N61165.AR.002852
CNC CHARLESTON
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TECHNICAL MEMORANDUM EVALUATION OF REFERENCES VALUES OF OFF-SITE LOCATIONS FOR ZONE J STORMWATER EFFLUENT EVALUATION REPORT CNC CHARLESTON SC
5/6/2002
ENSAFE INC.

Evaluation of Reference Values of Off-Site Locations for Zone J Stormwater Effluent Evaluation Report at CNC

PREPARED FOR: CNC BCT and Zone J Trustees

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DATE: May 6, 2002

Introduction

As central components of the local watershed, the Zone J water bodies receive stormwater runoff and other inputs from the majority of surrounding upland areas, including the Charleston Naval Complex (CNC), via numerous point and non-point source discharges. Point source discharge means a discharge which is released to the waters by a discernible, confined and discrete conveyance, including but not limited to a pipe, ditch, channel, tunnel, conduit, well, discrete fissure, container, rolling stock, concentrated animal feeding operation, vessel, or other floating craft from which waste is or may be discharged and regulated under the National Pollutant Discharge Elimination System (NPDES) program. Runoff pollution (technically known as non-point source pollution) occurs when rain or irrigation water flowing over hard surfaces, or loose soil, picks up pollutants and deposits them into the nearest lake, creek, estuary or groundwater supply. Currently, most non-point source discharges are not subjected to regulatory oversight.

According to USEPA (Guidance Manual for Preparations of NPDES Permit, 1991), it is recognized that stormwater runoff carries pollutants draining off streets and parking lots, construction and industrial sites, and mining, logging, and agricultural areas. Through natural or manmade conveyances, the runoff is channeled into and transported by gravity flow through a wide variety of drainage facilities. Runoff may purge accumulated pollutants out of gutters, catch basins, storm sewers, and drainage channels. Runoff eventually ends up in surface waters such as creeks, rivers, estuaries, bays and oceans. Runoff from urban and industrial areas has been considered as a non-point source of pollution.

In the Zone J Point of Entry Effluent Sampling Work Plan, it was determined that data from 18 non-point source stormwater samples from watersheds not influenced by CNC would be evaluated and used to calculate reference (background) concentration values as part of the stormwater effluent migration pathway scenario. The non-point source stormwater samples results are of naturally occurring conditions and/or associated with anthropogenic activities, and will be used to establish a baseline data set for comparison to CNC stormwater effluent samples to delineate contaminants that are attributable to CNC contamination of the water bodies. The goal was to collect stormwater for analysis from reference locations within these areas displaying similar watershed characteristics, i.e., types, sizes, sources, land uses and discharges, to those observed on the CNC property. The data collected from the reference locations are to be used as screening criteria/action levels during Step 3 of the Baseline Ecological Risk Assessment (ERA).

Tidal Excursion Zone/Map

Due to the dynamic estuarine system around Charleston Harbor, tide currents around the CNC were studied to determine the tidal excursion zones and areas for possible reference point locations. A tidal excursion is the net horizontal distance traversed by a water particle during a tide cycle of one flood and one ebb. Through hydrodynamic modeling, an excursion zone was established for the Charleston Harbor. During a tidal cycle, a particle released at CNC into the Cooper River at peak low tide can travel upstream for six hours. Similarly, a particle released at peak high tide can travel downstream for six hours. The estimated upstream tidal excursion into the Cooper River is about 4.5 miles and the downstream excursion will reach the entrance of the harbor, meaning that some particles released at CNC can be flushed out of the harbor during one tidal cycle. The upstream limit of tidal excursion on the Cooper River is located between the U.S. Naval Weapons Station and the discharge point of Goose Creek into the Cooper River. In addition to the Cooper River tidal excursion, a particle released at CNC can be transported into the Wando and Ashley Rivers by the tides with the limits of the upstream transport into the rivers of about five miles from their entrances. The zone extends up the Wando River towards the north side of Daniel Island and upstream on the Ashley River just north of the James Island connector and Highway 17. Conversely, the water bodies associated with Zone J can also be receptors of particles from Ashley and Wando Rivers and Charleston Harbor. Figures 1 and 2 show the ebb and flow tide currents within the tidal excursion zone for the rivers around Charleston Harbor.

Reference Location Selection

Public Works officials identified 58 stormwater discharge displaying similar watershed characteristics to those observed on CNC property. Maps obtained from these municipalities indicated that the following water bodies are potentially influenced by stormwater runoff: Goose Creek, Filbin Creek, Noisette Creek, Shipyard Creek, Cooper River, Ashley River, Hobcaw Creek, Wando River, and Shem Creek. An offsite reconnaissance/field survey was conducted to evaluate the 58 potential reference-sampling locations identified during the interviews with Public Works officials. A site visit was made to each location in order to collect information concerning physical characteristics impacting sampling potential. A ranking system was implemented and characteristics evaluated included: structure type, structure size, location, surrounding land use, tidal influence, presence of an alternate structure, time of day sample may be collected, traffic influence, accessibility, and presence of retention structure.

The following sites, shown in Table 1, were chosen as reference locations for the effluent stormwater. These locations were evaluated to determine acreage size, discharge to specific water body, land use classification, and types of businesses in operation relative to CNC past operations.

Table 1
Reference Locations

Municipality	Reference Location	Water Body Receiving Discharge	Acres	Landuse	Sample ID	Date of Rain Event
City of Hanahan	Dominion Drive	Goose Creek/Cooper River	20.67	Residential	REF001	1-6-02
	Bankton Drive	Goose Creek/Cooper River	41.46	Commercial/Industrial	REF002	1-14-02
	Remount Road/ Commerce Circle	Cooper River	63.75	Commercial/Industrial	REF003	1-25-02
	North Rhett (East)	Filbin Creek/Cooper River	18.66	Residential/Commercial	REF004	1-25-02
City of North Charleston	Rivers Avenue at Lillie's Game Room	Noisette Creek/Cooper River	344.72	Residential/Commercial	REF005	1-14-02
	Charleston Heights/ Food Bank	Cooper River	71.86	Residential/Commercial	REF009	1-6-02
	Charleston Heights/ Success Street	Cooper River	11.53	Residential/Commercial	REF010	1-25-02
	Bainbridge Avenue/ Spruill Avenue	Shipyard Creek/Cooper River	88.17	Residential/ Commercial/Industrial	REF011	2-7-02
City of Charleston	Ashley Marina	Ashley River	58.13	Commercial	REF012	2-7-02
	City Marina	Ashley River	53.65	Commercial	REF013	1-14-02
	King Street/ Meeting Street	Charleston Harbor	132.08	Residential/Commercial	REF014	1-14-02
	Market Street	Charleston Harbor	69.55	Residential/Commercial	REF015	1-14-02
Town of Mount Pleasant	Coleman Boulevard	Shem Creek/Charleston Harbor	62.44	Residential/Commercial	REF016	1-14-02
	Blockbuster Video/ Hwy. 17	Shem Creek/Charleston Harbor	97.81	Commercial	REF017	1-6-02
	Hidden Cove	Hobcaw Creek/ Wando River	54.28	Residential/Industrial	REF018	1-6-02

