Background Soil Investigation

Melville North Landfill
Portsmouth, Rhode Island

Northern Division
Naval Facilities Engineering Command
Contract Number N62472-90-D-1298
Contract Task Order 0172

November 1998

TETRA TECH NUS, INC.

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BACKGROUND SOIL INVESTIGATION

MELVILLE NORTH LANDFILL
PORTSMOUTH, RHODE ISLAND

COMPREHENSIVE LONG-TERM
ENVIRONMENTAL ACTION - NAVY (CLEAN) CONTRACT

Submitted to:
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Environmental Branch, Code 1823/JS
Naval Facilities Engineering Command
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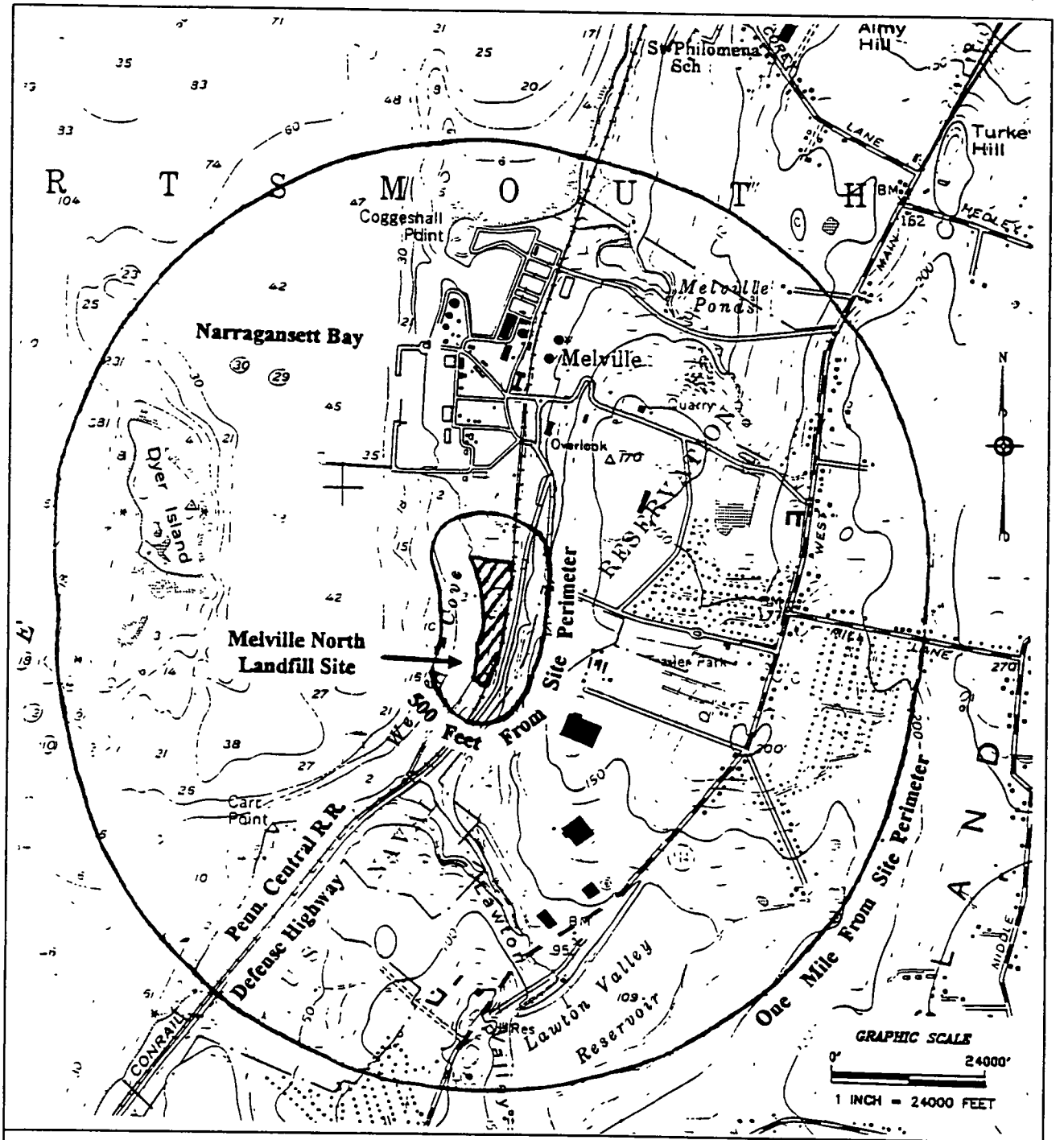
1.0 INTRODUCTION

This report has been prepared under the Comprehensive Long Term Environmental Action Navy (CLEAN) Contract No. N62472-90-D-298, Contract Task Order (CTO) 172. The statement of work requires Tetra Tech NUS, Inc. (TtNUS) to provide assistance to the Navy in determining background concentrations of contaminants that are naturally occurring in the soil environment located at the Melville North Landfill (MNLF) site on Aquidneck Island, in Portsmouth, Rhode Island (Figure 1-1). The MNLF site was formerly part of the Naval Education and Training Center (NETC) Newport. This report describes the background soil sampling investigation conducted in the vicinity of the MNLF site, and presents the results of the sampling, and the laboratory and statistical analyses conducted as part of the investigation. The report is presented in five sections: Introduction, Site Description and History, Field Investigation Activities, Data Analysis and Statistical Testing, and Conclusions and Recommendations.

1.1 PURPOSE AND OBJECTIVES

Previous investigations indicated that the background levels of certain chemicals may be higher in soils on Aquidneck Island than other areas of Rhode Island. Background samples provide baseline measurements to determine what the concentrations of these chemicals would be at a site if no releases occurred there. Based on the site characterization performed as part of the MNLF Site Investigation (SI), arsenic was identified as a chemical of concern for the site. The objective for the study summarized in this report is to provide sufficient data to establish background concentrations of arsenic in soils for the MNLF site by determining the occurrence, geochemical abundance, and variability (scatter) of surface and subsurface soil concentrations of arsenic occurring naturally in the environment. The background level for arsenic will be used to determine soil remediation target levels for the MNLF site.

The term "background", as defined in the RIDEM Site Remediation Regulation (DEM-DSR-01-93), refers to the ambient concentrations of hazardous substances present in the environment that have not been influenced by human activities, or the ambient concentrations of hazardous substances consistently present in the environment in the vicinity of the contaminated site that are the result of human activities unrelated to releases at the contaminated site.



BASE MAP IS A PORTION OF THE FOLLOWING U.S.G.S. 7.5 SERIES QUADRANGLE:
PRUDENCE ISLAND, RI 1955 PHOTOREVISED 1970 AND 1975

SITE LOCATION AND SURROUNDING FEATURES	FIGURE 1–1
MELVILLE NORTH LANDFILL – BACKGROUND SOIL INVESTIGATION REPORT	
NETC – NEWPORT, RI	

DRAWN BY:	A. PUTNAM	REV.:	0
CHECKED BY:	R. CLEAVER	DATE:	NOVEMBER 10, 1998
SCALE:	1" = 24000'	ACAD NAME:	DWG\MELVILL\SITEINV2\SITELOC

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In addition to sampling soils to provide background data for arsenic at MNLF, three samples were analyzed for full target analyte list (TAL) metals to support a separate investigation to establish background in soil levels for NETC base wide.

2.0 SITE DESCRIPTION AND HISTORY

NETC-Newport is located in the City of Newport, and Towns of Middletown, and Portsmouth, Rhode Island on the western shore of Aquidneck Island facing the east passage of Narragansett Bay. The Melville North Landfill Site is located in the Melville North area of Portsmouth along the shoreline of Narragansett Bay (Figure 1-1). The site is situated in a low-lying wetland area between Defense Highway and Narragansett Bay. The site covers approximately 10 acres and was used as a landfill for the Newport naval complex from World War II until 1955. The exact date the site first began to be used as a landfill is unclear, but indications are that use began after the war. Following its closure, wastes generated at the naval complex were disposed of at the McAllister Point Landfill.

The MNLF received wastes similar to those disposed of in McAllister Point Landfill, including spent acids, waste paints, solvents, waste oils (diesel, fuel, lube) and, potentially, PCBs. The waste quantity disposed of in the landfill is unknown. During visual inspections of the site, areas covered with oil and oil sludge were found to be scattered throughout the site. Mounds of oil-soaked soil appeared to have been trucked to the site and dumped. These oil-contaminated mounds could be the oil sludge materials obtained from the tank farms during tank cleaning operations, or the result of cleanup operations following oil spills. During the TtNUS SI field investigation, ash and cinders, metal debris, and construction debris were also observed in the landfill. In addition, four drums containing product were found during the 1995 removal action excavation.

Suspected source areas at the site included two suspected waste lagoons approximately 60 feet long and 25 feet wide in the center of the landfill. An oily waste pile formerly occupied the northwestern portion of the landfill before a 1993 removal action. Two possible impoundment areas occur in the southwest portion of the landfill.

The site was first studied in the early 1980s when the NETC Initial Assessment Study (IAS), completed in March 1983, identified MNLF as a site where suspected contamination may pose a threat to human health or the environment and concluded further study was required. The NETC Confirmation Study (CS) Report (including MNLF) was completed in May 1986. After the NETC was listed on the U.S. EPA's National Priorities List (NPL) of abandoned or uncontrolled waste sites, a Phase I RI/FS Report was issued in 1991 for five NETC sites (including the MNLF). On March 23, 1992 a Federal Facilities Interagency (FFA) was signed by the Navy, the State of Rhode

Island, and the EPA for four of the five Phase I RI/FS sites. The MNLF Site was excluded from this agreement because it was not owned by the Navy at the time of the NPL listing.

Removal actions at the site include the 1993 removal of an oily waste pile from the northern end of the site that included off-site disposal of approximately 800 cubic yards of soil and 100 cubic yards of railroad timbers. In the fall of 1995, 8,496 cubic yards of TPH-contaminated soil was excavated from two areas of the site in an interim removal action.

The site remained a part of NETC-Newport until September 1983 when it was excessed to the State of Rhode Island. Six months later, the site was sold to Melville Marine Industries, its present owner. Although the Navy is no longer the site owner under the property transfer agreement, the Navy is responsible for environmental restoration of the MNLF Site.

In 1996 and 1997, the Navy conducted an SI at the MNLF Site in accordance with RIDEM remediation regulations. Based on the SI and planned marina use of the site by its present owner, RIDEM notified the Navy that remediation to residential standards was required. The contaminants exceeding these standards are arsenic, lead, and TPH.

