CENPS-OP-DMMO

MEMORANDUM FOR RECORD 3 June 1991

SUBJECT: DECISION ON THE SUITABILITY OF DREDGED MATERIAL TESTED UNDER PSDDA GUIDELINES FOR BELLINGHAM MAINTENANCE DREDGING IN WHATCOM CREEK WATERWAY, SQUALICUM CREEK WATERWAY, AND I & J STREET WATERWAY TO BE DISPOSED OF AT THE BELLINGHAM BAY NONDISPERSIVE OPEN WATER DISPOSAL SITE AND ROSARIO STRAITS DISPERSIVE SITE.

1. The following summary reflects the PSDDA agencies'(Corps, Departments of Ecology and Natural Resources, and the Environmental Protection Agency) consensus decision on the acceptability of the sampling conducted between 13-17 November 1990 (Whatcom Waterway, Squalicum Waterway, I & J Street Waterway), 5 December (I & J Street Waterway), and 12-13 February 1991 (resampling of Squalicum Waterway and I & J Street Waterway) and subsequent analyses, discussed in Science Application International Corporation's (SAIC) report dated March 1991, to make a determination of suitability on the 299,125 cubic yards of dredged material proposed for maintenance dredging from the Bellingham Harbor navigation channels and adjacent berthing areas for disposal at the Bellingham Bay nondispersive PSDDA disposal site. A total of 12,000 cubic yards of material was characterized from Port of Bellingham berthing areas in Whatcom Waterway, 194,214 cubic yards of material was characterized from within the federal navigation channel and adjacent berthing areas in Squalicum Creek Waterway, and 92,911 cubic yards of material was characterized from the federal navigation channel and adjacent berthing areas in the I & J Street Waterway.

2. The PSDDA approved sampling and analysis protocols were followed, and quality assurance/quality control guidelines specified by PSDDA were generally complied with. Field sampling was initially sequenced into two separate efforts (i.e., round 1 and 2) to facilitate chemical analyses. Quality assurance failures of reference area samples and test samples during round 1 bioassay testing necessitated resampling some of the round 1 samples for a bioassay retest (i.e., round 3) for two of the bioassays (amphipod and sediment larval). Lastly, a fourth sampling effort was conducted to sample a berthing area in the I & J Creek Waterway not previously characterized and to resample two areas in the navigation channel requiring bioassay analyses before a suitability decision could be made. After reviewing all the data gathered for these characterizations the PSDDA agencies concluded that the data were sufficient and acceptable for regulatory decision-making under the PSDDA program.

3. A total of 33 (uncomposited/composited) analyses were conducted to characterize the material from the three waterways. Three uncomposited surface samples were analyzed from Whatcom Waterway, nine composited surface samples and three composited subsurface samples were analyzed from Squalicum Waterway, and fourteen uncomposited surface samples, one composited surface sample and three composited subsurface samples were analyzed from I & J Street Waterway. The distribution of samples (either uncomposited or composited samples) are shown in enclosures 1-3 (note that all samples with S prefix are single (uncomposited) samples and C prefix are composited samples) for each waterway. Round 1 chemistry analyses results are depicted in enclosure 4, showing all detected exceedances of PSDDA screening level (SL) guidelines. Round 2 chemical analysis exceedances of SL are depicted in enclosure 5, whereas

round 4 chemical analysis results for C18 are depicted in enclosure 6. Of the thirty-three management units tested, four (two from Squalicum: C3, C7; two from I & J: S13, C15) had no exceedances of chemistry guidelines for any of the 58 chemicals tested. Collectively, thirty-two chemicals of concern (COC) exceeded the PSDDA screening level (SL) (34 including total LPAH and HPAH), two COC (mercury and total DDT) exceeded the bioaccumulation trigger (BT), and four COC (mercury, zinc, 2-4-dimethylphenol, total DDT) exceeded the maximum level (ML) guideline among the remaining twenty-nine management units tested. There were nine chemicals with minor detection limit exceedances of PSDDA SLs (enclosure 7). Of the three samples analyzed from the Whatcom Creek Waterway, two failed on chemistry (i.e., one COC greater than 100% over ML, or two or more exceedances of ML) alone (see Phase II MPR, page A-23 to A-24), and the third (5700-04) failed the bioassay disposal guidelines (enclosure 8). Of the twelve analyses conducted in the Squalicum Creek Waterway, six dredged material management units (C1, C2, C5, C9, C10, C11,) failed the chemistry disposal guidelines due to elevated zinc levels (enclosure 4). Of the seventeen analyses conducted from the I & J Street Waterway, one dredged material management unit (DMMU) (S8) was judged unsuitable for unconfined open-water disposal (UCOWD) based on mercury exceedance of BT (i.e. greater than 1.5 ppm), whereas four DMMU from I & J Waterway (S9, S10, S11, C14) failed biological nondispersive disposal guidelines.

4. Tiered testing was conducted, and twenty of thirty-three analyses required bioassays due to chemical exceedances of SLs, with one analysis from the I & J Waterway (sample S8) exceeding the BT for mercury. The Corps elected not to perform biological testing (i.e., bioassays + bioaccumulation test) on this DMMU, and this DMMU is considered unsuitable for UCOWD. A total of eight DMMU exceeded PSDDA disposal guidelines for chemistry (test sediment >ML by 100%, or 2 or more exceedances of ML), and were judged unsuitable for UCOWD (see enclosure 4). Two DMMU exceeded the ML for zinc in Squalicum Creek Waterway (C8, C12), but were within allowable chemistry guidelines for biological testing (i.e., less than 100% greater than ML). Chemicals noted which exceeded the ML in the Whatcom Waterway were mercury, 4-Methylphenol, and total DDT (enclosure 4). In the Squalicum Waterway high zinc concentrations were responsible for failing eight DMMU. At the present time the PSDDA "dredgers option" (Phase I MPR, page 5-12 to 5-13) is not available if PSDDA maximum level chemical disposal guidelines are exceeded. Results and discussion of the four rounds of bioassays performed on the twenty samples follows below.

5. PSDDA interpretation and statistical analyses resulted in a nondispersive site bioassay decision matrix shown in enclosure 8, and a dispersive site bioassay decision matrix as depicted in enclosure 9. The round 3 retest of round 1 echinoderm/amphipod bioassays was adequate to allow regulatory decisions on the suitability of each DMMU included in this round for unconfined open-water disposal. Round 4 bioassay testing had no QA/QC problems, and individual bioassay data are depicted in enclosure 6. In summary, bioassay testing results were interpreted using both nondispersive and dispersive disposal guidelines. Of the twenty laboratory samples (single/composited) subjected to bioassay testing, five dredged material management units failed PSDDA nondispersive site interpretation guidelines (enclosure 8) and nine failed dispersive site guidelines for unconfined open-water disposal (enclosure 9). PSDDA interpretation guidelines specified in June 1988 EPTA, and Sediment Larvae bioassay interpretation guidelines clarified in the Phase II Management Plan Report (MPR) and the July 10, 1990 bioassay workshop were used to evaluate the bioassay data. Interpretation guidelines discussed in the Phase II MPR specified necessary clarifications/changes in the Echinoderm larval bioassay mortality and

abnormality performance standards for control sediment, reference sediment, and dredged material relative to those specified in June 1988 EPTA. No performance problems were encountered during round 1 and 2 testing for the Neanthes 10-day acute bioassay and saline microtox bioassays. However, severe problems with reference and test sediment sample performance were observed during the round 1 tests for the amphipod bioassay and the sediment larval (echinoderm: Dendraster excentricus) bioassay, necessitating resampling and retesting (round 3) based on QA/QC reference sample performance and results of sediment conventional/water quality monitoring which demonstrated probable test interference from sulfides and ammonia. Round 2 bioassays also had reference sample performance problems. An expanded discussion of bioassay reference performance problems (including ammonia and sulfide influences) and the PSDDA agency resolution of these problems allowing decision making to proceed for all bioassay testing rounds, including round 2 amphipod and echinoderm larval bioassay test results, are included in Appendix I.

6. The association of echinoderm larval mortality with bulk ammonia and dissolved ammonia in the round 3 retest (see Appendix I, enclosure 10), strongly implicates ammonia as contributing to the echinoderm mortalities observed for C4. Elevated ammonia concentrations in fine-grained sediments are generally the result of bacterial degradation of organic nitrogen compounds. While ammonia is not listed as a chemical of concern it is a plant nutrient, which when elevated can significantly increase toxicity in bioassays (Ankley, Katko, and Arthur, 1988). Ammonia generally results from the decomposition of nitrogenous organic matter, and is one of the major constituents of the complex nitrogen cycle. Ammonia toxicity in dredged material is acknowledged in a laboratory environment, but at a disposal site would be transitory and short lived (i.e., hours or less) due to rapid dilution in the surrounding water (Burkes and Engler, 1978). Ammonia toxicity has been well documented in the literature for Echinoderm embryo(s)/larvae and effects found are more pronounced in larvae (pluteus stage) than during the gastrulation stage of development (Kobayashi, 1984). The Echinoderm larval test measures successful larval attainment of the pluteus stage. Concentrations of ammonia as low as 1 to 3.2 mg/liter were associated with arrested fertilization and development in various sea urchin eggs in a study by Kobayashi (1984). Examination of the round 1 mortality response for C4 (see Appendix I, enclosure 1) indicated that bulk ammonia levels of 290 mg/kg measured in this sample would predict ($y = 34.6206 + 0.1878 x$) a mortality of 89.1 percent (actual mortality observed was 96.7 percent) and that round 3 bulk ammonia measurements of the resampled/retested C4 (170 mg/kg) would predict a mortality of 66.5 percent, which was very close to the observed mortality of 68.9 percent. Moreover, dissolved ammonia levels observed in round 3 echinoderm test beakers for C4 (48 hour measurements = 1.09 mg/l) predicted a mortality of 67.9 percent utilizing the regression equation ($y = 32.6756 + 32.2838 x$) found during round 1 testing, and predicted a mortality of 52.1 percent utilizing the round 3 regression equation ($y = 6.455 + 41.908 x$)(see Appendix I, enclosures 2 and 10). Collectively, these data suggest that the ammonia versus mortality response relationship was relatively stable between the two testing rounds. The dissolved ammonia concentrations measured in the C4 test beaker exceeded 1 mg/l (@ 48 hours) in both testing rounds 1 and 3, which was well within the range documented in the literature demonstrating an effect on echinoderm larval development. Examination of the chemistry in C4 showed that DDT slightly exceeded the PSDDA SL at 8.3 ppb (SL = 6.9 ppb). Two other DMMU (S6 and S7) contained higher levels of DDT at 10.2 and 16.2 ppb and both passed the biological disposal guidelines for all four bioassays (enclosures 4 and 5). Because the ammonia concentrations observed during both rounds 1 and 3 for C4 (bulk ammonia and dissolved ammonia) accounted for the mortalities observed in C4 it was recommended that best professional judgement be

exercised, and the echinoderm sediment larval bioassay results for C4 be set aside and not be used in the regulatory suitability decision. The remaining three bioassays all indicated this subsurface sample was suitable for unconfined open-water disposal.

7. The Squalicum Waterway subsurface failure of C10 due to high zinc levels of 5,000 ppm compared to 2,500 ppm in the overlying composited surface sample C8, which passed the PSDDA disposal guidelines, is of concern to the PSDDA agencies. The Evaluation Procedures Technical Appendix (EPTA, pages I-12 to I-13) states that it is unacceptable to dredge a surface sample and expose a more contaminated subsurface layer, unless the contaminated subsurface layer is either overdredged to remove all the contaminated material or capped with clean material. Because there is no place for the contaminated material, the PSDDA agencies thereby recommend leaving all material in composited sample C8 in place (approximately 9,000 cubic yards) which overlies C10, but will allow the dredging and disposal of those portions of C8 designated by field sampling stations 16 and 17 (approximately 4,073 cubic yards) making up the inner navigation channel portion of C8 (see enclosure 2).

8. Examination of the subsurface composited sample C14 in the I & J Port of Bellingham berthing area, which failed the disposal guidelines, requires some discussion. The surface sample S12 at this location passed both the nondispersive and dispersive bioassay disposal guidelines, with chemical SL exceedances for Cd, Hg, HPAH, dibenzofuran, and DDT noted in the chemical analysis performed (see enclosure 5). Examination of the chemistry for C14 indicated that there was only a single exceedance of the SL for 1,2,4-Trichlorobenzene at 7.5 ppb (current SL = 6.4; proposed SL change per 1991 Annual Review Meeting to be implemented on June 15, 1991 = 13 ppb). The source of the failure for this management unit was the Neanthes bioassay response resulting in a single hit failure under the PSDDA nondispersive disposal guidelines. Examination of the mortality responses within the five replicates for this sample indicated that there was a high degree of within sample variability (0, 80, 10, 40, 60 percent mortality), and suggests that this result may be anomalous or spurious. The other three bioassays indicated the material was suitable. Comparisons of the chemistry in S12 with underlying C14 indicates that the sediment quality should not be degraded relative to the surface material, although the apparent reason for the Neanthes hit in the subsurface sample is not clear, and there was no apparent QA/QC problem with the data. If the material in S12 is dredged, exposing the underlying sediments represented in C14 should not result in a sediment quality problem. The PSDDA agencies concluded that S12 could be dredged.

9. Enclosure 10 provides a chemistry and bioassay decision summary for each of the thirty-three DMMU tested relative to its suitability for unconfined openwater disposal at either the Bellingham Bay nondispersive site or the Rosario Staits dispersive site.

10. Enclosure 11 provides the cumulative volume testing summaries for each waterway for the federal and nonfederal (Port of Bellingham) portions of the project. Based on the above discussion and summary of chemical and bioassay results for the Bellingham Harbor Maintenance Dredging Characterization for Whatcom Creek Waterway, Squalicum Creek Waterway, and I & J Street Waterway, the PSDDA agencies concluded that all the material tested (12,000 cubic yards) from the Whatcom Creek Waterway is unsuitable, 93,901 cubic yards from the Squalicum Creek Waterway is suitable (100,313 cubic yards is unsuitable), and 68,178 cubic yards from the I & J Street Waterway is suitable (24,733 cubic yards is unsuitable) for dredging and disposal at the Bellingham Bay nondispersive disposal site.

11. The Corps proposes to dispose all dredged material suitable for unconfined open-water disposal at the Bellingham Bay nondispersive disposal site. The Port of Bellingham expects to dispose all its suitable material at the Bellingham Bay nondispersive site, but in the event the site closure on 1 November 1991 takes place before the Port completes it dredging, the Port would then utilize the Rosario Straits dispersive disposal site for the remainder of its material. All the Port's material found suitable under the PSDDA nondispersive site guidelines passed the more restrictive dispersive site guidelines except DMMU C18 (7,427 cy). The DMMU C18 material is only suitable for disposal at a nondispersive PSDDA site.

