



pennsylvania
DEPARTMENT OF ENVIRONMENTAL PROTECTION



Office of Water Management

Stroud Study: Impact of Chloride on Mayflies

Water Resources Advisory Committee
August 12, 2015

Toxicological Study - Chloride

- Stroud conducted toxicological research to determine the impact of chloride on mayflies.
- Chloride research was very similar to ongoing work (spring & summer 2015) concerning impact of sulfate on mayflies.

Toxicological Study - Chloride

Toxicological studies include acute and chronic responses to impact of chloride on mayflies.

Acute Variable:

- 50% Mortality (LC50)

Chronic Variables: (whole-life tests)

- % Survivorship
- Development Time
- Final Body Mass
- Instantaneous Growth Rate
- Population Growth Rate

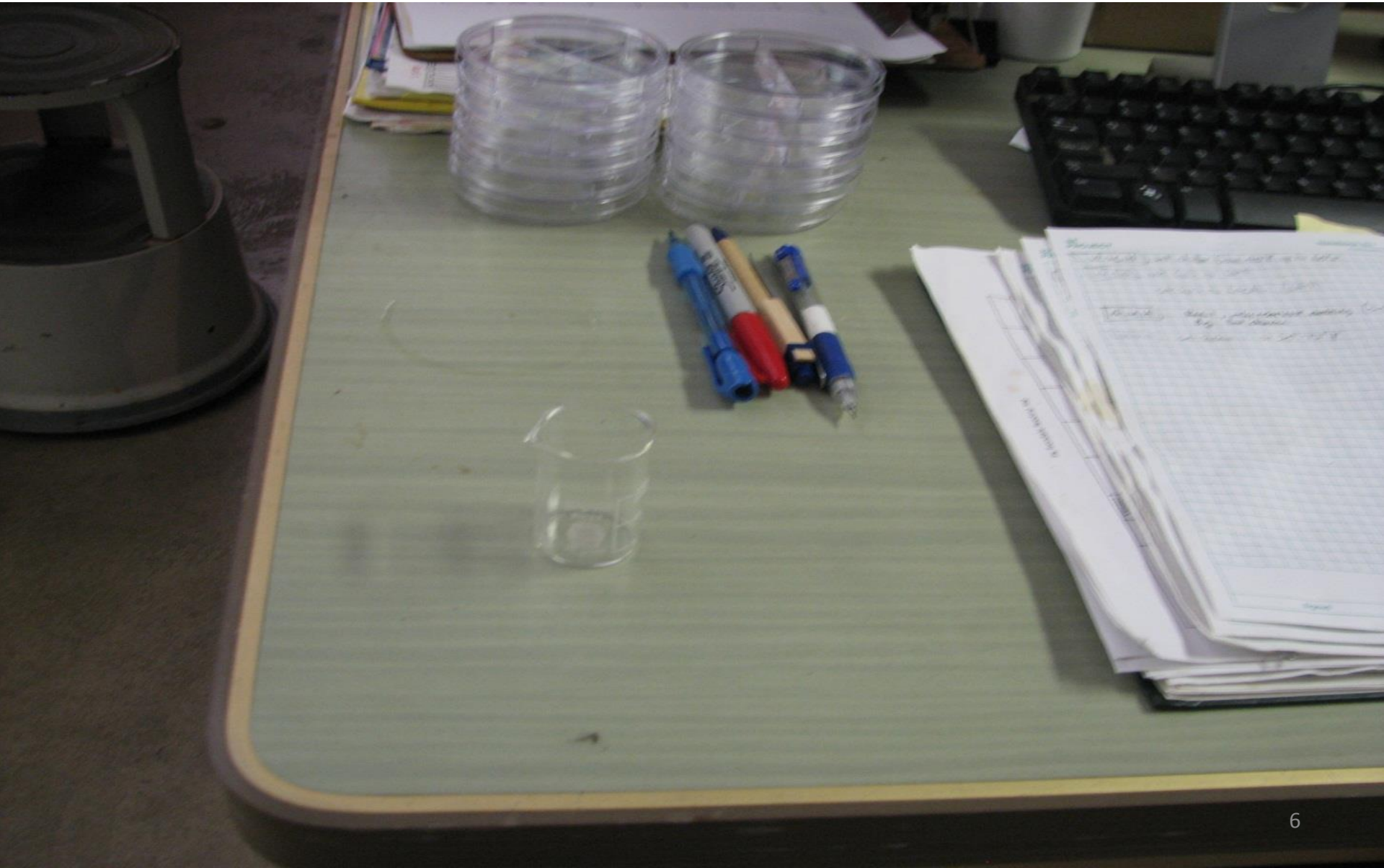
Toxicological Study - Chloride

Stream	County	Hardness
Spruce Run	Union	Low (6)
UNT to House Run	Greene	Medium (94)
Cedar Run	Clinton	High (212)
White Clay Creek	Chester	Medium (89)