3.0 FIELD INVESTIGATION ACTIVITIES

This section presents a description of the field investigation activities that were conducted as part of the background soil investigation for the MNLF Site and vicinity. The investigation activities included a reconnaissance survey with RIDEM to evaluate proposed background sampling locations, soil sampling and analysis of 20 background soil locations (plus QA/QC samples), and a global positioning system (GPS) survey of the background sample locations. The background soil sampling investigation was generally conducted in accordance with the Draft Final Work Plan (TtNUS, 1998), except as noted below.

As scoped in the Work Plan, background soil samples having a composition similar to the soil types that may have been found at the MNLF prior to landfilling activities were collected from surrounding areas at undisturbed locations determined to be free of influence from either the site or other non-uniformly distributed anthropogenic sources. Soil samples were collected from two soil types: the Newport Silt Loam and Matunuck Mucky Peat, as summarized in Table 3-1. Soil survey maps of the area are presented as Figures 3-1 and 3-2.

The objective stated in the approved Draft Final Work Plan was to obtain both surficial samples and shallow subsurface soil data to establish background concentrations of metals in the vicinity of the MNLF. Consistent with the Work Plan, samples were collected from the ground surface to the bottom of the vadose zone (or as deep as possible using hand augering techniques) at 20 locations. Where shallow refusals were met, multiple attempts were made to attempt to reach the bottom of the vadose zone. Two soil samples were collected from each sample location point: a surface sample (from the zero to 0.5 foot interval) and a subsurface sample (soil below the 0.5 foot depth). As indicated in Table 3-1, ten locations were in areas where the soil type is classified as the Matunuck Mucky Peat (BKG-SS01-MK through BKG-SS10-MK) and ten locations were in areas where the soil type is the Newport Silt Loam (BKG-SS01-NEB through BKG-SS10-NEB).

Soil samples were not collected from the two areas originally presented in the work plan targeting the Newport Silt Loam soil type.

- The Navy did not gain property access for the areas proposed east of the MNLF site;

TABLE 3-1

SOIL SAMPLE SUMMARY
BACKGROUND SOIL INVESTIGATION
MELVILLE NORTH LANDFILL
PORTSMOUTH, RHODE ISLAND

SAMPLE I.D.	SOIL TYPE	GENERAL LOCATION	SAMPLES COMPOSITED (Depth Intervals in feet)	ARSENIC (mg/kg)	COMMENTS
BKG-SS01-NEB-0015	Newport Silt Loam (NeB)	Lower Melville Pond	0 to 0 5 and 0.5 to 1 5	4 5J	Duplicate Pair 2
BKG-DUPL02-NEB	Newport Silt Loam (NeB)	Lower Melville Pond	0 to 0.5 and 0 5 to 1 5	3 9J	Duplicate Pair 2
BKG-SS02-NEB-0020	Newport Silt Loam (NeB)	Lower Melville Pond	0 to 0.5 and 0.5 to 2 0	4 4J	
BKG-SS03-NEB-0016	Newport Silt Loam (NeB)	Lower Melville Pond	0 to 0 5 and 0 5 to 1 6	6 2J	TAL Metals
BKG-SS04-NEB-0018	Newport Silt Loam (NeB)	Lower Melville Pond	0 to 0 5 and 0 5 to 1 8	9 5J	
BKG-SS05-NEB-0017	Newport Silt Loam (NeB)	Lower Melville Pond	0 to 0.5 and 0 5 to 1 7	5 6J	
BKG-SS06-NEB-0020	Newport Silt Loam (NeB)	West of campground access road	0 to 0 5 and 0 5 to 2 0	6 7J	
BKG-SS07-NEB-0020	Newport Silt Loam (NeB)	West of campground access road	0 to 0 5 and 0 5 to 2 0	7 4J	
BKG-SS08-NEB-0017	Newport Silt Loam (NeB)	West of campground access road	0 to 0 5 and 0 5 to 1 7	2 1J	Duplicate Pair 1
BKG-DUPL01-NEB	Newport Silt Loam (NeB)	West of campground access road	0 to 0.5 and 0 5 to 1 7	2 4J	Duplicate Pair 1
BKG-SS09-NEB-0018	Newport Silt Loam (NeB)	West of campground access road	0 to 0 5 and 0 5 to 1.8	10 8J	TAL Metals
BKG-SS10-NEB-0005	Newport Silt Loam (NeB)	West of campground access road	Not Composited (0 to 0 5)	5.3J	
BKG-SS10-NEB-0551	Newport Silt Loam (NeB)	West of campground access road	Not Composited (0 5 to 5 1)	5 7J	
BKG-SS01-MK-0005	Matunuck Mucky Peat (Mk)	South of Mount Hope Bridge	Not Composited (0 to 0 5)	11 5J	Duplicate Pair 3
BKG-DUPL03-MK	Matunuck Mucky Peat (Mk)	South of Mount Hope Bridge	Not Composited (0 to 0 5)	6 3J	Duplicate Pair 3
BKG-SS01-MK-0532	Matunuck Mucky Peat (Mk)	South of Mount Hope Bridge	Not Composited (0 5 to 3 2)	3 2J	
BKG-SS02-MK-0022	Matunuck Mucky Peat (Mk)	South of Mount Hope Bridge	0 to 0 5 and 0 5 to 2 2	8 4J	
BKG-SS03-MK-0022	Matunuck Mucky Peat (Mk)	South of Mount Hope Bridge	0 to 0 5 and 0.5 to 2.2	5 3J	
BKG-SS04-MK-0012	Matunuck Mucky Peat (Mk)	South of Mount Hope Bridge	0 to 0 5 and 0 5 to 1.2	12 3J	
BKG-SS05-MK-0010	Matunuck Mucky Peat (Mk)	South of Mount Hope Bridge	0 to 0 5 and 0 5 to 1 0	3 7J	
BKG-SS06-MK-0016	Matunuck Mucky Peat (Mk)	Dyer Island	0 to 0 5 and 0 5 to 1 6	7 4J	
BKG-SS07-MK-0020	Matunuck Mucky Peat (Mk)	Dyer Island	0 to 0 5 and 0 5 to 2 0	5 1J	TAL Metals
BKG-SS08-MK-0016	Matunuck Mucky Peat (Mk)	Dyer Island	0 to 0 5 and 0 5 to 1 6	4 3J	
BKG-SS09-MK-0023	Matunuck Mucky Peat (Mk)	Dyer Island	0 to 0 5 and 0 5 to 2 3	5 2J	
BKG-SS10-MK-0018	Matunuck Mucky Peat (Mk)	Dyer Island	0 to 0.5 and 0 5 to 1 8	3 9J	

NOTES: J - Quantitation approximate
mg/kg - milligrams per kilogram

FIGURE 3-1

SOIL SURVEY MAP 89

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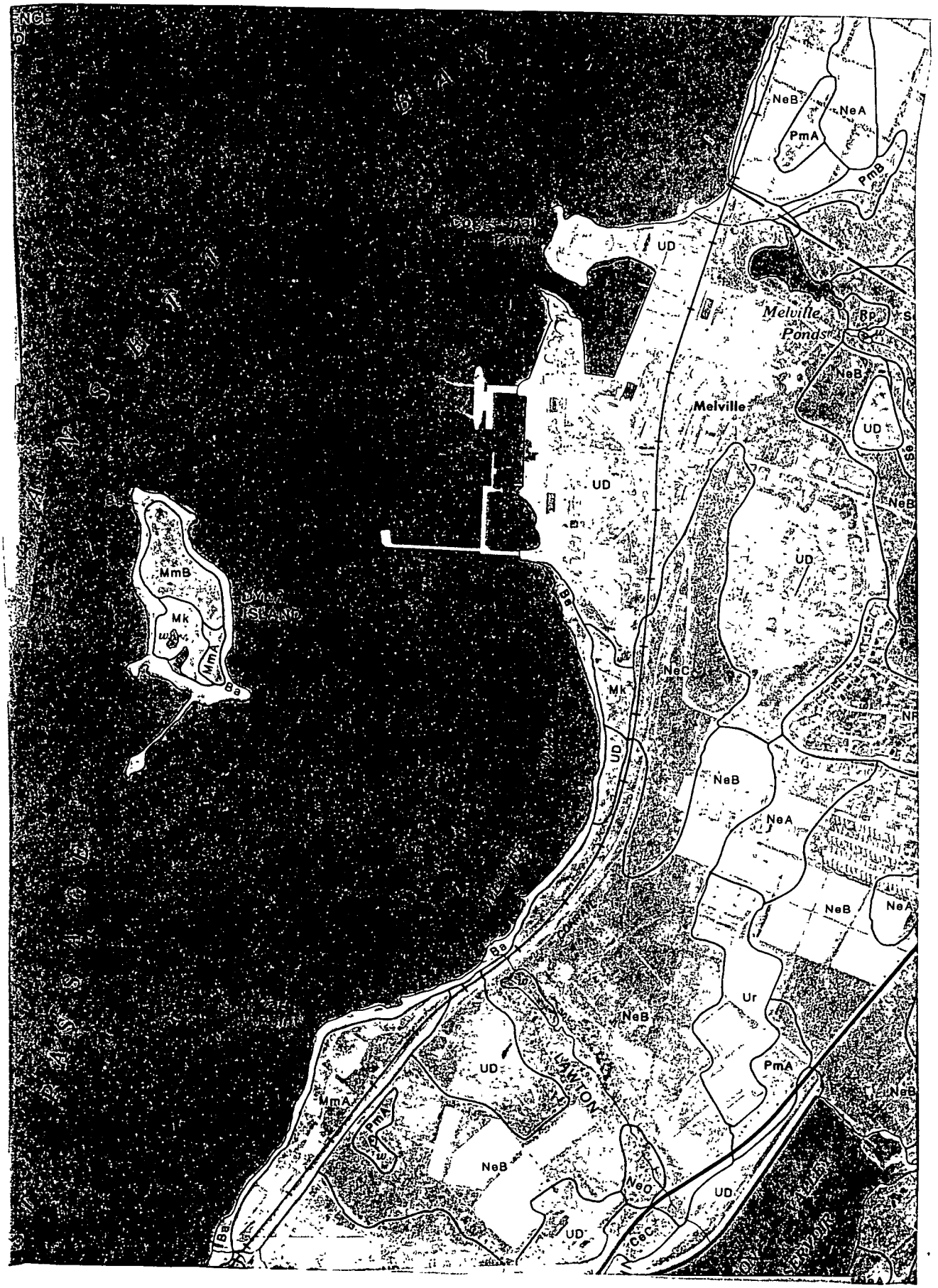

FIGURE 3-2

SOIL SURVEY MAP 99

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- The area south of the MNLF site and north of the Weaver Cove Public Boat Launch was determined to be unacceptable by field personnel during the sampling event. A thin layer of black material with a petroleum-like odor was encountered while hand augering in this area.

