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DYNAMAC
CORPORATION
Environmental Services

80 W. Lancaster Avenue
Devon, PA 19333

Telephone: 215-989-9400
Fax: 215-989-9414

Mr. Randy Sturgeon
U.S. EPA Region III
841 Chestnut Building
Philadelphia, PA 19107

Reference: Contract No. 68-W9-0005
Work Assignment No. C03034
DuPont Newport, Newport, Delaware

Subject: Revised Performance Schedule

Dear Mr. Sturgeon:

As per your request and discussions of the teleconference held on May 7, 1993, Dynamac has revised the document submitted to you on April 29, 1993.

Attachment 1 provides an Explanation of Procedures used to develop the Performance Standards as well as proposed the Sampling Plan.

Attachment 2 provides a Cost Estimate for the implementation of the proposed Sampling Plan.

If you have any questions, please call me at (215) 989-9400.

Sincerely,

Camille Costa, P.E.
Manager, Engineering

cc: Ms. Donna McGowan, US EPA Region III, CERCLA RPO
Mr. Robert Stecik, Vice President, Northeast Operations

Corporate Headquarters: The Dynamac Building, 2275 Research Boulevard, Rockville, MD 20850-3268

SAMPLING PLAN AND PERFORMANCE STANDARDS FOR THE DUPONT-NEWPORT SITE

A systematic sampling plan has been developed for the SDS wetlands, NDS wetlands, and Christina River at the DuPont-Newport site. The sampling plan has been designed to provide a statistically sound basis for testing the following hypothesis:

The growth of Chironomus tentans, survival of Chironomus tentans, and survival of Hyalella azteca are reduced in site sediments relative to the same endpoints for these organisms in sediments from an area unaffected by the DuPont-Newport site but otherwise the same.

Stratification of Site

To increase precision, the SDS wetlands, SDS pond, NDS wetlands, the Christina River upstream from the North Drainageway, and the Christina River downstream from the North Drainageway are considered to be different statistical strata or domains at the site, and systematic sampling has been designed for each stratum. The north drainageway, the northern half of the SDS wetlands and the north bank of the river along the NDS and CIBA-GEIGY were not included because it is anticipated that these areas will be remediated due to very high sediment contamination levels.

The statistical design developed for this report is based in part on a careful evaluation of the results of preliminary sediment toxicity testing conducted during the RI. The within-station variance and the coefficients of variation for sets of samples in each stratum were used in selecting the appropriate number of samples for each stratum and the necessary number of replicates at each station, as described below.

Replicates

In the RI sediment toxicity tests, four (4) replicate samples were collected at each sampling station. There was relatively little dispersion in the observed survival rates for *Chironomus tentans* and *Hyalella azteca*. Given that the average standard deviation across the site was 19% or lower in the RI tests, and assuming that the same standard deviation will be seen in future tests, it can be further assumed that six (6) replicates at each station will be sufficient to discern impacts related to contamination from other impacts. The choice of six (6) replicates is based on a statistical power analysis, given that the specified significant difference in survival rates is 32.5% relative to reference for *Chironomus tentans*, and 30% relative to reference for *Hyalella azteca*, as described below. That is, six (6) replicates will be sufficient to discern between significant differences and variation caused by background causes, given a standard deviation of less than 19%.

EPA guidance on performance standards for toxicity tests for these two organisms to be published this autumn will be recommending use of eight (8) replicates per station when the tightness of the variance is unknown; therefore the decision to use only six replicates is based largely on the small standard deviations in the preliminary data (Ankley, 1993; Norberg-King, 1993).

Number of Samples to be Collected from Each Stratum
The number of samples required to obtain a given precision with a specific confidence level can be obtained from the following equation:

$$n = \frac{(CV)^2\ (t_\alpha^2)}{p^2}$$

where n= number of stations
CV= coefficient of variation
p= allowable margin of error expressed as a percent
t= the two tailed t value obtained from standard statistical tables at the α level of significance and at (n-1) degrees of freedom. (Mason, B.J., 1983).

For this sampling plan, a confidence level of 95% has been chosen. The selected allowable margin of error is +/- 10%; this means that a +/- 10% precision is considered reasonable in making a determination for each stratum of the need for remediation based on the results of sediment toxicity tests. The coefficient of variation was developed from the preliminary *Chironomus tentans* and *Hyalella azteca* sediment toxicity tests presented in the RI (see Tables A, B,and C, which provide statistical summaries of the RI sediment toxicity data). Based on the RI data, the average coefficient of variation for each stratum is 39% or less (when 0% survival values are ignored). While the average coefficients of variation are different for each stratum, the average coefficient of variation across the site for survival for both organisms is 27.1%. To be conservative a coefficient of variation of 29% was used in the above equation to calculate the required number of samples in each stratum. Ignoring the 0% survival results in calculating the coefficient of variation for each stratum is assumed to be a reasonable step, because the sediments with extremely high mortality will clearly have to be remediated.

Using these values for the variables in the above equation (95% confidence, 10% error, and 29% site-wide coefficient of variation) yields 35 stations for each stratum. However, since the SDS pond is small and the whole pond will either be cleaned up or not, 35 stations will not be necessary there. Therefore, five (5) stations (locations based on professional judgement) will be placed in the SDS pond. The 35 stations in each of the other strata besides the SDS pond should be placed in a rectangular grid. The grids will be expanded or contracted to fit the size and approximate shape of the stratum. Based on maps provided in the RI, the approximate dimensions between nodes of the grids will be: SDS wetlands, 150' X 250'; NDS wetlands, 300' X 120'; Christina River upstream, 480' X 175'; Christina River downstream, 960' X 175'.