Toxicological Study - Chloride

Species of Mayfly	Family	Acute	Chronic
<i>Neocloeon triangulifer</i> <i>Genus formerly known as Centroptilum</i>	Baetidae	Yes	Yes
<i>Anafroptilum semirufum</i> <i>Genus formerly known as Centroptilum</i>	Baetidae	Yes	Yes
<i>Procloeon fragile</i>	Baetidae	Yes	Yes
<i>Maccaffertium modestum</i>	Heptageniidae	Yes	Yes
<i>Ephemerella invaria</i>	Ephemerellidae	Yes	No
<i>Leptophlebia cupida</i>	Leptophelbiidae	Yes	No

Toxicological Study - Chloride



Toxicological Study - Chloride



Toxicological Study - Chloride



Toxicological Study - Chloride



Toxicological Study - Chloride

Acute (CMC) Testing: Study Design

Stream	Cl - 1	Cl - 2	Cl - 3	Cl - 4	Cl - 5	Cl - 6
Spruce	0 / 0	250 / 500	500 / 1000	1000 / 2000	2000 / 4000	4000 / 8000
House	0 / 0	250 / 500	500 / 1000	1000 / 2000	2000 / 4000	4000 / 8000
Cedar	0 / 0	250 / 500	500 / 1000	1000 / 2000	2000 / 4000	4000 / 8000
WCC	0 / 0	250 / 500	500 / 1000	1000 / 2000	2000 / 4000	4000 / 8000

- Treatment = [Cl] for Baetidae (mg/L) / [Cl] for Non-baetidae (mg/L)
- 4 replicates for each set of conditions (treatment) in the acute study

Toxicological Study - Chloride

Chronic (CCC) Testing: Study Design

Stream	Cl - 1 0 mg/L	Cl - 2 125 mg/L	Cl - 3 250 mg/L	Cl - 4 500 mg/L	Cl - 5 1000 mg/L	Cl - 6 2000 mg/L
Spruce	4 / 0	4 / 0	4 / 0	4 / 0	4 / 0	4 / 0
House	4 / 0	4 / 0	4 / 0	4 / 0	4 / 0	4 / 0
Cedar	4 / 0	4 / 0	4 / 0	4 / 0	4 / 0	4 / 0
WCC	1 / 2	1 / 2	1 / 2	1 / 2	1 / 2	1 / 2

- Treatment = # of replicates for Baetidae) / # of replicates for *M. modestum*
- WCC data for baetids was not reported because it was not replicated
- *E. invaria* and *L. cupida* were not included in the chronic tests

Toxicological Study - Chloride

Mayfly Species	Test Water	LC50 (acute)	LC20 (chronic)	LC10 (chronic)
<i>N. triangulifer</i>	Soft	704	109	94
	Moderately Hard	2141	175	140
	Hard	1420	188	140
<i>A. semirufum</i>	Soft	107	114	104
	Moderately Hard	1827	279	235
	Hard	1336	128	102
<i>P. fragile</i>	Soft	472	168	150
	Moderately Hard	2110	332	303
	Hard	1765	245	210
<i>E. invaria</i>	Soft	2016	-	-
	Moderately Hard	4500	-	-
	Hard	4762	-	-
<i>L. cupida</i>	Soft	4667	-	-
	Moderately Hard	5921	-	-
	Hard	5832	-	-
<i>M. modestum</i>	Soft	2065	-	-
	Moderately Hard	2763	138 (WCC)	133 (WCC)
	Hard	4329	-	-

Previous Work - Chloride

Chloride Criteria	Acute (mg/L)	Chronic (mg/L)
EPA (1988)	860	230
British Columbia	600	150
Canada (2011)	640	120
From Iowa (2009)		
Default (H=200; Sul = 63)	629	389
Range (H = 50 to 800; Sul = 5 to 500)	405 - 1010	250 - 624
PA Soft (Spruce)	382	236
PA Moderately Hard (House)	597	369
PA Hard (Cedar)	703	435