Within each soil type, two general areas were selected for background soil sample collection. Areas which were sampled within the Newport Silt Loam soil type included: (1) the northern side of Lower Melville Pond, located approximately 0.8 miles north-northeast of MNLF; (2) the area west of the Melville Ponds Campground access road, located approximately 0.7 miles northeast of MNLF. Areas which were sampled within the Matunuck Mucky Peat soil type included: (1) the vicinity of the southern end of Mount Hope Bridge, located approximately 3.7 miles north-northeast of MNLF; (2) Dyer Island, located in Narragansett Bay, approximately 0.7 miles west-northwest of MNLF.

Consistent with the Work Plan, prior to collecting the soil samples, approximately the top 2 inches of the soil sample was removed from the location to limit the effects of potential pollutant sources such as automobile emissions, road runoff, or other common anthropogenic sources of soil contamination. Soil samples were collected by hand auger into a decontaminated stainless steel bowl and were homogenized using a stainless steel trowel and then transferred to the appropriate sample containers. All non-disposable sampling equipment that contacted the sample medium was decontaminated to prevent cross-contamination between sampling points, as specified in the Draft Final Work Plan. Field data were recorded on sample logsheets and in the field logbook. Appropriate chain-of-custody and sample handling and shipping procedures were adhered to, as detailed in the Work Plan.

All soil sampling locations were surveyed by TtNUS staff with GPS survey equipment (to sub-meter accuracy). General areas of background soil sample locations are presented in Figure 3-3. The surveyed sample location coordinates (northings/eastings) are presented in Appendix C.

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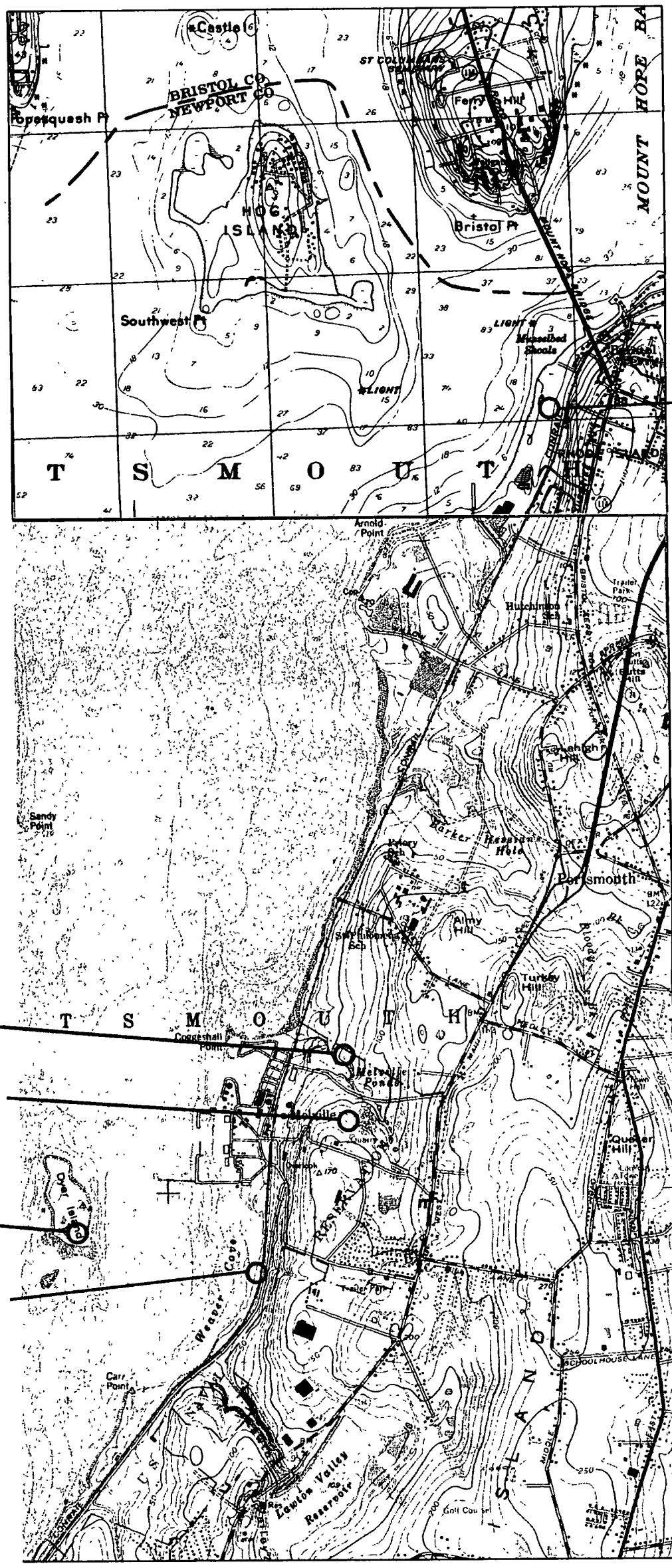

GRAPHIC SCALE

0' 3500'

NOTES:

1. ALL LOCATIONS TO BE CONSIDERED APPROXIMATE.
2. PLAN NOT TO BE USED FOR DESIGN.
3. PLAN BASED ON SCANNED IMAGES OF USGS QUADRANGLE SHEETS: PRUDENCE ISLAND, RI & BRISTOL, RI – MASS., SCALE IS APPROXIMATE.

BACKGROUND SOIL SAMPLING LOCATIONS		FIGURE 3–3	
DRAFT FINAL WORKPLAN – BACKGROUND SOIL INVESTIGATION		TETRA TECH NUS, INC.	
MELVILLE NORTH LANDFILL – PORTSMOUTH, RI			
DRAWN BY: R.G. DEWSNAP	REV.: 0	55 Jonspin Road	Wilmington, MA 01887
CHECKED BY: R. CLEAVER	DATE: 11 NOV 98	(978)658–7899	
SCALE: AS SHOWN	FILE NO.: \DWG\MELVILL\CTO172\BG_SSLOC.DWG		

11

CTO 172

DRAFT

Forty-six field samples were collected:

- 23 soil samples from the zero to 0.5 foot depth interval (including three field duplicates)
- 22 soil samples from 0.5 feet to between 1 foot and 5.1 feet below ground surface, depending on hand auger refusal or depth to the water table (including two field duplicates)
- 1 aqueous equipment rinsate blank

Additionally, split soil samples were collected at selected locations and provided to the RIDEM representative.

After these samples were collected, but prior to shipment for laboratory analysis, RIDEM and the Navy decided to composite all samples that were collected from each location from the zero to approximately 2-foot depth interval, for laboratory analysis. Samples were composited by TtNUS personnel in accordance with this decision, as summarized in Table 3-1. Following compositing, 26 samples (including 1 rinsate blank) were shipped for laboratory analysis (see Table 3-1). Also, as indicated in Table 3-1, those subsurface samples that had been collected to depths greater than approximately 2 feet were not composited with their associated surficial soil samples (zero to 0.5 feet), but were analyzed as separate samples because they were collected from a depth deeper than the desired interval.

All soil samples were analyzed for arsenic; soil from three sample locations was analyzed for TAL metals, as indicated in Table 3-1. Laboratory analysis was performed by a Rhode Island certified analytical laboratory subcontractor, GP Environmental Services, Inc., a laboratory previously approved by the Navy. Standard EPA analytical procedures were employed, in accordance with the Work Plan. Laboratory data review activities were then performed by a TtNUS chemist to ensure data quality, in accordance with the Draft Final Work Plan, and a data review memorandum was prepared. The analytical data and data review memorandum are presented in Appendix A.

4.0 DATA ANALYSIS AND STATISTICAL TESTING

Data analysis and statistical testing were performed following completion of the background soil sample analyses and analytical data review. The arsenic background data underwent several statistical comparisons to determine whether data from different soil types and depth categories are appropriately treated separately or combined into final background data set(s). The background analytical data for metals other than arsenic were briefly examined to determine descriptive statistics (mean, range, etc.); these metals will be integrated into the base wide background database for use in other NETC Newport investigations. Note that all statistical tests were performed in accordance with the guidance and recommendations presented in several EPA and related publications (EPA, 1989, 1992a, 1992b, and 1996; US Navy, 1997; Gilbert, 1987 and 1993) cited at the end of this report. The following sections describe the data analysis and statistical testing tasks.

4.1 ARSENIC DATA EVALUATION

Step 1: Arsenic background data sets were evaluated to determine if shallow surface soil data (defined as composite samples collected from less than or equal to 2 feet depth) are suitable for combination with deeper subsurface soil data (defined as composite samples from depths including points below 2 feet).

- For Matunuck Mucky Peat soil, 10 surface soil samples and one subsurface soil sample were collected. Appendix B, Table B-1, presents W-Test results evaluating the distributional shape for arsenic in Matunuck Mucky Peat surface soil data, which (based on best fit) could be assumed to be lognormal in shape, although a normal assumption cannot be rejected. Assuming a lognormal distribution, a 95 percent upper tolerance limit (UTL) was estimated for the arsenic surface soil data set. As shown in Appendix B, Table B-2, the arsenic concentration in subsurface soil does not exceed the 95 percent UTL associated with surface soil. Because of the small number of samples in the subsurface soil data set, it was not possible to perform any other statistical comparisons between the surface and subsurface soil data sets. Based on the UTL test results, the assumption that the surface and subsurface data sets are from statistically equivalent populations was not rejected, so these data sets were combined.

- For Newport Silt Loam soil, 10 surface soil samples and one subsurface soil sample were collected. Appendix B, Table B-3, presents W-Test results evaluating the distributional shape for arsenic in Newport Silt Loam surface soil data, which (based on best fit) could be assumed to be normal in shape, although a lognormal assumption cannot be rejected. Assuming a normal distribution, a 95 percent UTL was estimated for the arsenic surface soil data set. As shown in Appendix B, Table B-4, the arsenic concentration in subsurface soil does not exceed the 95 percent UTL associated with surface soil. Because there was only one subsurface soil sample in this data set, it was not possible to perform any other statistical comparisons between the surface and subsurface soil data sets. Based on the UTL test results, the assumption that the surface and subsurface data sets are from statistically equivalent populations was not rejected, so these data sets were combined.