Table 1
Reference Locations

Municipality	Reference Location	Water Body Receiving Discharge	Acres	Landuse	Sample ID	Date of Rain Event
Charleston Naval Complex	Drainage Basin 6	Cooper River	3.94	Industrial	REF006	1-6-02
	Drainage Basin 9	Noisette Creek/Cooper River	3.07	Industrial	REF007	3-2-02
	Drainage Basin 28 – North Charleston Discharge	Cooper River	20.63	Industrial	REF008	1-6-02

Analytical Results

A third party validator has validated the data for the 18 reference samples. Appendix A summarizes the results of the analytical data for the reference locations. Results for organic constituents were of low frequency and detection levels; therefore, background values for organic constituents were not calculated. Data for the inorganic constituents shows that six different reference locations had the maximum concentrations reported, with REF014 reporting the most values: 16 out of 23 detected constituents. Of the 23 constituents detected, seven (copper, cyanide, lead, mercury, nickel, silver and zinc) have saltwater surface water screening values. Maximum concentrations for copper, lead, mercury, and nickel were reported at REF014, and maximum concentrations for cyanide, silver and zinc were reported at REF013, REF015, and REF008, respectively, with detections exceeding corresponding regulatory values. Frequencies of detections for mercury, silver, and nickel were low; mercury and silver each had one detection and nickel had two.

Of particular note is the inorganic data from the King/Meeting Street location (REF014) that has the most COPCs identified. City of Charleston Public Works Department was unclear whether stormwater lines between established drainage basins for King and Meeting Streets connected with each other. Therefore, a composite of the two outfalls was collected. On January 14, 2002, during a low tide rainfall event, field personnel observed a low tide water line several feet below the outfall discharge from the seawall, and a steady outbound flow of stormwater effluent was discharging from the outfall pipes. Personnel also noted that the stormwater effluent discharging from the King Street outfall was clear in color with some suspended sediment; however, the discharge at the Meeting Street outfall was black in color with suspended sediment resembling dissolved marsh clay. During the preliminary site evaluations prior to the January 2002 rainfall, it was also noted that dark water was discharging from the Meeting Street outfall and clear water from the King Street outfall.

Statistical Approach

Background concentrations for surface water samples collected for Zone J at the Charleston Naval Complex were calculated using the "2 times the mean concentration method" ("2 X mean") outlined in Region IV's *Supplemental Guidance to Risk Assessment Guidance for Superfund* (RAGS) (USEPA, 1995) and the upper tolerance limit (UTL) method presented in *Statistical Guidance for Groundwater Monitoring Data at RCRA Facilities* (USEPA, 1989; 1992). The text below describes each method.

Data Evaluation

Prior to calculation of the "2 X mean" and UTLs, summary statistics were calculated on the 18 stormwater effluent reference samples. Table 2 summarizes the following statistics for this data group: minimum/maximum concentrations, average detected concentrations, average concentrations calculated using detected concentrations and one-half the quantitation limit, detection frequency, and percentage of nondetects. These statistics were used to determine the best data distribution.

Handling of Nondetect Data

The percentage of nondetect values (data with "U" or "UJ" qualifiers) was calculated for each inorganic in the data set to determine the statistical method to be used to obtain the UTL. The procedures for handling nondetects are as follows:

- If less than 50% of all values in a data set are nondetect, then each nondetect is replaced by half its reported detection limit (i.e., half of the U-qualified value). The statistical distribution of the data was then examined for normality. If the original or log-transformed data values were normally distributed, a parametric UTL was calculated; if not, a nonparametric UTL was determined.

- If nondetects exceeded 50%, a nonparametric UTL (i.e., a tolerance limit not based on a normal distribution) was used. To obtain the desired levels of coverage and confidence, the highest observed value in the data set was used as the nonparametric UTL (USEPA, 1992).

For background concentrations calculated using Region IV guidance ("2 times the mean concentration method"), one-half the quantitation limit was used for all nondetect values before the mean was calculated. Table 3 shows the "2 times the mean concentration method".

Tests for Normality

As explained above, if less than 50% of all reported values of an inorganic analyte in a data set are nondetect, calculation of a parametric UTL may be possible. After replacing each nondetect value by half its reported quantitation limit, the most representative distribution of the data was determined (nontransformed or log-transformed). These tools are used to determine normality, but results are questionable with small sample sizes, i.e., less than 20 to 30 observations (USEPA, 1992). As a result, professional judgment was the final arbiter of whether a data set was determined to be normally or lognormally distributed. Each statistical tool used is defined below.

Shapiro-Wilk Test

The Shapiro-Wilk test indicates whether a data set has a normal distribution by comparing a calculated *W*-statistic with an appropriate tabulated value of *W*. The null hypothesis is that the data set is normally distributed, while the alternate hypothesis is that the population is non-normal. Details concerning the calculation of the *W*-statistic are presented in Gilbert, 1987 and WDOE, 1992. The Washington Department of Ecology (WDOE) program MTCAStat Version 3.0 was used to determine whether data sets were normally or lognormally distributed. The program can be obtained at http://www.ecy.wa.gov/programs/tcp/tools/toolmain.html.