Total Number of Samples
As described above, six (6) replicates will be collected from each station for each organism (six (6) for *Chironomus tentans* and six (6) for *Hyalella azteca*). An additional sample will be collected from each station to be analyzed for physical and chemical characteristics (grain size, Ph, and the suite of TAL metals). At approximately 10% of the stations in each stratum, (four

(4) stations), duplicates for sediment physical and chemical characteristics will be collected to increase precision.

In addition, sediment toxicity tests, benthic community analyses, physical and chemical analyses will be conducted at two appropriate reference locations that will be as similar as possible to site sampling stations, particularly with respect to sediment physical characteristics, except for the absence of site influence.

Performance Standards for Conducting the *Hyalella azteca* survival, *Chironomus tentans* survival, and *Chironomus tentans* growth tests are as follows:

Background Station Survival *Chironomus tentans*: 70% (ASTM, 1992).

Background Station Survival *Hyalella azteca*: 80% (ASTM, 1992).

These background station survival rates are published in the American Society for Testing and Materials Standard Guide for Conducting Sediment Toxicity Tests with Freshwater Invertebrates (Standard E 1383-92). If the average survival rates fall below either of these percentages, the test is considered unacceptable.

Note: If these control survival rates are not achieved, the test will have to be repeated. Results from any tests with less than the above-specified survival rates for the controls will be considered invalid.

The need for remediation at different stations has been established based on the results of sediment toxicity tests and the performance standards set for this site. The performance standards for sediment toxicity tests at the DuPont-Newport site are based on a thorough review of the data presented in the RI (especially Tables C-10, C-12, C-13, and C-14; Woodward Clyde, 1992) and a statistical analysis. These standards are wholly consistent with the recommendations of EPA sediment toxicity experts (Norberg-King, 1993; Ankley, 1993), and provide a statistically sound indication of the need to remediate different portions of the site. These performance standards, when applied to the sediment toxicity tests conducted during the RI, support existing decisions to remediate the stations described in Table 1.

The sediment toxicity test performance standards are:

- 32.5% drop (difference of 32.5%) in relative *Chironomus tentans* survival (Figure 1),
- 30% drop (difference of 30%) in relative *Hyalella azteca* survival (Figure 2), and
- 35% reduction (factor of 35%) in relative *Chironomus tentans* growth (Figure 3).

Detailed statistical analyses of the sediment toxicity tests from the RI showed that an observed decrease is probably related to contamination, and not to other sources of variation, when there is a 32.5% or more drop in *Chironomus tentans* survival relative to the reference station (see Attachment A for an in-depth discussion of the statistical analysis of variance performed), a 30% drop in *Hyalella* survival, and a 35% reduction in *Chironomus* growth. It should be noted that while the analysis of variance indicates that an 18.7% drop in *Hyalella azteca* survival is the

TABLE 1

MAJOR REASONS WHY STATIONS REQUIRE REMEDIATION

1. AS03: Low benthic diversity, expected low *Hyalella azteca* survival (very low survival occurred in the RI but problems with the laboratory control of this test has decreased the validity of the data), high percent dominance of pollution tolerant benthos.

2. AS07: Extremely low benthic density, low *Chironomus tentans* survival, no vegetation present.

3. AS08: Extremely low benthic density, low taxa richness, extremely low *Chironomus tentans* survival.

4. AS09: Extremely low benthic density, low taxa richness, low *Chironomus tentans* survival.

5. RS01: Low benthic diversity, expected low *Hyalella azteca* survival (very low survival occurred in the RI but problems with the laboratory control of this test has decreased the validity of the data), high percent dominance of pollution tolerant benthos.

6. RS11: Low taxa richness, extremely high percent dominance of pollution tolerant benthos.

7. RS12: Low taxa richness, extremely high percent dominance of pollution tolerant benthos, low *Chironomus tentans* survival.

* This table was prepared by U.S. EPA Region III.*

minimum that could be detected with four replicates, a 30% drop has been set as the performance standard to be conservative,because the *Hyalella azteca* survival test in the RI was flawed by low survival of the control (Woodward Clyde, 1992).

The values chosen for the performance standards are the result of careful examination of the preponderance of evidence for the need to remediate particular stations at the site, as well as of the variation in the RI sediment toxicity test results. The following factors limited the choice of the selected performance standard values.

If the performance standard were set too low, then the result would be that, for example, stations AS09 and AS07 might not appear to need remediation, when ecological evidence indicates that they do require remedial action (see Figure 1). That is, stations AS09 and AS07 exhibit low benthic density and low benthic taxa richness, and high levels of chemical contamination (see Table 1). If a very large drop in relative survival was set as the standard, some stations might not be remediated where real ecological effects were being observed.

If the performance standard were set too high, then the result would be that some areas, which do not require remedial action, would appear to require such action. For example, if the performance standard for *Chironomus tentans* survival was set at a 10% decrease relative to the reference, then stations RS13 and AS12 would appear to need remediation (see Figure 1); however, the rest of the ecological evidence presented in the RI is not consistent with this result. That is, the RI indicates there is no need for remediation at these two stations.

