TECHNICAL MEMORANDUM

DETERMINATION OF BACKGROUND REFERENCE SCREENING VALUES FOR THE NIAGARA FALLS STORAGE SITE LEWISTON, NEW YORK

REVISION 2

Contract DACW 49-97-D-0001
Delivery Order 12
Submitted: June 2002

Submitted to:
U.S. Army Corps of Engineers
Buffalo District
Buffalo, New York

Submitted by:
MAXIM Technologies Inc®

The 191 acre Niagara Falls Storage Site (NFSS) was once a part of the Lake Ontario Ordnance Works (LOOW). Remedial Investigations (RIs) have been conducted to evaluate the presence and extent of environmental contamination at these facilities. Figure 1 shows the location of the NFSS and its relationship to the LOOW.

This document was prepared in support of the NFSS RI and describes the methods used to determine background reference screening values of radionuclides, metals, and polycyclic aromatic hydrocarbons (PAHs). Background reference screening values are chemical concentrations that will be compared to NFSS soil concentrations to determine whether site data are above or below background.

Background soil data used for the LOOW RI have been used in this document. The LOOW background database was supplemented with additional sampling data. Samples were analyzed for radionuclide metals, nonradionuclide metals, and PAHs. Data sets were developed that correspond with surface soil and all soil, resulting in two data sets for each type of analyte. Figure 1 shows background locations.

Background reference screening values were determined for each analyte and data set. Statistical analyses were used to test for data distribution, test for data outliers, and to estimate the 95th percentile Upper Tolerance Limit (UTL).

For a given analyte and data set, the UTL was determined to be the background reference screening value, unless the UTL was greater than the maximum reported concentration. When the UTL was greater than the maximum reported concentration, the maximum reported concentration was selected as the background reference screening value.

Table E1 summarizes background reference screening values for surface soil and all soil.

Table E1 - Background Reference Screening Concentrations for NFSS

Compound	CAS No.	*Background Reference Screening Concentration*	
Metals (mg/kg)		*All Soil*	*Surface Soil*
Aluminum	7429-90-5	19100	18400
Antimony	7440-36-0	0.94	0.94
Arsenic	7440-38-2	8.59	11.2
Barium	7440-39-3	257	279
Beryllium	7440-41-7	1	1
Boron	7440-42-8	10.1	10.1
Cadmium	7440-43-9	0.451	0.53
Calcium	7440-70-2	58900	45200
Chromium	7440-47-3	25.8	24.3
Cobalt	7440-48-4	35.5	57.4
Copper	7440-50-8	49.3	34.7
Iron	7439-89-6	36400	36400
Lead	7439-92-1	36.5	55.2
Lithium	7439-93-2	36.8	27.9
Magnesium	7439-95-4	14800	10200
Manganese	7439-96-5	2780	5510
Mercury	7439-97-6	0.209	0.214
Nickel	7440-02-0	38	37.5
Potassium	7440-09-7	2820	1820
Selenium	7782-49-2	0.35	0.37
Silver	7440-22-4	0.196	0.27
Sodium	7440-23-5	331	282
Vanadium	7440-62-2	35.2	34
Zinc	7440-66-6	130	78
Radionuclides (pCi/g)		*All Soil*	*Surface Soil*
Cesium-137	10045-97-3	0.343	0.343
Radium-226	13982-63-3	1.2	0.921
Radium-228	15262-20-1	1.26	1.26
Thorium-228	14274-82-9	1.64	1.64
Thorium-230	14269-63-7	1.39	1.6
Thorium-232	7440-29-1	1.24	1.24
Total Uranium	7440-61-1	3.57	3.94
Uranium-233/234	13966-29-5	1.65	1.68
Uranium-235	15117-96-1	0.211	0.241
Uranium-235/236	15117-96-1	0.0947	0.102
Uranium-238	7440-61-1	1.34	1.36
Organics (ug/kg)		*All Soil*	*Surface Soil*
2-Methylnaphthalene	91-57-6	341	600
Acenaphthene	83-32-9	330	110
Anthracene	120-12-7	500	500
Benzo(a)anthracene	56-55-3	95.6	220
Benzo(a)pyrene	50-32-8	80.1	240
Benzo(b)fluoranthene	205-99-2	99.9	260
Benzo(g,h,I)perylene	191-24-2	48.7	110
Benzo(k)fluoranthene	207-08-9	43	120
Chrysene	218-01-9	147	290
Dibenzo(a,h)anthracene	53-70-3	12.2	31.4
Fluoranthene	206-44-0	391	990
Fluorene	86-73-7	200	200
Indeno(1,2,3-cd)pyrene	193-39-5	59.5	160
Phenanthrene	85-01-8	320	320
Pyrene	129-00-0	332	560

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LIST OF ACRONYMS

bgs	below ground surface
CWM	Chemical Waste Management
CRQL	Contract Required Quantitation Limit
DOD	Department of Defense
DOE	Department of Energy
EA	EA Engineering, Science and Technology
g	Gram
GEL	General Engineering Laboratories
GPS	Global Positioning Systems
IWCS	Interim Waste Containment Structure
K	Kilogram
L	Liter
LOOW	Lake Ontario Ordnance Works
NJDEP	New Jersey Department of Environmental Protection
NLM	National Library of Medicine
mg	Milligram
NFSS	Niagara Falls Storage Site
NYSDEC	New York State Department of Environmental Conservation
PAH	Polycyclic Aromatic Hydrocarbon
PETG	Polyethylene Terephthalate Glycol
RI	Remedial Investigation
SCS	Soil Conservation Service
SOW	Scope of Work
SVOC	Semi Volatile Organic Compound
TAGM	Technical Administrative Guidance Memorandum
TAL	Target Analyte List
U	Not Detected
UCL	Upper Confidence Level on the Mean
UPL	Upper Prediction Limit
UTL	Upper Tolerance Limit
ug	Microgram
USACE	U.S. Army Corps of Engineers
USEPA	U.S. Environmental Protection Agency
VOA	Volatile Organic Analyte
WRS	Wilcoxon Rank-Sum

1.0 INTRODUCTION

This document describes the collection and analysis of samples used to determine background concentrations of radionuclides, metals, and polycyclic aromatic hydrocarbons (PAHs) near the Lake Ontario Ordnance Works (LOOW) (Defense Environmental Restoration Program - Formerly Used Defense Sites) and Niagara Falls Storage Site (NFSS) (Formerly Utilized Sites Remedial Action Program). In addition, a method to compare results of samples taken on NFSS with background results is presented. Background results will be used to determine the nature and extent of contamination at NFSS for the remedial investigation (RI) report. Further screening of the data sets may be done at the onset of the baseline risk assessment, which will be documented in a report separate from the remedial investigation report.