Table 2
Chemicals Detected in Stormwater Reference Samples
Charleston Naval Complex, South Carolina

Chemical	Detected Concentration Range	Detection Frequency	Average Detected Concentration	Average Concentration (½ SQLs)[1]	Data Distribution[2]	Percent Nondetect
Aluminum	79 – 11000	18 / 18	1639	1639	lognormal	0
Antimony	3.3 – 5.1	3 / 18	4.2	3.0	undetermined	83
Arsenic	5.6 – 13	4 / 18	7.9	3.4	undetermined	78
Barium	3.4 – 170	18 / 18	30.2	30.2	lognormal	0
Beryllium	0.1 – 0.48	2 / 18	0.290	0.207	undetermined	89
Cadmium	0.89 – 2.2	2 / 18	1.5	0.6	undetermined	89
Calcium	3400 – 130000	18 / 18	26728	26728	lognormal	0
Chromium	0.98 – 21	18 / 18	6.5	6.5	lognormal	0
Cobalt	1 – 3.200	3 / 18	2.1	1	undetermined	83
Copper	4.5 – 70	10 / 18	34.7	21	lognormal	44
Iron	290 – 9700	18 / 18	2067	2067	lognormal	0
Lead	1.8 – 100	16 / 18	18.6	16.8	lognormal	11
Magnesium	310 – 290000	18 / 18	24628	24628	lognormal	0
Manganese	4.4 – 100	18 / 18	37.3	37.3	lognormal	0
Nickel	1.7 – 9.1	11 / 18	3.8	2.6	undetermined	39
Potassium	310 – 120000	18 / 18	11839	11839	lognormal	0
Silver	4.4 – 4.4	1 / 18	4.4	1.2	undetermined	94
Sodium	1900 – 2300000	18 / 18	197667	197667	lognormal	0
Thallium	4.6 – 4.6	1 / 18	4.6	2.9	undetermined	94
Vanadium	1.5 – 32	18 / 18	7.8	7.8	lognormal	0
Zinc	13 – 1300	18 / 18	154	154	lognormal	0
Mercury	0.18 – 0.18	1 / 18	0.180	0.057	undetermined	94
Cyanide, Total	5.6 – 49	5 / 18	16.4	8	undetermined	72

Notes:
All units are micrograms per liter (µg/L).

[1] Average concentration calculated using the detected concentration and ½ the sample quantitation limit (SQL).
[2] Data distribution determined using probability plots and/or the Shapiro-Wilk test (Gilbert, 1987).
Data distribution definitions:
Lognormal indicates the logtransformed data are normally distributed.
Undetermined indicates that nonparametric UTL considered because nondetects exceed 50%.

Table 3
Summary of the "2 Times the Mean Concentration Method" for Stormwater Reference Samples
Charleston Naval Complex, South Carolina

Sample ID	Aluminum	Antimony	Arsenic	Barium	Beryllium	Cadmium	Calcium	Chromium	Cobalt	Copper	Iron	Lead	Magnesium	Manganese	Nickel
REF001	380	1.5	1.75	9	0.05	0.25	14000	1.6	0.5	1.3	290	1.9	1600	11	0.65
REF002	2500	1.5	1.75	14	0.05	0.25	18000	5.3	0.5	1.2	2300	4.4	560	21	3.6
REF003	1600	1.9	1.35	46	0.15	0.25	51000	3.7	0.4	8.3	1600	3.55	2500	76	3.2
REF004	3100	4.3	2.45	170	0.15	0.89	27000	14	0.4	44	4900	47	1500	62	8.3
REF005	1300	1.5	6.1	44	0.05	0.25	24000	9.9	0.5	12	2200	22	3300	51	2.3
REF006	310	1.5	1.75	3.4	0.05	0.25	7400	1.2	0.5	1.7	440	2.8	13000	7.8	0.65
REF007	760	1.9	1.35	5.7	0.15	0.25	9600	1.1	0.4	4.500	660	1.1	1000	4.4	0.85
REF008	970	1.5	1.75	16	0.05	2.2	4900	4.3	0.5	12	1400	21	530	28	2.6
REF009	79	1.5	1.75	29	0.05	0.25	37000	0.98	0.5	2.2	1300	1.8	2000	35	0.65
REF010	1100	1.9	1.35	21	0.15	0.25	18000	2.9	0.4	40	4000	15	14000	80	1.7
REF011	1250	10	5	28.5	0.1	2.5	44500	20.5	5	9.850	1650	12	27000	36.5	2.55
REF012	750	10	5	30	2	2.5	33000	6.4	1	27	1300	7.9	46000	36	2.4
REF013	660	1.5	6.7	12	0.05	0.25	5500	6.3	0.5	66	730	8.2	2600	19	2.5
REF014	11000	3.3	13	55	0.48	0.25	130000	21	3.2	70	9700	100	290000	100	9.1
REF015	1300	5.1	5.6	26	0.05	0.25	34000	6.9	2.2	65	1700	44	36000	36	3.3
REF016	550	1.5	1.75	14	0.05	0.25	6800	5.9	0.5	8.5	810	3.1	610	16	0.65
REF017	290	1.5	1.75	6.2	0.05	0.25	3400	1.6	0.5	2.1	330	4.9	310	12	0.65
REF018	1600	1.5	1.75	13	0.05	0.25	13000	3.4	0.5	2.2	1900	2	790	39	0.65
Frequency of Hits	18/18	3/18	4/18	18/18	2/18	2/18	18/18	18/18	3/18	10/18	18/18	16/18	18/18	18/18	11/18
Mean	1639	2.97	3.44	30.2	0.21	0.64	26728	6.5	1	21	2067	16.8	24628	37.3	2.57
2× Mean	3278	5.93	6.88	60.3	0.41	1.29	53456	13	2	42	4134	33.6	49256	74.5	5.14

Notes:
All units are micrograms per liter (μg/L).

Table 3
Summary of the "2 Times the Mean Concentration Method" for Stormwater Reference Samples
Charleston Naval Complex, South Carolina

Sample ID	Potassium	Silver	Sodium	Thallium	Vanadium	Zinc	Mercury	Cyanide
REF001	2500	0.35	11000	4.6	2.2	13	0.05	5
REF002	910	0.35	2000	2.25	9.1	63	0.05	5
REF003	1900	0.7	6500	3.15	6.2	86	0.05	5
REF004	3400	0.7	8900	3.15	14	240	0.05	5
REF005	2500	0.35	20000	2.25	6.2	140	0.05	6.8
REF006	6300	0.35	120000	2.25	4.2	69	0.05	5
REF007	1400	0.7	1900	3.15	2.6	19	0.05	5
REF008	740	0.35	3600	2.25	11	1300	0.05	5
REF009	2100	0.35	9900	2.25	1.5	35	0.05	5
REF010	6200	0.7	100000	3.15	6.2	120	0.05	5
REF011	17000	5	250000	5	5.85	85.5	0.05	5.6
REF012	22000	5	400000	5	5.8	91	0.05	8.6
REF013	2100	0.35	23000	2.25	9.5	94	0.05	49
REF014	120000	0.35	2300000	2.25	32	99	0.18	5
REF015	22000	4.4	290000	2.25	8.4	150	0.05	5
REF016	770	0.35	6200	2.25	4.2	59	0.05	12
REF017	310	0.35	2000	2.25	2.7	57	0.05	5
REF018	980	0.35	3000	2.25	8.7	50	0.05	5
Frequency of Hits	18/18	1/18	18/18	1/18	18/18	18/18	1/18	5/18
Mean	11839	1.17	197667	2.89	7.8	154	0.06	8.17
2× Mean	23679	2.34	395333	5.77	15.6	308	0.11	16.3

Notes:
All units are micrograms per liter (µg/L).