The statistical analysis behind setting the minimum difference for the performance standards can be summarized as follows (see Attachment A for a detailed explanation). Four (4) replicates were collected from each station for sediment toxicity tests in the RI. The variation between replicates at each station was measured. The average standard deviation for *Chironomus tentans* survival rates was approximately 19%, (the standard deviations for replicates for *Hyalella* survival and *Chironomus* growth were even lower; see Tables A, B, and C, which summarize data presented in the RI). Using this standard deviation, we conducted an analysis of variance (ANOVA) test to decide what amount of a difference could be attributed to contamination alone, given that there were four replicates from each station. This test was evaluated at a 95% confidence level, that is, with 95% confidence that when a pollutant effect is indicated by the results of the sediment toxicity tests, it is highly probable that there is a pollution effect at the site. (See calculations in Attachment A). As a result of the ANOVA tests, a 32.5% difference in relative *Chironomus tentans* survival was calculated as the minimum detectable difference. Similarly, we calculated an 18.7% difference in relative *Hyalella azteca* survival, and a 35% <u>reduction</u> in relative *Chironomus* growth, as the minimum detectable differences based on the RI data.

Again, while the analysis of variance indicates that an 18.7% drop in *Hyalella azteca* survival is the minimum that could be detected with four replicates, a 30% drop has been set as the performance standard to be conservative, because the *Hyalella azteca* survival test in the RI was flawed by low survival of the control (Woodward Clyde, 1992).

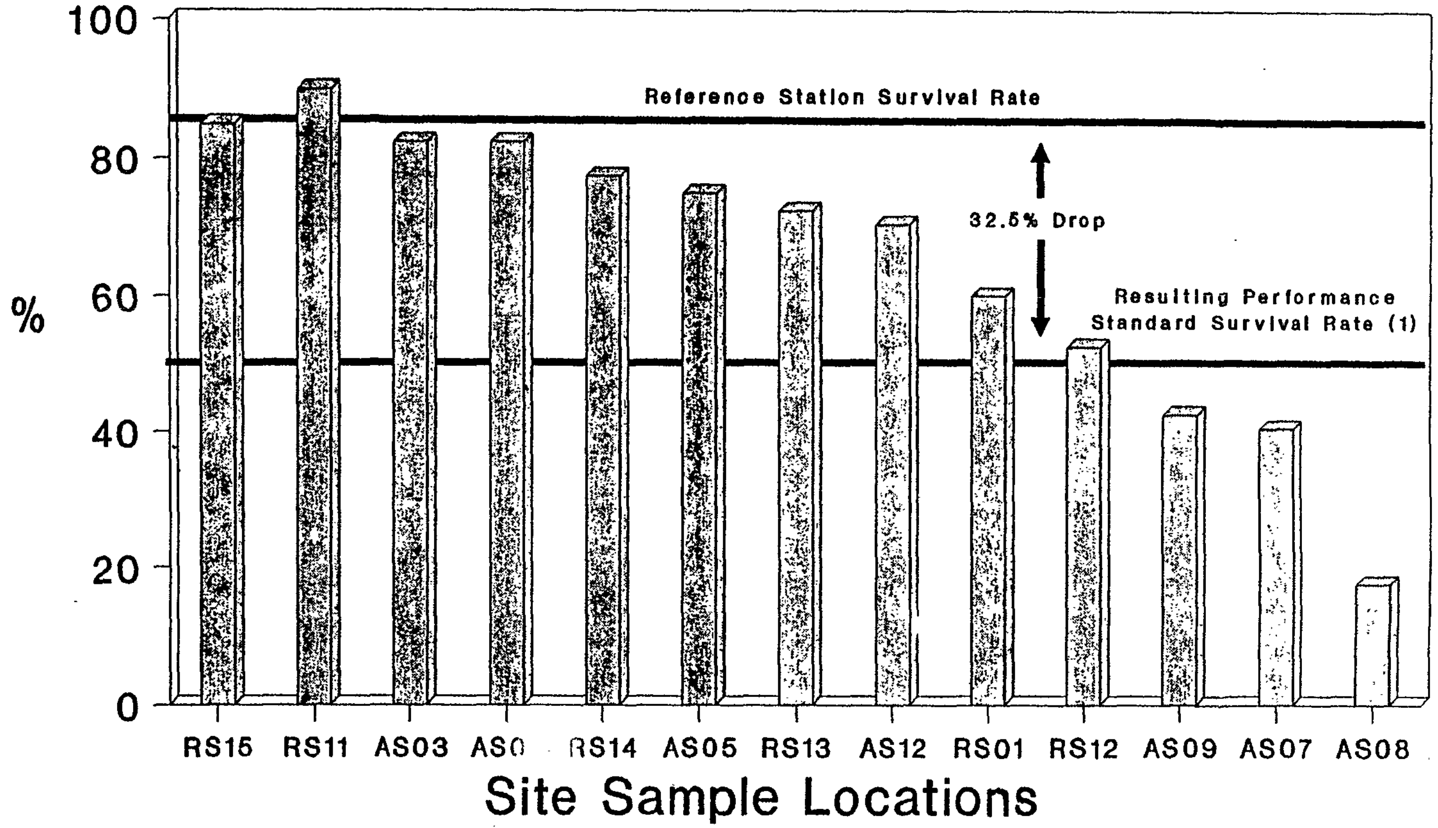
It is important to note that these performance standards have been approved by EPA sediment toxicity experts as discernable differences between reference and site stations (Norberg-King, 1993; Ankley, 1993), when an adequate number of replicates are used.

The use of six (6) replicates per station is recommended to ensure a powerful statistical test of the hypothesis that site sediments are adversely impacted. The more replicates are used, the more certain it will be that areas that appear to be unimpaired based on the results of the toxicity tests are, in fact, unimpaired at the site.