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Concur:

14 June 1991 — Date

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Enclosures

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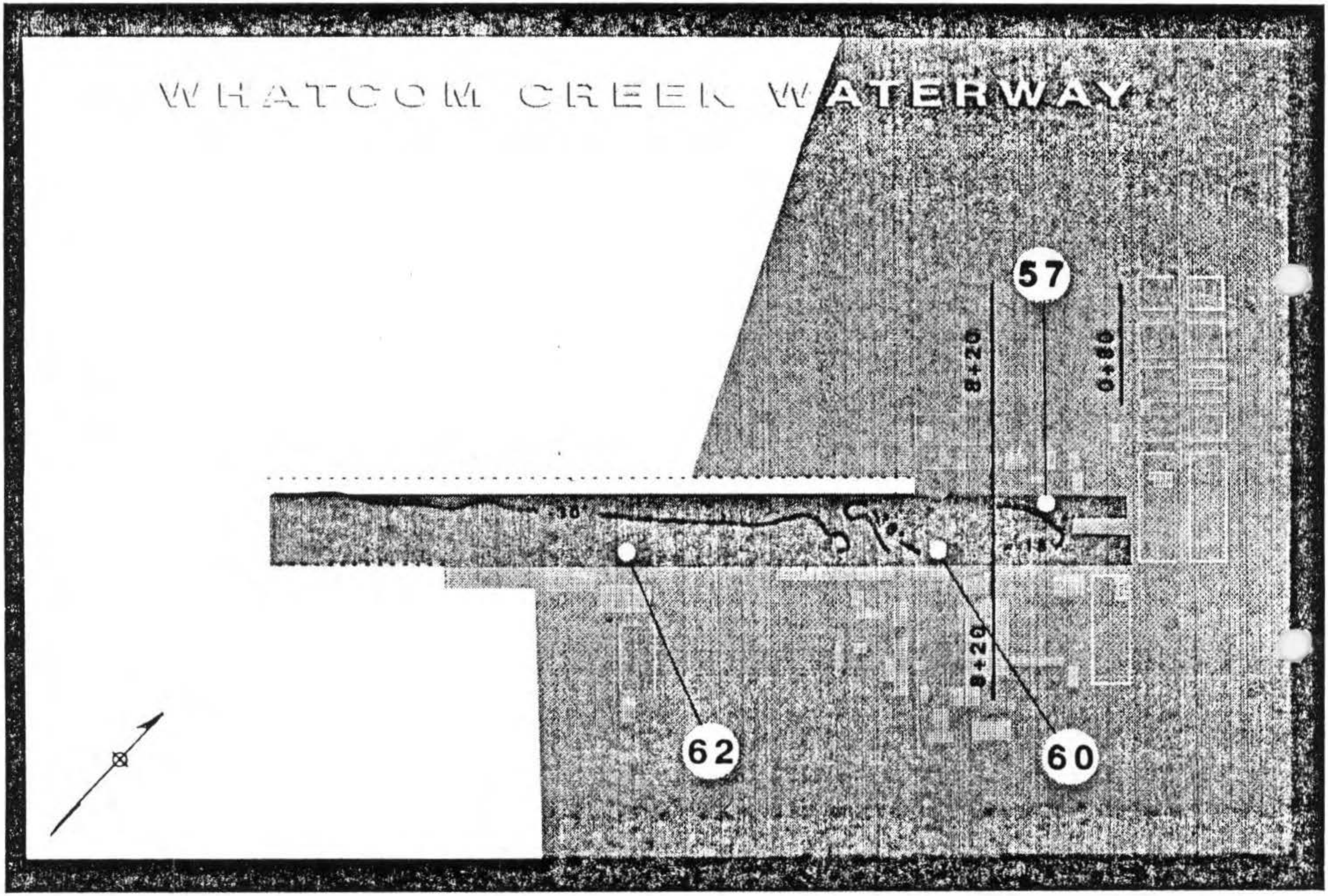
Literature Cited

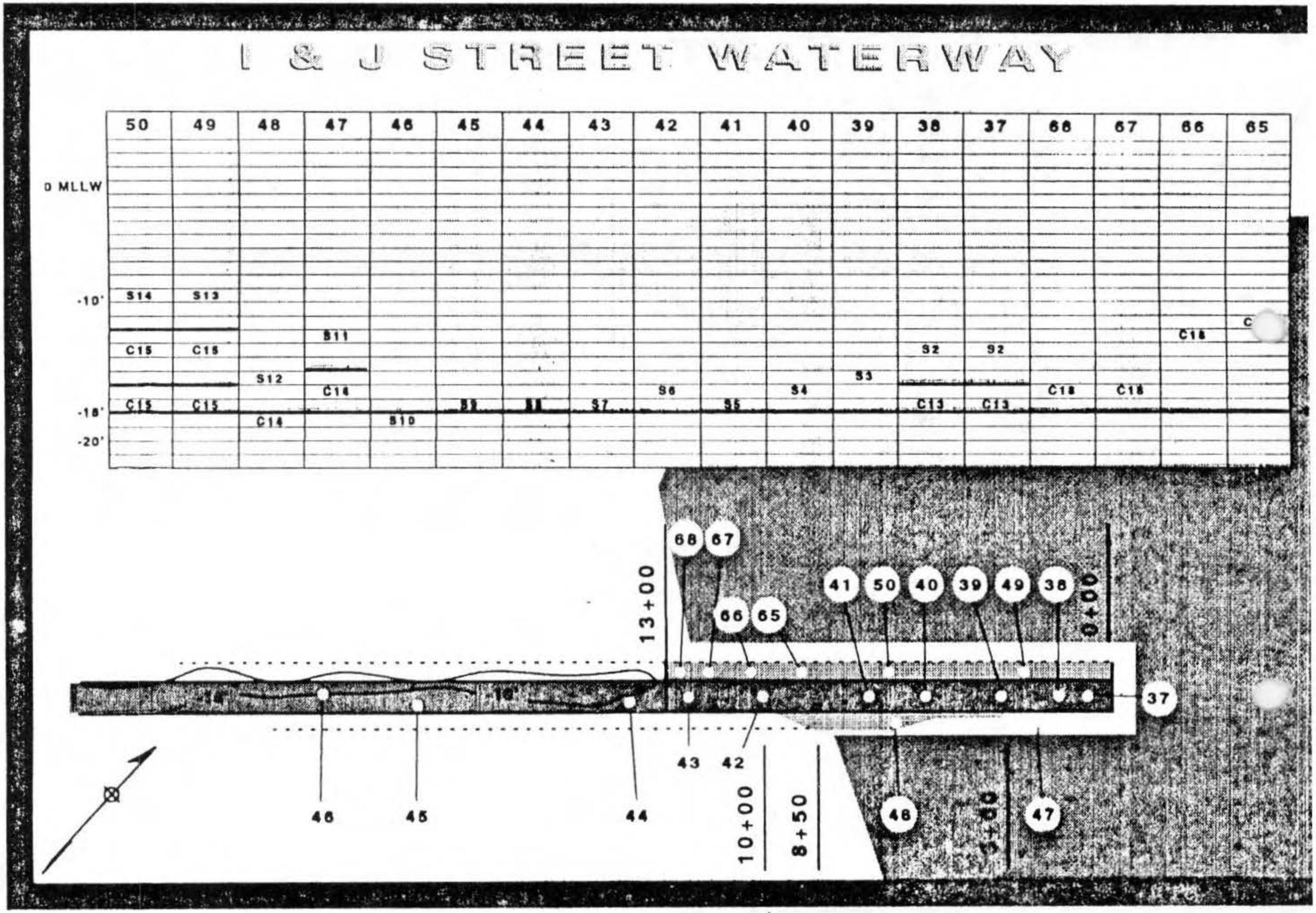
Ankley, G.T., A. Katko, and J. W. Arthur. 1988. Identification of Ammonia as an important sediment-associated toxicant in the lower Fox River and Green Bay, Wisconsin. Environmental Toxicology and Chemistry. Vol.9, pages 313-322.

Burkes, S.A. and R.M. Engler. 1978. Water Quality Impacts of Aquatic Dredged Material Disposal (Laboratory Investigations). Technical Report DS-78-4. U.S. Army Corps of Engineers; Waterways Experiment Station, Vicksburg, Mississippi.

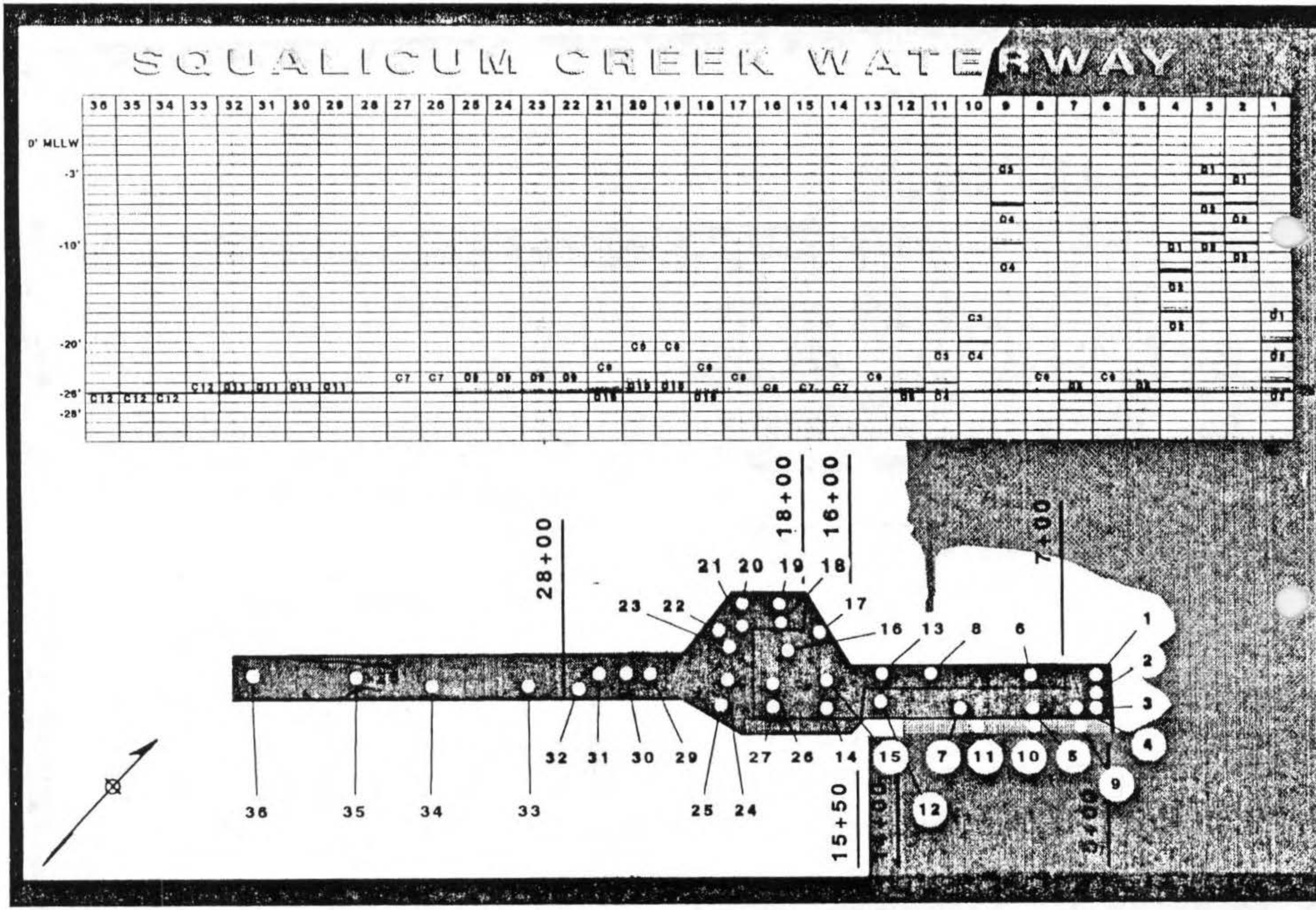
Kobayashi, N. 1984. Marine Ecotoxicological Testing with Echinoderms. In: Ecotoxicological Testing for the Marine Environment. Editors: G. Persoone, E. Jaspers, and C. Claus. State Univ. Ghent and Inst. Mar. Scient. Res., Bredene, Belgium. Vol. 1 (798 pp)



Enclosure 1


I & J STREET WATERWAY
50 49 48 47 46 45 44 43 42 41 40 39 38 37 68 67 66 65
0 MLLW
-10'
-18'
-20'
S14 S13 S11 S12 S2 S3 S4 S6 S5 S7 S10
C15 C14 C13 C18
13+00
10+00
8+50
0+00
68 67 66 65 41 50 40 39 49 38 37
43 42 46 45 44 48 47

Enclosure 2


SQUALICUM CREEK WATERWAY
0' MLLW
-3'
-10'
-20'
-26'
-28'
28+00
18+00
16+00
7+00
15+50

Enclosure 3

CHEMICAL/BIOASSAY/ CONVENTIONALS	1989 SL	1989 BT	1989 ML	ROUND 1 TESTING C1	C2	C4	C5	C6	C8	C9	C10	C11	C12	S6	S7	S8	S9	S10	5700-04	6000-04	6200-04	Sequim B Ref 1	Sequim B Ref 2	Sequim B Ref 3	Control
METALS (ppm dry wgt):																									
Antimony	20	146	200																						
Arsenic	57	507.1	700																						
Cadmium	0.96		9.6											1	1.4	1.8	1.8	1.1	1.4	3.5	1.4				
Copper	81		810																		260				
Lead	66		660																120	190					
Mercury	0.21	1.5	2.1					0.23						0.82	1.2	1.9 B	0.52	1.5	0.54	2.3 BM	4.3 BM				
Nickel	140	1,022									150														
Zinc	160		1,600	13000 M	6100 M		4300 M		2500 M	5700 M	5000 M	8300 M	3000 M							240					
ORGANIC CHEM. (ppb dry wgt):																									
Naphthalene	210		2,100																	890					
Acenaphthylene	64		640																	100					
Acenaphthene	63		630																	400	450				
Fluorene	64		640																	340	480				
Phenanthrene	320		3,200																	1400	1200				
Anthracene	130		1,300																	340	300				
2-Methylnaphthalene	67		670																	190					
Total LPAH	610		6,100																	3660	2553				
Fluoranthene	630	4,600	6,300																						
Pyrene	430		7,300																	1400	1400				
Benzo(a)anthracene	450		4,500																	480	670				
Chrysene	670		6,700																		830				
Benzofluoranthenes	800		8,000																		940				
Benzo(a)pyrene	680	4,964	6,800																						
Indeno(1,2,3-c,d)pyrene	69		5,200																	150	110				
Dibenzo(a,h)anthracene	120		1,200																						
Benzo(g,h,i)perylene	540		5,400																						
Total HPAH	1,800		51,000																	3710	4377				
1,2,4-Trichlorobenzene	6.4		64				8.1		9.8											32					
Hexachlorobenzene	23	168	230																	57					
4-Methylphenol	120		1,200																260	2900 M	130				
2-4-Dimethylphenol	10		50																						
Dibenzofuran	54		540																	260	230				
Total DDT	6.9	50	69		63.7 B	8.2								10.2	16.2	14.6			33.4	123 BM	41.4				
Aldrin	10	37																							
Heptachlor	10	37																							
Total PCB's	130	38	2,500		510															210					
BIOASSAYS																									
Amphipod (% mortality)						QA/ 61		QA/ 51	QA/ 57				QA/ 51	QA/ 51	QA/ 51				QA/ 97			QA/ 27	QA/ 66	QA/ 63	4
Echinoderm (% mortality)						QA/96.7		QA/55.7	QA/41.8				QA/64.2	QA/25.2	QA/51.9				QA/99.2			QA/66.3	QA/46.5	QA/81.6	0
Neanthes (% mortality)						14		12	4				4	6	4				100**			10	2	4	2
Microtox (N = nontoxic)						N		N	N				N	N	N				N			N	N	N	N
SEDIMENT CONVENTIONALS																									
Total Solids				67.5	70.2	58.1	53.2	53.9	52	54.4	52.3	52.3	51.5	64.6	49.6	48.3	63.1	46.4	50	33.1	52.9	50	71.6	51	
Total Volatile Solids				7.4	18.8	8.8	7.5	6.4	6.9	6	7.3	6.5	5.8	7.5	9.4	10.9	5.2	7.7	9.3	7.7	6.9				
TOC				0.03	10.8	4.67	2.84	2.55	2.17	2.15	2.77	2.27	1.93	3.32	4.54	5.62	3.16	3.06	4.25	0.027	3.8				
Ammonia				56	92	290	120	46	53	100	120	96	32	63	120	130	55	91	370	1100	234				
Total Sulfides				820	980	2200	980	830	950	800	850	1500	1400	540	1100	520	500	550	1700	2000	1400				
GRAIN SIZE																									
Gravel				42.7	36.6	0.3	0.4	0.2		0.6		0.2	0.2	1.9	13.9	0.4	0.3	0.4	6.8	2.1	6.6	1.6	1.6	0.6	
Sand				43.6	40.8	24.3	7	7.4	2.4	13.1	3.9	3.4	3.6	46.8	17.1	8.4	52.5	5	38	27.7	32	51.4	79.5	27.9	
Silt				14.6	18.7	59.9	83.1	80.1	90.1	73.3	83.3	87.7	85.2	29.8	47.7	54	28.2	64	30	46.8	41.7	28	9.1	54.2	
Clay				2.3	4	15.5	9.5	12.2	10.3	13	13.1	8.9	11	21.5	21.3	28.9	19	30.6	24.6	23.4	19.8	19.9	9.8	17.5	
PASS (P) / FAIL (F) CHEMICAL (C) / BIOASSAY (B)				F (C)	F (C)	R-3	F (C)	R-3	R-3	F (C)	F (C)	F (C)	R-3	R-3	R-3	U (C)	R-4	R-4	F (B)	F (C)	F (C)				