The MTCAStat program performs the W test on both the untransformed and log-transformed values if the sample size does not exceed 50.

Probability Plot Method

The probability plot of a normally or lognormally distributed data set should follow a straight line, i.e., correlation coefficient (r^2) should be greater than 0.90. If the line is curved, the data set is non-normal. The MTCAStat program evaluates data for lognormality and normality using the normal probability plot method. As a measure of how well the log-transformed and untransformed data fit a straight line, the r^2 values are calculated and displayed. A good fit (defined as $r^2 \geq 0.900$) for the logtransformed data is consistent with the default assumption of a lognormal distribution. If this criterion is not met, the r^2 for the untransformed data is used to test for a normal distribution. An r^2 is not calculated and displayed if the regression analysis of variance F-value is non-significant at the $p = 0.05$ level or cannot be calculated.

Output from the MTCA*Stat* program can be provided upon request for all sample data. Each metal has the normality output as a table and two figures that graph the probability plots for the normal and lognormal cases.

Calculation of UTL

After the transformation of the data has been established and the data set is determined to be normally distributed, a parametric UTL is calculated for each analyte. The UTL represents the upper limit of a tolerance interval for a given data set. The tolerance limits calculated in this background study represent one-sided UTLs with 95% coverage and 95% confidence. A one-sided UTL with 95% coverage and 95% confidence allows the user to assume that there is a 95% certainty that a given value is higher than 95% of the possible sample values from the population.

A one-sided UTL is calculated as shown in Equation 1, where x is the mean of the data, s is the standard deviation, and K is the one-sided normal tolerance factor based on the frequency of the data set. K is found in several statistical handbooks, including Gilbert (1987, Table A3); α is 0.05, p is 0.95. K is 2.54 for 18 samples. Equation 1: $UTL_{1-\alpha}(x) = \bar{x} + sK_{1-\alpha,p}$.

The calculated UTLs for Zone J are shown in Table 4. REF014 was initially evaluated for exclusion from the reference value data set; however, the results showed that except for calcium, magnesium, manganese, and sodium, the removal of the sample data did not cause an order of magnitude change in "the 2 times the mean" or UTL calculations.

Table 4
Summary of the UTLs for Stormwater Reference Samples
Charleston Naval Complex, South Carolina

Chemical	n	Mean (X) (µg/L)	Data Transformation	Type of UTL Calculated[a]	Standard Deviation (s) (unitless)	Tolerance Factor (k) (unitless)	UTL (µg/L)
Aluminum	18	1,639	lognormal	parametric	2,461	2.543	7,896
Antimony	18	2.97	undetermined	nonparametric	NA	NA	5.1
Arsenic	18	3.44	undetermined	nonparametric	NA	NA	13
Barium	18	30.2	lognormal	parametric	37.9	2.543	127
Beryllium	18	0.21	undetermined	nonparametric	NA	NA	0.48
Cadmium	18	0.64	undetermined	nonparametric	NA	NA	2.2
Calcium	18	26,728	lognormal	parametric	29,519	2.543	101,795
Chromium	18	6.50	lognormal	parametric	6.17	2.543	22.2
Cobalt	18	1	undetermined	nonparametric	NA	NA	3.2
Copper	18	21.0	lognormal	parametric	24.7	2.543	83.8
Iron	18	2,067	lognormal	parametric	2,255	2.543	7,802
Lead	18	16.8	lognormal	parametric	24.9	2.543	80.2
Magnesium	18	24,628	lognormal	parametric	67,617	2.543	196,577
Manganese	18	37.3	lognormal	parametric	27.1	2.543	106
Nickel	18	2.57	undetermined	nonparametric	NA	NA	9.1
Potassium	18	11,839	lognormal	parametric	27,922	2.543	82,844
Silver	18	1.17	undetermined	nonparametric	NA	NA	4.4
Sodium	18	197,667	lognormal	parametric	537,918	2.543	1,565,591
Thallium	18	2.89	undetermined	nonparametric	NA	NA	4.6
Vanadium	18	7.80	lognormal	parametric	6.88	2.543	25.3
Zinc	18	154	lognormal	parametric	291	2.543	894
Mercury	18	0.06	undetermined	nonparametric	NA	NA	0.18
Cyanide	18	8.2	undetermined	nonparametric	NA	NA	49

Notes:

a = The parametric UTL for lognormally distributed data calculated using equation: UTL = X + k(s). where X is the mean concentration, k is the tolerance factor (a = 0.05, p = 0.95), and s is the standard deviation. Nonparametric UTLs were set equal to the maximum detected concentration.

n = number of samples

Conclusions

Conceptual Approach

- The overall determination of reference values for Zone J had to take a unique approach from conventional methods. Because a goal of the RFI is to determine the CNC's contribution to contamination of the surrounding water bodies through stormwater runoff, it was necessary to identify other possible routes of stormwater contaminant migration, to quantify stormwater runoff from these routes, and to eventually compare results to runoff from CNC migration routes.

Tidal Excursion

- Providing one set of reference values is more defensible because of the tidal excursion zones of the surrounding water bodies. Though distribution of the data shows a majority of the maximum concentrations and the number of Saltwater-Surface Water Screening Values are located in the City of Charleston, the water bodies surrounding CNC can be receptors of particles from the rivers surrounding the City of Charleston.

Statistical Approach

- Review of the background concentrations in Table 5 generally shows the "2 X mean" values are more conservative for the two methods. Values for antimony, thallium, and cyanide are higher using the "2 X mean" method, but the rate of frequency of these constituents for stormwater effluent samples collected to date (36 samples, detections only), as shown in Table 6, is low. Antimony, which does not have a Saltwater-Surface Water Screening Value, was detected in two samples and exceeded background in one sample (EFF005); and cyanide, which has a screening value of 1 µg/L, was detected in one sample and did not exceed background. The screening value for thallium is 21.3 µg/L, and none of the results exceeded the screening value.