Figure 1

Survival (%) of Chironomus tentans Relative to RS15

(From Table C-10, DuPont/Newport RI, 1992)

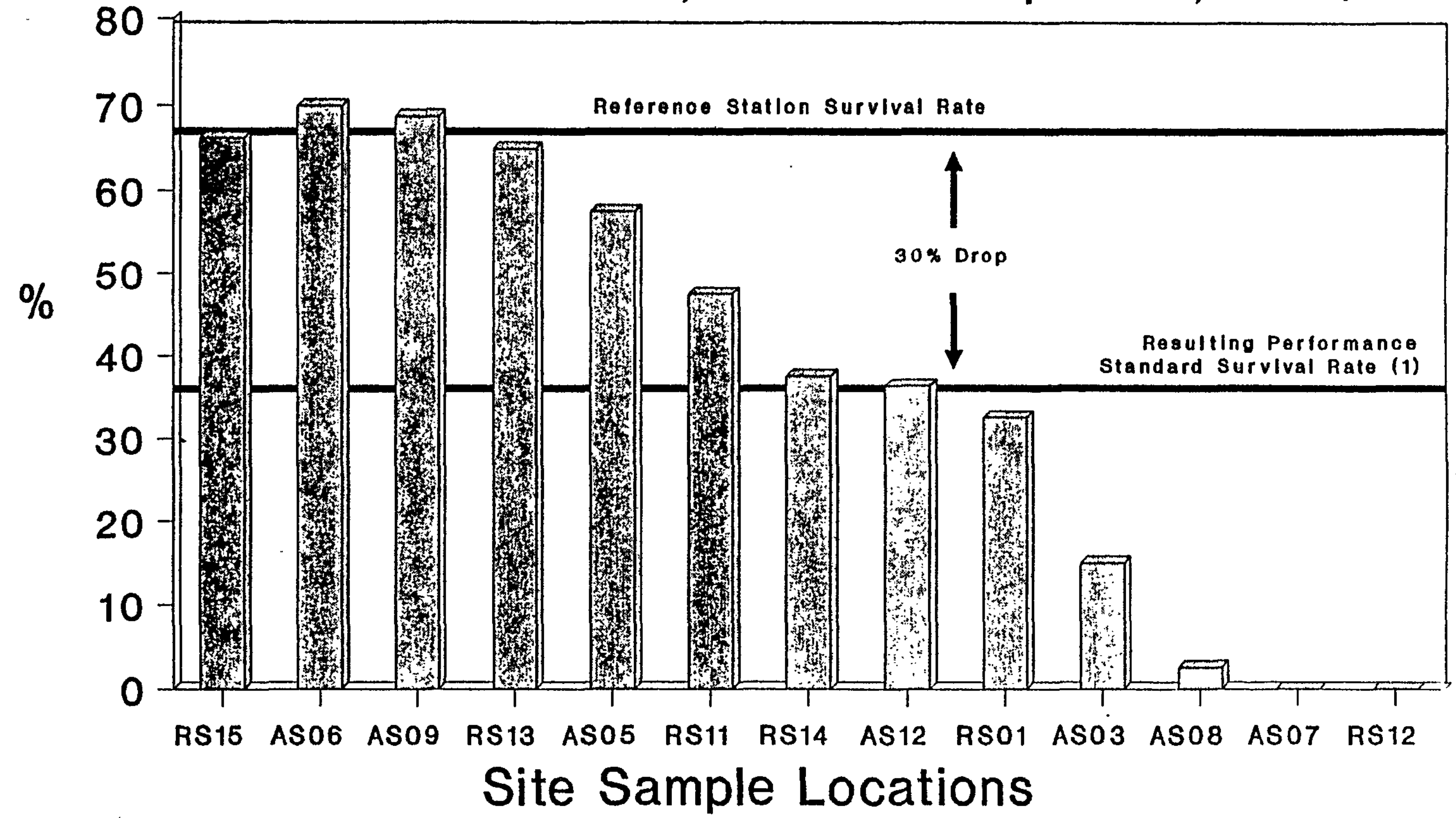


(1) Performance Standard Calculation:
85%(Reference Station RS15) - 32.5% = 52.5%

Figure 2

Survival (%) of Hyalella azteca Relative to RS15

(From Table C-14, DuPont/Newport RI, 1992)