LEGEND: M=Maximum Level; B=Bioaccumulation Trigger;
* Double Hit (Bioassay) Failure; ** Single Hit Failure;
BPJ=Best Professional Judgement; R-3(4) = Round 3(4) Testing;
U (C) Unsuitable for UCOWD without biological testing;
C3, C7, C15, S13 < SL (Pass (Chemistry), not shown)

Enclosure 4

CHEMICAL/BIOASSAY/ CONVENTIONALS	1989 SL	1989 BT	1989 ML	ROUND 2 TESTING C13	C14	S1	S2	S3	S4	S5	S11	S12	S14	Control	Samish Ref 5	Samish Ref 10	ROUND 3 (ROUND 1 BIOASSAY RETEST) C4	C6	C8	C12	S6	S7	Jetty I. Ref 1	Jetty I. Ref 2	Control
METALS (ppm dry wgt):																									
Antimony	20	146	200				110																		
Arsenic	57	507.1	700				220																		
Cadmium	0.96		9.6			1.2				1.3	1.3	1.3	1.2								1	1.4			
Copper	81		810				130																		
Lead	66		660				110																		
Mercury	0.21	1.5	2.1			0.654	0.76	0.58	0.71	0.86	1.1	1.1	0.632					0.23			0.82	1.2			
Nickel	140	1,022					520																		
Zinc	160		1,600								190								2500 M	3000 M					
ORGANIC CHEM. (ppb dry wgt):																									
Naphthalene	210		2,100								220														
Acenaphthylene	64		640																						
Acenaphthene	63		630				240				260														
Fluorene	64		640				330				300														
Phenanthrene	320		3,200				640				1100														
Anthracene	130		1,300				140				320		180												
2-Methylnaphthalene	67		670					71			160														
Total LPAH	610		6,100				1527				2360														
Fluoranthene	630	4,600	6,300								2200		1300												
Pyrene	430		7,300			480	800				2500	780	1700												
Benzo(a)anthracene	450		4,500								1000		750												
Chrysene	670		6,700								750		1400												
Benzofluoranthenes	800		8,000										860												
Benzo(a)pyrene	680	4,964	6,800																						
Indeno(1,2,3-c,d)pyrene	69		5,200										160												
Dibenzo(a,h)anthracene	120		1,200								86														
Benzo(g,h,i)perylene	540		5,400																						
Total HPAH	1,800		51,000				2053				7342	2019	6751												
1,2,4-Trichlorobenzene	6.4		64	8.4	7.5	11	12	12											9.8						
Hexachlorobenzene	23	168	230																						
4-Methylphenol	120		1,200								250														
2-4-Dimethylphenol	10		50					35																	
Dibenzofuran	54		540				240	61			200	55													
Total DDT	6.9	50	69			12.1	8.6	12.6	13.6	17.5	28.7	17.1	28.4				8.2				10.2	16.2			
Aldrin	10	37					23		15		16														
Heptachlor	10	37				25	32	13	32																
Total PCB's	130	38	2,500								357		193												
BIOASSAYS																									
Amphipod (% mortality)				27	25	30	33	34	47*	32	32	30	29	4	QA/ 38	QA/ 32	20	16	13	11	21	16	12	7	
Echinoderm (% mortality)				26.5	21.5	32.2	19.7	33.5	25.5	33.5	56.3**	37.4	30	0	QA/30.1	QA/31.3	68.9**	23.8	19.9	28.2*	15	23*	7.2	QA/26.1	
Neanthes (% mortality)				20	38**	18	6	24	24	0	4	8	4	4	0	2									
Microtox (N = nontoxic)				N	N	N	N	N	N	N	N	N	N	N	N	N									
SEDIMENT CONVENTIONALS																									
Total Solids				82.8	77.6	54	48.8	64	67.7	54.9	49.8	49	55.5		32	30	56.6	52.7	52.7	51.9	47.1	47	57.3		
Total Volatile Solids				2.1	3.6	4.9	1.7	9.4	6.5	4.6	10.4	6.9	7.9		8.76	11.9							2.7		
TOC				0.66	3.71	5.85	8	9.1	9.57	8.8	8.42	7.17	11.8		1.7	2							1.52		
Ammonia				19	37	150	92	170	86	110	290	200	120		840	700	170	110	89	55	83	140	66	86	
Total Sulfides				25	22	740	3100	650	230	650	240	620	320		18	13	130	17	8.6	3.4	960	110	18	41	
GRAIN SIZE																									
Gravel				2.4	1.9	1.2	0.6	9.4	11.3	12.4	1.8	7.3	9.6										0.9	0.3	
Sand				30.3	33.7	19.5	42.8	38.3	36.5	20.7	34.5	18.6	44.2		5.8	12.4							49.8	61.9	
Silt				35.3	35.4	62.5	47.9	38.3	40.7	54.1	53	56.5	28.2		82.4	76.7							37.6	27.4	
Clay				32	29	17	10.5	14	12.4	7.7	12	18	19		12.0	11.0							11.5	10.7	
PASS (P) / FAIL (F) CHEMICAL (C) / BIOASSAY (B)				P (B)	F (B)	P (B)	P (B)	P (B)	P (B)	P (B)	F (B)	P (B)	P (B)				BPJ P (B)	P (B)	P (B)	P (B)	P (B)	P (B)			

LEGEND: M = Maximum Level; B = Bioaccumulation Trigger;
* Double Hit (Bioassay) Failure; ** Single Hit Failure;
BPJ = Best Professional Judgement; R-3 = Round 3 Testing;
U (C) Unsuitable for UCOWD without biological testing;
C3, C7, C15, S13 < SL (Pass (Chemistry), not shown)

Enclosure 5

CHEMICAL/BIOASSAY/ CONVENTIONALS	1989 SL	1989 BT	1989 ML	ROUND 4 (Round 1 Chemistry for S9 & S10) S9	S10	C18	Jetty I. Ref	Control
METALS (ppm dry wgt):								
Antimony	20	146	200					
Arsenic	57	507.1	700					
Cadmium	0.96		9.6	1.8	1.1			
Copper	81		810					
Lead	66		660					
Mercury	0.21	1.5	2.1	0.52	1.5	0.27		
Nickel	140	1,022						
Zinc	160		1,600					
ORGANIC CHEM. (ppb dry wgt):								
Naphthalene	210		2,100					
Acenaphthylene	64		640					
Acenaphthene	63		630					
Fluorene	64		640					
Phenanthrene	320		3,200					
Anthracene	130		1,300					
2-Methylnaphthalene	67		670					
Total LPAH	610		6,100					
Fluoranthene	630	4,600	6,300					
Pyrene	430		7,300					
Benzo(a)anthracene	450		4,500					
Chrysene	670		6,700					
Benzofluoranthenes	800		8,000					
Benzo(a)pyrene	680	4,964	6,800					
Indeno(1,2,3-c,d)pyrene	69		5,200					
Dibenzo(a,h)anthracene	120		1,200					
Benzo(g,h,i)perylene	540		5,400					
Total HPAH	1,800		51,000					
1,2,4-Trichlorobenzene	6.4		64					
Hexachlorobenzene	23	168	230					
4-Methylphenol	120		1,200					
2-4-Dimethylphenol	10		50					
Dibenzofuran	54		540					
Total DDT	6.9	50	69					
Aldrin	10	37						
Heptachlor	10	37						
Total PCB's	130	38	2,500					
BIOASSAYS								
Amphipod (% mortality)				57**	48*	46*	21	5
Echinoderm (% mortality)				21.1*	20.4*	5.9	5.4	0
Neanthes (% mortality)				2	4	2	4	2
Microtox (N = nontoxic)				N	N	N	N	
SEDIMENT CONVENTIONALS								
Total Solids				52.1	44.2	76.6		
Total Volatile Solids				7.59	8.45	2.49		
TOC				5.2	7.7	0.77		
Ammonia				12	56	5.6		
Total Sulfides				92	810	420		
GRAIN SIZE								
Gravel				0.3	0.4	15.5		
Sand				52.5	5	65		
Silt				28.2	64	11.6		
Clay				19	30.6	7.4		
PASS (P) / FAIL (F) CHEMICAL (C) / BIOASSAY (B)				F (B)	F (B)	P (B)		

LEGEND: M = Maximum Level; B = Bioaccumulation Trigger;
* Double Hit (Bioassay) Failure; ** Single Hit Failure;
BPJ = Best Professional Judgement; R-3(4) = Round 3(4) Testing;
U (C) Unsuitable for UCOWD without biological testing;
C3, C7, C15, S13 < SL (Pass (Chemistry), not shown)

Enclosure 6

CHEMICAL	1989 SL	1989 BT	1989 ML	CHEMICALS EXCEEDING SL DUE TO LIMITS OF DETECTION								
				C6	S8	S9	S10	S11	5700-04	6000-04	6200-04	C18
ORGANIC CHEM. (ppb dry wgt):												
1,2,4-Trichlorobenzene	6.4		64	6.6 u	7.5 u		9.1 u		8.8 u		8.3 u	
Hexachlorobutadiene	29	212	290		30 u		30 u	30 u		44 u		
2 Methylphenol	10		72							13 u		
2-4-Dimethylphenol	10		50							13 u		
Pentachlorophenol	100	504	690							130 u		
Benzyl Alcohol	10		73							13 u		11 u
Benzoic Acid	216		690							220 u		
N-nitrosodiphenylamine	22	161	220							26 u		
Total DDT	6.9	50	69			9.9 u	12 u					

LEGEND:

u = undetected at concentration specified

Enclosure 7

BIOASSAY DECISION MATRIX FO ELLINGHAM MAINTENANCE DRED NG TESTING DATA

Enclosure 8

		BELLINGHAM MAINTENANCE DREDGING NONDISPERSIVE SITE BIOASSAY SUMMARY				UCOWD NONDISPERSIVE
SAMPLE ID	ROUND	AMPHIPOD	ECHINODERM	NEANTHES	MICROTOX	PASS/FAIL
C4	1/3	P	(F**)	P	P	PASS
C6	1/3	P	C/P	P	P	PASS
C8	1/3	P	C/P	P	P	PASS
C12	1/3	P	F*	P	P	PASS
S6	1/3	P	C/P	P	P	PASS
S7	1/3	P	F*	P	P	PASS
5700-04	1	QA/QC	QA/QC	F**	P	FAIL
C13	2	C/P	C/P	P	P	PASS
C14	2	C/P	C/P	F**	P	FAIL
S1	2	C/P	C/P	P	P	PASS
S2	2	C/P	P	P	P	PASS
S3	2	C/P	C/P	P	P	PASS
S4	2	F*	C/P	P	P	PASS
S5	2	C/P	C/P	P	P	PASS
S11	2	C/P	F**	P	P	FAIL
S12	2	C/P	C/P	P	P	PASS
S14	2	C/P	C/P	P	P	PASS
S9	4	F**	F*	P	P	FAIL
S10	4	F*	F*	P	P	FAIL
C18	4	F*	P	P	P	PASS

LEGEND:

UCOWD = UNCONFINED OPEN-WATER DISPOSAL

P = TEST SEDIMENT < 20 PERCENT ABSOLUTE OVER CONTROL (SEDIMENT/SEAWATER); BIOASSAY PASSES PSDDA NONDISPERSIVE DISPOSAL SITE INTERPRETATION GUIDELINES FOR UNCOWD.

C/P = TEST SEDIMENT > 20 PERCENT ABSOLUTE OVER CONTROL (SEDIMENT/SEAWATER) + < 30 PERCENT OVER REFERENCE AND NOT STATISTICALLY DIFFERENT FROM REFERENCE (t-Test, p>.05).

F* = DOUBLE HIT (> 20 PERCENT ABSOLUTE OVER CONTROL + < 30 PERCENT OVER REFERENCE + STATISTICALLY SIGNIFICANT FROM REFERENCE (t-Test, p<.05)). TWO DOUBLE HITS = UCOWD FAILURE.

F** = SINGLE HIT FAILURE (> 20 PERCENT ABSOLUTE OVER CONTROL + > 30 PERCENT OVER REFERENCE AND STATISTICALLY SIGNIFICANT FROM REFERENCE).

(F**) = SINGLE HIT FAILURE HIGHLY CORRELATED WITH SEDIMENT AMMONIA TOXICITY. BIOASSAY RESULT SET ASIDE FOR REGULATORY DECISION MAKING (BPJ).

enclosure 8

BIOASSAY DECISION ATRIX FOR BELLINGHAM MAINTE NCE DREDGING TESTING DATA

Enclosure 9

		BELLINGHAM MAINTENANCE DREDGING DISPERSIVE SITE BIOASSAY SUMMARY			UCOWD DISPERSIVE
SAMPLE ID	ROUND	AMPHIPOD	ECHINODERM	NEANTHES	PASS/FAIL
C4	1/3	P	(F**)	P	PASS
C6	1/3	P	C/P	P	PASS
C8	1/3	P	C/P	P	PASS
C12	1/3	P	F**	P	FAIL
S6	1/3	P	C/P	P	PASS
S7	1/3	P	F**	P	FAIL
5700-04	1	QA/QC	QA/QC	F**	FAIL
C13	2	C/P	C/P	P	PASS
C14	2	C/P	C/P	F**	FAIL
S1	2	C/P	C/P	P	PASS
S2	2	C/P	P	P	PASS
S3	2	C/P	C/P	P	PASS
S4	2	F**	C/P	P	FAIL
S5	2	C/P	C/P	P	PASS
S11	2	C/P	F**	P	FAIL
S12	2	C/P	C/P	P	PASS
S14	2	C/P	C/P	P	PASS
S9	4	F**	F**	P	FAIL
S10	4	F**	F**	P	FAIL
C18	4	F**	C/P	P	FAIL

LEGEND:
UCOWD = UNCONFINED OPEN-WATER DISPOSAL

P = TEST SEDIMENT < 20 PERCENT ABSOLUTE OVER CONTROL (SEDIMENT/SEAWATER); BIOASSAY PASSES PSDDA DISPERSIVE DISPOSAL SITE INTERPRETATION GUIDELINES FOR UNCOWD.

C/P = TEST SEDIMENT > 20 PERCENT ABSOLUTE OVER CONTROL (SEDIMENT/SEAWATER) + > 10 PERCENT (15% FOR ECHINODERM) OVER REFERENCE AND NOT STATISTICALLY DIFFERENT FROM REFERENCE (t-Test, p>.05).

F* = DOUBLE HIT (> 20 PERCENT ABSOLUTE OVER CONTROL + < 10 PERCENT (15% FOR ECHINODERM) OVER REFERENCE + STATISTICALLY SIGNIFICANT FROM REFERENCE (t-Test, p<.05)) TWO DOUBLE HITS = UCOWD FAILURE.