Step 2: After arsenic data sets were combined across all depth ranges for the Matunuck Mucky Peat soil type and separately for the Newport Silt Loam soil type, these two soil data sets were then compared to each other to determine if the distributional properties of the arsenic results represent statistically equivalent populations. The following evaluations were performed:

- Several exploratory data comparisons were performed. They determined an acceptable degree of similarity in the distributional shape of Matunuck Mucky Peat arsenic data versus Newport Silt Loam arsenic data. Appendix B, Table B-5, presents W-Test results evaluating the distributional shape for Newport Silt Loam data, which (based on best fit) could be assumed to be normal in shape, although a lognormal assumption cannot be rejected. Appendix B, Table B-6, presents W-Test results evaluating the distributional shape for Matunuck Mucky Peat data, which (based on best fit) could be assumed to be lognormal in shape, although a normal assumption cannot be rejected.

- Two other comparisons also revealed a similarity in descriptive statistics between these two soil types: Appendix B, Table B-7, shows that the two data sets possess similar arsenic concentrations at the 25th, 50th, 75th, and 95th quantiles. Appendix B, Table B-8, displays the close similarity of the maximum, minimum, and average arsenic concentrations between the two data sets.

- Appendix B, Figure B-1, illustrates that the cumulative frequency plots of the two data sets are also similar, based on a nearly linear match of the cumulative frequency distribution from each

soil type to the cumulative frequency distribution for the combined data set (comprised of both soil types).

Step 3: Several quantitative statistical comparisons were performed to determine if either data set exhibits arsenic concentrations that are statistically greater than arsenic levels in the other data set. These tests are designed to identify any across-the-board differences in the overall or average arsenic level between the two populations and also any differences in subsets comprised of the highest ranking concentrations in one data set that happen to be statistically greater than the corresponding upper concentration rank subsets from the other data set. For arsenic, the different background data sets were compared using the following tests:

- Student's t-test (difference in means for normal/lognormal data with equal variances)
- Satterthwaite t-test (difference in mean for normal/lognormal data with unequal variances)
- Bartlett's test (determines if background data subsets have equal variances)
- Mann-Whitney test (if rank distribution is similar given detection limits that are uniform)
- Gehan's test (if rank distribution is similar given that multiple detection limits exist)
- Quantile test (if rank distribution is similar for the upper concentrations subset of background)
- The test of proportions (if frequency of detection is similar given sufficient data points)
- Fisher's exact test (if frequency of detection is similar in the case of few data points)

As shown in Appendix B, Table B-9, the Matunuck Mucky Peat data set does not appear to contain arsenic concentrations statistically greater than those in the Newport Silt Loam data set. Appendix B, Table B-10, demonstrates the converse (Newport Silt Loam arsenic results are not greater than Matunuck Mucky Peat results).

In conclusion, these exploratory data evaluations and quantitative data comparisons indicate that arsenic results from the two soil type data sets can be combined, based on lack of any statistical findings that might suggest a basis for rejecting the assumption that the two populations are statistically equivalent.

Step 4: Once the arsenic data comprising the two soil types were combined, the following statistics were estimated to describe the final background data set:

- As shown in Appendix B, Table B-11, the best fitting distributional shape of the combined arsenic soil data set was determined to be lognormal (although an assumption of a normal shape could not be rejected).

- Two types of descriptive statistics were tabulated: Appendix B, Table B-12, presents the minimum, maximum, and mean for arsenic in the combined soil data set. Appendix B, Table B-13, presents the arsenic concentrations at the 25th, 50th, 75th, and 95th quantiles.

- To facilitate comparison of MNLF site-related arsenic results to background levels, Appendix B, Table B-14 presents the arsenic 95 percent UTL (11.8 mg/kg) and pertinent parameters such as log mean, log standard deviation, t-value, etc. that were applied to the UTL calculation. The UTL for arsenic was based on an assumption of a lognormal background population.

- The 95 percent UTL is defined as a tolerance limit expected to contain 95 percent of all possible measurements for the background data set. If a single sample collected from a site-related area yields a concentration greater than the 95 percent background UTL, then there is less than a 5 percent chance that this sample came from a population equivalent to the background data, and it is correct to conclude that site-related data are elevated above background. However, using the UTL test simultaneously on several site-related samples can lead to a false conclusion that the site data are elevated above background. For example, if the site population is really identical to the background population, then collecting 100 site-related samples would yield, on the average, 5 samples having concentrations exceeding the 95 percent background UTL.

- As a result of this bias, the UTL test is not generally valid as a stand-alone background test to determine whether any remedial action is needed at a site. Statistical guidance (US Navy, 1997) acknowledges that the UTL test can produce an unacceptably high false positive rate in cases where the site population is really no different from the background population. Therefore, UTL exceedances should be confirmed by additional statistical tests in which the false positive rate is controlled to less than a 5 percent error rate. In particular, an "elevated" concentration should be indicated only if there is found to be either an overall difference between the entire populations of site and background sample results (the t-test, the Mann-Whitney test, or Gehan's Test); hot spots at multiple locations (the upper ranks test); or if no

other tests are conclusive, an elevated frequency of detection in site versus background (the test of proportions or Fisher's Exact Test).

- It should also be noted that the 95 percent UTL is an estimated quantity based on a limited number of samples which approximates the true 95th percentile of the population's arsenic concentration. The UTL is therefore said to have a statistical coverage of 50 percent because such an estimated value is expected to be biased high one-half of the time or biased low one-half of the time, relative to the population's true 95th percentile.

4.2 DATA EVALUATION FOR OTHER TARGET ANALYTE LIST METALS

One soil sample representing Matunuck Mucky Peat and two soil samples representing Newport Silt Loam were analyzed for Target Analyte List (TAL) metals for future integration into a base wide background soils database. For metals other than arsenic, Appendix B, Table B-15, presents associated descriptive statistics, including the minimum, maximum, and mean for these three soil samples.

5.0 CONCLUSIONS AND RECOMMENDATIONS

Based on the site characterization performed as part of the MNLF SI, arsenic is present in site soil at levels that exceed the RIDEM residential direct exposure criteria soil objective of 1.7 mg/kg throughout the vadose zone. In accordance with RIDEM Remediation Regulations, a background soil investigation was conducted to determine if naturally occurring levels of arsenic in soils in the vicinity of the MNLF site are higher than the 1.7 mg/kg soil objective. Background concentrations in soil may be used to distinguish between concentrations related to site contamination and concentrations not related to the site activities, and to determine site-specific remediation target levels for the MNLF site. The investigation consisted of collecting more than 20 background soil samples from areas that have the same soil characteristics as the MNLF site (prior to landfilling activities), performing laboratory analyses for arsenic, evaluating the analytical results, and performing statistical analyses using appropriate methods based on the distribution of arsenic in the samples. Conclusions and recommendations of the MNLF soil background investigation are presented below.

5.1 CONCLUSIONS

To establish a background arsenic level in soil, samples were collected from non-impacted areas with soil composition similar to those at the MNLF site prior to landfilling activities. Based on soil survey maps presented in the USDA Soil Survey of Rhode Island, two soil types (Newport Silt Loam and Matunuck Mucky Peat) were selected as representing soils at the MNLF site. Samples were collected from the ground surface to the bottom of the vadose zone (or as deep as possible using hand augering techniques) at 20 locations (ten in Matunuck Mucky Peat soil type and ten in the Newport Silt Loam). Twenty composite surface soil samples (soils between 0.0 to 2.3-ft. depth) and two subsurface soils (soil below the approximate 2.3-ft. depth) were analyzed.

Data analysis and statistical testing of the arsenic background data included exploratory data evaluations and quantitative data comparisons to determine if the arsenic results from the two soil type data sets types (Newport Silt Loam and Matunuck Mucky Peat) can be combined.

Evaluation of the arsenic background data sets for both soil types determined that shallow surface soil data (defined as composite samples collected from an approximately 2 feet depth) are suitable

for combination with deeper subsurface soil data (defined as samples from depths below approximately 2 feet).

Exploratory data evaluations and quantitative data comparisons indicate that arsenic results from the two soil type data sets (Newport Silt Loam and Matunuck Mucky Peat) can be combined, based on lack of any statistical findings that might suggest a basis for rejecting the assumption that the two populations are statistically equivalent.

The following statistics were estimated to describe the final combined background data set:

- The best fitting distributional shape of the combined arsenic soil data set was determined to be lognormal (although an assumption of a normal shape could not be rejected).

- Two types of descriptive statistics were tabulated consisting of the minimum, maximum, and mean for arsenic in the combined soil data set, and the arsenic concentrations at the 25^{th}, 50^{th}, 75^{th}, and 95^{th} quantiles.

- The 95 percent UTL for arsenic was estimated at 11.8 mg/kg based on the assumption of a lognormal background population.

One soil sample representing Matunuck Mucky Peat and two soil samples representing Newport Silt Loam were analyzed for TAL metals for future integration into a base wide background soils database. Associated descriptive statistics, including the minimum, maximum, and mean for these three soil samples were determined.

5.2 RECOMMENDATIONS

A value of 11.8 mg/kg should be used as an arsenic background value against which MNLF site-related arsenic levels are compared. This value is the 95 percent UTL estimated for the arsenic background data set, based on an assumption of a lognormal background population.

As detailed in Section 4.1, the UTL test is not generally valid as a stand-alone background test upon which to base remedial actions at a site. It is recommended that site exceedances of the UTL be confirmed by additional statistical tests comparing site data to background, in which the

potential false positive rate is controlled to less than a 5 percent error rate. Potential additional tests recommended include the t-test, the Mann-Whitney test, Gehan's Test, the upper ranks test, test of proportions, or Fisher's Exact Test.