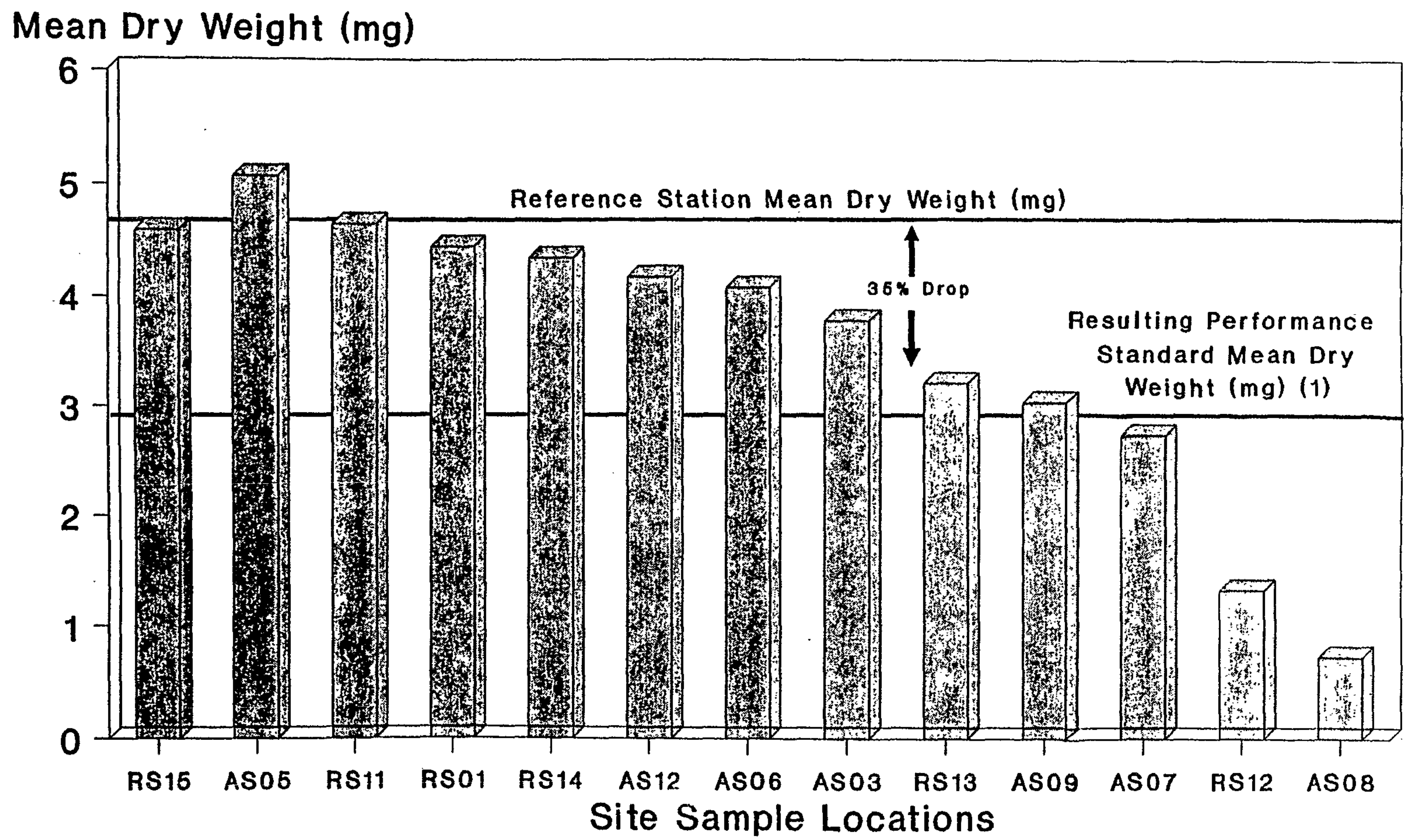


(1) Performance Standard Calculation:
66.5%(Reference Station RS15) - 30% = 36.5%

Figure 3

Summary of Weight Data for Chironomus tentans Relative to RS15

(From Table C-11, DuPont/Newport RI, 1992)



(1) Performance Standard Calculation:
4.592(Reference Station RS15) - 1.600(35%) = 2.992

TABLE A – COEFFICIENT OF VARIATION AMONG THE SURVIVAL RATES OF CHIRONOMUS TENTANS FROM THE NORTH AND SOUTH DISPOSAL SITES, AND CHRISTINA RIVER[1]

North Disposal Site

Station Location	Rep. #	Survival (%)	Average Survival (%)	Drop in % Survival[5]	SD[2]	CV (%)[3]
RS15 Reference Station	A	70	85		13	15
	B	90				
	C	100				
	D	80				
AS06	A	60	82.5	2.5	17	20
	B	90				
	C	100				
	D	80				
AS07 *	A	60	40	45	18	45
	B	50				
	C	20				
	D	30				
AS08 *	A	0	17.5	67.5	20	114
	B	30				
	C	0				
	D	40				
AS09 *	A	50	42.5	42.5	33	77
	B	40				
	C	80				
	D	0				
AS12	A	90	70	15	40	57
	B	90				
	C	10				
	D	90				
Average Drop in % Survival Rates[6]				34.5		
Average Standard Deviation of Survival Rates among Stations[7]					25.6	
Average Coefficient of Variation[8]						38.5

Chistina River

Station Location[4]	Rep. #	Survival (%)	Average Survival (%)	Drop in % Survival[5]	SD	CV (%)
RS15 Reference Station	A	70	85		13	15
	B	90				
	C	100				
	D	80				
RS11	A	90	90		14	15
	B	100				
	C	70				
	D	100				
RS12 *	A	50	52.5	32.5	13	24
	B	40				
	C	70				
	D	50				
RS01 *	A	60	60	25	8.1	13
	B	50				
	C	70				
	D	60				
RS13	A	80	72.5	12.4	17	23
	B	70				
	C	90				
	D	50				
RS14	A	100	77.5	7.5	17	22
	B	60				
	C	80				
	D	70				
Average Drop in % Survival Rates[6]				19.4		
Average Standard Deviation of Survival Rates among Stations					13.8	
Average Coefficient of Variation[8]						20

South Disposal Site

Station Location	Rep. #	Survival (%)	Average Survival (%)	Drop in % Survival[5]	SD	CV (%)
RS15 Reference Station	A	70	85		13	15
	B	90				
	C	100				
	D	80				
AS03	A	100	82.5	2.5	28	34
	B	40				
	C	90				
	D	100				
AS05	A	80	75	10	5.7	8
	B	80				
	C	70				
	D	70				
Average Drop in % Survival Rates[6]				6.3		
Average Standard Deviation of Survival Rates among Stations					16.9	
Average Coefficient of Variation[8]						21

(1) Table C–10, Woodward Clyde. 1992. Risk Assessment DuPont–Newport Site. Volume 2, Environmental Evaluation. August 7, 1992.
(2) Standard Deviation
(3) Coefficient of Variation
(4) RS07 is considered an outlier and was not considered in the coefficient of variation equation as requested by U.S. EPA.
(5) Indicates drop in % survival between reference station (RS15) and site stations.
(6) Indicates a 20.06% average reduction in survival rates between reference station (RS15) and site stations ((34.5%+19.4%+6.3%)/3).
(7) Indicates an 18.76 average standard deviation of survival rates among stations ((25.6+13.8+16.9)/3).
(8) Coefficient of variation averages were calculated without stations where 0% survival was recorded in Hyalella azteca or Chironomus tentans (*).