F** = SINGLE HIT FAILURE (> 20 PERCENT ABSOLUTE OVER CONTROL + > 10 PERCENT (15% FOR ECHINODERM) OVER REFERENCE AND STATISTICALLY SIGNIFICANT FROM REFERENCE).

(F**) = SINGLE HIT FAILURE HIGHLY CORRELATED WITH SEDIMENT AMMONIA TOXICITY. BIOASSAY RESULT SET ASIDE FOR REGULATORY DECISION MAKING (BPJ).

enclosure 9

Enclosure 10

SAMPLE ID	DMMU VOLUME (	CORPS / POB	TESTING ROUND	COC > SL	COC > BT	C	NONDISPERSIVE (PASS/FAIL)	DISPERSIVE (PASS/FAIL)
WHATCOM CREEK WATERWAY								
5700-04 (SURFACE)	4,000	POB	1	5			FAIL (B)	FAIL (B)
6000-04 (SURFACE)	4,000	POB	1	19	2	3	FAIL (C)	FAIL (C)
6200-04 (SURFACE)	4,000	POB	1	14	1	1	FAIL (C)	FAIL (C)
SQUALICUM CREEK WATERWAY								
C1 (SURFACE)	7,235	CORPS	1	1		1	FAIL (C)	FAIL (C)
C2 (SUBSURFACE)	22,067	CORPS	1	1		1	FAIL (C)	FAIL (C)
C3 (SURFACE)	11,820	POB	1	0			PASS (C)	PASS (C)
C4 (SUBSURFACE)	21,060	POB	1/3	1			PASS (B)	PASS (B)
C5 (SURFACE)	9,662	CORPS	1	2		1	FAIL (C)	FAIL (C)
C6 (SURFACE)	22,689	CORPS	1/3	1			PASS (B)	PASS (B)
C7 (SURFACE)	14,685	CORPS	1	0			PASS (C)	PASS (C)
C8 (SURFACE)	13,073 (9,000)[1]	CORPS	1/3	2		1	PASS (B)	PASS (B)
C9 (SURFACE)	22,076	CORPS	1	1		1	FAIL (C)	FAIL (C)
C10 (SUBSURFACE)	6,273	CORPS	1	2		1	FAIL (C)	FAIL (C)
C11 (SURFACE)	24,000	CORPS	1	1		1	FAIL (C)	FAIL (C)
C12 (SURFACE)	19,574	CORPS	1/3	1		1	PASS (B)	FAIL (B)
I & J STREET WATERWAY								
S1 (SURFACE)	3,418	CORPS	2	6			PASS (B)	PASS (B)
S2 (SURFACE)	3,418	CORPS	2	17			PASS (B)	PASS (B)
S3 (SURFACE)	3,418	CORPS	2	7			PASS (B)	PASS (B)
S4 (SURFACE)	3,418	CORPS	2	4			PASS (B)	FAIL (B)
S5 (SURFACE)	3,418	CORPS	2	3			PASS (B)	PASS (B)
S6 (SURFACE)	3,418	CORPS	1/3	3			PASS (B)	PASS (B)
S7 (SURFACE)	3,418	CORPS	1/3	3			PASS (B)	FAIL (B)
S8 (SURFACE)	3,358	CORPS	1	3	1		NS (C[2])	NS (C[2])
S9 (SURFACE)	5,483	CORPS	1/4	2			FAIL (B)	FAIL (B)
S10 (SURFACE)	5,226	CORPS	1/4	2			FAIL (B)	FAIL (B)
S11 (SURFACE)	4,253	POB	2	21			FAIL (B)	FAIL (B)
S12 (SURFACE)	3,768	POB	2	5			PASS (B)	PASS (B)
S13 (SURFACE)	3,672	POB	2	0			PASS (C)	PASS (C)
S14 (SURFACE)	3,672	POB	2	11			PASS (B)	PASS (B)
C13 (SUBSURFACE)	9,618	CORPS	2	1			PASS (B)	PASS (B)
C14 (SUBSURFACE)	6,413	POB	2	1			FAIL (B)	FAIL (B)
C15 (SUBSURFACE)	16,095	POB	2	0			PASS (C)	PASS (C)
C18 (SURFACE)	7,427	POB	4	1			PASS (B)	FAIL (B)
TOTAL: TESTED/FAILED	299,125/137,046						14/33 FAIL	18/33 FAIL

[1] Volume noted in parenthesis is volume overlying subsurface sample C10, which will be left in place and not dredged. Remainder of material (4,073 cy) is suitable for dredging.

[2] Exceeded mercury bioaccumulation trigger (mercury BT = 1.5 ppm); bioaccumulation test not performed, dredged material management unit therefore not suitable for unconfined open-water disposal (UCOWD).

LEGEND:
DMMU = DREDGED MATERIAL MANAGEMENT UNIT
PASS (B) = PASSES BIOASSAY DISPOSAL GUIDELINES
PASS (C) = PASSES CHEMISTRY DISPOSAL GUIDELINES (ALL COC < SL)
FAIL (C) = FAILS CHEMISTRY DISPOSAL GUIDELINES (i.e., >100% ML; or greater than 2 exceedances ML)
NS = NOT SUITABLE FOR UCOWD WITHOUT BIOLOGICAL TESTING
POB = PORT OF BELLINGHAM
FAIL (B) = FAILS BIOASSAY DISPOSAL GUIDELINES

enclosure 10

Summary Decision Matrix of Tested Bellingham Dredged Material for Unconfined Openwater Disposal at Bellingham Nondispersive[1] Disposal Site.

WATERWAY	FEDERAL (CORPS)		PORT OF BELLINGHAM		TOTALS:			
	volume (cy) suitable	volume (cy) unsuitable	volume (cy) suitable	volume (cy) unsuitable	Total tested volume (cy)	volume (cy) suitable	volume (cy) unsuitable	percent (%) unsuitable
Whatcom Creek Waterway	NO TEST	NO TEST	0	12,000	12,000	0	12,000	100
Squalicum Creek Waterway	61,021	100,313	32,880	0	194,214	93,901	100,313	51.6
I & J Street Waterway	33,544	14,067	34,634	10,666	92,911	68,178	24,733	26.6
GRAND TOTALS:	94,565	114,380	67,514	22,666	299,125	162,079	137,046	45.8

Enclosure 11

...ort of Bellingham dredged material suitable for dispersive site disposal at Rosario Straits except 7,427 cy of material (I & J Street Waterway: C18)

enclosure 11

APPENDIX I: BIOASSAY QUALITY ASSURANCE/QUALITY CONTROL PERFORMANCE SUMMARY, INCLUDING INTERPRETION ALTERNATIVES FOR ROUND 2 AMPHIPOD AND ECHINODERM SEDIMENT LARVAL BIOASSAYS.

FACTS BEARING ON INTERPRETATION OF BIOASSAYS, ESPECIALLY AMPHIPOD AND ECHINODERM SEDIMENT LARVAL BIOASSAYS:

After reviewing chemistry data for the thirty-three analyses (dredged material management units) performed (see discussion in suitability memorandum), the PSDDA agencies determined that biological testing would be required for 20 dredged material management units (DMMU) before suitability decisions could be made on the material. Biological testing initially proceeded for seventeen DMMU and was separated into two sequential testing rounds. Initial preliminary chemistry results (where internal laboratory QA validation had not been accomplished) for round 1 testing indicated the other three DMMU (S8, S9, S10) exceeded or were equal to the bioaccumulation trigger for mercury (BT = 1.5 ppm), and the Corps decided initially not to conduct the necessary standard bioassays and bioaccumulation test for these DMMU. Subsequently, laboratory validation indicated that two of those DMMU (S9 and S10) were actually less than the BT (i.e., must be greater than 1.5 ppm to exceed BT for mercury) and therefore not subject to the bioaccumulation testing requirement. These two DMMU were resampled in April and underwent normal bioassay testing (round four) along with the Port of Bellingham berthing area DMMU (C18) to assess their suitability for unconfined open-water disposal. Problems were encountered during the running of bioassays for the initial two rounds of biological testing. Some of the sediments were subsequently resampled and retested (round three) to correct these problems. Details are included in the following discussion.

Initial bioassay testing during round 1 indicated major QA/QC problems for both the amphipod and echinoderm larval bioassays due to reference area sediment performance failures. There were no quality assurance performance problems with either the <u>Neanthes</u> 10-day acute bioassay or the saline microtox bioassays. Examination of the ancillary sediment conventional data and water quality data for ammonia and sulfides for the amphipod and echinoderm bioassays indicated that ammonia and sulfide concentrations likely contributed heavily to mortalities observed in both the test sediments and the associated reference area sediments (No problems were observed with either the <u>Neanthes</u> or microtox bioassay performance during either rounds 1, 2, 3 or 4 testing. Both of these bioassays appear to be relatively insensitive to ammonia, sulfide, and grain size effects).

Round 1 reference sample performance (Sequim Bay) failures were observed in both the amphipod bioassay and echinoderm sediment larval bioassay. Subsequent analyses of sediment conventional and water quality data indicated both bioassays were correlated with bulk sulfides and bulk/dissolved ammonia (see enclosures 1-4). Normally, aeration of beakers for the sediment larval bioassay is not required unless dissolved oxygen levels drop below 5 ppm (mg/kg), and therefore no aeration occurred during round 1 testing. It was suspected, however, that aeration might help to ameliorate the effects of sediment sulfides and ammonia toxicity during the running of the round 2 bioassays. Therefore, the Dredged Material Management Office, in consultation with the PSDDA agency technical representatives and after discussions with Mr. Tim Thompson (Parametix), directed the bioassay testing lab (Parametrix) to aerate the round 2 echinoderm bioassay in an attempt to drive off bulk sulfides and reduce the toxicity of ammonia. Additionally, it was decided to run Samish Bay reference material in lieu of Sequim Bay, due to the latter's poor performance in round 1. Unfortunately, during the round 2 testing, the Samish Bay reference samples still failed to meet PSDDA reference performance limits of less than or equal to 20 percent mortality relative to control (sediment/seawater) in both the amphipod and echinoderm bioassays, although the comparative test sediment mortality responses appeared to be much better than round 1 (see enclosures 1-4).

Examination of the levels of dissolved ammonia measured at the begining and end of each bioassay (amphipod and echinoderm) were comparably lower in round 2 than round 1 relative to bulk ammonia concentrations measured in sediments tested (see enclosures 5-8). Significant regression lines fitted to the scatter plots demonstrated the magnitude of differences (i.e., differences in regression lines (slopes)) between the initial and final dissolved ammonia test beaker measurements between rounds.

Round 1 amphipod and echinoderm test results were judged by the regulatory agencies as having failed acceptable QA/QC requirements and these two bioassay tests would have to be repeated. This subsequently required remobilizing and sediment resampling due to holding time expiration of round 1 sediments for bioassays. Round 3 retesting of the round 1 material using Jetty Island reference sediments finally met the reference sediment performance criteria for both the amphipod and echinoderm bioassays, although a second within-batch reference sample for the Blair Waterway characterization (also included with the Bellingham samples) failed the performance limits for the echinoderm bioassay (see enclosures 9-10). It should be noted that results of the second and third bioassay runs compared to round 1, appear to support the conclusion that aeration reduced but did not eliminate ammonia toxicity (see enclosure 12, lower figure), although the aeration also ameliorated or eliminated the sulfide problems previously noted in round 1 (see enclosure 3). The combined display of echinderm mortality relative to dissolved ammonia (@ 48 hours) for all three testing rounds suggests that there was an effect due to aeration, but that it may be due to the reductions in the combined influences of both ammonia and sulfide. Comparative mortalities in both echinoderm and amphipod bioassays were markedly lower between the two testing rounds (1 and 3) and the explanation for the mortality reduction for the amphipod bioassay is unclear at this time (see enclosure 9). Examining the bulk ammonia versus echinoderm mortality responses between the three testing rounds (see enclosures 1 and 10, and upper figure of enclosure 12) indicated that there were substantial differences in the regression slopes, whereas the slopes were essentially the same for each round for dissolved ammonia versus mortality (enclosures 2 and 10, and lower figure of enclosure 12). No explanation is readily apparent to discern why the regression slopes for dissolved ammonia versus bulk ammonia were higher in round 3 than round 1 (see enclosure 11). Collectively, data for all three bioassay rounds strongly implicate ammonia as an important contributing factor to observed echinoderm and possibly amphipod bioassay mortalities. It also indicates that ammonia effects are persistent for the echinoderm bioassay, and that this test species (Dendraster excentricus) is very sensitive to relatively low dissolved ammonia levels, as demonstrated by the three rounds of testing data (lower figure enclosure 12).

Interpreting the round 2 amphipod and echinoderm sediment larval bioassay test sediment results were problematic given the two reference sample performance failures, which may have been in part a consequence of the poorly matched grain sizes of the test and reference sediments (see enclosure 4). The following options for interpreting the amphipod and echinoderm test sediment results for round 2 are discussed below.

ALTERNATIVES:

1. Set aside both amphipod and echinoderm results and make regulatory decision on Neanthes and Microtox results only.

2. Retest the two bioassays.

3. Relax reference sample performance standards using best professional judgement.

4. Use round 3 reference data to interpret round 2 results.

5. Establish a generic reference sample response/administrative default (i.e., pool data from Samish Bay and Jetty Island Reference samples, where aeration was utilized to establish an average response).

DISCUSSION OF ROUND 2 INTERPRETATION ALTERNATIVES:

Alternative 1 does not appear to be an acceptable alternative to the PSDDA regulatory agencies. The PSDDA agencies collectively did not feel comfortable making a suitability decision utilizing only the remaining two bioassay results. The consensus was that the amphipod and echinoderm bioassay results were critical to the suitability decision matrix.

Alternative 2 is not a reasonable alternative, because everything that could be done to address the round 1 problems was tried in order to make the test work, which included aerating the test beakers and collection and use of new reference samples (i.e., Samish Bay). The test sediment responses appear to be reasonable, and interpretation of the results is possible if the reference sample performance problem can be overcome.

Alternative 3 is considered a reasonable approach given the problems currently being experienced with reference area performance. The MPR allows for exercising best professional judgement when reference sample performance is not met, and this alternative is certainly a viable option of dealing with the round 2 interpretation issue.

Alternative 4 was considered, but the Jetty Island reference sediment conventionals (i.e., grain size, etc.) did not match the round 2 test sediments (see enclosure 13). However, one of the two round 3 reference samples achieved the performance guideline for the echinoderm sediment larval test, and both reference samples were successful for the amphipod bioassay (see enclosure 9).

Grain size characteristics of the round 2 and round 3 reference sediments (Samish Bay and Jetty Island) effectively bracket the entire spectrum of grain sizes analyzed in round 2 testing (enclosure 13). Percent fines for round 2 reference samples (i.e., 88% & 94%) were generally higher than round 2 test sediments (i.e., 47% - 80% with a mean = 63% fines), whereas the grain sizes for the round 3 reference data (i.e., 49.1% & 38.1% fines) were coarser. Therefore, alternative 5 is the most viable alternative. Establishing a generic reference sediment by pooling the four reference sediment responses (where aeration was utilized) for the two bioassays provides an administrative reference sediment default that would enable a reasonable interpretation of the data to proceed. These data are depicted in enclosure 14, which shows that the average reference still exceeds the PSDDA **reference sample performance limit of less than or equal to 20% over the seawater control (or control sediment for amphipod bioassay)** for the echinoderm embryo bioassay (i.e., 23.9 %), but meets the performance requirement for the amphipod bioassay (i.e., 18.25 %). Exercising alternative 3 is therefore necessary to enable regulatory interpretation to proceed for the echinoderm sediment larval bioassay, thereby relaxing the reference sample performance limit using best professional judgement. Considering the variable response observed in both bioassays among the reference samples in round 1 and 3 testing, the average response is reasonable and reflects the additive contributing influences of sediment conventionals.

