WORK PLAN FOR THE INVESTIGATION OF THE SOIL STOCKPILE AND THE SOUTHWEST CORNER

TOLEDO 103C LANDFILL
TOLEDO, OHIO

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TABLE OF CONTENTS

Page

LIST OF FIGURES
(Following Text)

LIST OF TABLES
(Following Text)

APPENDICES

1.0 INTRODUCTION

1.1 GENERAL

The purpose of this report is to present a work plan for the investigation of the soil stockpile and the southwest corner at the RACER Properties, LLC Toledo 103C Landfill (Site) located south of the General Motors LLC (GM), located at 1455 West Alexis Road in Toledo, Ohio.

1.2 SITE BACKGROUND

The RACER Properties LLC Toledo 103C Landfill (Site) has been subjected to remedial investigations and remedial actions, as documented in historical reports prepared by Conestoga-Rovers & Associates (CRA) during the period 1999 through 2001. The location of the Site is presented on Figure 1.

The Site consists of approximately 33 acres. The Site is bounded by the GM plant to the north, by the rail road to the east, wooded area to the south, and a recreational area to the west. The Site includes areas adjacent to Silver Creek and its tributary ditches and is zoned industrial.

The United States government originally built the plant in 1941. GM acquired the plant and surrounding land in 1956. In 1999, the 33 acres south of the plant were acquired by Remediation and Liability Management Co., Inc. (REALM) a wholly owned subsidiary of General Motors. Following the bankruptcy of General Motors, RACER Properties, LLC acquired the property on March 31, 2011.

2.0 ENVIRONMENTAL SETTING

This section describes the climate, hydrology, topography, geology, and hydrogeology in the vicinity of the Site.

2.1 CLIMATE

The normal monthly temperature in Toledo, Ohio varies from an average low of 23.1 degrees Fahrenheit in January to an average high of 71.8 degrees Fahrenheit in July, with an average annual temperature of 48.5 degrees Fahrenheit. The average monthly precipitation varies from a low of 1.8 inches in February to a high of 3.5 inches in June, with an average annual precipitation of 31.2 inches.

2.2 HYDROLOGY

The Site is located in the Halfway Creek drainage Basin that flows into Lake Erie. Silver Creek passes through the southern section of the Site and enters Halfway Creek approximately 4 miles east of the Site. Silver Creek is approximately 7 miles in length. On an 1899 topographic map, Silver Creek is shown flowing directly into Lake Erie; however, by the mid-1930s it was rerouted downstream of the Site, and now flows into Halfway Creek, and then into Lake Erie. In the vicinity of the Site, Silver Creek is approximately 10 to 15 feet wide and up to 2 feet deep during normal conditions. The Ohio Environmental Protection Agency (Ohio EPA) has designated Silver Creek as a warm water habitat that may potentially be used for agricultural or industrial water supply usage, and for primary contact recreational usage. Silver Creek is not gauged; therefore, no historical flow data is available. Groundwater seepage has been observed along the side banks of Silver Creek in several locations.

Five on-Site ditches flow intermittently into Silver Creek. Ditch A and Ditch B are located along the west side and east side of the Former Disposal Area (FDA), respectively. Ditch C and Ditch D are located on the east side of the property, while Ditch E is located at the south end of the property.

The majority of the Site, including the ditches and former holding pond, are located within the 100-year flood plain of Silver Creek. The Former Disposal Area is in an area of minimal flooding between the limits of the 100-year and 500-year floods (National Flood Insurance Program, June 4, 1980).

2.3 TOPOGRAPHY

Site topographic contours range from 596 to 610 feet above mean sea level (AMSL). The dominant Site topographic features include Silver Creek, which runs west to east through the Site, and its tributary ditches.

2.4 REGIONAL GEOLOGY AND HYDROGEOLOGY

The regional geology is characterized by approximately 50 to 80 feet of unconsolidated glacial drift overlying Silurian-age dolomites and evaporites.

The soils in the vicinity of the Site are generally classified as Bixler-Dixboro association soils. These are nearly level or gently sloping, somewhat poorly drained soils that formed in loamy and sandy glacial lake sediment. These soils have moderate permeability.

2.5 LOCAL GEOLOGY AND HYDROGEOLOGY

Based on the inspection of the soil samples collected during previous Site drilling activities, geologic materials at the Site consist of clayey and silty sands to a depth approximately 5 to 10 feet. From 5 to 32 feet, silty clay till was encountered. Underlying the clay till is a groundwater-yielding zone of fairly well sorted medium and fine sands. The shallow clayey and silty sands appear to be hydraulically isolated from the lower medium and fine sands by the clay till. The shallow saturated zone appears to be 0 to less than 7 feet thick and may represent a perched water-bearing zone. The shallow groundwater generally flows towards Silver Creek and likely discharges to Silver Creek during most of the year.

3.0 INVESTIGATION ACTIVITIES

3.1 PRE-MOBILIZATION ACTIVITIES

The following sections describe the pre-mobilization activities related to work to be conducted under this Work Plan.

3.1.1 HEALTH AND SAFETY PLAN

To ensure that all on-Site personnel are properly protected from potential exposure to Site-related constituents, the existing Site-specific Health and Safety Plan (HASP) has been updated to include the additional Work Plan activities. A project health and safety officer has completed a hazard analysis for all the additional activities. The hazard analysis identified the potential hazards, evaluated the level of personal protective equipment that will be used during the Work Plan activities, and described the personnel decontamination procedures required to control any potential personal exposures during implementation of this Work Plan.

The HASP was prepared and implemented consistent with Occupational Safety and Health Administration (OSHA) 29 CFR 1910.120.

Contractors will follow their own Health and Safety Plan that will be consistent with the Site-Specific Health and Safety Plan.

3.1.2 AIR AND PARTICULATE MONITORING

Air and particulate monitoring will be performed for worker health and safety during drilling activities. The monitoring results will determine any necessary upgrades to respiratory and particulate worker protection. Monitoring action levels are identified in the HASP.

3.1.3 CONTRACTOR PROCUREMENT

All contractors will complete and must pass CRA's health and safety evaluation prior to receiving approval to perform services relating to Site activities.

A qualified drilling contractor will be procured for the drilling activities outlined in this Work Plan. The driller will install boreholes as directed by CRA. All drilling contractors will provide documentation that personnel are certified to work on Hazardous Waste Operations and Emergency Response (HAZWOPER) Sites, prior to arriving on Site. Personnel will have their HAZWOPER documentation with them during Site work.

An accredited laboratory will be procured for the laboratory analytical activities (soil waste analyses) outlined in this Work Plan. The selected analytical laboratory will perform all analyses in accordance with accepted industry methods.

A qualified surveyor will be procured following the installation activities outlined in this Work Plan. The surveyor will record the easting, northing and elevation coordinates of all sample locations.

An approved transporter will transport the investigation-derived waste to an appropriate regulated disposal facility.

3.2 MOBILIZATION AND SITE PREPARATION

The drilling contractor will be responsible for construction of the temporary facilities such as the staging area and decontamination pad. The driller will keep all drilling equipment and materials in a designated staging area at the Site when not in use.

3.3 SOIL ACTIVITIES

This subsection presents the activities related to investigating soil at the Site.

3.3.1 SOIL STOCKPILE INVESTIGATION

In 2007 GM constructed a building addition to the former Plant 2. The stockpiled soil came from final grading around the building addition. The soil was intended to be used as fill for the City of Toledo's construction of a new roadway connecting Laskey and Hydramatic Drive (to provide an access route to landlocked parcels owned by the Toledo Port Authority). However, the City roadway project fell through. The soil stockpile was primarily clean-fill brought on-site by the contractor mixed with some soil formerly underlying a parking lot in the extreme eastern edge along the east side of the property.

The soil stockpile will be investigated based upon the guidelines set forth in ASTM D 6009-96 Standard Guide for Sampling Waste Piles (Appendix A). The soil stockpile will be roughly segregated into 500 cubic yard subsections. The soil pile contains approximately 4,000 CY of material and therefore will be split into eight subsections for sampling. All soil borings will be advanced to the full depth of the stockpile. Each subsection will be sampled for analysis of the parameter presented in Table 3.1 as described in the following below. One composite sample per boring will be collected for analysis of Target Compound List (TCL) semi-volatile organic compounds (SVOC) and Target Analyte List (TAL) Metals (non-earth). Three to four discrete samples per boring will be analyzed for polychlorinated biphenyls (PCBs) and one discrete sample per boring will be analyzed for TCL volatile organic compounds (VOC).

Each borehole for the Soil Stockpile will be continuously sampled using a photoionization detector (PID). Immediately upon opening the split-spoon or discrete soil sampler, soil screening will be performed with a PID (HNu, Microtip, or equivalent) for the presence of undifferentiated organic vapors. This is accomplished by running the PID along the length of the soil sample interval. The highest reading will be recorded. If the PID reading for the current sample interval is the highest measured so far at this borehole, a representative portion of the soil sample will be retained for potential VOC sampling by collecting an undisturbed sample using an En Core® Soil Sampler.

3.3.2 SOUTHWEST CORNER INVESTIGATION

Based upon review of the previous investigations in the Southwest Area further delineation of PCBs is required. Three areas remain in the Southwest Area that exceed the Residential U.S. EPA Region 9 PRG of 1.1 mg/kg for total PCBs. Four historical sample locations will be located onsite using a handheld GPS device and survey data available in the CRA EquIS database for this site. TP-B2-00, BH239-00, HA-8, and BS-1-89 will be located due historical PCB values. Four soil borings will be placed around TP-B2-00, four soil borings will be placed around BS-1-89/HA-8, and three soil borings will be placed around BH239-00. The historical PCB results in the Southwest Corner indicate that only the top four feet of soil needs to be investigated. Therefore, soil samples will only be collected from the uppermost four feet in this area and analyzed for PCBs.

3.3.3 BOREHOLE ADVANCEMENT

Each boring will be advanced using a Geoprobe unit equipped with disposable tube samplers or a drill rig equipped with hollow-stem augers (HSA) and split spoon samplers. Each borehole will be continuously sampled using disposable sample tubes or decontaminated split spoons. The drill rig and crew will install the boreholes as directed by CRA. All borehole locations will be stratigraphically logged by CRA.

The split spoons (if used) will be decontaminated after each continuously sampled soil interval by scrubbing, an Alconox wash, and a water rinse.

Following installation the borehole will be abandoned by filling the boring with bentonite chips or grout to within approximately 1 foot of ground surface. The top of the borehole will be completed to match existing surrounding conditions (e.g., concrete, gravel).

All soil cuttings, disposable sample tubes (if used), discarded sample supplies, used sample containers, and used PPE will be containerized in drums and staged on Site for future disposal.

3.3.4 SOIL SAMPLE COLLECTION AND ANALYSES

All sampling and analysis conducted under this Work Plan will be performed in accordance with the Region 5 RCRA Quality Assurance Project Plan Policy (April 1998) as appropriate for the site.

Following field screening, stratigraphic logging of each sample interval will be performed. Visual examination, physical observation, and manual tests are used to aid in classifying and grouping soil samples in the field.

Sample containers will be filled in the order of VOCs, SVOCs, PCBs, and metals. The remainder of that selected interval will be composited into containers for analyses of non-volatile parameters. New disposable gloves will be used to collect the sample material at each interval. Laboratory-supplied containers that have been precleaned by the laboratory or supplier will be used. All sample containers will be filled directly from the sampling equipment (disposable sleeve or split spoon) to the sample containers.

Proposed borehole locations are presented in Figures 2 and 3, respectively.

3.4 SAMPLE PRESERVATION, CHAIN-OF-CUSTODY, AND SHIPMENT

Laboratory-supplied, pre-cleaned sample containers will be used to collect all samples. Sample containers, preservation, holding time periods, packaging, and shipping requirements are presented in Table 3.2. All samples will be identified using a unique sample identification number. The sample numbering system has been designed to uniquely identify every sample from each sampling program and event. This numbering system consists of the sample matrix code, sample collection date, initials of sampler, and sequential number beginning with 001 for each sampling event.

An example of the sample numbering system follows:

MC-12609-mmddyy-XX-001

Where: MC (Matrix Code) = –SW – Surface Water
58502 = CRA Project Number
mmddyy = Date in month/day/year
XX = Samplers first and last initials
001 = Sequential number for event

A transport container provided by the laboratory will be used for storage of the collected samples on Site and transportation of the samples to the analytical laboratory. The samples will be kept in the transport container, and will be cooled to approximately 4°C from the time of sample collection to the time of delivery to the laboratory. The transport container will be packed with the samples, wet ice, and packing material to ensure that the appropriate sample temperature is maintained and that the sample containers are not broken in transit.