Sample Calculation: Site Station AS06

Standard Deviation formula: $s = \sqrt{\frac{\sum_{i=1}^{n} (X_i - \bar{X})^2}{n-1}}$

Where: $X_1 = 60,\ X_2 = 90,\ X_3 = 100,\ X_4 = 80,\ \bar{X} = 82.5,\ n = 4.$

Standard Deviation (s) = 17

Sample Calculation: Site Station AS06

Coefficient of Variation formula: $CV = \frac{s}{\bar{X}} * 100$

Where: $s = 17,\ \bar{X} = 82.5$

Coefficient of Variation (CV) = 20

TABLE B – COEFFICIENT OF VARIATION AMONG THE SU[illegible] RATES OF HYALELLA AZTECA FROM THE NORTH AND SOUTH DISPOSAL SITE[illegible]D CHRISTINA RIVER[1]

North Disposal Site

Station Location	Rep. #	Survival (%)	Average Survival (%)	Drop in % Survival[5]	SD[2]	CV (%)[3]
RS15 Reference Station	A	65	66.25		2.5	3.8
	B	65				
	C	70				
	D	65				
AS06	A	65	70		12.2	17
	B	80				
	C	55				
	D	80				
AS07 *	A	0	0	66.25	0	0
	B	0				
	C	0				
	D	0				
AS08 *	A	5	2.5	63.75	2.8	115
	B	5				
	C	0				
	D	0				
AS09 *	A	85	68.8		18	24
	B	80				
	C	50				
	D	60				
AS12	A	35	36.3	29.9	12	33
	B	45				
	C	20				
	D	45				
Average Drop in % Survival Rates[6]				53.3		
Average Standard Deviation of Survival Rates among Stations[7]					8.6	
Average Coefficient of Variation[8]						25

Chistina River

Station Location[4]	Rep. #	Survival (%)	Average Survival (%)	Drop in % Survival[5]	SD	CV (%)
RS15 Reference Station	A	65	66.25		2.5	3.8
	B	65				
	C	70				
	D	65				
RS11	A	55	47.5	18.8	6.5	14
	B	40				
	C	45				
	D	50				
RS12 *	A	0	0	66.25	0	0
	B	0				
	C	0				
	D	0				
RS01 *	A	10	32.5	33.8	33	102
	B	50				
	C	70				
	D	0				
RS13	A	50	65	1.25	23.5	36
	B	85				
	C	85				
	D	40				
RS14	A	35	37.5	28.8	22	59
	B	10				
	C	65				
	D	40				
Average Drop in % Survival Rates[6]				29.8		
Average Standard Deviation of Survival Rates among Stations[7]					17.0	
Average Coefficient of Variation[8]						36.3

South Disposal Site

Station Location	Rep. #	Survival (%)	Average Survival (%)	Drop in % Survival[5]	SD	CV (%)
RS15 Reference Station	A	65	66.25		2.5	3.8
	B	65				
	C	70				
	D	65				
AS03	A	20	15	51.3	4	27
	B	15				
	C	10				
	D	15				
AS05	A	50	57.5	8.8	9.6	17
	B	50				
	C	70				
	D	60				
Average Drop in % Survival Rates[6]				30.1		
Average Standard Deviation of Survival Rates among Stations[7]					6.8	
Average Coefficient of Variation[8]						22

(1) Table C–14, Woodward Clyde. 1992. Risk Assessment DuPont–Newport Site. Volume 2, Environmental Evaluation. August 7, 1992.
(2) Standard Deviation
(3) Coefficient of Variation
(4) RS07 is considered an outlier and was not considered in the coefficient of variation equation as requested by U.S. EPA.
(5) Indicates drop in % survival between reference station (RS15) and site stations.
(6) Indicates a 37.7% average reduction in survival rates between reference station (RS15) and site stations ((53.3%+30.1%+29.8%)/3).
(7) Indicates a 10.8 average standard deviation of survival rates among stations ((8.6+17.0+6.8)/3).
(8) Coefficient of variation averages were calculated without stations where 0% survival was recorded in Hyalella azteca or Chironomus tentans (*).