It is recognized that after any necessary remedial action occurs at NFSS, a final status survey will be completed to show compliance with cleanup goals stipulated in the record of decision. If deemed necessary in the final status survey plan, an adequate background reference location would be chosen. At this location, a statistically prescribed number of background soil samples would be taken for comparison to site final status survey results.

2.0 SAMPLE LOCATIONS

Samples of background soils were collected under LOOW contract (EA Engineering, Science and Technology - EA) for the USACE Remedial Investigation (RI) of the Lake Ontario Ordnance Works (LOOW). Two locations were sampled during the Phase I investigation of the LOOW, and fifteen locations were sampled during the Phase II investigation. As indicated in the LOOW phase II RI report (USACE 2002), background sampling locations are mostly located in the buffer area of the former LOOW. These areas were considered to be representative background sampling locations, since they are close to NFSS, and presumably unimpacted by LOOW or NFSS site-related activities. Background sample locations are shown on Figure 1. Locations were chosen based on availability of rights-of-entry (ROE). EA provided geological logging of all the test holes and all labor in the collection of the samples including Parratt-Wolff, Incorporated as the direct push contractor. EA performed a topographic survey of the background sampling locations. The Phase II sampling proceeded in two mobilizations on October 4, 2000 and during November 5-7, 2000 (USACE 2002).

Table 1 shows both the NFSS (Maxim) and LOOW (EA) sample location numbers, the approximate distance of the background locations to the closest NFSS border, and the soil type of each location. Soil classifications are based on information in the Soil Survey of Niagara County (United States Department of Agriculture, Soil Conservation Service, 1972). Table 2 shows historical and current land use at the background locations based on SCS and rights-of-entry information recently obtained by USACE Buffalo.

Background surficial soil samples were collected from twelve soil types. Five surficial soil types were depicted on the NFSS property (SCS, 1972). Three of the five surficial soil types mapped at the NFSS are the same soil types as the background surficial soil samples, as indicated in

Table 1. Six of the background sampling locations had soil types different than those found at the NFSS.

3.0 FIELD METHODS

Surface samples were collected in one-inch diameter two-foot long polyethylene terephthalate glycol (PETG) liners using a geoprobe mounted on a truck, a tractor, or with a hand auger. Sample intervals were from 0 to 0.5 feet below the ground surface. Subsurface samples were collected with the geoprobe unit from a 0.5 foot interval immediately above the underlying Gray Clay Layer, at refusal, or at a maximum depth of 20 feet bgs. Eight of the locations encountered the Gray Clay Layer (BKGD-3, BKGD-4, BKGD-5, BKGD-6, BKGD-9, BKGD-10, BKGD-14, and BKGD-16). Six of the locations encountered refusal before reaching the Gray Clay Layer (BKGD-7, BKGD-8, BKGD-11, BKGD-12, BKGD-13 and, BKGD-15). At one location, BKGD-17, the maximum depth planned (20 feet below the ground surface) was achieved. Soil intervals that were sampled are indicated in Table 1. At several of the locations, multiple geoprobe samples were collected to attain the required volume of material for analytical testing.

4.0 GEOLOGY

Geology of the background locations was variable. Details are shown on boring logs provided by EA (Appendix A). Generally, the surface soil samples consisted of brown to dark brown silty clay or clayey silt material, sometimes with additional reddish or gray coloration,. However, surface sample locations BKGD-10, BKGD-14, and BKGD-15 consisted of dark brown very fine sand, brown silt, and dark brown sandy silt, respectively. The descriptions of the soil from subsurface samples generally consisted of clay-rich material. The predominant material was silty clay, with some sand, silt, and/or gravel in the matrix.

5.0 ANALYSES

Samples collected during the LOOW RI were used to determine background. The LOOW RI samples were collected in two phases. Analytes and samples included from each phase are described below.

Samples collected from two locations during the Phase I LOOW RI were analyzed for Volatile Organic Compounds (VOCs), Semivolatile Organic Compounds (SVOCs), Polycyclic Aromatic Hydrocarbons (PAHs), nitroaromatics, Target Analyte List (TAL) metals, and Polychlorinated Biphenyls (PCBs)/pesticides. Phase I samples were analyzed by EA under EA's contract for the LOOW RI. The data used for background at NFSS includes only PAHs and TAL metals. Phase I locations are BKGD-1 and BKGD-2 and are shown on Figure 1.

Surface soil samples collected from 15 locations were analyzed for SVOCs, PAHs, TAL metals, selected radiological isotopes, and total uranium during the Phase II LOOW RI. Corresponding

subsurface soil samples were analyzed for TAL metals, selected radiological isotopes, and total uranium. Locations sampled during the Phase II LOOW RI are BKGD-3 through BKGD-17 and are shown on Figure 1.

Phase II samples were analyzed by two laboratories. The LOOW project analyzed samples for PAHs and metals under EA's contract. GEL laboratories analyzed samples collected for SVOCs, radiological isotopes, and total uranium under Maxim's NFSS contract in accordance with the Quality Assurance Project Plan (QAPP) (USACE, 1999). For the NFSS, QA samples collected by Maxim were analyzed by NTS. Analytical results are included in Appendix B.

6.0 DATA MANAGEMENT

6.1 Nondetects

Radionuclides and nonradionuclides were sometimes reported as nondetects in all samples analyzed. If a chemical was not detected in at least one sample, a background UTL was not calculated. The discussion of nondetects below only applies to chemicals detected in at least one background sample.