The chain-of-custody record will be signed and included in each of the transport containers, and the transport containers will be sealed with packing tape and custody seals. The transport containers will be delivered to the analytical laboratory by overnight courier service. Laboratory personnel will inspect the transport containers upon receipt and notify the project personnel of any difficulties with sample integrity, sample temperature, or holding time. Samples are tracked internally by the laboratory throughout all phases of analysis, with access restricted to authorized personnel. Completion of the field forms, sample key, and chain-of-custody forms will help to prevent misidentification of samples and to track the samples.

3.5 LABORATORY ANALYTICAL METHODS

Soil and sediment samples will be analyzed for specified chemical constituents off Site by the project laboratory. The methods that will be used for sample analysis are presented in Table 3.3. Specific analytes and targeted quantitation limits for chemical constituents are presented in Table 3.4.

3.6 QUALITY ASSURANCE/QUALITY CONTROL

3.6.1 LEVEL OF QA/QC EFFORT

To assess the quality of data resulting from the field investigative activities, field duplicate samples, field blank samples (equipment rinse), and matrix spike samples will be collected and submitted to the analytical laboratory.

Quality assurance/quality control (QA/QC) samples will be collected as follows:

- 1 duplicate sample every 10 investigative samples
- 1 field/equipment blank every 10 investigative samples or every day sampling equipment is used and decontaminated
- 1 matrix spike/matrix spike duplicate sample every 20 investigative samples

The field duplicate will be prepared as a split sample and will be submitted blind to the laboratory to avoid laboratory bias of field QA/QC samples. The sample will be split by alternately filling the investigative and duplicate sample bottles for the same parameters.

The QA/QC samples will be collected and assessed in accordance with standard data validation procedures. Field duplicate samples will be analyzed to check for sampling and analytical reproducibility. Field duplicate samples are to be used as a measure of precision throughout the sampling event. Comparison of field duplicate samples will be based upon the target analytes, both non-detected and detected, and the relative percent differences (RPD) of each analyte's concentrations. The parameters that do not meet the criteria may only be used as qualitative measures. Professional judgment by the data validator will determine the RPD limits on a sample-to-sample basis. All QA/QC samples will be used to qualify the data in accordance with standard data validation procedures and not to correct the data.

3.6.2 LABORATORY REPORT DELIVERABLES

Laboratory reports for samples collected will consist of the following data deliverables:

1. Case Narrative
    i) Date of issuance
    ii) Project name and number
    iii) Any deviations from intended analytical strategy
    iv) Condition of samples "as received"
    v) Discussion of whether or not sample holding times were met
    vi) Discussion of technical problems or other observations that may have created analytical difficulties
    vii) Discussion of any laboratory quality control checks that failed to meet project criteria
2. Chemistry Data Package
    i) Dates of sample collection, receipt, preparation, and analysis
    ii) Cross-reference of laboratory to project sample identification numbers
    iii) Description of data qualifiers used
    iv) Methods of sample preparation and analysis
    v) Sample results in tabular format
    vi) Method blank data, LCS data, duplicate sample data, MS/MSD data, surrogate compound spike data
    vii) Fully executed chain-of-custody document

3.6.3 DATA REVIEW AND VALIDATION

Upon receipt of the final data packages from the project laboratory the data will be reviewed and validated. The data review will evaluate the final analytical results, holding time period compliance, equipment blank sample data, field duplicate sample data, method blank data, LCS data, laboratory duplicate data, surrogate compound spike data, and MS/MSD sample data.

Validation of the data will consist of evaluating the QA/QC data based on the applicable review criteria specified in:

- "U.S. EPA Contract Laboratory Program National Functional Guidelines for Inorganic Data Review", EPA-540/R-94/013, February 1994
- "U.S. EPA Contract Laboratory Program National Functional Guidelines for Organic Data Review", USEPA-540/R-99/008, October 1999
- "Ohio EPA Tier I Data Validation Manual", January 2006

Assessment of analytical data will include checks for data consistency by looking for comparability of duplicate analyses, potential sample contamination as indicated by results of rinsate sample analyses, laboratory QA procedures, adherence to accuracy and precision criteria, transmittal errors, and anomalously high or low parameter values. The results of these data validations will be presented in a data quality assessment and validation memorandum.

The data package will include a full deliverable package capable of allowing the recipient to reconstruct QC information and compare it to QC criteria.

3.7 EQUIPMENT DECONTAMINATION

Prior to mobilization to the Site, and prior to commencing any drilling activities, the Geoprobe unit or drill rig and all associated equipment will be thoroughly cleaned with a high pressure, low volume, hot water wash to remove any mud, oils, hydraulic fluid, or other foreign matter.

After each continuously sampled soil interval, drilling equipment which contacted the soil will be decontaminated by scrubbing, followed by an Alconox wash, and finished with a water rinse.

If necessary, the drilling equipment will be cleaned between the investigation areas to minimize the potential for tracking impacted materials across the Site. Only the equipment which came in contact with contaminated materials (e.g., rods, split spoon, vehicle wheels) would potentially require decontamination between investigation areas.

Prior to demobilization, the drilling equipment will be thoroughly cleaned and inspected before being allowed to demobilize from the Site.

Decontamination will be performed with a high pressure, low volume, hot water wash on the equipment decontamination pad (on the new pad that was set up during mobilization activities, or on the existing decontamination pad). Wastewater from all decontamination activities will be collected and placed in a designated storage tank pending disposal. The tank will be marked with appropriate placards pending off-Site disposal. The solids from decontamination activities will be transferred to a designated storage container pending off-Site disposal.

3.8 SURVEYING

All new sample locations (boreholes and monitoring wells) will be flagged/staked after completion for future surveying. The surveyor will be provided with a list of the new sample locations and a CADD drawing of the Site.

The surveyor will record the easting, northing and elevation coordinates of each sample location. The easting and northing coordinates will be in units of feet, will be consistent with the Ohio North State Plane NAD 83 system, and will be accurate to ±1 feet. The elevation coordinates will be in units of feet, will be consistent with the NGVD 88 system, and will be accurate to ±0.01 foot.

Following the field survey, the surveyor will provide CRA with an updated CADD drawing showing the coordinates of the new sample locations, and an .xls file listing the coordinates.

3.9 SITE RESTORATION AND DEMOBILIZATION

All investigation-derived waste will be containerized in drums and staged at the Site's staging area, as directed by CRA. The drilling contractor will remove all equipment and un-used supplies from the Site upon demobilization.

Flagging/stakes will remain in place for the use of the surveyors. Following CRA's review and acceptance of the survey data, CRA will return to the Site and remove all flagging/stakes.

3.10 WASTE CHARACTERIZATION AND DISPOSAL

Following completion of stratigraphic logging and borehole installation, all soil cuttings will be containerized in drums. CRA personnel will group the drums according to similar soil material based on visual observation and PID measurements. One composite soil sample will be collected from each group of drums.

One wastewater sample, one sample of the solids from wastewater decontamination activities, and one representative composite sample from each group of drummed soil material, will be collected and submitted for waste characterization parameters. The samples will each be analyzed for Toxicity Characteristic Leaching Procedure (TCLP) analyses of VOCs, SVOCs, PCBs, Metals (RCRA 8), and for reactivity, corrosivity, and ignitability (RCI).

Following receipt of the sample analyses, the wastewater, the solids from decontamination activities, each group of drummed soil material, and the drummed non-soil waste (e.g., PPE), will be transported to and disposed at an appropriate regulated facility.

3.11 ECOLOGICAL RISK SCREENING

Currently, RACER intends to use the soil pile as clean fill for placement at some other locations. The soil will be screened against soil values protective of ecological receptors. If the soil exceeds those screening values (but not those for human health), the soil will either not be used for surface soil in a location that will serve as habitat or the exceedances will be evaluated in terms of its potential effects.

With respect to the PCB sampling, the areas being subsampled are most likely too small, individually and in sum, to pose ecological risks from PCBs. In total, the area being subsampled is probably less than one-twentieth of an acre. Unless the PCB concentrations are very high, the small area precludes much chance of ecological risk. Nonetheless, this assumption will be checked when the results are received.

With respect to the ecological risk screening, after data are collected screening benchmarks will be selected from those found at "http://www.epa.gov/R5Super/ecology/html/screeningbench.html" or other scientifically defensible sources. The actual benchmarks used will be selected in consultation with U.S. EPA.

4.0 REPORTING/DOCUMENT PREPARATION

4.1 DOCUMENTATION OF FIELD ACTIVITIES

A field logbook will be maintained to record a detailed description of the work performed on the Site each day that active work is conducted. The field logbook will describe project events, decisions, and activities in sufficient detail for project documentation. The field logbook will record information such as:

i) Date
ii) Meteorological conditions
iii) On-Site field and contractor personnel
iv) On-Site equipment
v) General Site activities
vi) Investigation activities (e.g., drilling/sampling progress, difficulties encountered)
vii) Any safety issues

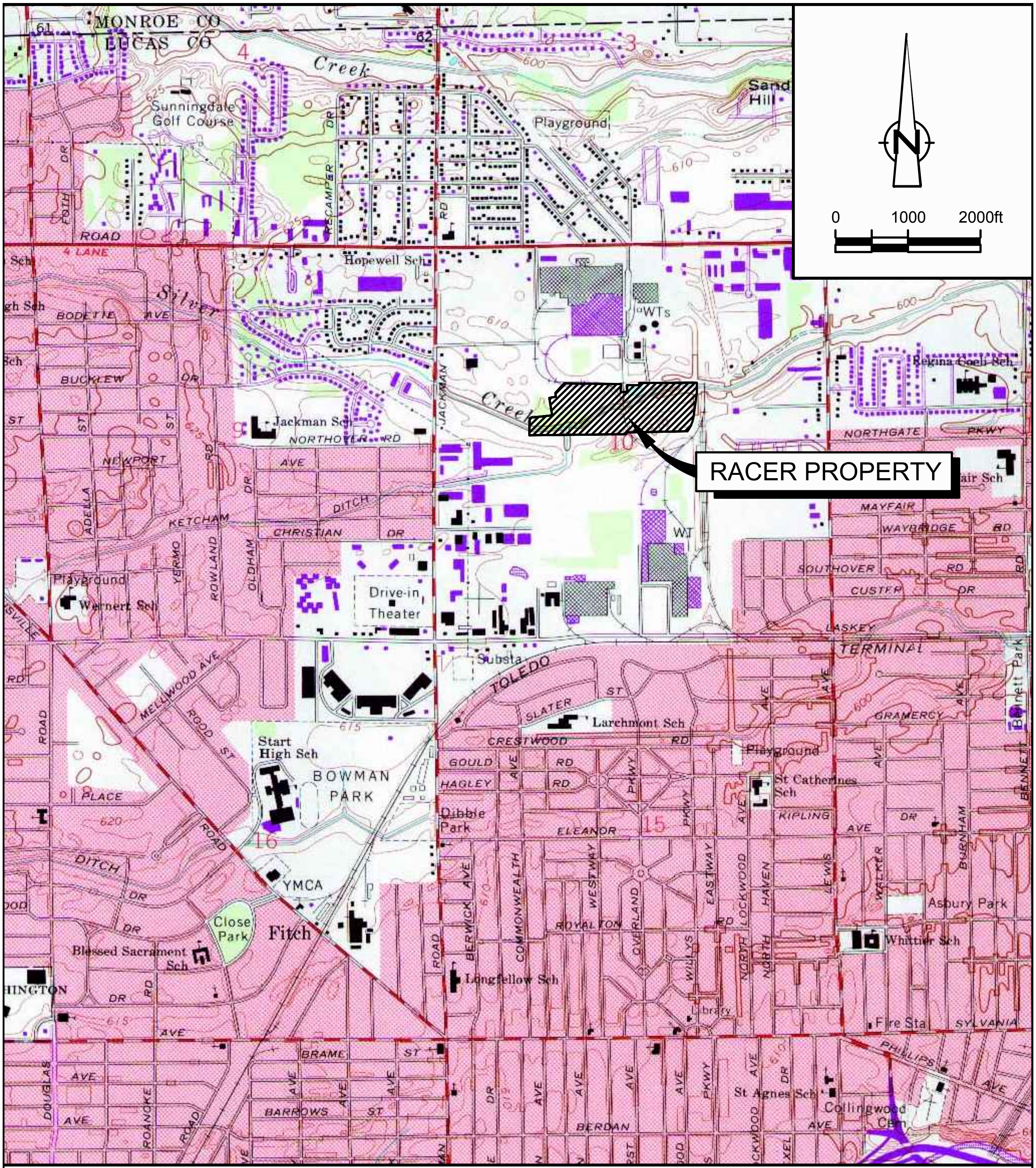
All logbooks will be:

i) Bound so pages cannot be added or removed
ii) Consecutively numbered pages
iii) Factual and complete
iv) All errors will be lined out with a single line, initialed, and dated
v) Recorded in water-proof ink
vi) "Closed out" by signing just below the last entry at the end of each day
vii) Started on a new page for each day's work

4.2 COMPLETION OF REPORT

Upon completion of the Work Plan activities, an Investigation Report will be prepared to present a summary of the investigation activities. The report will also include an evaluation of the analytical data and recommend corrective actions (if any) for each of the investigated areas.