Data Comparison

- Table 6 summarizes the CNC stormwater effluent onsite constituents detected, compares the results to Region IV Saltwater Surface Water Chronic Screening Values, identifies COPCs, and compares the results to inorganic reference values. Based on the information provided in this memorandum and the fact that the "2 X the mean" method is more conservative, "2 X mean" reference values should be utilized in the screening process during the COPC refinement stage of the ERA.

Table 5
Comparison of Calculated Background Concentrations
Charleston Naval Complex, South Carolina

Chemical	2× Mean	UTLs
Aluminum	3277.67	7896.48
Antimony	5.93	5.10
Arsenic	6.88	13.00
Barium	60.31	126.50
Beryllium	0.41	0.48
Cadmium	1.29	2.20
Calcium	53455.56	101795.06
Chromium	13.00	22.19
Cobalt	2.00	3.20
Copper	41.98	83.83
Iron	4134.44	7801.59
Lead	33.63	80.21
Magnesium	49255.56	196576.60
Manganese	74.52	106.18
Nickel	5.14	9.10
Potassium	23678.89	82844.16
Silver	2.34	4.40
Sodium	395333.33	1565591.49
Thallium	5.77	4.60
Vanadium	15.59	25.30
Zinc	307.83	893.78
Cyanide, Total	16.33	0.18

Notes: All units are microgram per liter (μg/L).

Table 6
Summary of COPCs of Stormwater Effluent Samples

COMPOUND NAME	SAMPLE ID	RESULTS (µg/L)	SCREENING VALUE	# OF COPCs	REFERENCE VALUE	# OF EXCEEDANCES REMAINING
2,4-Dimethylphenol	EFF043	***1.3***	NV	*3*	NV	*3*
	EFF014	***1***				
	EFF040	***0.53***				
2-Methylphenol (o-Cresol)	EFF045	***5.2***	NV	*6*	NV	*6*
	EFF013	***4.3***				
	EFF041	***0.9***				
	EFF047	***0.8***				
	EFF042	***0.7***				
	EFF040	***0.38***				
3&4-Methylphenol (m&p-cresol)	EFF041	***0.75***	NV	*1*	NV	*1*
4,4'-DDD	EFF044	***0.065***	0.025	*1*	NV	*1*
Acenaphthene	EFF058	6.4	9.7	*0*	NV	*0*
Aluminum	EFF011	***13000***	NV	*36*	3278	*3*
	EFF004	***4500***				
	EFF014	***3600***				
	EFF040	***2300***				
	EFF002	***1700***				
	EFF006	***1200***				
	EFF010	***1200***				
	EFF013	***1200***				
	EFF035	***970***				
	EFF068	***930***				

Table 6
Summary of COPCs of Stormwater Effluent Samples

COMPOUND NAME	SAMPLE ID	RESULTS (µg/L)	SCREENING VALUE	# OF COPCs	REFERENCE VALUE	# OF EXCEEDANCES REMAINING
Aluminum	EFF065	*900*				
	EFF066	*810*				
	EFF069	*570*				
	EFF005	*520*				
	EFF067	*520*				
	EFF034	*440*				
	EFF041	*320*				
	EFF044	*320*				
	EFF048	*260*				
	CAP001	*250*				
	EFF057	*250*				
	EFF058	*240*				
	EFF012	*230*				
	EFF064	*220*				
	EFF001	*200*				
	EFF007	*200*				
	EFF009	*170*				
	EFF008	*140*				
	EFF043	*140*				
	EFF063	*140*				
	EFF003	*120*				
	EFF019	*98*				
	EFF042	*86*				
	EFF045	*84*				
	EFF031	*51*				
	EFF047	*36*				

Table 6
Summary of COPCs of Stormwater Effluent Samples

COMPOUND NAME	SAMPLE ID	RESULTS (µg/L)	SCREENING VALUE	# OF COPCs	REFERENCE VALUE	# OF EXCEEDANCES REMAINING
Antimony	EFF005	***6***	NV	***2***	5.93	***1***
	EFF012	***4.4***				
Arsenic	EFF011	***190***	36	***1***	6.88	***1***
	CAP001	35				
	EFF019	15				
	EFF012	5.2				
	EFF034	4.8				
	EFF014	4				
	EFF013	3.9				
	EFF048	3.4				
Barium	EFF011	***120***	NV	***36***	60.3	***2***
	EFF067	***100***				
	EFF068	***44***				
	EFF014	***44***				
	EFF012	***41***				
	EFF066	**26**				
	EFF065	**26**				
	EFF004	**25**				
	EFF002	**23**				
	EFF010	**22**				
	EFF064	**20**				
	EFF035	**20**				
	EFF001	**19**				
	EFF006	**17**				
	EFF069	**13**				
	EFF058	**13**				
	EFF042	**13**				

Table 6
Summary of COPCs of Stormwater Effluent Samples

COMPOUND NAME	SAMPLE ID	RESULTS (µg/L)	SCREENING VALUE	# OF COPCs	REFERENCE VALUE	# OF EXCEEDANCES REMAINING
Barium	EFF003	**12**				
	EFF040	**11**				
	EFF048	**9.9**				
	EFF013	**9.9**				
	EFF041	**8.7**				
	EFF007	**8.5**				
	EFF009	**8.2**				
	EFF034	**8.1**				
	EFF063	**7.6**				
	EFF005	**7.6**				
	EFF057	**7.1**				
	CAP001	**5.6**				
	EFF043	**5**				
	EFF019	**4.2**				
	EFF031	**3.6**				
	EFF008	**3.6**				
	EFF044	**3.4**				
	EFF045	**3.3**				
	EFF047	**2.6**				
Benzo(a)pyrene	EFF041	***1.3***	NV	*2*	NV	*2*
	EFF040	***0.95***				
Benzo(b)fluoranthene	EFF041	***1.5***	NV	*3*	NV	*3*
	EFF040	***1.2***				
	EFF008	***0.39***				
Benzo(g,h,i)perylene	EFF041	***0.75***	NV	*1*	NV	*1*