U.S. EPA Toxicological Dataset – Taxa List

	Species	Genus		Species	Genus		Species	Genus
1	<i>Acipenser oxyrinchus</i>	<i>Acipenser</i>	28	<i>Fundulus kansae</i>	<i>Fundulus</i>	55	<i>Planorbella campanulata</i>	<i>Planorbella</i>
2	<i>Agria sp.</i>	<i>Agria</i>	29	<i>Gambusia affinis</i>	<i>Gambusia</i>	56	<i>Poecilia reticulata</i>	<i>Poecilia</i>
3	<i>Ambystoma maculatum</i>	<i>Ambystoma</i>	30	<i>Gammarus pseudolimnaeus</i>	<i>Gammarus</i>	57	<i>Pseudacris crucifer</i>	<i>Pseudacris</i>
4	<i>Ameiurus melas</i>	<i>Ameiurus</i>	31	<i>Gasterosteus aculeatus</i>	<i>Gasterosteus</i>	58	<i>Pseudacris triseriata</i>	
5	<i>Anguilla rostrata</i>	<i>Anguilla</i>	32	<i>Gyraulus circumstriatus</i>	<i>Gyraulus</i>	59	<i>Salmo trutta</i>	<i>Salmo</i>
6	<i>Brachionus calyciflorus</i>	<i>Brachionus</i>	33	<i>Gyraulus parvus</i>		60	<i>Rana clamitans</i>	<i>Rana</i>
7	<i>Bufo americanus</i>	<i>Bufo</i>	34	<i>Isonychia bicolor</i>	<i>Isonychia</i>	61	<i>Rana sylvatica</i>	
8	<i>Caecidotea communis</i>	<i>Caecidotea</i>	35	<i>Lampsilis fasciola</i>	<i>Lampsilis</i>	62	<i>Sphaerium nitidum</i>	<i>Sphaerium</i>
9	<i>Cambarus sp.</i>	<i>Cambarus</i>	36	<i>Lampsilis siliquoidea</i>		63	<i>Sphaerium simile</i>	
10	<i>Carassius auratus</i>	<i>Carassius</i>	37	<i>Lasmigona complanata</i>	<i>Lasmigona</i>	64	<i>Tubifex tubifex</i>	<i>Tubifex</i>
11	<i>Centroptilum triangulifer</i>	<i>Centroptilum</i>	38	<i>Lepidostoma sp.</i>	<i>Lepidostoma</i>	65	<i>Villosa constricta</i>	<i>Villosa</i>
12	<i>Ceriodaphnia dubia</i>	<i>Ceriodaphnia</i>	39	<i>Lepomis cyanellus</i>	<i>Lepomis</i>	66	<i>Villosa delumbis</i>	
13	<i>Chironomus attenuatus</i>	<i>Chironomus</i>	40	<i>Lepomis macrochirus</i>		67	<i>Villosa iris</i>	
14	<i>Chironomus dilutus</i>		41	<i>Libellulidae</i>	<i>Libellulidae</i>			
15	<i>Crangonyx sp.</i>	<i>Crangonyx</i>	42	<i>Limnodrilus hoffmeisteri</i>	<i>Limnodrilus</i>			
16	<i>Cyprinella leedsii</i>	<i>Cyprinella</i>	43	<i>Lirceus fontinalis</i>	<i>Lirceus</i>			
17	<i>Cyprinella lutrensis</i>		44	<i>Lithobates catesbeianus</i>	<i>Lithobates</i>			
18	<i>Daphnia ambigua</i>	<i>Daphnia</i>	45	<i>Lumbriculus variegatus</i>	<i>Lumbriculus</i>			
19	<i>Daphnia magna</i>		46	<i>Margaritifera falcata</i>	<i>Margaritifera</i>			
20	<i>Daphnia pulex</i>		47	<i>Megalonaisas nervosa</i>	<i>Megalonaisas</i>			
21	<i>Diaptomus clavipes</i>	<i>Diaptomus</i>	48	<i>Musculium transversum</i>	<i>Musculium</i>			
22	<i>Elliptio complanata</i>	<i>Elliptio</i>	49	<i>Nemoura trispinosa</i>	<i>Nemoura</i>			
23	<i>Elliptio lanceolata</i>		50	<i>Nephelopsis obscura</i>	<i>Nephelopsis</i>			
24	<i>Epioblasma brevidens</i>	<i>Epioblasma</i>	51	<i>Oncorhynchus mykiss</i>	<i>Oncorhynchus</i>			
25	<i>Epioblasma capsaeformis</i>		52	<i>Physa gyrina</i>	<i>Physa</i>			
26	<i>E. torulosa rangiana</i>		53	<i>Physa heterostropha</i>				
27	<i>Erpobdella punctata</i>	<i>Erpobdella</i>	54	<i>Pimephales promelas</i>	<i>Pimephales</i>			

Note:

Centroptilum triangulifer (#11)
now known as
Neocloeon triangulifer



Questions?

Rodney Kime

Bureau of Point & Non-Point Source Management

rkime@pa.gov

(717) 787-9637