Nondetects were reported differently for nonradionuclides and radionuclides. For nonradionuclides, one-half of the reported "U" value was used as a surrogate concentration for nondetects.

Radionuclides were assumed to be present at the reported concentration, regardless of laboratory qualifier. If a radionuclide was detected in at least one background sample, the contract required quantitation limit (reported "U" value, CRQL) was used as the surrogate concentration.

Surrogate values used for nondetects are indicated in the "Concentration Used in Calculations" column of the calculation work sheets shown in Appendix C.

6.2 Radionuclide Results Reported as Negative Values or Zero

Based on instrument responses, some radionuclide results were reported as negative values. The log of a value less than or equal to zero is undefined. When the distribution was determined to be more lognormal than normal and when negative values were reported by the lab, the data could not be log transformed. After transforming the concentrations that were greater than zero, zeroes were inserted as surrogate log-transformed values for the data that could not be transformed. The resulting data were used to perform the statistical calculations.

6.3 Other Data Excluded from the Database

Some alpha, beta, and potassium-40 data were analyzed and reported by the laboratory. These data were unplanned and were therefore excluded from the database.

Some samples were analyzed for PAHs by both Maxim and EA. EA samples were analyzed using method 8310, and Maxim data were analyzed in accordance with the NFSS QAPP using method 8270 (USACE, 1999). EA data were used when corresponding results from both methods were available for the same location and depth interval. Method 8310 usually provides better detection limits for PAHs than method 8270. Appendix B indicates the analytical results and the reporting laboratory.

6.4 Data Sets

Two data sets were developed:

1. Soil (includes both surface and subsurface sample data)
2. Surface soil (includes only surface sample data, collected from the interval 0-0.5 feet below the ground surface)

7.0 STATISTICAL ANALYSIS

The data distribution was examined for each data set and analyte. The following list summarizes the statistical analysis:

1. Determine data distribution using the Shapiro-Wilks test
2. Test for outliers using Grubbs' test
3. If outliers were identified, the outlier was removed if site history or current use would explain the presence of the outlier (Outliers were retained in the data set and were considered extreme values in a distribution when no historical justification for their removal was available)
4. The new data set was analyzed beginning with Step 1; if no outlier was identified, the process continues in Step 5
5. Calculate the 95th percentile Upper Tolerance Limits (UTLs) and 95th percentile Upper Confidence Level on the Mean (UCL).
6. Compare the UTL to the maximum reported value. The selected background value for screening is the lower of the UTL and the maximum detect.

7.1 Distribution

The Shapiro-Wilks test was used to determine whether a data distribution was more normal or lognormal. Gilbert's Statistical Methods for Environmental Pollution Monitoring was referenced for the Shapiro-Wilks calculation (Gilbert, R.O., 1987).

$$d = \sum_{i=1}^{n} \left(x_i - x_{avg}\right)^2 \qquad W = \frac{1}{d} \sum_{i=1}^{k} a_i \left(x_{(n-i+1)} - x_i\right)^2$$

Where:

d = denominator of the W statistic

n = number of samples
x_i = individual sample results
x_{avg} = average result
k = n/2 if n is even or (n-1)/2 if n is odd
W = Shapiro-Wilk statistic
a = coefficient from table
$\alpha = 0.05$

If the calculated W statistic exceeded the tabulated value then the distribution was determined to be normal. If the calculated W statistic did not exceed the tabulated value, the distribution was assumed to be lognormal.

Data distributions were summarized in Tables 3 through 8. Statistical work sheets were included in Appendix C, and example calculations were included in Appendix D.

7.2 Outliers

Outlier tests were performed on background data sets. Some outlier tests are applicable only for data sets with at least 25 samples. Grubbs' test for outliers was used, which would be appropriate for large and small data sets.

An underlying assumption of Grubbs' test for outliers is that the distribution of the data set is normal when the outlier is removed. For this reason, outliers were not identified when the resulting data set was not normally distributed.

Grubbs' test is performed by calculating two values, the Grubbs statistic and the Critical Value for comparison with the Grubbs statistic. The Grubbs statistic was calculated as:

$$G = \frac{\max | y_i - y_{avg} |}{s}$$

Where:
G = Grubb statistic
max = maximum reported value
N = number of samples
$t^2_{(\alpha/2N,N-2)}$ = from student t distribution
y_i = result
y_{avg} = arithmetic mean result
s = standard deviation for the sample of a population

The critical value was calculated as:

$$CriticalValue = \frac{(N-1)}{\sqrt{N}} \sqrt{\frac{t^2_{(\alpha/2N,N-2)}}{N-2+t^2_{(\alpha/2N,N-2)}}}$$

For this test, alpha of 0.01 was used, indicating 99% confidence.

No outliers were identified if G < Critical Value.

Grubbs' test results were summarized in the statistical work sheets, included in Appendix C. Example calculations were included in Appendix D.

Outliers were identified by the Grubb's test in surficial samples BKGD-12 (selenium) and BKGD-17 (arsenic and lead).

As indicated in Table 2, BKGD-12 is on property owned by a hunting and gaming club. Selenium dioxide is used to "blue" gun metal, and selenium is used in various copper alloys that could be associated with ammunition (NLM, 2002). Selenium is a common contaminant at ammunition facilities. Because selenium could be a result of the current land use, the selenium concentration reported in BKGD-12 was considered to be an outlier and was not included in the background calculations.

Lead arsenate was historically used as a pesticide and herbicide. Lead arsenate was employed extensively on apple orchards to control the codling moth (NLM, 2002; NJDEP, 1999). Lead arsenate was also used for control of agricultural pests in vegetable fields and other fruit orchards, as well as golf courses and turf farms (NJDEP, 1999). BKGD-17 is apparently adjacent to an old fruit orchard, where lead arsenate would have been used as a pesticide. Lead and arsenic were identified as outliers by Grubbs' test in BKGD-17, and these compounds are likely to be a result of historical land use. Consequently, lead and arsenic concentrations reported at BKGD-17 were excluded from the background calculations.