Table 6
Summary of COPCs of Stormwater Effluent Samples

COMPOUND NAME	SAMPLE ID	RESULTS (µg/L)	SCREENING VALUE	# OF COPCs	REFERENCE VALUE	# OF EXCEEDANCES REMAINING
Benzo(k)fluoranthene	EFF041	***1.6***	NV	***2***	NV	***2***
	EFF040	***1.1***				
Beryllium	EFF011	***4.5***	NV	***3***	0.41	***1***
	EFF004	***0.16***				
	EFF014	***0.15***				
bis(2-Ethylhexyl)phthalate	EFF019	***16***	NV	***11***	NV	***11***
	EFF005	***4***				
	EFF002	***2.6***				
	EFF014	***2.6***				
	CAP001	***1.4***				
	EFF040	***1.2***				
	EFF058	***1.1***				
	EFF042	***0.69***				
	EFF057	***0.66***				
	EFF009	***0.63***				
	EFF041	***0.62***				
Cadmium	EFF011	3.3	9.3	***0***	1.29	***0***
	EFF012	2.7				
	EFF067	0.61				
	EFF006	0.6				
	EFF005	0.52				
Calcium	EFF011	***260000***	NV	***36***	53456	***6***
	EFF012	***160000***				
	EFF067	***70000***				
	EFF006	***66000***				

Table 6
Summary of COPCs of Stormwater Effluent Samples

COMPOUND NAME	SAMPLE ID	RESULTS (µg/L)	SCREENING VALUE	# OF COPCs	REFERENCE VALUE	# OF EXCEEDANCES REMAINING
Calcium	EFF013	*66000*				
	EFF058	*61000*				
	EFF014	*50000*				
	EFF010	*47000*				
	EFF068	*44000*				
	EFF057	*43000*				
	EFF063	*42000*				
	EFF065	*40000*				
	EFF035	*39000*				
	EFF009	*34000*				
	EFF001	*29000*				
	EFF004	*29000*				
	EFF066	*24000*				
	EFF034	*23000*				
	EFF048	*23000*				
	EFF069	*23000*				
	EFF002	*20000*				
	EFF005	*20000*				
	EFF007	*20000*				
	EFF064	*20000*				
	CAP001	*19000*				
	EFF003	*16000*				
	EFF042	*14000*				
	EFF040	*12000*				
	EFF045	*9300*				
	EFF043	*9200*				
	EFF031	*6900*				
	EFF019	*5800*				
	EFF044	*5700*				

Table 6
Summary of COPCs of Stormwater Effluent Samples

COMPOUND NAME	SAMPLE ID	RESULTS (µg/L)	SCREENING VALUE	# OF COPCs	REFERENCE VALUE	# OF EXCEEDANCES REMAINING
Calcium	EFF041	***3500***				
	EFF008	***3200***				
	EFF047	***2900***				
Carbazole	EFF040	***0.56***	NV	***1***	NV	***1***
Chromium	EFF011	31	50	***0***	13	***0***
	CAP001	11				
	EFF014	11				
	EFF040	6.6				
	EFF002	5.9				
	EFF004	5.6				
	EFF006	4.7				
	EFF019	4.6				
	EFF068	3.3				
	EFF065	3				
	EFF010	2.9				
	EFF066	2.6				
	EFF005	2.4				
	EFF034	2.4				
	EFF035	2.3				
	EFF013	2.2				
	EFF041	2				
	EFF048	2				
	EFF058	2				
	EFF064	2				
	EFF069	1.7				
	EFF012	1.5				
	EFF067	1.5				

Table 6
Summary of COPCs of Stormwater Effluent Samples

COMPOUND NAME	SAMPLE ID	RESULTS (µg/L)	SCREENING VALUE	# OF COPCs	REFERENCE VALUE	# OF EXCEEDANCES REMAINING
Chromium	EFF001	1.2				
	EFF043	1.1				
	EFF042	0.96				
	EFF057	0.95				
Chrysene	EFF040	***2.2***	NV	***2***	NV	***2***
	EFF041	***2.1***				
Cobalt	EFF011	***2.8***	NV	***4***	2	***1***
	EFF006	***1.4***				
	EFF014	***1.2***				
	EFF048	***0.96***				
Copper	EFF011	***130***	2.9	***29***	42	***1***
	EFF012	***37***				
	EFF014	***35***				
	EFF031	***35***				
	EFF006	***34***				
	EFF008	***30***				
	EFF068	***25***				
	EFF019	***16***				
	EFF048	***14***				
	EFF004	***13***				
	EFF005	***12***				
	EFF065	***12***				
	EFF035	***10***				
	EFF044	***10***				
	EFF066	***10***				

Table 6
Summary of COPCs of Stormwater Effluent Samples

COMPOUND NAME	SAMPLE ID	RESULTS (µg/L)	SCREENING VALUE	# OF COPCs	REFERENCE VALUE	# OF EXCEEDANCES REMAINING
Copper	EFF067	*10*				
	EFF003	*9.5*				
	EFF013	*8.7*				
	EFF047	*7.1*				
	EFF010	*6.9*				
	EFF058	*6.5*				
	EFF064	*5.8*				
	EFF045	*5.4*				
	EFF069	*5.2*				
	EFF034	*5*				
	EFF007	*4.8*				
	EFF009	*4.5*				
	EFF057	*4.5*				
	EFF063	*3.8*				
Cyanide, Total	CAP001	*5.4*	1	*1*	16.3	*0*
Dibenzofuran	EFF058	*0.94*	NV	*1*	NV	*1*
Endosulfan sulfate	EFF040	*0.053*	NV	*1*	NV	*1*
Fluoranthene	EFF040	*4.1*	1.6	*3*	NV	*3*
	EFF041	*4.1*				
	EFF058	*1.7*				
Fluorene	EFF058	*0.4*	NV	*1*	NV	*1*
Heptachlor	EFF012	*0.014*	0.0036	*1*	NV	*1*

Table 6
Summary of COPCs of Stormwater Effluent Samples

COMPOUND NAME	SAMPLE ID	RESULTS (µg/L)	SCREENING VALUE	# OF COPCs	REFERENCE VALUE	# OF EXCEEDANCES REMAINING
Indeno(1,2,3-cd)pyrene	EFF041	***0.62***	NV	*2*	NV	*1*
	EFF008	***0.59***				
Iron	EFF011	***180000***	NV	*36*	4134	*2*
	EFF014	***5100***				
	EFF006	***2100***				
	EFF040	***1800***				
	EFF004	***1600***				
	EFF013	***1500***				
	EFF002	***1300***				
	EFF068	***1000***				
	EFF010	***910***				
	EFF005	***870***				
	EFF065	***790***				
	EFF066	***780***				
	EFF035	***710***				
	EFF063	***670***				
	EFF064	***580***				
	EFF034	***520***				
	EFF069	***520***				
	EFF067	***510***				
	EFF001	***440***				
	EFF007	***300***				
	EFF048	***290***				
	EFF058	***290***				
	EFF009	***280***				
	EFF041	***280***				
	EFF012	***270***				
	EFF043	***220***				