Additional corroborating evidence supporting this approach is provided in enclosure 13 for the amphipod reference data scatter plots for Samish Bay and Jetty Island, where a highly significant correlation coefficient ($p<.01$) was found between percent fines and percent mortalities. The regression equation derived from this relationship for various percent fines predicts mortalities for the test sediments, would be bracketted by those observed for the four reference sediments (see enclosure 13), and predicts for example, that sediment grain size effects on the amphipod bioassay response could account for 23.7 percent mortality given 70 percent fines in the reference sample, which is well within the grain size effects prediction range observed by Dewitt et.al. (1988)[1]. Scatter plots of echinoderm mortality versus percent fines for the four reference samples from Samish Bay and Jetty Island failed to show any discernable pattern by comparison (enclosure 13).

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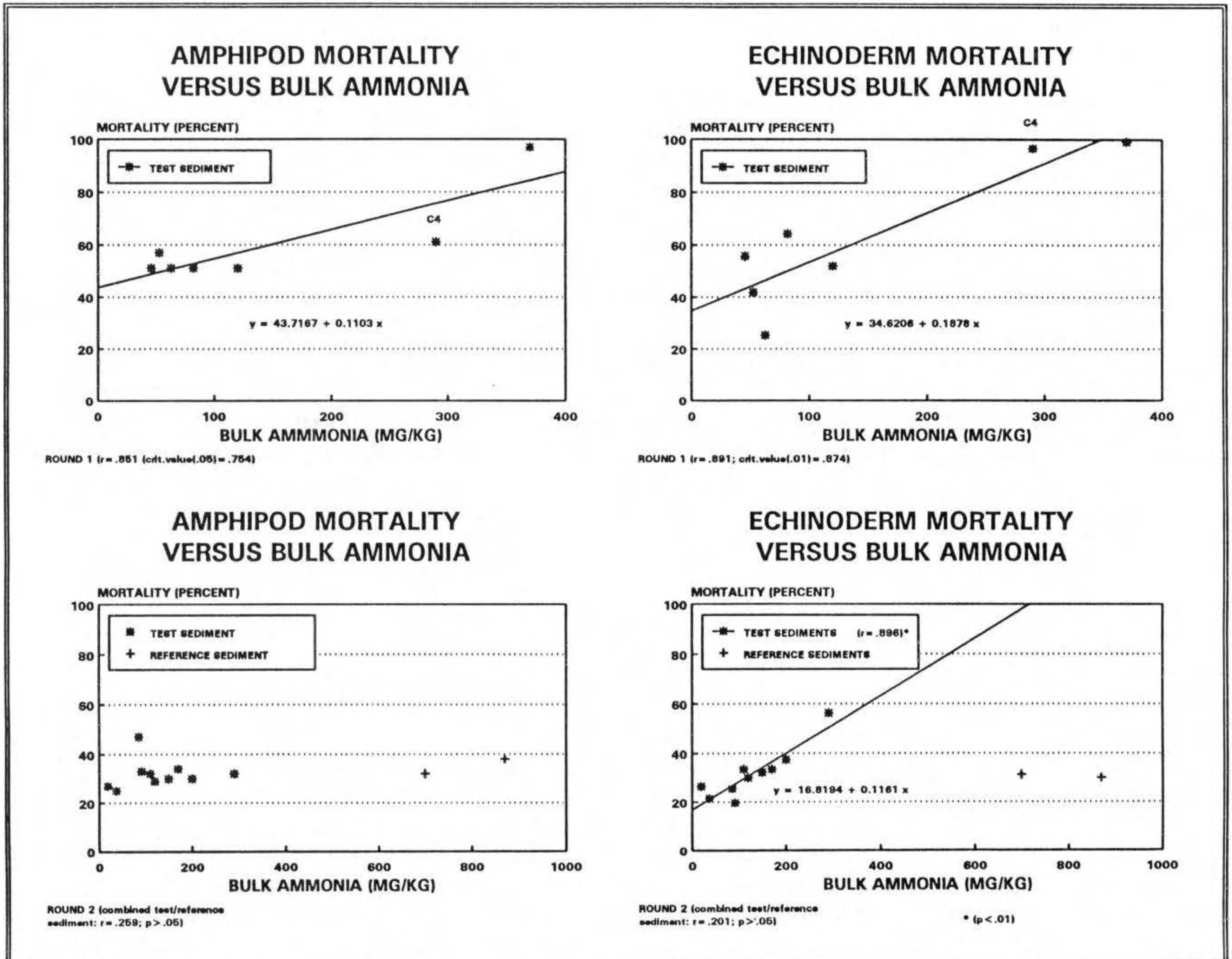
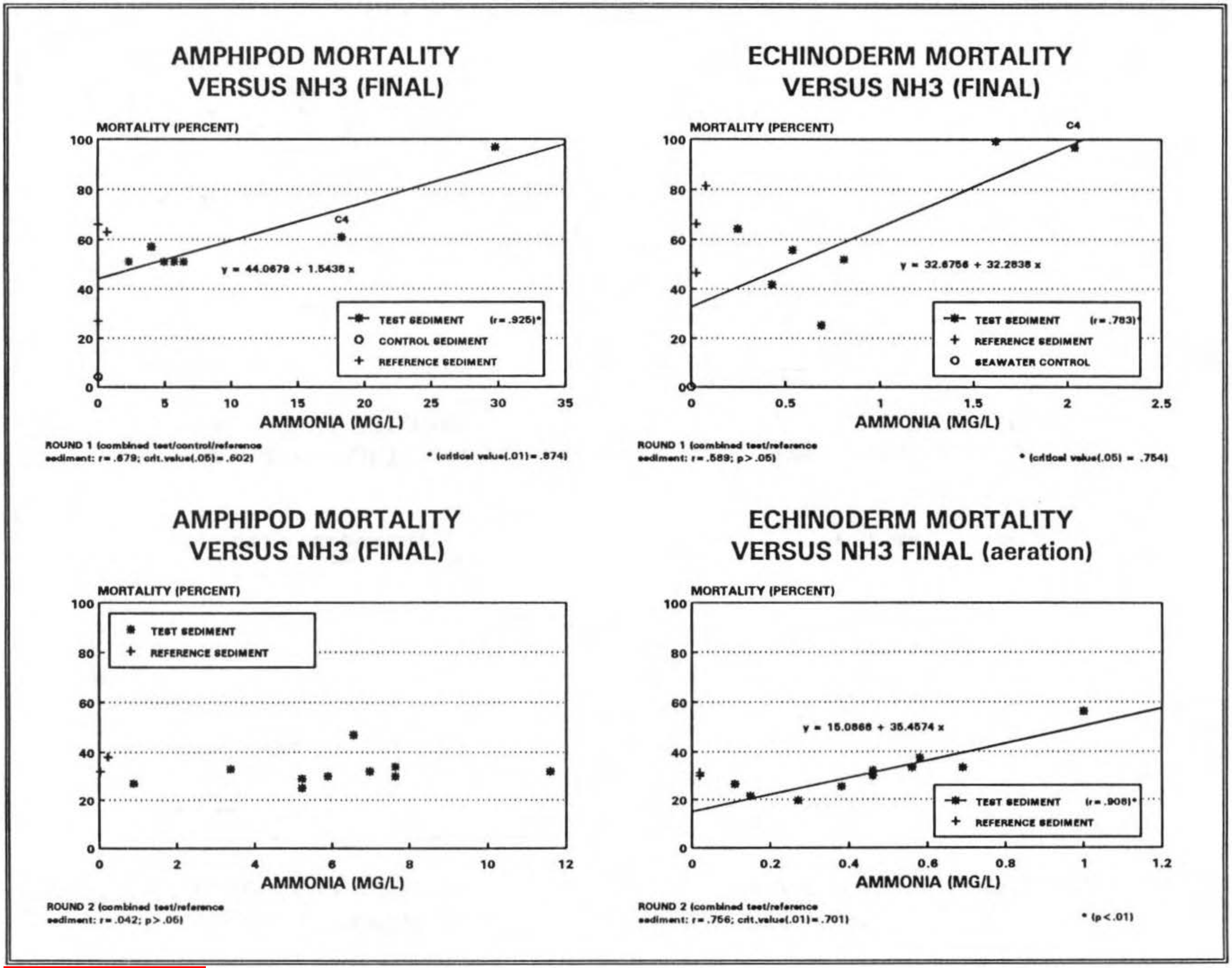
[1] Dewitt, H. T, G. R. Ditsworth and R.C. Swartz. 1988. Effects of Natural Sediment Features on Survival of the Phoxocephalid Amphipod, Rhepoxynius abronius. Marine Environmental Research 25: 99-124.

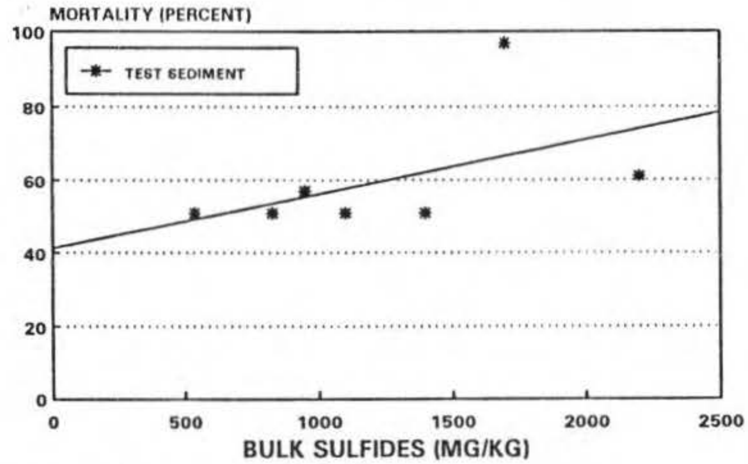

AMPHIPOD MORTALITY VERSUS BULK AMMONIA
MORTALITY (PERCENT)
TEST SEDIMENT
C4
y = 43.7167 + 0.1103 x
BULK AMMMONIA (MG/KG)
ROUND 1 (r=.851 (crit.value(.05)=.754)
ECHINODERM MORTALITY VERSUS BULK AMMONIA
MORTALITY (PERCENT)
C4
TEST SEDIMENT
y = 34.6206 + 0.1878 x
BULK AMMONIA (MG/KG)
ROUND 1 (r=.891; crit.value(.01)=.874)
AMPHIPOD MORTALITY VERSUS BULK AMMONIA
MORTALITY (PERCENT)
TEST SEDIMENT
REFERENCE SEDIMENT
BULK AMMONIA (MG/KG)
ROUND 2 (combined test/reference sediment: r=.259; p>.05)
ECHINODERM MORTALITY VERSUS BULK AMMONIA
MORTALITY (PERCENT)
TEST SEDIMENTS (r=.896)*
REFERENCE SEDIMENTS
y = 16.8194 + 0.1161 x
BULK AMMONIA (MG/KG)
ROUND 2 (combined test/reference sediment: r=.201; p>.05)
* (p<.01)

Enclosure 1


AMPHIPOD MORTALITY VERSUS NH3 (FINAL)
MORTALITY (PERCENT)
C4
y = 44.0679 + 1.5438 x
TEST SEDIMENT (r=.925)*
CONTROL SEDIMENT
REFERENCE SEDIMENT
AMMONIA (MG/L)
ROUND 1 (combined test/control/reference sediment: r=.679; crit.value(.05)=.602)
* (critical value(.01)=.874)
ECHINODERM MORTALITY VERSUS NH3 (FINAL)
MORTALITY (PERCENT)
C4
y = 32.6756 + 32.2838 x
TEST SEDIMENT (r=.783)*
REFERENCE SEDIMENT
SEAWATER CONTROL
AMMONIA (MG/L)
ROUND 1 (combined test/reference sediment: r=.589; p>.05)
* (critical value(.05) = .754)
AMPHIPOD MORTALITY VERSUS NH3 (FINAL)
MORTALITY (PERCENT)
TEST SEDIMENT
REFERENCE SEDIMENT
AMMONIA (MG/L)
ROUND 2 (combined test/reference sediment: r=.042; p>.05)
ECHINODERM MORTALITY VERSUS NH3 FINAL (aeration)
MORTALITY (PERCENT)
y = 15.0868 + 35.4574 x
TEST SEDIMENT (r=.908)*
REFERENCE SEDIMENT
AMMONIA (MG/L)
ROUND 2 (combined test/reference sediment: r=.756; crit.value(.01)=.701)
* (p<.01)

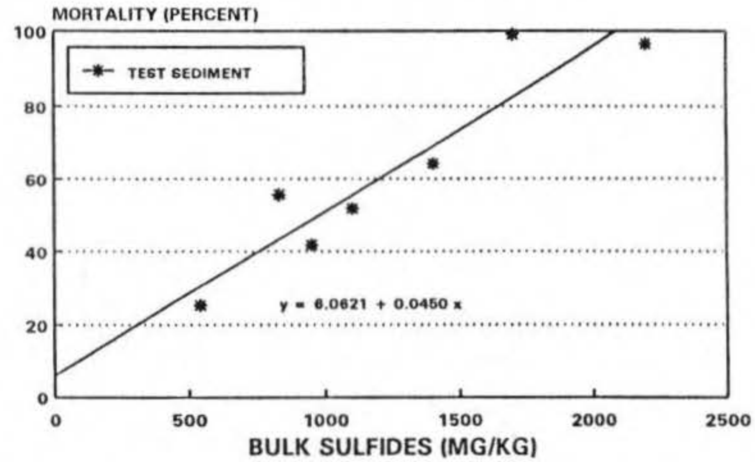
Enclosure 2

AMPHIPOD MORTALITY VERSUS BULK SULFIDES



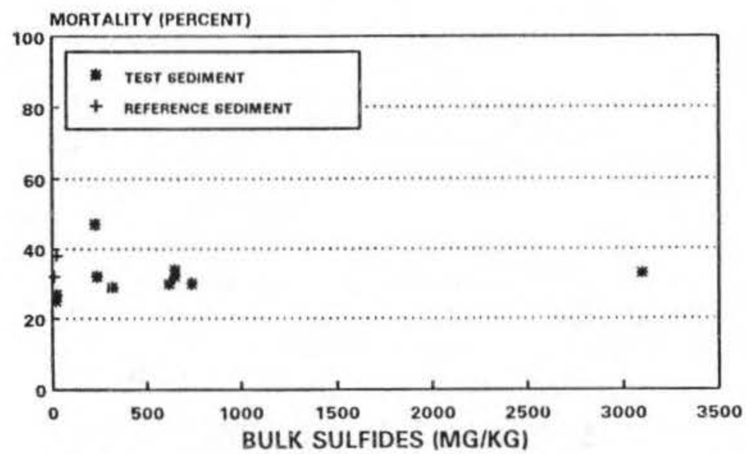
ROUND 1 (r = .50, p > .05)

ECHINODERM MORTALITY VERSUS BULK SULFIDES*



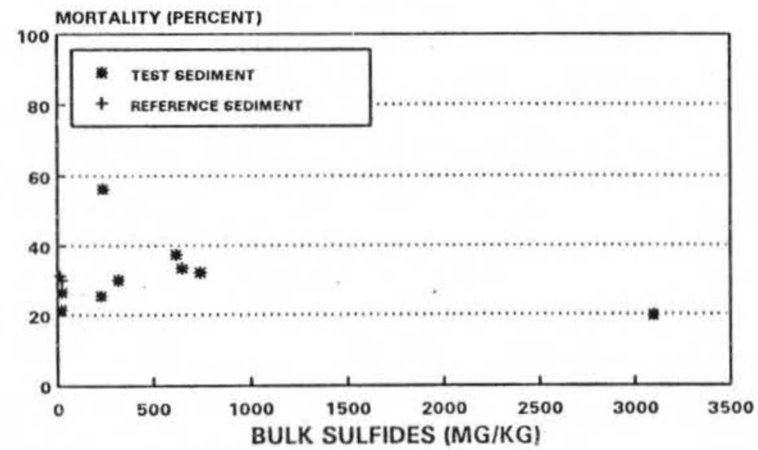
ROUND 1 (r = .93; crit.value(.01) = .874)

AMPHIPOD MORTALITY VERSUS BULK SULFIDES



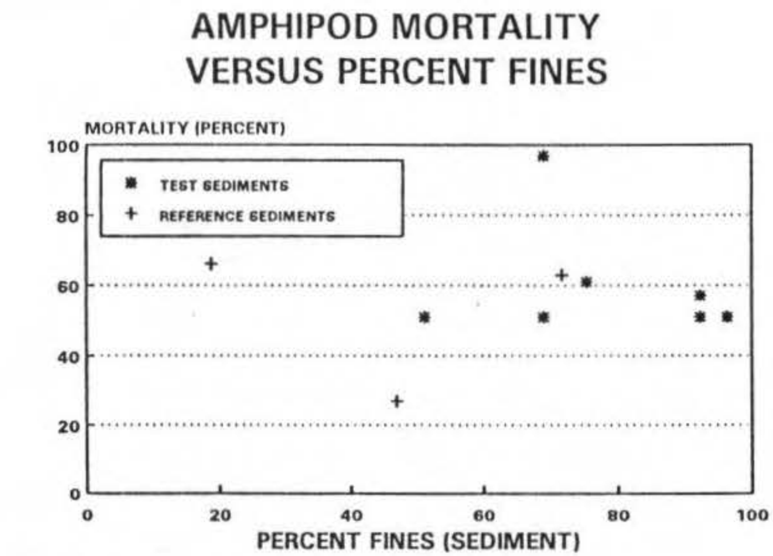
ROUND 2 (combined test/reference sediment: r = .024; p > .05)

ECHINODERM MORTALITY VERSUS BULK SULFIDES

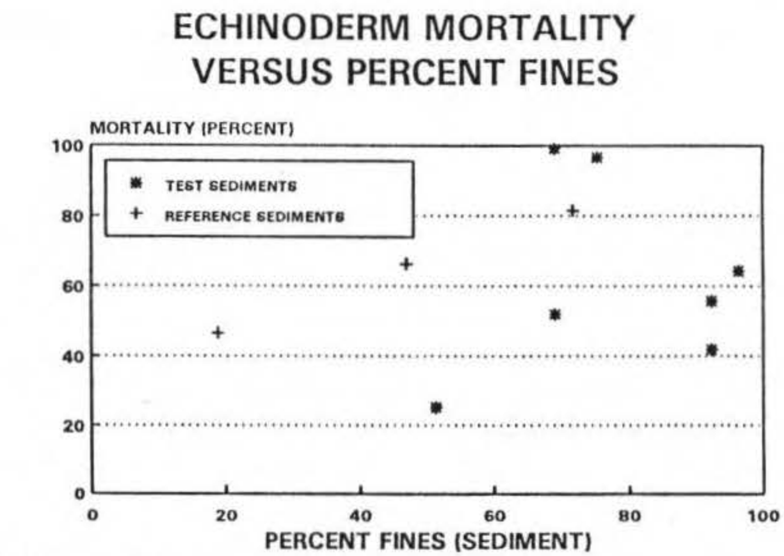


ROUND 2 (combined test/reference sediments: r = .295; p > .05)

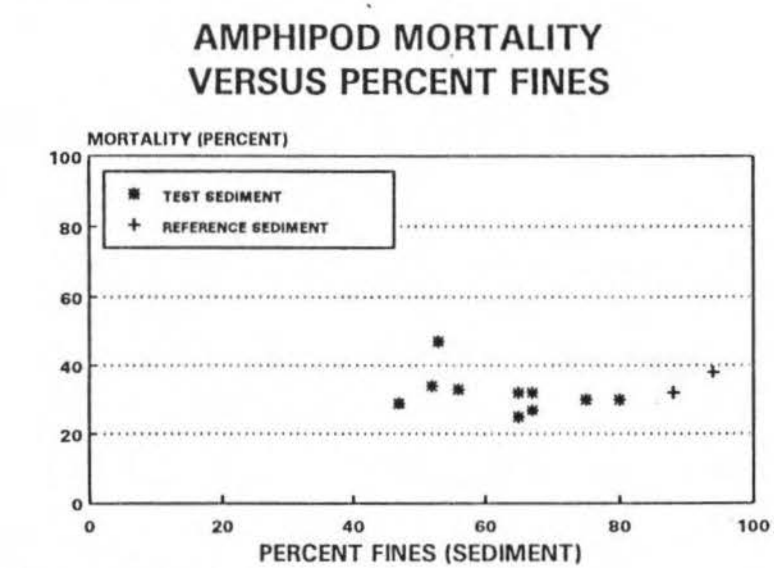
Enclosure 3



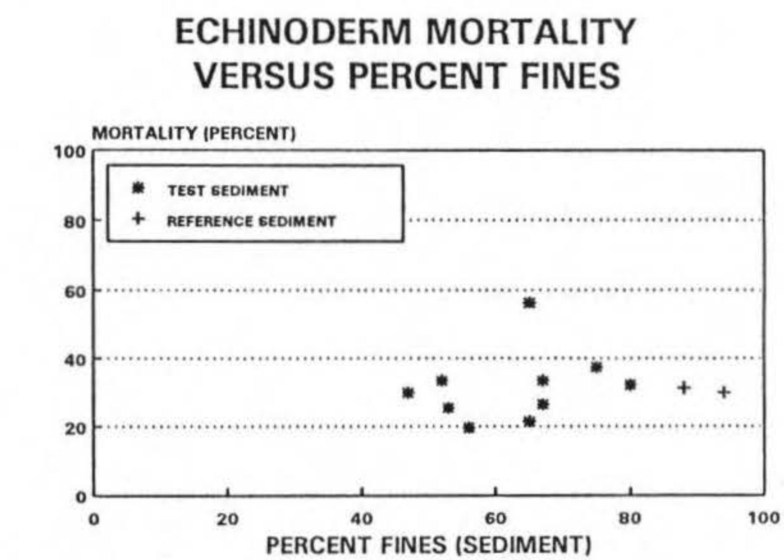
ROUND 1 (combined test/reference sediments: $r = .015$; $p > .05$)



ROUND 1 (combined test/reference sediments: $r = .205$; $p > .05$)



ROUND 2 (combined test/reference sediments: $r = .395$; $p > .05$)

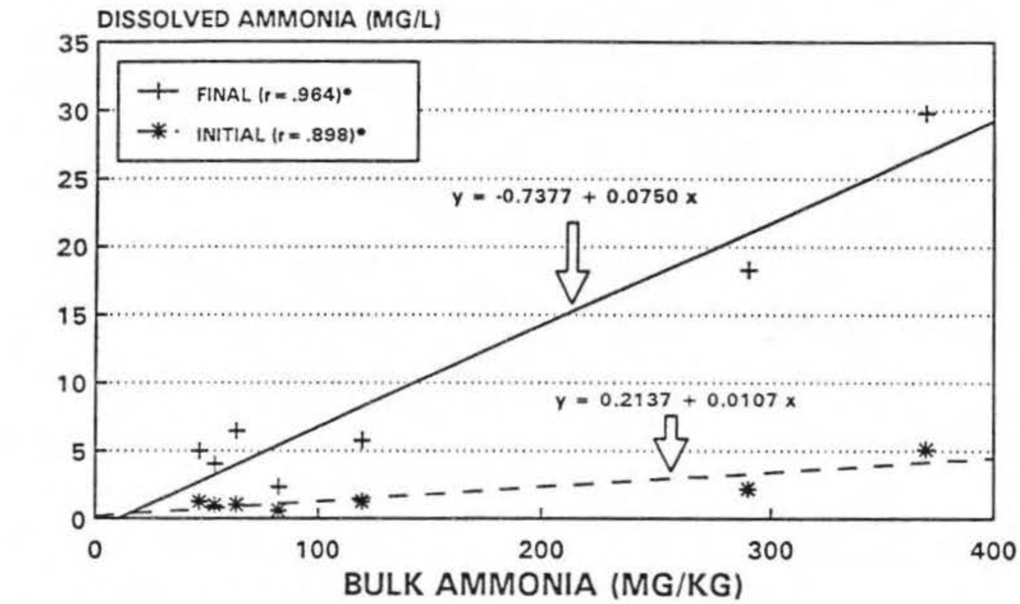


ROUND 2 (combined test/reference sediments: $r = .250$; $p > .05$)

Enclosure 4

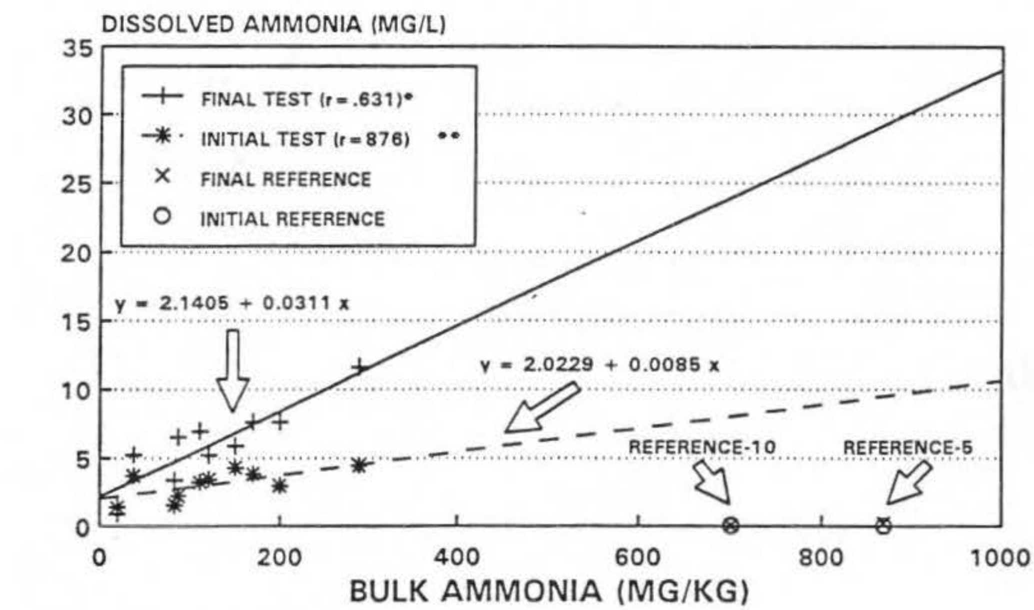
Enclosure 5

BULK AMMONIA (SEDIMENT)
VERSUS DISSOLVED AMMONIA (AMPHIPOD TEST)



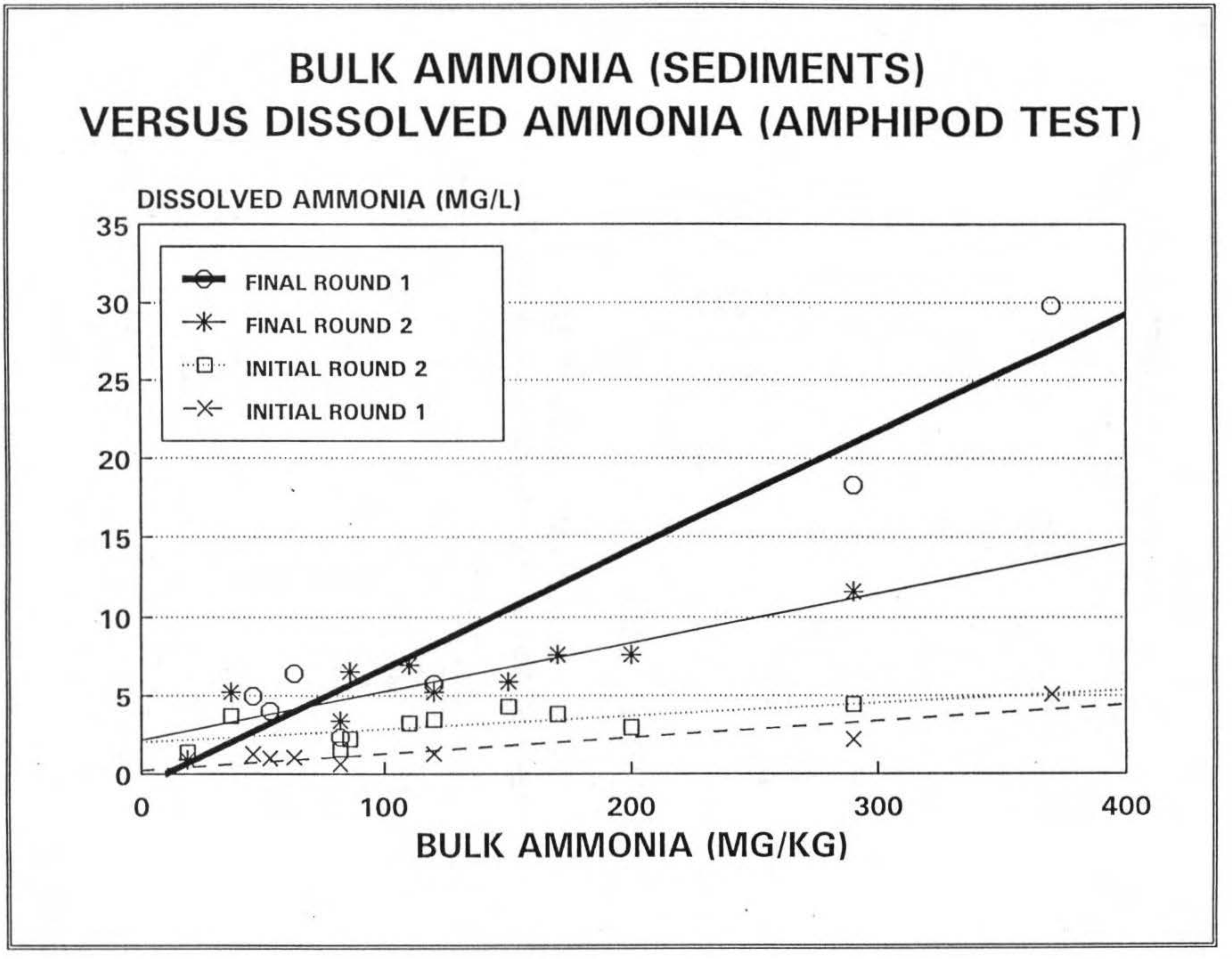
ROUND 1 TEST SEDIMENT/NO REFERENCE DATA
(INITIAL/FINAL NH3 READINGS) * $p < .01$

BULK AMMONIA (SEDIMENT)
VERSUS DISSOLVED AMMONIA (AMPHIPOD TEST)



ROUND 2 (INITIAL/FINAL NH3 READINGS)
* $p > .05$ ** $p < .01$

enclosure 5



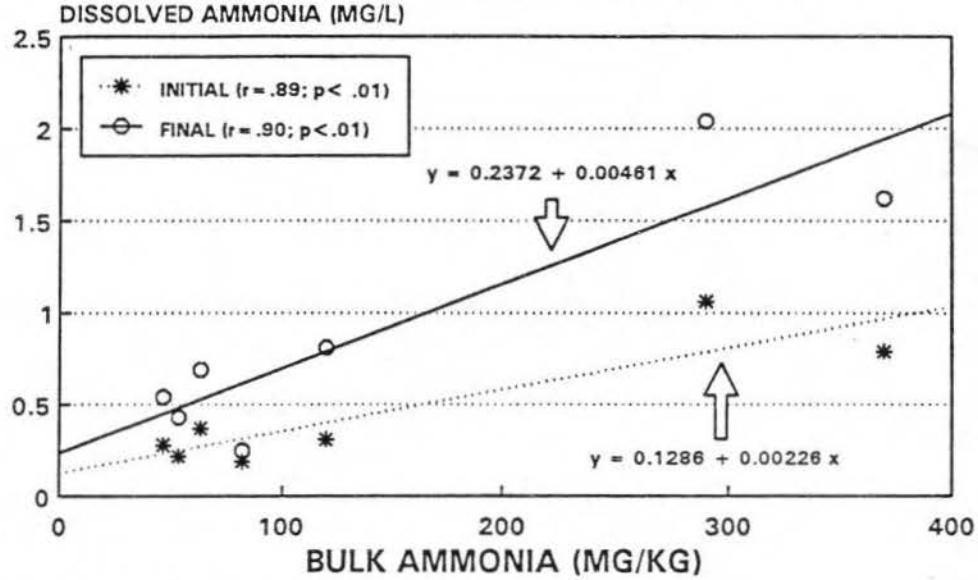
BULK AMMONIA (SEDIMENTS)
VERSUS DISSOLVED AMMONIA (AMPHIPOD TEST)
DISSOLVED AMMONIA (MG/L)
FINAL ROUND 1
FINAL ROUND 2
INITIAL ROUND 2
INITIAL ROUND 1
0
5
10
15
20
25
30
35
0
100
200
300
400
BULK AMMONIA (MG/KG)

Enclosure 6

Enclosure 7

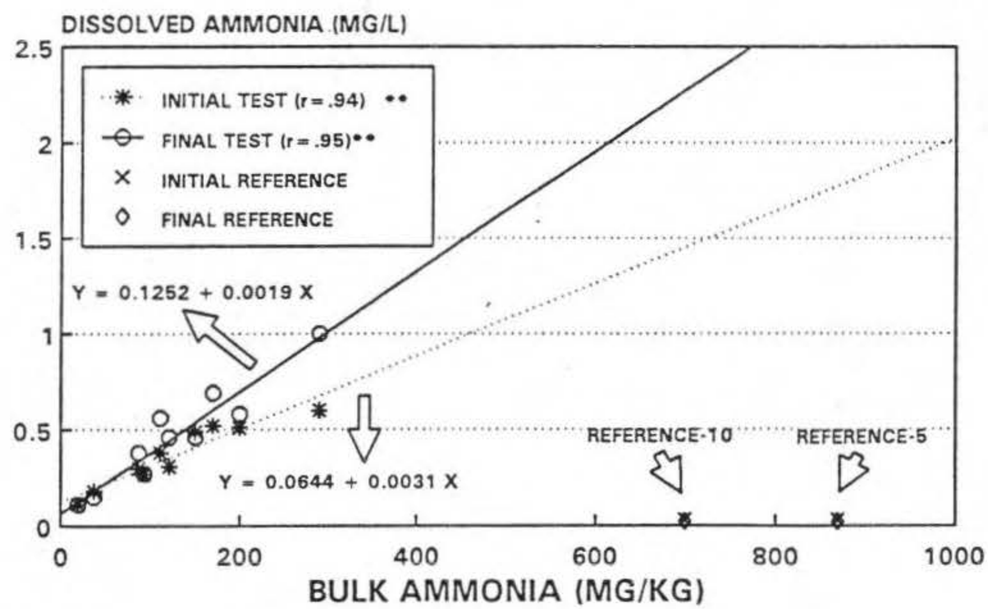
BULK AMMONIA (SEDIMENT) VERSUS DISSOLVED AMMONIA*

(DATA SHOWN INCLUDES TEST SEDIMENT ONLY; NO REFERENCE DATA)



*ROUND 1 (INITIAL/FINAL NH4 READING)
NO AERATION DURING ECHINODERM TEST

BULK AMMONIA (SEDIMENT) VERSUS DISSOLVED AMMONIA (ECHINODERM)*

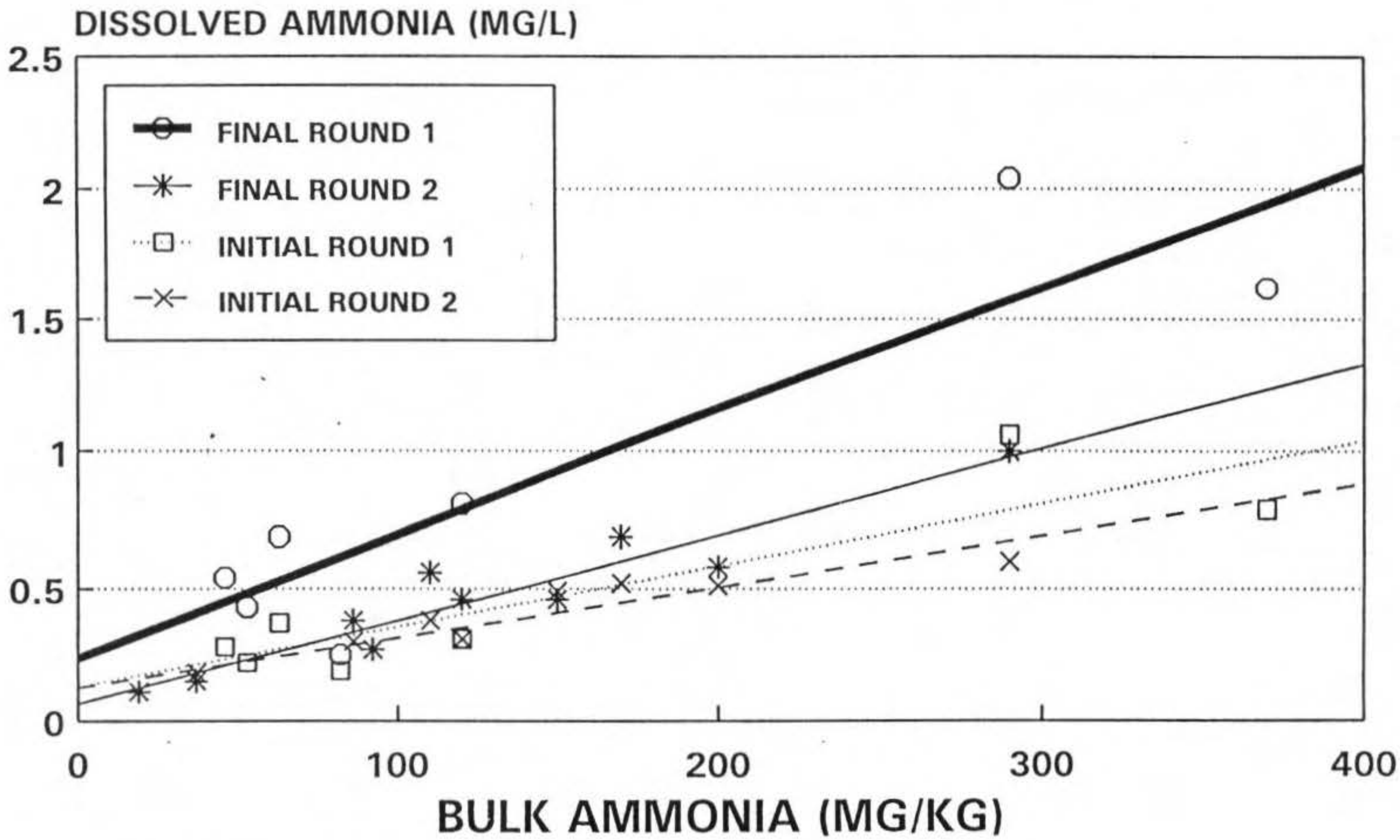


*ROUND 2 (INITIAL/FINAL NH3 READING)
WITH AERATION DURING ECHINODERM TEST

** p<.001

enclosure 7

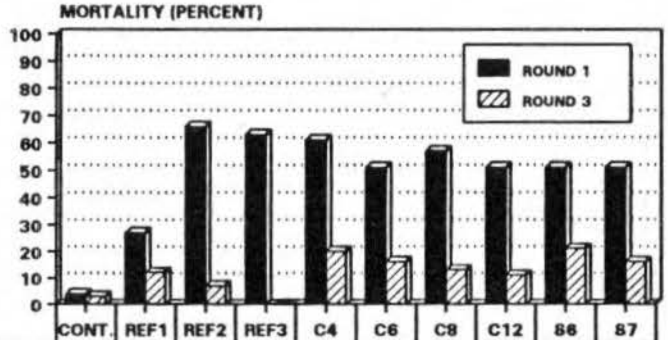
BULK AMMONIA (SEDIMENTS) VERSUS DISSOLVED AMMONIA



ECHINODERM BIOASSAY TEST SEDIMENT
DATA ONLY, ROUND 2 WITH AERATION.

Enclosure 8

AMPHIPOD BIOASSAY
ROUND 1 VERSUS ROUND 3

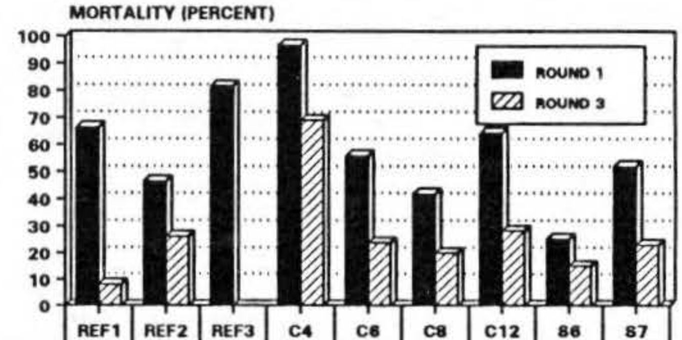


	CONT.	REF1	REF2	REF3	C4	C6	C8	C12	86	87
ROUND 1	4	27	66	63	61	51	57	51	51	51
ROUND 3	3	12	7		20	16	13	11	21	16

STATION/SAMPLE ID

SEQUIM BAY = ROUND 1 REFERENCE
JETTY ISLAND = ROUND 3 REFERENCE
REF2 = BLAIR WATERWAY (JETTY ISLAND)

ECHINODERM BIOASSAY
ROUND 1 VERSUS ROUND 3

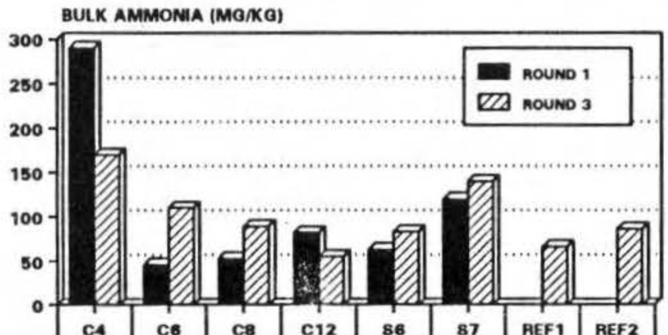


	REF1	REF2	REF3	C4	C6	C8	C12	86	87
ROUND 1	66.3	46.5	81.6	96.7	55.7	41.8	64.2	25.2	51.9
ROUND 3	8	26.1		68.9	23.8	19.9	28.2	15	23

STATION/SAMPLE ID

SEQUIM BAY = ROUND 1 REFERENCES
JETTY ISLAND = ROUND 3 REFERENCE
REF2 = BLAIR WATERWAY (JETTY ISLAND)

COMPARATIVE BULK AMMONIA (SEDIMENTS)
ROUND 1 VERSUS RETEST (ROUND 3)

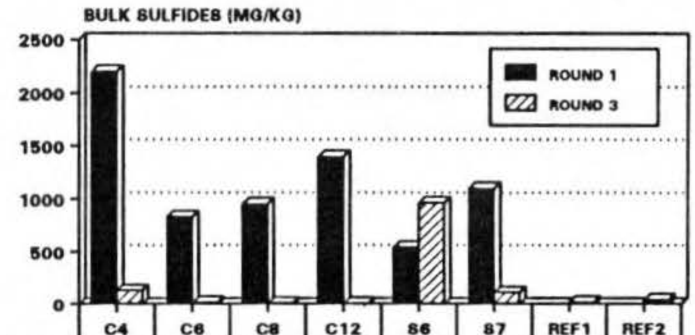


	C4	C6	C8	C12	86	87	REF1	REF2
ROUND 1	290	46	53	82	63	120	NA	NA
ROUND 3	170	110	89	55	83	140	66	86

STATION/SAMPLE ID

REF1 = JETTY ISLAND (BELLINGHAM)
REF2 = JETTY ISLAND (BLAIR)
NA = NOT ANALYZED (EXCEEDED HOLDING TIME)

COMPARATIVE BULK SULFIDES (SEDIMENTS)
ROUND 1 VERSUS RETEST (ROUND 3)



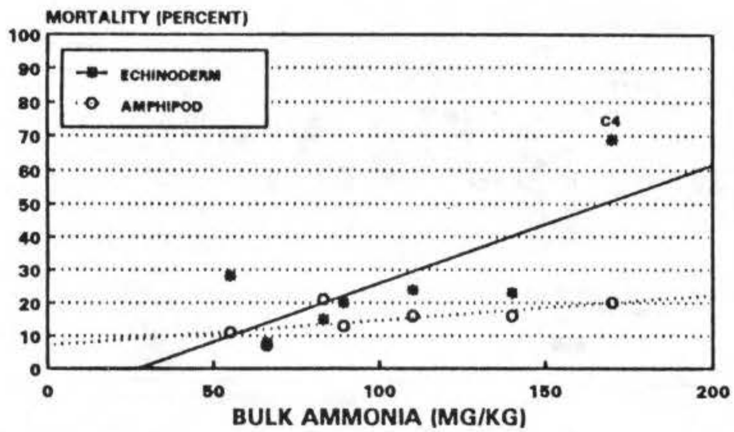
	C4	C6	C8	C12	86	87	REF1	REF2
ROUND 1	2200	830	950	1400	540	1100	NA	NA
ROUND 3	130	17	8.6	3.4	960	110	18	41

STATION/SAMPLE ID

REF1 = JETTY ISLAND (BELLINGHAM)
REF2 = JETTY ISLAND (BLAIR)
NA = NOT ANALYZED (EXCEEDED HOLDING TIME)

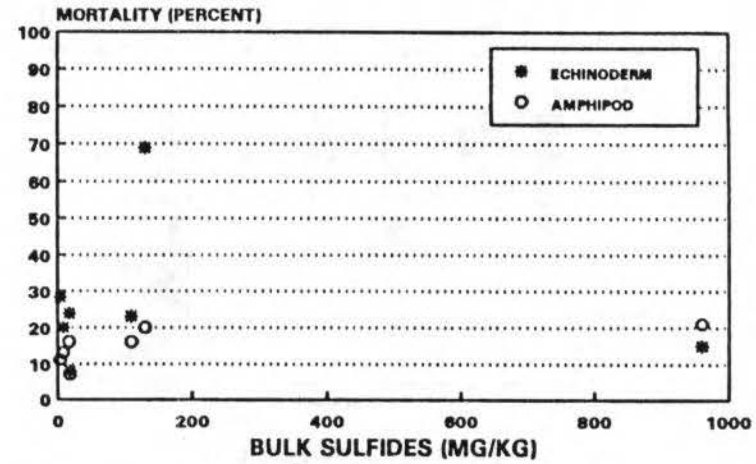
Enclosure 9

BIOASSAY MORTALITY VERSUS BULK AMMONIA



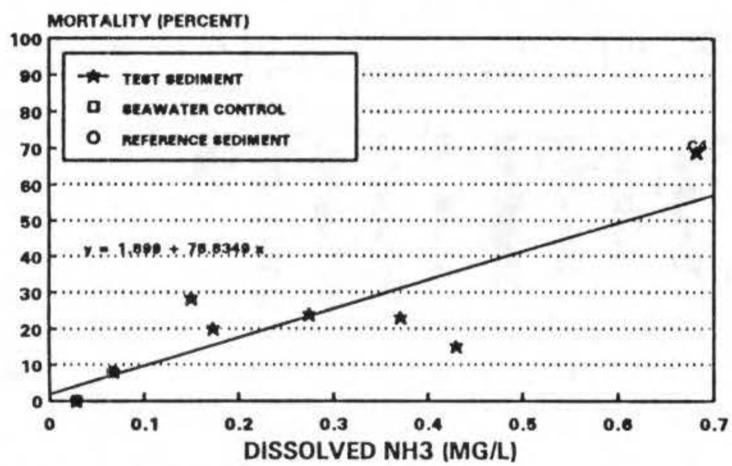
ROUND 3 (ROUND 1 RETEST)
ECHINODERM: r = .742 (p > .05)
AMPHIPOD: r = .633 (p > .05)