In summary, arsenic, lead, and selenium were identified as outliers based on Grubbs' test as well as land use. As discussed above, outlier results for these compounds were excluded from the background calculations, as shown in Appendices C and D. Other results for these compounds were included in the calculations that are documented in Appendix C.

7.3 UTL Calculation

The UTL was calculated using calculations from Gilbert (Gilbert, 1987) One Sided Upper Tolerance Limit, where:

$$\text{UTL} = \text{Average} + ks$$

$$k = \frac{Z_{1-p} + \sqrt{Z_{1-p}^2 - ab}}{a}$$

$$a = 1 - \frac{Z_{1-\gamma}^2}{2(N-1)}; b = Z_{1-p}^2 - \frac{Z_{1-\gamma}^2}{N}$$

s = standard deviation for the sample of a population
$z_{(1-p)}$ = critical value of the distribution (value looked up in table)
$z_{(1-\chi)}$ = critical value of the distribution (value looked up in table)

UTLs were summarized in Tables 3 through 8. Statistical work sheets were included in Appendix C, and example calculations were included in Appendix D.

7.4 UCL Calculation

Two calculations were used for the UCL. Each is applicable to a different data distribution.

1. Lognormal distribution (Land, 1971; USEPA, 1992) $UCL_{lognormal} = e^A$, where:

Where:

$$A = \left(x_{avg} + 0.5(\text{variance}) + h_{n,v} \frac{s}{\sqrt{N-1}} \right)$$

$UCL_{lognormal}$ is the 95th percentile Upper Confidence Level on the mean
e = exponent
x_{avg} = arithmetic mean
N = number of samples
s = standard deviation for the sample of a population
h = h-statistic for (n-1) samples with a square root variance of v; excerpted from Gilbert, 1987

2. Normal distribution (Gilbert, 1987)

$$UCL_{normal} = x_{avg} + t_{1-\alpha,n-1} \frac{s}{\sqrt{N}}$$

UCLs were shown on the statistical work sheets included in Appendix C, and example calculations were included in Appendix D.

7.5 Selection of Background Reference Screening Value

The selected background value for screening is the lower of the UTL and the maximum concentration detected. These background reference screening values will be compared to site data to determine the extent of contamination. In each exposure unit, individual sample results will be compared to the background screening value. It is recognized that when the 95th percentile UTL is used as a background screening value, a site data distribution that is equivalent to the background data distribution would be identified as site data that exceeds background in five percent of the cases. However, other recommended approaches for comparison of site data to background concentrations involve collection of equal numbers of random samples from both site and background locations. Judgmental sampling was performed at the NFSS. Random sampling may be performed at the NFSS in the future for the final status survey (see section 1.0).

A lower background value would eliminate fewer compounds during screening comparisons and would be more conservative. Using the maximum reported background concentration as the screening concentration would be a conservative screening method because site data could identify a chemical as above background when the concentration is naturally occurring or present due to historical use. Consequently, the maximum background concentration was used as the screening concentration when the maximum background concentration was less than the UTL.

Summary tables indicate the range of concentrations reported by the laboratory, the frequency of detection, outliers removed for a given parameter, UTL, selected background concentration, type, and notes.

Tables 3 through 8 include background concentrations that may be used for screening comparisons (i.e., indicated as "Selected" in the tables).

Tables 3 and 4 summarize background reference screening values for all soil. Table 3 summarizes radionuclides and Table 4 summarizes nonradionuclide metals.

Tables 5 and 6 summarize background reference screening values for surface soil. Table 5 summarizes radionuclides, and Table 6 summarizes nonradionuclide metals

Tables 7 and 8 summarize background reference screening values PAHs in surface soil and all soil, respectively.

Calculation work sheets in Appendix C provide statistical values and corresponding information to facilitate review and use of these values.

Example calculations are shown in Appendix D using background surface soil data. These include summary statistics, the UCL, UTL, and tests for outliers used to develop the proposed background reference screening concentrations.

8.0 COMPARISON TO BACKGROUND EVALUATION CONDUCTED BY LOOW

NFSS RI background values and comparisons are similar to background values and comparisons for the LOOW RI . Differences in the two approaches include:

- The LOOW RI used a 95% upper prediction limit (UPL), while the NFSS RI is using a 95% UTL. Values of UPL and UTL are similar for most analytes at the two sites.
- The LOOW RI procedure used Wilcoxon Rank-Sum (WRS) test to compare the background data set with data collected from the site when more than 5 samples were collected per investigation area. This approach is only recommended when random (non-judgmental) samples are taken from both the site and background area. Furthermore, size and distribution of data sets from both site and background locations should be similar, which is not always the case for the two sites.

- The LOOW RI procedure did not remove any outliers from the background data set.
- The LOOW RI procedure examined surface and subsurface soils separately (not all soils together, as done for NFSS).

9.0 REFERENCES

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TABLES

Table 1
Distance and Soil Type of Background Samples

NFSS Location Number	LOOW Location Number	Depth of Subsurface Sample (ft) [a]	Distance from NFSS Boundary (ft)	Mapped Soil Type
NA	B1	12-14	8,300	Madalin silt loam [b,d]
NA	B2	14-16, 2-4	9,300	Madalin silt loam [b,d]
B001	B3	11-11.5	1,467	Rhinebeck silt loam, 0 to 2 percent slopes [b,d]
B002	B4	10-10.5	1,867	Rhinebeck silt loam, 0 to 2 percent slopes [b,d]/Ovid silt loam, 0 to 2 percent slopes [b,d]
B003	B5	9-9.5	5,600	Cut and fill land [d]/Madalin silt loam [b]
B004	B6	11.5-12	8,800	Cosad fine sandy loam [d]/Rhinebeck silt loam, 0 to 2 percent slopes [b,d]
B005	B7	5.5-6	7,600	Canandaigua silt loam [c,d]
B006	B8	5.5-6	6,000	Sun silt loam [c,d]
B007	B9	19.5-20	4,000	Ovid silt loam, 0 to 2 percent slopes [b,d]/Madalin silt loam [b,d]
B008	B10	19.5-20	10,667	Elnora loamy fine sand, 0 to 2 percent slopes [d]
B009	B11	11.5-12	3,867	Ovid silt loam, 0 to 2 percent slopes [b,d]/Madalin silt loam [b,d]
B010	B12	11-11.5	8,000	Appleton silt loam, 0 to 3 percent slopes [d]
B011	B13	6.5-7	9,600	Lockport silt loam [d]/Lakemont silty clay loam [d]
B012	B14	13.5-14	9,333	Rhinebeck silt loam, 0 to 2 percent slopes [b,d]
B013	B15	16.5-17	16,267	Phelps gravelly loam, 0 to 5 percent slopes [d]
B014	B16	15.5-16	6,133	Rhinebeck silt loam, 0 to 2 percent slopes [b,d]
B015	B17	19.5-20	7,067	Madalin silt loam [b,d]
		average	7286	

Notes:

[a] All surface soil background samples were taken from zero to six inches bgs.