A draft report will be submitted approximately one month after receipt of the final analytical data.



SOURCE: USGS QUADRANGLE MAP:
TOLEDO, OHIO-MICHIGAN

figure 1

SITE LOCATION
RACER SITE 1099, TOLEDO 103C LANDFILL
Toledo, Ohio

012609-T02(026)GN-DE001 AUG 30/2011

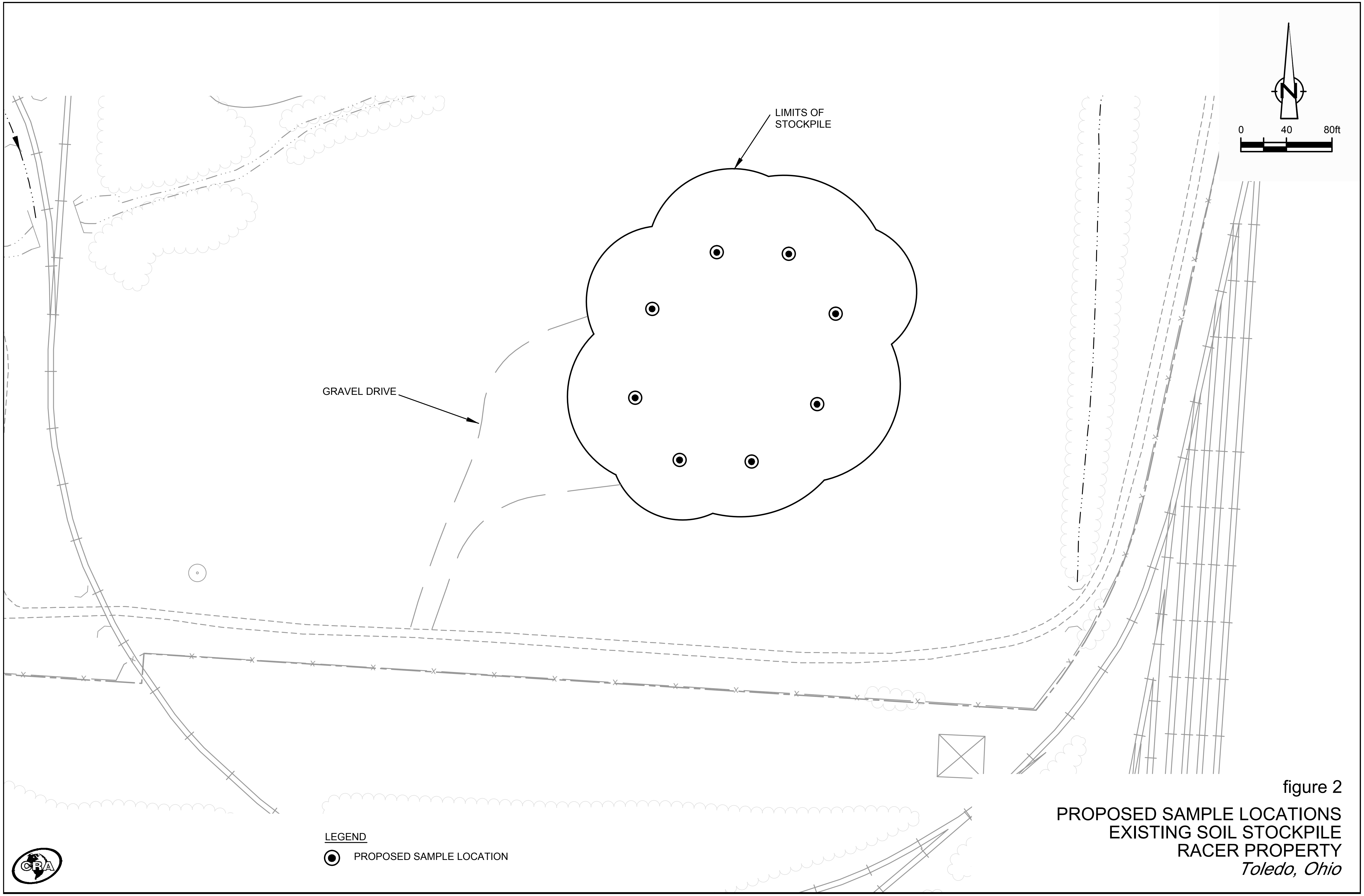
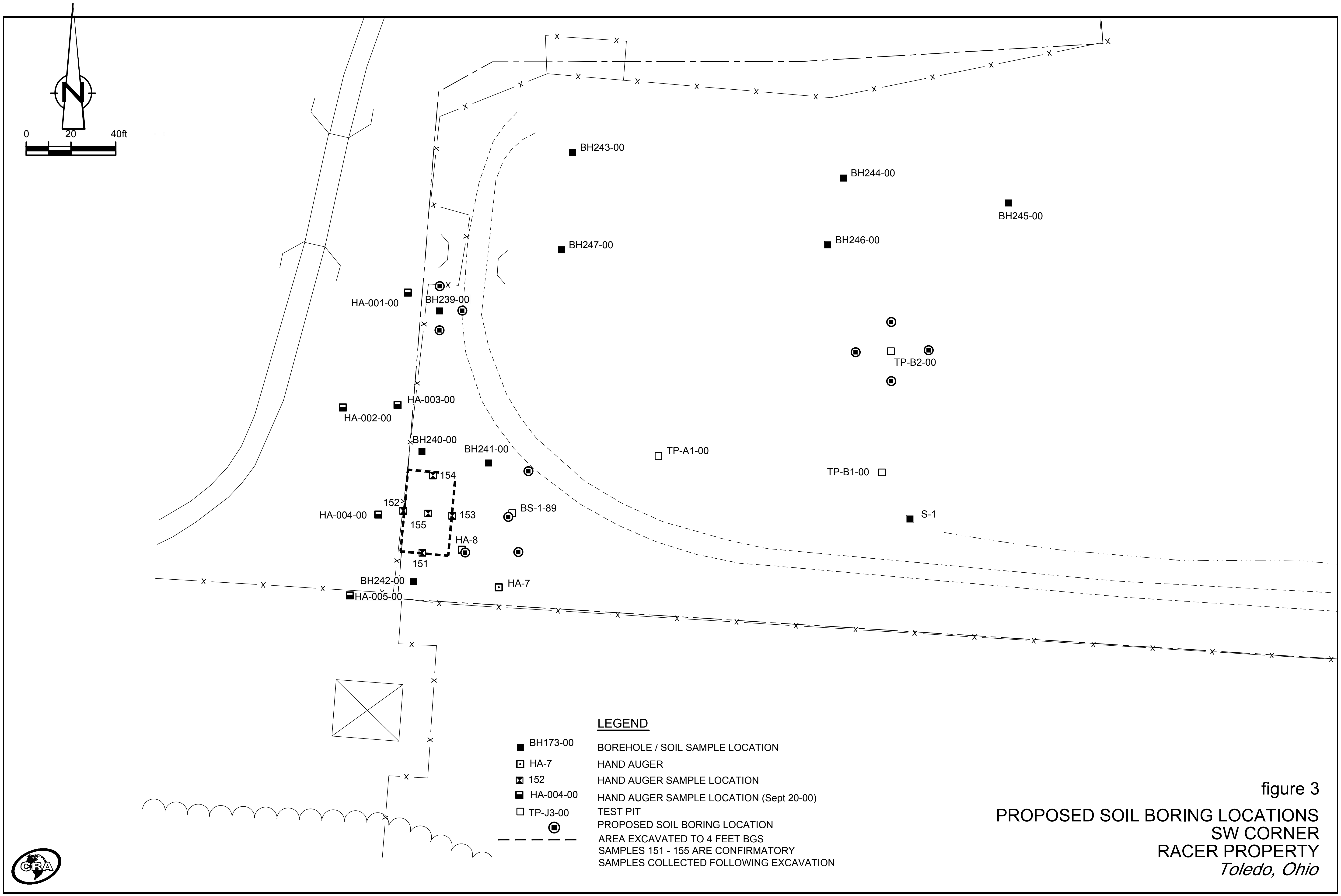


figure 2

PROPOSED SAMPLE LOCATIONS
EXISTING SOIL STOCKPILE
RACER PROPERTY
Toledo, Ohio

012609-T02(026)GN-DE002 AUG 30/2011



LEGEND

■ BH173-00	BOREHOLE / SOIL SAMPLE LOCATION
⊡ HA-7	HAND AUGER
☒ 152	HAND AUGER SAMPLE LOCATION
⬓ HA-004-00	HAND AUGER SAMPLE LOCATION (Sept 20-00)
☐ TP-J3-00	TEST PIT
◉	PROPOSED SOIL BORING LOCATION
— — —	AREA EXCAVATED TO 4 FEET BGS SAMPLES 151 - 155 ARE CONFIRMATORY SAMPLES COLLECTED FOLLOWING EXCAVATION

figure 3

PROPOSED SOIL BORING LOCATIONS
SW CORNER
RACER PROPERTY
Toledo, Ohio

012609-T02(026)GN-DE003 AUG 30/2011

TABLE 3.1

SUMMARY OF SAMPLING AND ANALYSIS PROGRAM
SOIL STOCKPILE AND SOUTHWEST CORNER INVESTIGATION
TOLEDO 103C LANDFILL
TOLEDO, OHIO

Investigation Activity	*Sample Matrix*	*Type of Sample*	*Laboratory Parameters*	*Investigative Samples*	*Quality Control Samples*			*Total*
					Equipment Blanks (1)	*Field Duplicates*	*MS/MSD (2)*	
Soil Stockpile	Soil	Composite	TCL SVOC, Site-specific TAL Metals,	8		1	1	10
	Soil	Grab	TCL VOC	8		1	1	10
	Soil	Grab	PCB	32		3	2	35
Southwest Corner	Soil	Grab	PCB	12	1	1	1	15

Notes:

(1) - Equipment / Field blank samples will not be required if dedicated or disposable sampling equipment is used.
(2) - Matrix Spike/Matrix Spike duplicate (MS/MSD) analyses are required for samples submitted for organic and inorganic analyses are to be analyzed at a frequency of one per group of twenty (20) or fewer investigative samples for the activities detailed above.

PCB = Polychlorinated Biphenyls
VOC = Volatile Organic Compounds
SVOC = Semi-Volatile Organic Compounds
TCL = Target Compound List
TAL = Target Analyte List

TABLE 3.2

CONTAINER, PRESERVATION, SHIPPING AND PACKAGING REQUIREMENTS
SOIL STOCKPILE AND SOUTHWEST CORNER INVESTIGATION
TOLEDO 103C LANDFILL
TOLEDO, OHIO

Analyses	*Sample Containers* [1]	*Preservation*	*Maximum Holding Time from Sample Collection* [2]	*Volume of Sample*	*Shipping*	*Normal Packaging*
SOLID (Soil)						
VOC	Three 5 gram EnCores® per analysis	Iced, 4 ± 2° C	Freeze or preserve in water and/or methanol within 48 hours 14 days from collection until analysis	Fill completely	Overnight or Hand Deliver	Foam Liner or Bubble-wrap
SVOC	One 4-ounce glass jar [1]	Iced, 4 ± 2° C	14 days for SVOC extraction 40 days after extraction for analysis	Fill to shoulder of jar	Overnight or Hand Deliver	Foam Liner or Bubble-wrap
Polychlorinated Biphenyls (PCB)	One 4-ounce glass jar [1]	Iced, 4 ± 2° C	14 days for extraction 40 days after extraction for analysis	Fill to shoulder of jar	Overnight or Hand Deliver	Foam Liner or Bubble-wrap
Metals	One 4-ounce glass jar [1]	Iced, 4 ± 2° C	180 days (mercury 28 days) for analysis	Fill to shoulder of jar	Overnight or Hand Deliver	Foam Liner or Bubble-wrap

Notes:

[1] - Multiple parameters on a single sample may be combined into one single 16 ounce glass jar.
[2] - These are technical holding times, i.e., are based on time elapsed from time of sample collection.
VOC = Volatile Organic Compounds
SVOC = Semi-Volatile Organic Compounds

TABLE 3.3

SUMMARY OF ANALYTICAL METHODS
SOIL STOCKPILE AND SOUTHWEST CORNER INVESTIGATION
TOLEDO 103C LANDFILL
TOLEDO, OHIO

Parameter [1]	*Preparation Method* [2]	*Analytical Method* [2]
VOC	SW-846 5035	SW-846 8260B
SVOC	SW-846 3550B	SW-846 8270C
PCB	SW-846 3545	SW-846 8082
Metals		
ICP Metals	SW-846 3050B	SW-846 6010B
ICP/MS Metals	SW-846 3050B	SW-846 6020
Mercury	SW-846 7471A	SW-846 7471A

Notes:

[1] Refer to Tables 1.2 for the compounds/elements of each parameter group.

[2] Preperation and Analytical Method References:

- SW-846 - "Test Methods for Evaluating Solid Wastes, Physical/Chemical Methods ", SW-846, 3rd Edition, and Promulgated Updates, November 1986. Actual method versions employed will include the latest promulgated version of the method adopted by the lab.

PCB = Polychlorinated Biphenyls
NA = Not Applicable
VOC = Volatile Organic Compounds
SVOC = Semi-Volatile Organic Compounds

TABLE 3.4

SOIL SAMPLE PARAMETER LIST
SOIL STOCKPILE AND SOUTHWEST CORNER INVESTIGATION
TOLEDO 103C LANDFILL
TOLEDO, OHIO

		Estimated Quantitation Limits (EQL)[1]	*Method Detection Limits (MDL)*[2]	*Regional Screening Levels (RSL)*[3]
Compound	CAS No.	*Soil (µg/kg)*	*Soil (µg/kg)*	*Industrial Soil (µg/kg)*
Target Compound List (TCL) Volatile Organic Compounds (VOC)				
Acetone	67-64-1	20	6.3	630,000,000
Benzene	71-43-2	5	0.23	5,400
Dichlorobromomethane	75-27-4	5	0.28	1,400
Bromoform	75-25-2	5	0.33	220,000
Bromomethane	74-83-9	5	0.54	32,000
2-Butanone (MEK)	78-93-3	20	1.4	200,000,000
Carbon disulfide	75-15-0	5	0.44	3,700,000
Carbon tetrachloride	56-23-5	5	0.37	3,000
Chlorobenzene	108-90-7	5	0.33	1,400,000
Chloroethane	75-00-3	5	0.86	61,000,000
Chloroform	67-66-3	5	0.29	1,500
Chloromethane	74-87-3	5	0.41	500,000
1,1-Dichloroethane	75-34-3	5	0.36	17,000
1,2-Dichloroethane	107-06-2	5	0.34	2,200
1,1-Dichloroethene	75-35-4	5	0.52	1,100,000
1,2-Dichloropropane	78-87-5	5	0.69	4,700
cis-1,3-Dichloropropene	10061-01-5	5	0.34	8,300
trans-1,3-Dichloropropene	10061-02-6	5	0.54	8,300
Ethylbenzene	100-41-4	5	0.26	27,000
2-Hexanone	591-78-6	20	0.63	1,400,000
Methylene Chloride	75-09-2	5	0.67	53,000
4-Methyl-2-pentanone (MIBK)	108-10-1	20	0.54	53,000,000
Styrene	100-42-5	5	0.15	36,000,000
1,1,2,2-Tetrachloroethane	79-34-5	5	0.34	2,800
Tetrachloroethene	127-18-4	5	0.52	2,600
Toluene	108-88-3	5	0.27	45,000,000
Trichloroethene	79-01-6	5	0.42	14,000
Vinyl chloride	75-01-4	5	0.39	1,700
Xylenes, Total	1330-20-7	10	0.67	2,700,000
1,1,1-Trichloroethane	71-55-6	5	0.56	38,000,000
1,1,2-Trichloroethane	79-00-5	5	0.39	5,300
Cyclohexane	110-82-7	10	0.33	29,000,000
1,2-Dibromo-3-Chloropropane	96-12-8	10	1.3	69
Ethylene Dibromide	106-93-4	5	0.5	170
Dichlorodifluoromethane	75-71-8	5	0.5	400,000
cis-1,2-Dichloroethene	156-59-2	5	0.36	2,000,000
trans-1,2-Dichloroethene	156-60-5	5	0.41	690,000
Isopropylbenzene	98-82-8	5	0.16	11,000,000
Methyl acetate	79-20-9	10	1.4	1,000,000,000
Methyl tert-butyl ether	1634-04-4	20	0.43	220,000
1,1,2-Trichloro-1,2,2-trifluoroethane	76-13-1	5	1.3	180,000,000
1,2,4-Trichlorobenzene	120-82-1	5	0.27	99,000
1,2-Dichlorobenzene	95-50-1	5	0.36	9,800,000
1,3-Dichlorobenzene	541-73-1	5	0.35	--
1,4-Dichlorobenzene	106-46-7	5	0.66	12,000

TABLE 3.4

SOIL SAMPLE PARAMETER LIST
SOIL STOCKPILE AND SOUTHWEST CORNER INVESTIGATION
TOLEDO 103C LANDFILL
TOLEDO, OHIO

Compound	CAS No.	*Estimated Quantitation Limits (EQL)*[1] *Soil (µg/kg)*	*Method Detection Limits (MDL)*[2] *Soil (µg/kg)*	*Regional Screening Levels (RSL)*[3] *Industrial Soil (µg/kg)*
TCL VOC (continued)				
Trichlorofluoromethane	75-69-4	5	0.34	3,400,000
Chlorodibromomethane	124-48-1	5	0.55	3,300
Methylcyclohexane	108-87-2	10	0.31	--
TCL Semi-volatile Organic Compounds (SVOC)				
1,1'-Biphenyl	92-52-4	50	27	210,000
2,2'-oxybis[1-chloropropane]	108-60-1	100	9.5	22,000
2,4,5-Trichlorophenol	95-95-4	150	25	62,000,000
2,4,6-Trichlorophenol	88-06-2	150	80	160,000
2,4-Dichlorophenol	120-83-2	150	20	1,800,000
2,4-Dimethylphenol	105-67-9	150	20	12,000,000
2,4-Dinitrophenol	51-28-5	330	80	1,200,000
2,4-Dinitrotoluene	121-14-2	200	27	5,500
2,6-Dinitrotoluene	606-20-2	200	21	620,000
2-Chloronaphthalene	91-58-7	50	3.3	82,000,000
2-Chlorophenol	95-57-8	50	27	5,100,000
2-Methylnaphthalene	91-57-6	6.67	3.3	4,100,000
2-Methylphenol	95-48-7	200	80	31,000,000
2-Nitroaniline	88-74-4	200	9.1	6,000,000
2-Nitrophenol	88-75-5	50	27	--
3,3'-Dichlorobenzidine	91-94-1	100	18	3,800
3-Nitroaniline	99-09-2	200	16	--
4,6-Dinitro-2-methylphenol	534-52-1	150	80	49,000
4-Bromophenyl phenyl ether	101-55-3	50	13	--
4-Chloro-3-methylphenol	59-50-7	150	21	62,000,000
4-Chloroaniline	106-47-8	150	17	8,600
4-Chlorophenyl phenyl ether	7005-72-3	50	13	--
4-Nitroaniline	100-01-6	200	26	86,000
4-Nitrophenol	100-02-7	330	80	--
Acenaphthene	83-32-9	6.67	3.3	33,000,000
Acenaphthylene	208-96-8	6.67	3.3	--
Acetophenone	98-86-2	100	9.2	100,000,000
Anthracene	120-12-7	6.67	3.3	170,000,000
Atrazine	1912-24-9	200	9.1	7,500
Benzaldehyde	100-52-7	100	12	100,000,000
Benzo[a]anthracene	56-55-3	6.67	3.3	2,100
Benzo[a]pyrene	50-32-8	6.67	3.3	210
Benzo[b]fluoranthene	205-99-2	6.67	3.3	2,100
Benzo[g,h,i]perylene	191-24-2	6.67	3.3	--
Benzo[k]fluoranthene	207-08-9	6.67	3.3	21,000
Bis(2-chloroethoxy)methane	111-91-1	100	22	1,800,000
Bis(2-chloroethyl)ether	111-44-4	100	2	1,000
Bis(2-ethylhexyl) phthalate	117-81-7	50	19	120,000

TABLE 3.4

SOIL SAMPLE PARAMETER LIST
SOIL STOCKPILE AND SOUTHWEST CORNER INVESTIGATION
TOLEDO 103C LANDFILL
TOLEDO, OHIO

TCL SVOC (continued)

Compound		*Estimated Quantitation Limits (EQL)*[1] *Soil (µg/kg)*	*Soil (µg/kg)*	*Regional Screening Levels (RSL)*[3] *Industrial Soil (µg/kg)*
Butyl benzyl phthalate	85-68-7	50	10	910,000
Caprolactam	105-60-2	330	37	310,000,000
Carbazole	86-74-8	50	27	--
Chrysene	218-01-9	6.67	1.1	210,000
Dibenz(a,h)anthracene	53-70-3	6.67	3.3	210
Dibenzofuran	132-64-9	50	3.3	1,000,000
Diethyl phthalate	84-66-2	50	16	490,000,000
Dimethyl phthalate	131-11-3	50	17	--
Di-n-butyl phthalate	84-74-2	50	15	62,000,000
Di-n-octyl phthalate	117-84-0	50	27	--
Fluoranthene	206-44-0	6.67	3.3	22,000,000
Fluorene	86-73-7	6.67	3.3	22,000,000
Hexachlorobenzene	118-74-1	6.67	2.1	1,100
Hexachlorobutadiene	87-68-3	50	27	22,000
Hexachlorocyclopentadiene	77-47-4	330	27	3,700,000
Hexachloroethane	67-72-1	50	9	120,000
Indeno[1,2,3-cd]pyrene	193-39-5	6.67	3.3	2,100
Isophorone	78-59-1	50	13	1,800,000
Naphthalene	91-20-3	6.67	3.3	18,000
Nitrobenzene	98-95-3	100	2.2	24,000
N-Nitrosodi-n-propylamine	621-64-7	50	27	250
N-Nitrosodiphenylamine	86-30-6	50	21	350,000
Pentachlorophenol	87-86-5	150	80	2,700
Phenol	108-95-2	50	27	180,000,000
Phenanthrene	85-01-8	6.67	3.3	--
Pyrene	129-00-0	6.67	3.3	17,000,000
3 & 4 Methylphenol	15831-10-4	400	20	91,000,000

Polychlorinated Biphenyls (PCB) as Aroclors

Compound		*Estimated Quantitation Limits (EQL)*[1] *Soil (µg/kg)*	*Method Detection Limits (MDL)*[2] *Soil (µg/kg)*	*Regional Screening Levels (RSL)*[3] *Industrial Soil (µg/kg)*
Aroclor-1016	12674-11-2	33	21	21,000
Aroclor-1221	11104-28-2	33	16	540
Aroclor-1232	11141-16-5	33	14	540
Aroclor-1242	53469-21-9	33	13	740
Aroclor-1248	12672-29-6	33	17	740
Aroclor-1254	11097-69-1	33	17	740
Aroclor-1260	11096-82-5	33	17	740

TABLE 3.4

SOIL SAMPLE PARAMETER LIST
SOIL STOCKPILE AND SOUTHWEST CORNER INVESTIGATION
TOLEDO 103C LANDFILL
TOLEDO, OHIO

		Estimated Quantitation Limits (EQL) [1]	*Method Detection Limits (MDL)* [2]	*Regional Screening Levels (RSL)* [3]
Compound		*Soil (mg/kg)*	*Soil (mg/kg)*	*Industrial Soil (µg/kg)*
Site-specific TAL Metals				
Aluminum	7429-90-5	20	9.6	990,000,000
Antimony	7440-36-0	1	0.39	410,000
Barium	7440-39-3	20	0.071	190,000,000
Beryllium	7440-41-7	0.5	0.043	2,000,000
Calcium	7440-70-2	500	16	--
Cadmium	7440-43-9	0.2	0.036	800,000
Cobalt	7440-48-4	5	0.16	300,000
Chromium	7440-47-3	0.5	0.2	1,500,000,000
Copper	7440-50-8	2.5	0.74	41,000,000
Iron	7439-89-6	10	4.9	720,000,000
Potassium	7440-09-7	500	6.2	--
Magnesium	7439-95-4	500	5.1	--
Manganese	7439-96-5	1.5	0.074	23,000,000
Mercury	7439-97-6	0.1	0.015	43,000
Silver	7440-22-4	0.5	0.1	5,100,000
Sodium	7440-23-5	500	66	--
Nickel	7440-02-0	4	0.27	20,000,000
Vanadium	7440-62-2	5	0.12	5,200,000
Zinc	7440-66-6	2	1	310,000,000
Arsenic	7440-38-2	1	0.3	1,600
Lead	7439-92-1	0.3	0.19	800,000
Selenium	7782-49-2	0.5	0.45	5,100,000
Thallium	7440-28-0	1	0.55	10,000

Notes:

[1] - Please note that these are targeted quantitation limits and are presented for guidance only. Actual quantitation limits are highly matrix dependent and may be elevated due to matrix effects, QA/QC problems and high concentrations of target and non-target analytes.