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APPENDIX A
ANALYTICAL LABORATORY RESULTS

TETRA TECH NUS, INC. **INTERNAL CORRESPONDENCE**

C-NAVY-11-98-1272W

Date: November 4, 1998 cc: File 1679-4.10

To: James Forrelli

From: Maureen Parker MP for MP

Subject: Partial Tier II Data Validation, Project No. 1679, SDG No. 98-10-060
GPL Laboratories, LLLP
CTO 172 Melville North Landfill, Portsmouth, Rhode Island

TAL Metals: 3/ Soils/BKG-SS03-NEB-0016, BKG-SS09-NEB-0018, BKG-SS07-MK-0020

Arsenic only: 22/ Soils/BKG-SS01-NEB-0015, BKG-SS02-NEB-0020, BKG-DUPL01-NEB, BKG-SS04-NEB-0018, BKG-SS05-NEB-0017, BKG-SS06-NEB-0020, BKG-SS07-NEB-0020, BKG-SS08-NEB-0017, BKG-SS10-NEB-0005, BKG-SS10-NEB-0551, BKG-DUPL-02-NEB, BKG-SS01-MK-0532, BKG-SS01-MK-0005, BKG-SS02-MK-0022, BKG-SS03-MK-0022, BKG-SS04-MK-0012, BKG-SS05-MK-0010, BKG-SS06-MK-0016, BKG-SS08-MK-0016, BKG-SS09-MK-0023, BKG-SS10-MK-0018, BKG-DUPL03-MK
Field Duplicate Pairs: BKG-SS08-NEB-0017/BKG-DUPL01-NEB
BKG-SS01-NEB-0015/BKG-DUPL02-NEB
BKG-SS01-MK-0005/BKG-DUPL03-MK

TAL Metals Rinsate Blank:
1 water/ BKG-SS09-RB01

A partial tier II data validation was performed on the TAL metals and arsenic data associated with the soil samples collected at the Melville North Landfill site on September 29 – October 1, 1998. The TAL metals and arsenic samples were analyzed by EPA method ILM04.0. The data were evaluated based on the following parameters:

* o Data Completeness
o Laboratory and Field Blank Analyses
o Laboratory Duplicate Results
o Field Duplicate Precision

* All quality control criteria were met for this parameter.

Laboratory and Field Blank Analyses

SOIL SAMPLES:

The laboratory and field blank analyses were used to calculate the following contaminants in the maximum concentrations indicated:

ANALYTE	MAXIMUM CONCENTRATION (µg/L)	ACTION LEVEL (mg/kg)
Aluminum	85.5	85.5
Barium	2.4	2.4
Cadmium	0.5	0.5
Calcium	306	306
Chromium	0.86	0.86
Cobalt	0.7	0.7
Copper	4.4	4.4
Iron	95.1	95.1
Magnesium	114	114
Manganese	2.1	2.1
Potassium	130	130
Silver	1.04	1.04
Sodium	264	264
Thallium	6.5	6.5
Zinc	21	21

Blank actions are required for cadmium and sodium in several soil samples. No further qualifications are necessary, because the sample results are either non-detected or greater than the action levels.

AQUEOUS SAMPLE:

The laboratory blank analyses were used to calculate the following contaminants in the maximum concentrations indicated:

ANALYTE	MAXIMUM CONCENTRATION (µg/L)	ACTION LEVEL (µg/L)
Aluminum	85.5	427.5
Barium	0.9	4.5
Cadmium	0.5	2.5
Calcium	201	1005
Cobalt	0.8	4.0
Copper	2.8	14
Iron	32.9	164.5
Magnesium	114	570
Potassium	86.9	434.5
Silver	0.8	4.0
Thallium	6.5	32.5
Zinc	5.9	29.5

Blank actions are required for aluminum, barium, calcium, copper, iron, magnesium, potassium, and zinc in the rinsate blank BKG-SS09-RB01. No further qualifications are necessary, because the sample results are either non-detected or greater than the action levels.

Laboratory Duplicate Results

The Relative Percent Difference (RPD) for lead is above the 35% quality control criteria for the laboratory duplicate analysis of sample BKG-SS07-MK-0020. The positive results for lead are qualified as estimated, (J) in affected samples.

Field Duplicate Precision

The Relative Percent Difference (RPD) for arsenic is above the 50% quality control criteria for the field duplicate pair BKG-DUPL03-MK/BKG-SS01-MK-0005. The positive results for arsenic are qualified as estimated, (J) in affected samples.

Overall Assessment of the Data

The data are acceptable for use as qualified. Blank actions are required for cadmium and sodium in several soil samples due to laboratory and field blank contamination. Blank actions are required for aluminum, barium, calcium, copper, iron, magnesium, potassium, and zinc in the rinsate blank BKG-SS09-RB01 due to laboratory blank contamination. The positive results for lead in the soil samples are estimated due to laboratory duplicate imprecision. The positive results for arsenic in the soil samples are estimated due to field duplicate imprecision.

Attachments

cc: File 1679 - 4.10

Soil TAL Metal Analysis (mg/kg)
Site: Melville Landfill
Case: 172; SDG: WO# 98-10-060

EPA Sample Number	BKG-DUPL03-MK		BKG-DUPLO1-NEB		BKG-DUPLO2-NEB		BKG-SS01-MK-0005	
Station Location	BKG-DUPL03-MK		BKG-DUPLO1-NEB		BKG-DUPLO2-NEB		BKG-SS01-MK-0005	
Date Sampled	9/29/98		10/1/98		9/30/98		9/29/98	
Date Extracted								
Date Analyzed								
Dilution Factor	1		1		1		1	
Percent Solids	64 2		94.0		79.5		39.5	
QC Identifier	Field Dup. BKG-SS01-MK-0005		Field Dup. BKG-SS08-NEB-0017		Field Dup. BKG-SS01-NEB-0015		Field Dup. BKG-SS01-MK-0005	
Aluminum								
Antimony								
Arsenic	6.3	J	2.4	J	3.9	J	11 5	J
Barium								
Beryllium								
Cadmium								
Calcium								
Chromium								
Cobalt								
Copper								
Iron								
Lead								
Magnesium								
Manganese								
Mercury								
Nickel								
Potassium								
Selenium								
Silver								
Sodium								
Thallium								
Vanadium								
Zinc								

Soil TAL Metal Analysis (mg/kg)
Site: Melville Landfill
Case: 172; SDG: WO# 98-10-060

BKG-SS01-MK-0532		BKG-SS01-NEB-0015		BKG-SS02-MK-0022		BKG-SS02-NEB-0020		BKG-SS03-MK-0022		BKG-SS03-NEB-0016	
BKG-SS01-MK-0532		BKG-SS01-NEB-0015		BKG-SS02-MK-0022		BKG-SS02-NEB-0020		BKG-SS03-MK-0022		BKG-SS03-NEB-0016	
9/29/98		9/30/98		9/29/98		9/30/98		9/29/98		9/30/98	
1		1		1		1		1		1	
75.9		84.9		42.8		87.2		52.3		87.6	
None		Field Dup. BKG-SS01-NEB-0015		None		None		None		None	
										15300	
										0.87	U
3.2	J	4.5	J	8.4	J	4.4	J	5.3	J	6.2	J
										32 6	
										0.51	
										0.53	
										541	
										12.0	
										5 4	
										14.0	
										17700	
										44.0	J
										2000	
										204	
										0.10	
										11.5	
										392	
										0.89	
										0.17	U
										66 5	U
										0 85	U
										23.1	
										40 3	

Soil TAL Metal Analysis (mg/kg)
Site: Melville Landfill
Case: 172; SDG: WO# 98-10-060

BKG-SS04-MK-0012		BKG-SS04-NEB-0018		BKG-SS05-MK-0010		BKG-SS05-NEB-0017		BKG-SS06-MK-0016		BKG-SS06-NEB-0020	
BKG-SS04-MK-0012		BKG-SS04-NEB-0018		BKG-SS05-MK-0010		BKG-SS05-NEB-0017		BKG-SS06-MK-0016		BKG-SS06-NEB-0020	
10/1/98		9/30/98		10/1/98		9/30/98		9/30/98		9/30/98	
1		1		1		1		1		1	
21.7		83.0		43 9		86.0		67.0		84.8	
None		None		None		None		None		None	
12.3	J	9 5	J	3.7	J	5.6	J	7.4	J	6.7	J

U - Not detected; UJ - Detection limit approximate; J - Quantitation approximate;
* - From dilution analysis; R - Rejected; EB/TB - Equipment/Trip Blank contamination

Soil TAL Metal Analysis (mg/kg)
Site: Melville Landfill
Case: 172; SDG: WO# 98-10-060

BKG-SS07-MK-0020		BKG-SS07-NEB-0020		BKG-SS08-MK-0016		BKG-SS08-NEB-0017		BKG-SS09-MK-0023		BKG-SS09-NEB-0018	
BKG-SS07-MK-0020		BKG-SS07-NEB-0020		BKG-SS08-MK-0016		BKG-SS08-NEB-0017		BKG-SS09-MK-0023		BKG-SS09-NEB-0018	
9/30/98		9/30/98		9/30/98		10/1/98		9/30/98		10/1/98	
1		1		1		1		1		1	
71.9		82 6		69.1		94.7		78.8		84.1	
None		None		None		Field Dup. BKG-SS08-NEB-0017		None		None	
10700										12900	
0.76	U									0 80	U
5 1	J	7.4	J	4 3	J	2.1	J	5 2	J	10.8	J
6.2										21.1	
0 36										0.36	
0 37	U									0.38	U
996										366	
11.5										11.4	
3.1										3 6	
11.0										9.1	
14500										13700	
33.9	J									15.2	J
2530										1570	
113										179	
0.04										0.13	
9 4										7.4	
695										366	
0.45										0.58	
0.15	U									0.15	U
3800										63.0	U
0.75	U									0.78	U
20.9										18.9	
32.4										24.9	

Soil TAL Metal Analysis (mg/kg)
Site: Melville Landfill
Case: 172; SDG: WO# 98-10-060

BKG-SS10-MK-0018		BKG-SS10-NEB-0005		BKG-SS10-NEB-0551	
BKG-SS10-MK-0018		BKG-SS10-NEB-0005		BKG-SS10-NEB-0551	
9/30/98		10/1/98		10/1/98	
1		1		1	
51.0		89.0		92 4	
None		None		None	
3.9	J	5 3	J	5.7	J

U - Not detected; UJ - Detection limit approximate; J - Quantitation approximate;
* - From dilution analysis; R - Rejected; EB/TB - Equipment/Trip Blank contamination

Aqueous TAL Metal Analysis (ug/l)
Site: Melville Landfill
Case: 172; SDG: WO# 98-10-060