[b] Identified at the NFSS

[c] Identified "near" the NFSS

[d] Identified in a background sample

NA Not applicable; location sampled during the Phase I LOOW investigation, so no corresponding sample was split for radionuclide analysis

Rhinebeck silt loam, Madalin silt loam, and Ovid silt loam were identified at the NFSS and at background sample locations.

Made land and Madalin silt loam (loamy subsoil variant) were identified at the NFSS but not at background sample locations.

In the soil type column, the "/" designates the sample location was bordering on the soil types shown

Table 2
Former and Current Use of Background Locations

EA Location Number	Former Use Pre LOOW (1942)	Former Use	Current Use
BKGD-1	Farm	LOOW Buffer Land	Lewiston-Porter Schools
BKGD-2	Farm	LOOW Buffer Land	Residential
BKGD-3	Forest	LOOW Buffer Land	Roadway for CWM to get to clay pits
BKGD-4	Orchard	LOOW Buffer Land	Private roadway
BKGD-5	Farm	LOOW Buffer Land	Lewiston-Porter Schools (open land)
BKGD-6	Highway/None	LOOW Buffer Land	Residential
BKGD-7	Farm/Orchard	LOOW TNT storage (igloos)	USA National Guard: Weekend training site
BKGD-8	Farm/Orchard	LOOW TNT storage (igloos)	USA National Guard: Weekend training site
BKGD-9	Farm	LOOW Buffer Land	CWM property and roadway
BKGD-10	Farm	LOOW Buffer Land	Farm
BKGD-11	Farm	LOOW Buffer Land	CWM property and roadway
BKGD-12	Farm	LOOW Buffer Land	Residential/gun club
BKGD-13	Farm	LOOW Buffer Land	Farm
BKGD-14	Farm	LOOW Buffer Land	Forest (privately owned)
BKGD-15	Residential	Residential	Residential
BKGD-16	Farm	LOOW Buffer Land	Lewiston-Porter Schools
BKGD-17	Farm	LOOW Buffer Land	Lewiston-Porter Schools

Notes: See Figure 1 for sample locations.

Table 3 - Selected Background Reference Screening Concentrations for NFSS

Radionuclides All Soil - pCi/g

Compound	CAS No.	Distribution	Maximum+	Q	Minimum+	Q	Average+	UCL	UTL	Frequency	Selected	Source	Notes
Cesium-137	10045-97-3	Lognormal	0.343		0.00213	U	0.083	0.174	0.658	15/30	0.343	Maximum	
Radium-226	13982-63-3	Normal	1.3		0.394		0.806	0.861	1.2	30/30	1.2	UTL	
Radium-228	15262-20-1	Normal	1.26		0.365		0.935	0.999	1.39	30/30	1.26	Maximum	
Thorium-228	14274-82-9	Normal	1.64		0.595		1.12	1.2	1.7	30/30	1.64	Maximum	
Thorium-230	14269-63-7	Normal	1.62		0.444		0.888	0.958	1.39	30/30	1.39	UTL	
Thorium-232	7440-29-1	Normal	1.24		0.368		0.908	0.978	1.4	30/30	1.24	Maximum	
Total Uranium	7440-61-1	Lognormal	3.94		1.22		2.18	2.36	3.57	30/30	3.57	UTL	
Uranium-233/234	13966-29-5	Lognormal	1.68		0.281		0.798	0.903	1.65	30/30	1.65	UTL	
Uranium-235	15117-96-1	Normal	0.241		0.023	U	0.0984	0.114	0.211	4/30	0.211	UTL	
Uranium-235/236	15117-96-1	Normal	0.102	U	0.000881	U	0.0436	0.0508	0.0947	5/30	0.0947	UTL	
Uranium-238	7440-61-1	Normal	1.36		0.367		0.796	0.873	1.34	30/30	1.34	UTL	