[2] - Method Detection Limits (MDL) are also presented for guidance only. Actual MDLs will vary depending on sample specific preparation factors. The MDLs are also highly matrix dependant and may be elevated due to matrix effects, QA/QC problems and high concentrations of target and non-target analytes. Laboratory MDLs are updated on a periodic basis and the MDLs in effect when the samples are analyzed will be used for reporting purposes.

[3] - Regional Screening Level (RSL) Summary Table, Industrial Soil, June 2011.

-- Not Available

APPENDIX A

ASTM D 6009-96 STANDARD GUIDE FOR SAMPLING WASTE PILES

Designation: D 6009 – 96

Standard Guide for
Sampling Waste Piles[1]

1. Scope

1.1 This guide provides guidance for obtaining representative samples from waste piles. Guidance is provided for site evaluation, sampling design, selection of equipment, and data interpretation.

1.2 Waste piles include areas used primarily for waste storage or disposal, including above-grade dry land disposal units. This guide can be applied to sampling municipal waste piles.

1.3 This guide addresses how the choice of sampling design and sampling methods depends on specific features of the pile.

1.4 *This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.*

2. Referenced Documents

2.1 *ASTM Standards:*

D 1452 Practice for Soil Investigation and Sampling by Auger Borings[2]

D 1586 Test Method for Penetration Test and Split-Barrel Sampling of Soils[2]

D 1587 Practice for Thin-Walled Tube Geotechnical Sampling of Soils[2]

D 4547 Practice for Sampling Waste and Soils for Volatile Organics[3]

D 4687 Guide for General Planning of Waste Sampling[3]

D 4700 Guide for Soil Sampling from the Vadose Zone[2]

D 4823 Guide for Core-Sampling Submerged, Unconsolidated Sediments[4]

D 5088 Practice for Decontamination of Field Equipment Used at Nonradioactive Sites[5]

D 5314 Guide for Soil Gas Monitoring in the Vadose Zone[5]

D 5451 Practice for Sampling Using a Trier Sampler[3]

D 5518 Guide for Acquisition of File Aerial Photography and Imagery for Establishing Historic Site-Use and Surficial Conditions[5]

D 5730 Guide to Site Characterization for Environmental Purposes with Emphasis on Soil, Rock, the Vadose Zone and Ground Water[5]

3. Terminology

3.1 *Definitions of Terms Specific to This Standard:*

3.1.1 *hot spots*—strata that contain high concentrations of the characteristic of interest and are relatively small in size when compared with the total size of the materials being sampled.

3.1.2 *representative sample*—a sample collected such that it reflects one or more characteristics of interest (as defined by the project objectives) of the population from which it was collected.

3.1.2.1 *Discussion*—A representative sample can be a single sample, a set of samples, or one or more composite samples.

3.1.3 *waste pile*—unconfined storage of solid materials in an area of distinct boundaries, above grade and usually uncovered. This includes the following:

3.1.3.1 *chemical manufacturing waste pile*—a pile consisting primarily of discarded chemical products (whether marketable or not), by-products, radioactive wastes, or used or unused feedstocks.

3.1.3.2 *scrap metal or junk pile*—a pile consisting primarily of scrap metal or discarded durable goods such as appliances, automobiles, auto parts, or batteries.

3.1.3.3 *trash pile*—a pile of waste materials from municipal sources, consisting primarily of paper, garbage, or discarded nondurable goods that contain or have contained hazardous substances. It does not include waste destined for recyclers.

4. Significance and Use

4.1 This guide is intended to provide guidance for sampling waste piles. It can be used to obtain samples for waste characterization related to use, treatment, or disposal; to monitor an active pile; to prepare for closure of the waste pile; or to investigate the contents of an abandoned pile.

4.2 Techniques used to sample include both in-place evaluations of the pile and physically removing a sample. In-place evaluations include techniques such as remote sensing, on-site gas analysis, and permeability.

4.3 Sampling strategy for waste piles is dependent on the following:

4.3.1 Project objectives including acceptable levels of error when making decisions;

4.3.2 Physical characteristics of the pile, such as its size and configuration, access to all parts of it, and the stability of the pile;

4.3.3 Process that generated the waste and the waste characteristics, such as hazardous chemical or physical properties, whether the waste consists of sludges, dry powders or granules, and the heterogeneity of the wastes;

4.3.4 History of the pile, including dates of generation,

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[1] This guide is under the jurisdiction of ASTM Committee D-34 on Waste Management and is the direct responsibility of Subcommittee D34.01 on Sampling and Monitoring.

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[2] *Annual Book of ASTM Standards*, Vol 04.08.

[3] *Annual Book of ASTM Standards*, Vol 11.04.

[4] *Annual Book of ASTM Standards*, Vol 11.02.

[5] *Annual Book of ASTM Standards*, Vol 04.09.

methods of handling and transport, and current management methods;

4.3.5 Regulatory considerations, such as regulatory classification and characterization data;

4.3.6 Limits and bias of sampling methods, including bias that may be introduced by waste heterogeneity, sampling design, and sampling equipment.

4.4 It is recommended that this guide be used in conjunction with Guide D 4687, which addresses sampling design, quality assurance, general sampling considerations, preservation and containerization, cleaning equipment, packaging, and chain of custody.

4.5 A case history of the investigation of a waste pile is included in Appendix X1.

5. Site Evaluation

5.1 Site evaluations are performed to assist in designing the most appropriate sampling strategy. An evaluation may consist of on-site surveys and inspections, as well as a review of historical data. Nonintrusive geophysical and remote sensing methods are particularly useful at this stage of the investigation (see Guide D 5518). Table 1 summarizes the effects that various factors associated with the waste pile, such as the history of how the pile was generated, have upon the strategy and design of the sampling plan. The strategic and design considerations are discussed as well.

5.2 *Generation History*—The waste pile may have been created over an extended time period. A remote sensing method that is very useful in establishing historical management practices for waste piles is aerial imagery. Aerial photographs are widely available and may be used to determine the history of a waste pile, sources of waste, and the presence and distribution of different strata. Satellite imagery could be used for larger waste piles.

5.2.1 The date of generation could be important with respect to the types of processes that generated the waste, the characteristics of the waste, the distribution of the constituents, and regulatory concerns.

5.2.2 The type of process that generated the waste will determine the types of constituents that may be present in the waste pile. Chemical variability will influence the number of samples that are required to characterize the waste pile unless a directed (biased) sampling approach is acceptable.

5.2.3 The delivery method of the material to the waste pile could influence the concentrations of the constituents, affect the overall shape of the pile, or create physical dissimilarity within the waste pile through sorting by particle size or density.

TABLE 1 Strategy Factors

Waste Pile Factors	Strategic Considerations	Design Considerations
Generation history	Date of generation	Analysis required
	Types of processes	Location of samples
	Characteristics by process	
	Delivery method	
	Current management	
	Regulatory considerations	
Physical characteristics of pile:	Physical variability of pile	Number of samples
– size	Access	Location of samples
– shape	Safety	Equipment selection
– stability		
Waste characteristics	Constituents present	Number of samples
	Constituent distribution	Analysis required
	Heterogeneity	Location of samples
	– physical variability	Representative samples
	– chemical variability	Equipment selection

5.2.4 If the pile is under current management and use, the variability in constituent types and concentrations may be affected. Current management activities also may influence the regulatory status of the waste pile.

5.2.5 Regulatory considerations will typically focus on waste identification questions, in other words is the material a solid waste that should be regulated and managed as a hazardous waste (**1**).[6] This may involve a limited, directed sampling approach, particularly if a regulatory agency is conducting the investigation. A more comprehensive sampling design may be required to determine if the waste classifies as hazardous. Remediation efforts and questions regarding permits may focus on characterizing the entire pile, possibly as the removal of material is occurring. It should be noted that concentrations of contaminants near regulatory levels may increase the number of samples required to meet the objectives of the investigation. These regulatory levels could be those established to determine if a waste is hazardous, or "cleanup" levels set for a removal or remediation.

5.3 *Physical Characteristics of Pile*—Several physical characteristics of the waste pile must be considered during the site evaluation. Variability in size, shape, and stability of the pile affects access to it to obtain samples as well as safety considerations. Physical variability will influence the number of samples that are required to characterize the waste pile unless a directed (biased) sampling approach is considered to be acceptable. Techniques that might be used include resistivity and seismic refraction (for determining the depth of very large piles).

5.3.1 The size of the waste pile will influence the sampling strategy in that increasing size is often accompanied by increased variability in the physical characteristics of the waste pile. The number of samples, however, that are needed to characterize a waste pile adequately will typically be a function of the study objectives as well as the inherent variability of the pile.

5.3.2 The shape of the waste pile can influence the sampling strategy by limiting access to certain locations within the pile, and if it is topologically complex it is difficult to lay out a sampling grid. Also, a waste pile may extend vertically both above and below grade, making decisions regarding the depth of sample collection difficult.

5.3.3 The stability of the waste pile also can limit access to both the face and the interior of the pile. The use of certain types of heavier sampling equipment also could be limited by the ability of the pile to bear the weight of the equipment.

5.4 *Waste Characteristics:*

5.4.1 The constituents could include inorganics, volatile organic compounds (VOCs), and semivolatile organic compounds (including pesticides and polychlorinated biphenyls (PCBs)) (see Practice D 4547). Speciality analyses may be warranted, such as leaching tests or analyses for dioxin/

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[6] The boldface numbers in parentheses refer to the list of references at the end of this standard.

furans or explosive compounds. Soil gas sampling is a minimally intrusive technique that may detect the presence and distribution of volatile organic compounds in soils and in porous, unconsolidated materials. Appropriate applications for soil gas monitoring are identified in Guide D 5314.

5.4.2 The distribution of constituents in the waste pile could be influenced by changes in the manufacturing process which resulted in changes in the composition of the waste; the length of time the material has remained in the pile (particularly for VOCs); the mode of delivery of the waste materials to the pile; and management practices, such as mixing together wastes from more than one process.

5.4.3 Physical and chemical variabilities would include variability in the chemical characteristics of the material within the pile, as well as variability in particle size, density, hardness, whether brittle or flexible, moisture content, consolidated, or unconsolidated. The variability may be random or found as strata of materials having different properties or containing different types or concentrations of constituents.

5.4.3.1 Geophysical survey methods may be used on piles to estimate physical homogeneity, which may or may not be related to chemical homogeneity, and to detect buried objects, both of which may need to be considered during the development of the sampling design and the safety plan for the investigation. The most suitable technique for detecting nonmetallic objects is electromagnetics. Ground-penetrating radar, a more sophisticated and complex technique, also may be considered. Electromagnetic techniques are suited particularly to large piles that contain leachate plumes (for example, mine tailings) or for the detection of large discontinuities in a pile (for example, different types of wastes or the transition from a disposal area to background soils). For metallic objects, metal detectors and magnetometers are useful and relatively easy to use in the field.

5.5 *Potential Investigation Errors:*

5.5.1 Equipment selection can bias sampling results even if the equipment is used properly. Bias can result from the incompatibility of the materials that the sampling equipment is made of with the materials being sampled. For example, the equipment could alter the characteristics of the sample. Some equipment will bias against the collection of certain particles sizes, and some equipment cannot penetrate the waste pile adequately.

5.5.2 Equipment, use, and operation can introduce error (bias) into the characterization of a waste pile. Sampling errors typically are caused when certain particle sizes are excluded, when a segment of the waste pile is not sampled, or when a location outside the pile is inadvertently sampled.

5.5.3 When stratification, layering, or solid phasing occurs it may be necessary to obtain and analyze samples of each of the distinct phases separately to minimize sampling bias. Care should be taken when sampling stratified layers to minimize cross contamination. Proper decontamination procedures should be used for all sampling equipment (see Practice D 5088).

5.5.4 Statistical bias includes situations where the data are not normally distributed or when the sampling strategy does not allow the potential for every portion of the pile to be sampled.

6. Sampling Strategy

6.1 Developing a strategy for sampling a waste pile requires a thorough examination of the site evaluation factors listed in Section 5. The location and frequency of sampling (number of samples) should be outlined clearly in the sampling plan, as well as provisions for the use of special sampling equipment, access of heavy equipment to all areas of the pile, if necessary, and so forth.

6.1.1 *Representative Sampling*—The collection of a representative set of samples from a waste pile typically will be complicated by the presence of a number of the site evaluation factors **(2,3)**.

6.1.2 *Heterogeneous Wastes*—Waste piles may be homogeneous, for applied purposes, or may be quite heterogeneous in particle size and contaminant distribution. If the particle sizes of the material in the waste pile and the distribution of contaminants are known, or can be estimated, then less sampling may be necessary to define the properties of interest in the waste pile. An estimate of the variability in contaminant distribution may be based on process knowledge or determined by preliminary sampling **(4)**. The more heterogeneous the waste pile is, the greater the planning and sampling requirements.

6.1.3 *Strata and Hot Spots*—A waste pile also could contain strata that have less internal variation in physical properties or concentrations of chemical constituents than the remainder of the waste pile **(2,5)**. For example, strata may be present in a waste pile due to changes in the process that generated the waste, or if different processes at a facility contribute waste to different parts of the waste pile. A stratified sampling strategy would consider this situation by conducting independent sampling of each stratum, which could reduce the number of samples required. These strata could be in specific areas of the waste pile **(4)**. Also, hot spots may be present in the waste pile that are unique in composition **(2,5)**.

6.2 *Specific Sampling Strategies:*

6.2.1 Although the most appropriate method for evaluating material in waste piles is to sample at or immediately following the point of generation (for example, conveyor belt), most sampling problems involve existing or in-place waste piles. Therefore, the following discussion will focus on in-place waste piles. Sampling strategies available for waste piles include directed or judgmental sampling, simple random sampling, stratified random sampling, systematic grid sampling, and systematic sampling over time **(2,6)**. General concerns about the collection of a representative sample, the existence of potential heterogeneity in the waste pile, the presence of strata within the waste pile, and the existence of distinct hot spots within the waste pile may also influence the selection of an appropriate sampling strategy and development of the sampling plan **(5)**. The following paragraphs provide an introduction to determining the appropriate number of samples to collect and the sampling strategies available for determining sample locations.

6.2.2 *Determining the Frequency or Number of Samples*—The frequency of sampling or the number of samples to collect typically will be based on several factors including the study objectives, properties of wastes in the pile, degree of confidence required, access to sampling points, and budgetary constraints. Practical guidance for determining the number of samples is included in Guide D 4687 and Refs (2, 3).

6.2.3 *Directed Sampling*—Directed sampling (Fig. 1) is based on the judgment of the investigator and will not result necessarily in a sample that reflects the characteristics of the entire waste pile. Directed sampling also is called judgmental sampling, authoritative sampling, or nonprobability sampling. The experience of the investigator often is the basis for sample collection, and, depending on the study objectives, bias should be recognized as a potential problem. For preliminary screening investigations of a waste pile and for certain regulatory investigations, however, directed sampling may be appropriate. A directed sampling strategy could call for the collection of a composite sample from the surface area or the collection of discrete grabs at the surface of the pile (see Fig. 1). Directed sampling would typically focus on worst case conditions in a waste pile, for example, the most visually contaminated area or most recently generated waste.

6.2.4 *Simple Random Sampling*—Simple random sampling (Fig. 2) ensures that each element in the waste pile has an equal chance of being included in the sample (2). This may be the method of choice when, for purposes of the investigation, the waste pile is randomly heterogeneous (5). If the waste pile contains trends or patterns of contamination, a stratified random sampling or systematic grid sampling strategy would be more appropriate (2) (see 6.2.5 and 6.2.6).

6.2.4.1 A simple random approach could use a grid with random grids selected for sample collection (see Fig. 2). Note that the grid size could be selected based on the number of samples that are required (some guidance suggests having at least ten times the number of grids as samples required). Once the grid is overlaid and the sampling locations are selected, the decision must be made to collect either a discrete grab sample (surface), a composite of surface samples taken from predesignated locations within the grid cell (based on compass points), a vertical composite to a specified depth, or discrete grab samples at specified depths. If discrete grab samples are desired at specified depths, they typically would be collected at the same location as the bore hole is advanced into the pile. Figure 2 illustrates the collection of vertical composites at each of the randomly selected locations.

6.2.5 *Stratified Random Sampling*—Stratified random sampling (see Fig. 3) may be useful when distinct strata or homogeneous subgroups are identified within the waste pile (2). The strata may be located in different areas of the pile or may be comprised of different layers (see Fig. 3). This approach is useful when the individual strata may be considered internally homogeneous or at least have less

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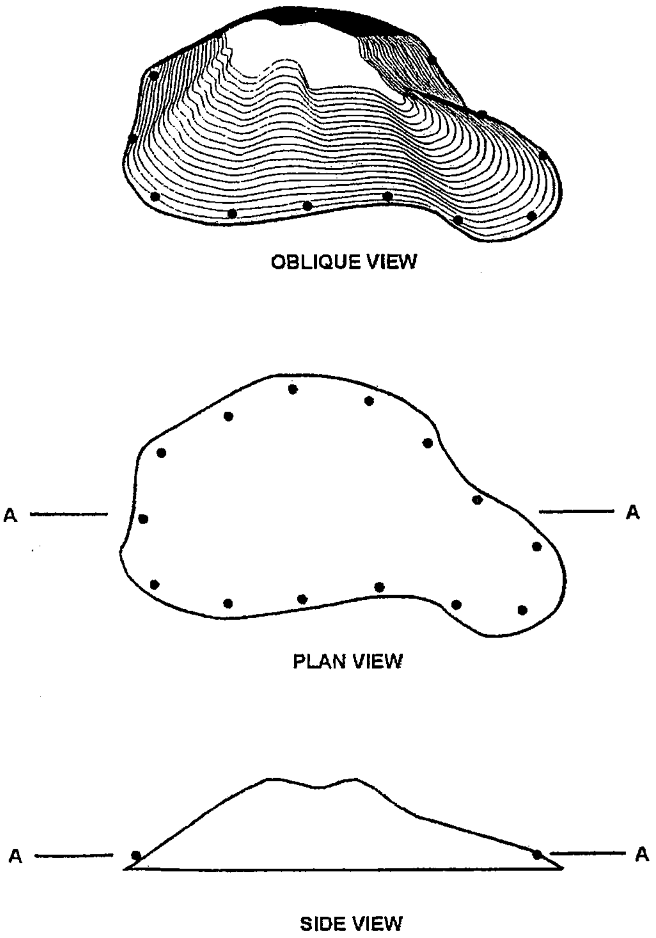

FIG. 1 Waste Pile Sampling Strategy—Directed Sampling

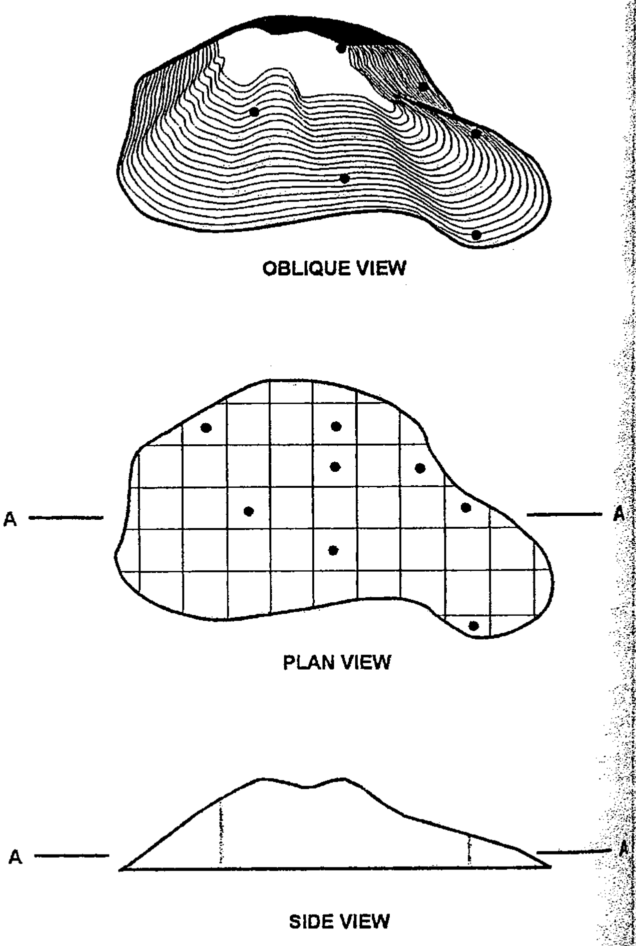

FIG. 2 Waste Pile Sampling Strategy—Simple Random Sampling

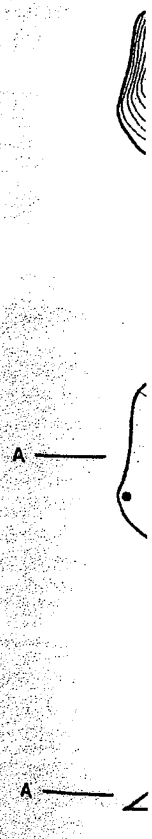

FIG. 3 W

internal variation in what would otherwise be considered a heterogeneous waste pile (2). Information on the waste pile usually is required to establish the location of individual strata unless process knowledge or changes in the composition of the material is obvious, such as with discoloration or with the type of waste. The grid may be utilized for sampling several horizontal layers if the strata are oriented horizontally (4). A simple random sampling approach then is used within each stratum. The use of a stratified random sampling strategy may result in the collection of fewer samples. Figure 3 illustrates a scenario where the number of samples collected in each stratum varies (plan view), and discrete grabs are collected in each boring at predesignated depths (side view).

6.2.6 *Systemic Grid Sampling*—Systematic grid sampling (see Fig. 4) involves the collection of samples at fixed intervals and is useful when the contamination is assumed to be distributed randomly (2). This method also is commonly used with waste piles when estimating trends or patterns of contamination or when the objective is to locate hot spots. This approach may not be acceptable if the entire waste pile is not accessible or if the sampling grid locations become phased with variations in the distribution of contaminants within the waste pile (6). It also may be useful for identifying the presence of strata within the pile. The grid and starting points should be laid out randomly over the waste pile, yet the method allows for rather easy location of exact sample locations by means of the grid (see Fig. 4). The same considerations discussed in 6.2.4 concerning the depth of each sample (surface, vertical composite, discrete grabs at depth) also should be considered. Figure 4 illustrates the collection of vertical composites at each grid, which could be difficult and costly. Also note that the grid size typically would be adjusted according to the number of samples that are required.

6.2.7 *Systematic Sampling Over Time*—Systematic sampling over time at the point of generation is useful if the material is being sampled from a conveyor belt or being delivered by means of truck or pipeline to the waste pile. The sampling interval can be determined on a time basis, for example, every hour from a conveyor belt or pipeline discharge, or from every third truck load. The time between intervals is influenced by the factors addressed in 6.2.2.

6.2.8 *Alternative Approach*—In many cases, an objective of waste pile characterization is to determine the impact of the pile on the environment. At times this may be accomplished more easily by sampling the routes by which contaminants are dispersed from the pile than through direct sampling of the pile, especially for piles that are difficult to

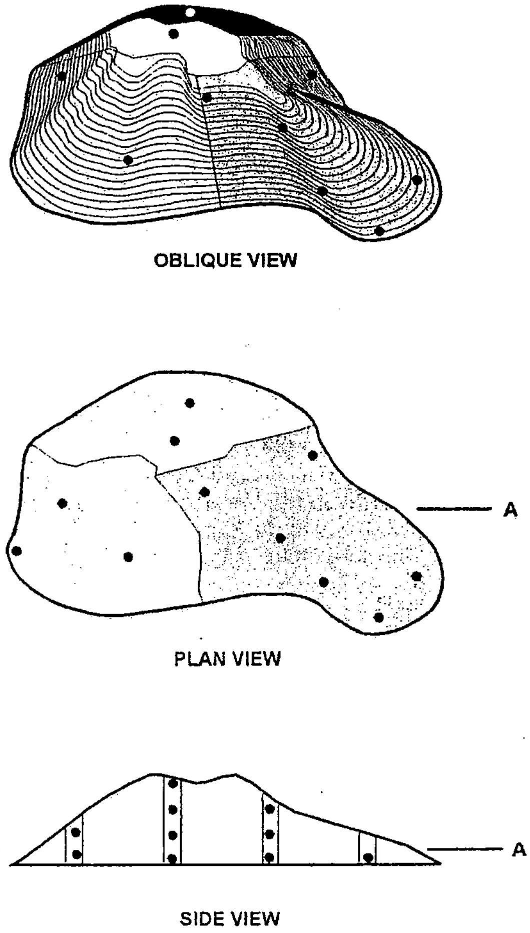

FIG. 3 Waste Pile Sampling Strategy—Stratified Random Sampling

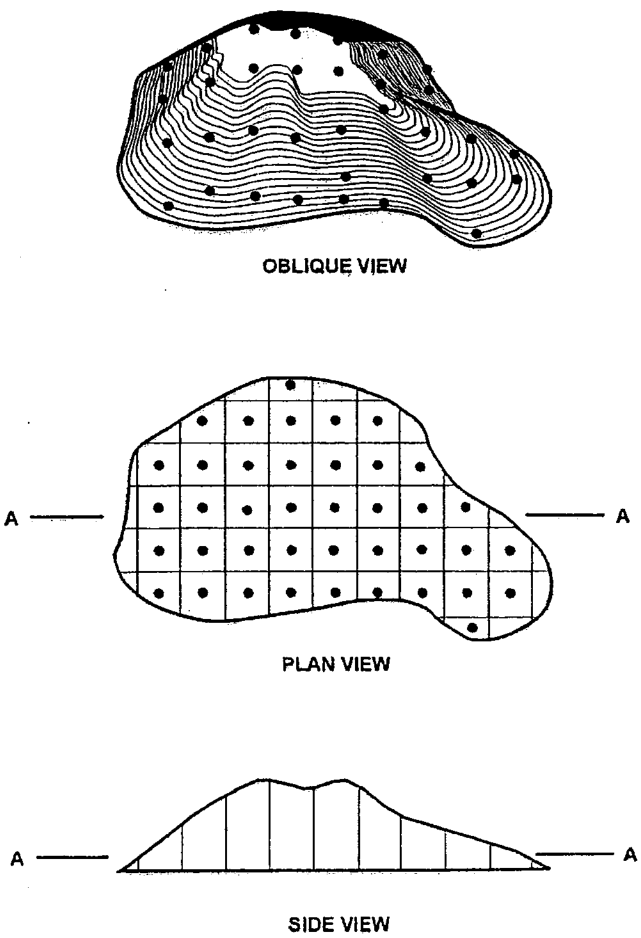

FIG. 4 Waste Pile Sampling Strategy—Systematic Grid Sampling

TABLE 2 Sampling Devices Suitable for Waste Piles[A]