Sample Calculation: Site Station AS06

Standard Deviation formula:

$$s = \sqrt{\frac{\sum_{i=1}^{n} (X_i - \bar{X})^2}{n-1}}$$

Where: $X_1 = 65,\ X_2 = 80,\ X_3 = 55,\ X_4 = 80,\ \bar{X} = 70,\ n = 4$

Standard Deviation (s) = 12.2

Sample Calculation: Site Station AS06

Coefficient of Variation formula: $CV = \frac{s}{\bar{X}} * 100$

Where: $s = 12.2,\ \bar{X} = 70$

Coefficient of Variation (CV) = 17

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TABLE C – SUMMARY OF WEIGHT DATA FOR CHIRONOMUS TENTANS EXPOSED FOR 12 DAYS
TO CHRISTINA RIVER, NORTH AND SOUTH DISPOSAL SITE WETLAND SEDIMENTS[1]

North Disposal Site

Station Location	Rep. #	Avg. Dry Wt. (mg)	Mean Dry Wt. (mg)	Drop in Dry Wt. (mg)[5]	SD[2]	CV[3]
RS15	A	4.876	4.592		0.247	5.378
	B	4.548				
	C	4.661				
	D	4.283				
AS06	A	4.89	4.078	0.514	0.687	16.84
	B	3.38				
	C	3.657				
	D	4.383				
AS07	A	1.003	2.733	1.859	2.238	81.88
	B	0.888				
	C	3.465				
	D	5.577				
AS08 *	A	0	0.726	3.866	0.859	118
	B	1.68				
	C	0				
	D	1.223				
AS09 *	A	4.903	3.031	1.561	2.110	69.64
	B	3.563				
	C	3.658				
	D	0				
AS12	A	4.554	4.174	0.418	0.308	7.387
	B	3.88				
	C	4.289				
	D	3.971				
Average Drop in Weight (mg)[6]				1.6436		
Average Standard Deviation of Mean Dry Weight Among Stations[7]					1.24	
Average Coefficient of Variation[8]						35.4

Christina River

Station Location[4]	Rep. #	Avg. Dry Wt. (mg)	Mean Dry Wt. (mg)	Drop in Dry Wt. (mg)[5]	SD	CV
RS15 Reference Station	A	4.876	4.592		0.247	5.378
	B	4.548				
	C	4.661				
	D	4.283				
RS11	A	4.6	4.647		0.623	13.41
	B	5.188				
	C	3.788				
	D	5.012				
RS12	A	1.724	1.328	3.264	0.449	33.86
	B	1.258				
	C	1.607				
	D	0.722				
RS01	A	5.54	4.444	0.148	0.765	17.21
	B	4.212				
	C	3.76				
	D	4.262				
RS13	A	3.055	3.208	1.384	1.132	35.30
	B	4.18				
	C	3.926				
	D	1.67				
RS14	A	4.677	4.341	0.251	0.445	10.25
	B	3.982				
	C	4.773				
	D	3.933				
Average Drop in Weight (mg)[6]				1.26175		
Average Standard Deviation of Mean Dry Weight Among Stations[7]					0.68	
Average Coefficient of Variation[8]						21.98

South Disposal Site

Station Location	Rep. #	Avg. Dry Wt. (mg)	Mean Dry Wt. (mg)	Drop in Dry Wt. (mg)[5]	SD	CV
RS15 Reference Station	A	4.876	4.592		0.247	5.378
	B	4.548				
	C	4.661				
	D	4.283				
AS03	A	3.81	3.781	0.811	0.498	13.17
	B	3.23				
	C	3.653				
	D	4.431				
AS05	A	5.98	5.069		1.078	21.26
	B	3.513				
	C	5.241				
	D	5.56				
Average Drop in Weight (mg)[6]				0.811		
Average Standard Deviation of Mean Dry Weight Among Stations[7]					0.788	
Average Coefficient of Variation[8]						17.22

(1) Table C–11, Woodward Clyde. 1992. Risk Assessment DuPont–Newport Site. Volume 2, Environmental Evaluation. August 7, 1992.
(2) Standard Deviation
(3) Coefficient of Variation
(4) RS07 is considered an outlier and was not considered in the coefficient of variation equation as requested by U.S. EPA.
(5) Indicates drop in dry weight (mg) between reference station (RS15) and site stations.
(6) Indicates an average drop in dry weight of 1.24 mg between the reference station (RS15) and site stations (1.642+1.261+.811)/3).
(7) Indicates a 0.903 average standard deviation of mean dry weight among stations ((1.052+.610+.608)/3).
(8) Average coefficient of variation was calculated without stations where average dry weights of 0 mg were recorded in Chironomus tentans (*).

Sample Calculation: Site Station AS06

Standard Deviation formula: $s = \sqrt{\frac{\sum_{i=1}^{n} (X_i - \bar{X})^2}{n-1}}$

Where: $x_1 = 4.89,\ x_2 = 3.38,\ x_3 = 3.657,\ x_4 = 4.383,\ \bar{X} = 4.078,\ n = 4$

Standard Deviation (s) = .687

Sample Calculation: Site Station AS06

Coefficient of Variation formula: $CV = \frac{S}{\bar{X}} * 100$

Where: $s = 0.687,\ \bar{x} = 4.078$

Coefficient of Variation (CV) = 16.84

AR3[illegible]070

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Attachment A

A factorial analysis of variance (ANOVA) was utilized to determine the minimum detectable change in growth and survivability of *Chironomus tentans* and the survivability of *Hyalella azteca* in sediments collected from the allegedly impaired areas due to contamination, when compared to data obtained for the reference location when four (4) replicates per station are collected. H_0 asserts that the test area is not impaired when compared to the reference location. The equation used to compute the changes in averages is based on a 1 X 2 (1 sampling event by 2 areas: reference location and allegedly impaired area) factorial analysis of variance and is presented below (Green, 1979).

$$F_{0.95}(1,2(r-1)\,df) = \frac{SS_{calc} \div 1\ df}{SS_{err} \div 2(r-1)\,df}$$

Where:

$F_{0.95}(1,2(r-1)\ df)$ = F-value for $\alpha = 0.95$ at 1 df (numerator); 2(r-1) df (denominator).

$$SS_{calc} \div 1\ df = (\Delta\overline{X}\ r)^2 \div 2r$$

$$SS_{err} \div 2(r-1)\ df = s^2$$

df	=	degrees of freedom,
r	=	number of replicates, and
s^2	=	variance among stations in all three strata per organism per test.
H_0	=	The area is not impaired when compared to the reference location.