U = analyte was not detected at or above the reporting limit

Q = laboratory qualifier

UCL = upper confidence limit

UTL = upper tolerance limit

+ = includes detected and "U" qualified data

Table 4 - Selected Background Reference Screening Concentrations for NFSS

Metals **All Soil - mg/kg**

Compound	CAS No.	Distribution	Maximum+	Q	Minimum+	Q	Average+	UCL	UTL	Frequency	Selected	Source	Notes**
Aluminum	7429-90-5	Normal	19100		4380		11300	12500	20400	34/34	19100	Maximum	
Antimony	7440-36-0	Lognormal	0.94	BN	0.23	UN	0.304	0.4	1.18	13/34	0.94	Maximum	
Arsenic	7440-38-2	Lognormal	11.4		1.7		4.11	4.63	8.59	33/33	8.59	UTL	60.4 was eliminated as an outlier based on site history - BKGD-SO-17-0.5
Barium	7440-39-3	Lognormal	279	*	45.2	*	111	127	257	34/34	257	UTL	
Beryllium	7440-41-7	Lognormal	1		0.12	B	0.593	0.68	1.59	34/34	1	Maximum	
Boron	7440-42-8	Lognormal	10.1	BN	1.3	UN	3.96	5.3	15.7	29/34	10.1	Maximum	
Cadmium	7440-43-9	Lognormal	0.53	B	0.02	U	0.069	0.119	0.451	12/34	0.451	UTL	
Calcium	7440-70-2	Lognormal	58900	BN	994	UN	25100	78600	299000	30/34	58900	Maximum	
Chromium	7440-47-3	Normal	25.8		5.3		16.7	18.3	28.7	34/34	25.8	Maximum	
Cobalt	7440-48-4	Lognormal	57.4	N*	2.2	BN*	11.4	14.1	35.5	34/34	35.5	UTL	
Copper	7440-50-8	Normal	49.3	*	4.1		23.7	27.6	52.7	34/34	49.3	Maximum	
Iron	7439-89-6	Normal	36400	*	6240	*	21500	23700	38200	34/34	36400	Maximum	
Lead	7439-92-1	Lognormal	55.2		2.8		10.8	13.4	36.5	33/33	36.5	UTL	209 was eliminated as an outlier based on site history - BKGD-SO-17-0.5
Lithium	7439-93-2	Normal	36.8		4.6		20.1	22.6	38.7	34/34	36.8	Maximum	
Magnesium	7439-95-4	Normal	14800		931		7220	8340	15600	34/34	14800	Maximum	
Manganese	7439-96-5	Lognormal	6650	*	70		751	949	2780	34/34	2780	UTL	
Mercury	7439-97-6	Lognormal	0.27		0.013	BN	0.0606	0.0707	0.209	13/34	0.209	UTL	
Nickel	7440-02-0	Normal	38	*	5.8	*	20.5	22.9	38.5	34/34	38	Maximum	
Potassium	7440-09-7	Normal	3200		138		1270	1480	2820	34/34	2820	UTL	
Selenium	7782-49-2	Normal	0.37	B	0.17	U	0.16	0.185	0.35	8/33	0.35	UTL	1.3 was eliminated as an outlier based on Grubbs' test and site history - BKGD-SO-12-0.5
Silver	7440-22-4	Lognormal	0.27	B	0.11	U	0.0931	0.104	0.196	2/34	0.196	UTL	
Sodium	7440-23-5	Lognormal	331	B	51.7	B	170	194	379	34/34	331	Maximum	
Vanadium	7440-62-2	Normal	35.2		9.9		22.1	24.3	38.3	34/34	35.2	Maximum	
Zinc	7440-66-6	Lognormal	266	*	23.1	*	57.5	64.6	130	34/34	130	UTL	

* = duplicate analysis was outside control limits

B = result is less than CRDL, but greater than or equal to the instrument detection limit

N = matrix spike recovery was outside control limits

U = analyte was not detected at or above the reporting limit

Q = laboratory qualifier

** = data was eliminated if the Grubbs Test for Outliers or site history identified it as such

UCL = upper confidence limit

UTL = upper tolerance limit

+ = includes detected and "U" qualified data

Table 5 - Selected Background Reference Screening Concentrations for NFSS

Radionuclides Surface Soil - pCi/g

Compound	CAS No.	Distribution	Maximum+	Q	Minimum+	Q	Average+	UCL	UTL	Frequency	Selected	Source	Notes
Cesium-137	**10045-97-3**	**Normal**	0.343		0.00968	U	0.138	0.179	0.366	13/15	0.343	Maximum	
Radium-226	**13982-63-3**	**Normal**	0.921		0.394		0.744	0.809	1.1	15/15	0.921	Maximum	
Radium-228	**15262-20-1**	**Normal**	1.26		0.365		0.903	1.01	1.51	15/15	1.26	Maximum	
Thorium-228	**14274-82-9**	**Normal**	1.64		0.595		1.1	1.22	1.78	15/15	1.64	Maximum	
Thorium-230	**14269-63-7**	**Normal**	1.62		0.444		0.927	1.05	1.6	15/15	1.6	UTL	
Thorium-232	**7440-29-1**	**Normal**	1.24		0.473		0.879	0.983	1.46	15/15	1.24	Maximum	
Total Uranium	**7440-61-1**	**Normal**	3.94		1.22		2.3	2.61	4.06	15/15	3.94	Maximum	
Uranium-233/234	**13966-29-5**	**Normal**	1.68		0.281		0.913	1.07	1.78	15/15	1.68	Maximum	
Uranium-235	**15117-96-1**	**Normal**	0.241		0.023	U	0.102	0.127	0.244	3/15	0.241	Maximum	
Uranium-235/236	**15117-96-1**	**Normal**	0.102	U	0.0185	U	0.0508	0.0618	0.112	4/15	0.102	Maximum	
Uranium-238	**7440-61-1**	**Normal**	1.36		0.367		0.86	0.994	1.61	15/15	1.36	Maximum	