EPA Sample Number	BKG-SS09-RB01	
Station Location	BKG-SS09-RB01	
Date Sampled	10/1/98	
Date Extracted		
Date Analyzed		
Dilution Factor	1	
Percent Solids	0.0	
QC Identifier	Rinsate Blank	
Aluminum	80.1	U
Antimony	4.2	U
Arsenic	3 0	U
Barium	2.4	U
Beryllium	0.20	U
Cadmium	0 40	U
Calcium	306	U
Chromium	0.86	
Cobalt	0.60	U
Copper	4 4	U
Iron	95.1	U
Lead	1.7	U
Magnesium	81.5	U
Manganese	2 1	
Mercury	0 10	U
Nickel	1.3	U
Potassium	130	U
Selenium	1 9	U
Silver	0.80	U
Sodium	264	
Thallium	4.1	U
Vanadium	0 80	U
Zinc	21 0	U

U - Not detected; UJ - Detection limit approximate; J - Quantitation approximate;
* - From dilution analysis; R - Rejected; EB/TB - Equipment/Trip Blank contamination

APPENDIX B
STATISTICAL ANALYSIS SUPPORTING DOCUMENTATION

Figure B-1: Comparison of Frequency Distributions for Arsenic

In Two Soil Types: Matunuck Mucky Peat (MK) Versus Newport Silt Loam (NE)

Concentrations labelled next to data points allow comparison of the percent of sampling points with Arsenic levels at or below the labelled concentration in MK soil or NE soil versus in the combined data

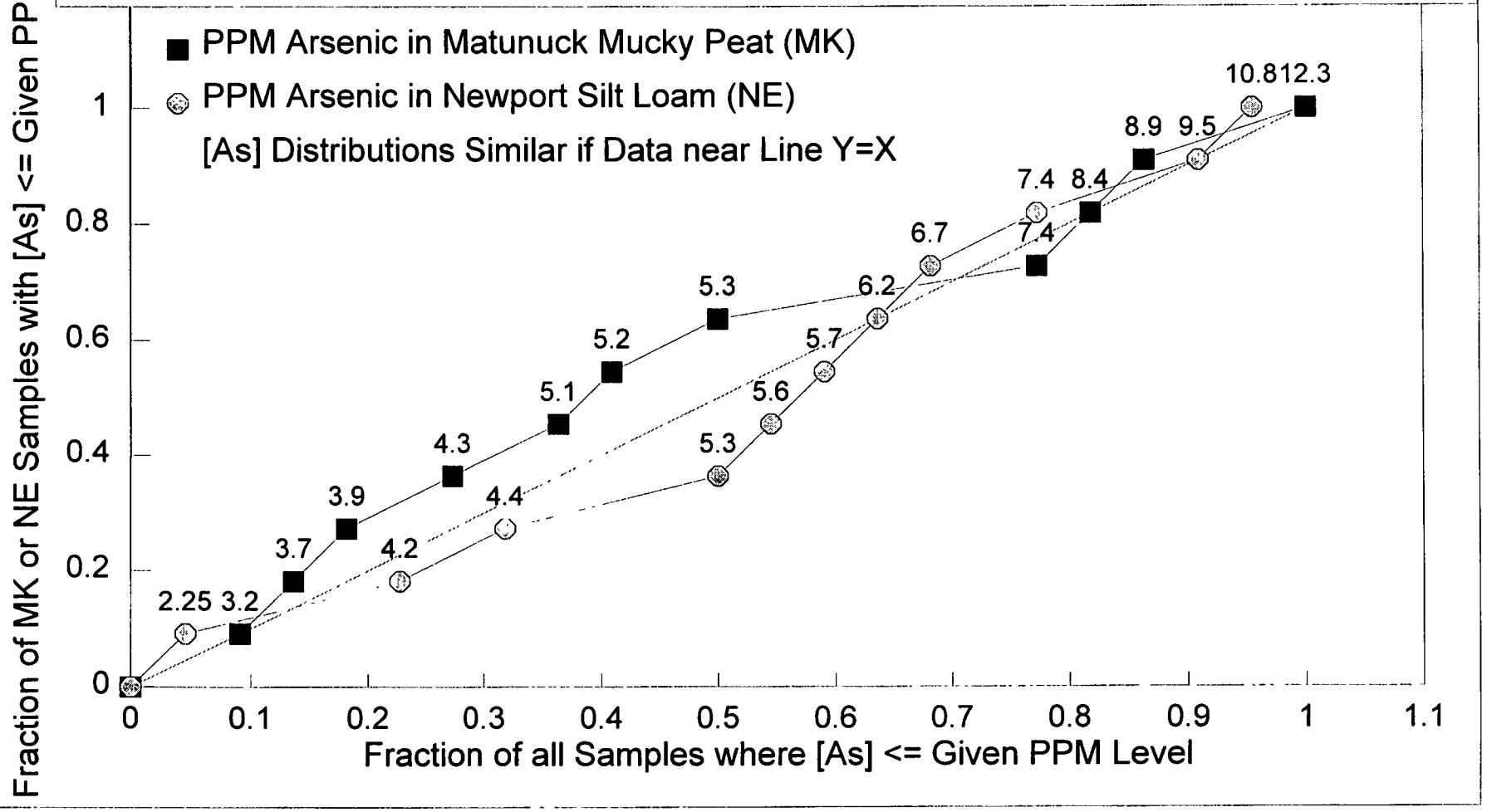

TABLE B-1
STATISTICAL DISTRIBUTION OF SURFACE SOIL DATA FOR MATUNUCK MUCKY PEAT
MELVILLE NORTH LANDFILL
PORTSMOUTH, RHODE ISLAND

Substance	Number of Sample Results	Degrees of Freedom	Statistical Distribution of Data	Results of Shapiro-Wilk or Shapiro-Francia Distribution Tests			Standard Deviation or Log Standard Deviation	Arithmetic Mean of All Site Results	Maximum Positive Site Concentration
				W-norm	W-lognorm	W-Table			
Arsenic	10	9	lognormal better fit than normal	0.8786	0 9345	0.842	0.397	6.45	12.3
			but both distributions pass W-Test						

Notes:

Units are mg/kg.
Number of sample results excludes rejected data or blank-qualified data. Duplicates are consolidated into one result
Statistical distribution of data is determined using Shapiro-Wilk test for n <= 50, Shapiro-Francia test for n > 50. Statistical significance level is 0.05.
A normal distribution is assumed if the test statistic W-norm. is >= than the reference value (W-table), and W-norm. > W-lognorm.
A lognormal distribution is assumed if the test statistic W-lognorm. is >= the reference value (W-table), and W-lognorm. >= W-norm
A lognormal distribution is also the default assumption if neither distribution passes Shapiro test
Arithmetic mean may include positive detections and non-detected results (detection limits are divided by two).

TABLE B-2

ARSENIC UPPER TOLERANCE LIMIT FOR MANUTUCK MUCKY PEAT: SUBSURFACE VS. SURFACE SOIL UTL

MELVILLE NORTH LANDFILL

PORTSMOUTH, RHODE ISLAND

Name of Test:	95% Upper Tolerance Limit (UTL)						
Question Posed:	Subsurface Maximum > UTL for Surface Soil Data ?						
Assumptions Valid	Surface Soil data must fit lognormal or normal shape						
Test Criterion	Subsurface Concentration > Surface Soil 95% UTL?						
Conclusion: Subsurface > UTL? YN	Surface Soil	Subsurface	Log of	Log of	t	Surface Soil	Subsurface
Substance	Detect Freq	Detect Freq	Mean	Std Deviation	Value	UTL	Maximum
Arsenic N	10/10	1/1	1.79	0 397	1 8331	12 9	3 2

Units are mg/kg

TABLE B-3
STATISTICAL DISTRIBUTION OF SURFACE SOIL DATA FOR NEWPORT SILT LOAM
MELVILLE NORTH LANDFILL
PORTSMOUTH, RHODE ISLAND

Substance	Number of Sample Results	Degrees of Freedom	Statistical Distribution of Data	Results of Shapiro-Wilk or Shapiro-Francia Distribution Tests			Standard Deviation or Log Standard Deviation	Arithmetic Mean of All Site Results	Maximum Positive Site Concentration
				W-norm	W-lognorm	W-Table			
Arsenic	10	9	normal better fit than lognormal	0.9709	0 9561	0 842	2.53	6.24	10.8
			but both distributions pass W-Test						

Notes:

Units are mg/kg.
Number of sample results excludes rejected data or blank-qualified data. Duplicates are consolidated into one result
Statistical distribution of data is determined using Shapiro-Wilk test for n <= 50, Shapiro-Francia test for n > 50. Statistical significance level is 0.05.
A normal distribution is assumed if the test statistic W-norm is >= than the reference value (W-table), and W-norm. > W-lognorm.
A lognormal distribution is assumed if the test statistic W-lognorm. is >= the reference value (W-table), and W-lognorm >= W-norm.
A lognormal distribution is also the default assumption if neither distribution passes Shapiro test
Arithmetic mean may include positive detections and non-detected results (detection limits are divided by two).

TABLE B-4

ARSENIC UPPER TOLERANCE LIMIT FOR NEWPORT SILT LOAM: SUBSURFACE VS. SURFACE SOIL UTL

MELVILLE NORTH LANDFILL

PORTSMOUTH, RHODE ISLAND

Name of Test:	95% Upper Tolerance Limit (UTL)						
Question Posed:	Subsurface Maximum > UTL for Surface Soil Data?						
Assumptions Valid:	Surface Soil data must fit lognormal or normal shape						
Test Criterion	Subsurface Concentration > Surface Soil 95% UTL?						
Conclusion: Subsurface > UTL? Y/N	Surface Soil	Subsurface		Standard	t	Surface Soil	Subsurface
Substance	Detect Freq	Detect Freq	Mean	Deviation	Value	UTL	Maximum
Arsenic N	10/10	1/1	6 24	2 53	1 8331	11 1	5 7

Units are mg/kg.

TABLE B-5
STATISTICAL DISTRIBUTION OF BACKGROUND SOIL DATA FOR NEWPORT SILT LOAM
MELVILLE NORTH LANDFILL
PORTSMOUTH, RHODE ISLAND

Substance	Number of Sample Results	Degrees of Freedom	Statistical Distribution of Data	Results of Shapiro-Wilk or Shapiro-Francia Distribution Tests			Standard Deviation or Log Standard Deviation	Arithmetic Mean of All Site Results	Maximum Positive Site Concentration
				W-norm	W-lognorm	W-Table			
Arsenic	11	10	normal better fit than lognormal	0 96	0 9471	0.85	2.41	6.19	10 8
			but both distributions pass W-Test						

Notes:

Units are mg/kg.
Number of sample results excludes rejected data or blank-qualified data. Duplicates are consolidated into one result
Statistical distribution of data is determined using Shapiro-Wilk test for n <= 50, Shapiro-Francia test for n > 50. Statistical significance level is 0.05.
A normal distribution is assumed if the test statistic W-norm. is >= than the reference value (W-table), and W-norm. > W-lognorm
A lognormal distribution is assumed if the test statistic W-lognorm is >= the reference value (W-table), and W-lognorm >= W-norm.
A lognormal distribution is also the default assumption if neither distribution passes Shapiro test.
Arithmetic mean may include positive detections and non-detected results (detection limits are divided by two).