This equation simplifies to:

$$F(1,2(r-1)\,df) = \frac{(\Delta\overline{X}\ r)^2}{2r * s^2}$$

Since the change in the average is the only unknown variable, the equation is rearranged to:

$$\Delta\overline{X} = \sqrt{\frac{F_{0.95}(1,2(r-1)\,df) * 2 * s^2}{r}}$$

Table A-1
Parameters and Results for the Factorial ANOVA

Test	$F_{0.95}(1,2(r-1)df)$	r	s^2	Resulting $\Delta\overline{X}$
Chironomus survival	5.99	4	352	> 32.5%
Chironomus growth	5.99	4	0.815	> 1.6 mg (35%)
Hyalella survival	5.99	4	117	> 18.7%

Results

A change greater than the minimal detectable change will result in the rejection of the null hypothesis, therefore asserting that the area in question is impaired when compared to the reference location and requires clean-up. The minimal detectable change in *Chironomus* survival is a difference of 32.5%, in *Hyalella* survival is a difference of 18.7%, and in *Chironomus* growth is a factor of 35%. These values can be used as performance standards for the RI. In summary, because of the observed differences (variances, or standard deviations) in the four replicates per stations used in the RI sediment toxicity tests, a statistical analysis as described above shows the minimum differences that can be discerned from background variation at the site. These performance standards are consistent with the advice from EPA sediment toxicity experts.

ATTACHMENT 2

Cost Estimates for Sediment Tests at DuPont, Newport

Laboratory	Physical Tests		Chemical Test	Toxicity Tests		Benthic Macroinvertebrate	
				10-day Toxicity Test			
	pH	Grain Size	TAL Metals	*Chironomus* (i)	*Hyalella* (l)	Community Structure (m)	
ENSR, Inc.	NA	NA	NA	$1,300.00	$1,000.00	NA	
ATI Corp.	$15.00	$27.50 (h)	$493.75	NA	NA	NA	
Analytikem, Inc.	$5.00	$150.00	$345.00	$1,600.00 (j) $400.00 (k)	$1,800.00 (j) $400.00 (k)	NA	
RMC	$8.00	NA	$390.00	$900.00	$900.00	NA	
IT Corp.	NA	$159.00	NA	NA	NA	NA	
Dynamac	NA	NA	NA	NA	NA	$2,500.00	Totals
Average Cost/Test	$9.33	$112.17	$409.58	$878.10	$780.00	$2,500.00	$4,689.18
Cost/Area (a)	$326.67	$3,925.83	$14,335.42	$30,733.33	$27,300.00	NR	$76,621.25
Cost of Dups or Reps/Area (b)	$37.33	$448.67	$1,638.33	$153,666.67	$136,500.00	NR	$292,291.00
Total Cost/Area (c)	$364.00	$4,374.50	$15,973.75	$184,400.00	$163,800.00	NR	$368,912.25
South Disposal Site (SDS) Pond Cost (d)	$46.67	$560.83	$2,047.92	$4,733.33	$4,300.00	NR	$11,688.75
SDS Pond Dups or Reps Cost (e)	$9.33	$112.17	$409.58	$23,666.67	$21,500.00	NR	$45,697.75
Total SDS Pond Cost	$56.00	$673.00	$2,457.50	$28,400.00	$25,800.00	NR	$57,386.50
Cost/Reference Location (f)	$18.67	$224.33	$819.17	$6,400.00	$6,000.00	$15,000.00	$28,462.17
Total Cost (g)	$1,549.33	$18,619.67	$67,990.83	$778,800.00	$693,000.00	$30,000.00	$1,589,959.83

(a) Excluding the south disposal site (SDS) pond. Utilizes Average Cost/Test and assumes 35 stations from each area. Does not include duplicates for sediment chemistry and physical properties or replicates for sediment toxicity and benthic community study.

(b) Excluding the SDS pond. Assumes 4 duplicates/area (approximately 10% of samples collected/area) for sediment chemistry and physical properties and 6 replicates for each sediment toxicity and benthic community study.

(c) Excludes SDS pond.

(d) Utilizes Average Cost/Test and assumes 5 stations. Does not include duplicates for sediment chemistry and physical properties or replicates for sediment toxicity and benthic community study.

(e) Assumes 1 duplicate (approximately 10% of samples collected in the SDS pond) for sediment chemistry and physical properties and 6 replicates for each sediment toxicity and benthic community study.

(f) Assumes 1 station/reference location and 1 duplicate/location for sediment chemistry and physical properties and 6 replicates for each sediment toxicity and benthic community study.

(g) Assumes 4 areas, the SDS pond, and 2 reference locations.

(h) Price equals the average of the pipette method ($30) and the hydrometer method ($25).

(i) Test yields both growth and survival data.

(j) For the first sample. (Based on approximately 16 samples.)

(k) For each additional sample. (Based on approximately 16 samples.)

(l) Test yields survival data only.

(m) Benthic Macroinvertebrate Community Structure study yields percent (%) dominance, abundance, and diversity.

NA – Not Applicable. No quote for this service was obtained from this company.

NR – Not Requested. Community structure will be analyzed at the reference locations only.

Note: Every company will give quantity discounts. Therefore, actual prices may be lower.