U = analyte was not detected at or above the reporting limit

Q = laboratory qualifier

UCL = upper confidence limit

UTL = upper tolerance limit

+ = includes detected and "U" qualified data

Table 6 - Selected Background Reference Screening Concentrations for NFSS

Metals **Surface Soil - mg/kg**

Compound	CAS No.	Distribution	Maximum+	Q	Minimum+	Q	Average+	UCL	UTL	Frequency	Selected	Source	Notes**
Aluminum	7429-90-5	Normal	18400		4380		11600	13400	21700	16/16	18400	Maximum	
Antimony	7440-36-0	Lognormal	0.94	BN	0.24	UN	0.292	0.444	1.36	6/16	0.94	Maximum	
Arsenic	7440-38-2	Lognormal	11.4		2.3		4.4	5.41	11.2	15/15	11.2	UTL	60.4 was eliminated as an outlier based on site history - BKGD-SO-17-0.5
Barium	7440-39-3	Lognormal	279	*	45.2	*	124	160	372	16/16	279	Maximum	
Beryllium	7440-41-7	Normal	1		0.18	B	0.636	0.736	1.21	16/16	1	Maximum	
Boron	7440-42-8	Lognormal	10.1	BN	1.8	U	3.15	4.57	12.8	12/16	10.1	Maximum	
Cadmium	7440-43-9	Lognormal	0.53	B	0.02	U	0.0953	0.312	1.17	8/16	0.53	Maximum	
Calcium	7440-70-2	Lognormal	45200		994		8610	15900	59000	16/16	45200	Maximum	
Chromium	7440-47-3	Normal	24.3	N	5.3		17.3	19.5	29.8	16/16	24.3	Maximum	
Cobalt	7440-48-4	Lognormal	57.4	N*	2.2	BN*	12	19.6	64.4	16/16	57.4	Maximum	
Copper	7440-50-8	Normal	34.7	*	4.4	*	18.3	22.6	42.9	16/16	34.7	Maximum	
Iron	7439-89-6	Normal	36400	*	6240	*	21000	24900	43300	16/16	36400	Maximum	
Lead	7439-92-1	Lognormal	55.2		4.7		16.4	23.5	65.4	15/15	55.2	Maximum	209 was eliminated as an outlier based on site history - BKGD-SO-17-0.5
Lithium	7439-93-2	Normal	27.9		4.6		15.7	19	34.3	16/16	27.9	Maximum	
Magnesium	7439-95-4	Normal	10200		931		4470	5700	11500	16/16	10200	Maximum	
Manganese	7439-96-5	Lognormal	6650	*	70		817	1480	5510	16/16	5510	UTL	
Mercury	7439-97-6	Lognormal	0.27		0.05	U	0.0595	0.0794	0.214	9/16	0.214	UTL	
Nickel	7440-02-0	Normal	37.5	*	5.8	*	18.5	22.4	40.8	16/16	37.5	Maximum	
Potassium	7440-09-7	Normal	1820		138		898	1100	2050	16/16	1820	Maximum	
Selenium	7782-49-2	Normal	0.37	B	0.18	U	0.211	0.256	0.464	7/15	0.37	Maximum	1.3 was eliminated as an outlier based on Grubbs' test and site history - BKGD-SO-12-0.5
Silver	7440-22-4	Lognormal	0.27	B	0.11	U	0.11	0.139	0.317	2/16	0.27	Maximum	
Sodium	7440-23-5	Lognormal	286		51.7	B	125	149	282	16/16	282	UTL	
Vanadium	7440-62-2	Normal	34		9.9		22.3	25.4	40.1	16/16	34	Maximum	
Zinc	7440-66-6	Normal	78	*	23.1	*	52.6	59.4	91.6	16/16	78	Maximum	

* = duplicate analysis was outside control limits

B = result is less than CRDL, but greater than or equal to the instrument detection limit

N = matrix spike recovery was outside control limits

U = analyte was not detected at or above the reporting limit

Q = laboratory qualifier

** = data was eliminated if the Grubbs Test for Outliers or site history identified it as such

UCL = upper confidence limit

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Table 7 - Selected Background Reference Screening Concentrations for NFSS

Organics	Surface Soil - ug/kg												
Compound	**CAS No.**	**Distribution**	**Maximum+**	**Q**	**Minimum+**	**Q**	**Average+**	**UCL**	**UTL**	**Frequency**	**Selected**	**Source**	**Notes**
2-Methylnaphthalene	**91-57-6**	**Lognormal**	600		20	U	98.1	227	869	1/15	600	Maximum	
Acenaphthene	**83-32-9**	**Lognormal**	500	U	15	U	0.747	195	741	1/15	110	Maximum	UTL is less than the maximum, but there is only one detection; consequently, maximum detect selected.
Anthracene	**120-12-7**	**Lognormal**	500	U	0.92	U	60.6	1280	2860	2/16	500	Maximum	
Benzo(a)anthracene	**56-55-3**	**Lognormal**	220		0.7	U	32.1	169	529	10/16	220	Maximum	
Benzo(a)pyrene	**50-32-8**	**Lognormal**	240		2.4	U	30.2	112	396	12/16	240	Maximum	
Benzo(b)fluoranthene	**205-99-2**	**Lognormal**	260		3.9	U	37.5	129	465	13/16	260	Maximum	
Benzo(g,h,I)perylene	**191-24-2**	**Lognormal**	110		1.8	U	17.1	38.7	147	10/16	110	Maximum	
Benzo(k)fluoranthene	**207-08-9**	**Lognormal**	120		0.74		15.8	61.8	214	12/16	120	Maximum	
Chrysene	**218-01-9**	**Lognormal**	290		0.7	U	42.2	228	731	13/16	290	Maximum	
Dibenzo(a,h)anthracene	**53-70-3**	**Lognormal**	38	PG	1.9	U	5.9	9.22	31.4	5/16	31.4	UTL	
Fluoranthene	**206-44-0**	**Lognormal**	990	PG	2.3		132	555	1780	15/16	990	Maximum	
Fluorene	**86-73-7**	**Lognormal**	200	U	2.7	U	37.9	305	986	2/16	200	Maximum	
Indeno(1,2,3-cd)pyrene	**193-39-5**	**Lognormal**	160		1.3	U	19.5	59.7	225	11/16	160	Maximum	
Phenanthrene	**85-01-8**	**Lognormal**	320	J	0.88	U	42.2	202	698	15/16	320	Maximum	
Pyrene	**129-00-0**	**Lognormal**	560		1.5		87.5	390	1300	15/16	560	Maximum	

D = surrogate or matrix spike recoveries were not obtained because the extract was diluted for analysis