Location and Waste Type	Sampling Devices	ASTM Standard	Limitations
Subsurface Powdered, granular, or soil-like solids; sludges	split-barrel push coring device	D 1586 D 1587 D 4700 D 4823	Limited application for sampling moist and sticky solids, or particles with diameter 0.6 cm (0.25 in.) or more. Depth limitation of about 1 m.
	trier	D 5451	May not retain core sample of very dry granular materials. Not applicable to sampling solid wastes with particle diameter >½ the diameter of the sampling tube.
	auger	D 1452 D 4700	Does not collect undisturbed sample.
	thin-walled tube sampler	D 4823 D 4700	Collects relatively undisturbed core. Difficult to use on gravelly or rocky soils.
	drill rigs		Used for geoenvironmental exploration. To minimize sample contamination, avoid those using a water-based drilling fluid.
	soil gas samplers	D 5314	Used for volatile organic compounds.
Surface Powdered, granular, or soil-like solids; sludges	trowel or scoop	D 4700	Not applicable to sampling deeper than 8 cm (3 in.). Difficult to obtain reproducible mass of sample. May exclude certain particle sizes, especially large aggregates.
Slag	hammer/chisel Impact device		Changes particle size.

[A] This table is not all inclusive; other equipment may be used.

TABLE 3 Excavation and Removal Equipment for Waste Piles

Excavation and Removal Equipment	General Excavation	Ability to Excavate Hard and Compacted Material	Soil Hauling	Mixing of Solids, Soil	Spreading Cover	Site Maneuverability
Wheel or crawler Mounted backhoe	A[A]	A	B[B]/O[C]	A	A	A/B
Wheel or crawler Mounted front-end loader	A	A	A/B	A	A	A/B
Skid steer loader	A	B	B	A	B	A
Bulldozer	A	A	O	O	A	B

[A] A = Good choice. Equipment is fully capable of performing function listed.
[B] B = Secondary choice. Equipment is marginally capable of performing function listed.
[C] O = Not applicable or poor choice.

characterize. For example, ground water up-and-down gradient from the pile could be sampled to check for ground water contamination. The vadose zone below the pile also might be sampled to detect leachate (and potential ground water contamination) through soil sampling, vacuum lysimeters, or soil gas. Surface water and sediment in drainage channels down gradient from the pile also might be sampled. Surface soils, air samples, and contaminants deposited on vegetation can be used as indicators of atmospheric transport of contaminants from the pile, including both particulate and volatile materials. Such approaches will seldom replace pile sampling completely, but they may reduce the number of pile samples needed to make remedial action decisions (see Guide D 5730), also Refs (**7,8,9**).

7. Selection of Sampling Equipment

7.1 Wastes in piles are often complex, multiphase mixtures of solids and semisolids. The wastes can range from powders to granules to large, heterogeneous solid fragments and can cover many acres in area. No single type of sampler can be used to collect representative samples of all types of waste from piles. Large, thick piles may require drill rigs to obtain samples from depth. The sampling of gases from within the pile requires other types of equipment. Table 2 lists typical waste types and the corresponding recommended samplers to use.

7.2 Sampling at depth from inside the pile may require heavy equipment designed for excavation or removal of soil or rock. Table 3 lists such equipment and its applications for sampling waste piles (**10**).

7.3 Sampling equipment should be constructed of materials that are compatible with the waste to be sampled. Compatibility refers to the physical durability, lack of chemical reactivity with the waste, and lack of potential for contamination of the waste with analytes of concern. Typical materials of construction include stainless steel, plastic, and glass.

8. Data Use

8.1 The decisions that will be made based upon the data must be identified early in the planning process since these affect the approach to the problem and how the data will be evaluated. Decisions affecting waste classification, closure, and post-closure issues, are examples of the uses of the data. Methods to determine the volume of contaminated material in a pile or pile strata may be needed. Standard mathematical formulas for calculating the volume of a cone, cylinder, various prisms, and so forth, may be used.

8.1 *Statistical Considerations:*

8.1.1 Data quality assessment (DQA) methods are used to evaluate the data for any anomalies and to evaluate the assumptions for statistical evaluation. The statistician makes use of both subjective judgment (graphical analysis for identification of trends and anomalies) and statistical models and inference (for example, outlier detection, autocorrelation estimation) in the investigation of data for validity of the assumptions needed to make a statistical test. Classical statistical models assume that the samples collected from the population of interest are independent and have an identical probability distribution (that is, normal distribution with constant mean and variance). Random sampling is a method to ensure independence. The probability distributional assumptions are part of DQA that will determine if the classical statistical model is appropriate for the collected data. For directed sampling, the sampling is subjective and the sample results are typically judged on a qualitative basis.

8.1.2 Simple random sampling will provide an unbiased estimate of the average waste concentration, that is, an estimate of the mean. This unbiased estimate is independent of the geometry of the pile and of the distribution of the concentration of the contaminants, but it may not have the smallest variance. Other sampling designs, such as systematic grid sampling or stratified random sampling, may provide an average that has a smaller variance. If the waste pile has uneven topography, the calculation of the mean concentration of the pile should be a volume-weighted average, using core volume as the weighting factor to reduce the variance of the estimated mean.

8.1.2.1 For simple random sampling and systematic grid sampling designs, histogram and normal probability plots of the sample data can be used to judge if the data conform to normal distribution. If not, there are several alternatives. First, the classical statistical model may still be considered robust for the decision-making process. Second, a transformation of the data may approximate a normal distribution of the data. For example, logarithmic transformation will normalize data that are lognormal originally. If the data are lognormal, the question of whether to use the arithmetic mean or the geometric mean for decision-making purposes must be decided. Third, an alternative statistical model based on nonparametric methods, but which uses weaker assumptions, may be proposed to analyze the decision-making process. It may be advisable to consult a statistician.

8.1.2.2 For the stratified random sampling design, the test of normality is not straightforward. Generally, it requires a mathematical model to take out the strata effects first, then test for normality using the residuals. A statistician should be consulted.

8.1.2.3 In any of these cases, alternative consequences of the level of uncertainty can be calculated prior to collecting the data. These alternatives can be used by decision-makers to select the best strategy to minimize the environmental risks.

9. Keywords

9.1 piles; sampling; waste

APPENDIX

(Nonmandatory Information)

X1. WASTE PILE—A CASE HISTORY

X1.1 Background—The waste pile was generated by a facility that produces brass alloys from scrap metal. The byproduct from this operation was slag, which was generated in the recovery furnace. The slag was ground subsequently in a ball mill prior to being reintroduced into the recovery furnace. A large amount of the ground slag was disposed of in a waste pile which covered about one acre. No active management was occurring with the waste pile. No buried containers or extremely heterogenous material (unground slag) was suspected of being present in the waste pile based on facility records and interviews of personnel.

X1.1.1 Lead and cadmium were the constituents of concern based on process knowledge, and the possibility for the waste being hazardous was the regulatory consideration. The potential for off-site migration of contaminants was also an immediate concern, and this was considered in the development of the Phase 1 study design. Figure X1.1 shows a site map of the facility and the slag pile. Figure X1.2 shows a computer enhancement of the slag pile, and Fig. X1.3 shows a topographic view of the pile.

X1.2 Phase 1:

X1.2.1 *Objective*—The primary objective of the initial investigation was to determine if the slag in the waste pile classified as hazardous based on the concentration of lead and cadmium in a leach test. A secondary objective was to provide preliminary information on the potential migration and transport of contaminants from the waste pile off-site. The sampling plan for this initial investigation utilized a directed sampling strategy to provide a preliminary estimate of the lead concentration in the waste, the variability of contaminant concentrations in the pile, and the potential for leaching using the applicable leaching procedure mandated in regulations. Four composite samples were collected from the surface (0 to 15 cm or 0 to 6 in.) of the waste pile at locations within the four quadrants. The following environmental samples were also collected:

X1.2.1.1 Several soil samples in the vicinity of the waste pile,

X1.2.1.2 Sediment upstream and downstream in a stream which borders the facility,

X1.2.1.3 Sediment in a ditch which contained runoff from the pile, and

X1.2.1.4 Two background soil samples.

X1.2.2 Figure X1.4 shows the Phase 1 sampling locations within the slag pile, and Fig. X1.5 shows the same sampling locations on the topographic map of the pile.

X1.2.3 *Results*—Zinc, copper, cadmium, and lead were

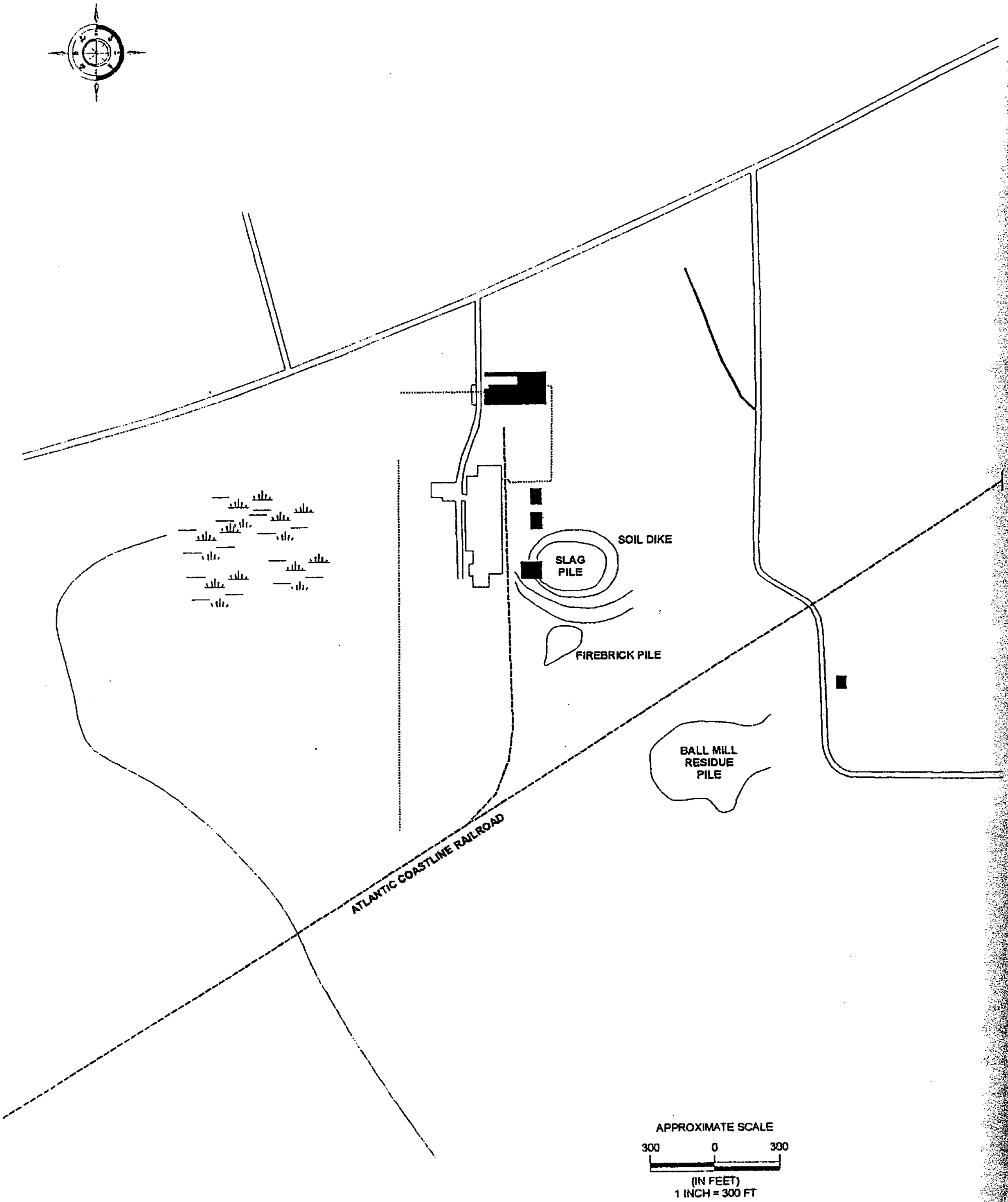

FIG. X1.1 Site Map

all elevated (compared to background) in the samples collected from the waste pile, and the concentrations did not appear to vary significantly between the samples. Since lead and cadmium are regulated constituents, a leach test completed, and the lead results exceeded the regulatory of 5 mg/L. Cadmium was just under the regulatory