Table 6
Summary of COPCs of Stormwater Effluent Samples

COMPOUND NAME	SAMPLE ID	RESULTS (µg/L)	SCREENING VALUE	# OF COPCs	REFERENCE VALUE	# OF EXCEEDANCES REMAINING
Iron	CAP001	***190***				
	EFF003	***190***				
	EFF019	***190***				
	EFF057	***190***				
	EFF044	***160***				
	EFF042	***140***				
	EFF045	***95***				
	EFF008	***92***				
	EFF031	***74***				
	EFF047	***55***				
Lead	EFF006	***80***	8.5	*7*	33.6	***2***
	EFF014	***38***				
	EFF041	***25***				
	EFF002	***18***				
	EFF005	***15***				
	EFF012	***15***				
	EFF040	***9.6***				
	EFF008	7.8				
	EFF068	7.5				
	EFF035	6.1				
	EFF004	5.5				
	EFF065	5.4				
	EFF011	4.9				
	EFF066	4.9				
	EFF013	4.7				
	EFF001	4.5				
	EFF048	4.4				
	CAP001	4.3				

Table 6
Summary of COPCs of Stormwater Effluent Samples

COMPOUND NAME	SAMPLE ID	RESULTS (µg/L)	SCREENING VALUE	# OF COPCs	REFERENCE VALUE	# OF EXCEEDANCES REMAINING
Lead	EFF019	3.3				
	EFF064	3.1				
	EFF042	2.7				
	EFF034	2.5				
	EFF069	2.5				
	EFF057	2.4				
Magnesium	EFF012	***100000***	NV	***36***	49256	***2***
	EFF013	***93000***				
	EFF058	***47000***				
	EFF057	***40000***				
	EFF035	***36000***				
	EFF011	***34000***				
	EFF063	***28000***				
	EFF042	***25000***				
	EFF048	***18000***				
	EFF067	***18000***				
	EFF068	***18000***				
	EFF009	***16000***				
	EFF006	***10000***				
	EFF014	***10000***				
	EFF034	***7100***				
	EFF066	***6900***				
	EFF005	***6300***				
	EFF019	***6000***				
	EFF065	***4700***				
	EFF010	***4200***				
	EFF064	***3800***				
	EFF043	***2900***				

Table 6
Summary of COPCs of Stormwater Effluent Samples

COMPOUND NAME	SAMPLE ID	RESULTS (µg/L)	SCREENING VALUE	# OF COPCs	REFERENCE VALUE	# OF EXCEEDANCES REMAINING
Magnesium	EFF069	*2500*				
	EFF007	*2100*				
	EFF040	*2100*				
	EFF044	*1800*				
	EFF004	*1600*				
	EFF003	*1300*				
	EFF001	*1200*				
	EFF031	*960*				
	EFF002	*840*				
	CAP001	*560*				
	EFF045	*520*				
	EFF008	*370*				
	EFF041	*310*				
	EFF047	*290*				
Manganese	EFF011	*900*	NV	*36*	74.5	*5*
	EFF063	*140*				
	EFF014	*110*				
	EFF067	*98*				
	EFF012	*85*				
	EFF040	*73*				
	EFF058	*49*				
	EFF006	*41*				
	EFF013	*39*				
	EFF068	*37*				
	EFF009	*32*				
	EFF064	*32*				
	EFF066	*27*				
	EFF010	*25*				

Table 6
Summary of COPCs of Stormwater Effluent Samples

COMPOUND NAME	SAMPLE ID	RESULTS (µg/L)	SCREENING VALUE	# OF COPCs	REFERENCE VALUE	# OF EXCEEDANCES REMAINING
Manganese	EFF035	*23*				
	EFF005	*20*				
	EFF048	*17*				
	EFF069	*17*				
	EFF002	*16*				
	EFF043	*16*				
	EFF065	*16*				
	EFF001	*14*				
	EFF034	*13*				
	EFF004	*9.9*				
	EFF057	*9.4*				
	EFF041	*8.7*				
	EFF042	*8.2*				
	EFF019	*7.2*				
	EFF003	*6.5*				
	EFF007	*6.3*				
	EFF031	*5.1*				
	EFF008	*5*				
	EFF044	*4.6*				
	CAP001	*4.2*				
	EFF047	*3.2*				
	EFF045	*3.1*				
Mercury	CAP001	*0.22*	0.025	*2*	0.11	*2*
	EFF013	*0.12*				
Methoxychlor	EFF047	*0.17*	0.03	*1*	NV	*1*
Nickel	EFF011	*18*	8.3	*2*	5.14	*2*

Table 6
Summary of COPCs of Stormwater Effluent Samples

COMPOUND NAME	SAMPLE ID	RESULTS (µg/L)	SCREENING VALUE	# OF COPCs	REFERENCE VALUE	# OF EXCEEDANCES REMAINING
Nickel	EFF012	***8.5***				
	EFF014	6				
	EFF006	4.5				
	CAP001	3.1				
	EFF068	2.6				
	EFF042	2.6				
	EFF010	2.3				
	EFF013	2.1				
	EFF058	2				
	EFF009	1.8				
	EFF005	1.8				
	EFF004	1.7				
	EFF065	1.3				
Pentachlorophenol	EFF005	***14***	7.9	***3***	NV	***3***
	EFF006	***14***				
	EFF067	***14***				
Phenanthrene	EFF040	***2.6***	NV	***2***	NV	***2***
	EFF041	***2.1***				
Potassium	EFF013	***41000***	NV	***36***	23679	***3***
	EFF012	***38000***				
	EFF058	***24000***				
	EFF035	***18000***				
	EFF057	***17000***				
	EFF011	***14000***				
	EFF063	***13000***				
	EFF068	***13000***				