BIOASSAY MORTALITY VERSUS BULK SULFIDES



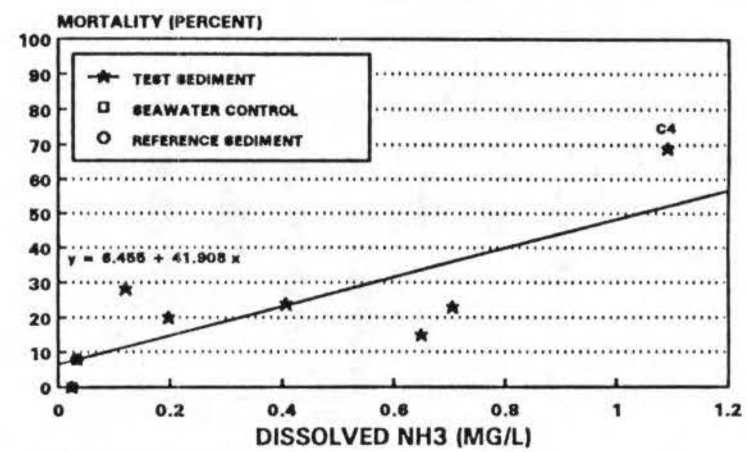
ROUND 3

ECHINODERM MORTALITY VERSUS DISSOLVED NH3 (INITIAL)



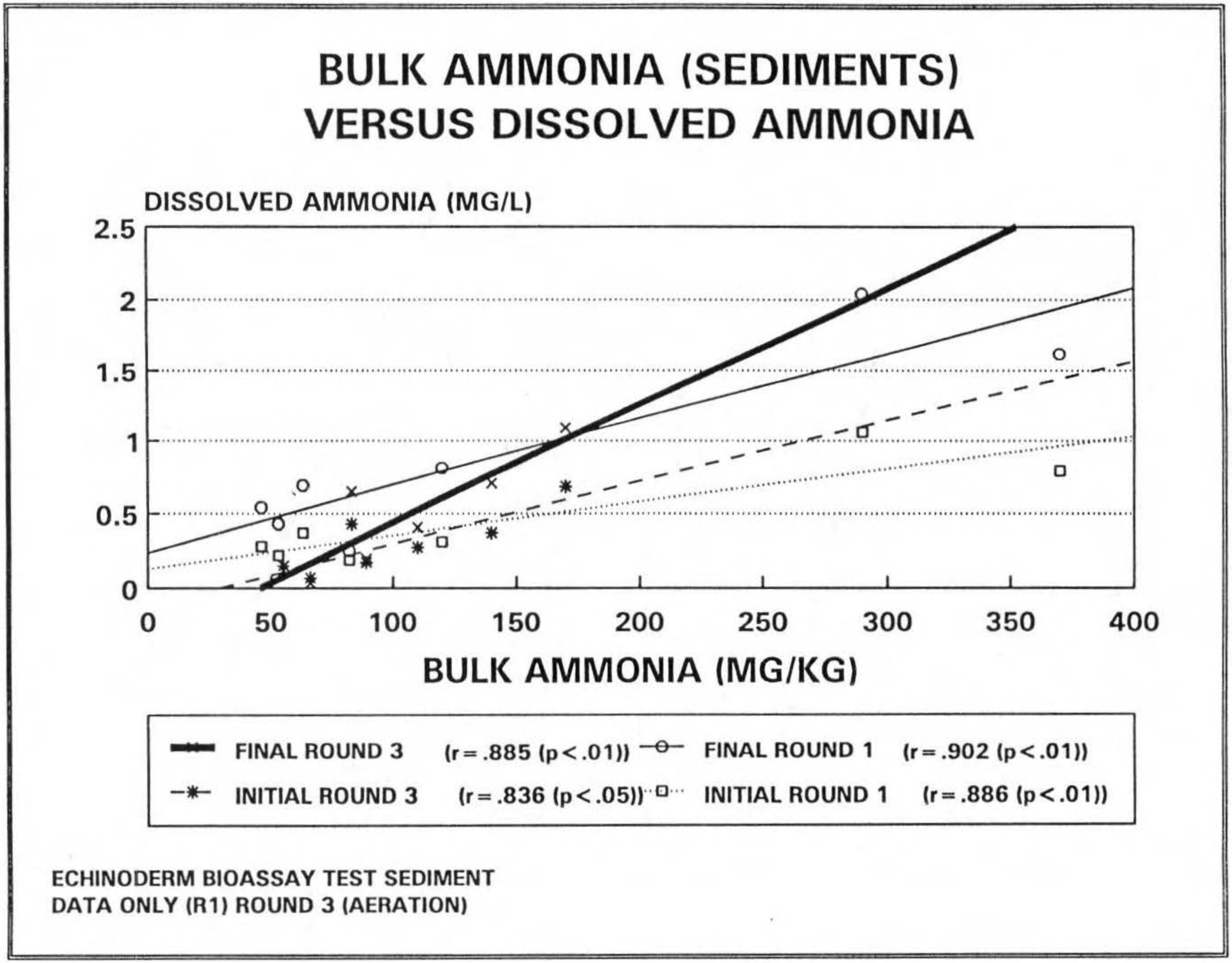
ROUND 3 (ROUND 1 RETEST)
r = .830 (crit.value(.05) = .707)

ECHINODERM MORTALITY VERSUS DISSOLVED NH3 (FINAL)



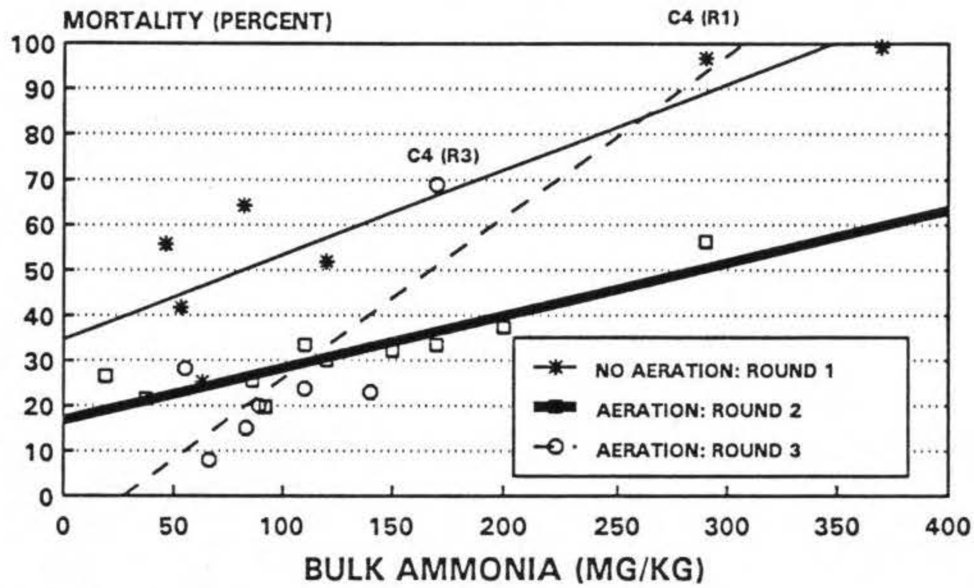
ROUND 3 (ROUND 1 RETEST)
r = .780 (crit.value(.05) = .707)

Enclosure 10



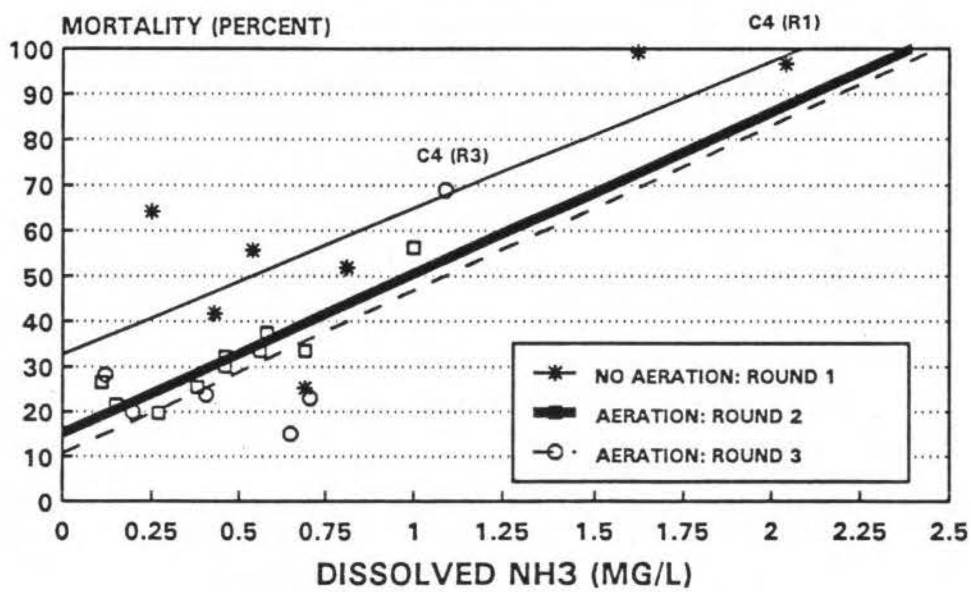
Enclosure 11

ECHINODERM MORTALITY VERSUS BULK AMMONIA



SIGNIFICANT REGRESSION LINES FOR EACH TESTING ROUND

ECHINODERM MORTALITY VERSUS DISSOLVED NH3 (FINAL)



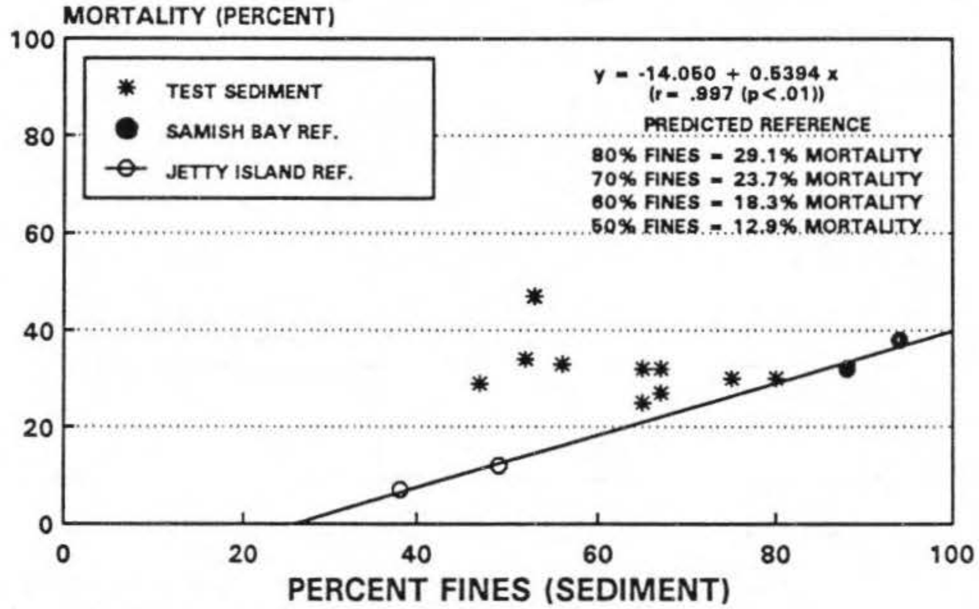
SIGNIFICANT REGRESSION LINES FOR EACH TESTING ROUND

Enclosure 12

enclosure 12

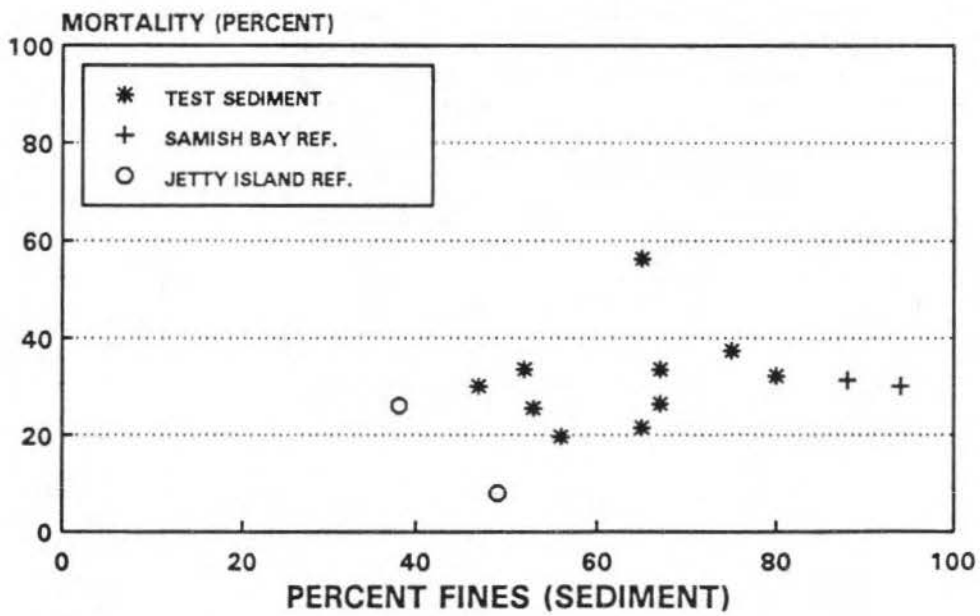
Enclosure 13

AMPHIPOD MORTALITY VERSUS PERCENT FINES



ROUND 2 EVALUATION

ECHINODERM MORTALITY VERSUS PERCENT FINES



ROUND 2 EVALUATION

encl 13

Enclosure 14

ADMINISTRATIVE DEFAULT REFERENCE FOR **AMPHIPOD** BIOASSAY
ROUND 2 (BELLINGHAM MAINTENANCE DREDGING)

	SAMISH BAY REFERENCE		JETTY ISLAND REFERENCE		MEAN REFERENCE
REP.#	REF5(R2)	REF10(R2)	REF1(BEL)	REF2(BLAIR)	POOLED DATA (N=20)
1	15	10	5	10	
2	50	35	15	0	
3	50	50	15	15	
4	35	20	10	5	
5	40	45	15	5	
MEAN	38	32	12	7	22.25
SD	14.40	16.81	4.47	5.70	17.13

ADMINISTRATIVE DEFAULT REFERENCE FOR **ECHINODERM EMBRYO** BIOASSAY
ROUND 2 (BELLINGHAM MAINTENANCE DREDGING)

	SAMISH BAY REFERENCE		JETTY ISLAND REFERENCE		MEAN REFERENCE
REP.#	REF5(R2)	REF10(R2)	REF1(BEL)	REF2(BLAIR)	POOLED DATA (N=20)
1	29.8	38.1	14.1	18.4	
2	28.0	55.7	0	21.9	
3	40.4	38.1	12.3	31.0	
4	19.2	12.2	3.5	17.3	
5	33.1	12.2	9.9	41.9	
MEAN	30.1	31.3	8.0	26.1	23.86
SD	7.72	18.82	5.99	10.34	14.48

enclosure 14