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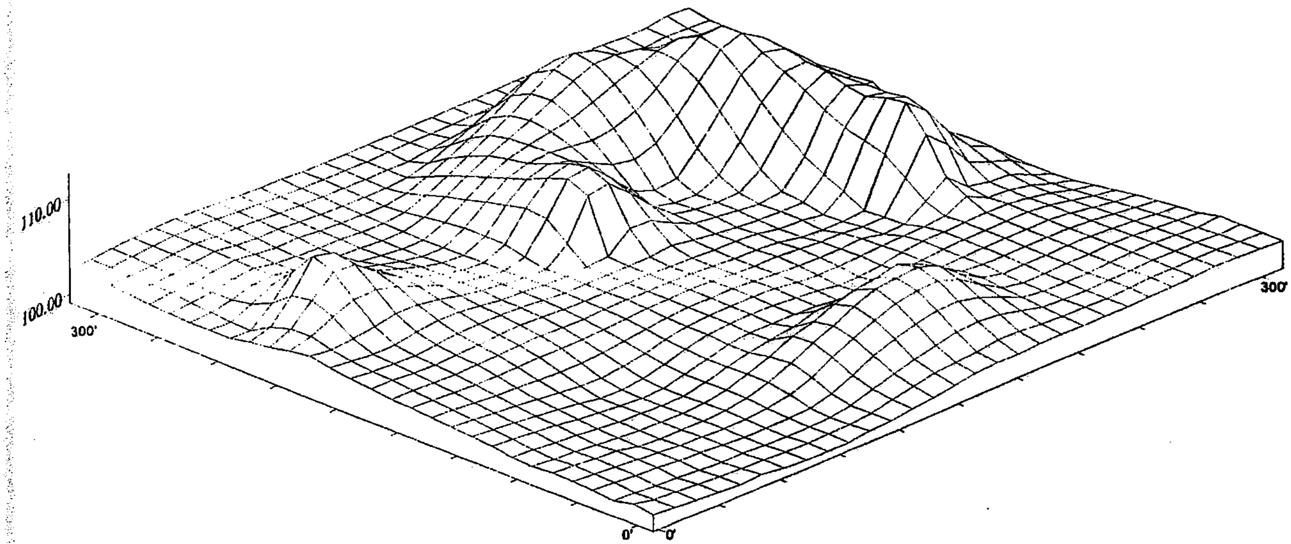

FIG. X1.2 Computer Enhancement of the Slag Pile (Front View) Scale 1:1:2

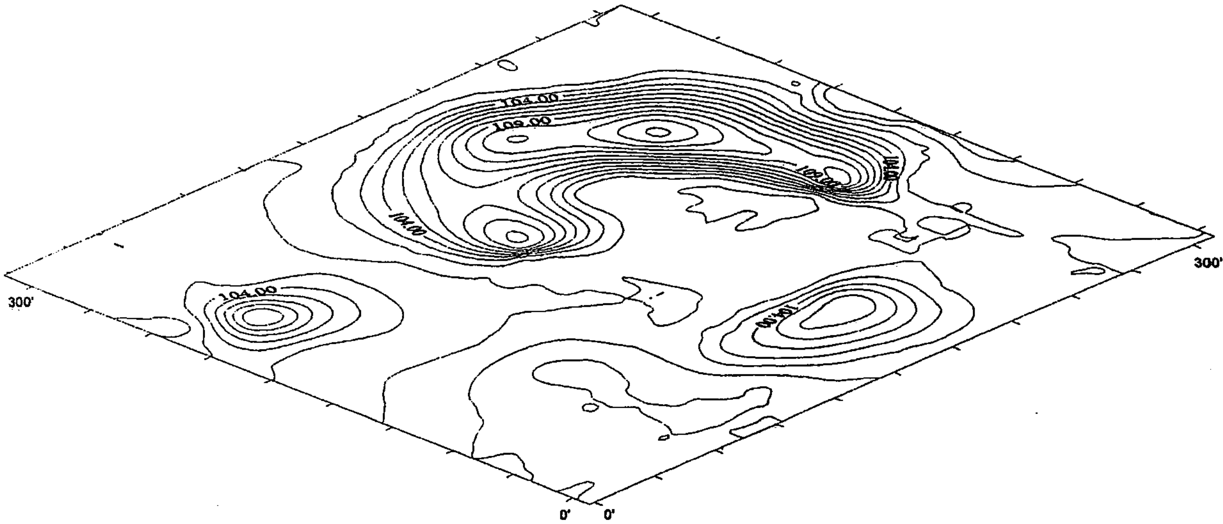

FIG. X1.3 Topographic View of the Slag Pile

1.0 mg/L. Lead and cadmium concentrations in the soil were to 3 times above background, and the drainage ditch and ownstream sediment sample also had elevated lead and admium levels.

X1.2.4 *Conclusion*—The waste pile contained slag that is azardous for lead. The waste pile required further characrization to determine the variability in the pile. The resence of lead and cadmium in soils and the stream ediment downstream of the facility was confirmed and hould be investigated further to determine the extent of ontaminant transport.

1.3 Phase 2:

X1.3.1 *Objective*—The objective is to characterize the aste pile further using a systematic grid sampling design. his design will delineate horizontal and vertical variability in lead and cadmium concentrations. The Phase 1 investigation also provided a good estimate of the anticipated variability in the waste pile. The number of samples required to characterize the waste pile adequately was calculated based on the average concentration, the anticipated variability, the regulatory level of concern, and the specified confidence interval. The grid size then was adjusted to accommodate the projection on the required number of samples. Composite samples were collected within each grid cell based on one center point and eight points on the compass (45° intervals) equidistant from the center point. Ten percent of the grids were designated for vertical as well as surface (0 to 15 cm or 0 to 6 in.) sample collection. Additionally, 10 % of the grids were designated randomly for duplicate sampling (using a different aliquot pattern) to check the preliminary estimate on the variability. Additional

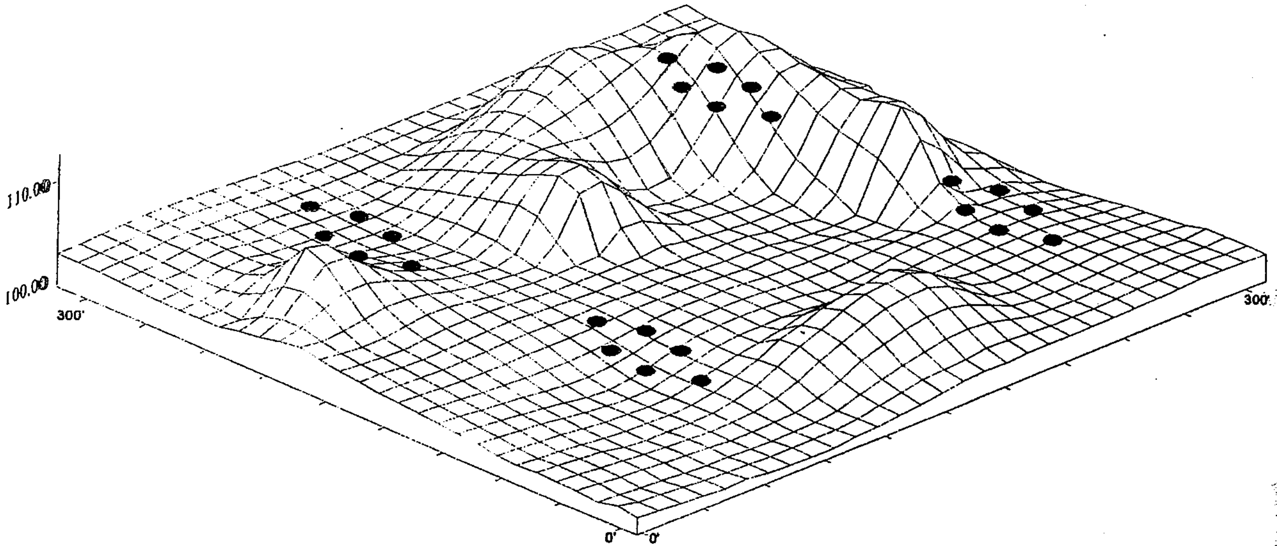

FIG. X1.4 Front View of the Slag Pile Showing Sampling Locations Scale 1:1:2

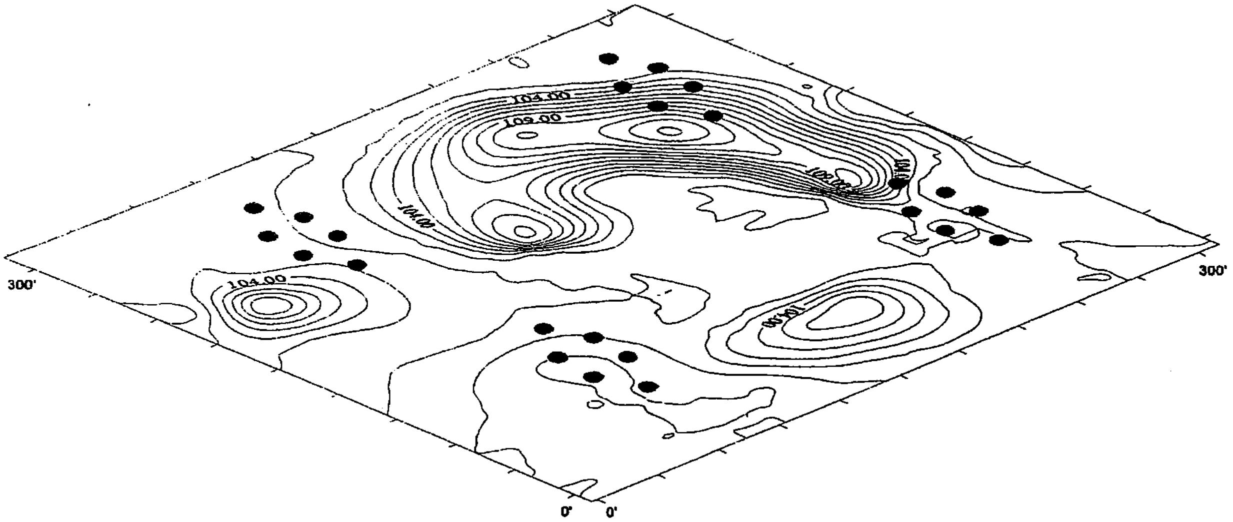

FIG. X1.5 Topographic View of the Slag Pile Showing Sampling Locations

environmental sampling was conducted but will not be covered in this discussion.

X1.3.2 *Results*—The results supported the initial Phase 1 investigation with lead consistently exceeding the regulatory level. Cadmium consistently was below the regulatory level.

X1.3.3 *Conclusion*—The waste pile was characteristic for lead and classified as hazardous according to the applicable regulations. There was no significant variability with depth, although several gradients were noticed across the grid based on lead concentration (scan) results.

X1.4 Phase 3:

X1.4.1 *Objective*—The objective is to determine the volume of the waste pile in order to estimate both disposal cost and the total amount of the civil penalty to charged to the owner of the pile. The waste pile was surv using standard surveying techniques.

X1.4.2 *Results*—The results were used to calculate volume using geometric principles. Also, a computer p gram was utilized which constructs contours based on surveying information. The computer program was used check of the manual method, which produced a result was 10 % higher in volume than the computer program.

X1.4.3 *Conclusion*—For penalty calculation purposes smaller estimate was utilized; however, the actual treat and disposal costs could reflect the larger estimate.

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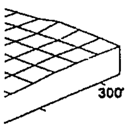

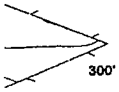

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