Table 6
Summary of COPCs of Stormwater Effluent Samples

COMPOUND NAME	SAMPLE ID	RESULTS (µg/L)	SCREENING VALUE	# OF COPCs	REFERENCE VALUE	# OF EXCEEDANCES REMAINING
Potassium	EFF067	*11000*				
	CAP001	*10000*				
	EFF009	*10000*				
	EFF042	*9200*				
	EFF048	*8200*				
	EFF010	*7700*				
	EFF066	*5800*				
	EFF006	*5100*				
	EFF014	*4400*				
	EFF044	*4300*				
	EFF034	*3700*				
	EFF069	*3500*				
	EFF004	*3100*				
	EFF019	*3000*				
	EFF005	*2500*				
	EFF065	*2500*				
	EFF003	*2400*				
	EFF007	*2400*				
	EFF064	*2300*				
	EFF040	*1700*				
	EFF043	*1700*				
	EFF001	*1100*				
	EFF008	*1000*				
	EFF002	*900*				
	EFF031	*770*				
	EFF045	*670*				
	EFF047	*360*				
	EFF041	*300*				

Table 6
Summary of COPCs of Stormwater Effluent Samples

COMPOUND NAME	SAMPLE ID	RESULTS (µg/L)	SCREENING VALUE	# OF COPCs	REFERENCE VALUE	# OF EXCEEDANCES REMAINING
Pyrene	EFF040	***3.1***	NV	***3***	NV	***3***
	EFF041	***2.6***				
	EFF058	***0.97***				
Selenium	EFF064	5.6	71	***0***	NV	***0***
Sodium	EFF013	***800000***	NV	***36***	395333	***2***
	EFF012	***770000***				
	EFF035	***320000***				
	EFF058	***310000***				
	EFF057	***300000***				
	EFF067	***260000***				
	EFF011	***220000***				
	EFF042	***210000***				
	EFF068	***190000***				
	EFF063	***170000***				
	EFF048	***140000***				
	EFF009	***130000***				
	EFF006	***81000***				
	EFF066	***75000***				
	EFF014	***74000***				
	EFF065	***74000***				
	EFF034	***59000***				
	EFF005	***51000***				
	EFF019	***48000***				
	EFF064	***33000***				
	EFF010	***30000***				
	CAP001	***21000***				
	EFF043	***20000***				

Table 6
Summary of COPCs of Stormwater Effluent Samples

COMPOUND NAME	SAMPLE ID	RESULTS (µg/L)	SCREENING VALUE	# OF COPCs	REFERENCE VALUE	# OF EXCEEDANCES REMAINING
Sodium	EFF069	***14000***				
	EFF044	***9500***				
	EFF031	***8100***				
	EFF040	***6500***				
	EFF007	***6000***				
	EFF003	***4700***				
	EFF001	***3100***				
	EFF045	***2600***				
	EFF008	***2400***				
	EFF004	***2300***				
	EFF047	***2100***				
	EFF002	***1600***				
	EFF041	***1600***				
Thallium	EFF014	*5.5*	21.3	***0***	5.77	***0***
	CAP001	*5.2*				
	EFF008	*4.6*				
Tin	EFF009	***5***	NV	***2***	NV	***2***
	EFF010	*4.7*				
Vanadium	CAP001	***21***	NV	***36***	15.6	***1***
	EFF014	***14***				
	EFF006	***8.8***				
	EFF040	***8.7***				
	EFF005	***8.5***				
	EFF004	***8.1***				
	EFF045	***6.6***				
	EFF010	***6.1***				

Table 6
Summary of COPCs of Stormwater Effluent Samples

COMPOUND NAME	SAMPLE ID	RESULTS (µg/L)	SCREENING VALUE	# OF COPCs	REFERENCE VALUE	# OF EXCEEDANCES REMAINING
Vanadium	EFF002	*5.9*				
	EFF065	*5.4*				
	EFF013	*5.3*				
	EFF011	*5*				
	EFF068	*4.7*				
	EFF047	*4.2*				
	EFF067	*4.1*				
	EFF008	*4*				
	EFF035	*4*				
	EFF034	*3.8*				
	EFF057	*3.5*				
	EFF058	*3.4*				
	EFF066	*3.4*				
	EFF042	*3.2*				
	EFF031	*2.9*				
	EFF001	*2.6*				
	EFF064	*2.4*				
	EFF009	*2.3*				
	EFF043	*2.3*				
	EFF069	*2.3*				
	EFF048	*2.2*				
	EFF063	*2.2*				
	EFF041	*1.9*				
	EFF007	*1.7*				
	EFF012	*1.7*				
	EFF044	*1.6*				
	EFF003	*1.4*				
	EFF019	*1.4*				

Table 6
Summary of COPCs of Stormwater Effluent Samples

COMPOUND NAME	SAMPLE ID	RESULTS (µg/L)	SCREENING VALUE	# OF COPCs	REFERENCE VALUE	# OF EXCEEDANCES REMAINING
Zinc	EFF011	***530***	86	***12***	308	***3***
	EFF014	***530***				
	EFF012	***460***				
	EFF001	***150***				
	EFF002	***140***				
	EFF009	***130***				
	EFF040	***120***				
	EFF058	***110***				
	EFF065	***110***				
	EFF010	***100***				
	EFF007	***99***				
	EFF067	***91***				
	EFF019	74				
	EFF005	73				
	EFF003	66				
	EFF048	58				
	EFF031	57				
	EFF066	55				
	EFF006	51				
	EFF068	50				
	EFF008	47				
	EFF057	46				
	EFF013	44				
	EFF063	38				
	EFF034	35				
	EFF035	33				
	EFF064	33				
	CAP001	28				
	EFF004	19				

Table 6
Summary of COPCs of Stormwater Effluent Samples

COMPOUND NAME	SAMPLE ID	RESULTS (µg/L)	SCREENING VALUE	# OF COPCs	REFERENCE VALUE	# OF EXCEEDANCES REMAINING
Zinc	EFF069	18				
	EFF044	16				

REFERENCES

Gilbert, R.O. (1987). *Statistical Methods for Environmental Pollution Monitoring.* Van Nostrand Reinhold, New York.

USEPA. (1992). *Statistical Training Course for Ground-Water Monitoring Data Analysis*, Office of Solid Waste Management Division.

Washington Department of Ecology (WDOE). (1998). *Supplement to Statistical Guidance for Ecology Site Managers.* Toxics Cleanup Program. Olympia, WA.

WDOE. (1992). *Statistical Guidance for Ecology Site Managers.* Toxics Cleanup Program.(92-54) Olympia, WA.