TABLE B-6
STATISTICAL DISTRIBUTION OF BACKGROUND SOIL DATA FOR MATUNUCK MUCKY PEAT
MELVILLE NORTH LANDFILL
PORTSMOUTH, RHODE ISLAND

Substance	Number of Sample Results	Degrees of Freedom	Statistical Distribution of Data	Results of Shapiro-Wilk or Shapiro-Francia Distribution Tests			Standard Deviation or Log Standard Deviation	Arithmetic Mean of All Site Results	Maximum Positive Site Concentration
				W-norm	W-lognorm	W-Table			
Arsenic	11	10	lognormal better fit than normal	0.8837	0.9513	0.85	0.422	6.15	12.3
			but both distributions pass W-Test						

Notes:

Units are mg/kg.
Number of sample results excludes rejected data or blank-qualified data Duplicates are consolidated into one result.
Statistical distribution of data is determined using Shapiro-Wilk test for n <= 50, Shapiro-Francia test for n > 50 Statistical significance level is 0.05.
A normal distribution is assumed if the test statistic W-norm is >= than the reference value (W-table), and W-norm > W-lognorm.
A lognormal distribution is assumed if the test statistic W-lognorm. is >= the reference value (W-table), and W-lognorm. >= W-norm.
A lognormal distribution is also the default assumption if neither distribution passes Shapiro test
Arithmetic mean may include positive detections and non-detected results (detection limits are divided by two).

TABLE B-7
QUANTILE RANGE DISTRIBUTIONS OF BACKGROUND SOIL DATA FOR NEWPORT SILT LOAM AND MATUNUCK MUCKY PEAT
MELVILLE NORTH LANDFILL
PORTSMOUTH, RHODE ISLAND

	Matunuck Mucky Peat Background Soil Data Distribution															Newport Silt Loam Background Soil Data Distribution															
	Concentration Range of NONDETECTED Results									Concentration Range of POSITIVE Results								Concentration Range of NONDETECTED Results									Concentration Range of POSITIVE Results							
	Min	Min to 25 %		25% to 75%		75% to 95%		95% to Max		Min to 25 %		25% to 75%		75% to 95%		95% to Max		Min	Min to 25 %		25% to 75%		75% to 95%		95% to Max		Min. to 25 %		25% to 75%		75% to 95%		95% to Max	
Substance	Detect Limit	No. Pts	25% Quantile	No. Pts	75% Quantile	No. Pts	95% Quantile	No. Pts	Max D L	No. Pts	25% Quantile	No. Pts	75% Quantile	No. Pts	95% Quantile	No. Pts	Max Conc	Detect Limit	No. Pts	25% Quantile	No. Pts	75% Quantile	No. Pts	95% Quantile	No. Pts	Max D L	No. Pts	25% Quantile	No. Pts	75% Quantile	No. Pts	95% Quantile	No. Pts	Max Conc
Arsenic	---	13	---	13	---	13	---	13	---	3	3 9	6	8 4	2	12 3	13	12 3	---	13	---	13	---	13	---	13	---	3	4 4	6	7 4	2	10 8	13	10 8

Notes

Units are mg/kg
The 25 % quantile of a set of samples is an estimate of the concentration such that 25 % of the population has concentrations less than this magnitude
Number of points refers to the number of samples in the set displaying concentrations between the quantile shown to the immediate left and the quantile shown to the right
Background quantiles for two soil types are juxtaposed to check for unequal ranges of results that would preclude statistically combining the two background data sets
Number of sample results excludes rejected data or blank-qualified data Duplicates are consolidated into one result
Number of samples may vary based on the number of usable results

TABLE B-8
OCCURRENCE AND DISTRIBUTION OF ARSENIC IN NEWPORT SILT LOAM AND MATUNUCK MUCKY PEAT
MELVILLE NORTH LANDFILL
PORTSMOUTH, RHODE ISLAND

Chemical	Matunuck Mucky Peat Background Soil Data							Newport Silt Loam Background Soil Data						
	Frequency of Detection	Minimum Detected Concentration	Minimum Qualifier	Maximum Detected Concentration	Maximum Qualifier	Mean of All Data	Location of Maximum Concentration	Frequency of Detection	Minimum Detected Concentration	Minimum Qualifier	Maximum Detected Concentration	Maximum Qualifier	Mean of All Data	Location of Maximum Concentration
Arsenic	11/11	3 2	J	12 3	J	6 15	BKG-SS04-MK-0012	11/11	2 1	J	10 8	J	6 19	BKG-SS09-NEB-0018

Notes

Units are mg/kg
Number of sample results excludes rejected data or blank-qualified data Duplicates are consolidated into one result
Mean of all data includes positive detections and non-detected results Detection limits are divided by two
Frequency of detection refers to number of times compound was detected among all samples versus total number of samples
Number of samples may vary based on the number of usable results

TABLE B-9
DETERMINATION OF WHETHER MATUNUCK MUCKY PEAT (MK) DATA ARE GREATER THAN NEWPORT SILT LOAM (NE) DATA
MELVILLE NORTH LANDFILL
PORTSMOUTH, RHODE ISLAND

Name of Test: / Question Posed:		Detection Freq Z or Fisher: MK Freq > NE Freq ?				Upper Ranks: Majority are MK?				Mann-Whitney/Gehan: Ranks of MK > NE?				Student's or Satterthwaite T-test: MK Mean > NE Mean ?					Bartlett's Test for Equal Standard Deviations: MK Standard Deviation = NE Std Dev.?						
Assumptions Valid Test Criterion:		#ND & Pos >=5 or use Fisher P value <= 0 05 ?				# MK spls (s) in Top r P<=0 05 that #s>=k				<40% ND or use Gehan P value <=0 05 ?				#s>2,#b>2,>=85% Pos, both norm/log t-Value > t-Table					#s>2,#b>2, MK & NE both normal or both lognorm F-Value<=F-Table (Students T) If not, Satterthwaite						
Conclusion: MK > NE? YN / Substance		NE Freq	MK Freq	P Value	YN	r	k	P Value	YN	P Value	Test	Used	YN	NE Mean@	MK Mean@	t Value	t Table	YN	NE Distrib	MK Distrib	Std Dev NE@	Std Dev MK@	F Value	F Table	YN
Arsenic	N	11/11	11/11		NA	5	3	0 5000	N	0 7228			N	1 75	1 73	-0 0784	1 7247	N	lognormal	lognormal	0 424	0 422	0 0004	3 8480	Y

Units are mg/kg.

A statistical significance level (P value) of 0 05 is used for all tests that directly compare MK to NE A two-sided significance level of 0 1 is used for Bartlett's test for equal variance

For each test, a YES or NO decision is presented only if all assumptions are met The overall decision (is MK > NE) for each chemical appears at the left and is based on four criteria

(1) Overall decision is YES if any one of the Mann-Whitney/Gehan, Upper Ranks Test, or T-Test is YES, regardless of other test results

(2) Overall decision is NO if at least one of Mann-Whitney/Gehan, Upper Ranks Test, or T-Test is NO, and none of the aforementioned tests are YES

(3) Overall decision is YES/NO if Z/Fisher Test is YES/NO, respectively, and other tests are NA Z-test is treated as lowest priority since it relies on detection frequency, not magnitude of results

(4) Overall decision is NA if all tests are NA (Chemicals assigned NA are still included in human health risk-based screening and/or risk assessment)

# NDs or # Pos	Number of non-detected (ND) or positive (Pos) results in data set, not including rejected data or blank-qualified data
# s or # b	Number of MK (s) or NE (b) samples, not including rejected data or blank-qualified data.
s = b	Standard deviation of MK results must not be different from the standard deviation of NE results
P value	Probability or significance level is defined as the chance of a false positive If P <= 0 05 then test determines MK > NE with 95 % confidence
% ND	Mann-Whitney test used if < 40% of data Non-Detected and detect limits uniformly below the range of positive values. If not, the Gehan Test is used
@	Mean and standard deviations are shown of log-transformed data when distributions are of this type, ie , if MK and NE distributions both match lognormal, and both T-test and Bartlett's test are applicable (Arithmetic mean and normal standard deviation are shown only for illustration in the event that these tests are NA)
r,k	The upper ranks test calculates the probability that k or more samples from the top r ranks of the combined MK and NE data set are comprised of MK data if both populations are in fact equal

TABLE B-10
DETERMINATION OF WHETHER NEWPORT SILT LOAM (NE) DATA ARE GREATER THAN MATUNUCK MUCKY PEAT (MK) DATA
MELVILLE NORTH LANDFILL
PORTSMOUTH, RHODE ISLAND

Name of Test: / Question Posed:		Detection Freq: Z or Fisher: NE Freq > MK Freq ?				Upper Ranks: Majority are NE?				Mann-Whitney/Gehan: Ranks of NE > MK?				Student's or Satterthwaite T-test: NE Mean > MK Mean ?					Bartlett's Test for Equal Standard Deviations: NE Standard Deviation = MK Std Dev ?						
Assumptions Valid / Test Criterion		#ND & Pos >=5 or use Fisher P value <= 0 05 ?				# NE spls (s) in Top r P<=0 05 that #s>=k				<40% ND or use Gehan P value <=0 05 ?				#s>2,#b>2,>=85% Pos, both norm/log t-Value > t-Table					#s>2,#b>2, NE & MK both normal or both lognorm F-Value<=F-Table (Students T) If not, Satterthwaite						
Conclusion: NE > MK? YN / Substance		MK Freq	NE Freq	P Value	YN	r	k	P Value	YN	P Value	Test	Used	YN	MK Mean@	NE Mean@	t Value	t Table	YN	MK Distnb	NE Distrib	Std Dev MK@	Std Dev NE@	F Value	F Table	YN
Arsenic	N	11/11	11/11		NA	13	8	0 1935	N	0 2996			N	6 15	6 19	0 0286	1 7247	N	normal	normal	2 79	2 41	0 2068	3 8480	Y

Units are mg/kg

A statistical significance level (P value) of 0 05 is used for all tests that directly compare NE to MK A two-sided significance level of 0 1 is used for Bartlett's test for equal variance