U = analyte was not detected at or above the reporting limit

J = estimated value below the reporting limit

Q = laboratory qualifier

UCL = upper confidence limit

UTL = upper tolerance limit

+ = includes detected and "U" qualified data

Table 8 - Selected Background Reference Screening Concentrations for NFSS

Organics **All Soil - ug/kg**

Compound	CAS No.	Distribution	Maximum+	Q	Minimum+	Q	Average+	UCL	UTL	Frequency	Selected	Source	Notes
2-Methylnaphthalene	91-57-6	Lognormal	600		19	U	68.7	99.4	341	2/30	341	UTL	
Acenaphthene	83-32-9	Lognormal	500	U	13	U	55	92.8	330	2/34	330	UTL	
Anthracene	120-12-7	Lognormal	500	U	0.8	U	45.1	361	1070	3/34	500	Maximum	
Benzo(a)anthracene	56-55-3	Lognormal	220		0.61	U	16.6	25.1	95.6	12/34	95.6	UTL	
Benzo(a)pyrene	50-32-8	Lognormal	240		2.1	U	15.8	20.8	80.1	14/34	80.1	UTL	
Benzo(b)fluoranthene	205-99-2	Lognormal	260		1.6		19.6	26	99.9	18/34	99.9	UTL	
Benzo(g,h,I)perylene	191-24-2	Lognormal	110		1.5	U	10.5	14.1	48.7	12/34	48.7	UTL	
Benzo(k)fluoranthene	207-08-9	Lognormal	120		0.52		8.36	11.2	43	14/34	43	UTL	
Chrysene	218-01-9	Lognormal	290		0.63	U	21.6	39.6	147	18/34	147	UTL	
Dibenzo(a,h)anthracene	53-70-3	Lognormal	38	PG	1.6	U	3.96	4.47	12.2	6/34	12.2	UTL	
Fluoranthene	206-44-0	Lognormal	990	PG	0.99	U	65.5	110	391	18/34	391	UTL	
Fluorene	86-73-7	Lognormal	200	U	2.4	U	34.4	143	520	3/34	200	Maximum	
Indeno(1,2,3-cd)pyrene	193-39-5	Lognormal	160		1.1	U	10.4	15.5	59.5	13/34	59.5	UTL	
Phenanthrene	85-01-8	Lognormal	320	J	0.76	U	33.6	125	447	20/34	320	Maximum	
Pyrene	129-00-0	Lognormal	560		0.56	U	44.4	94.8	332	19/34	332	UTL	

D = surrogate or matrix spike recoveries were not obtained because the extract was diluted for analysis

U = analyte was not detected at or above the reporting limit

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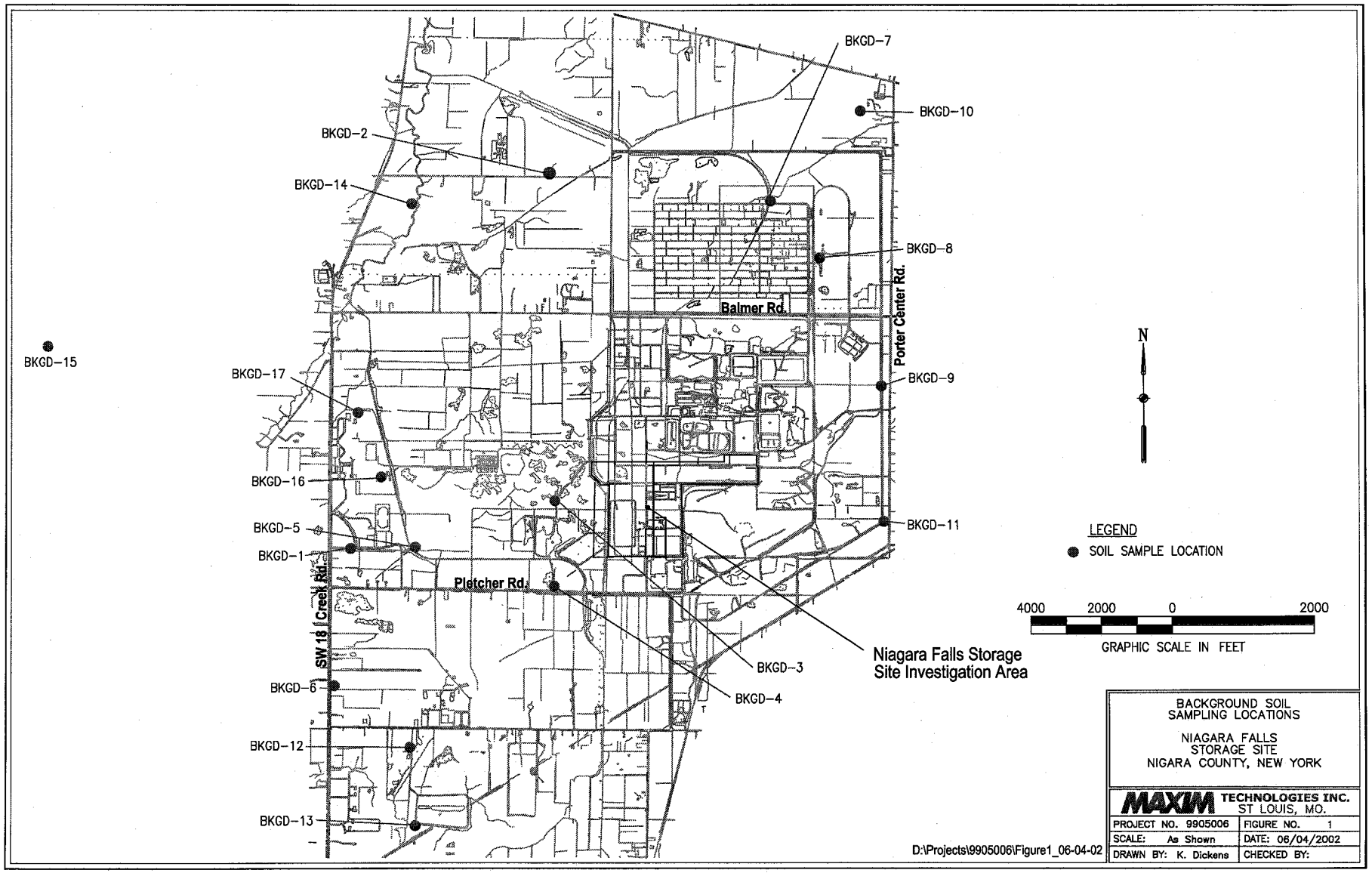
FIGURES



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BACKGROUND SOIL
SAMPLING LOCATIONS

NIAGARA FALLS
STORAGE SITE
NIGARA COUNTY, NEW YORK

MAXIM TECHNOLOGIES INC.
ST LOUIS, MO.

PROJECT NO. 9905006	FIGURE NO. 1
SCALE: As Shown	DATE: 06/04/2002
DRAWN BY: K. Dickens	CHECKED BY: