemicals that have been, or may be approved for use.
- **Prior to authorization for field use, jar tests shall be conducted** to be sure the right chemical is selected for the site.

Current Methods for Treating Pumped Construction Site Water

- Pumped into stilling basin consisting of rock baffle and rock outlet

Current Methods for Treating Pumped Construction Site Water

- Pumped into a sediment bag made of geotextile fabric

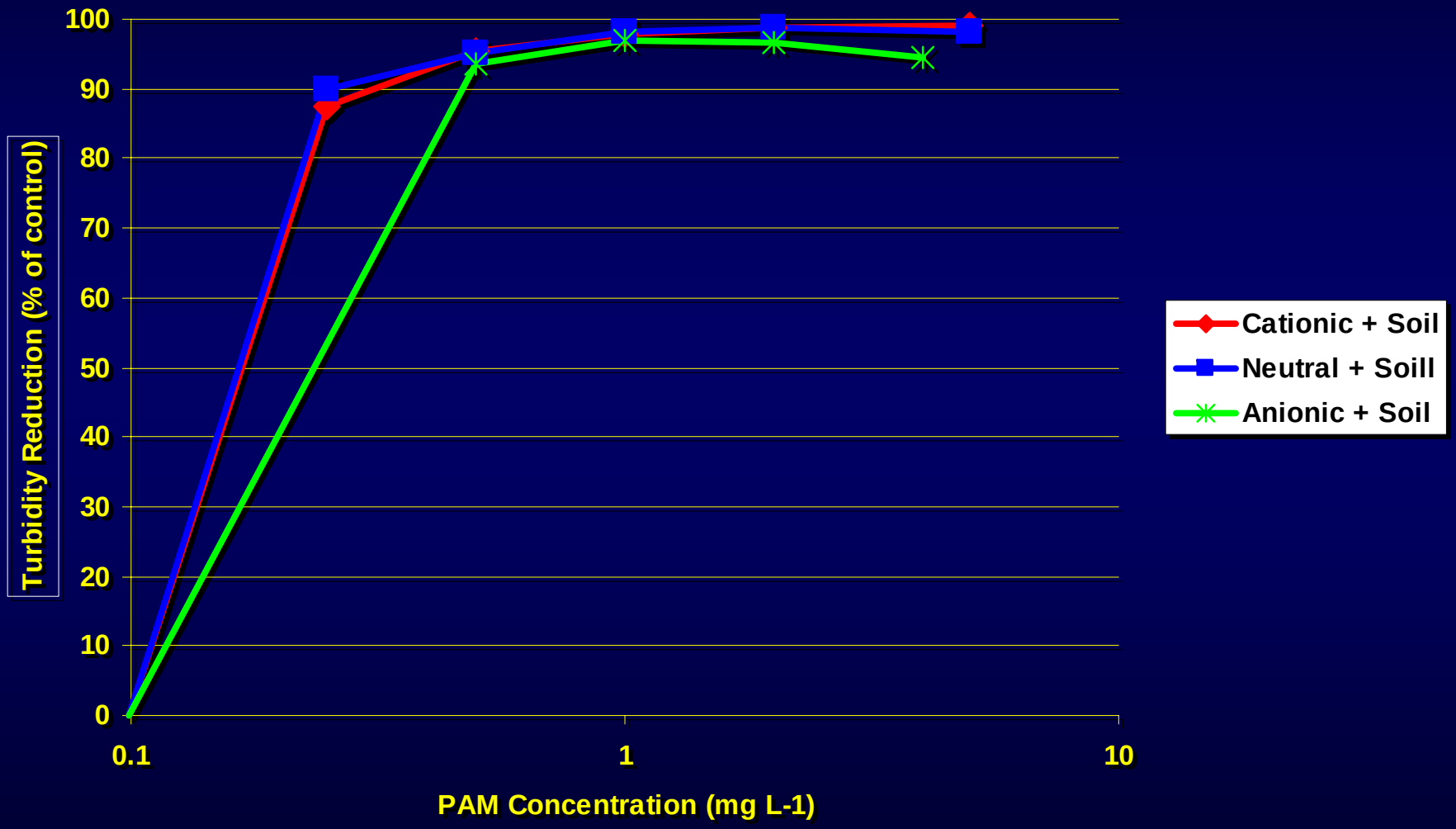
Example Problem Site

Plymouth Soil Properties

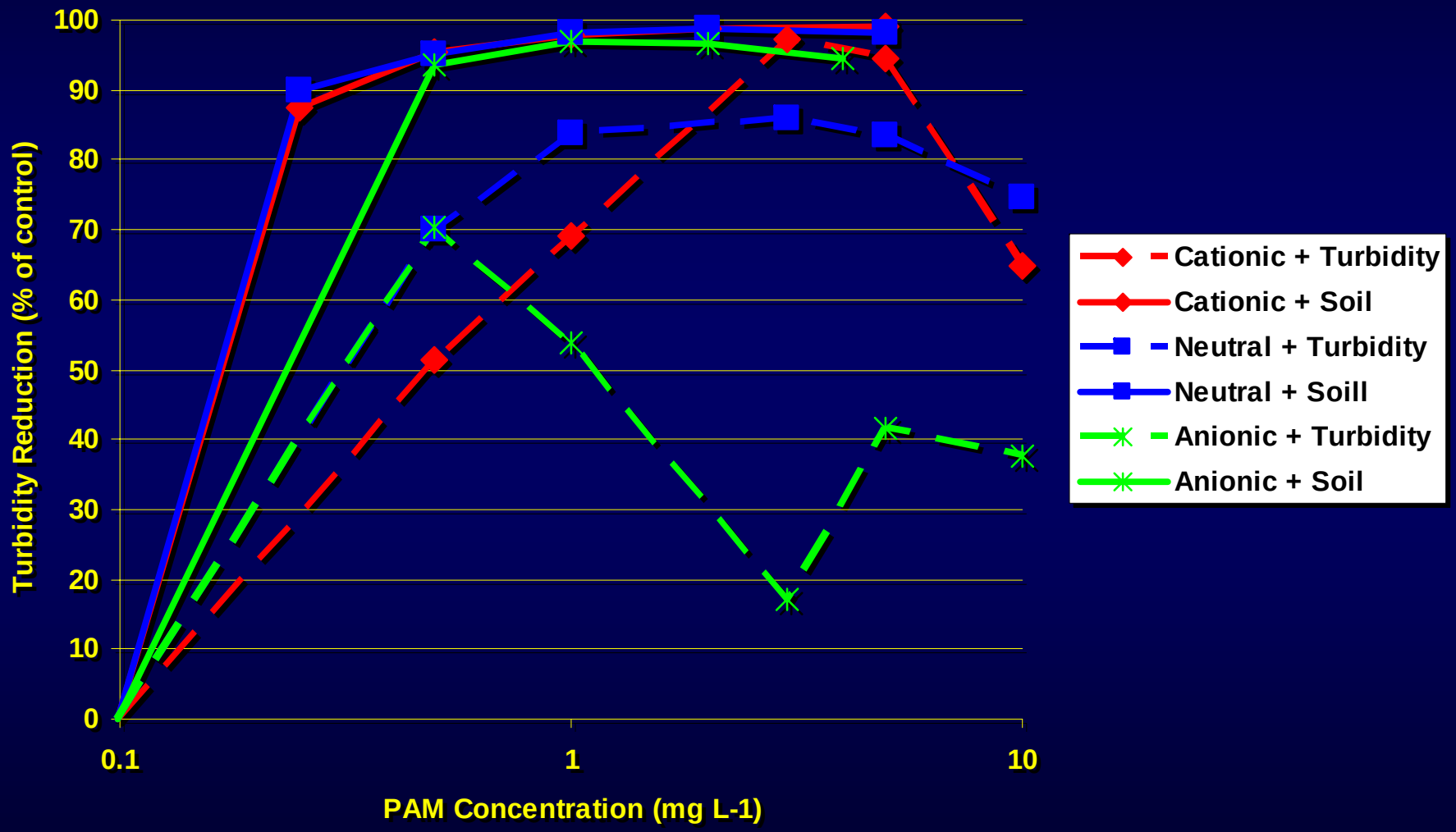
Sand %	Silt %	Clay %	Kaolinite %	Vermiculite %	Smectite %	pH	CEC (fine clay)	CEC (coarse clay)
74	10	16	55	25	20	4.7	23	17

CEC is a good indicator of clay type, and possibly turbidity problems

Turbidity Reduction: Whole Soil

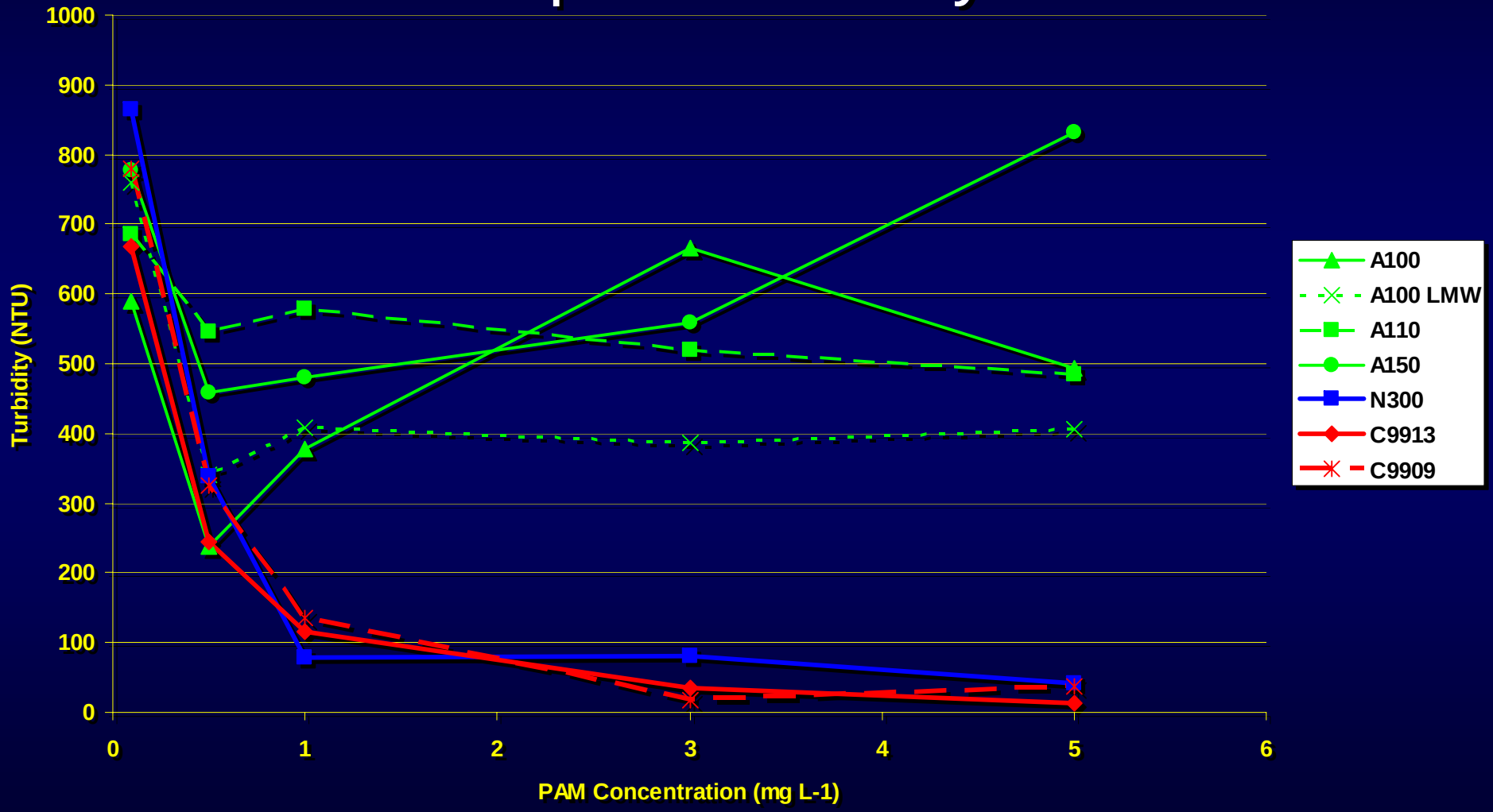


Turbidity Reduction: Supernatant

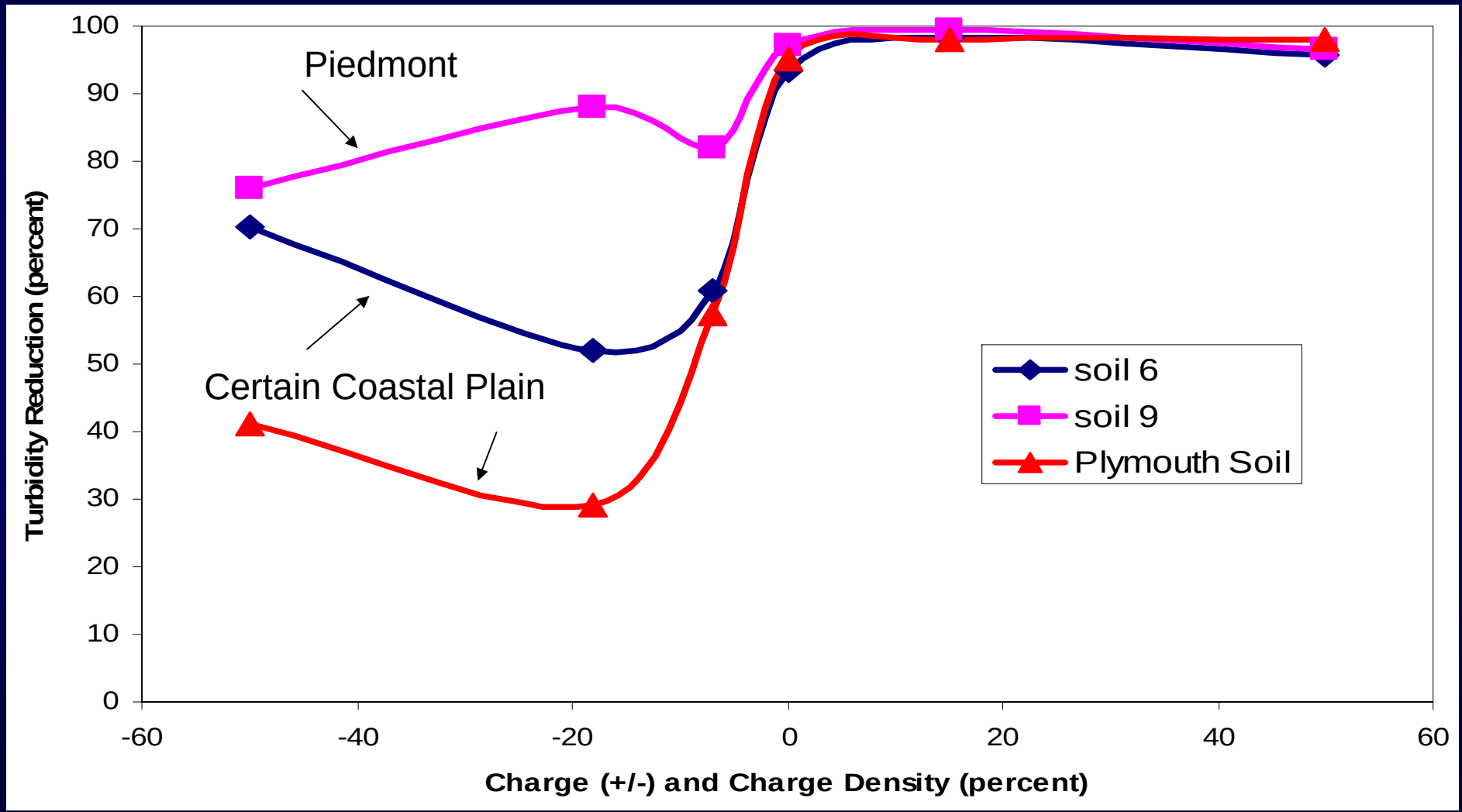


Screening of PAMs

Supernatant Only



PAM Chemistry Effect – 3 Soils

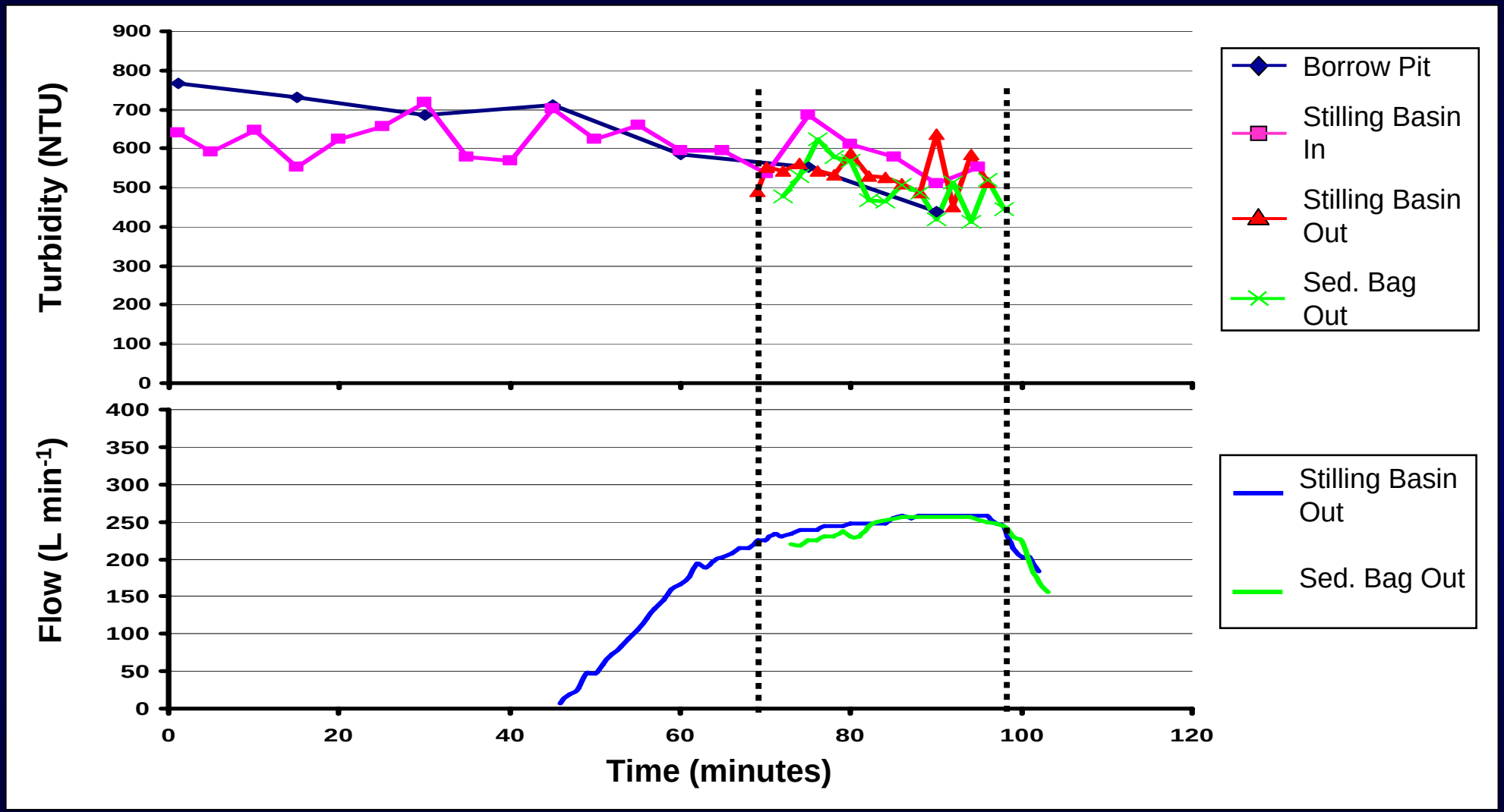


Field Testing: Generate Turbid Water

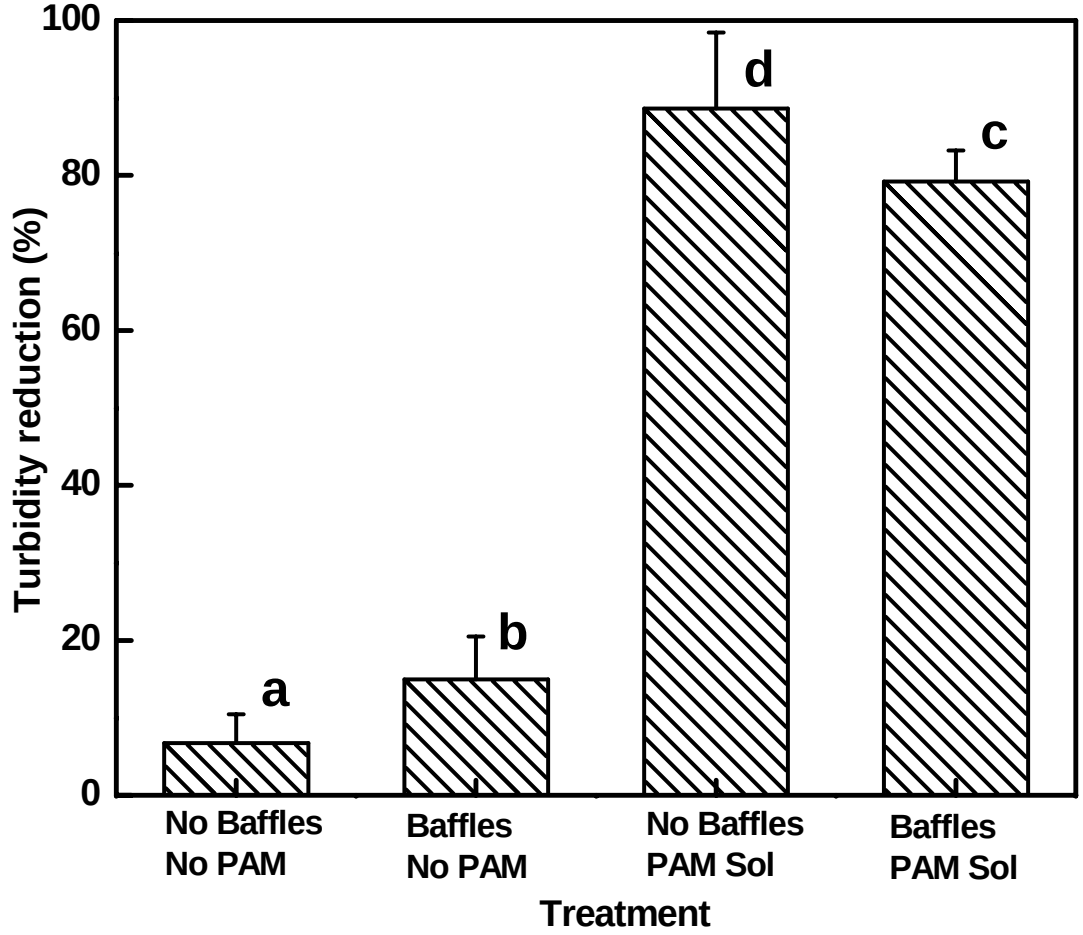
Pump to Stilling Basin

Basin Design Treatments in Stilling Basin

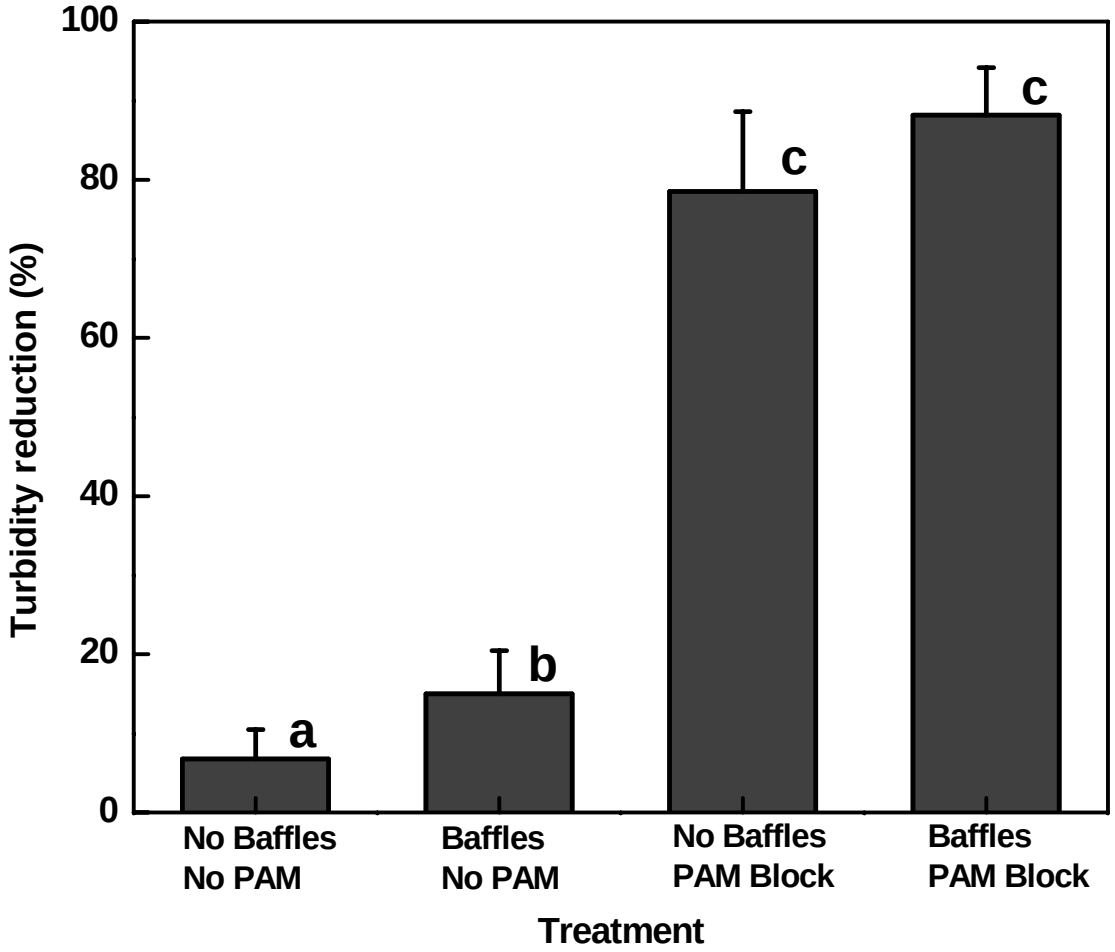
No PAM


Turbidity (NTU)
900
800
700
600
500
400
300
200
100
0
Borrow Pit
Stilling Basin In
Stilling Basin Out
Sed. Bag Out
Flow (L min-1)
400
350
300
250
200
150
100
50
0
Stilling Basin Out
Sed. Bag Out
0
20
40
60
80
100
120
Time (minutes)

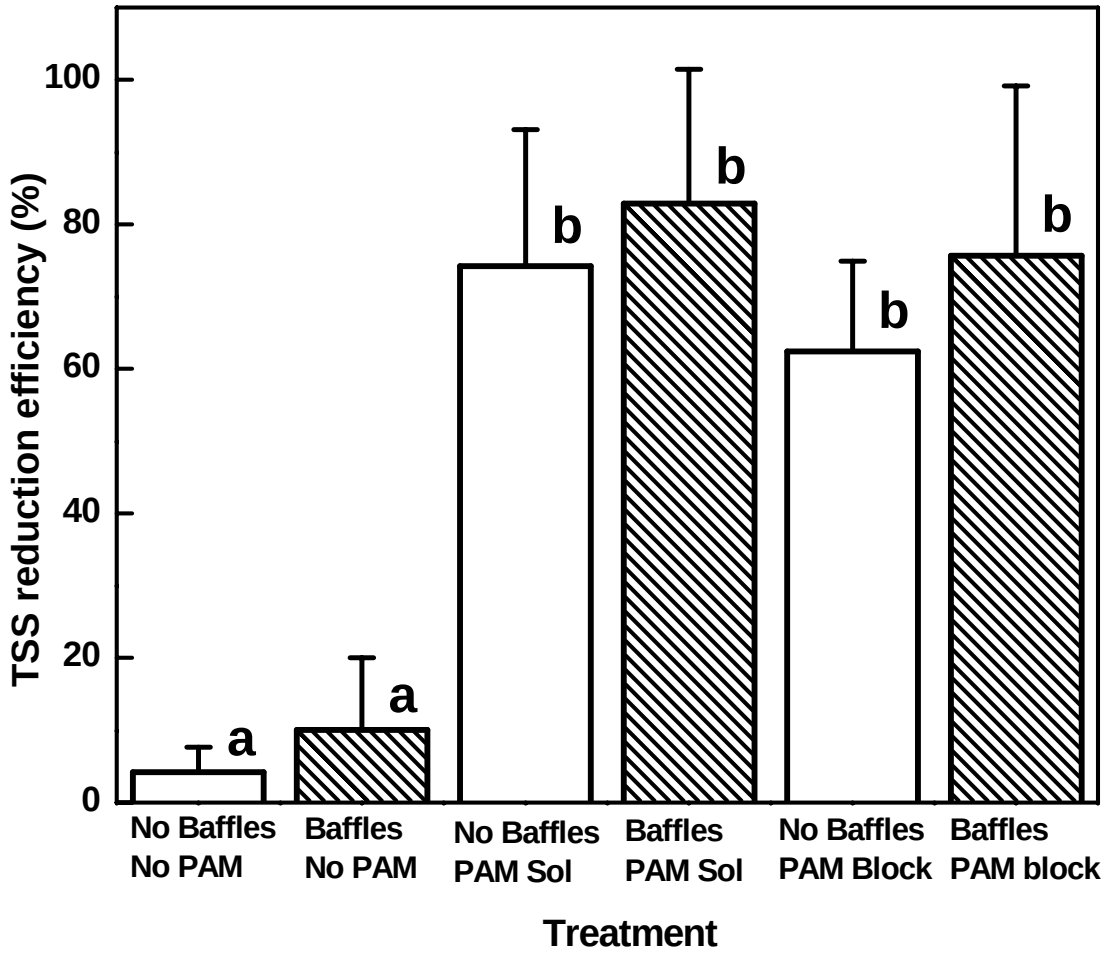
PAM Solution Treatment



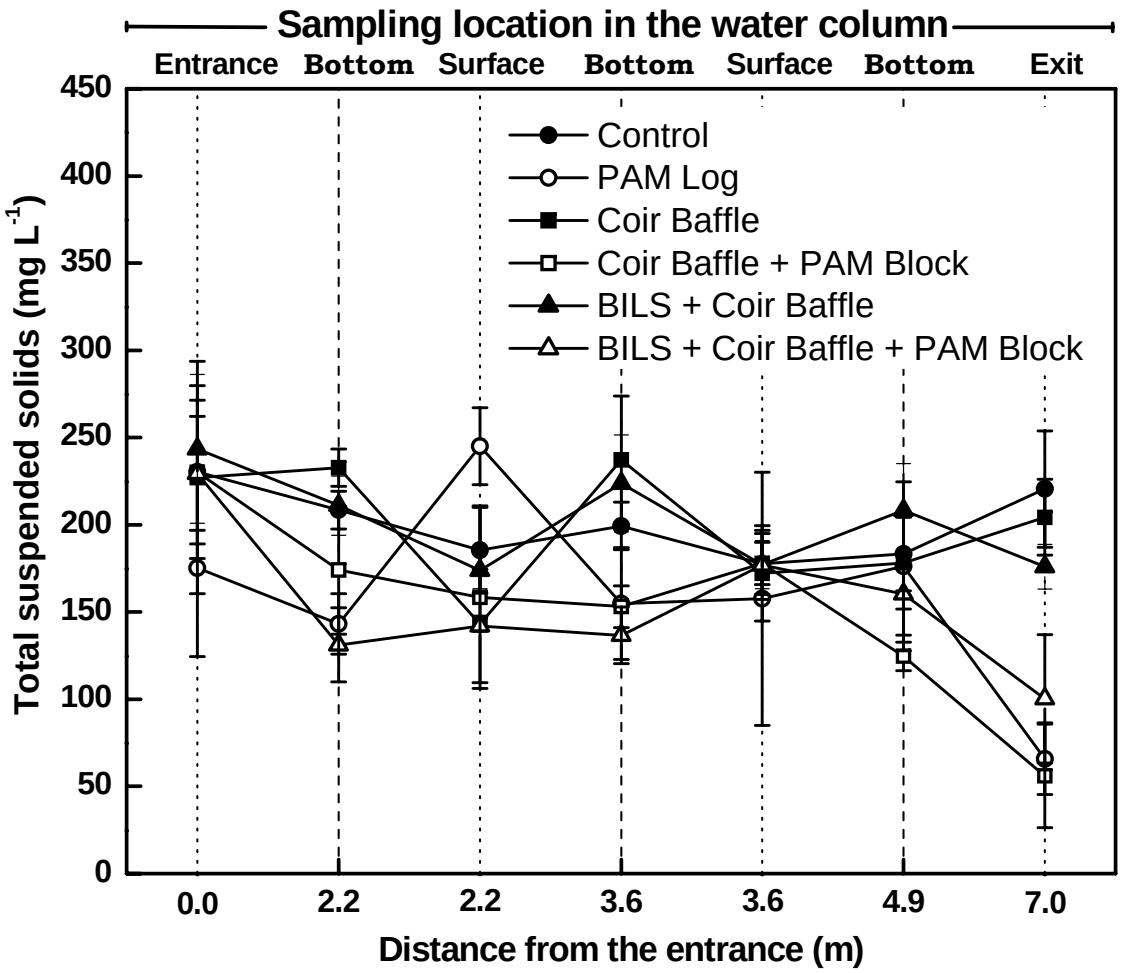
PAM Block Treatment



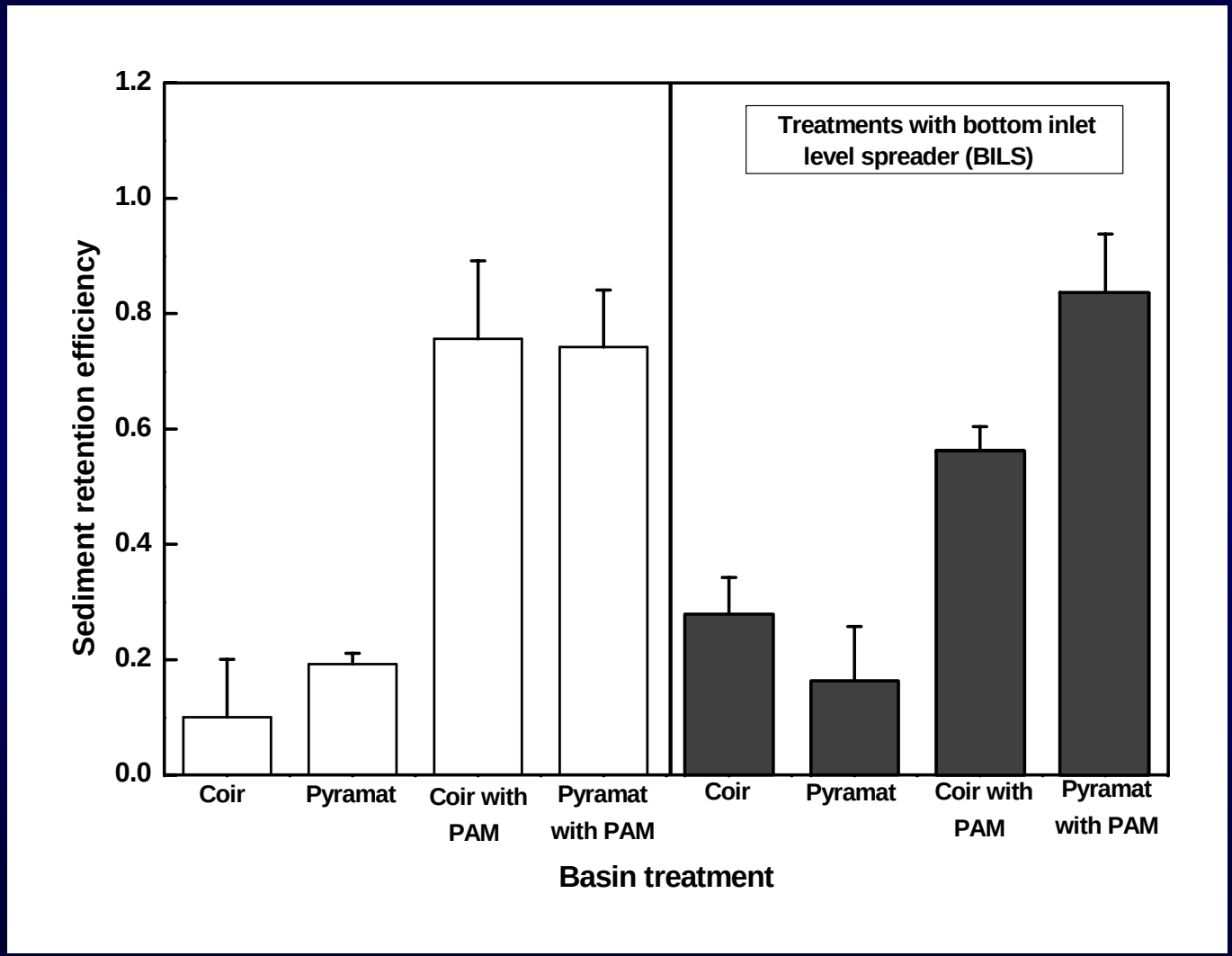
Both Dosing Methods



Sampling Points Through Basin



Baffle and Bottom Inlet Effects



Sediment Capture Rate

Treatment	Coir Baffle	Pyramat Baffle
Open space fraction (OSF)	0.45 (± 0.03)	0.1 (± 0.02)
	Sediment fraction captured by baffles†	
Without PAM	0.07 (± 0.02)	0.02 (± 0.00)
With PAM	0.40 (± 0.05)	0.22 (± 0.06)
	Sediment fraction trapped in the basin† ‡	
Without PAM	0.10 (± 0.10)	0.19 (± 0.01)
With PAM	0.75 (± 0.33)	0.74 (± 0.09)


West Coast Systems
Chitosan Enhanced Sand Filtration
with Batch Treatment
2nd Tank
Instrument box
2nd Pump
Batch Tank
1st Tank
Sand Filter

Example Batch System Setup

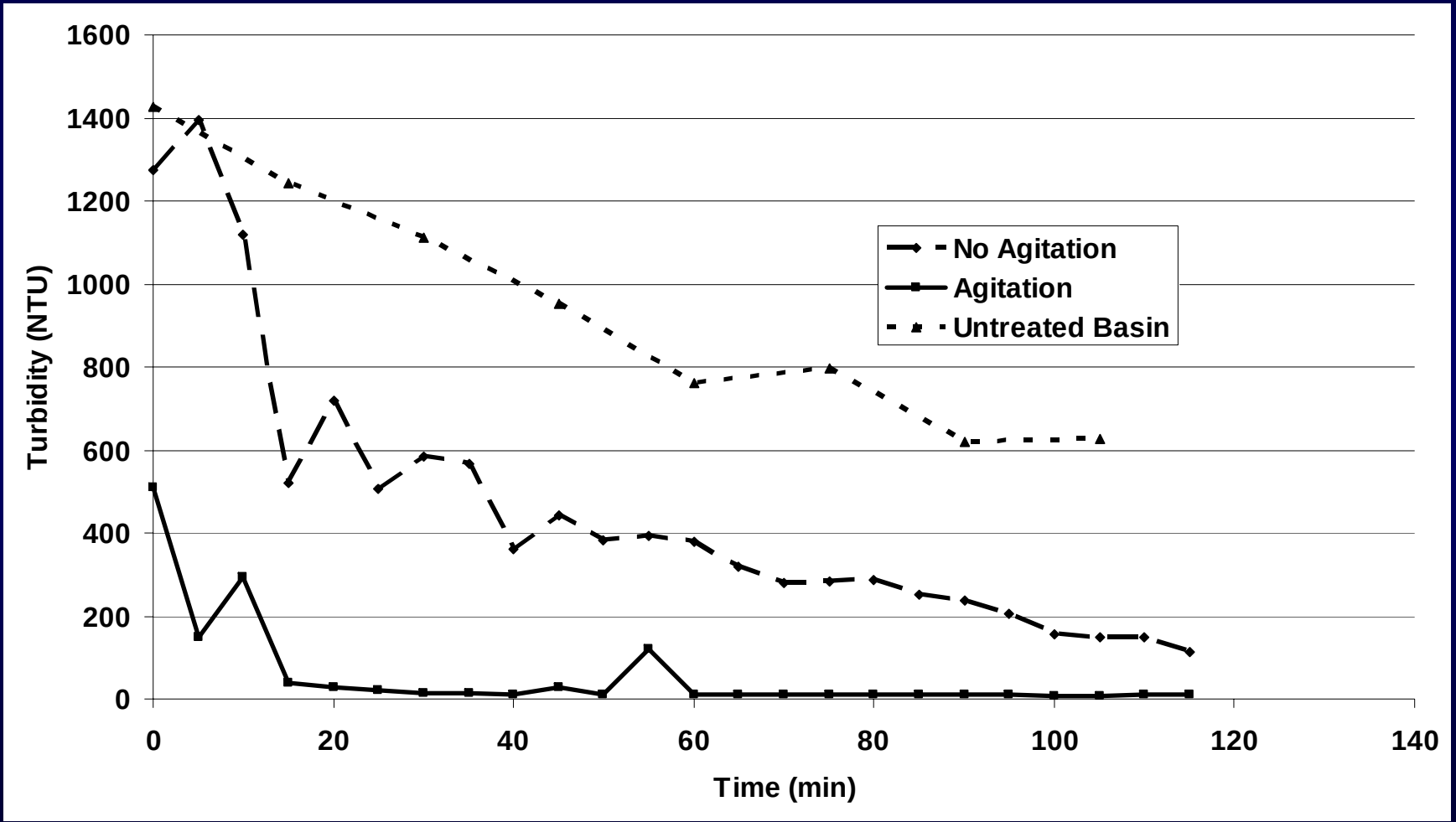
Example Control Trailer

Example CTS Controller System

Influent & Effluent Monitoring

Automatic Recirculation
Of Noncompliant Discharge

Surface PAM Solution Application



Conclusions & Recommendations

- Both PAM dosing systems (liquid at intake, log at pump hose outlet) worked well in reducing turbidity and TSS significantly.
- When dealing with fine, suspended sediment, the use of porous baffles alone will not affect turbidity. However, one baffle is recommended when PAM is used to catch floating flocs.
- Increasing retention time from 1.5 h to 24 h did not improve turbidity reduction.
- When PAM is used, there is no evidence of turbidity or TSS removal beyond the first baffle, except just before the outlet, possibly through interception with the dam.
- The latter two findings suggest that much smaller stilling basins can be installed when PAM is used. A progressively shallow bottom might enhance floc interception and removal.

PAM Dosing Options

- Pumping into pipe/channel with PAM installed.
- Injecting PAM solution into pumped water.

Post-Treament Options

- Stilling basin
- Geotextile bag
- Filtration (sand, membrane)

Treatment Costs

- 1 lb PAM treats 100,000 gallons = $7
- All other costs are highly variable: how much pumping is needed, how often, etc.

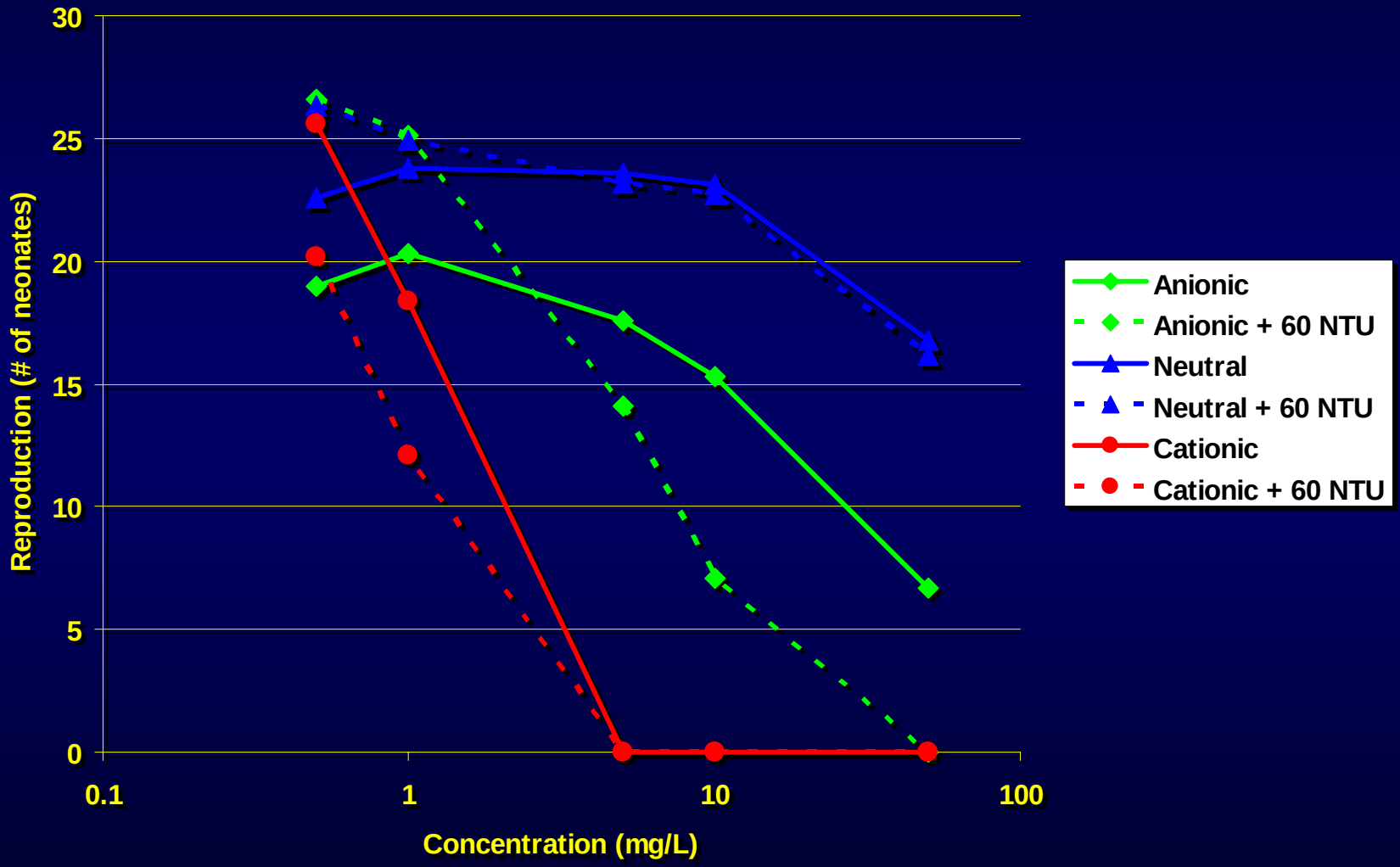
PAM Toxicity?

- PAM is known to be relatively non-toxic as measured by acute (LD_{50}) tests.
- Chronic tests on fish also show low toxicity.
- Chronic tests on smaller species not widely done.

Ceriodaphnia dubia Tests

- Conducted by DENR-DWQ-Aquatic Toxicology Unit.
- Used PAM solutions replaced daily.
- Measured mortality and reproduction rates after 7 days.
- Determined acceptable discharge concentrations.

Ceriodaphnia Results



Recent Reproduction Tests

- Lumberton sediment effects at 125 NTU
- APS 705 effects at 5 mg/L
- Cationic Nalco 9907 effects at 1 mg/L
- Results of combinations of PAM and sediment inconclusive

North Carolina PAM List

http://h2o.enr.state.nc.us/ws/PAMS_list.htm

- **Approved for use in dosing turbid water.**
- **Requires a settling basin or sediment bag after dosing.**

- **Powders:**

		Max Dose (ppm)
– Applied Polymer Systems	APS 705	27.7
– Applied Polymer Systems	APS 712	59.3
– Applied Polymer Systems	APS 730	5.6
– Applied Polymer Systems	APS 740	5.2

- **PAM Logs**: APS 703d, 703d#3, 706b

Suspended Sediment Effects
Newcombe & McDonald, 1991

- Review of 120 Studies

Rank	Description of effect
14	>80 to 100% mortality
13	>60 to 80% mortality
12	>40 to 60% mortality, severe habitat degradation
11	>20 to 40% mortality
10	0 to 20% mortality
9	Reduction in growth rates
8	Physiological stress and histological changes
7	Moderate habitat degradation
6	Poor condition of organism
5	Impaired homing
4	Reduction in feeding rates
3	Avoidance response, abandonment of cover
2	Alarm reaction, avoidance reaction
1	Increased coughing rate

Their Results...

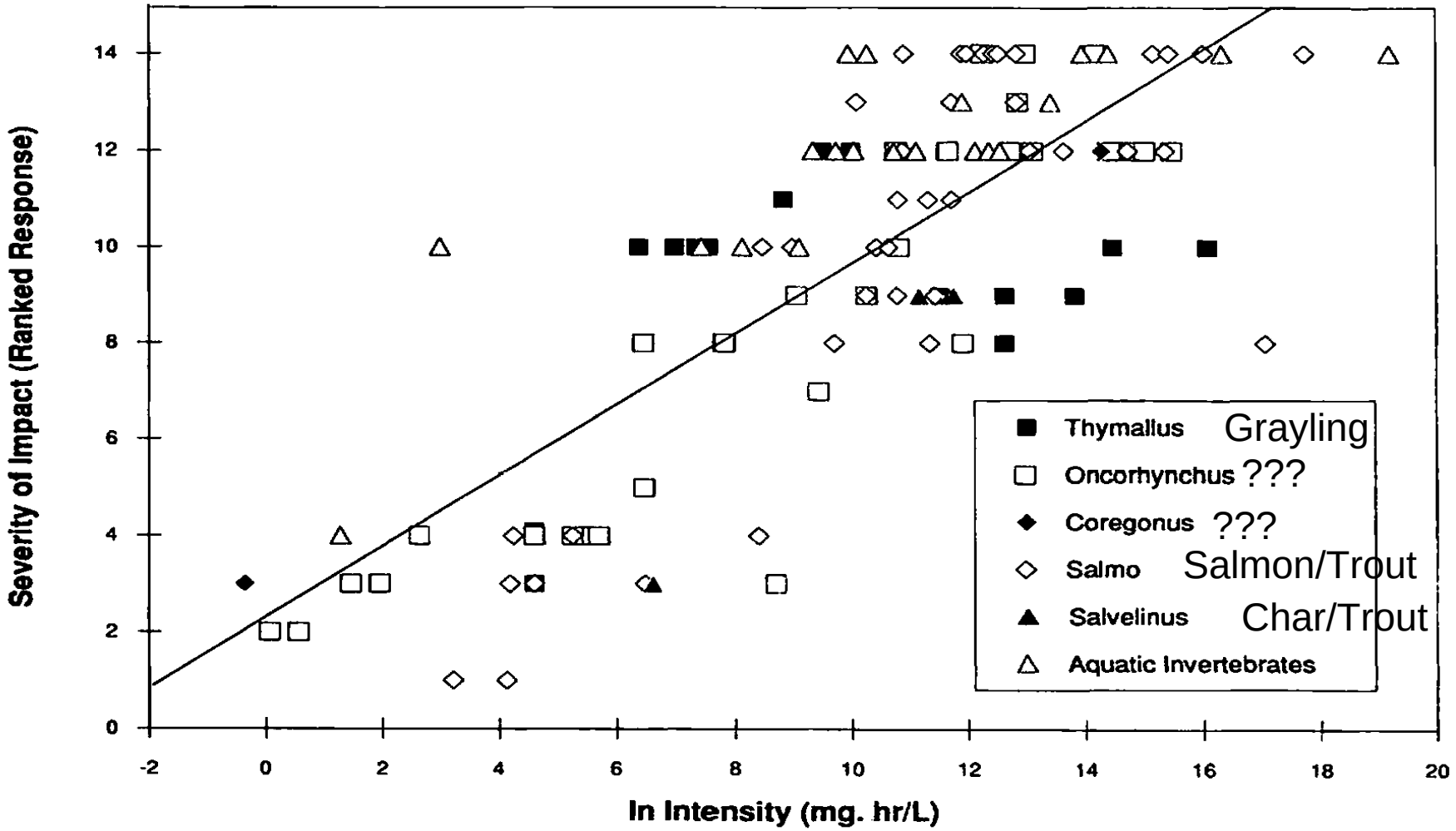
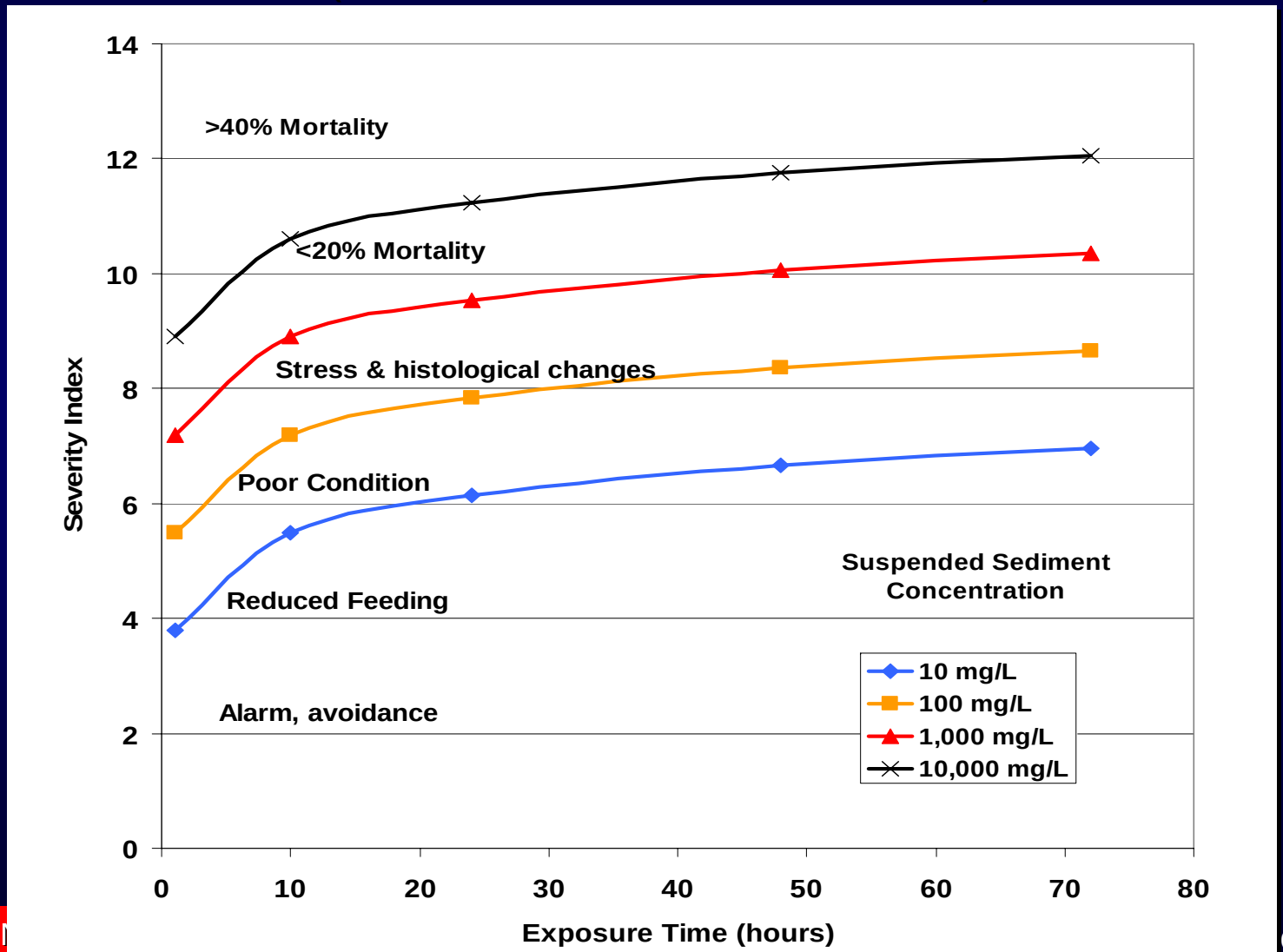


FIGURE 2.—Relationship between $\log_e$ (ln) of suspended sediment intensity and severity of effects on salmonid fishes and aquatic invertebrates. Severity of effect = 0.738 $\log_e$ intensity + 2.179; $r^2 = 0.638$, $N = 120$. Intensity is concentration (mg/L) times duration of exposure (h).

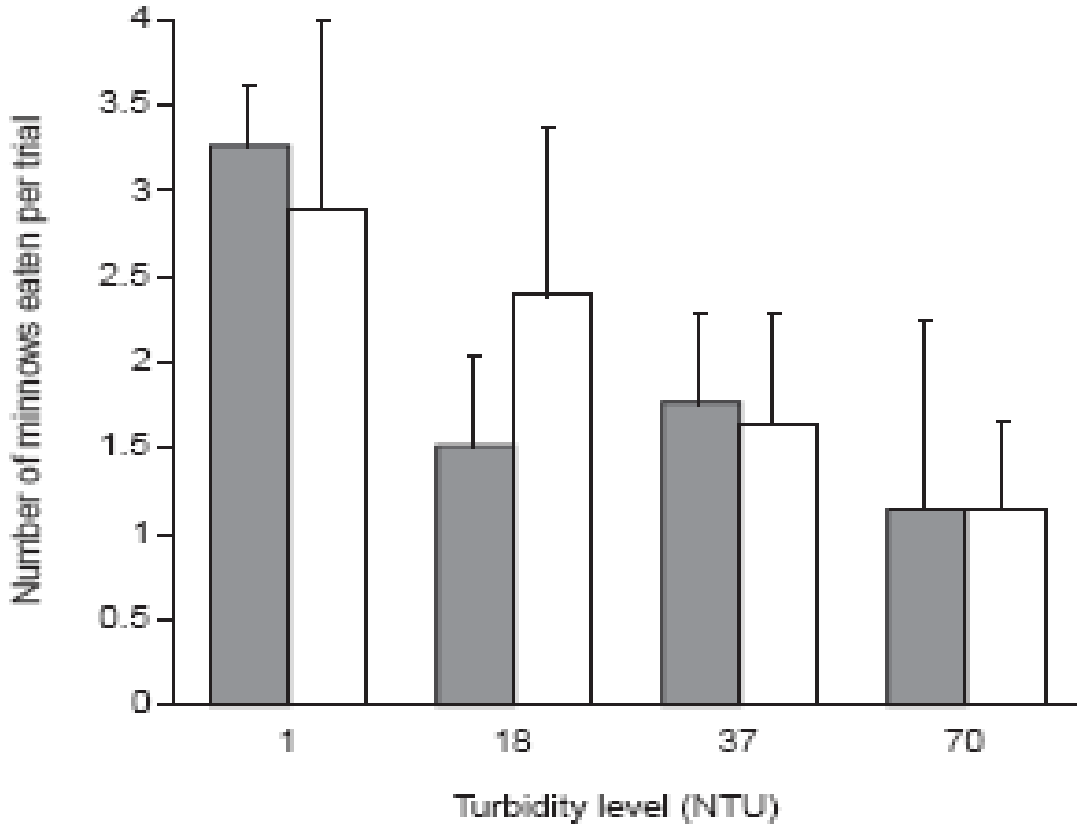
Suspended Sediment Effects on Aquatic Organisms

(from Newcombe & McDonald, 1991)



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