For each test, a YES or NO decision is presented only if all assumptions are met The overall decision (is NE > MK) for each chemical appears at the left and is based on four criteria

(1) Overall decision is YES if any one of the Mann-Whitney/Gehan, Upper Ranks Test, or T-Test is YES, regardless of other test results

(2) Overall decision is NO if at least one of Mann-Whitney/Gehan, Upper Ranks Test, or T-Test is NO, and none of the aforementioned tests are YES

(3) Overall decision is YES/NO if Z/Fisher Test is YES/NO, respectively, and other tests are NA Z-test is treated as lowest priority since it relies on detection frequency, not magnitude of results

(4) Overall decision is NA if all tests are NA (Chemicals assigned NA are still included in human health risk-based screening and/or risk assessment)

# NDs or # Pos.	Number of non-detected (ND) or positive (Pos) results in data set, not including rejected data or blank-qualified data
# s or # b	Number of NE (s) or MK (b) samples, not including rejected data or blank-qualified data
s = b	Standard deviation of NE results must not be different from the standard deviation of MK results
P value	Probability or significance level is defined as the chance of a false positive If P <= 0 05 then test determines NE > MK with 95 % confidence
% ND	Mann-Whitney test used if < 40% of data Non-Detected and detect limits uniformly below the range of positive values If not, the Gehan Test is used
@	Mean and standard deviations are shown of log-transformed data when distributions are of this type, ie , if NE and MK distributions both match lognormal, and both T-test and Bartlett's test are applicable (Arithmetic mean and normal standard deviation are shown only for illustration in the event that these tests are NA)
r,k	The upper ranks test calculates the probability that k or more samples from the top r ranks of the combined NE and MK data set are comprised of NE data if both populations are in fact equal

TABLE B-11
STATISTICAL DISTRIBUTION OF COMBINED BACKGROUND SOIL DATA
MELVILLE NORTH LANDFILL
PORTSMOUTH, RHODE ISLAND

Substance	Number of Sample Results	Degrees of Freedom	Statistical Distribution of Data	Results of Shapiro-Wilk or Shapiro-Francia Distribution Tests			Standard Deviation or Log Standard Deviation	Arithmetic Mean of All Site Results	Maximum Positive Site Concentration
				W-norm	W-lognorm	W-Table			
Arsenic	22	21	lognormal better fit than lognormal	0 943	0 9881	0 911	0.413	6 17	12.3
			but both distributions pass W-Test						

Notes:

Units are mg/kg.
Number of sample results excludes rejected data or blank-qualified data Duplicates are consolidated into one result
Statistical distribution of data is determined using Shapiro-Wilk test for n <= 50, Shapiro-Francia test for n > 50. Statistical significance level is 0.05
A normal distribution is assumed if the test statistic W-norm. is >= than the reference value (W-table), and W-norm. > W-lognorm.
A lognormal distribution is assumed if the test statistic W-lognorm is >= the reference value (W-table), and W-lognorm >= W-norm
A lognormal distribution is also the default assumption if neither distribution passes Shapiro test.
Arithmetic mean may include positive detections and non-detected results (detection limits are divided by two)

TABLE B-12
OCCURRENCE AND DISTRIBUTION OF ARSENIC IN COMBINED BACKGROUND SOIL DATA SETS
MELVILLE NORTH LANDFILL
PORTSMOUTH, RHODE ISLAND

	Newport Silt Loam and Matunuck Mucky Peat Combined Background Soil Data								
Chemical	Frequency of Detection	Minimum Detected Concentration	Minimum Qualifier	Maximum Detected Concentration	Maximum Qualifier	Mean of All Data	Location of Maximum Concentration	Minimum Detection Limit	Maximum Detection Limit
Arsenic	22/22	2 1	J	12 3	J	6 17	BKG-SS04-MK-0012	--	--

Notes

Units are mg/kg
Number of sample results excludes rejected data or blank-qualified data Duplicates are consolidated into one result
Mean of all data includes positive detections and non-detected results Detection limits are divided by two
Frequency of detection refers to number of times compound was detected among all samples versus total number of samples
Number of samples may vary based on the number of usable results

TABLE B-13
QUANTILE RANGE DISTRIBUTIONS OF COMBINED BACKGROUND SOIL DATA SETS
MELVILLE NORTH LANDFILL
PORTSMOUTH, RHODE ISLAND

Substance	Newport Silt Loam and Matunuck Mucky Peat Combined Data Distribution															
	Concentration Range of NONDETECTED Results									Concentration Range of POSITIVE Results						
	Min. Detect Limit	Min. to 25%		25% to 75%		75% to 95%		95% to Max		Min. to 25 %		25% to 75%		75% to 95%		95% to Max	
		No. Pts	25% Quantile	No. Pts	75% Quantile	No. Pts	95% Quantile	No. Pts	Max. D L	No. Pts	25% Quantile	No. Pts	75% Quantile	No. Pts	95% Quantile	No. Pts	Max. Conc.
Arsenic										5	4 28	12	7 65	4	12 1	1	12 3

Notes:

Units are mg/kg.
The 25 % quantile of a set of samples is an estimate of the concentration such that 25 % of the population has concentrations less than this magnitude.
Number of points refers to the number of samples in the set displaying concentrations between the quantile shown to the immediate left and the quantile shown to the right
Number of sample results excludes rejected data or blank-qualified data Duplicates are consolidated into one result
Number of samples may vary based on the number of usable results.

TABLE B-14
ARSENIC UPPER TOLERANCE LIMIT BASED ON COMBINED DATA SET
MELVILLE NORTH LANDFILL
PORTSMOUTH, RHODE ISLAND

Name of Statistic:	95% Upper Tolerance Limit (UTL)				
Assumptions Valid	Background data must fit lognormal or normal shape				
Substance	Frequency of Detection	Log of Mean	Log of Std Deviation	t Value	Upper Tolerance Limit
Arsenic	22/22	1 74	0 413	1 7207	11 8

Units are mg/kg

TABLE B-15
OCCURRENCE AND DISTRIBUTION OF OTHER METALS IN COMBINED BACKGROUND SOIL DATA SETS
MELVILLE NORTH LANDFILL
PORTSMOUTH, RHODE ISLAND

	Newport Silt Loam and Matunuck Mucky Peat Combined Background Soil Data								
Chemical	Frequency of Detection	Minimum Detected Concentration	Minimum Qualifier	Maximum Detected Concentration	Maximum Qualifier	Mean of All Data	Location of Maximum Concentration	Minimum Detection Limit	Maximum Detection Limit
Aluminum	3/3	10700		15300		13000	G-SS03-NEB-0016	--	--
Barium	3/3	6 2		32 6		20	G-SS03-NEB-0016	--	--
Beryllium	3/3	0 36		0 51		0 41	G-SS03-NEB-0016	--	--
Cadmium	1/3	0 53		0 53		0 302	G-SS03-NEB-0016	0 37	0 38
Calcium	3/3	366		996		634	KG-SS07-MK-0020	--	--
Chromium	3/3	11 4		12		11 6	G-SS03-NEB-0016	--	--
Cobalt	3/3	3 1		5 4		4 03	G-SS03-NEB-0016	--	--
Copper	3/3	9 1		14		11 4	G-SS03-NEB-0016	--	--
Iron	3/3	13700		17700		15300	G-SS03-NEB-0016	--	--
Lead	3/3	15 2	J	44	J	31	G-SS03-NEB-0016	--	--
Magnesium	3/3	1570		2530		2030	KG-SS07-MK-0020	--	--
Manganese	3/3	113		204		165	G-SS03-NEB-0016	--	--
Mercury	3/3	0 04		0 13		0 09	G-SS09-NEB-0018	--	--
Nickel	3/3	7 4		11 5		9 43	G-SS03-NEB-0016	--	--
Potassium	3/3	366		695		484	KG-SS07-MK-0020	--	--
Selenium	3/3	0 45		0 89		0 64	G-SS03-NEB-0016	--	--
Sodium	1/3	3800		3800		1290	KG-SS07-MK-0020	63	66 5
Vanadium	3/3	18 9		23 1		21	G-SS03-NEB-0016	--	--
Zinc	3/3	24 9		40 3		32 5	G-SS03-NEB-0016	--	--

Notes

Units are mg/kg
Number of sample results excludes rejected data or blank-qualified data Duplicates are consolidated into one result
Mean of all data includes positive detections and non-detected results Detection limits are divided by two
Frequency of detection refers to number of times compound was detected among all samples versus total number of samples
Number of samples may vary based on the number of usable results

APPENDIX C
SAMPLE LOCATION COORDINATES

TABLE C-1

SOIL LOCATION COORDINATES
BACKGROUND SOIL INVESTIGATION
MELVILLE NORTH LANDFILL
PORTSMOUTH, RHODE ISLAND

SOIL TYPE	GENERAL LOCATION	SAMPLE I.D.	EASTING	NORTHING
Newport Silt Loam (NeB)	Lower Melville Pond	BKG-SS01-NEB-0015	560748 570	185381 506
		BKG-SS02-NEB-0020	560752 458	185317 716
		BKG-SS03-NEB-0016	560781 946	185216 313
		BKG-SS04-NEB-0018	560802 634	185119 049
		BKG-SS05-NEB-0017	560749 507	185388 828
	West of campground access road	BKG-SS06-NEB-0020	561295 585	184019.271
		BKG-SS07-NEB-0020	561303 932	184002 245
		BKG-SS08-NEB-0017	561274 205	183894 582
		BKG-SS09-NEB-0018	561237.883	183849 735
		BKG-SS10-NEB-0005	561203 226	183864 927
		BKG-SS10-NEB-0551	561203 226	183864 927
Matunuck Mucky Peat (Mk)	South of Mount Hope Bridge	BKG-SS01-MK-0005	565810.762	199646 330
		BKG-SS01-MK-0532	565810 762	199646 330
		BKG-SS02-MK-0022	565805 800	199647.339
		BKG-SS03-MK-0022	565799 163	199627 926
		BKG-SS04-MK-0012	565767.615	199691.228
		BKG-SS05-MK-0010	565752.316	199631.354
	Dyer Island	BKG-SS06-MK-0016	554906.202	181147.180
		BKG-SS07-MK-0020	554943 772	181130 665
		BKG-SS08-MK-0016	554900.395	181224.046
		BKG-SS09-MK-0023	554873 343	181281 781
		BKG-SS10-MK-0018	554850 687	181415 316

East/north NAD27 conus